ANNEX VI
FINAL NARRATIVE REPORT

1. Description

1.1. Name of beneficiary of grant contract: **Natural Resources Institute**, University of Greenwich, UK.

1.2. Name and title of the Contact person: **Dr Philip C Stevenson**.

1.3. Name of partners in the Action:

Malawi:	**Stephen Nyirenda,** ***DARS, Lunyangwa Research Station (DARS)***
	Gudeta Sileshi, ICRAF, ***World Forestry Centre (ICRAF) ****
	John Kamanula, ***Mzuzu University (MU)***
Zimbabwe:	**Brighton Mvumi,** ***University of Zimbabwe (UZ)****
	Phosiso Sola, ***Southern Alliance for Indigenous Resources****
	(* covering work in Zambia)
UK:	**Monique Simmonds,** ***Royal Botanic Gardens, Kew; (Kew)***
	Steve Belmain, ***University of Greenwich*****.**

1.4. Title of the Action: **Southern African Pesticidal Plants (SAPP) Project. Caesalpinioid woodlands of Southern Africa: optimising the use of pesticidal plants.**

1.5. Contract number: - **ICART/CRARF/GC/005/06 9 ACP SAD 1-11**

1.6. Start date and end date of the reporting period: **01 Jan 2007 – 31 Dec 2009**

1.7. Target country(ies) or region(s): **Malawi, Zimbabwe, Zambia**

1.8. Final beneficiaries &/or target groups[1] (if different) (including numbers of women and men):

Target groups of the capacity building in this project include researchers and students in the following institutions:

University of Zimbabwe, Faculty of Agriculture, Mzuzu University, University of Zambia, Department of Agric Research Services, Malawi.

Final beneficiaries are farmers & extension staff in the project sites.

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[1] "Target groups" are the groups/entities who will be directly positively affected by the project at the Project Purpose level, and "final beneficiaries" are those who will benefit from the project in the long term at the level of the society or sector at large.

*As an example the beneficiaries from **MALAWI** include*

At Jenda & Nchenachena**:** 35 men and about 8 women and 30 Men & 15 women respectively who are actively involved in vegetable trials in two farm clubs

Over 150 Smallholder farmers neighbouring the project trial sites in Northern Malawi and about 33 Extension Staff in the two Extension Planning Areas (Champhira and Nchenachena).

Other beneficiaries include 1 BSc Student (Louis Mwalima) due to finish this coming semester, Two Field Technicians (Chicco Kayange & Paulos Maluwa) attending Diploma course at the Natural Resources College (NRC) in Malawi and two PhD students (Mr Stephen Nyirenda and John Kamanula) registered and completed a three months extraction and isolation techniques at University of Greenwich

In addition, there are about 200 additional smallholder farmers around our two sites. Besides, Lunyangwa Research Station and Mzuzu University staff are involved in SAPP project.

At Lunyangwa Research Station
Two research technicians from Lunyangwa Research Station, Richard Kazota and Arsen Mhlanga who are pursuing a Diploma course in Agriculture at Natural Resources College in Lilongwe, Malawi, and three research assistants (Mr B. Masewo, Miss G. Kumwenda and Miss L. Ngoma) are participating in the project.

At Mzuzu University
A lecturer (Mr Fred Masumbu), two graduate technicians (Rashid Chiposa and Charles Luhana) and one laboratory assistant (Mr Elvis Manda) of Chemistry Department are involved in storage field trials data collection and phytochemical analysis of pesticidal plants as part of capacity building.

One BSc (Education) student, Mr Daniel Saka is writing a proposal on "*Screening of indigenous plants for pesticidal activity against* Sitophilus *spp. in stored maize grain*" and will be supervised by Mr John Kamanula.

Mr. J. Kamanula and Stephen Nyirenda registered with NRI (UoG) in UK for MPhil/PhD, and went for a three months training in analytical chemistry, where they learnt the theory and practical aspects of analytical chemistry techniques in GC/MS, HPLC/MS and laboratory safety. They also had training in advanced bioassay techniques on storage pests and red spider mite.

Similar numbers of technical beneficiaries are associated with the project through UNivesrity of Zimbabwe and are detailed elsewhere in the report while the numbers of farmers directly involved in the prject in Zimbabwe and Zambia together number about 1100.

1.9. Country (ies) in which the activities take place (if different from 1.7):

Malawi, Zimbabwe, Zambia & UK.

2. Assessment of implementation of Action activities

2.1. Executive Summary of the Action

The principal requirement for most poor African farmers is simple; food security. While the production of sufficient food is paramount, additional yields can generate income and is the only route for many African farmers to raise themselves out of poverty. Productivity is limited by numerous biotic and abiotic constraints but insect pest management is arguably the most important since it is a constraint over which even the poorest farmers can have some direct control and if left unmanaged has severe consequences. Commercial insecticides usually work but they have limited distribution in rural areas, are often adulterated or inappropriately applied and increasingly are ineffective due to insect resistance. Health and safety is also a serious issue since insecticides are applied with no protective clothing; there is no mechanism to ensure food safety for consumers, and little concern for chronic effects. The environmental impact for wildlife, crop pollinators and natural enemies is also severe and the cost of correctly applied synthetics can be prohibitive. The SAPP project, within the clear aims and objectives of the ICART CRARF initiative, conducted research and training activities. The outcome was the optimisation of the use of pesticidal plants as an alternative and appropriate pest management option for the poorest African farmers with the overall aim of helping to improve livelihoods through improved productivity and storage.

Farmer surveys conducted during this project have highlighted these problems which are well understood by farmers and have led to many avoiding commercial products altogether[2]. Perhaps surprisingly and despite a wide knowledge of the plant materials relatively few farmers used pesticidal plants. This may be simply due to a lack of knowledge but its also the result of experiences with ineffective materials. These experiences can be terminal in terms of farmers regard for pesticidal plants. Indeed this happened with some trials in Choma, Zambia in our project where some farmers using ineffective materials left the trail. This demonstrates how critical it is that farmers and extension services work together to optimise these products based on a thorough scientific understanding of the underlying mechanisms of activity. This is certainly the strategy for synthetic products so why not for plant based products? Generations of farmers have used plants in this way, making the technology familiar, trusted and acceptable, but their priority in agricultural policy is low. This may be due to knowledge gaps or may be because there are few commercial incentives or revenues to drive policy as is the case with commercial synthetic pesticides.

The project conducted its research and training under 8 work packages.

WP1. Management and reporting. The project, while led by NRI, was run with a community spirit among partners and a genuine friendship has been developed among us. This was in large part due to the intrinsic role each partner played so everyone was a major player in the project. Meetings were well attended and considerable efforts were made by each partner to organise events with the inclusion of local officials and government representatives. Each partner made considerable efforts to make good presentations and report to the lead institute on time and with substance.

WP2. Acquire information. The acquisition of information about pesticidal plants in Southern Africa was carried out through literature surveys, trawling through existing databases (e.g. SEPASAL, Flora Zambesiaca etc.) and most important of all through surveys with farmers. We interviewed around 500 farmers in Malawi, Zimbabwe and Zambia and combined all this information to produce a priority list of pesticidal plant species for Caesalpinioid woodlands (Miombo) which comprised 12 indigenous plant species and 4

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2 Belmain, S.R. & Stevenson, P.C. 2001. *Pesticide Outlook* (6), 233-238 & www.nri.org/sapp

exotics. Information about the plant species is collated in a database on the SAPP project website www.nri..org/sapp.

According to the surveys of the use of pesticidal plants for stored products a knowledge of pesticidal plants was strongly associated with respondents' level of education, age, and farming experience whereas actual use of pesticidal plants was associated only with gender (female) and education level. When farmers were surveyed about the use of pesticidal plants on field crops *Tephrosia vogelii* accounted for up to 61% of the species known to the respondents in Malawi and Zambia, respectively. Farmers with small landholding sizes were more inclined to use pesticidal plants than those with medium and large landholding highlighting the importance of this management alternative for the poorest farmers. Over 45% of the respondents strongly believed that pesticidal plants were easily used in pest control suggesting their promotion to have potential. Surprisingly few farmers in North Malawi had knowledge of Neem but this can be explained by the fact that Neem doesn't flower in the cooler north and so doesn't produce the most effective plant part – the neem seed kernel. The most important pests were reportedly *Sitophilus zeamais* (maize weevils on maize), *Callosobruchus maculatus* (bruchids on cowpea), *Tetranychus urticae* (red spider mite on tomato) and *Brevicoryne brassicae* (aphid) and *Agrotis ypsilon* (cutworm) on Brassica rape. The most important livestock pests were *Rhipicephalus evertsi evertsi* and *R. appendiculata.* These pests constituted the target species for the remainder of the project. Research articles describing these surveys have been submitted for peer review and publication in *International Journal of Pest Management* and *Agriculture and Human Values*.

WP 3 Chemical analysis: We conducted chemical analysis of 8 of the priority species including, *Securidaca longepedunculata, Tephrosia vogelii, T. candida, Lippia javanica, Vernonia amygdaline, Strychnos spinosa* and *Bobgunnia madagascariensis*. In *S. longepedunculata* we identified 2 novel saponins and determined their activity against three storage pests. This work is now published (Stevenson et al,. 2009, *J. Agric. Fd. Chem*, v 57, p 8860). Work *B. madagascariensis* and *T. candida* on the other species has identified 6 new compounds, and papers describing this are submitted and in preparation respectively. We have conducted detailed bioassays of these plant species and identified ways in which their use can be optimised. For example, we showed that the use of *Tephrosia* was optimised by making leaf extracts in dilute liquid soaps since the active chemicals are not water soluble (the only solvent available to farmers) and the soap extracts could help extract up to 5 times more efficiently than water. As a consequence all field trials now use liquid soaps to make the extracts. This has the added benefit of ensuring the final spraying formulation contains a spreading agent/surfactant. Without a surfactant the efficacy of the material is severely compromised. We also identified ways in which *S. longepedunculata* use on stored products might be optimised by using water extracts particularly since we now know the active components are saponins which are water soluble. Submerging seeds in a water extract will ensure that each seed is coated but will also have the benefit of drowning any pre-storage infestation. The need to solarise the seed to dry the extract after soaking before storage also helps to reduce pre storage infestation. We also demonstrated that the source (location) of a plant was important in its content of active components and that related species (e.g. *T. candida* and *T. vogelii*) were not necessarily chemically equivalent. Indeed we recommend using *T. vogelii* and NOT *T. candida* for pest management since the content of bioactive components in the latter are 100 times less concentrated making the plant material ineffective. Promoting its use to farmers and the subsequent pest control failure would have substantial and terminal negative impact on farmers regard for pesticidal plants as described above. *T. vogelii* is already promoted for cultivation alongside maize to enhance soil fertility and its additional value as a pesticidal plant make this the most important pesticidal plant in the region. However, it is not universally effective. Indeed *S. zeamais* are almost totally

resistant to its effects whereas Bruchids are highly susceptible. *S. zeamais* is however highly susceptible to *S. longepedunculata*.

WP4 Vertebrate toxicity. Vertebrate toxicity studies were only carried out on plant species (6 in total) for which data had not previously been published. Overall most species showed some toxicity at very high doses including *Lippia javanica* a species that has medicinal properties and is consumed as a herbal tea - but at low doses - the kind of amounts likely to be encountered during normal use - all species tested were non-toxic. One paper describing this work has been submitted to *Human and Experimental Toxicology*.

WP 5. Participatory rural appraisal (PRA). Overall PRAs were an outstanding opportunity to demonstrate how best to use plant materials to farmers and provide others who were not directly involved an opportunity to learn about their use. In storage trials *Sitophilus* and *Prostephanus* were shown to be much more resilient than the bean bruchid (*Acanthoscelides obtectus*) although all were susceptible to *B. madagascariensis*, *Lippia javanica* and *A. indica*. *L. javanica* was as effective at controlling cattle ticks as an amitraz-based acaricide Tickbuster® and shown to substantially reduce aphid populations on rape and red spider mite on tomato so provides an important and field proven plant species for a wide range of uses in southern Africa. Further development of this species is required particularly with formulations to optimise efficacy. It is also distributed very widely, and particularly common on road verges so its use will have little impact on natural stands or the population in general. In southern Zambia *S. longepedunculata* was the most effective plant material against *Sitophilus* and was as effective as the commercial products Actellic for up to 5 months. Other species with promise from field trials include *Solanum pandurifoprme* (syn *S. incanum*), *Vernonia amygdalina* and *Tithonia diversifolia* all three of which were effective at controlling aphids and Lepidoptera on rape although red spider mite was more difficult to control.

WP6 Propagation. Some important and effective species were either easy to cultivate (*Tephrosia* species) or abundant in the wild (*Lippia javanica*, *Tithonia diversifolia*) and their use as a pesticidal plant presently poses no obvious threat to their distribution or occurrence. However, other species found to be of considerable value including *S. longepedunculata* and *B. madagascariensis*, while widespread were not abundant so efforts were made to develop protocols for their propagation both in nurseries and in laboratories. Both species are difficult to cultivate. This study indicated that germination of *S. longepedunculata* can be significantly increased *in vitro* techniques that avoid damping-off and other pathogens. Soaking the seeds for 30 minutes in 0.5% sodium dichloroisocyanurate with a drop of Tween20 was sufficient to avoid contamination. Soaking for long periods of time was not necessary. Germination of *Bobgunnia* was optimised by soaking in hot water for 24 hours prior to sowing. Protocols were further developed for the propagation of Securidaca and Bobgunnia using micro-propagation techniques and seed pre-treatment. In micro prop it is possible to generate very quickly numerous plantlets that will be able to plant out.

WP7 Marketing of pesticidal plants The SAPP project sought to encourage the marketing of pesticidal plants as a cash crop for small-scale farmers living in the Caesalpinioid woodland eco-region. This aimed at promoting formalisation of pesticidal plant use for agricultural pest management to increase crop yields, reduce storage losses and protect livestock. A sector analysis was conducted to characterise the pesticide industry in Zambia. Findings from the study indicated that the pesticide sector was not fully developed as most pesticides were imported and no form of value addition was conducted in country. The lack of pesticide manufacturing industries implies totally new investments would have to be made in terms of technology to produce such natural pesticides locally.

However the increasing demand for organic products results in an increased demand for organic inputs such as natural pesticides. The Organic Producers and Processors Association of Zambia (OPPAZ) has a membership of over 1900 producers which require organic inputs in production. OPPAZ members export certified organic products to EU markets, USA and South Africa in excess of 500 metric tons of fresh vegetables and 30 metric tons of groundnuts among other products annually. Therefore the organic products industry is a sure market for plant pesticides. W have considered that the material most conducive to small scale enterprise production and marketing is *Tephrosia vogelii* which can be produced easily and requires simply usage instructions. However, there appears to be much work needed to develop a regulatory framework. Under current Pesticides and Toxic Substances Regulations 1994 there is no distinction between synthetic chemical products and plants. While plants are presently used widely, this occurs outside the formal regulation applied to synthetic products. It may be possible for countries to accept categorisations in other countries with established regulatory frameworks for bio-pesticides such as the USA. While *T. vogelii* has known toxicity its active ingredient rotenone (http://www.epa.gov/oppsrrd1/reregistration/REDs/rotenone_red.pdf) is registered on the lowest toxicity rung of agricultural products in the US and is considered only moderately hazardous by WHO (http://www.who.int/ipcs/publications/pesticides_hazard_rev_3.pdf) in both cases with respect to the pure chemical active ingredient. The plant material we propose using contains rotenoids at less than 1% by weight amd this registration elsewhere may help to facilitate its preparation and sale in countries where it is already used widely. This will be looked at further under a follow on project.

WP8 Training and capacity building. The training and capacity building of scientists in the three target countries has been prolific and includes 2 PhD students, and numerous MSc and BSc students. Along with this the project partners and their respective institutional teams have all gained considerable experience working in multidisciplinary and multinational teams carrying out large scale biological experiments and preparing reports and research articles for peer review. This experience has led to several partners and associates having the skills to independently seek new funds.

Exit strategy. During the final year of the project partners sought additional funds from new sources to continue to expand areas of work found to be promising. The include US$400,000 from the McKnight Foundation Southern Africa Community of Practise to continue work on the development of *Tephrosia vogelii* for pest control in legumes, GB£90,000 over three years to continue work on pesticidal plants in stored products in Malawi and €1,000,000 from the EUs ACP Science and Technology program to develop and expand the scientific network across African drylands (www.nri.org/ADAPPT) initiated by SAPP and expand and enhance work on pesticidal plants across the region.

Outputs: The research has generated one published and 6 submitted research articles and at least 10 additional papers that are still in preparation. In addition the project produced a policy paper as a chapter in a McKnight distributed reported on pest management in Southern Africa along with information leaflets and a website that acts a resource for the project and a plant database of information about the target species.

2.2. Activities and results

Please list all the activities in line with Annex 1 of the contract during the reporting period

WORK PACKAGE 1

Activity 1.1. Project inception workshop

A one-week inception workshop was held at the Jodrell Laboratory, Royal Botanic Gardens, Kew UK (22-25 January 2007) organised by Phil Stevenson (NRI/Kew). Roles & responsibilities for project partners were defined, and research protocols and activity plans shared – notably for farmer surveys and field bioassays. The meeting was attended by each project partner (see 1.3) plus other UK project team members including Dr Steve Belmain, Dr Steve Davis, Professor David R Hall, Ms Olwen Grace. Dr Paul Smith (Millennium Seed Bank) and Jonathon Timberlake (Flora Zambesiaca) also attended in an external advisory capacity. Mr Mark Parnell (Project/Financial Controller, NRI, University of Greenwich) advised partners of their fiscal responsibilities and to review the contractual arrangements for the financial control of the project and for the assessment of the agreed tasks and deliverables. The meeting also provided an opportunity to enable all partners learn about each others experience, to define the procedures for working together to achieve project outputs since all work-packages were *inter*dependent and require input from several partners. Annual meetings were held along with 5 monthly mid year meetings and these often coincided with project activities to ensure the best use of time.

During the preparation of the proposal each partner was assigned responsibility for overseeing activities on a Work Package (WP) and at this meeting gave a presentation of their WP and how the activities should be carried out. This provided an opportunity for all other partners and team members to contribute into the design and planning of each work package and activity. The project implementation strategy for the three years was developed and agreed. The minutes of the workshop were formally recorded and this served as a guide for follow-up action. Minutes are available for viewing at the project website www.nri.org/sapp under documents.

Activity 1.2. Annual meetings

Two annual meetings were held. The annual meeting year 1 was held at Lilongwe Hotel, Lilongwe Malawi, 19-23 November, 2007 and was organised by Dr Gudeta Sileshi (ICRAF). The annual meeting year 2 was held at St John of God, Mzuzu, Malawi. 8-12 December, 2008 and was organised by John Kamanula (Mzuzu University).

The overall objectives of these mid-year meetings were

- Minutes of the mid-year coordination meetings
- Reviewing Progress & activities by Work package leaders
- Planning work package activities going forward

Activities specific to annual meeting 1 were:

- Reviewing procedures for movement of plant material between African countries and to UK and Material Transfer Agreements
- Planning for publicising activities – notably website updates www.nri.org/sapp
- Bioassay for field pests and storage pests developed

Activities specific to annual meeting 2 were:

- Reviewing procedures for movement of plant material between African countries and to UK and material Transfer Agreements
- To meet up with the Program coordinator for ICART and monitoring and evaluation officers Drs C. Tiziakara and M. Murata respectively and the Vice Chancellor of Mzuzu University, Professor Landson Mhango and update them on project progress and get their feedback towards project progress.
- Planning for publicising activities – notably website updates www.nri.org/sapp
- Field visits to meet farmers and see field screening for pesticidal plants against field and storage pests at Nchenachena.

Activity 1.2. Mid Year Coordination meetings

3 mid-year coordination meetings were held

1.Korea Garden Lodge, Lilongwe, Malawi, 9-12th July 2007 (organised by Stephen Nyirenda)

2.Cairo Protea Hotel, Lusaka, Zambia, 24-28th June 2008 (organised by Dr. Phosiso Sola).

3.Lilongwe Sunbird Hotel, Lilongwe Malawi, 5-9th October (organised by Dr G. Sileshi).

The overall objectives of these mid-year meetings were:

- To review progress and discuss work carried out during the previous six months usually by presentation of results.
- To plan the forthcoming activities to the next meeting and beyond.
- To assess progress of each work package and determine changes to log frame or work plan.
- To review minutes of the previous meeting

Specific activities on mid-year meeting 1

- SEPASAL Training was given to all project partners and approximately 28 other meeting participants by Phil Stevenson (project leader) in uploading and accessing information on this invaluable website. SEPASAL is a database of uses of plants species in primarily dry-land Africa.
- Assembling a priority list of plant species for the project
- The meeting also invited about 30 participants from Ministry of Agriculture and Food Security, Environmental Affairs, Forestry Research Institute, University of Malawi, Pesticide board and the Department of Agricultural Research Services. This provided a great opportunity to promote the activities of the project to many relevant stakeholders in Malawi and gain their support for the project.
- To meet ICART-CRARF Staff and learn about the overall project from SADC perspective through presentations from Joel Motswagole and Dr. Monica Murata.

Specific additional activities on mid-year meeting 2

- To visit field sites in Choma, Zambia & see field trials on stored product protection using pesticidal plants.

Specific additional activities on mid-year meeting 3

- To go through the log frame and project work plan to determine priorities in last few months particularly with respect to outputs.

The annual and mid-year meetings provided some partners with a first opportunity to gain experience of this type of meeting.

ICART Stakeholders & Grantees Meeting, 15-19 Sept, St George Hotel, Pretoria, South Africa.

SAPP partners or their representatives participated in the ICART Stakeholders and Grantees meetings in Pretoria, South Africa. The meeting was a mid-term review of the ICART supported projects under SADC. The major output of the workshop was to determine project progress against time bound objectives and to get grantees thinking about an exit strategy. The meeting provided a great opportunity to meet other grantees and share problems and successes. It also provided an opportunity for younger representatives of partners to attend a workshop. For example Mr Charles Luhana, on behalf of Mr J. Kamanula, attended the Grantees Workshop, and Vincent Ziba (SAFIRE) attended on behalf of Phosiso Sola.

Activity 1.3. Activity reporting

Interim reports have been submitted as requested throughout the project to the ICART M & E officer (Dr M Murata). Project partners have provided reports to the project leader on time and as specified in sub-contracts and these have served as tools for assembling the quarterly project reports and annual reports as well as this final technical report.

Activity 1.4. Final Technical Report

The present report constitutes the Final Technical Report.

Activity 1.5 Project output and dissemination strategy. (see also Section 2.5)

Website: (See section 2.6 p**.**78**)**

Research Outputs (Journal publications): **(**See section 2.6 p**.**78 and associated documentation**)**

Conference attendance (Abstracts and oral presentations): **(**See section 2.6 p**.**78 and associated documentation**)**

WORK PACKAGE 2

Activity 2.1. Acquire info about pesticidal plants

Surveys of SEPASAL/Flora Zambesiaca databases (http://www.kew.org/ceb/**sepasal**/ & http://apps.kew.org/efloras/fz/intro.html) at Kew were undertaken during year 1 for information about plants that occur in target countries with reported biological activities against arthropods. A list of accepted scientific names of approximately 100 plants from Caesalpinioid woodlands with data about their uses and some data about their chemistry was collated with particular reference to known activities associated with invertebrate toxicity. Owing to the priorities of farmers, availability of materials and need to reduce the work load

of the project to more manageable numbers as detailed in the proposal a priority list of 12 Caesalpinioid woodland plants and 5 exotics were agreed as follows.

- **Priority Caesalpinioid woodland species list**
  - *Aloe ferox*
  - *Bobgunnia madagascariensis*
  - *Dolichos kilimandscharicus*
  - *Euphorbia* (spp.)
  - *Lippia javanica*
  - *Neorautanenia mitis*
  - *Solanum panduriforme*
  - *Securidaca longepedunculata*
  - *Strychnos spinosa*
  - *Tephrosia vogelii/candida*
  - *Vernonia* (spp.)
  - *Cissus quadrangularis*
- **Non-indigenous species**
  - *Tithonia diversifolia*
  - *Azadirachta indica* – Neem.
  - *Tagetes minuta*
  - *Cymbopogon* spp.

One project target was to build a database of pesticidal plant uses from surveys and information gathered from farmers or other sources during the course of the project. Originally SEPASAL was to be used but there have developed some serious technical problems with this database associated with multi node use. As a consequence the project used the project website as the database and provides more comprehensive information about the species on our priority list.

Farmer surveys

Partners at SAFIRE, UZ, MU, DARS & ICRAF undertook surveys of farmers to assess plants used to control pests. This information was required to help prioritize the shortlist list of plants above. An initial questionnaire was designed by Dr. G. Sileshi with input from all partners for capturing individual farmers' perceptions of pesticidal plants used in Malawi, Zimbabwe and Zambia at various locations. Site location was very important and were chosen if they had

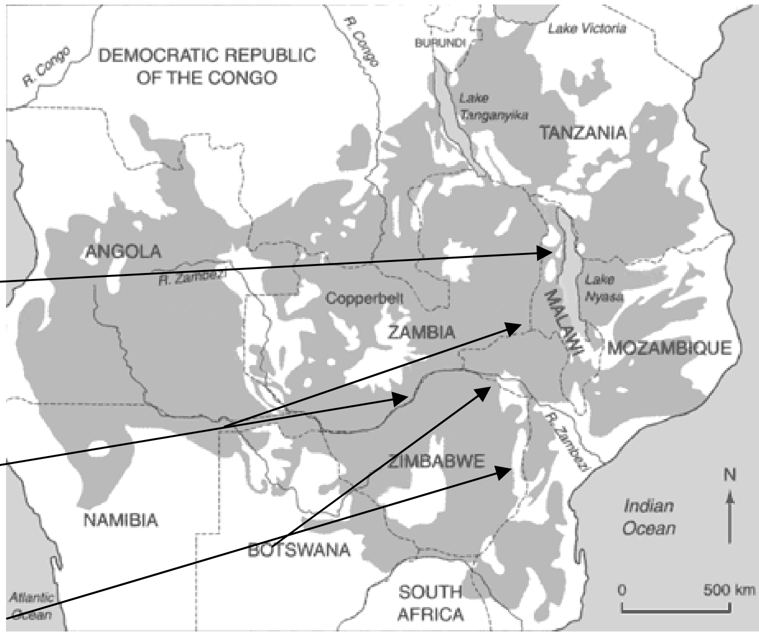
i) high production potential of target commodity (legumes, maize, rape, tomato livestock etc),
ii) known use of indigenous pesticidal plants by local community,
iii) availability of the pesticidal plants,
iv) existence of other livelihood projects facilitated by partners in the same area.

Field locations for SAPP Project research and surveys

Malawi
- Nchenachana
- Champhira

Zambia
- Chipata
- Choma

Zimbabwe
- Muzarabani
- Nyanga



Caesalpinioid (Miombo) woodland zone

1. **Surveys of pesticidal plant use for controlling field pests**

A survey was conducted among 168 vegetable farmers in northern Malawi and 91 farmers in eastern Zambia to investigate farmers' perception of pest management practices in tomato and brassicas with an emphasis on pesticidal plants.

Synthetic pesticides were the principal management tool with 75% of respondents. Over 70% of the respondents in Malawi and Zambia were aware of pesticidal plants and over 74% of the female respondents had actually used them compared to 55% of the male respondents. *Tephrosia vogelii*, *Tithonia diversifolia*, *Azadirachta indica*, *Vernonia amygdalina* and *Euphorbia tirucalli* were most frequently reported as the species used for control of pests in vegetable crops. *Tephrosia vogelii* accounted for 61% and 53% of the species known to the respondents in Malawi and Zambia, respectively. Farmers with small landholding sizes were more inclined to use pesticidal plants than those with medium and large landholding highlighting the importance of this management alternative for the poorest farmers. Over 45% of the respondents strongly believed that pesticidal plants were widely available and easily used in pest control suggesting their promotion to have potential success. The survey has been submitted to *Agriculture and Human Values*. See appendix for the full paper.

