ANNEX 1 – THE PROJECT

1. Cover page

a. **Proposal Title:** Safer Options for Smallholder Management of Cereal Grain Storage Insect Pests in Zimbabwe

b. **Project start date and duration:** 1 November 2011, 24 months

c. **Total Budget requested in US$:** 60,000

2. Abstract

The proposed study seeks to develop safer, effective and environmentally-friendly options for managing stored-grain insect pests in maize and sorghum that are suitable for smallholder farmers. The options to be evaluated include combinations of: biopesticides and diatomaceous earths (DEs); insect growth regulators (IGR) and DEs; and DEs and a pyrethroid. The options should be effective against *Prostephanus truncatus*, a new storage insect pest in Zimbabwe. The efficacy of these novel and hopefully synergistic pest management combinations will be determined, firstly in the laboratory. Thereafter, promising options will be tested simultaneously in on-station and on-farm trials and by farmer experimenters participating in farmer field schools. Other stakeholders (eg private sector, extension, pesticide registration authority, farmer association representatives) will be engaged in the research process to help validate the trials and facilitate the process of getting those combinations deemed by stakeholders to be the most appropriate options, into social and economic use. The study will be conducted by 2 MPhil students registered with University of Zimbabwe: one with a bias in crop protection, while the other will have a development and action research background.

3. The Problem

Maize is the most important staple grain in rural southern Africa, and in Zimbabwe it is grown by at least 80% of the inhabitants, most of whom are smallholder farmers. In areas that receive marginal rainfall, sorghum is also an important staple food crop. Climate change is likely to increase the importance of sorghum in semi-arid areas of southern Africa as the chances of maize crop failure increase. Mano and Nhemachena (2006) predicted a temperature increase of 2-4°C and an average rainfall decrease of 10-21% in Zimbabwe by 2100. About 68% of Zimbabwean farmers were already found to be making efforts to adjust to changing climatic conditions (Mano and Nhemachena, 2006), and protecting ever more valuable food stocks will be an important part of this.

Hybrid maize and improved sorghum cultivars are widely grown by Zimbabwean smallholder farmers mainly because of their high yield potential. Unfortunately, these cultivars are more susceptible to storage insect pests compared to the lower yielding traditional cultivars (Kossou *et al*., 1994) and therefore the risk of post-harvest loss is high. In 2007, the Larger Grain Borer (LGB), *Prostephanus truncatus* was reported in several parts of Zimbabwe (Nyagwaya, 2009). LGB is a devastating storage beetle which inflicts at least 3 times higher losses when compared to losses caused by the normal range of storage insect pests. Hence any grain protection strategy developed must also be effective against this pest. The pest has been reported in several southern and eastern African countries and therefore could also benefit from the findings of the proposed study.

Grain storage as a household food security strategy is widely practised by smallholder farmers throughout sub-Saharan Africa. Storage insect pests are the biggest threat, often forcing farmers to sell their grain prematurely because of pest infestation. The costs of agricultural inputs, food and feed are increasing on the global market. It is therefore imperative that post-harvest losses, are minimised in order to maintain a steady supply of safe food and feed, and increased control over income-earning opportunities. Currently, the control of storage pests is heavily dependent on contact pesticide treatment. The range of stored-product protectants is narrowing as consumers are questioning their safety and environmental impact. These factors are likely to lead to the withdrawal of some major grain protectants in the US and Europe, which will affect their availability in developing countries since most of the active ingredients of these pesticides are imported from there.

Insect resistance to both contact insecticides and phosphine as a result of misuse of insecticides and insect evolution continues to increase and has been reported in many countries (Subramanyam and Harein, 1990; Guedes *et. al*, 1996). In Zimbabwe, natural populations of *Sitophilus zeamais*, showed malathion resistance of up to six-fold compared to a susceptible laboratory strain (Giga and Mazarura, 1990), corroborating the dissatisfaction expressed by smallholder farmers regarding the efficacy of chemical grain protectants on the market (Donaldson *et al*., 1997).

The challenge is to develop safe, cost-effective, ecologically sound and sustainable alternatives to (or at least for reducing the use of) synthetic insecticides while still meeting the needs of smallholder farmers. A wide range of grain protectants have been investigated in the laboratory as single options. More potential can be realised by combining these options for synergistic effect (Golob *et al*., 2002). If end-users are to benefit from such interventions, it is important that, the efficacies of these options are demonstrated at the operational scale in relation to pest ecology, technological considerations, extension strategies, economic and other social issues. These are all taken into account by the multi-stakeholder approach, which we propose in this study.

4. Associated Projects

Two previous research projects conducted in Zimbabwe and Tanzania have demonstrated that both imported and raw locally or regionally occurring DEs are extremely effective against storage pests. However, synergism was fully not explored. In addition, recent research has shown the presence of LGB in Zimbabwe which needs to be factored into the research process. The proposed project will also link with the Protracted Relief Programme (PRP), a multi-donor funded programme being implemented in Zimbabwe. Through PRP, Catholic Relief Services (CRS) (an international NGO), is working in partnership with local NGOs, to address livelihoods challenges including food security, in 12 districts across Zimbabwe using the Farmer Field Schools (FFS) approach. Some of these districts will be targeted by the proposed project to take advantage of the already existing institutional framework. Existing FFS activities include conservation agriculture and seed multiplication. The addition of grain and seed storage will complement the other efforts, which will play a vital role in ensuring food and income security.

5. Literature Review

Effectiveness of storage pest management options varies with type of grain, prevailing insect species, and environmental conditions (temperature; RH) and storage systems. Some of the options with potential for adaptation to smallholder storage systems are shown in Appendix 1. The majority of the treatments have previously been tested as single options or as EC formulations for use in developed countries but without controlling the whole pest spectrum (see Appendix 1). A number of the studies have been conducted under laboratory conditions only or for typical commercial storage conditions. This limits application of the findings to tropical smallholder farmers (eg Chintzoglou et al., 2008; Subramanyam et al 2007). The proposed study puts emphasis on combining the different products to: (i) enhance efficacy through synergism; and (ii) reduce application rates of these options thereby reducing the total cost of the treatment/ product. Fundamental to storage pest management is the understanding of pest flight behaviour and the seasonal population dynamics around loaded or empty stores. Data on the interaction and relative abundance of resident versus re-infestation can help improve pest management strategies.

One of the perennial stumbling blocks in African agricultural research and development has been the lack of relevance of research themes and extension 'messages' to the majority of concerns faced by the continent's smallholder farmers (Simpson and Owens, 2002). It is known that getting knowledge into social and economic use requires a range of different stakeholders to be collectively engaged in the research process (Mvumi *et al*., 2008). The multi-stakeholder approach proposed in this study helps to overcome institutional barriers and enhance relevance of findings to both intermediate and end-users.

The FFS, a form of adult education, evolving from the concept that farmers learn optimally from field observation and experimentation (van den Berg, 2004), will be used in the current study to help farmers tailor their storage pest management options to their diverse and dynamic socio-ecological conditions. An FAO review (2006) of the status of FFS in Zimbabwe showed that application of FFSs have largely been centred around integrated production and pest management of vegetables, cotton, cereals, integrated soil water and nutrient management and livestock. Very little attention has been paid to post-harvest pest management if at all.

6. Research Approach and Conceptual Framework

This project will conduct laboratory testing of innovative combinations of storage pest management options. Thereafter, promising options will be tested simultaneously in on-station and on-farm trials and by farmer experimenters participating in FFSs. Other stakeholders (eg private sector, extensionists, pesticide registration authority, farmer association representatives) will be engaged in the research process to help validate the trials and facilitate the process of getting those options deemed by stakeholders to be the most appropriate into use. The on-station research allows rigour, on-farm allows adaptation while the farmer-managed FFS trials stimulate innovation and allows uptake of research results based on experiential learning and decision-making by farmers. The supervisory team will assist the students to design and setup laboratory, on-station and on-farm trials. These trials will involve extension staff, private sector, and the pesticide regulation authority. The students will also work with the NGO (CRS) and government extension workers in supporting the FFS farmers' grain protection experimentation in selected districts where the FFS approach has been used for ≥ 4 years. The multi-dimensional research approach allows the students to acquire diverse skills, ranging from laboratory techniques to demand-led action research processes. . The involvement of other key stakeholders will help to refine the research process and increase relevance and ownership of research outputs.