Table 2.1: Pesticidal plant use and their effects based on farmers' information in Malawi

Local Name	Common Name	Botanical Name/Family	Plant part	Used on	Side effects
Mtetezga, Gulinga	Fish beans	*Tephrosia* spp *(Fabaceae pea family)*	L	Storage, Vet & Veg pests, Agroforestry	Icthyotoxin
Dema, Dindya		*Dolichos spp or Mucuna spp (Fabaceae)*	Rt	Storage, Veg pests	poison
Chigumbilo, Heji, Delia, Belibeli	Yellow daisy	*Tithonia diversifolia (Compositae)*	L & F	Storage, Veg pests	sneezing, running nose
Mulundu, Chalonde, Chilonde		*Bobgunnia (Swartzia) madagascariensis (Leguminosae/Fabaceae)*	P & L	Storage, Veg pests	Icthyotoxin
Mzobala	Knobwood	*Fagara davyi (Rutaceae)*	L, B& Rt	Veg pests	Medicinal
Mlangali	Common tree euphorbia	*Euphorbia ingens (Euphorbiceae)*	Latex,	Termites, Vet and Veg pests	poison
Nkhazi, Mduzi	Milk bush	*Euphorbia tirucalli (Euphorbiceae)*	Latex	Termites, Vet & Veg pests	poison
Nyathela, Mululuzga Soyo	Bitter leaf	*Vernonia spp (Compositae)*	L & Rt	Field, vet and storage pests	Sneezing & chest pains
Nthuma, nthula	Thorn apple	*Solanum spp (Solanaceae)*	F	Veg pest	Nausea, poison
Kanufu	Basil	*Ocimum spp (Lamiaceae)*	L, F	Veg pests	
Mvunguti	Sausage Tree	*Kigelia Africana (Bignoniaceae)*	F	Veg pests	Poison
Mjoyi, Nampini	Silver cluster leaf	*Terminalia sericea (Combretaceae)*	L	Veg pets	
Welensky	Marigold	*Tagetes minuta (Compositae)*	L, F	Veg pests	
Chinthembwe	Aloe	*Aloe spp (Aloaceae)*	L	Lice, Hair conditioner	
Senderela	Toona tree Cindrella	*Toona ciliata*	L	Veg pests, agroforestry	

L=Leaf; Rt = root; F = fruit; B = bark; P = pods

2. **Surveys of pesticidal plants use for controlling stored product pests N. Malawi and Eastern Zambia.**

This study was conducted with the following objectives: (1) to assess farmers' knowledge and perceptions of pests of stored maize and beans, (2) to identify farmers' indigenous pest management practices, and (3) to assess farmers' use of pesticidal plants as an effective management option for the control of stored maize and beans in northern Malawi and eastern Zambia. A household survey was conducted using semi-structured questionnaires administered to farmers. The results showed that farmers are knowledgeable about the pests that damage stored maize and beans. Over 93% of the respondents in the study areas in both countries experienced pest damage to maize and beans. The majority (71%) of respondents in

the study areas in Malawi indicated bruchid beetles as the major pest of stored beans and over 46% mentioned grain weevils (*Sitophilus* spp.) and the larger grain borer (*Prostephanus truncatus*) as the major pests of stored maize. In Zambia, 59% and 36 % indicated grain weevils and LGB to be the major insect pests of stored maize, respectively. In Malawi, maize and beans were stored predominantly in sacks (54% for beans and 97% for maize) whereas in Zambia, maize was mainly stored in granaries (81%) and beans in sacks (82%). Most of the respondents had knowledge of pesticidal plants. Among the pesticidal plant species, Tephrosia (*Tephrosia vogelii* Hook) was known by the majority of respondents in Malawi (86%) and Zambia (62%). However, only 18% in Malawi and 6% in Zambia had actually used it. Knowledge of pesticidal plants was associated with respondents' level of education, age, and farming experience. Over 78% of the respondents who attend at least primary school, 74% of those in the aged group of 25-40 years, and 76% of those with over 5 years of farming experience were more knowledgeable than the others. Actual use of pesticidal plants was significantly associated only with gender and education level. A paper reporting this work was submitted for publication in the *International Journal of Pest Management* (see associated documentation).

- Out of 86 respondents in Nchenachena, 48 were men and 38 women whereas at Champhira, there were 47 men and 34 women who participated in the surveys.
- The majority were 25-40 years old (57 %) at Nchenachena and 41-60 (40 %) at Champhira..
- Most farmers attained secondary and primary school education (49 and 47 %, respectively) at Nchenachena and 22 and 67 %, respectively, at Champhira.
- Most farmers said they grow hybrid maize (79 and59 %, Nchenachena and Champhira, respectively)) and for beans it was kalima and maluwa (37 %).
- Over 80 % harvest their maize by stooking.
- Sacks are the most popular method of storing maize grain and beans (56 and 81 %, respectively)
- About 62 % of respondents indicated Sitophilus spp as the main destructive insect pest in stored maize.
- About 73 % use Actellic Super dust to control insect pests and only 9 % indicated using pesticidal plants.
- Most farmers said synthetic pesticides are expensive.
- The major sources of information on pesticidal plants were through parents and friends (42 and 23 %, respectively), Extension researchers (14 %) and other methods (16 %).
- About 45 % said Tephrosia was effective where as over 80 % of the respondents did not know about neem. However, they were ready to cultivate both Tephrosia and neem if given seeds.

3. Farmer Surveys In Southern Zambia & Zimbabwe.

Farmers responses were similar in some ways to those of farmers in Malawi – particularly with respect to the most important pests. In Choma storage pests are a big problem, farmers listed up to five per crop. *Sitophilus oryzae* emerged as the major problem in stored maize followed by the lager grain borer (LGB) (*Prostephanus truncatus*) which did not seem to be very wide spread. The worst pest in cow peas were the bruchids (Callosobruchus maculatus) (Table 2.2). Traditionally the Choma people did not use any form of pesticide until 2001 when they started using DDT and Chirindamatura dust. Interestingly LGB became a major pest in 2005 onwards and since then losses to storage pest have been consistently high. Prevalence increases from August yet grain is not treated until October, which explained huge losses experienced from December onwards.

A socio-economic survey was conducted in the three districts Choma, Muzarabani and Nyanga to assess pesticidal plants use and storage problems faced by farmers. The survey revealed that more than 88% of the households indicated that they grew maize and more than 65% reported pest infestation. Yield ranged from 671.5kg in Nyanga to 2,435.2kg in Muzarabani. Loss was estimated to be as high as 22% (Table 2.3 and 2.4). Quite a number of households reported loss of cattle to pest related diseases, 28%, 48.6%, 65% for Nyanga, Muzarabani and Choma respectively. However, very few farmers were harvesting and using plant pesticides (Figure 1). In fact, a large proportion of interviewed farmers preferred using the conventional synthetic pesticides. Major reasons cited for the preference were that the effectiveness of conventional pesticides is known. None of the respondents harvest pesticidal plants for sale.

Table 2.2: Major storage pests in Choma, Zambia

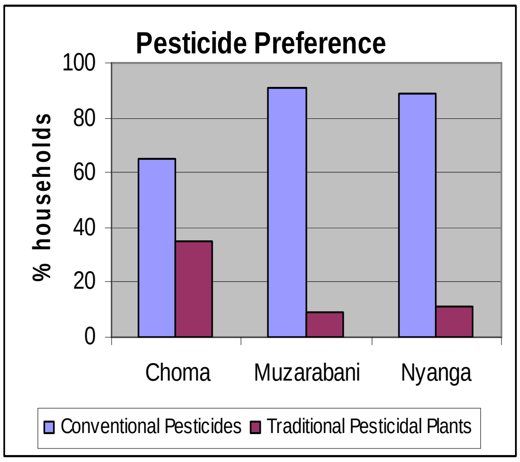
STORAGE PEST (Maize)	**Common Name**	***Scientific name***	**RANK**		**Final rank**		
			FIRST	**SECOND**	**THIRD**	**SCORE**	
Musunse	Weevils	*Sitophilus. oryzae*	41	4	1	46	1
Chidokola	LGB	*Prostephanus truncatus*	7	24	1	32	2
Mbeba	Rats	*Rattus* spp.	0	7	8	17	4
Lumoma	Termites	*Macrotermes* spp.	0	6	23	29	3
Nkonkolekwa	Grain moth	*Sitotroga cerealella*		1	5	7	5
Cowpeas							
Musunse	Bruchids	*Callosobruchus. maculatus*	32	2	1	35	1
Tuvwiya	Small worms		6	18	6	30	2
Lumoma	Termite	*Macrotermes* spp.	2	8	14	24	3
Mbeba	Rats	*Rattus* spp.	2	4	8	14	4
TICKS							
Zyamabala	Band legged tick	*Rhipicephalus evertsi*	31	2	5	38	1
Tusalala	brown ear tick	*Rhipicephalus appendiculata*	6	9	17	32	2
Zituba	Grey tick	*Boop[hilus* spp	2	18	7	27	3
RAPE							
Chizuki	Aphids	*Brevicroyne brassicae*	12	22	3	37	1
Insonzi	Grasshoppers	*Not known*	26	3	1	30	2
Bandambo	Cutworms	*Agrotis spp.*	1	6	14	21	3
Busulanyama	Red ants		1	2	2	16	4
Tomatoes							
Luubilili	Red spider mites	*Tetranychus urticae*	33	5	1	39	1
Chimbalanwe	Fungi		8	14	4	26	3
Havunyangwa	Green worm	*Helicoverpa* spp.	3	6	18	27	2
Bwiinakuku	Whitefly	*Bemisia tabaci*	1	4	1	6	4

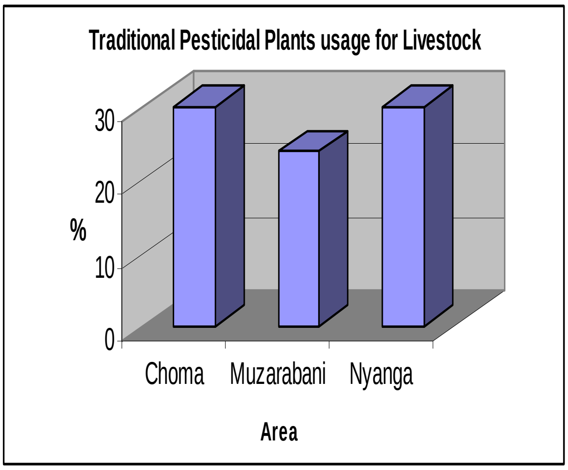
Table 2.3: Maize cultivation and storage

Variable	Maize			Beans		
	Nyanga	Muzarabani	Choma	Nyanga	Muzarabani	Choma
Households that grow and store maize and cowpeas (%)	100	88	100	50	20	23
Area grown (ha)	0.896	1.6	1.3	0.336	0.2-6	0.38
Average harvest per household 2006/07 season (kg)	671.5	2435.2	1083	51	155	163
Average amount stored for future use per household (kg)	547.4	798	647	22	48	145
Households reporting pest infestation (%)	79.6	65.1	72.5	29.2	45	8.3
Amount of lost to pests (kg)	150	124.6	100	2.08	10.6	25
Harvest sold for income (%)	<10	67.2	50	56	66	11

Table 2.4: Protection of tomatoes

Variable	Choma	Nyanga	Muzarabani
Households growing tomatoes (%)	56	48.9	16
Area planted to tomatoes (acres)	80	29	0.2
Average harvest (kg)	348	605	395
Households reporting loss to pest (%)	88.9	87	71
Average potential tomato harvest lost to pests %	31.8	96.4	





3. **Farmer Surveys In Eastern Zimbabwe**.

At the commencement of the project, participatory surveys were conducted in Nyanga and Centenary (Muzarabani) districts to identify pesticidal plants occurring and used by households in the target areas. The communities were also asked to prioritise these plants for research purposes (Table 2.5).

Household surveys were conducted in both Goromonzi district (Chinamora) from 11 to 13 September 2008 and Muzarabani district from 1-5 December 2008, using standard questionnaires. The major objectives of both surveys were:

- to determine the production patterns of smallholder farmers in the areas including pesticide use patterns

- to identify the particular pesticidal plant species commonly used by farmers in the two districts
- to use the data to predict potential farmer adoption for plant pesticides.

In Chinamora, wards were selected from those with a high market gardening activities. A total of 84 smallholder farmers, were interviewed by a team of four UZ BSc Agricultural Economics students and a UZ MSc Agricultural Economics student.

In Muzarabani, wards were selected from the upper Muzarabani areas where farmers practice mixed farming including both dryland and garden crops and as well as livestock. Farmers were chosen from wards that had diverse settlements, that is communal, old resettlement areas and the new resettlement areas. A team of 2 UZ BSc Agricultural Economics students, three agricultural extension officers (Ministry of Agriculture staff based in the district) and one UZ MSc Agricultural Economics student were the enumerators.

Table 2.5: List of Pesticidal Plants Prioritised by Communities in the Nyanga and Centenary (Muzarabani) districts of Zimbabwe.

Domain	**Major Pests**	**Prioritized Pesticidal Plants**	**Plant part and application method**
Grain storage	• Weevils (*Sitophilus* spp & *Callosobruchus* spp) • Grain moth (*Sitotroga cerealella*)	• *Dichrostachys cinerea* (mupangara) • *Aloe* spp. • *Lippia javanica* (zumbani) • *Bobgunnia (Schwarztia) madagascariensis* (mucherekesa) • *Bauhunia thoningii* (mutukutu/musekesa)	• Fruit ashes & admixed with grain • Leaf ashes admixed with grain • Dried leaves crushed and admixed with grain • Dry fruits harvested, crushed or burnt into ashes and admixed • Dry fruits crushed into powder & admixed
Tomatoes and rape	• Red spider mite; Ball worm (*Heliothis* spp); Aphids	• *Lippia javanica* (zumbani) • *Solanum panduriforme* (nhundurwa)	• Green leaves crushed & soaked in water for 1-2 days and applied as a spray • Mature fruits crushed and & soaked in water for 1-2 days and applied as a spray
Livestock ectoparasites	• 1)*Boophilus microplus* • 2) *Rhipicephalus eversti*, lice	• *Strychnos spinosa* (mutamba) • *Solanum panduriforme* (nhundurwa) • *Lippia javanica* (zumbani)	• Immature fruits crushed and either applied directly or soaked in water for 1-2 days and applied as a spray • Mature fruits crushed and & soaked in water for 1-2 days and applied as a spray • Green leaves crushed & soaked in water for 1-2 days and applied as a spray

Results for Goromonzi district (Chinamora) show that the communal area is a major producer of horticultural produce for the Harare urban population. Almost all the households use synthetic chemical pesticides for pest control. About 23% of the farmers registered that they were aware of some pesticidal plants. A smaller proportion knew and actually used some plant pesticides in their production (Table 2).

The few farmers using pesticidal plants, reported that they used them as a cheaper alternative to chemical pesticides. The use of chemical pesticides was predominant because farmers reported that they lacked knowledge on pesticidal plants and some that they were not as effective as synthetic chemical products resulting in a noticeable loss of crop quality and quantity.

The feedback from our survey suggests that there is considerable scope for promotion of optimised strategies for using pesticidal plants. One strategy that has been employed is farmer participatory trials and this is described in later section.

Information leaflets are being produced for the priority species but are not all finished since they are awaiting inputs from work being carried out on this project. An example is illustrated below.

WORK PACKAGE 3.

Activity 3.1 Chemical profiling and plant chemical analysis.

Securidaca longepedunculata

S. longepedunculata is an important tree of Caesalpinioid woodlands. In West Africa there is a tradition of using its roots in pest control for stored grain but this use is absent from the SAPP projects geographical focus. Since it also occurs in Caesalpinioid woodlands there has been an opportunity within the project to introduce this material to farmers as a new pesticidal plant. This has been successful in Choma, Zambia during this year and reported below under work package 5. While not as effective as Actellic Super dust *Securidaca* roots were the most effective plant material.

Saponins in the root and stem bark of *Securidaca longepedunculata* were shown to be responsible for the deterrent and toxic effects of the roots of this species against storage pests including *Sitophilus* spp., *Rhizopertha domenica* and *Callosobruchus* species and this work has been published during the project and the full data can be obtained from the published paper (Stevenson et al., 2009 *J. Fd. Agric. Chem*. **57** (19), 8860–8867 (see associated documents). The structures of the saponins identified during the project are in Fig 3.1. Field work – particularly at Choma in Zambia and in Northern Malawi has shown farmers that S. longepedunculata is a very useful source of pesticidal material. However, the active part is the root and this has led to various additional areas of work including propagation described later in this report and also an analysis of the stem bark. The stem bark produces the active saponins and so may provide a way of optimising the use of this species by using stem bark rather than using root bark; a more sustainable application of the species which is not a common plant species in Caesalpinioid woodland. Furthermore, if we can develop the use of water extracts of the bark rather than use powdered material then this again will help to make plant material more economic by reducing the amounts of plant material required. This is presently being investigated on a follow up project funded by DelPHE of the British council and this will be described later under exit strategies.

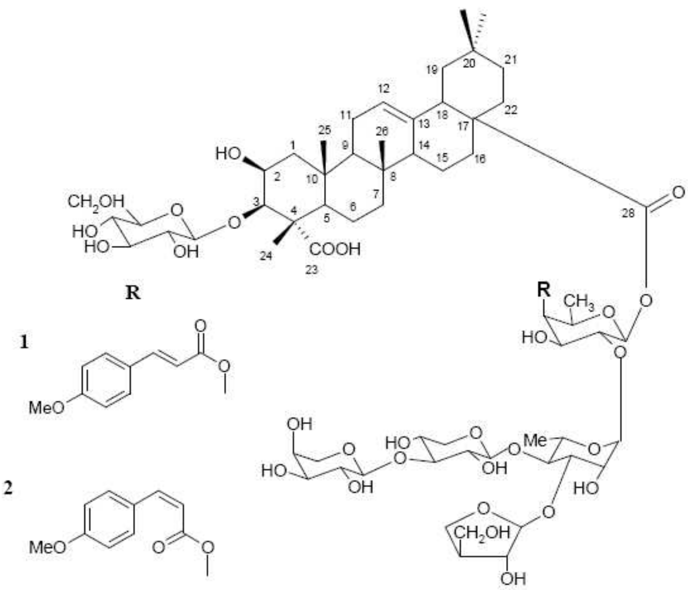


Fig 3.1 Structure of two new Securidaca *saponins that have insecticidal activity against Callosobruchus maculatus and* Sitophilus oryzae *(Stevenson et al., 2009 J. Ag. Fd. Chem. 57, 8860-8867)*

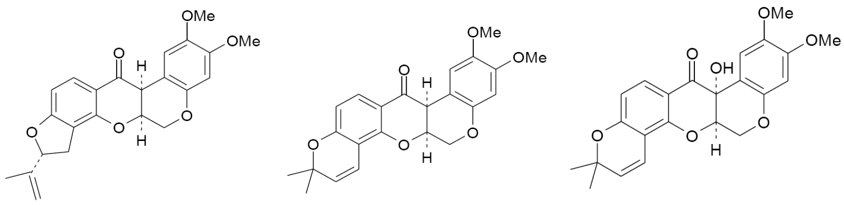
Insecticidal saponins from Securidaca longepedunculata *can be extracted in water for use on stored grain and vegetable crops being applied with a sprayer or a brush. They have a natural surfactant property to help spreading.*

Grain can be submerged briefly in water extracts before storage to coat grain in active compounds. This can have an additional effect of drowning pre-storage infestation

Tephrosia vogelii & T. candida

Tephrosia comprises a genus of some 350 species of which about half are endemic to Africa and Madagascar and two, *T. candida* (endemic to India and now introduced to Afrcia) and *T. vogelii* are of particular importance in pesticidal plant use in Africa. Best known as fish poisons, it is increasingly used by farmers to control insect pests of vegetable crops and stored products. In addition, the two species are easy to cultivate and so are a natural first choice pesticidal plant in Africa – particularly Caesalpinioid woodland. In light of this we have used it as a positive control – a bench mark plant material to which we can compare the activities of other less well known species.

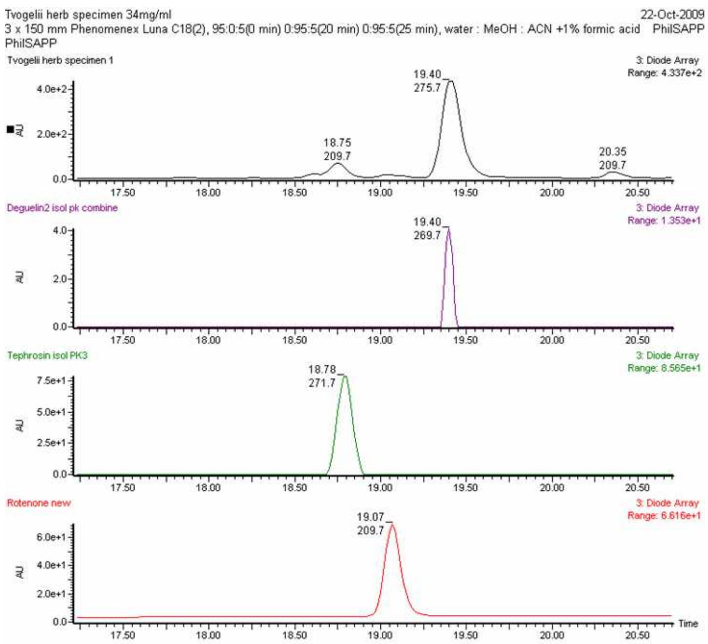
According to general literature the principal active ingredient responsible for the ichtyotoxic activity of *Tephrosia* is widely considered to be rotenone (Fig 3.2). Analysis during this year has clarified some problems identifying rotenone in Tephrosia. Our work has shown that this compound is absent from *T. vogelii* from near Lilongwe but present in small quantities in material collected in the mountains near Mzuzu. Thus the location is important in the occurrence of rotenone.



Rotenone Deguelin Tephrosin

Fig 3.2 Structures of rotenone, deguelin and tephrosin – rotenone was absent from or at very low concentrations in leaves, roots and pods of T. vogelii.

The other question surrounds whether the activity of this plant material can be attributed to rotenone only or whether the two related and much more abundant rotenoids from *T. vogelii* tephrosin and deguelin, are active. Surprisingly There is presently no evidence in the literature that attributes insect toxicity to tephrosin and deguelin. Deguelin and Tephrosin have been isolated and their activity evaluated against several insects from the leaves of *T. vogelii*. Their activity will be evaluated against red spider mite and aphids at Lunyangwa Research station at Mzuzu during 2009. If we can confirm their activity then this will corroborate the broad assumptions about the value of this plant material as an alternative pesticide.



T. vogelii (Lilongwe)

Deguelin

Tephrosin

Rotenone

Fig 3.3 HPLC chromatograms showing the chemical profile of T. vogelii showing the major component being Deguelin and no rotenone despite all the grey literature pointing to this as the principal active component.

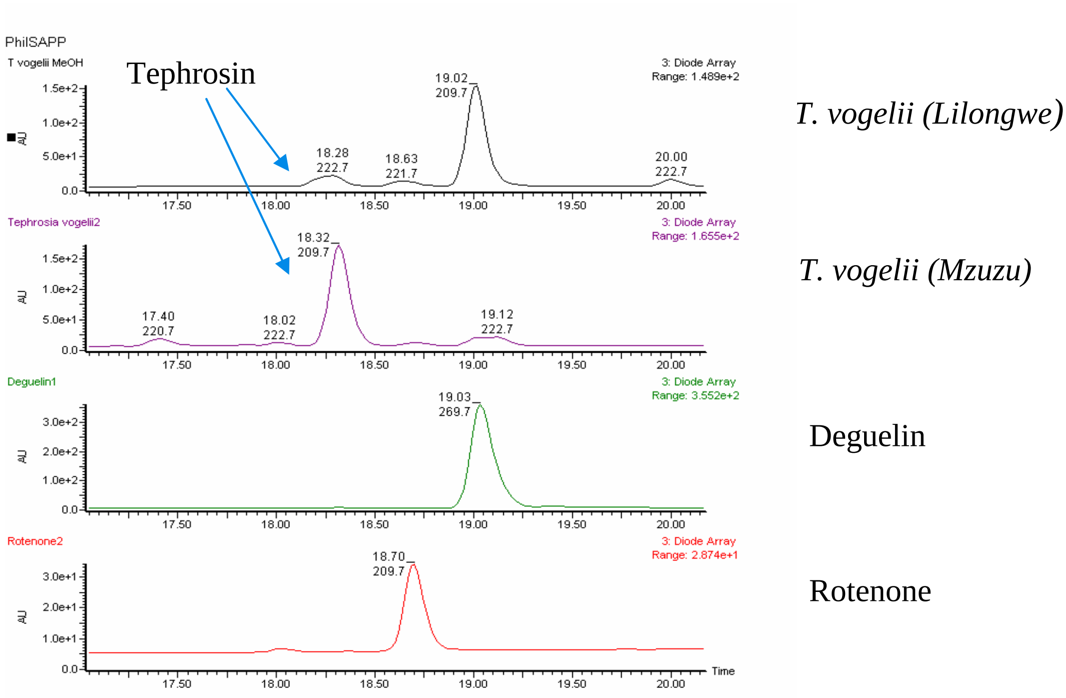


Fig 3.4 HPLC chromatogram showing the variation in the chemical profile of T. vogelii *depending on where its collected. This variation is important since bioassays have shown that while deguelin is active against* Callosobruchus maculatus *that tephrosin is less active against it so it is important to ensure that material being promoted for pesticidal plant work contains primarily deguelin.*

Which species is best to use- T. candida vs. *T. vogelii***.**

Tephrosia spp are promoted widely to improve soil fertility owing to their ability to fix nitrogen and their high foliar content of N, K, Ca and Mg so can be ploughed back into the soil as a green manure particularly for high nutrient depleting crops like maize. *Tephrosia* spp. (there are some 350 species) are also generally thought to share the same pesticidal properties and so provide a useful secondary resource as a pesticide for farmers. Present agro-forestry policy is promoting *T. candida* in preference to *T. vogelii*; a strategy accepted by farmers since *T. candida* produces almost twice as much biomass. It is assumed by both farmers and extension workers that *T candida* is pesticidal in the same way as *T. vogelii* since in general the chemistry of species within a genus is similar. Apart from their height at maturity they are very similar morphologically – at least at a superficial level – and very difficult for anyone but the most experienced legume botanists to distinguish.

Analysis of the foliage of *T. candida* during this project has demonstrated that this species is in fact very low in the rotenoids that bestow the pesticidal properties on this genus (Fig 3.5). In deed, they contain no tephrosin or rotenone at all and we have only been able to detect deguelin at concentration less than 1% of that found in *T. vogelii*. Thus T. candida is a poor pesticidal plant and should be avoided for soil improvement programs if the farmers are expecting to be able to use them as pesticides as well. The main compound in the non-polar flavonoid region of the chemical profile was obovatin 5-methyl ether (Fig 3.6) an inactive flavone. This compounds occurs with a group of related flavones.

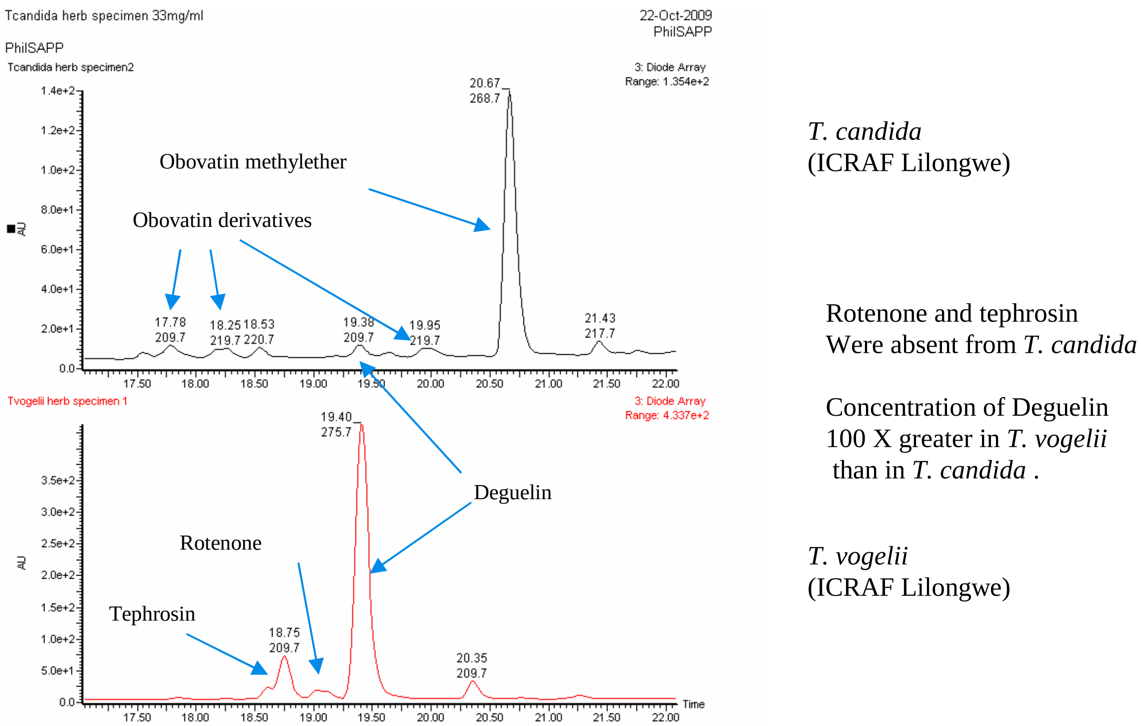


Fig 3.5 HPLC chromatogram showing the chemical differences between foliage of T, vogelii and T. candida. The rotenoid content of T candida is less than 1% of that recorded in T. vogelii.

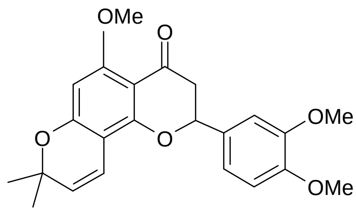


Figure 3.6 Obovatin 5-methyl ether is the major flavonoid in T. candida.

Liquid soaps to optimize extraction of poorly water soluble pesticidal plant compounds.

One other issue regarding the use of *T. vogelii* leaves as an on-farm pesticide in Africa is that farmers invariably extract the leaves in water. Indeed – this is true for all pesticidal plants that are sprayed. There is certainly no organic solvent available to farmers, yet rotenoids like deguelin – are not very soluble in water. Analysis of methanol extract containing large quantities of all the rotenoids compared with a water extracts (Fig 3.7) shows this clearly. However, when we extracted the leaves in a solution containing a small quantity of soap (Decon 90 at 2%) this encouraged a larger amount of the rotenoids to be extracted. While not as effective as methanol, it was far better than water alone.

It is likely that farmers will be able to obtain liquid soaps fairly easily and their use will enhance the extraction. This may also give farmers a greater incentive to use a spreading agent in the tank mix. Discussions with farmers often revealed that while they understand that they should use surfactants in the spray tank to help spread the chemical pesticide or plant extract on the otherwise hydrophobic leaf surface they often do not to save costs. By using a surfactant to extract the plant material, this may optimize the extraction of the biologically active components while also optimizing their effect on the plant when sprayed.

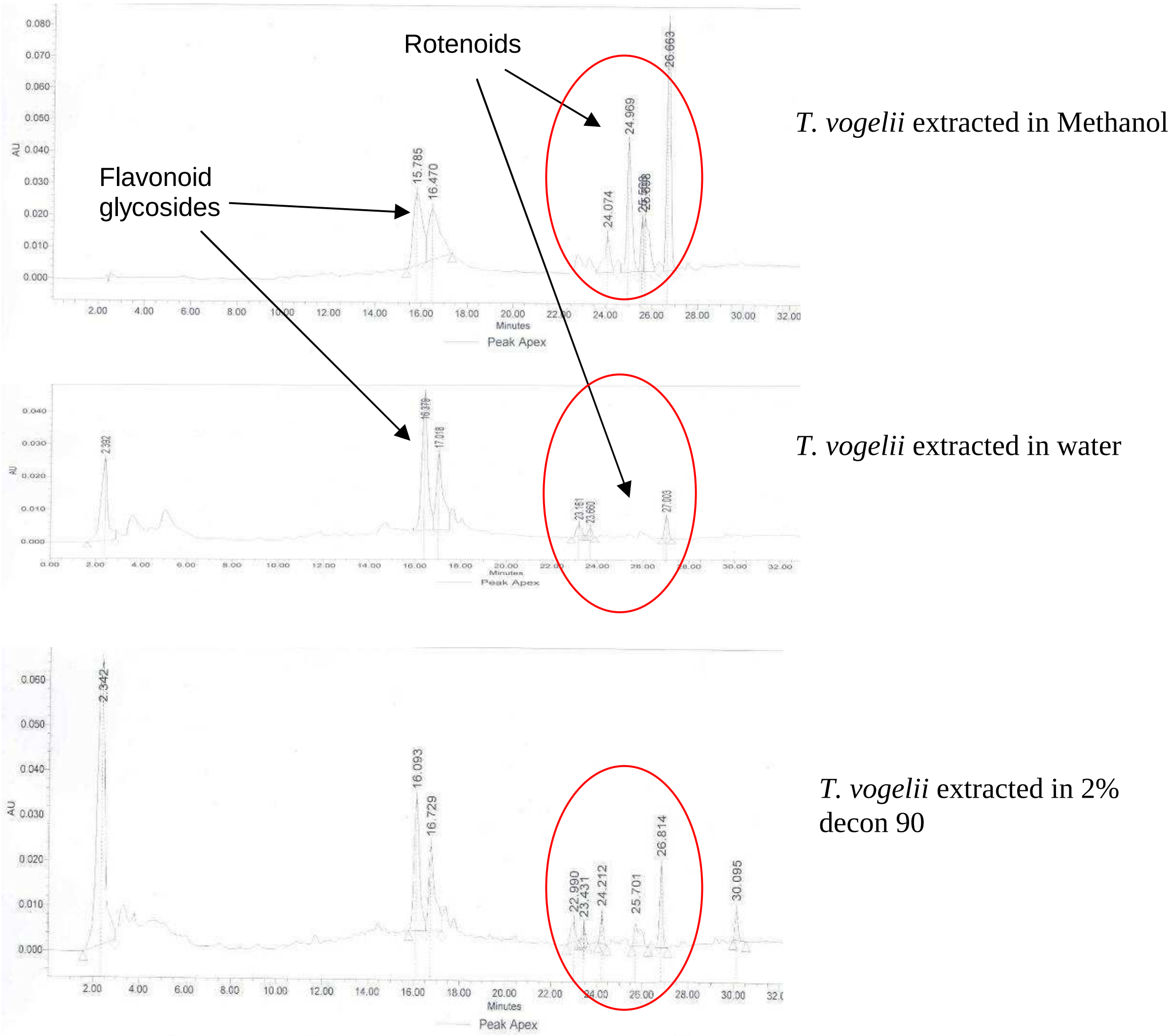


Fig 3.7 a, b & c showing that Decon 90 (c) a general purpose surfactant extracts rotenoids more efficiently from Tephrosia *than water so is a way of optimising field application of this plant material*.

Quantitative analysis of this extraction process with 1% and 5% Tween 20 revealed that a 1% tween solution extracted 3 times more rotenoid than water and 5% extracted at least 5 times more rotenoid based on a comparison of integrated peaks area under deguelin (Fig 3.8). Consequently all our promotion activities now advise farmers to extract pesticidal plants with liquid soap. While 1% is too high for spraying it is advised that famers to extract 1 part plant material in 10 parts soap solution (at between 1 – 5% liquid soap) over night and then dilute to 1% before spraying. Most farmers even with pesticides do not use surfactants to assist with spreading and sticking despite knowing that this is a better way to use pesticides. Thus by incorporating the use of a soap at an early stage in the process – at the extraction stage – the soap will already be in the spray formulation to assist with spreading and sticking.

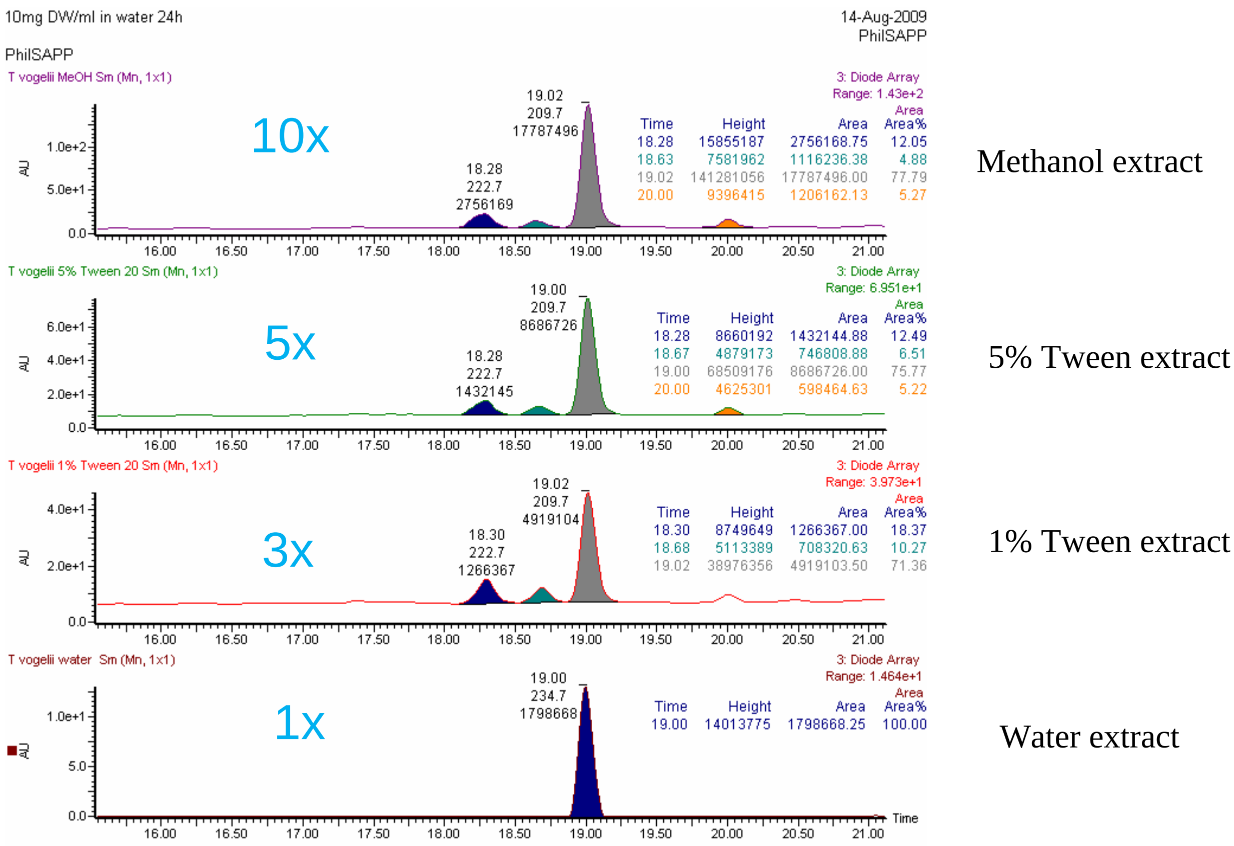


Fig 3.8 Extraction of T. vogelii *in Tween optimizes the extraction efficiency compared to water alone and at 5% is 50% as efficient as methanol. The inclusion of liquid soaps in the extraction process ensures the final extract sprayed onto crops contains a surfactant that would otherwise likely be omitted by the farmers.*

Antifeedant and toxicity bioassays were carried out to determine if this enhanced the biological activity with a model insect *Spodoptera littoralis*. This was done using an established glass fibre disc assay (Simmonds et al, 1990; *J. Chem. Ecol.*, 16, 3167) where discs are treated with plant extracts and placed in a chamber with a food deprived larva of the test insect along with a control disc treated with sucrose. The Feeding indices is calculated from the formula C-T/C+T % where C = the amount of control discs eaten and T = the amount of treatment disc eaten. A no choice experiment is carried out in a similar way but the amount of treatment disc eaten by one insect having no choice is calculated when the amount of control disc eaten by another insect larva reaches 50%.

In addition, we evaluated the effect on mortality in the 2nd and 4th instars and development (as a percentage of the control) of the insect. We compared the extracts of *Tephrosia* with rotenone and also the extract of the roots of a related leguminous species *Neorautanenia mitis* which we have shown contains many more rotenoids than *Tephrosia* including rotenone (Fig 3.9)The extract of the roots of a related species *Neorautanenia mitis* contains many more rotenoids than *Tephrosia* including rotenone and may be an excellent additional plant pesticide that needs to be further exploited.

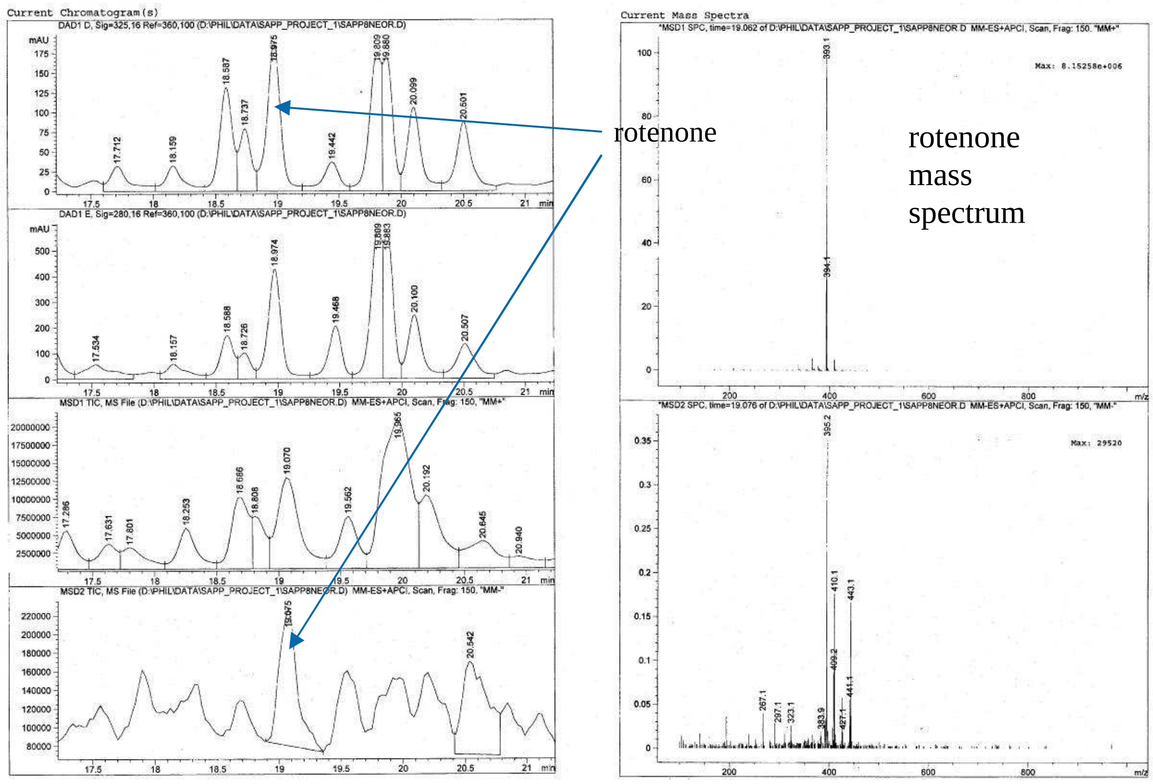


Fig 3.9 Rotenone occurs in high concentration in Neorautanenia mitis *but not in related* Dolichos kilimandscharicus *which is reported to be a pesticidal plant.*

No extract of *Tephrosia* collected so far that we have tested against this model lepidopteran pest insect *Spodoptera littoralis* has shown antifeedant activity although the extract of *N. mitis* was weakly antifeedant (Table 3.1). Since both plants contain rotenoids, and rotenone and deguelin had no antifeedant effect any pest control value these plants have will lie in their toxicity. In this respect there does appear to be toxicity and developmental inhibition in *T. vogelii* leaf methanol extracts suggesting there may be more value in *T. vogelii* as a pesticidal plant than previously supposed. However, the nature of the compounds responsible for this effect is not clear since the Decon 90 extract appeared to be more toxic than both the water and methanol extracts. This may be an artefactual effect of the detergent.

A series of bioassays conducted on other priority species during the year showed that *S. longepedunculata* stem bark has some potential where previously only the roots were thought to have any pest control value. The 0.1g/ml extract was antifeedant to the larvae of *S. littoralis,* and showed some significant development inhibition and toxicity. However, the effect was less profound than that of the neem seed kernel extracts in methanol and decon 90. The potency of the toxic effect of Decon 90 and methanol extracts of neem compared with that of the water extract does support the concept that a detergent based extraction solvent may optimize solubilisation of less polar active components like the tetranortriterpenoids, nimbin and salanin which are thought to be responsible for toxicity and all occur in the methanol and Decon 90 extracts of neem seed kernel. However, the water extract showed some anti-feedancy usually associated with the diterpenoids azadirachtin suggesting that water does extract this important component of the neem seed kernel arsenal.

Table 3.1 Effect of various rotenoids containing extracts on *Spodoptera littoralis*

Species or sample	Conc mg/ml	Feeding Index (sem)	Devel %	Mortality 2nd instar	Mortality 4th instar
Rotenone	1 mg/ml	-16.9 (16.33)	59*	50*	50*
Deguelin	1 mg/ml	4.7 (10.69)	57*	30*	35*
T. vogelii leaf Decon 90	0.1g/ml	12.3(19.11)	70	55*	55*
T. vogelii leaf Water	0.1g/ml	-63.3(7.43)	52*	25	20
T. vogelii leaf MeOH	0.1g/ml	10.9 (13.64)	56*	20	0
T. vogelii leaf MeOH	0.01g/ml	-50.3(9.06)	93	0	0
Neorautanenia mitis	0.1g/ml	49.8(3.78)*	75	40*	45*
Decon 90		-18.5(12.71)	96	0	0
Control			100	0	0

Table 3.2 Effect of various pesticidal plant extracts on *Spodoptera littoralis*

Species or sample	Conc g/ml	Feeding Index (Sem)	Devel %	Mortality 2nd instar	Mortality 4th instar
S. longepedunculata stem bark	0.1	88.7(7.52)**	37*	55*	45*
Dolichos kilimandscharicus	0.1	-45.7(5.9)	83	40*	35*
Solanum panduriforme	0.1	-53.4(12.92)	88	50*	30*
Entada rheedei pods	0.1	-45.2(9.38)	82	50*	45*
Euphorbia tirucalli	0.1	-64.7(11.48)	77	55*	40*
Neem seed kernel MeOH	0.1	100(0.0)**	18**	100**	75**
Neem seed kernel Decon 90	0.1	-30(32.61)	19**	100**	75**
Neem seed kernel Water	0.1	85.8(5.81)	21**	15	0
Cucumis anguria fresh skin	0.01	-22.5(6.56)	84	35*	25
Vernonia spp mzuzu	0.1	10.6 (19.26)	78	20	0
Tithonia diversifolia	0.1	4.5 (11.82)	78	5	20
Decon 90		-18.5(12.71)	96	0	0
Control			100	0	0

- P<0.05 ** P<0.01

Nimbin and salanin which occur at high concentrations in the seed kernel with azadirachtin were absent from neem leaves and azadirachtin was only present at very low concentrations suggesting that the value of leaves as a pesticidal material for farmers is lower than the seed kernels. The methanol extracts of *Solanum panduriforme*, *Dolichos kilimardscharicus*, *Entada rheedei* and *Euphorbia tirucali* were all toxic to the larvae of *S. litura* at 2nd and 4th instars but the effect was less potent than the extract of *S. longepedunculata* and neem kernels (Table 3.2)

Bobgunnia madagascariesnsis.

Bobgunnia madagascariensis (syn. *Swartzia madagascariensis*) like *T. vogelii* is reported by farmers to be anti-insect – particularly in stored grain where it is used as a powder and against field pests as a water extract sprinkled onto the plants (See surveys

above). It is also well known by researchers both in the project team and elsewhere for this purpose and thus presents a good target species for the project. We conducted a detailed analyses of the extract of the dried pods, the plant part most favoured and frequently used by farmers, and have confirmed using NMR the presence of a kaempferol-O-pentaglycoside (Fig 3.10). In addition we have identified two related quercetin-O-pentaglycoside and a second kaempferol-O-pentaglycoside. Two of these compounds have only very recently been reported elsewhere as cordylasin A and B, (Veitch et al. 2008 Phytochem. 69: 2329-2335) however, the two pentaglycoside in which glucose has substituted galactose are previously not reported and are reported here for the first time. The determination of the structures of these compounds is reported in a research paper that has been submitted to *Tetrahedron Letters* and the text of which is provided with the additional documentation.

We also previously reported the presence of saponins in this species and have now confirmed by NMR the structures of 3 of these. The most abundant is previously reported with the common name putranoside C and is shown in Fig 3.11 while two others were identified as the 3-*O*-[β-D-glucopyranosyl-(1→2)-[α-L-rhamnopyranosyl-(1→3)]-β-D-glucuronopyranoside], 28-*O*-β-D-glucopyranosyl ester of oleanolic acid previously reported from this species but not from the pods, and the 3-*O*-[β-D-xylopyranosyl-(1→2)-[α-L-rhamnopyranosyl-(1→3)]-β-D-glucuronopyranoside], 28-*O*-β-D-glucopyranosyl ester of oleanolic acid which is reported from this species for the first time. These compounds have previously been reported to be ichthyotoxins and have molluscicidal properties (Borel & Hostetman 1987, *Helv. Chim. Acta*, **70**: 570). We are still to conduct bioassays to determine their potential insect toxicity. Of course if the compounds are active, their water solubility may enable the development of a water-based extract application process similar to that for *Securidaca longepedunculata* about which we have previously reported.

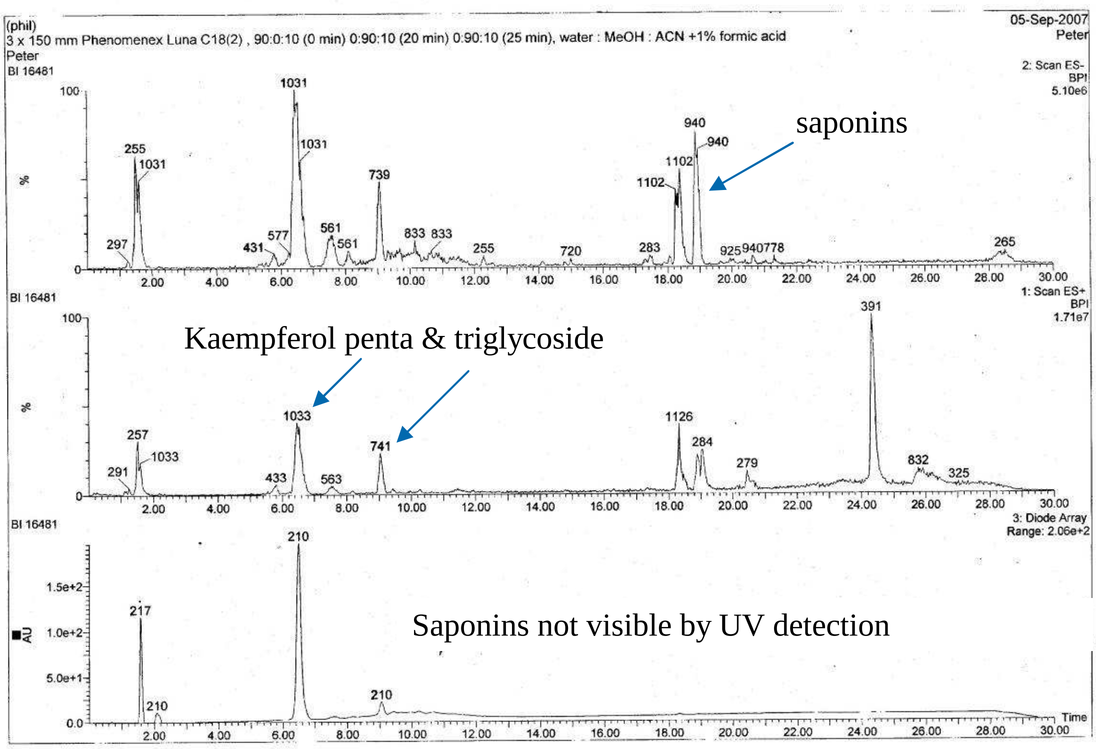
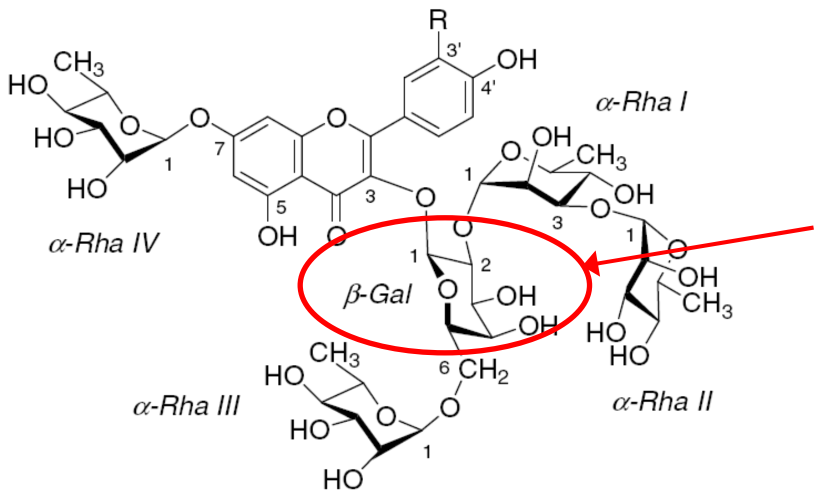


Fig 3.9 Chromatograms of *Bobgunnia madagascariensis* showing the presence of rare flavonoid pentaglycosides and saponins.

We have also identified luteolin and eriodyctiol in the pods of *B. madagascariensis* (Fig 3.12) While the latter has no known insect biological activities luteolin and its glycosides have been reported to be feeding deterrent to *Spodoptera exigua* & *S. litura* (from *Vernonia cinerea*), oviposition deterrents to the leaf miner *Liriomyza trifolii*, and toxic to the bean weevil *Acathoscelides obtectus* and may explain the activity of this species to Acanthosceldies reported later from field trials.



Two compounds known from *Cordyla* spp. We have found derivatives in which this galactose is substituted by glucose and are not previously known. Possibly important taxonomically. Will test in biological activity tests.

1 R = OH; Cordylasin A
2 R = H; Cordylasin B

Fig 3.10 Chemical structures of new flavonoids identified in *Bobgunnia madagascariensis* reproduced from Veitch *et al*., Phytochem, vol. 69 p. 2329.

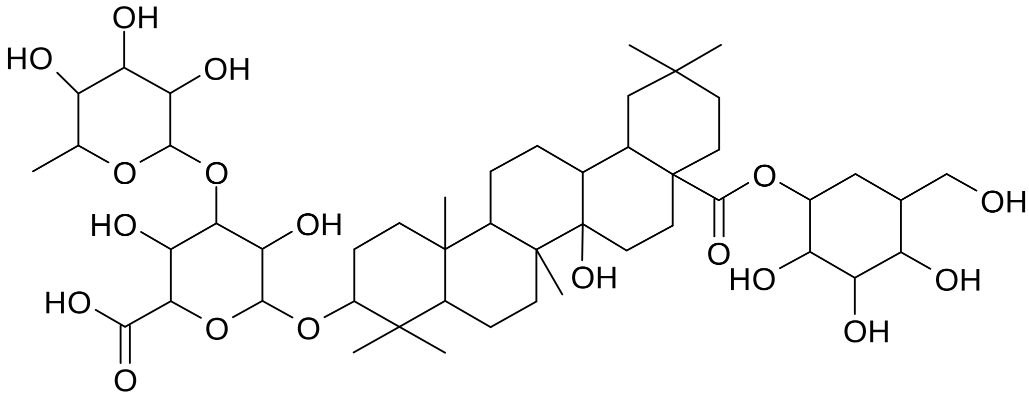
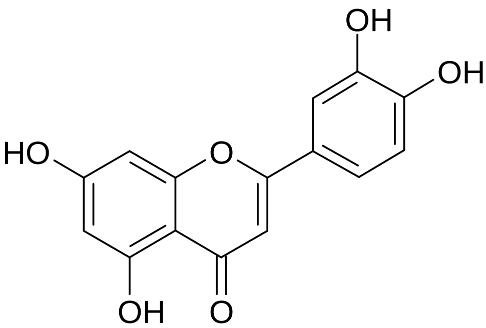


Fig 3.11 Putranoside C: a 3-*O*-[α-L-rhamnopyranosyl-(1→3)-β-D-glucuronopyranoside], 28-*O*-β-D-glucopyranosyl ester of oleanolic acid. One of 3 related saponins isolated from pods of *B. madagascariensis*.



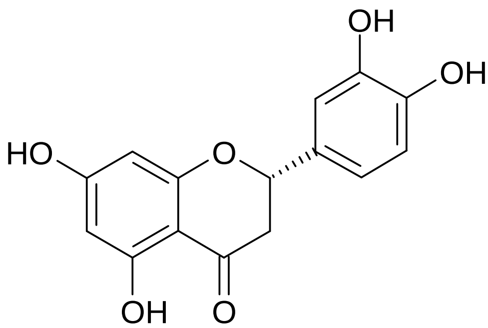


Fig 3.12 Luteolin and eriodyctiol isolated from pods of B. madagascariensis.

Activity 3.2. Repellent and toxic properties of pesticidal plants against stored product insects

The principal target pest species in storage are *Sitophilus zeamais* on maize grain and *Callosobruchus maculatus* on cowpea. Both pests cause substantial damage to stored grains. Current treatments include Actellic dusts. These are effective but are costly and in some cases a full years use cost between 5 and 10% of the value of the product. Pesticidal plants to protect stores against damage from these pests are one of the major targets.

Sitophilus zeamais on maize grain.

Callosobruchus maculatus on cowpea

Bioassays to test plant materials against *C. maculatus* were aimed at determine the effects on oviposition (the adults do not feed so the main target is the adult and the prevention of oviposition). Cowpeas were placed in tubes (5 reps of 5g each (~25 beans) and to this was added 100mg of dried, ground plant material (= 2.5% w/w). There were 5 untreated controls. 3 Female & 1 male *C. maculatus* were added to each treatment. After 2 weeks @ 27± 2oC, 60-80% RH[7]. Original weevils removed (most dead – they only live for 14 days). Eggs on each bean were counted and after further 6-8 weeks all emerged adults counted.