7. Objectives and Hypotheses

The broad objective is to develop safer alternative pest management methods to the current organophosphate-based synthetic insecticides for use by smallholder farmers against insect pests attacking stored maize and sorghum. The specific objectives and corresponding hypotheses of the study are:

Objective 1: To evaluate the synergistic effects of combining biopesticides, diatomaceous earths (DEs) and insect growth regulators (IGRs) against key storage pests of maize and sorghum under laboratory and on-station conditions respectively.	***Hypothesis:*** Levels of synthetic pesticide use can be significantly reduced through synergistic effects of various grain protectants for improved safety of workers, consumers and the environment.
Objective 2: To determine population dynamics of key storage pests in maize and sorghum stores	***Hypothesis:*** The population dynamics of storage pests can be used as a basis for developing effective pest management strategies
Objective 3: To collectively test strategies used against storage pests in maize and sorghum under typical smallholder farming conditions, with farmers, extensionists, and other stakeholders	***Hypotheses:*** i. Identified strategies are as effective as conventional pesticides under smallholder farmer management; ii. Collective action research helps get storage knowledge into social and economic use
Objective 4: To support the integration of grain storage pest management options into the existing FFS curricula in Zimbabwe.	***Hypothesis:*** FFSs are effective if the post-harvest and pre-harvest pest management aspects are addressed

8. Methodology

The research will be conducted by two MPhil students registered with University of Zimbabwe (UZ) using a multi-dimensional approach of laboratory, on-station, on-farm and action research. Fieldwork will be conducted over two storage seasons beginning August 2011.

*Experiment 1 (**Both students – one focussing on maize the other on sorghum**):* Bioassays to determine laboratory efficacy of the various grain protectants against the test insects in maize and sorghum will be conducted. The treatment options using application rates derived from literature, will include: Untreated control; Spinosad; Spinosad+protect-It; 'Spindeba'; Diflubenzuron+methoprene; Methoprene+protect-It; Spinosad +local DE; Methoprene + local DE; Protect-It + permethrin; Commercial organophosphate + pyrethroid (see Appendix 1 for details).

Experiment 2 ***(Both students – one focussing on maize the other on sorghum)****:* On the basis of the laboratory outcome and using both maize and sorghum, researcher-managed experiments will then be conducted at the Institute of Agricultural Engineering (IAE), Hatcliffe Farm (located about 20km from University of Zimbabwe) in smallholder stores (already built for research purposes). The experiments will be a completely randomised design with each treatment replicated 4 times. Site visits will be bi-monthly for grain sampling over 8 months.

Experiment 3 ***(Student 1)***: The population dynamics of storage pests within and around the IAE storage structures will be studied to determine: the significance of re-infestation versus resident/ hidden infestation; and peak re-infestation periods. Data on flight catches will be obtained using traps. Meteorological data will be collected from the nearest station to help interpret the population dynamics.

Experiment 4 ***(Both students – one focussing on maize the other on sorghum)***: Using results from Experiment 1, a field site will be identified to establish researcher-managed *on-farm trials* to test the most promising protectant combination options. Sites where LGB occurs will also be targeted. The experiment will be a completely randomised design with each treatment replicated 4 times. Site visits will be bi-monthly for grain sampling over 8 months.

Experiment 5 ***(Student 2):*** Work with existing FFSs, whose members are interested in using their experiential learning approach to test different storage pest management options. The novel storage protectant options will be discussed with the farmers, enabling them to decide and pick from the "menu" of treatments for testing against their 'normal practice' (farmer practice). A baseline study will be conducted initially to establish the current farmer practices. Training will be provided to farmers groups on how to apply the novel storage options to grain, and the farmers will be visited every 3 months (or an interval discussed and agreed with farmers to coincide with the average frequency of grain withdrawal for milling purposes) to discuss and share their assessment of the different protectant options. An end-of-project evaluation (including an economic assessment) of the options will be done.

All on-station and on-farm experiments will be repeated in Year 2 with appropriate modifications. In designing the experiments, particular attention will be given to *Rhyzopertha dominica* and LGB which are known to be more tolerant to DEs than the normal insect pest spectrum when used as a single option (Stathers et al., 2004). However, it is important that other pests occurring in the same environment at the same time are also effectively controlled. Farmers normally mix varieties of each crop during harvesting or storage except for those that are kept as seed; hence no effort will be made to assess varietal responses to treatments.