The results showed that the most effective plant materials were *Tephrosia vogelii* and *Neorautanenia mitis*. The only other species that showed any effects against bruchids was *Vernonia amygdalina* (Table 3.3). For these active plants the leaf material affected the adults only and not the subsequent survival of eggs that were laid with the exception of *T. vogelii* (Table 3.3). Interestingly when leaf extracts in acetone were tested (Table 3.4) by coating grain with the extract the toxicity of *T. vogelii* towards adults whereas the effect on eggs was more profound. Indeed there was a greater efficacy for most of the plant species tested against the eggs, thus the use of plant extracts for coating grain may be a more effective way

of controlling infestation than simply using the plant material It is also possible to be more efficient with scarce plant species but there are implications on the flavour of grain after coating so this may be most appropriate for use with grain stored for sowing in subsequent seasons rather the food stores.

Table 3.3 Biological effect of Miombo pesticidal plants on oviposition and egg emergence of C. maculatus.

Plant Material	Mean No. Eggs ±SD*	Mean Emergence ±SD	% Egg Survival
A. indica	206.6 ± 19.31 g	64.6 ± 10.78 ad	31.3%
T. vogelii	11.2 ± 3.42 f	2.0 ± 1.58 c	17.9%
S. longepedunculata	122.4 ± 8.91 eh	68.6 ± 11.67 ad	56.0%
B. madagascariensis	109.2 ± 57.4 bcdeh	57.8 ± 32.49 abd	52.9%
S. panduriforme	99.4 ± 6.35 h	57.2 ± 10.47 d	57.5%
D. kilimandscharicus	118.2 ± 5.54 deh	64.0 ± 9.97 ad	54.1%
V. adoensis	64.2 ± 26.94 h	27.8 ± 28.73 bcd	43.3%
E. tirucalli	142.2 ± 2.17 cdeh	64.2 ± 16.66 ad	45.1%
M. pruriens	122.6 ± 10.21 cdeh	51.6 ± 8.32 abd	42.1%
T. minuta	165.6 ± 4.58 acefg	64.8 ± 11.30 ad	39.1%
N. mitis	13.0 ± 4.58 f	9.0 ± 8.75 bc	69.2%
control	149.4 ± 14.43 abcde	59.0 ± 6.36 abd	39.5%

*Numbers followed by the same letter are not significantly different.

Table 3.4: Oviposition and emergence of C. maculatus adults from cowpea treated with Acetone extracts (5mg/ml) of different pesticidal plants.

Plant Extract	Mean No. Eggs ±SD	Mean No. of Adults emerged ±SD	Mean % Survival
A. indica	127.8 ± 27.35 a	10.6 ± 19.87 a	8.3%
T. vogelii	83.4 ± 29.88 a	0.2 ± 0.45 a	0.2%
S. longepedunculata	107.8 ± 26.58 a	7.6 ± 7.80 a	7.1%
B. madagascariensis	110.0 ± 38.84 a	2.8 ± 2.49 a	2.5%
S. panduriforme	134.2 ± 23.12 a	13.6 ± 16.29 a	10.1%
D. kilimandscharicus	147.4 ± 7.20 a	61.0 ± 6.24 b	41.1%
V. amygdalina	111.4 ± 21.22 a	10.0 ± 11.51 a	9.0%
E. tirucalli	145.8 ± 14.62 a	20.4 ± 13.43 a	24.4%
M. pruriens	88.4 ± 24.23 a	21.6 ± 17.39 a	11.2%
T. minuta	105.0 ± 17.48 a	11.8 ± 10.33 a	1.6%
N. mitis	114.8 ± 35.81 a	1.8 ± 3.49 a	6.5%
Blank	110.6 ± 45.72 a	53.4 ± 21.97 b	57.3%

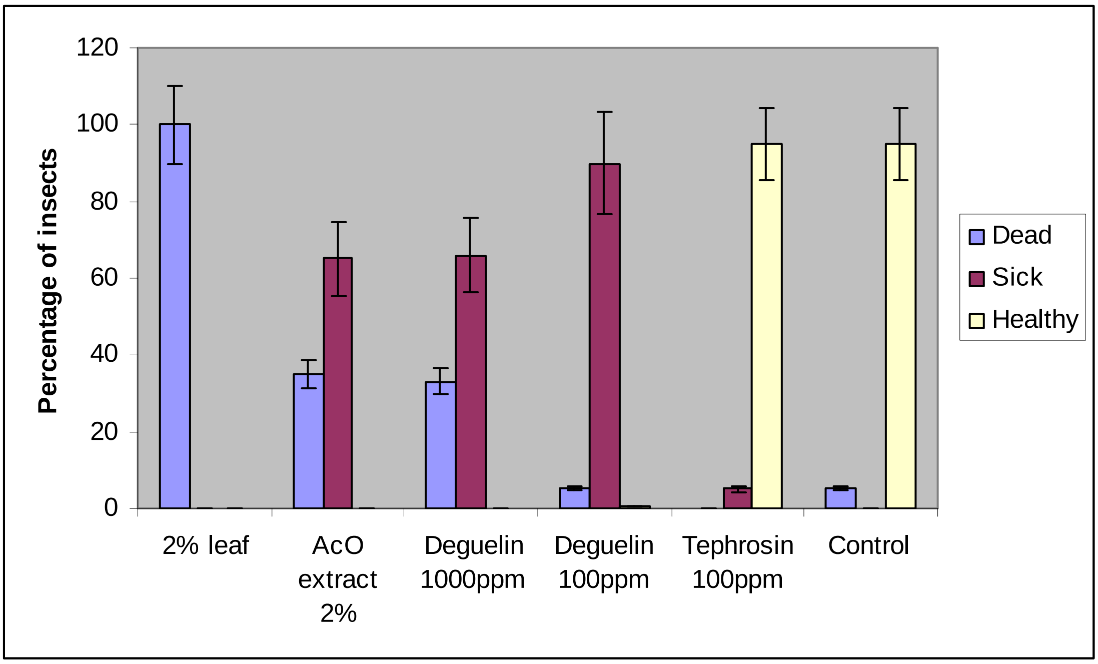
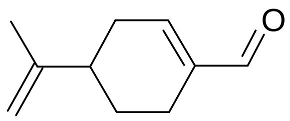


Fig 3.13 *Percentage mortality of adult* C. maculatus *after 48h on treated grain.*

To investigate the chemicals responsible for the biological activity of *Tephrosia vogelii* we presented adult bruchids with grain that had been treated with either 2% leaf powder or the equivalent leaf extract in acetone to 2% leaf powder along with deguelin and tephrosin the two major rotenoids in the leaves. Grain was coated with the extracts by rotating in a rotary evaporator until the solvent had evaporated. The most striking results showed that the leaf material of *T. vogelii* is highly toxic to the adults and all adults were dead with 2% leaf after 48h. However, the extract was less effective. However, while only 33% of adults were dead after 48h with the 2% extract the remainder were very sick and incapable of oviposition. Deguelin was as effective as the whole leaf extract and thus explains the activity of the extracts. Interestingly the lower the concentration the less potent the effect. This supports suggestions above that *T. candida* is NOT appropriate for pest control since the concentration of rotenoids in this species are lower by more than 100 times compared to T. vogelii. Interestingly deguelin at 100ppm was more potent that tephrosin at the same concentration indicating that the source of T. vogelii could be important. As mentioned above some *T. vogelii* leaf material collected in Mzuzu was high in Tephrosin and low in deguelin. So it is important to ensure that the material being used by farmers is higher in deguelin. Presently without analysis in UK it is difficult to see how this could be managed in Malawi although the training of two partners in analytical chemistry using HPLC and LC MS could mean that there will be scope to conduct these analysis in Malawi provided they have access to equipment.

Chemical analysis and bioassays of *Lippia javanica* and other pesticidal materials against grain borers (Mzuzu University, J. Kamanula).

Volatile compounds were extracted from *Lippia javanica* in hexane and analysed by GC/MS. The results are shown in Table 3.5. The major compound was identified as 4-(1-methylethenyl)-1-Cyclohexene-1-carboxaldehyde (perillaldehyde) (15.6 min)and this was identified along with 3,7-dimethyl-1,6-Octadien-3-ol (15.04 min.), 4-(1-methylethenyl)-1,4-Pentadiene (16.1 min.), Germacrene D (20.13 min.), Cyclododecane (24.09 min.) and Phytol (31.13 min.).



perillaldehyde

Repellency evaluation of L. javanica hexane, dichloromethane and methanol leaf fractions against S. zeamais *after 1, 2 and 24 hrs of exposure.*

The extracts of *Lippia javanica* exhibited repellency (positive values) and attraction (negative values) against *S. zeamais* after 1, 2 and 24 hrs of exposure (table 3.6). Generally, for all treatments, there were significant (F= 6.555; *P* = 0.0001) differences in the repellency, which increased with dosage and exposure time. After one hour, the highest dosage (1.256 mg/cm^2 filter paper) for hexane fraction (HF) significantly (*P*=0.0001) showed highest repellency (51.0 %) against *S. zeamais*. After 24 hrs, the repellent effect exhibited by the highest dosage of DCM to *S. zeamais* did not differ significantly (p >0.05) from 0.628 mg/cm^2 for hexane. The repellent effect of the methanol extract was significantly (*P*=0.0001) different for all dosages compared to both hexane and DCM extracts. The hexane fraction contains the perillaldehyde suggesting that this component was associated with the repellent effect.

Table 3.6. Mean percent repellency values for hexane, dichloromethane and methanol fractions isolated from L. javanica *leaves against* S. zeamais *after 48 hrs of exposure.*

Fraction	Dosage (mg/cm^2)	Mean repellency (%)after 1 hour	2 hours	24hours
Hexane	0.126	-27.00[a]	-13.00[a]	-24.00[a]
	0.251	-19.00[a]	2.00[ab]	19.00[a]
	0.628	16.00[b]	21.00[abc]	74.00[de]
	1.256	51.00[d]	64.00[d]	92.00[e]
Dichloromethane	0.126	11.00[b]	-22.00[a]	7.00[ab]
	0.251	16.00[b]	-5.00[a]	22.00[bc]
	0.628	30.00[c]	47.00[cd]	47.00[cd]
	1.256	-22.00[a]	41.00[bcd]	66.00[de]
Methanol	0.126	-4.00[abc]	3.00[ab]	-13.00[ab]
	0.251	13.00[ab]	3.00[ab]	-5.00[ab]
	0.628	-9.00[ab]	-17.00[a]	-24.00[a]
	1.256	3.00[a]	8.00[ab]	-22.00[a]
F= 6.555; *P* = 0.0001 ; α =0.05				

Negative values indicates attraction and positive values repellency

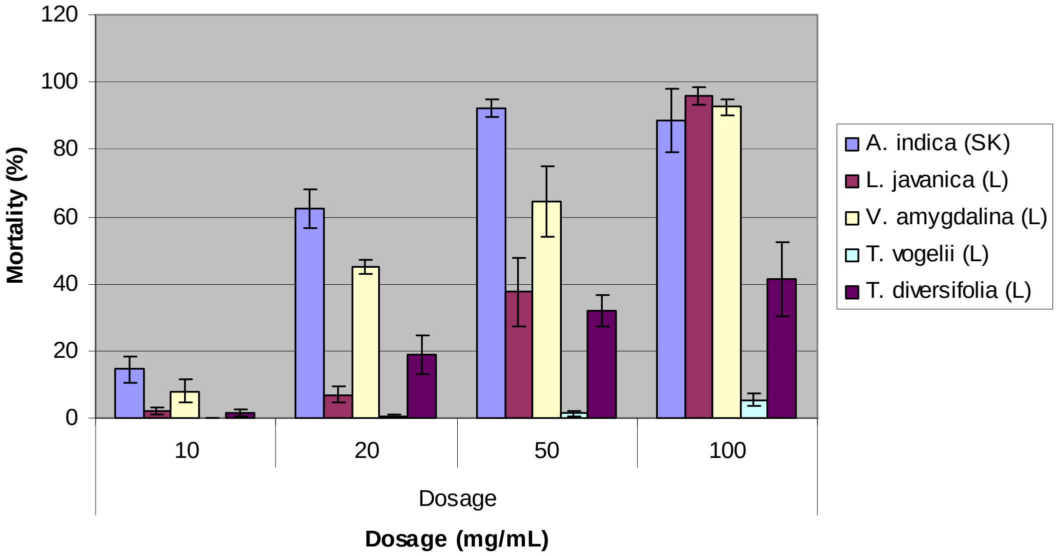
Contact toxicity of *A. indica*, *T. vogelii*, *T. diversifolia*, *V. amygdalina*, *L. javanica* against *S. zeamais*.

Contact toxicity results of *A. indica*, *T. vogelii*, *T. diversifolia*, *V. amygdalina*, *L. javanica* against *S. zeamais* are shown in Table 5 and Figure 4. The results showed that plant materials were toxic to adult *S. zeamais* after 48 hrs of exposure. The toxicity increased with concentration and type of plant material. The lowest concentration (10 mg/ml) exhibited lowest mortalities for all plants after 48 hours of exposure. *A. indica*, *T. diversifolia* and *V. amygdalina* showed high toxicities against *S. zeamais*, with LC_{50} values of 12.82 ± 1.35, 20.89 ± 1.58 and 22.96 ± 1.37 mg/ml, respectively compared to *T. vogelii* and *L. javanica*

(Table 3.7). However, the highest concentration (100 mg/ml) of *L. javanica* showed significantly (*P*=0001) higher mortality of *S. zeamais* than both *T. vogelii* and *T. diversifolia* after 48 hrs of exposure (Figure 4)

Table 3.7 LC_{50} values methanol extracts of A. indica *seed kernel*, T. vogelli, T. diversifolia, V. amaygdalina *and* L. javanica *leaves against* S. zeamais *after 48 hrs of exposure.*

Plant species	LC_{50} mg/ml (mean ± SEM)	R^2	95 % CI Lower	Upper
A. indica	12.82 ± 1.35	0.775	7.11	23.12
V. amygdalina	22.96 ± 1.37	0.897	12.11	43.55
L. javanica	274.79 ± 1.65	0.991	103.04	732.82
T. diversifolia	20.89 ± 1.58	0.830	6.10	30.06
T. vogelii	30.62 ± 4.23	0.971	1.82	515.23



SK = seed kernel; L = leaf

Figure 3.14.. Contact toxicities of A. indica *seed kernel*, T. vogelii, T. diversifolia, V. amygdalina *and* L. javanica *leaves methanol extracts against* S. zeamais *after 48 hrs.*

Effect of S. longepedunculata (RB), Agauria (L), Vernonia (L), Dolichos (R), C. nardus (L) and T. diversifolia (L) on larger grain borer.

Dried plant material of *S. longepedunculata (Root Bark), Agauria salicifolia (Leaf), Vernonia amygdalina (Leaf), Dolichos kilimandscharicus (Root), Cymbopogon nardus (L)* and *Tithonia diversifolia (L)* was tested against larger grain borer. Each plant material was admixed with 10 g of maize grain at 2 %, w/w. Ten adult (n=10) LGB (1-7 days old) were added to the treated maize grain and mortality was evaluated every week for 5 weeks. *Securidaca longepedunculata* produced 70 % mortality (cumulative) of adult LGB after 5 weeks but none of the other plant species showed activity (Fig 3.15). It is not yet clear from

this work whether this effect was caused by the high content of methylsalicylate or the saponins described earlier in the report.

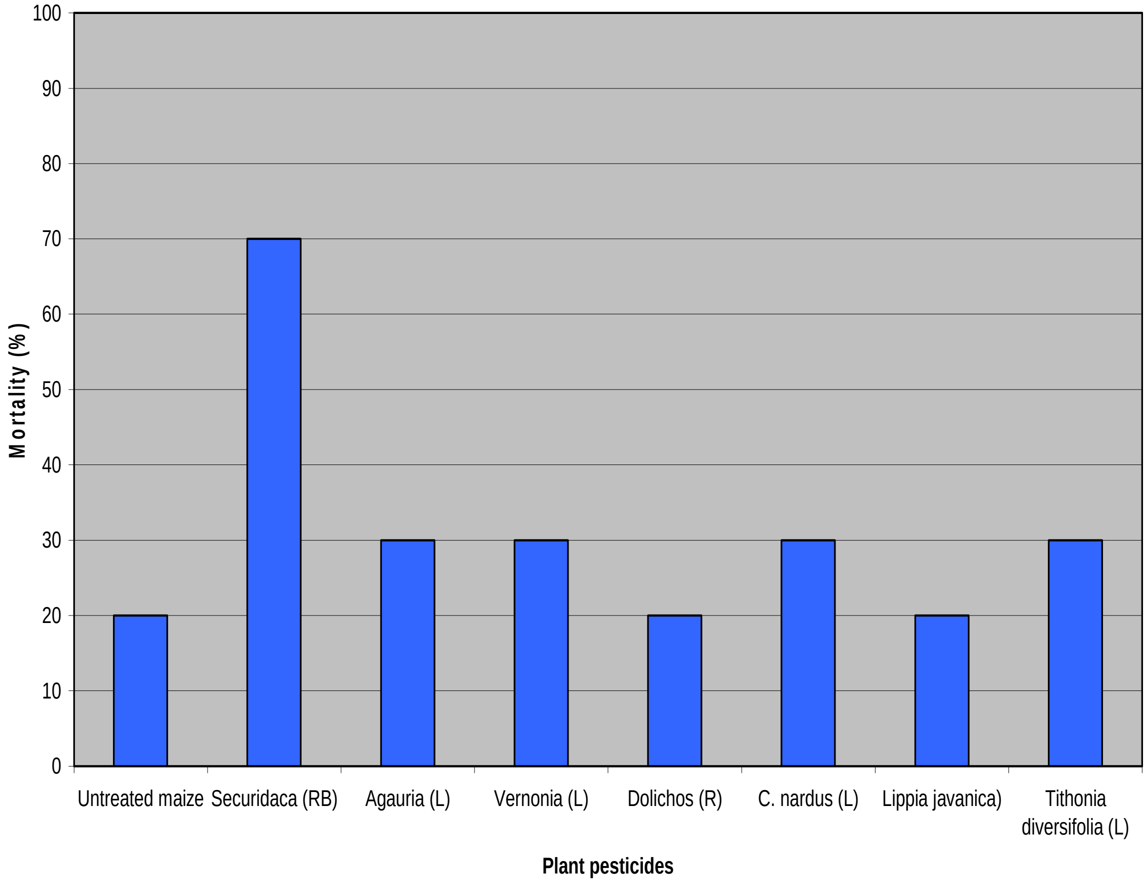


*Figure 3.15 Mortality (%) of adult Larger grain borer (*Prostephanus truncatus*) in maize treated with pesticidal plants (2 %, w/w) after 5 weeks.*

Mode of Action studies

The mode of action of pesticidal plants is already well-known to vary, with some plants causing direct contact toxicity, anti-feedancy, and/or anti-oviposition effects while other plants repel insects by interfering with the insect's chemoreception and orientation behaviours. Repellency may occur when the insect comes in direct contact with the plant compounds or it may occur at a distance through volatile compounds carried in the air. Many insects use air-borne volatile compounds to locate their food, find mates and discover egg laying sites. The use of repellents against insects is well established for interfering with host orientation and selection, particularly for mosquito and other biting flies.

The use of pesticidal plants in agriculture also suggests that many plants have repellent properties against certain insects. Plant materials that can be shown to be highly repellent but not directly toxic may result in safer application and less danger for people who may accidentally ingest food recently treated with pesticidal plants, particularly in the context of stored grain protection. Based on our existing understanding of different stored grain insects and their host orientation behaviours, we wanted to discover if pesticidal plants affect host orientation and selection (i.e. repel insects from treated grain), and whether different stored product insect species are affected in the same generic way.

To do this, we used Ethovision tracking and motion analysis software. This is a computerised behavioural tracking programme that can monitor insect movements within an experimental arena, allowing insect movements to be analysed for their distance moved, velocity and angular velocity relative to features present in the arena (see Figs. 3.16 and 3.17).

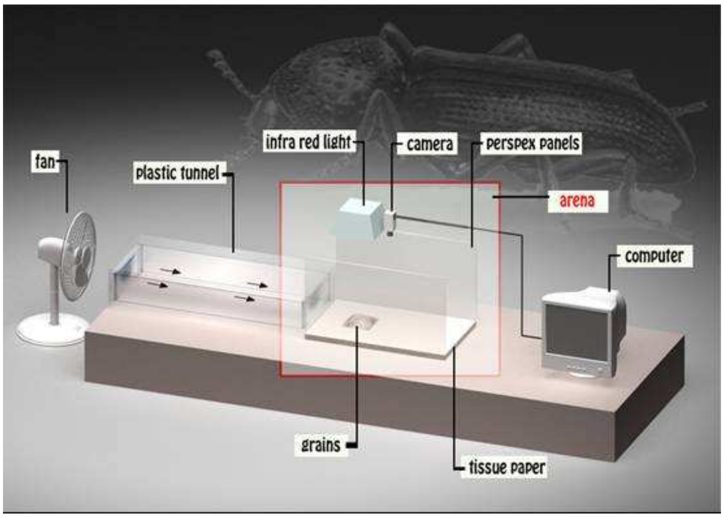


Figure 3.16 Diagram of the Ethovision experimental design. Individual insects are placed downwind of a pile of grain that has been treated with a powdered pesticidal plant (5% w/w). Insect movements and responses to the odour are recorded by the video camera, with the information stored on a computer for subsequent analysis.

Experimental trials have compared the responses of *Sitophilus zeamais* vs. *Rhyzopertha dominica* and pesticidal plant powder admixed at 5% (*w/w*) vs. untreated grain. In all cases individual insects are placed 20 cm downwind (wind speed 1.0 m/s) of whole wheat grain (50 g).

Results indicate that *Sitophilus zeamais* walking adults will orientate upwind in response to the food volatile compounds. This host finding behaviour is adversely affected by a number of powdered plant materials, indicating that *S. zeamais* is indeed repelled to varying degrees by different pesticidal plants.

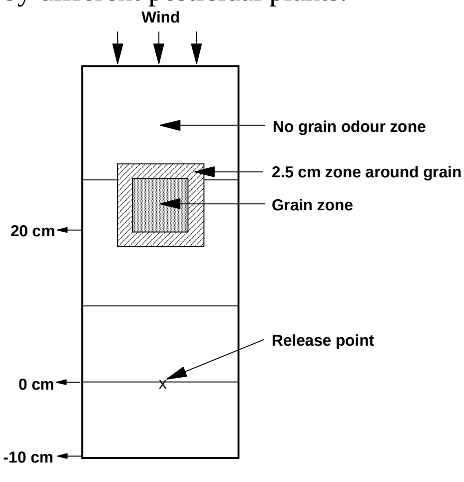


Figure 3.17 The experimental arena showing that the insect is released 20cm downwind of a pile of grain.

Table 3.8 Percentage of S. zeamais adults positively orientating towards food grain as affected by a range of pesticidal plants admixed with the grain.

Treatment	Percentage of insects coming within 2.5cm of grain zone (n=12)	Percentage of insects reaching food and remaining in grain (n=12)
Untreated	100	100
Azadirachta indica	17	0
Bobgunnia madagascariensis	33	8
Tithonia diversifolia	8	8
Tagetes minuta	17	0
Tephrosia vogelii	33	8
Solanum panduriforme	33	0
Securidaca longepedunculata	8	0
Euphorbia tirucalis	33	0

Results with *Rhyzopertha dominica* are inconclusive as it does not appear that walking adults orientate to food volatiles. Untreated grain does not appear to be attractive to *R. dominica*. This is not entirely unexpected, as the evolutionary strategies adopted by many insect species within the Bostrichid insect family involve finding food by chance and then recruiting conspecifics through the release of aggregation pheromones. This suggests that *R. dominica* does not "smell" its food and it is, therefore, equally unresponsive to potential repellent compounds that may be admixed with its food.

Table 3.9 Percentage of R. dominica adults positively orientating towards food grain as affected by a range of pesticidal plants admixed with the grain. Response rates are no different than finding food by chance by simply walking upwind.

Treatment	Insects within 2.5cm of grain zone (n=12) (%)	Insects reaching food and remaining in grain (n=12) (%)
Untreated	42	33
Azadirachta indica	33	33
Bobgunnia madagascariensis	50	42
Tithonia diversifolia	42	42
Tagetes minuta	33	33
Tephrosia vogelii	50	42
Solanum panduriforme	33	33
Securidaca longepedunculata	42	33
Euphorbia tirucali	33	33

From these preliminary results we can hypothesize that pesticidal plants will not protect grain through repellency for all insect species. Any potential repellent properties found within

pesticidal plants are unlikely to affect insects such as *R. dominica* and *Prostephanus truncatus*, which appear to rely on insect-derived aggregation pheromones as opposed to plant-derived volatiles for host finding. Toxicity may be a more important mode of action for controlling insects that do not naturally orientate to host volatiles. Further research will be carried out in the third year of the SAPP project to test further plant and insect species with a view to submitting a manuscript for publication in a peer-reviewed journal by December 2009.

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WORK PACKAGE 4

Activity 4.1 Provide vertebrate toxicity data of up to 10 species to assess potential human health and animal risks

BACKGROUND: The main aspects of this activity are to determine the efficacy of plant materials against livestock ticks and determine the safety of material currently being used or promoted. There is a false universal assumption that ‘natural’ or ‘plant based’ equals safe but this couldn’t be further from the truth especially with plants that have known biological activities against other animals. Pesticidal plants can present a significant health risk to users when extracting, pounding or concentrating active ingredients yet virtually no work has been published internationally on their vertebrate toxicity. Greatest risks exist when pesticidal plants are used for post-harvest treatment especially when toxic species originally developed and promoted for use in field pest management such as *Tephrosia* spp. where they present little problem are promoted by poorly informed extension organisations for use on stored food stuffs. It is therefore essential to develop the capacity within SADC countries to evaluate their toxicity and ensure appropriate promotion to end users.

RESEARCH ACTIVITIES: Single-dose acute toxicities of *Strychnos spinosa* unripe mature fruits and *Lippia javanica* leaf extracts which are used as acaricidal plants in some parts of Zimbabwe, were tested in sexually mature mice at the Faculty of Veterinary Science, University of Zimbabwe (UZ). The experiments were conducted in March and May 2008 respectively Dosages of 0, 25, 50 and 75 % *v/v* of *S. spinosa* extracts were orally administered to 34 mice while 0, 12.5, 25 and 37.5% of *L. javanica* extracts was administered to 32 sexually mature mice in 2 completely randomised design experiments. This work is submitted to *Human and Experimental Toxicology* as a full paper manuscript (See additional documentation)

A third experiment was conducted in September 2008, using *Bobgunnia madagascariensis* dry mature fruits which are used as grain protectants in some parts of the country. Lower concentrations of 0, 2, 5 and 10% *w/v* were used mainly to cover the concentrations that would normally be used by farmers in the field. The study was carried out by a UZ MSc Animal Science Student. In all the experiments, 4 ml of the plant extracts was orally introduced to the mice and the animals were monitored for 4 weeks. Initially the mice refused

to take in the plant extracts voluntarily when they were incorporated in water prompting the use of gavage needles. Oral administration was under the supervision of a qualified veterinarian.

All the 3 plants showed acute toxicity at different levels. Overall, mortalities were high: *S. spinosa* – 83%, *L. javanica* -37% and *B. madagascariensis* -75% (Tables 4.1 – 4.3). These results indicate that unripe *S. spinosa* fruits; ripe dry *B. madagascariensis* fruits and *L. javanica* leaf extracts may have deleterious implications on human and animal health at the inclusion levels used in these experiments. These plants were further tested (see below) during the final year at lower concentrations and also to determine any toxic differences between mature and immature fruit of *S. spinosa* since the immature fruit is used against ticks and was shown to be highly toxic to the mice yet the mature fruit is eaten by man and other mammals.

Table 4.1 Mortality of BALB/c mice after single dose oral administration of different concentrations of aqueous suspensions of whole unripe fruit of Strychnos spinosa

Hours post treatment	**Mortality of mice after exposure to different concentrations of whole *S. spinosa* fruit**				**Pooled mortality of mice after exposure to *S. spinosa*(n =30)**
Dose	**0%**	**25%**	**50%**	**75%**	
n	**4**	**10**	**10**	**10**	
0 - 12	0	1	3	1	5(16.7)
13 – 24	0	4	3	5	12(40.0)
25 – 36	0	1	1	3	5(16.7)
37 – 48	0	0	0	0	0(0.0)
49 – 60	0	0	1	0	1(3.3)
61 – 72	0	1	1	0	2(6.7)
Mortality (%)	**0**	**7 (70)**	**9 (90)**	**9(90)**	**25(83.4)**

Table 4.2. Mortality of mice (BALB/c) after oral administration of different concentrations of aqueous suspensions Lippia javanica

Hours post treatment	**Mortality of mice after exposure to different concentrations of *L. javanica***				**Pooled Mortality of mice exposed to *L. javanica* (n=24)**
Dose	**0%**	**25%**	**50%**	**75%**	
n	**8**	**8**	**8**	**8**	
0 - 12	0	0	0	1	1(4.2)
13 – 24	0	0	0	0	0
25 – 36	0	1	1	2	4 (16.7)
37 – 48	0	2	0	2	4(16.7)
49 – 60	0	0	0	0	0
61 – 72	0	0	0	0	0
Mortality (%)	**0**	**3(37.5)**	**1(12.5)**	**5(62.5)**	**9(37.6)**

In subsequent experiments, the following plant materials were similarly tested: *Cissus quadrangularis* succulent tissue used as a grain protectant in Zambia and *Vernonia amygdalina* leaves use as a vegetable pesticide in Malawi. Lower concentrations of 0, 2, 5 and 10% *w/v* were used mainly to reflect the concentrations that would normally be used by farmers in the field. *C. quadrangularis* had the least overall mortality of 20.8%. No mortalities were recorded with *V. amygdalina*.

Table 4.3. Mortality of mice (BALB/c) after oral administration of different concentrations of aqueous suspensions Bobgunnia madagascariensis

Hours post treatment	**Mortality of mice after exposure to different concentrations of *B. madagascariensis* fruit**				**Pooled mortality after exposure to *B. madagascariensis* (n =24)**
Dose (%)	**0**	**2**	**5**	**10**	
n	**8**	**8**	**8**	**8**	
0 - 12	0	0	0	2	2(8.3)
13 – 24	0	0	4	3	7(29.2)
25 – 36	0	1	1	2	4(16.7)
37 – 48	0	3	0	1	4(16.7)
49 – 60	0	1	0	0	1(4.2)
61 – 72	0	0	0	0	0(0.0)
Mortality (%)	**0**	**5 (62.5)**	**5 (62.5)**	**8(100)**	**18(75)**

In similar experiments, the plant materials were tested at lower concentrations to identify the minimum toxic lethal dose levels. Concentrations used for the plants were: 0, 0.1%, 1% and 5% for *Strychnos spinosa* and 0.1%, 0.5% and 1% for *B. madagascariensis*. Very low mortalities were recorded: *S. spinosa* – 4.2% and *B. madagascariensis* – 0%). The low mortalities combined with lack of development of clinical signs suggest that the plant material are not toxic at concentrations at which they are used in the field.

Table 4.4. Mortality of BALB/c mice after single dose oral administration of different concentrations of pesticidal plants

Dosage (%)	**Mortality (%)**	**Overall Mean Mortality (%± sd)**
S. spinosa	(n = 32)	
0	0	
25	70	83.4 ± 43
50	90	
75	90	
L. javanica	(n = 30)	
0	0	
12.5	37.5	37.4±28
25	12.5	
37.5	62.5	
B. madagascariensis	(N = 24)	
0	0	
2	62.5	64.3±41
5	62.5	
10	100	
C. quadrangularis	(N = 24)	
0	0	
2	0	20.8
5	8.3	
10	12.5	

The experiment with *V. amygdalina* was also repeated at higher concentrations of 15, 25 & 75% *w/v* (Expt. 2). Again, no behavioural change, development of clinical signs or mortality was recorded for the duration of the experiments. Therefore *V. amygdalina* is not acutely toxic to Balb/c mice and could have no adverse effects on humans or animals.

WORK PACKAGE 5

Activity 5.1. Participatory Rural Appraisal of pesticidal plants and field studies

Postharvest uses of pesticidal plants in Eastern Zimbabwe:

Laboratory validation of pesticidal plant materials for field trials.

The efficacy of pesticidal plants used by farmers in Nyanga and Muzarabani districts, namely *Bobgunnia madagascariensisa* and *Lippia javanica* was evaluated and compared to the standard botanical *Azadichracta indica* against grain storage insects. Cultures of the major grain storage insects *(Sitophilus zeamais*, *Acanthoscelides obtectus* and *Prostephanus trancatus)* were setup at the Crop Science Department, University Of Zimbabwe. The pesticidal plants were admixed with grain at 0%, 2%, 3.5%, 5%, 7% and 10% w/w. Mortalities under different treatment concentrations were recorded at 7, 14 and 21 days post exposure except for *A. obtectus* whose mortality were recorded up 14 days only.

L. javanica and *B. madagascariensis* were not very effective against *S. zeamais* and *P. truncatus*, although some insecticidal activity against these insects was recorded compared to the untreated control (Figures 5.1 – 5.2). *B. madagascariensis* at 3.5% w/w caused the highest mortality against *S. zeamais* at 21 days exposure than all other plants. The powders of dried leaves of *L. javanica* and *A. indica* and the fruits of *B. madagascariensis* when admixed with beans, insect populations of *A. obtectus* were reduced significantly with mortality of over 90% (Fig 5.3). This indicates that powder from leaves and fruits of *L. javanica* and *B. madagascariensis* respectively can be used as a stored grain protectant against the insect *A. obtectus* at concentrations between 2% and 10% (w/w) in beans by small-scale farmers though 2%w/w would be the optimum application rate.

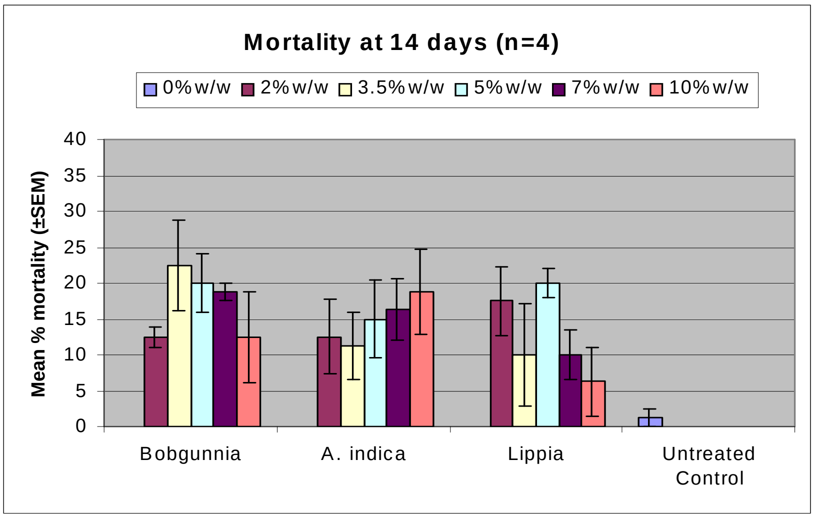


Fig 5.1: Mean % mortality of S. zeamais on maize treated with pesticidal plants at different concentrations

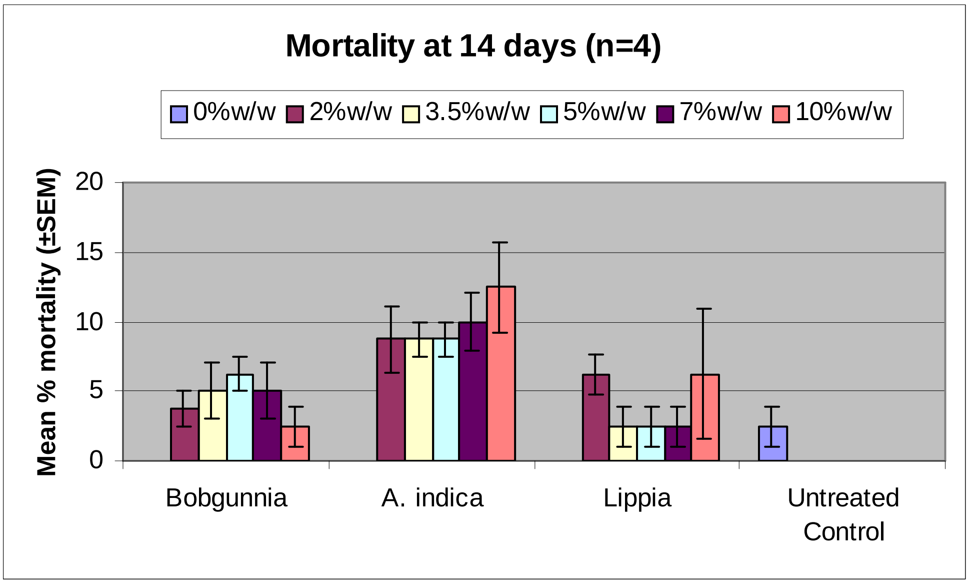


Fig 5.2: Mean cumulative % mortality of P. truncatus in maize grain treated with pesticidal plants at different concentrations.

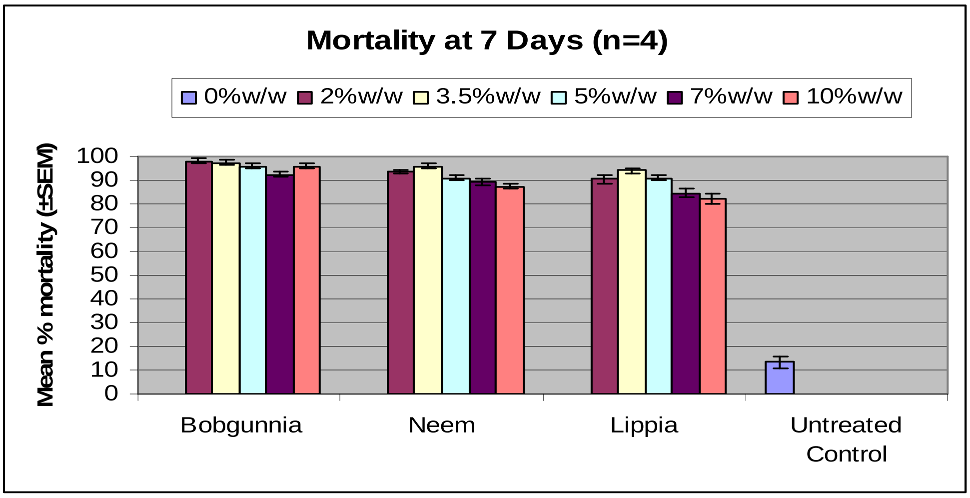


Fig 5.3 Mean % adult mortality of A. obtectus in beans treated with pesticidal plants at different concentrations after 7 days.

From the same experiments it was observed that *L. javanica* and *B. madagascariensis* did have a significant impact on F1 adult emergence of *A. obtectus* from beans and while the plants were effective at reducing F1 emergence of *P. truncatus* and *S. zeamais* the effective was less profound than from *A. obtectus*. Bruchids are notoriously susceptible to some plant materials and strategies to target this pest using plant instead of pesticides would have considerable impact. The same results could not be obtained against maize insect storage insects (Figs 5.4-5.6).

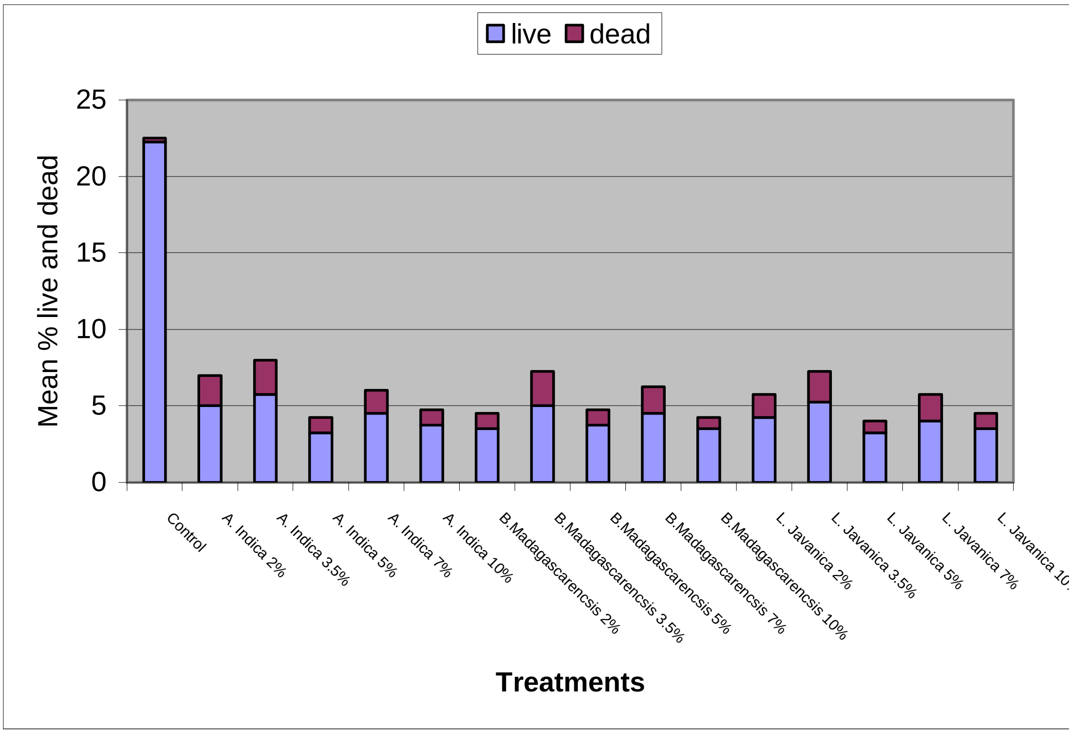


Fig 5.4: Effect of pesticidal plants in maize grain on S.zeamais F1 emergence (n=4)

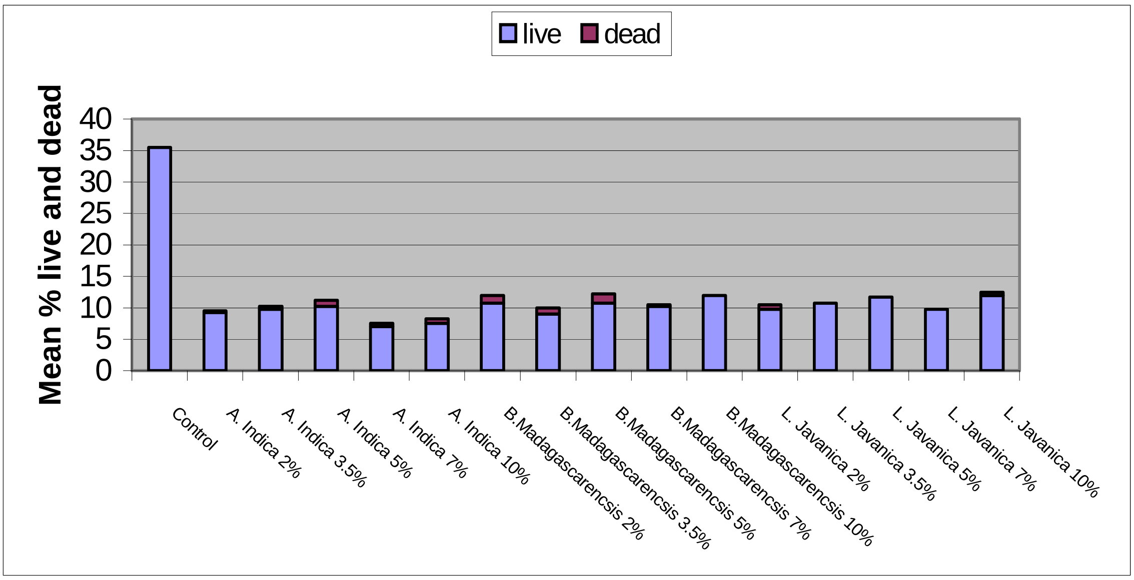


Fig 5.5: Effect of pesticidal plants in with maize on P. truncatus *F1 emergence (n=4)*

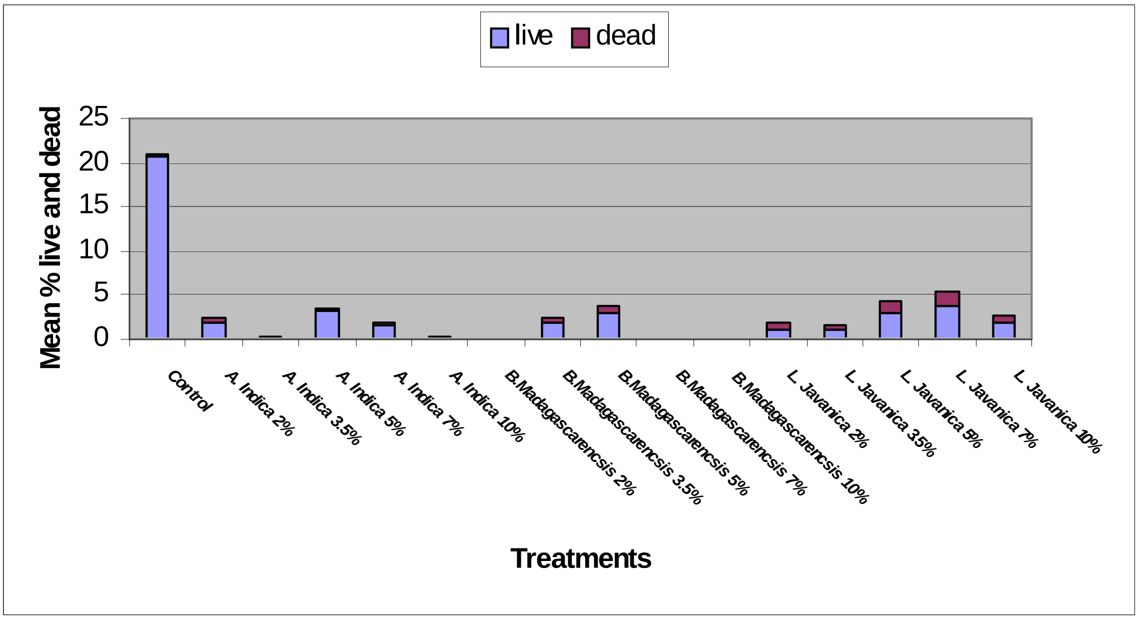


Fig 5.6: Effect of admixing pesticidal plants with dried beans on A. obtectus *F1 emergence (n=4)*

Evaluation of effect of storing plant materials on their subsequent efficacy.

An experiment was conducted determine the effect of storing pesticidal plants under ambient conditions on subsequent efficacy and shelf life. The same pesticidal plants used by farmers in Nyanga and Muzarabani districts, *Bobgunnia madagascariensis* and *Lippia javanica,* were compared to standard botanical *Azadichracta indica* against grain storage insects. The plant powders were admixed with grain at concentrations of 0%, 3.5%, 5%, and 7% w/w. The pesticidal plants were stored under ambient conditions and applied to fresh grain after every 3 weeks for 9 weeks. At each application, fresh insects were introduced and mortalities were recorded at weekly intervals.

The results showed that using stored plants under ambient conditions does reduce efficacy, as the potency of the pesticidal plants declined over the 9-week test period both in maize and beans although this effect was not dramatic. Shelf life of the pesticidal plants at 3% w/w was 3 weeks but increased to almost 6 weeks when at 7% w/w concentration (Figs 5.7 and 5.8). Against *A. obtectus*, the plant material was still effective even after the 9 week storage period of the plant material indicating the high susceptibility of the insect.

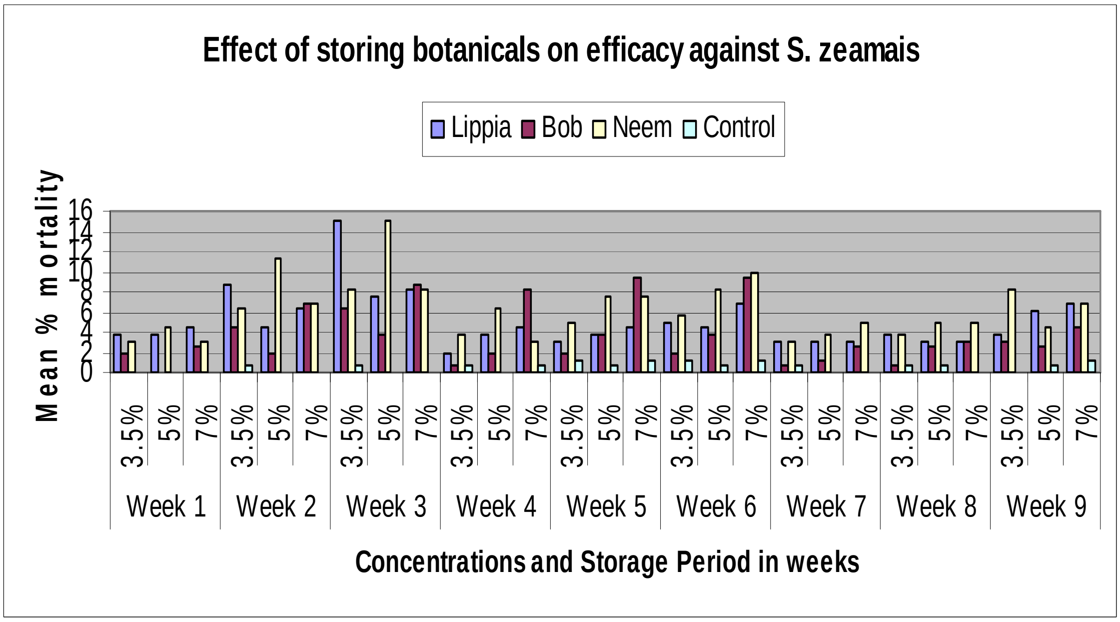


Fig 5.7: A comparison of efficacy of pesticidal plants stored under ambient conditions for 9 weeks against S. zeamais

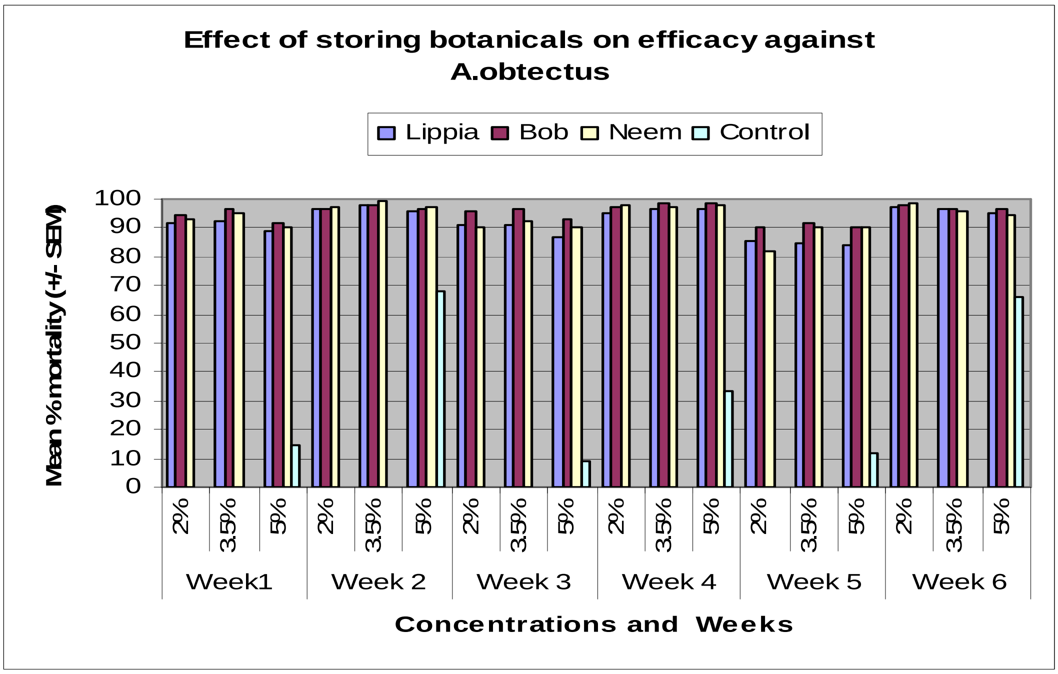


Fig 5.8: A comparison of efficacy of pesticidal plants stored under ambient conditions for 6 weeks against A. obtectus in dried beans

On-station experiments

An experiment was set up at the Institute of Agricultural Engineering (IAE) (Ministry of Agricultural Engineering, Mechanisation and Irrigation) at the Hactliffe Farm in Harare, Zimbabwe using bagged maize and beans (20kg and 10kg per treatment respectively) to determine efficacy and persistence of pesticidal plants against storage pests under typical on-farm storage conditions. The plants tested included *Bobgunnia madagascariensis* mature fruits, *Lippia javanica* leaves, *Aloe* spp. compared to a standard botanical *Azadirachta indica* (leaves) and these were applied at concentrations of 2% and 5% w/w in powder form except for *Aloe* spp which was

applied as ashes according to farmer practice. Aloe plant material was inadequate was therefore applied on beans only and at a concentration of 2%w/w. A commercial synthetic pesticide and untreated control were also included for comparison.

The plant materials did have some effect but not sufficient to suppress grain damage and insect multiplication as much as Actellic Super dust. Among the plants tested, *B. madagascariensis* 2% w/w showed the greatest pesticidal potential for up to 16 weeks and it was able to suppress grain damage and insect multiplication than Neem. There was no significant difference between Neem and *B. madagascariensis* at all treatment levels (P >0.05) for grain damage. Overall, only Actellic Super dust differed significantly from all other treatments for grain damage and total live insects. In beans all the plant materials were able to suppress grain damage to below 4%, and overall Aloe was the most effective and there was no significant difference between Aloe and ASD for grain damage and insect multiplication for up to 16 weeks (Fig 5.9).

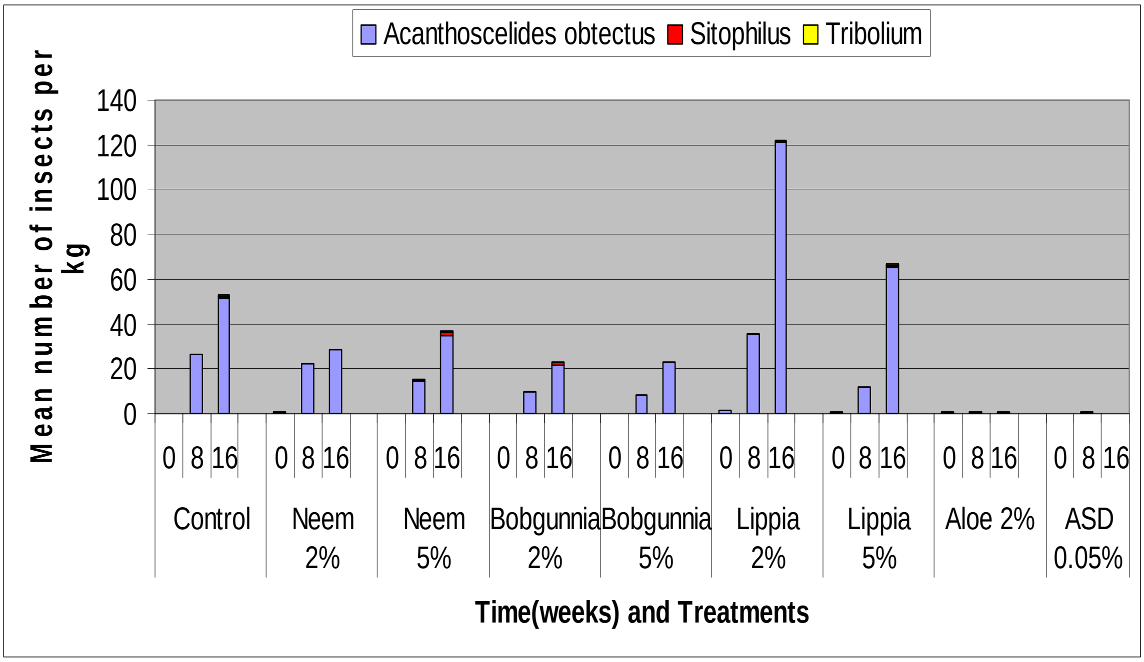


Fig 5.9: Mean number of insects (live and dead) per kg of beans treated with pesticidal plants during the 16-week storage period (n=4)

Field experiments:
Field experiments were set-up in Nyanga and Muzarabani districts of Zimbabwe using *B. madagascariensis*, *Dichrostachys cinerea*, *Bauhunia thoningii*, *Lippia javanica* and *Aloe* spp. previously identified by the farming community. The plant materials were applied at 2% w/w on threshed maize and beans or cowpeas as fruit or leaf powder, except for *Aloe* spp. which was used as an ash. Actellic Super dust (at label rate) and neem, *Azadirachta indica* (at 2%w/w) were used as positive controls while untreated grain served as negative control. Grain was sampled from each treatment at the beginning of the experiment and at 8-week intervals subsequently, and analysed in the laboratory for insect numbers and species, and grain damage. The experiments were conducted from September 2007 to March 2008 with participation of SAFIRE, UZ and the respective farming communities.