The combinations will be formulated where applicable in the laboratory at UZ and the treatments will be applied as dusts admixed with grain in conformity with common farmer practices in southern Africa. Efficacy in on-station trials will be determined based on natural field infestations with augmented releases of key pests where necessary. However, field tests will have to rely on natural infestation only for ethical reasons.

Efficacy and persistence parameters: Efficacy and persistence of the protectants in smallholder stores will be assessed based on insect spectrum, insect numbers, grain damage, and grain moisture content obtained from collected grain samples. In the FFS trials, participatory assessment of the efficacy of the protectants using the parameters identified by the farmers themselves will be undertaken and the results compared with those from researcher-managed trials. All the grain to be used in the studies will be purchased from the surrounding community to avoid prejudicing the farmers in the event of total loss of grain in some treatments.

Data analyses: Data analyses will be carried out using appropriate statistical packages. Treatments means will be compared using analysis of variance (ANOVA) with Tukey's test being used for further comparisons. Specific statistical advice will be provided by a qualified biometrician who is a member of the research team.

9. Dissemination, communication and exit strategy

At the end of each storage season, stakeholder meetings will be held whereby; farmers, private sector , researchers and extension agents examine samples from the different treatments, ask questions, judge with their own eyes, offer suggestions or ‘reality checks’. Private sector will be involved throughout the trials so that they can eventually register the best options with the Regulatory Authority and facilitate wider scale availability of the products in future. The results of the research project will be disseminated through incorporation of the findings into the national in-service training programme for extension staff so that they can cascade the information to farmers. The study findings will be used to update UZ teaching curricula for BSc and MSc students doing Environmental Science and Crop Protection programmes. The inclusion of an NGO will also facilitate wider promotion in other non-target districts. The FFS approach will also drive direct application by farmers for those options that they find appropriate to their circumstances. Other information-sharing avenues that will be used include farmer field days, seminars, conferences, workshops at community, national (eg FAO-led Agriculture Coordination Working Group), regional and international levels; and publications in popular magazines and appropriate journals. The media (electronic and print) will also be engaged wherever possible to disseminate the results more widely.

10. Budget: US$60,000 (***see attached Excel file for details)***

11. Project Management

a. Monitoring and Evaluation (M&E)

A project workplan (See appendix 2) will be used to ensure activities are executed as planned, or are altered as necessary, based on learning generated by the project. That learning will be captured through: regular meetings between the students and their supervisors about their experiments and progress; laboratory and on-station observations of trials and data records and analyses; students’ regular oral and written presentations (departmental requirement), progress reports; reports of multi-stakeholder evaluations of both the on-station and farmers own storage experiments/assessment criteria. A participatory and iterative M&E framework with clear milestones will be developed at project commencement and reviewed periodically as the project evolves to enhance opportunities for further learning and sharing. The action research approach of the field work will mean the results and achievements are not only of a quantitative nature but will require deeper insights of a qualitative, contextualised narrative of the process. The collective action learning process will involve the different stakeholders developing and validating progress indicators associated with the effectiveness of both the approach and the grain protectant options being tested. This information will itself be used to refine the approach (through effective learning cycles of action research); the recommendations regarding the grain protectant options; and the research process itself. The project impact pathway (presented in Appendix 3) will also be used to key monitor project performance.

b. Team organization and qualifications

MPhil Students 1 & 2 (Time commitment - 100%) - Designing, implementation, monitoring of experiments as well data collection and analysis.

Dr. Brighton Mvumi (Time commitment - 15%) (for *Detailed CV for PI see attached Word File*) **-** Overall project co-ordination, financial management, reporting and supervision of two MPhil. students

Dr. Tanya Stathers (Time commitment – 1 %) - Provision of technical back-up, advice on experimental designs & supervision of students

Dr. Susan Kageler (Time commitment - 5%) - Provision of support in experimental designs and statistical analyses to students.