Results showed that the plant materials did have some effect but not sufficient to suppress grain damage and insect multiplication as much as Actellic Super dust or neem. Among the plants tested, *B. madagascariensis* showed the greatest pesticidal potential for up to 16 weeks. Overall, only Actellic Super dust differed significantly from all other treatments for grain damage and total live insects. Grain damage and insect numbers were already high at start of experiment (14% & 80-120 insects/kg respectively) and this could have contributed to the apparent lack of effectiveness (Figs. 5.10-5.13)

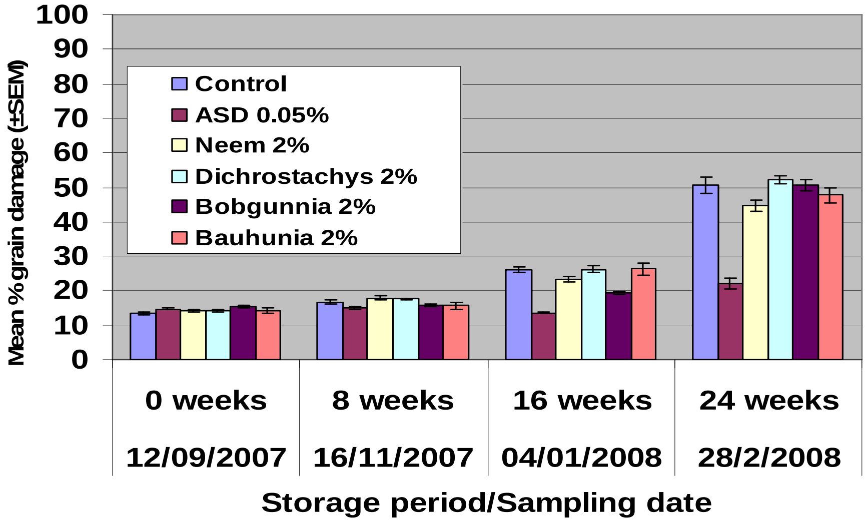


Fig. 5.10: Grain damage in Muzarabani district, 2007/08 storage season

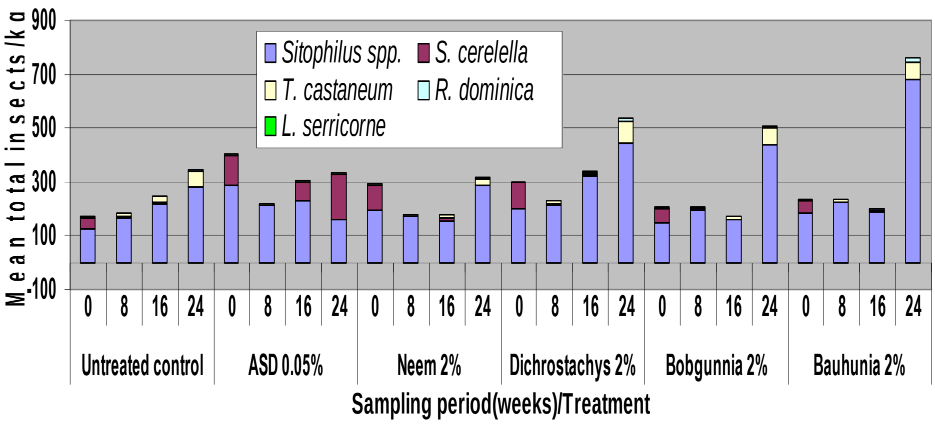


Fig. 5.11: Total (live+dead) insect population per kg of stored maize in Muzarabani district, 2007/08 storage season

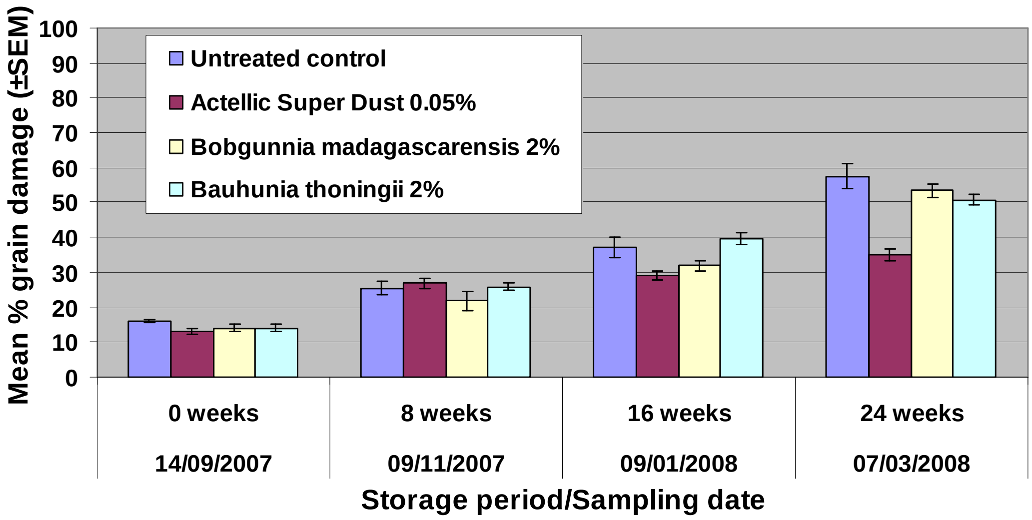


Fig. 5.12: Grain damage in Nyanga district, 2007/08 storage season

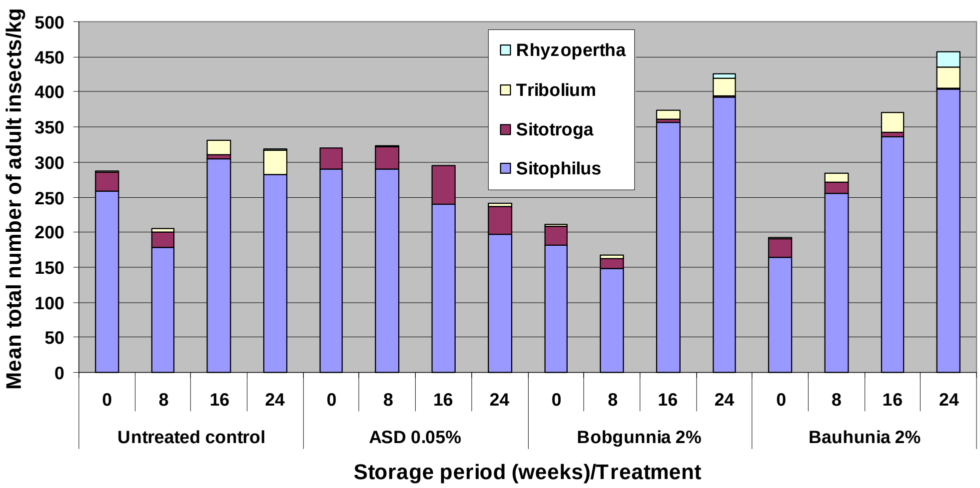


Fig. 5.13: Total (live+dead) insect population per kg of stored maize in Nyanga district, 2007/08 storage season

Based on the results, it was recommended to repeat experiments with focus on fewer pesticidal plants and include a higher concentration of 5% w/w. In addition there is need to *optimise* performance of the plants by using grain with low damage, improving treatment timing, using freshly prepared plants, and using adequately dry plants. Further studies are required to explore dose-response modelling and to identify the active ingredients so as to optimise the use of pesticidal plants.

Vegetable pest control - Plot experiments

The objective for conducting plot experiments was to determine pesticidal plant efficacy for the selected treatment application rates. *L. javanica* was dried, processed and stored as powder formulation, while S*olanum delagoense* was used as in lab and pot experiments. The experiments were undertaken in Crop Science department's field plots in August to December 2008 using *L. javanica* and *S. delagoense* applied at 12.5%, and 25% (w/v) respectively and compared to neem at the same rate as *L. javanica* and commercial synthetic pesticides. All subsequent procedures were the same as for pot experiments except that aphids were not artificially inoculated but rather natural infestation occurred. The results are presented in Figs. 5.14 and 5.15.

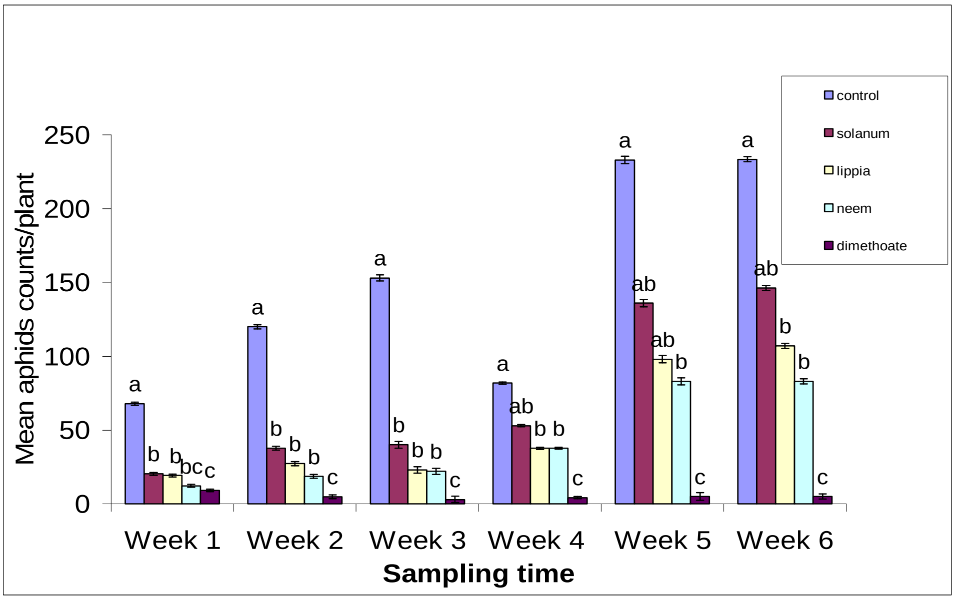


Fig. 5.14: Effects of different treatments on weekly mean aphid population recorded 24 hrs after spraying

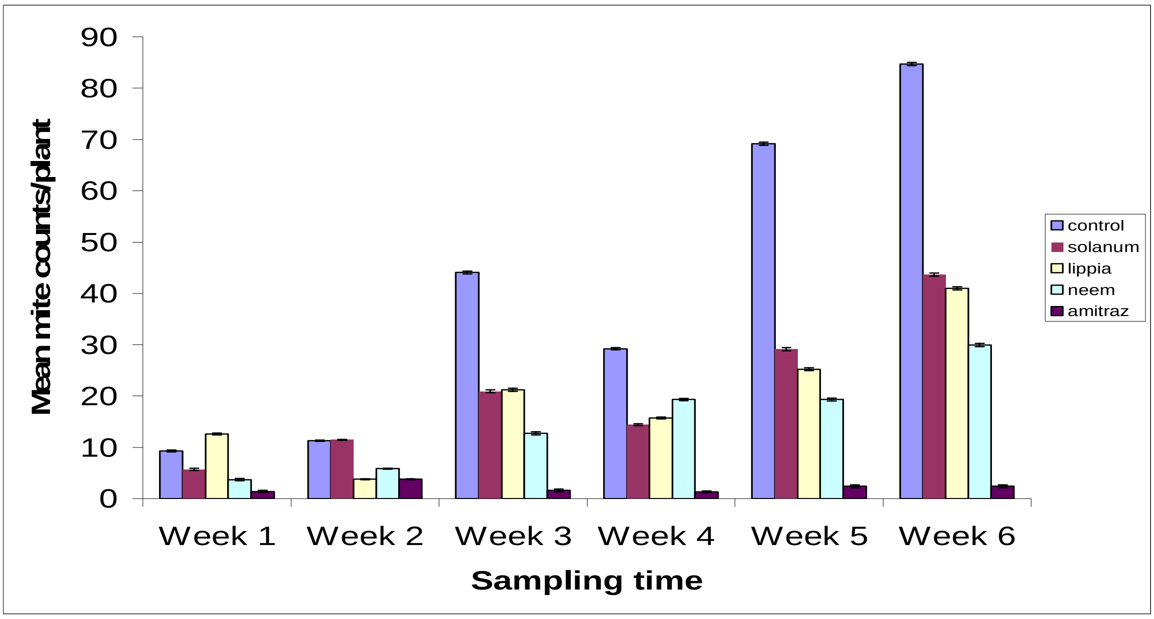


Fig. 5.15: Effects of different treatments on weekly mean red spider mite population recorded 24 hrs after spraying

L. javanica and *S. delagoense* extracts applied at *12.5%* and *25% (v/v)* respectively, have the potential to suppress aphids and red spider mite populations.

L. javanica was used in powder formulation in the plot experiments to address seasonal unavailability of the fresh leaf material during the dry winter period. *L. javanica* and *S. delagoense* aqueous extracts have the potential to suppress aphids and red spider mite populations. Based on these results, the application rates of *Lippia* at 12.5% and *Solanum* at 25% (v/v) are recommended.

Field experiment
The objective of this experiment was to determine the pesticidal efficacy of *Lippia javanica* extracts against aphids and red spider mites..

The *L. javanica* and Neem plant material used was dried, processed and stored as powder formulation. The experiments were undertaken in Nyanga in three different fields in October to December 2009 using *L. javanica* applied at 12.5% (w/v) and compared to *Neem* at the same rate as *L. javanica* and commercial synthetic pesticides. The pests were allowed to fully establish through naturally infestation within the crop for two weeks before spraying started. Sampling was done once a week 24hrs after treatment application. The aphids were counted in situ while the mites were censured with the aid of a microscope in the laboratory. The preliminary results suggest that *L. javanica* extracts applied at 12.5% has the potential to suppress aphid populations as compared to Neem extracts as the two had similar efficacy (Fig. 5.16).

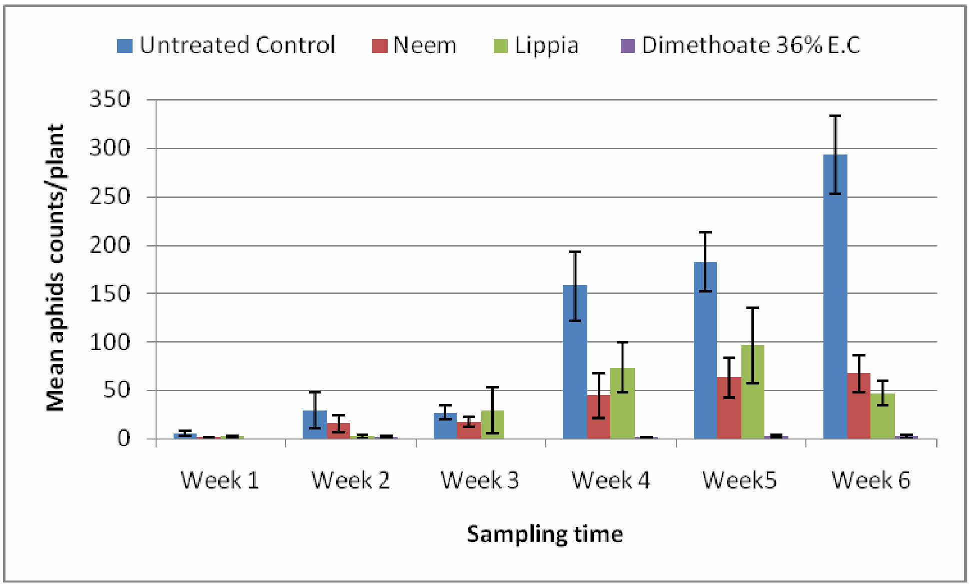


Fig. 5.16: Effects of different treatments on weekly mean aphid population/plant recorded 24 hrs after spraying at one of the sites in Nyanga

Efficacy of Strychnos spinosa *(Lam.) and* Solanum panduriforme *(Incanum) Fruit-extracts in the Control of Ticks on Cattle in Zimbabwe*

The efficacy of *Strychnos spinosa* and *Solanum panduriforme* fruit-extracts in controlling cattle ticks was evaluated at Henderson Research Station in Mazowe district, from mid November to end of December 2007, in collaboration with Faculty of Veterinary Science at

University of Zimbabwe. This work has been written up and will be submitted imminently to a *South African Journal of Animal Science*. A full text of the paper is attached in the appendix. Ripe *S. panduriforme* and mature but unripe *S. spinosa* fruits were each homogenized and mixed with cold water to achieve concentrations of 5%, 10% and 20% (w/v) and kept for 48 h. The treatments included the three concentrations of each plant species, Tickbuster (amitraz) spray (positive control) and no treatment (negative control). All the treatments were applied as surface sprays (using knapsack sprayer) on 32 Mashona cattle at weekly intervals. Animals were held in a cattle crush and ticks on individual cattle were identified, counted and recorded daily with the help of six trained station workers. Animals in different treatment groups were kept in separate paddocks to avoid the rub-on effect. Peripheral blood samples were collected by a qualified veterinarian for parasite screening.

Table 5.1 Least squares means (± SEM) of total tick counts (pooled data) for a post-acaricide treatment period of 7 d. (n = 4)

Treatments	**Mean (± SE) Daily Tick counts (Day 1 to 7)**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Treated control (Amitraz)	3.8^{c}	2.6^{c}	2.6^{d}	3.6^{d}	1.1^{c}	1.6^{c}	2.0^{c}
Untreated control	61.0^{a}	63.2^{a}	55.8^{a}	53.2^{a}		62.3^{a}	59.9^{a}
5 % *S. panduriforme* (w/v)	29.0^{cb}	28.8^{cb}	26.0^{c}	27.0^{c}	27.0^{b}	28.5^{cb}	32.3^{ab}
10 % *S. panduriforme* (w/v)	47.5^{ab}	45.0^{ab}	49.5^{ab}	50.3^{ab}	46.1^{ab}	50.4^{ab}	47.9^{ab}
20 % *S. panduriforme* (w/v)	35.3^{ab}	35.0^{ab}	30.5^{cb}	33.5^{cb}	33.9^{ab}	31.9^{b}	32.3^{ab}
5 % *S. spinosa* (w/v)	24.4^{cb}	27.3^{cb}	24.3^{cd}	25.0^{c}	23.6^{bc}	22.8^{bc}	22.6^{bc}
10 % *S. spinosa* (w/v)	36.5^{ab}	38.1^{ab}	38.8^{abc}	39.3^{abc}	37.7^{ab}	37.4^{ab}	39.5^{ab}
20 % *S. spinosa* (w/v)	37.6^{ab}	38.0^{ab}	38.2^{abc}	38.8^{abc}	43.0^{ab}	38.8^{ab}	37.5^{ab}

Within a column, LS means with different superscript letters differ ($P < 0.05$)

The 5% *S. panduriforme* treatment was more effective ($P < 0.05$) than the other fruit-extract concentrations of the same plant species against all ticks (Table 4). The 5% treatment of *S. spinosa* fruit-extract was more effective ($P < 0.05$) against all ticks although there was a gradual increase in *Rhipicephalus appendiculatus* and *Rhipicephalus evertsi evertsi* counts after the third week (Fig 5.17). The treatments were ranked, in descending order of efficiacy, as Tickbuster, 5% *S. panduriforme*, 5% *S. spinosa*, and the other treatments that were of equal rank. No haemoparasites were detected implying that animals did not suffer from clinical tick-borne diseases. Overall, the results indicate that *S. panduriforme* and *S. spinosa* individually have some acaricidal effect on ticks on cattle**.**

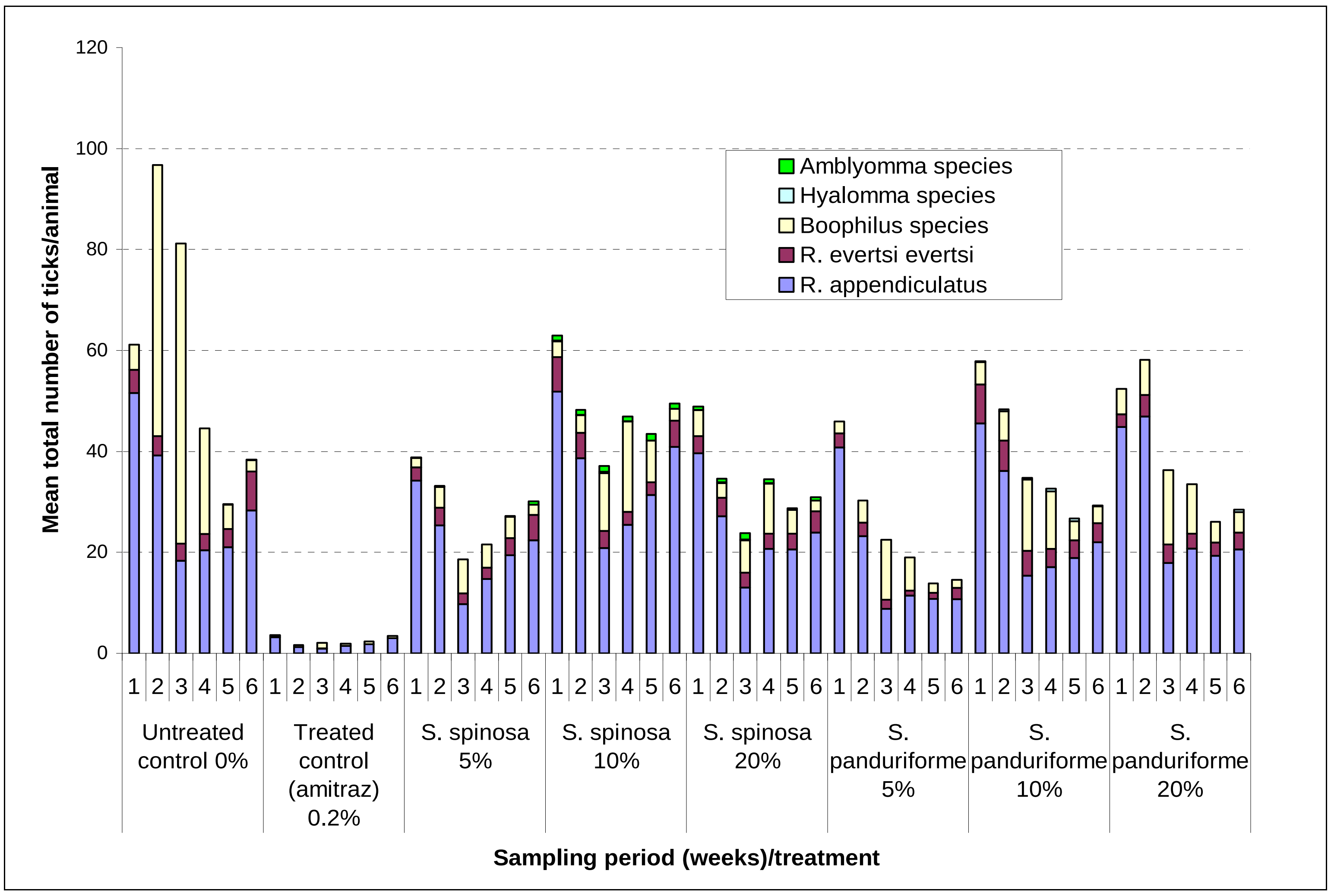


Fig. 5.17 Comparison among treatments of different tick species and total tick counts for 6 weeks (November – December 2007) after weekly application of the treatments (n = 4)

Using a similar methodology, another experiment was conducted in April to May 2008 using *Lippia javanica* leaf water extract on 20 Mashona steers.

Lippia javanica leaf-extracts at 10% and 20 w/v were as effective at controlling cattle ticks as an amitraz-based acaricide Tickbuster® and even at a concentration of 5% the *L. javanica* leaf-extracts were effective compared to the control although the differences were not all significant (Table 5.2). These results indicate that at sufficient concentrations *L. javanica* is an effective alternative control for cattle ticks and may provide farmers in remote parts of southern Africa with an effective tick control option. Peripheral blood samples were collected weekly for parasite screening. The untreated control had higher least square mean tick count than all the other treatments but no haemoparasites were detected implying that animals did not suffer from clinical tick-borne diseases. Overall, the results indicate that *L. javanica* leaf-extracts are acaricidal (Fig 5.18).

Table 5.2 Least squares means (± SEM) of total tick counts (pooled data) for a post-acaricide treatment of 7 days (n = 4)

Treatment	**Mean daily tick counts (Day 1 to Day 7)**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Tickbuster (amitraz)	11.7^{c}	1.9^{b}	0.3^{b}	0.1^{c}	0.4^{b}	0.6^{b}	1.4^{b}
Negative control	167.3^{a}	100.0^{a}	133.1^{a}	142.3^{a}	143.0^{a}	105.6^{a}	103.3^{a}
5% *L. javanica* (w/v)	97.9^{b}	73.7^{a}	85.5^{a}	59.9^{b}	58.6^{b}	69.7^{a}	80.9^{a}
10% *L. javanica* (w/v)	28.8^{c}	19.0^{b}	17.6^{b}	15.7^{cb}	14.7^{b}	15.6^{b}	13.2^{b}
20% *L. javanica* (w/v)	28.5^{c}	23.4^{b}	22.4^{b}	25.8^{cb}	27.5^{b}	31.6^{b}	18.2^{b}
± SEM	15.36	8.51	13.74	14.03	17.28	9.70	10.56

Within a column, LS means with a common superscript letter are not different ($P > 0.05$)

The SAPP project, correspondence to Dr Phil Stevenson, Email: p.c.stevenson@gre.ac.uk

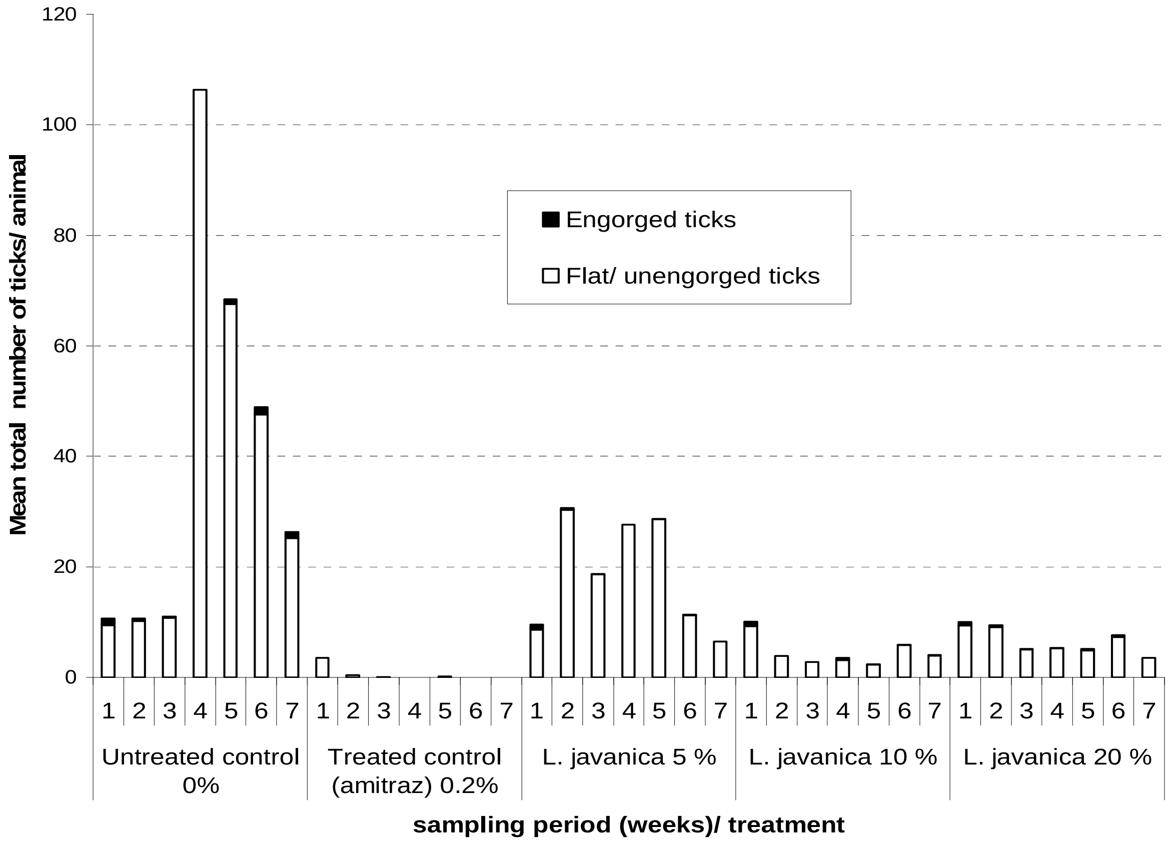


Fig. 5.18 Comparison of engorged, flat and total weekly tick counts on cattle over 7 weeks (April-May 2008) after weekly application of the L. javanica leaf extracts & Amitraz treatments (n = 4).

On-farm efficacy of Lippia javanica (Burm F.) leaf extracts on cattle ticks

On-farm experiments were carried out in Nyanga and Muzarabani districts between February and March 2009 where the 10% w/v leaf aqueous extract of *L. javanica* were tested against a commercial acaricide and normal farmers' practice (monthly dipping) on ticks. Animals under *Lippia* treatment had mean total tick counts of 24 and 95 /animal for Nyanga and Muzabani respectively. The animals were considered infested according to Government of Zimbabwe standards (Department of Veterinary Services) which recommends <10 ticks/ animal. Amitraz had 3 and 5 ticks/animal for Nyanga and Muzarabani respectively which means the commercial product is still effective. Nyanga had lower tick counts than Muzarabani for farmer practice from week 2 to 7 of experiment. This is because they have a history of lower tick challenges at the site because of its topographical location and use more frequent use of commercial acaricides. There was evidence of *L. javanica* acaricidal activity under these on-farm conditions but comparative advantage was not clear due to absence of a well-monitored negative control (Fig 24-25). Under on-farm conditions including an untreated control would be unacceptable since we were using the farmers' cattle for the experiments.

This was a very interactive trial with the farmers in the same treatment groups working together preparing and treating the animals. A total of 27 farmers attended the feedback meeting to mark the end of the experiment in Muzarabani while 35 attended in Nyanga. At these meetings, experiences from the different groups were shared while the research team also shared the scientific results. The participants in the *Lippia javanica* group, while appreciating the trial, cited the tedious work involved in harvesting and preparing the plant material, which competed for labour especially during the peak demand period for tobacco, a cash crop. This was especially the case in Muzarabani. It also emerged from the discussions that the animals under *L. javanica* had a shiny coat colour compared to untreated animals.

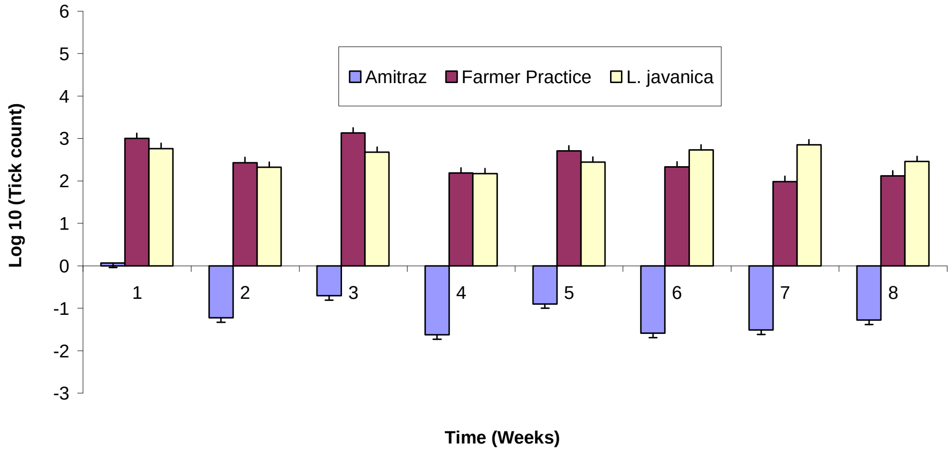


Figure 5.19: Effect of *Lippia javanica* on tick challenge in Muzarabani

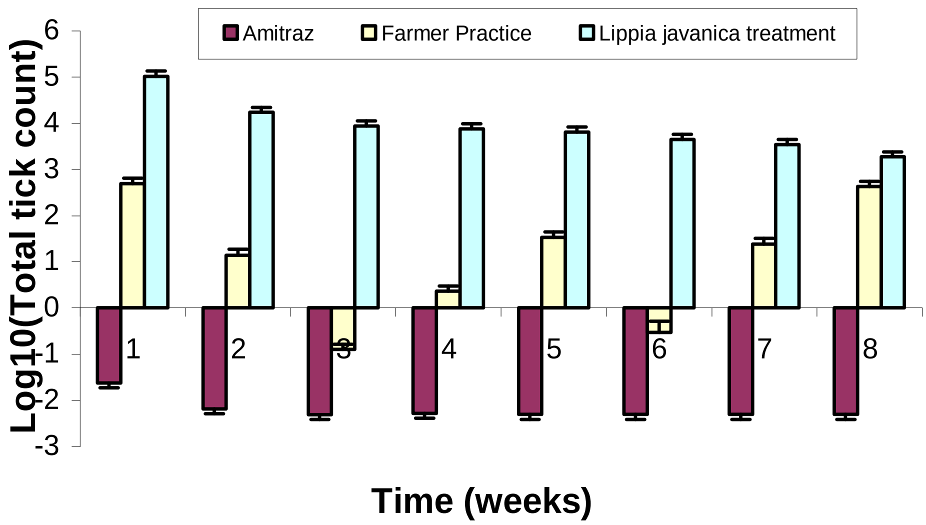


Figure 5.20: Effect of *Lippia javanica* tick challenge in Nyanga

Laboratory bioassays,

To get a deeper understanding of the effect of pesticidal plants on cattle ticks, further laboratory experiments were conducted with *S. spinosa*, *L. javanica* and *S. panduriforme* using an adaptation of the Soberane's technique. Three different concentrations of 5 %, 10 % and 25 % were incubated with tick larvae and mortalities for each treatment level recorded after 24 and 48 h. The results showed pesticidal activity of the extracts with the 5% inclusion level optimal and will prevent over-harvesting (Fig 5.21). Under controlled conditions, a lower concentration was thus required than the on-station optimal inclusion rate of 10%.

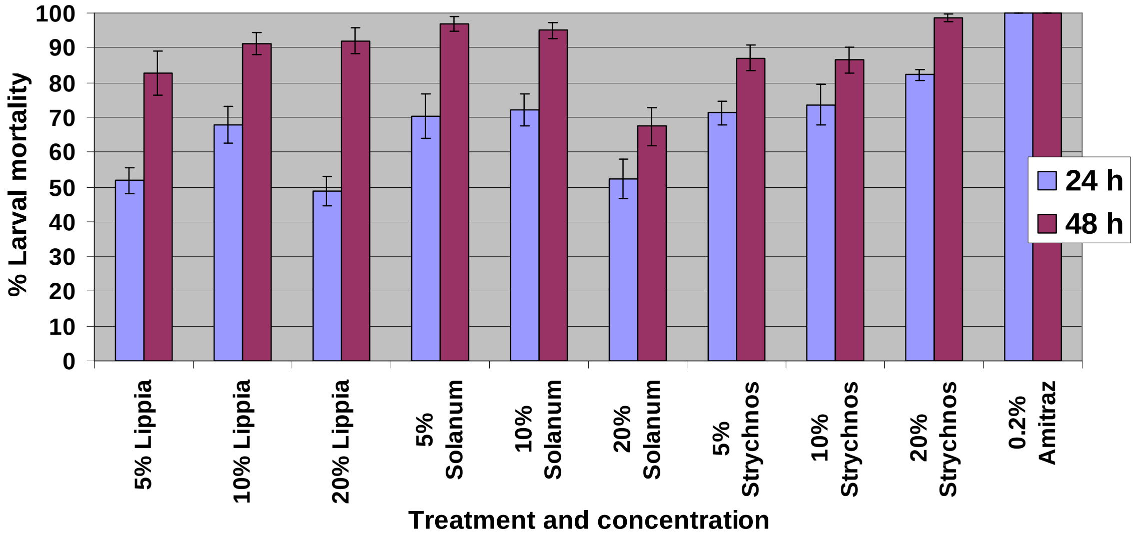


Fig.5.21. Mortality (%) of tick larvae exposed to different treatments for 24h and 48h

Field pest trials on tomato and Brassica rape in Malawi

A PRA tool was developed by Dr Phosiso Sola and used to identify common pesticidal plants used in crop and livestock pest management. We conducted on-farm Field Trials on vegetables (included Rape and Tomato) at Champhira and Nchenachena EPAs.
Dried plants were extracted in 0.1% liquid soap at a concentration of 2% (W/V). Extracts were tested at two sites Jenda and Nchenachena over three seasons (repeated three times= three trial in total for each area). Preliminary results show that pesticidal plants are promising especially in management of aphids on Rape but less effective against red-spider mites in tomatoes. Example field data is shown in Tables 5.3 – 5.5 but the data from the field trials in Malawi are written up in the upgrade report by Stephen Nyirenda who is registered as p[art of the SAPP project as MPhil/PhD student at University of Greenwich (UK). The report is available although too big to include here.

Table 5.3: Effect of pesticidal plants on Tomato yield, plant height and canopy spread at Jenda Nov., 2008 – Feb., 2009

Treatments	Total Yield Kg/ha	Marketable yield kg/ha	% Yield damage	Plant height (cm)	Canopy spread (cm)
T. diversifolia	36289	30883[b]	19.8[bc]	42.50	38.25[a]
A. indica	28617	23469[d]	27.2[ab]	43.0	35.75[ab]
T. vogelli	20414	16477[f]	28.0[ab]	40.50	34.75[ab]
S. panduriforme	24414	20055[e]	26.8[b]	41.50	40.00[a]
V. amygdalina	32742	26352[c]	15.2[bc]	43.50	38.00[a]
Phoskil	38320	36406[a]	5.5[c]	42.75	39.50[a]
Unsprayed	21590	15117[f]	46.8[a]	36.25	31.50[a]
Mean	28912	24117	24.2	41.43	36.82
Sed (±)	6668.7	5793.2	9.50	2.695	1.860
CV %	32.6	34.0	55.6	9.7	7.2
Sign. Level	Ns	*	*	ns	**

Table 5.4: Aphids and Diamondback moth counts in rape at Jenda and Nchenachena

Treatments	Jenda		Nchenachena	
	Aphids	DBM	Aphids	DBM
Tithonia diversifolia	57.3 b	4.67 b	7.75	1.0
Azadirachta indica	51.7 b	3.67 b	9.0	1.0
Tephrosia vogelii	40.3 bc	3.33 b	9.0	1.0
Solanum panduriforme	44.0 bc	4.33 b	6.5	0.75
Vernonia adoensis	53.7 b	4.33 b	7.25	0.75
Phoskil	10.3 c	5.0 ab	2.5	1.0
Unsprayed/CONTROL	103.7 a	6.67 a	9.25	1.0
Mean	51.6	4.57	7.35	0.929
Sed	17.84	0.88	2.48	0.1942
CV (%)	42.4	23.6	48.0	29.6
Significance	**	*	ns	ns

Table 5.5: Mean counts of red spider mites and aphids in tomatoes at Jenda (Champhira)

Treatments	Red spider mite	Aphids
Tithonia diversifolia	31.0 b	6.75 b
Azadirachta indica	31.2 b	7.00 b
Tephrosia vogelii	35.8 ab	8.75 ab
Solanum panduriforme	37.0 ab	8.25 ab
Vernonia adoensis	31.5 b	7.00 b
Phoskil	11.8 c	1.5 c
Unsprayed	51.0 a	12.5 a
Mean	32.7	7.39
Sed	6.33	1.649
CV (%)	27.4	31.5
Significance	***	***

Storage pest trials on maize and beans in Malawi

On-farm storage trials were conducted from July 2008 to February 2009 storage season at two sites: Nchenachena extension planning area (EPA) and Champhira EPA in Rumphi and Mzimba districts, respectively. The aim of the trials was explained in advance to the farmers at a pre trial farmer work shop. Selection of farmers to participate in the trials was done with the assistance of agricultural extension workers (AEW) from Mzuzu Agricultural Development Division (MZADD) in the Northern region of Malawi. The criterion was to select one farmer from one section of the EPA (five

sections in each EPA) who had attended frequently the farmer schools and was willing to participate in the trials. Small sacks (25 kg) were used for storing maize grains since most of the farmers in the study areas used sacks for grain storage. As above, the work on storage pests trials in Malawi have been written up as a MpHil/PhD upgrade report for the University of Greenwich by John Kamanula who is registered for this higher degree. The report is available although too big to include here.

Figure 5.22 shows percent damage for maize grain after 5 months of storage at Nchenachena and Champhira EPAs. Neem seed kernel reduced damage from 66.0 to 14.6 % at Champhira and 36.2 to 4.6 % (Nchenachena), representing a decrease in damage of 78 % and 87 %, respectively. Actellic super dust was superior to neem seed kernel. It produced a decrease in damage of 99 % at each site. Bean results will be presented at this year's mid-year meeting.

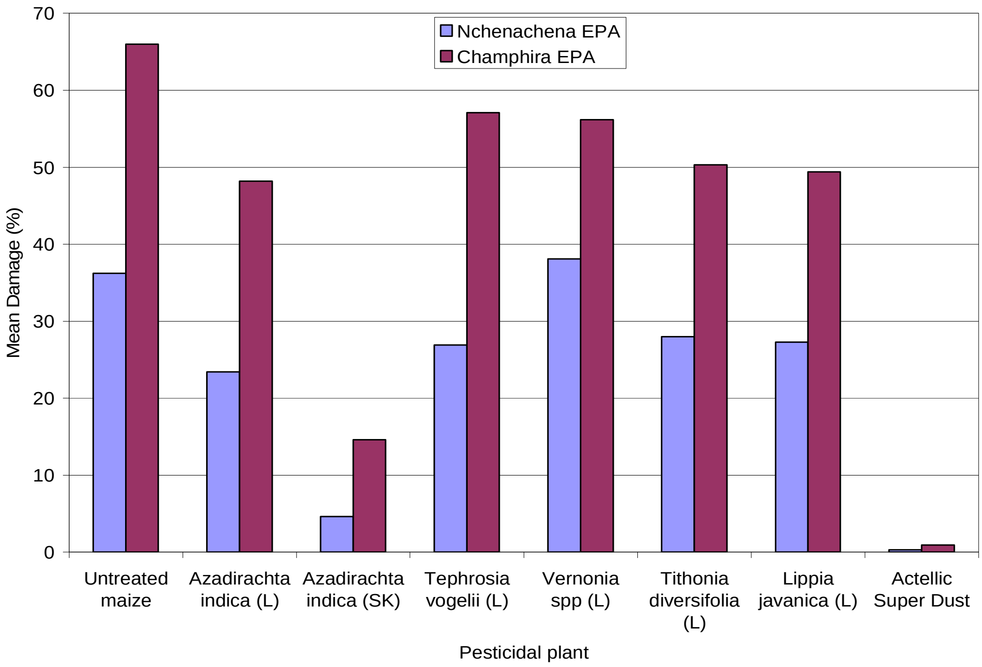


Figure 5.22: Percent damage for maize grain treated with dry powdered plant material (2 %, w/w) and Actellic Super Dust (0.05 %) after 5 months of storage at Nchenachena and Champhira EPAs

In 2009 storage season, *S. longepedunculata* root powder and water extract (2 % each), neem water extract (2 %), ASD (0.05 %) and Actellic super 50 EC were used to treat maize against storage insect pests. The results are shown in Figure 5.23. After 210 days (7 months), the maize damage was reduced from 94 % in the untreated maize to 31 % in *S. longepedunculata* treated maize. Water extracts were not as effective as *S. longepedunculata* Root Bark preparation. As indicated from laboratory trials *S. longepedunculata* shows the greatest promise among Miombo plant species as a material for storage protection of Maize. Since the water extracts were not as effective some effort needs to be invested in optimising this process top see if the application rate was sufficient. The fact that S. longepedunculata was still effective albeit less so than the Actellic dust after 210 days indicates considerable promise for this alternative pesticidal plant.

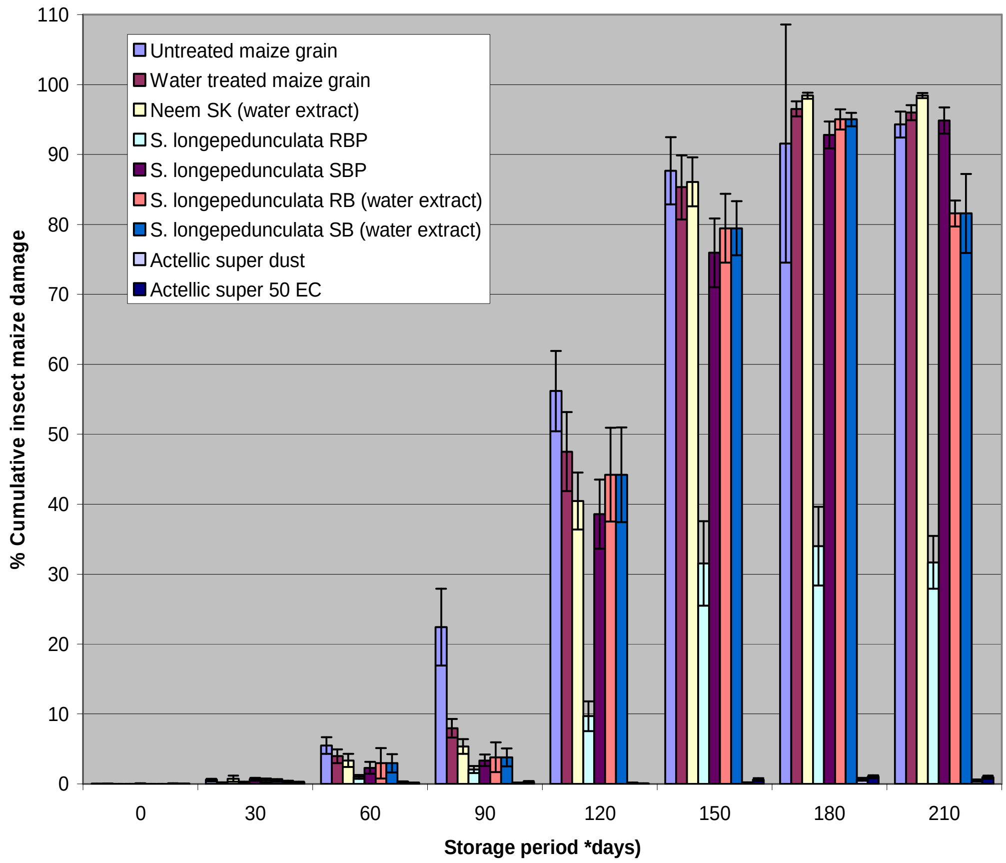


Figure 5.23 Grain damage for untreated maize and maize treated with S. longepedunculata root bark powder and water extract, neem SK water extract, ASD and Actellic 50 EC for a period of 210 days.

Storage pest field trials in Choma, Zambia (SAFIRE)

Species prioritisation

Farmer trials were initiated at community meetings which aimed at introducing the SAPP project objectives, documenting use of pesticidal plants and prioritising species for the trials. The meeting in Nachibanga ward Choma was attended by approximately 100 people. Nachibanga ward was divided into six sections each consisting of at least two villages to facilitate the trials. At the end of the introductory meeting the farmers had prioritised three species for each crop of interest.

<u>Setting up of trials</u>

Storage trials were established in the three districts during the 2007/08, whilst during the 2008/09 season political tensions prevented the set up of trials in Zimbabwe. In Zimbabwe both field and storage trials were undertaken whilst in Zambia only storage trials were established. Collection and processing of the plant material was based on the farmer method. This was mainly mixing of powder with grain. The trial material was brought to a central place where treatment application was conducted using a standard protocol. The trial was conducted with 5 farmer groups. Each farmer group selected a lead farmer to host the trial. The selection criterion used included:

- Farmer experience and ability to communicate
- Farmers who are known in the community to be experienced in the crops targeted and familiar with the technology i.e. pesticidal plants under trial
- Farmers who are known to be experimenters or innovators of technologies
- Farmers who are willing to collaborate and ability to function as a member of a group.

Table 5.6 Pesticidal plants used in the 2007/08 trials were as follows.

Choma	Muzarabani	Nyanga
Supper Actelic chirinda matura dust	Supper Actelic chirinda matura dust	Supper Actelic chirinda matura dust
Securidaca longipendiculata	*Bobgunnia madagascarensis*	*Bobgunnia madagascarensis*
Cassia abbreviata	*Dichrosyschys cineria*	Aloe ash
Cissus quadingularis	*Bauhinia thonningii*	*Bauhinia thonningii*
Bobgunnia madagascarensis	*Lippia javanica*	
	Neem	

Table 5.7 Profile of farmers participating in the storage trials

Village representative	**Village**	**Villages represented**	***Number of farmers***		
			Males	**Females**	*Total*
Choma					
Thomas Mukonka	Sikalundu	Situkali, Haluyasa, Huvumba, Kayongo	17	20	*37*
Davison Masowe	Mulimo	Mutuwabulongo, Simatanga	8	11	*19*
Simon Mudebwe	Halwindi	Chiweza	19	*30*	*39*
Rose Munamuzunga	Mulamfu	Kachele, Hamabonka	20	40	*60*
Mozzy Kaumba	Kaumba	Nachibanga, Chinene, Munkombwe, Chilibamba, Hambala	15	25	*40*
Total			**79**	***126***	***205***
Muzarabani					
Protoctor Makombe		Village 1			
Mrs. Machiridza		Village 2 and 3			
Anywhere Muchenje		Village 4			
Mr. Mavhunga		Village 5			
Total			**383**	***388***	***771***
Nyanga					
Rosina Tsvamuno	Kambudzi	Kambudzi	*5*	*20*	*25*
Constance Mandipaza	Nyamande	Nyamande	*6*	17	*23*
Maria Dzambacheka	Sakarombe	Sakarombe	2	28	*30*
Raxson Munembe	Munembe	Munembe	12	8	*20*
Catherine Sanyatwe	Sanyatwe	Sanyatwe	7	21	*29*
Anna Pfunguro	Munembe	Mandidewa, Dzimano, Mukurakudya and Mususa	2	20	*22*
Total			***34***	***113***	***147***
Total			***496***	***627***	***1,123***


i)


ii)

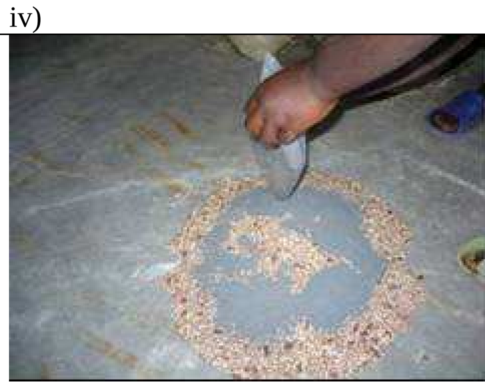

iii)


iv)


v)


vi)


Vii)


viii)


ix)


x)

Establishment of storage trials in Choma, Muzarabani and Nyanga, i) preparation of experimental material by the Zambia team with community members is Nachibanga ward, ii) weighing of samples as per protocol by Vincent Ziba in Zambia, iii) weighed patricidal material packed for use, iv) mixing of the grain before sampling, Dr. Mvumi demonstrating process in Muzarabani, v) weighing of maize into 20 kg samples in Choma, vi) weighing of beans into 5 kg samples by the Nyanga team and community members of Guramatunhu ward, vii) application of *Cassia abbreviata* on maize in Choma, viii) application of aloe ash to beans in Nyanga, ix) mixing of maize with pesticide in Nyanga and x) packing and labelling of samples in Choma

Farmer assessments

Monitoring of the effectiveness of the pesticidal plants was undertaken at two levels. The first level was the farmer participatory monitoring system. Each farmer group was trained in recording observations in a book using a standard format monitoring presence of infestation, types of pests and degree of attack (scale 1 to 10). These records were reviewed and summarised on a monthly basis by staff and community members. Consequently several community meetings were held where contact farmers presented monitoring data from the trials as recorded in their monitoring books. These meetings were used to feedback results from the lab and compare performance of trials between (replicates) village clusters (Figure 3). From the farmers' assessment the *Sitophilus zeamais* was the most prevalent pest which was already present at treatment time in some of the areas. From these discussions the community drew up their own ranking of the performance of the pesticidal plants and these comments were incoporated into the design of the 2008/09 trials. At the end of the first trial the Choma farmers concluded that the Super Actelic (the synthetic pesticide) was the most effective followed by *Securidaca longepedunculata* and *Cissus quadrangularis* in maize whilst in cowpeas *Cassia abbreviate* performed better than *Cissus*. The worst treatment in maize was *Cassia* from the farmer's assessment whilst the lab analysis did not show much difference with *Bobgunnia madagascariensis* (Table 8). It was interesting to note that although no LGB was identified in the trial samples it was prevalent in the farmer granaries. By the end of the trials a total of 1125 farmers had been reached.

Community feedback meetings in Choma; (top left) Farmers during plenary sessions, (top right) farmer group discussions prior to presentations and (bottom left) presentation from Sikalundu farmer group

Table: 5.8 Choma community assessment of the performance of pesticidal plants in maize storage

	Sikalundu group	**Mulamfu group**	**Mulimo group**	**Halwindi group**	**Kaumba group**	**UNZA Lab**
Pests 1st Seen	11th Oct 2007	27th Sept 2007	Oct 2007	7th Nov 2007	13th Oct 2007	1st Nov 2007
Which pest	Weevils (musunse)	Weevils (musunse)	Weevils (musunse)	Weevils (musunse)	Weevils (musunse)	Weevils (musunse)
Treatment Most pest	C. abbreviata (Mululwe)	C. abbreviata (Mululwe	control	C. abbreviata (Mululwe	C. abbreviata (Mululwe	Bobgunnia (muyongolo)
Best treatment	**Actelic**	**Actelic**	**Actelic**	**Actelic**	**Actelic**	**Actelic**
Ranking treatments	Actelic Securidaca Cissus Bobgunnia Cassia Control	Actelic Securidaca Cassia Cissus Bobgunnia Control	Actelic Securidaca Cissus Bobgunnia Cassia Control	Actelic Securidaca Cissus Bobgunnia Cassia Control	Actelic Cissus Bobgunnia Cassia Control	Actelic Securidaca Cissus Bobgunnia Cassia Control
Pest granaries	Weevils LGB	Weevils	Weevils LGB Moth	Weevils LGB	Moth LGB	

Laboratory analysis

Samples of maize and beans from storage trials in Choma were collected and analysed with the assistance of students from the University of Zambia. The investigations included identification and counting of pests, number of holes per grain and weight loss due to damage. The 2007/08 trials were concluded in May 2008 in Zambia and prematurely in April 2008 in Zimbabwe amid political tension. The trials in Zimbabwe were undertaken in collaboration with the University of Zimbabwe and more details are in their report. However, indications were that the plant materials did have pesticidal properties, however effectiveness was up to16 weeks, after which there was no significant difference with the control. The most effective were neem and Bogunnia. In Zambia the storage trials ran for 24 weeks and the performance of *Securidaca* and *Cissus* were significantly different from the control and the other plants materials (Figure 5.24). Performance of *Bobgunnia* and *Cassia* were worse than the control for both cowpeas and maize storage. This was attributed to introduction of moisture into the experiment through use of plant material that was not sufficiently dried. (high moisture exacerbates pest infestation).

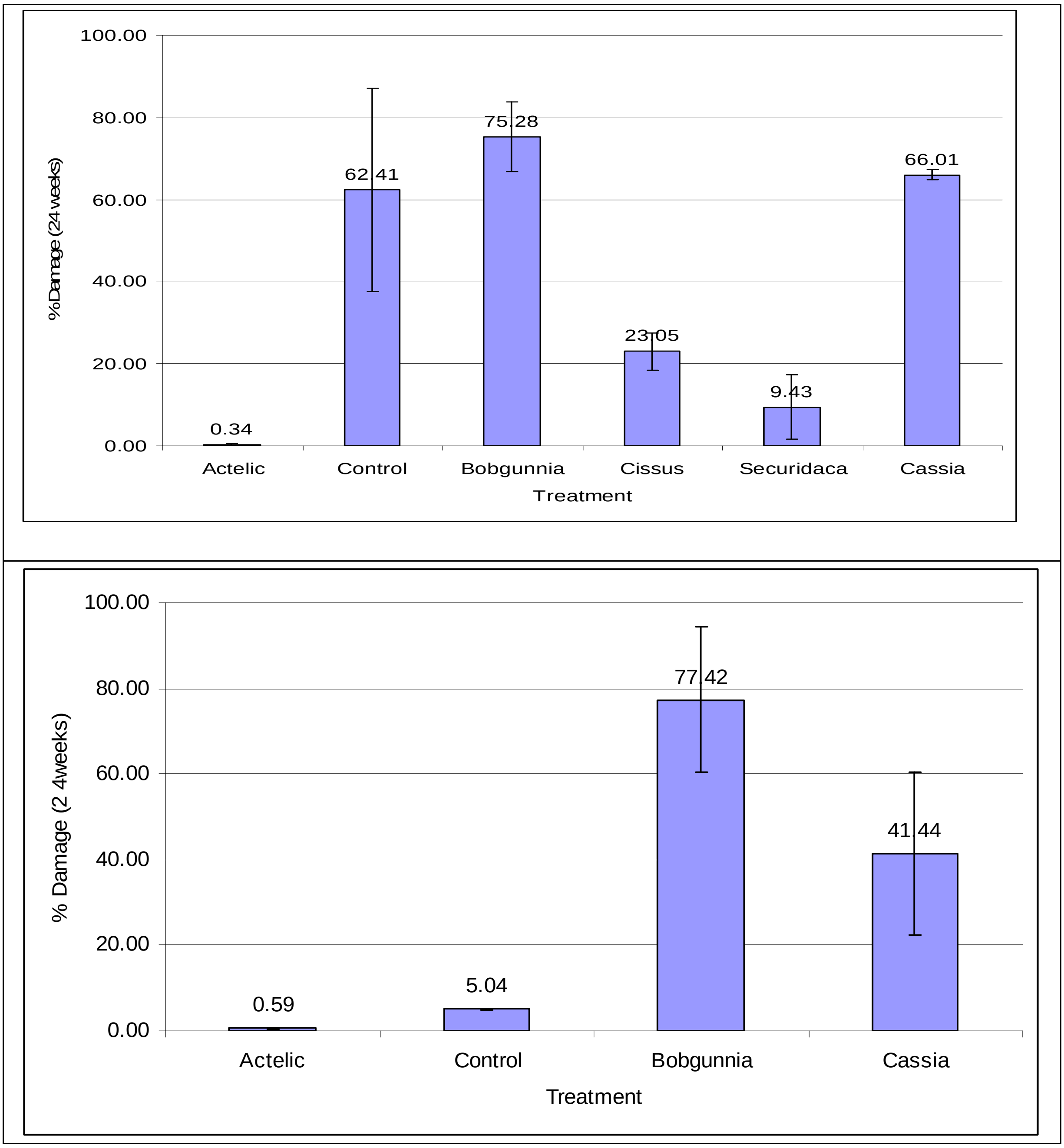


Figure 5.24: Results of the 2007/2008 farmer trials in Choma (top) mean % damage of treated maize, (top) and (bottom) mean % damage of treated cow peas

During the 2008/09 season SAFIRE did not facilitate any trials in Zimbabwe due to political instability. In the 2008/2009 trials an additional concentration was included for each treatment as well as a *Securidaca* water extract. This increased the quantity of plant material required to run the trial, as a result the replicates (number of farmer groups) was reduced from six to three. Preparation and application procedures remained the same but more rigorously testing of moisture content for both the plant material and the grain was undertaken. In both cases moisture content was maintained below 12%.