Ms Louisa Nyagwaya (Time commitment - 10%) - Provide technical support, coordination of data collection, and organising meetings

Mr. Wilfred Munguri (Time commitment - 5%) - Provide operational field support, in setting up and conducting community action research.

c. Key members of the research team: see Summary CVs attached

12. References:

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Appendix 1: Range of proposed storage pest management options and their mode of action

Option components*	**Category**	**Mode of action**	**Comment**
Spinosad	Naturally occurring soil actinomycete; *Saccharopolyspora spinosa*	Toxic to insects on contact and ingestion of treated substrates followed by action on the nervous system	Not very effective against *S. oryzae*, *T. castaneum* and *O. surinamensis*; (Nayak *et al.*, 2005); Information on the efficacy and persistence typical in tropical environmental conditions and on maize and sorghum, is lacking. Spinosad has low mammalian toxicity and is therefore safe to mix with food. Efficacy against *Tribolium confusum* found to increase by addition of DEs (Vayias *et al*., 2009)
Protect-It	Naturally occurring diatomaceous earth[1]) (DE)	Physical; when in contact with insect pests, DEs absorb the wax from the cuticle of the insect, causing dehydration and death.	Commercial and imported DE. Beetles of the bostrichid family tolerant to DEs and require higher application rates for effective control (Stathers *et al.*, 2002; Stathers *et al.*, 2004). DEs have extremely low toxicity to mammals and are very safe to mix with food.
Chemutsi	Local DE	Similar to Protect-It	Obtained from deposits in Zimbabwe; effective against a range of storage pests (Mvumi, et al. unpublished)
'Spindeba'	contains DE, a soil bacteria metabolite and a solvent	Similar to Spinosad plus physical action similar to Protect-It	Laboratory tests at 100ppm dust against *P. truncatus* adults, gave a virtual 100% adult mortality within 7 days, and prevented progeny emergence (Stathers, 2003)
Diflubenzuron	Insect Growth Regulator (IGR)	Chitin synthesis inhibitor acting on early developmental stages of insects	To be imported for trial purposes
Methoprene	IGR	Synthetic juvenile hormone reducing progeny development of by preventing development of immature stages.	Ineffective against *Sitophilus* spp. but effective when combined with Diflubenzuron (Daglish and Wallbank, 2005). Additive effect found when EC formulation was combined with a DE .Expensive when used alone.
Permethrin	Pyrethroid	Affects the central nervous system	Bostrichids (*P. truncatus* and *R. dominica*) susceptible but not to OPs (Golob *et al.*, 1985). Addition of low doses of pyrethroid found to reduce effective dose rate of DEs (Athanassiou, 2006)

*These options are not yet registered in Zimbabwe as grain protectants except for Permethrin. Protect-It registration has been initiated by a private company while Spinosad is registered for use on high value export crops only (peas, ornamentals and flowers). Registration can only be initiated based on field data under conditions in which the treatments will be used and through participation of the stakeholders including possible registrants (private sector).

[1] Diatomaceous earths (DEs) are soft whitish powders formed from the fossils of tiny marine and fresh water planktons.

Appendix 2: Project Workplan

Project specific objectives, activities and ***milestones***	Yr1 (2011-2012)				Yr2 (2012-2013)			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Objective 1. To evaluate the synergistic effects of combining biopesticides, diatomaceous earths and insect growth regulators against key storage pests of maize and sorghum under laboratory *[STUDENT 1 (S1)(Maize) &STUDENT 2(S2)(Sorghum)]*								
Activity 1.1 Preparation for laboratory bioassays. *Sourcing materials and equipment, and commencement of rearing of field captured test insects, and experimental design by December 2011*	X							
Activity 1.2 Laboratory bioassays to assess efficacy of innovative protectant combinations against adult mortality and progeny emergence of the main maize and sorghum storage insect pests. *Bioassays set up by early Dec and completed by mid Feb. Preliminary analysis and reporting completed by end April to inform on-station and on-farm trials.*	X	X	X O					
Activity 1.3 Selection of most promising options to include in on-station and on-farm trials. *Consultation with different stakeholders to confirm which combination options to test in field trials, decision made by end of Jul 2011*		X						
Activity 1.4 Literature review for thesis. *Collecting of relevant literature (ongoing throughout 2 years), 1st draft of relevant background literature to Objective 1 submitted by end July 2012, final draft submitted by Jan 2013.*	X	X	XO	X	X	X	XO	
Activity 1.5 Development of dissemination output. *Using the literature review and the study report, in consultation with the stakeholders develop at least one dissemination output of this study by end Oct 2013*				X		X		XO
Objective 2: To establish population dynamics of key storage pests in maize and sorghum stores *[S1]*								
Activity 2.1 Preparation for population dynamics study. *Sourcing materials, equipment, met data and experimental design by Jan*	X							
Activity 2.2 Storage pest population dynamics study. *Grain in store by end July of each year. Regular 4 weekly sampling of insect spectrum present in grain and around the storage structures. Visual presentation and analysis of insect population dynamics data collected by end of Apr each yr.*		X	X	X		X	X	X
Activity 2.3 Impact of climate on storage pest population dynamics. *Met data collected and interpreted every 8 weeks. Analysis of impact of different climate factors on the different insect species population dynamics concluded and reported on by end April each year.*		X	X	XO		X	X	XO
Activity 2.4 Literature review for thesis. *Collecting of relevant*	X	X	XO	X	X	X	XO	

Project specific objectives, activities and ***milestones***	Yr1 (2011-2012)				Yr2 (2012-2013)			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
literature (ongoing throughout 2 years), 1st draft of relevant background literature to Objective 2 submitted by end July 2012, final draft submitted by Jan 2013.								
Activity 2.5 Development of dissemination output. *Using the literature review and the population dynamics study report, develop at least one dissemination output of the findings of this study by end Apr 2013*			X	XO			X	XO
Objective 3: To collectively test strategies used against storage pests in maize and sorghum under typical smallholder farming conditions, with farmers, extensionists and other stakeholders. *[S1 – Maize; S2-Sorghum)*								
Activity 3.1. Preparation for on-station and on-farm trials. *Sourcing sites, commodities, treatments by end Aug each yr. Experimental design (involving other stakeholders in the process) and plan by end Aug each yr.*	X	X			X	X		
Activity 3.2 On-station (researcher managed) trial to assess efficacy of most promising innovative protectant combinations. *On-station trials set up by end Aug each yr, sampling done 8 weekly for 9 months. Involve and capture the perspectives of different stakeholders in the M&E of the treatments. Analysis and reporting by end Oct 2013*		X	X	XO		X	X	X O
Activity 3.3 On-farm (farmer managed) trial to assess efficacy of most promising innovative protectant combinations. *On-farm trials set up by mid Sept, sampling done every 8 weeks for a 9 month storage period. Involve and capture the perspectives of different stakeholders in the M&E of the different treatments. Analysis and reporting by end Oct 2013*		X	X	XO		X	X	XO
Activity 3.4 Literature review for thesis. *Collecting of relevant literature (ongoing throughout 2 years), 1st draft of relevant background literature to Objective 4 submitted by end July 2011, final draft submitted by July 2013.*			X		X		XO	X
Activity 3.5 Development of dissemination output. *Using the literature review and the study report, in consultation with the stakeholders involved in the project develop at least one dissemination output of the findings of this study by end Oct 2013*						X	X	XO
Objective 4: To support the integration of grain storage pest management options into the existing FFS curricula in Zimbabwe. *[S2]*								
Activity 4.1 Preparation for FFS grain storage experimentation. *Introduction to the selected FFS groups, and discussion to ascertain their interest in different types of grain protection options, presentation of the results of the laboratory (Obj1&2) trials. Discussion regards priority options for the FFS members to test, and grain quantities,*					X			

Project specific objectives, activities and *milestones*	**Yr1 (2011-2012)**				**Yr2 (2012-2013)**			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
storage periods and locations, assessment criteria etc. Co-development of an experimental design for the FFS grain storage experiments by mid July.								
Activity 4.2 Conduct a baseline of farmer practices. *Hold focus group discussions and key informant interviews on current pest management options in the target FFS areas.*					X			
Activity 4.3 Training on application of grain protectants. *Training session on principles of admixing grain protectants, capturing farmers' experiences and questions by end July.*					X			
Activity 4.3 Setting up of FFS grain storage trials. *Delivery of clearly labelled chosen grain protectant options, advise where requested regards setting up the trials, monitoring of farmers practice and storage conditions at set up. Develop record keeping assessment system with each farmer group, to enable sharing of their trials progress, this should include set up data.*						X		
Activity 4.4 Monitoring and evaluation of FFS grain storage trials. *3 monthly grain storage M&E meetings with the FFS participating farmers, during which samples of the different treatments are viewed, the data is discussed and any conclusion noted.*						X	X	X
Activity 4.5 Development of recommendations regards inclusion of storage experimentation in FFS. *Multi-stakeholder meeting organised for FFS farmers to share their learning and recommendations regards their storage experiments. Development of recommendations (including curricula) by FFS farmers, facilitators, funding programmes, extn and research on inclusion of storage experiments in FFS and what additional training materials are required to support this. Analysis and reporting of the FFS grain storage experience.*							X	XO
Activity 4.6 Literature review for thesis. *Collecting of relevant literature (ongoing throughout 2 years), 1st draft of relevant background literature to Objective 5 submitted by end July 2011, final draft submitted by July 2013.*		X	X	X	X	X	XO	
Activity 4.7 Development of dissemination output. *Using the literature review and the study report, in consultation with the stakeholders involved in the project develop at least one dissemination output of the findings of this study by end Oct 2013*						X	X	XO

Key: *blue italicised text* = activity milestone; X shows when activity will happen; O=output

S1 = Student 1; S2 = Student 2

Appendix 3: Project impact pathway

Objective	Activity	Output	Outcome	Impact
1. To evaluate the synergistic effects of combining biopesticides, diatomaceous earths (DEs) and insect growth regulators (IGRs) against key storage pests of maize and sorghum under laboratory and on-station conditions respectively.	• Rearing of field captured key storage insect pests • Procurement of grain protectants • Procurement of untreated sorghum and maize • Lab bioassays data collection-mortality assessment • Data analysis	• Lab efficacy and application rates on sorghum and maize determined. • At least 4 candidate protectants identified for further testing on-station or on-farm • At least 1 publication produced	• Efficacious candidate combinations of grain protectants and optimum application rates identified for on-station and on-farm testing with stakeholders	Increased food security and livelihood improvements through identification of safe and effective grain protectants
2. To determine population dynamics of key storage pests in maize and sorghum stores	• Procurement of insect pest traps • Procurement of untreated grain • Repair of model smallholder grain stores • Setting up of the traps • Trap catch assessment • Meteorological data collection and analysis	• Population dynamics of storage pests mapped out throughout the year • Effect of environmental factors on insect pest movement established • One publication produced	• The significance of re-infestation versus resident/ hidden infestation determined; • Peak re-infestation periods established	Increased food security and livelihood improvements through improved timing of postharvest pesticide application and addressing sources of infestation
3. To collectively test strategies used against storage pests in maize and sorghum under typical smallholder farming conditions, with farmers, extensionists, and other stakeholders	• Procurement of grain sampling equipment • Procurement of untreated grain • Repair of model smallholder grain stores (on-station stores) • Site selection and mobilisation of farmers (on-farm experiments) • Regular sampling • Data collection and analysis • Stakeholder meetings	• On-station experiments done • On-farm experiments done • Stakeholder input captured and considered • Number and nature of stakeholders participating in experiments captured • At least 2 field days • At least one publication produced	• Efficacious candidate combinations of grain protectants and optimum application rates identified for registration and uptake by private sector	Increased food security and livelihood improvements through identification of safe and effective grain protectants together with stakeholders

Objective	Activity	Output	Outcome	Impact
4. To support the integration of grain storage pest management options into the existing FFS curricula in Zimbabwe.	• Identification of FFS groups, and discussion to ascertain their interest in different types of grain protection options, • Conduct a baseline of farmer practices through focus group discussions and key informant interviews on current pest management options in the target FFS areas • Presentation of the results of the laboratory (Obj1&2) trials • Discussion regards priority options for the FFS members to test, and grain quantities, storage periods and locations, assessment criteria etc. • Co-development of an experimental design for the FFS grain storage • Training on application of grain protectants - principles of admixing grain protectants, capturing farmers' experiences and questions • Setting up of FFS grain storage trials • Develop record keeping assessment system with each farmer group, to enable sharing of their trials progress • Monitoring and evaluation of FFS grain storage trials • Development of recommendations regards	• No. of regular grain storage M&E meetings with the FFS participating farmers • Farmer storage practices in the target areas captured and incorporated in the through focus group discussions and key informant interviews on current pest management options in the target FFS areas • No. of participating farmers whose capacity in grain storage management is build through training sessions • Participatory M&E system developed at group level to collect data • No of multi-stakeholder meeting organised for FFS farmers to share their learning and recommendations regards their storage experiments. • Development of recommendations (including curricula) by FFS farmers, facilitators and stakeholders • At least two media	• Grain storage management capacity of participating farmers and extension staff developed • FFS curricula improved to capture postharvest aspects • Recommendations for grain protection validated	Grain postharvest losses reduced thereby contributing towards increasing food security and livelihood of rural people.

Objective	Activity	Output	Outcome	Impact
	inclusion of storage experimentation in FFS.	articles • At least one publication		
5. To build the capacity of African scientists	• Quality training provided to students through research activities and in collaboration with other	• Two theses produced • At least 5 information products disseminated (publications-journal articles, popular articles, media articles etc)	• 2 Masters students trained in Postharvest Science and Technology	• No. of postharvest scientists in the Zimbabwe and the region increased by two. • The trained scientists participate in other collaborative postharvest projects.

Appendix 4: Risk management strategy

Identified potential Risks/ Assumptions	Impact on the research/expected outcomes	Risk management strategy/ plan	Role of team members	Risks monitoring / indicators and reporting
Staff turn over	Project failure	Co-investigators are in place to continue	PI overall management of project Remaining staff continue to provide academic support to students in experimental design and statistical analysis, Review of student submissions, and setting field experiments implementation of project,	PI/Co-investigators move to another organisation/Co-investigators report to RUFORUM
Political instability due to national elections	Research sites inaccessible/No field data in one of the 2 years	Focus on lab and on-station experiments and the conduct field experiments in one of the years	All project team members to participate in switch	Political violence reports in trial sites
Crop failure due to drought	Scarcity of grain for field experiments/Risk of losing trial grain to consumtion	Reduced size of experiment. Establish good rapport with farmers and extension staff Identify alternative sources of grain for purchase to the trial sites.	PI overall & students	FEWSNET and AGRITEX National Early Warning Unit reports
Vehicle unavailability	Missing of some readings and failure to carry out some operations	Have backup truck	PI	Vehicle breakdown for > 2 wks

Appendix 5: The communication strategy

Group targeted	Information need	Communication Channel	Communication Tool	Feedback mechanism
Trial host farmers	Test products, Application techniques, Efficacy data	Print, electronic	Field days, sms, web pages, Evaluation meetings, Photographs	Evaluation forms in print and electronic on web
Farmer Field Schools	Test products, Application techniques, Efficacy data	Print, electronic	Field days, sms, web pages, Evaluation meetings, Photographs	Evaluation forms in print and electronic on web
Government Departments/ Extension agents	Improved crop postharvest management	Print as manuals, electronic	Product manuals, Fact sheets, workshops, seminars, field days, photographs, e-mail, sms, web pages	Evaluation forms in print and electronic on web
Students	All technical details	Print and electronic	Product manuals, workshops, seminars, field days, progress reports, publications, e-mail, sms, web pages	Evaluation forms in print and electronic on web
RUFORUM	Project progress, impact	Print and electronic	Conferences	Summaries of questions/comments raised at conferences in print and electronic on web
Non-Governmental organizations	What postharvest practices and technology work under farmer conditions; How to preserve OPV seed	Print, electronic	Product manuals, Fact sheets, workshops, seminars, field days, e-mail, sms, web pages	Evaluation forms in print and electronic on web
Agrochemical companies	Demand for pesticide products and information	Print, electronic	Product manuals, workshops, seminars, field days, e-mail, sms, web pages	Evaluation forms in print and electronic on web
Policy makers	Performance of grain protectants Farmer evaluations	Print, electronic	Product manuals, workshops, seminars, field days, policy briefs	Evaluation forms in print and electronic on web
Scientists and researchers	Techniques, methods	Print, electronic	Product manuals, workshops, seminars, publications, field days, e-mail, sms, web pages	Summaries of questions/comments raised at conferences in print and electronic on web