Trials in Zambia were run for 32 weeks to June 2009. All the plant materials were effective for 16 weeks in maize except for *Bobgunnia* 5%. *Securidaca* treatments (2% and 5%) had less than 10% damage up to 24 weeks after which no treatments were effective. In cowpeas pest control lasted for merely 8 weeks for most treatments after which mean percentage damage was more than 40%.

However, *Cissus* and *Bobgunnia* 2% were effective until week 16 whilst *Bobgunnia* 5% was effective until week 32 (Figure 5).

Work package 6

Activity 6.1. Propagation criteria

During the first Annual meeting partners agreed that propagation criteria be developed for Securidaca (*Securidaca longepedunculata*), Bobgunnia (*Bobgunnia madagascariensis*) and Lippia (*Lippia javanica*). Securidaca is a particularly useful tree for storage protection (see activities under Work package 3 and 5) and like Bobgunnia, while distributed widely throughout Caesalpinioid woodlands is not abundant and any program to promote its use could exact substantial pressure on natural stands of this species. Preliminary results of germination studies on Securidaca showed very low (<20%) germination. Germination rates of intact Securidaca seed were very low (<50% of seeds emerging after 34 days), seeds lose viability rapidly and seedlings grow very slowly. Figure 6.1 a shows a Securidaca seedlings under greenhouse conditions after 4 months. Securidaca is also cited as a problematic species in literature as having poor seed germination and natural regeneration. Bobgunnia on the other hand presents unique problems in future domestication endeavours because plants propagated from seed exhibit a high degree of genetic variability. Its seed has a hard coat. Therefore, seed pre-treatment is required to improve germination and growth in the field. On the other hand *Lippia* germinated very well (>80% germination) without pre-treatment. The literature also shows that it can be grown from seed (and also from cuttings) easily, it grows relatively fast even under difficult circumstances, requiring little maintenance. In addition, it was found abundantly especially along roadsides. Therefore, development of propagation protocols for Lippia was subsequently deemed unnecessary.

Protocols were developed for the propagation of Securidaca and Bobgunnia using micro-propagation techniques and seed pre-treatment. A Zambian MSc student undertook a thesis research entitled "Preliminary studies on micro-propagation of *Securidaca longepedunculata* and *Bobgunnia madagascariensis*". The student was registered in the University of Wales at Bangor under the supervision of Dr Zewge Teklehaimanot and myself. The World Agroforestry Centre (ICRAF) sourced seeds of both Securidaca and Bobgunnia for *in vitro* micro-propagation, and the various *in vitro* tests were carried out between the 17th March and 17th August 2008 in the Plant Tissue Culture laboratory at the Royal Botanic Garden, London. The experiments involved: *in vitro* germination, shoot initiation, multiplication and rooting of shoots.

The study indicated that germination of Securidaca can be significantly increased in vitro techniques that avoid damping-off and other pathogens. Soaking the seeds for 30 minutes in 0.5% sodium dichloroisocyanurate with a drop of Tween20 was sufficient to avoid contamination. Soaking for long periods of time was not necessary.

(a) Four-months old seedling of *Securidaca longepeducnulata*

(b) Seedlings of *Bobgunnia madagascariensis*

(c) *In-vitro* culture of *Securidaca longepeducnulata*

(d) Excised shoot (from c) sprouts multiple shoots and each shoot produces one plant

Fig 6.1 Photos of Securidaca and Bobgunnia in propagation using traditional and micro-propagation techniques. Photos: *P.C. Stevenson (2008)*

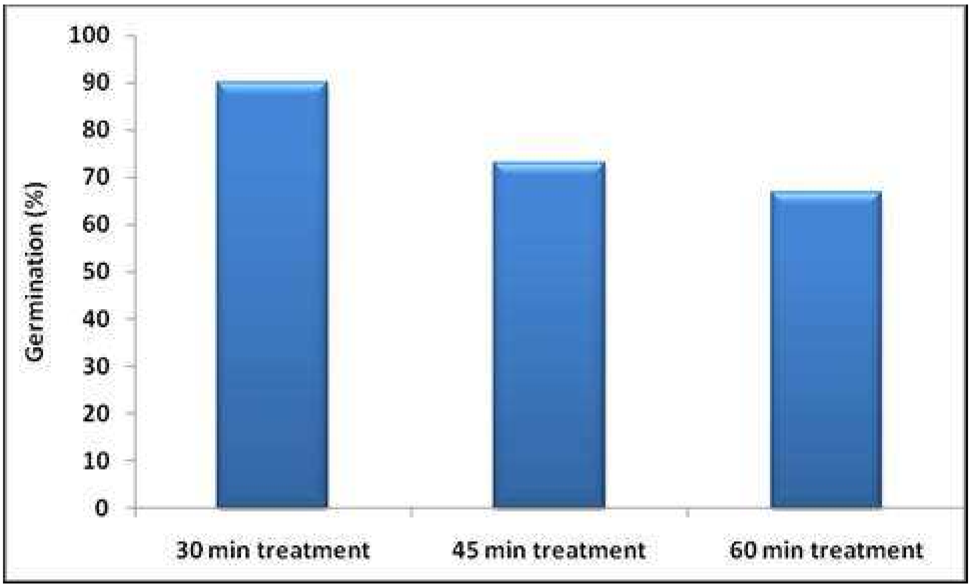


Fig 6.2: Germination (%) of Securidaca after 30, 45 and 60 minute sterilisation. Each replication had 10 seeds in a Petri dish (Zulu, 2008)

Seedlings germinated *in vitro* produced at least 2 re-sprouts as potential explants sources for subsequent sub culturing (Figure 6.2). Observation of *in vitro* germinated seedlings showed seedlings can produce an average of 4 re-sprouts without hormone treatment after cutting of the shoot tip in 7 weeks. However, the number of re-sprouts could be increased with an appropriate hormone.

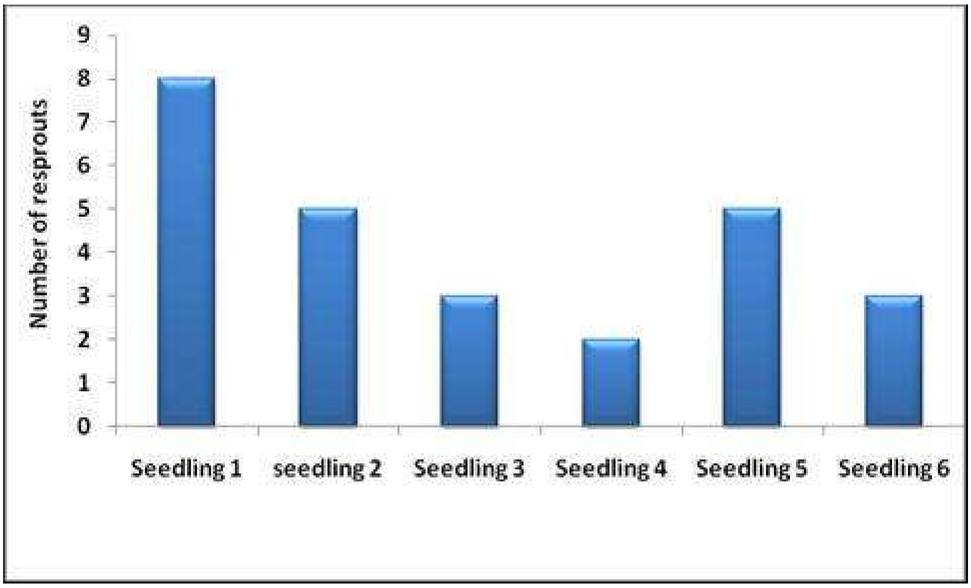


Fig. 6.3: Number of resprouts per seedling of Securidaca (Zulu 2008)

Explant response to shoot multiplication of Securidaca was encouraging with 3 mg/l of 2-isopentanyladenine (2iP), 0.1 mg/l of Thidiazuron (TDZ) on Gamborg's media (B5) and Murashige & Skoog (MS) media. B5 media + TDZ gave the best coppicing. In vitro rooting of Securidaca was achieved with liquid B5 media supplemented with 0.1 mg/l of both IBA and NAA.

Seeds of Bobgunnia pre-treated by nicking and soaking in deionised water with a drop of Tween 20 for 24 hours gave 70 % germination rate on B5 media. Seeds pre-treated by only soaking in deionised water with a drop of Tween 20 for 24 hours gave a poor germination rate of 35 % on B5 media. This same treatment with seeds cultured on MS media also recorded a poor germination of 30

%. This means that better in vitro germination of Bobgunnia could be achieved with nicking the seeds. However, shoot multiplication and root induction experiments were not successful.

Table 6.1: Seeds cultured on Gamborg's B5 and MS media (Zulu 2008)

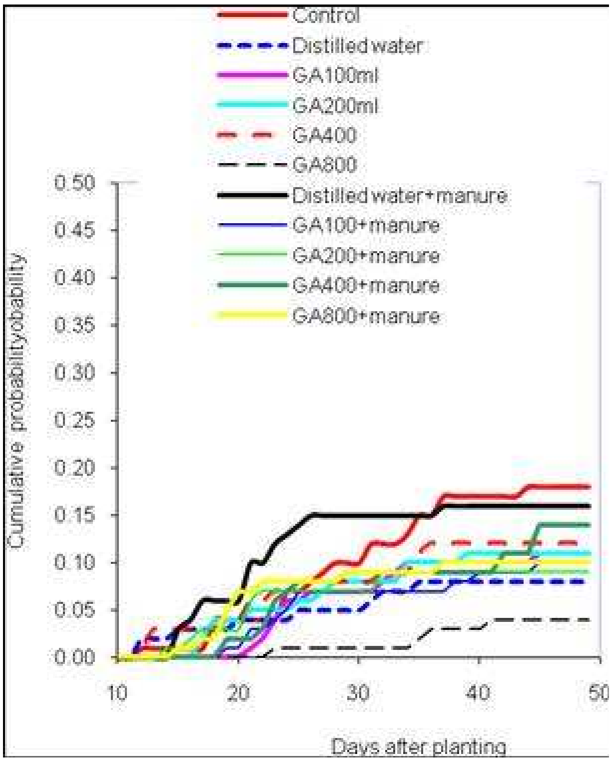
Medium	Seed pre treatment	Germination (%)
Gamborg's B5	Seeds nicked + soaked in Tween 20 for 24 hours	70 %
	Seeds soaked in Tween 20 for 24 hours only	35 %
MS medium	Seeds soaked in Tween 20 for 24 hours only	30 %

A Malawian undergraduate student under Mzuzu University/ICRAF supervision was involved in this study. Thesis research entitled "Effect of pre-treatment methods and potting mixtures on seed germination and early seedling growth of *Bobgunnia (Swartzia) Madagascariensis* (Desv) and *Securidaca Longipedunculata*" was completed. The study was conducted at Chitedze Agricultural Research Station during January–April 2009. Bobgunnia seeds were soaked in water for 12 and 24 hours. Another treatment involved soaking Bobgunnia and Securidaca seeds in different gibberellic acid (GA_3) concentrations (control = 0 mg/l, 100 mg/l, 200 mg/l, 400 mg/l and 800 mg/l] for 24 hours. For each treatment, 200 seeds were immersed in 500 ml flasks with 200 ml of the different solutions. Then the seeds were sown in black polythene tubes filled with two different potting mixtures: (1) without compost manure (Sand + forest soil in 1:1 mixture) and (2) with compost manure (sand + forest soil + compost manure in 1:1:1 mixture). Factorial experiments in a completely randomized design of four replicates of 25 seeds per replicate were used. Results of the studies are briefly described below.

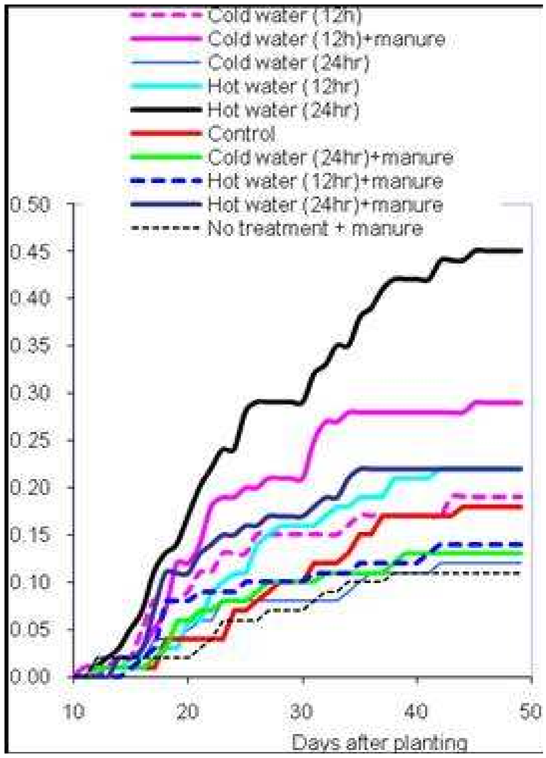
Table 1 shows germination percentages in Bobgunnia seed planted in potting media (with and without compost manure) after soaking in water for 12 and 24 hours. Germination was enhanced by prolonging seed soaking in hot or cold water. Highest germination in both potting mixture was recorded in hot water seed soaking for 24 hours compared with the control treatment. Among the gibberellic acid (GA_3) treatments, the highest cumulative germination was recorded in 400 mg/l GA_3 with compost manure while the lowest was in 800 mg/l GA_3 without compost manure. Germination probability was generally higher when seeds were treated with gibberellic acid than when they are not (Figure 6.4).

Table 6.2: Effect of soaking time (hours) and gibberellic acid (GA_3) concentration (mg/l) and compost manure on germination (%) of seeds of *Bobgunnia madagascariensis* (Blackson 2008)

Treatment	Soaking time (hr) or GA_3 concentration (mg/l)	Without compost manure	With compost manure
Control	No soaking	18	10
Hot water	12 hr	22	14
	24 hr	45	22
Cold water	12 hr	19	30
	24 hr	12	13
GA_3	100	11	10
	200	11	10
	400	12	14
	800	4	10



(b) With gibberellic acid



(b) Without gibberellic acid

Figure 6.4. Probability distribution of germination of Bobgunnia seeds with different treatments (Blackson 2008)

Seed germination in Securidaca significantly differed with gibberelic acid seed treatment. The highest seed germination (42.6%) in media with compost manure was recorded in the control (without gibberelic acid). Seed treatment with 200 mg/l of GA_3 significantly enhanced germination in media without compost manure compared to potting medium with compost manure and 800 mg/l GA_3 (Table 2). Seeds also germinated early and uniformly in these treatments.

Table 6.3. Effect of gibberellic acid (GA_3) concentration on seed germination in Securidaca longipedunculata (Blackson 2008)

GA_3 concentration (mg/l)	Without compost manure	With compost manure
0 (Control)	25.6	42.6
100	27.6	23.7
200	37.1	10.2
400	18.0	13.9
800	13.9	2.7

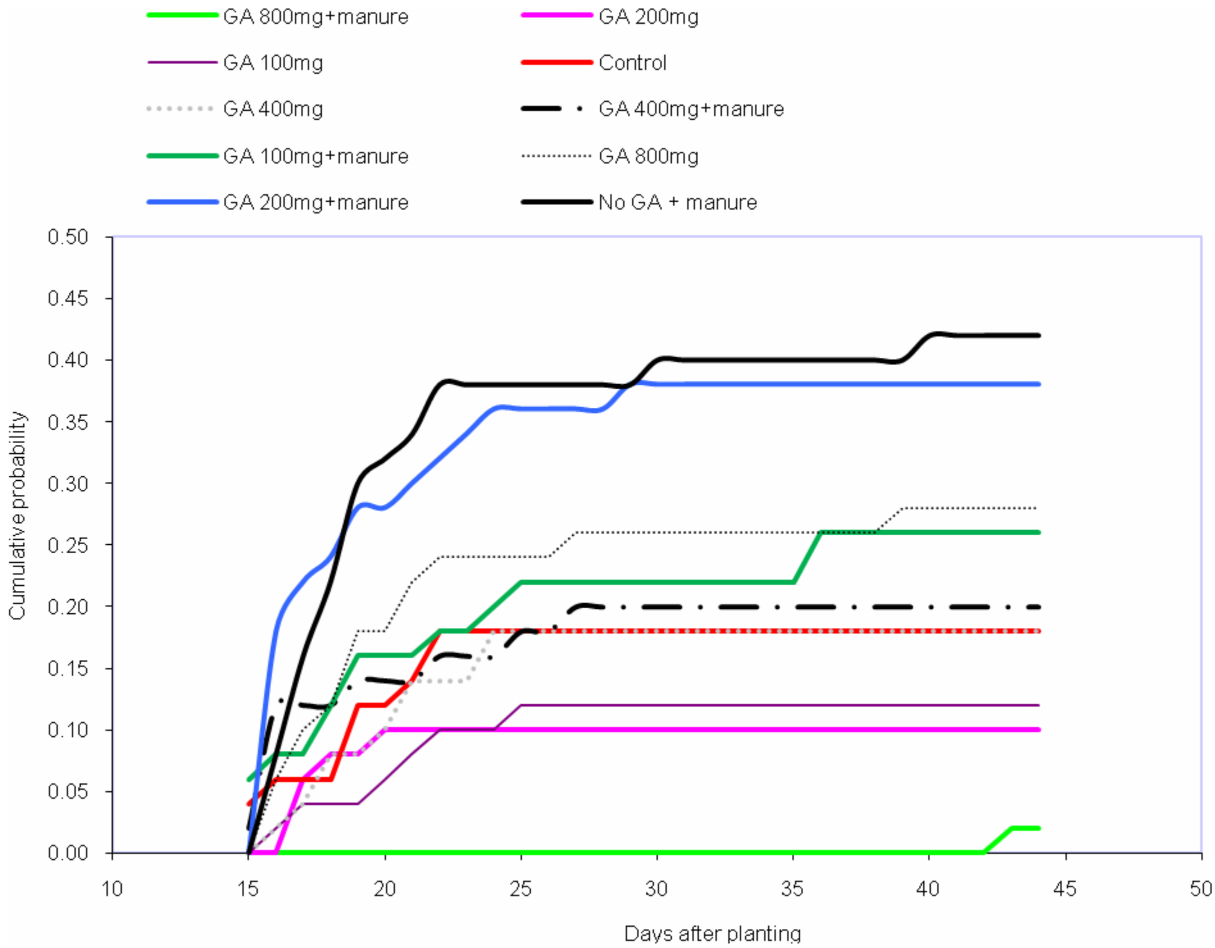


Figure 6.5. Probability distribution of germination of Securidaca seeds with different treatments

<u>Activity 6.2. Harvesting improved</u>

A draft guideline for germplasm collection has been prepared to guide germplasm collection and harvesting plant materials for other uses (Annex). Natural seed stands of Securidaca and Bobgunnia have been identified in Zambia and Malawi for future collection and trees are being monitored to identify the best time and place for seed collection. For the other species this is also established based on observation and literature review.

<u>Activity 6.3. Cultivation</u>

Efforts to collect seeds of pesticidal plants from natural stands have given us a very useful lesson. Seed or other planting materials as well as parts for pesticidal use are difficult to find in natural stands in large quantities. The review of the literature and the studies above highlighted how cultivation on farm can significantly help in making pesticidal plants available to farmers. The lesson learnt is that clonal mass production of Securidaca is crucial especially that the species is being unsustainably harvested by exploitation of the roots. Micropropagation may hugely complement *in situ* conservation strategies. Large scale micropropagation of desired genotypes of Bobgunnia is also required to overcome the genetic variability especially with plants propagated from seed. Over 20 kg of Bobgunnia seed was collected and stored under refrigerated conditions for future use.

Through the household surveys and participatory approaches it was learnt that *Tephrosia vogelii* is the most popular pesticidal plant in eastern Zambia and northern Malawi. Therefore, in December 2007 one hectare of *Tephrosia vogelii* was established and maintained at Msekera Research Station in eastern Zambia. In December 2008, another two hectares of the same species was established at

Chitedze Research Station in Malawi (Figure 5). These continued to serve as a seed sources as well as source of pesticidal products for anyone to use or phytochemical analyses.

Figure 6.6. A partial view of the *Tephrosia vogelii* field established at Chitedze Research Station in Malawi. Photo G. Sileshi

WORK PACKAGE 7

Activity 7.1 Marketing of pesticidal plants (Zimbabwe)

The SAPP project sought to encourage the marketing of pesticidal plants as a cash crop for small-scale farmers living in the Caesalpinioid woodland eco-region. This aimed at promoting formalisation of pesticidal plant use for agricultural pest management to increase crop yields, reduce storage losses and protect livestock. A sector analysis was conducted to characterise the pesticide industry in Zambia. Findings from the study indicated that the pesticide sector was not fully developed as most pesticides were imported and no form of value addition was conducted in country. The lack of pesticide manufacturing industries implies totally new investments would have to be made in terms of technology to produce such natural pesticides locally.

However the increasing demand for organic products results in an increased demand for organic inputs such as natural pesticides. The Organic Producers and Processors Association of Zambia (OPPAZ) has a membership of over 1900 producers which require organic inputs in production. OPPAZ members export certified organic products to EU markets, USA and South Africa in excess of 500 metric tons of fresh vegetables and 30 metric tons of groundnuts among other products annually. Therefore the organic products industry is a sure market for plant pesticides.

Major Players in the Market

The pesticide industry had only 23 companies registered with Crop Life, an association for all pesticide companies in Zambia. There were only 12 major players in the pesticide industry including Crop Park, Plant grichem, Manner Agro, Crop serve, Amiran Tiwgar, Agrivet, minelands, ATS, Prime Agric center, Sygenba and cropchem. It is important to note that all the firms listed above are distributing companies as there has not been any known manufacturing of chemical in Zambia. All the chemicals on the shelves are imported into the country from countries such as china (which supplies about 50% of the Chemical), South Africa, Zimbabwe and India (Figure 7.1). Most companies highlighted inadequate financial

resources, unavailability of appropriate technology and inadequate skills as major challenges in venturing into the manufacturing business. The trends are that registered distribution points (companies) have steadily increased from 26,149 and 202 in 2002, 2004 and 2007 respectively. Additionally registered Pesticides and Toxic Substances (PTS) increased rapidly from 181 in 2002 to 723 in 2007.

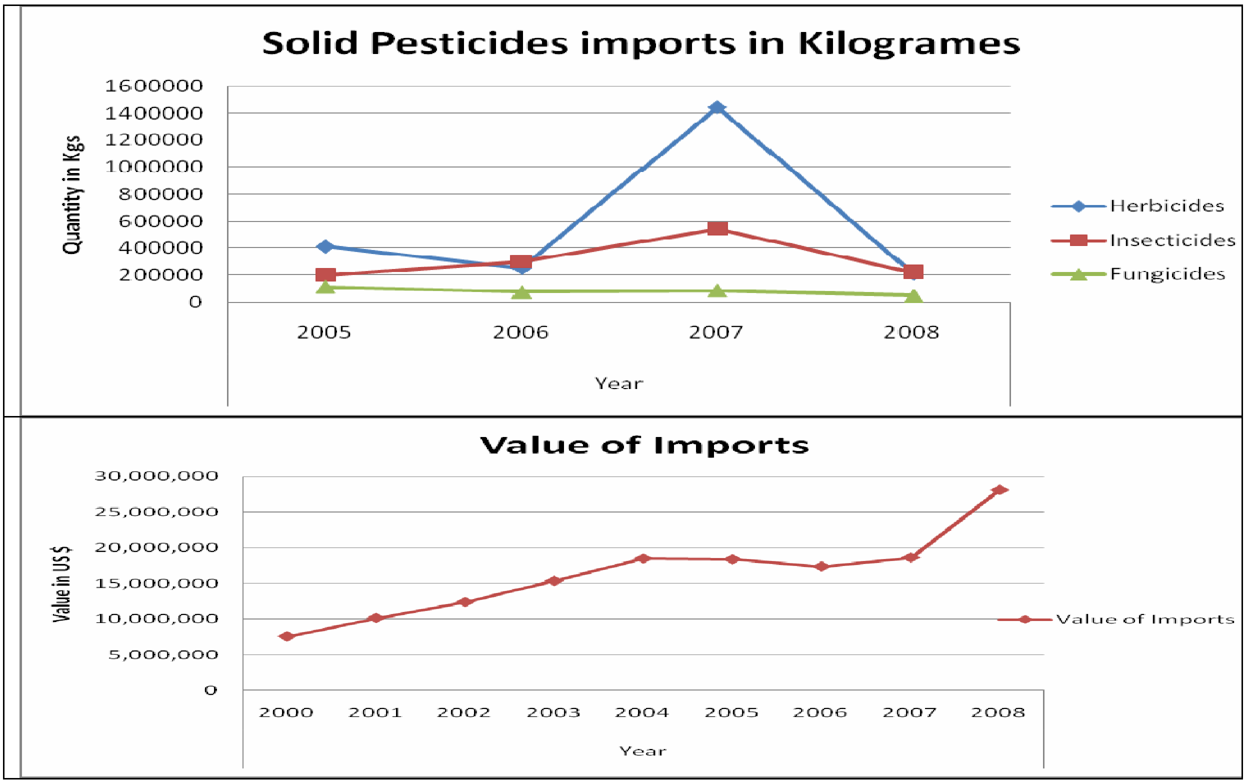


Figure 7.1: Volume of imports of pesticides into Zambia
Source: ECZ annual reports 2005 to 2008 and Central Statistical Office (CSO) 2009

<u>Legal framework</u>
The Environmental Protection and Pollution Control Act (EPPCA) No. 12 enacted in 1990 (cap 204 of the laws of Zambia) provides the main legal framework for the Pesticide industry in Zambia. Part VII and sections 57 to 65 of the EPPCA lay the legislative framework for Zambia's environmental policy on pesticides. Part M, sections 81 to 86, provides for the establishment of the inspectorate of the Environmental Council (ECZ) which was founded in 1992. The legislation has undergone some amendments in the resent years and is being revised to include restriction of Persistent Organic Pollutants (POPs). This is expected to stiffen regulations in the use of Banned pesticides. Currently, trade in the pesticide industry is regulated by the Environmental Council of Zambia (ECZ). However, the ECZ on its own does not have enough capacity to monitor activities in the pesticide industry, for instance.

- Some chemicals are registered under the Pharmaceutical Act while others are registered under the Environmental Protection and Pollution Control Act creating confusion in the issuance of import permits registration and regulation
- Repackaging of chemicals by players is done without following procedures in the International code of conduct
- Many unregistered traders operate at open markets

Therefore, the council is complemented by other government and nongovernmental organizations. Crop life Zambia is one such organisation which provides training, information and advocate for good

practices in pesticide trade. A number of legislation instruments are in place to guide the operations in this sector.

International code of Conduct for the Distribution and Use of Pesticides (2002

The Food and Agriculture Organisation (FAO) of the United Nations established an International code of Conduct for the Distribution and Use of Pesticides (2002). This code details the standards to be followed in the testing of pesticides, packaging, advertising, labelling, storage and disposal of pesticides among other issues related to pesticide use and distribution. It also provide a base for many of the national policies and also helps countries that have not yet established regulatory controls on quality and suitability of pesticide products needed to promote the judicious and efficient use of pesticide products and handling of potential risks associated with their use. The code also seeks to encourage responsible and generally acceptable trade practices. Article number six (6) of the code highlights the technical and regulatory requirements that government and the industry should endeavour to enforce. For example governments should introduce necessary legislation, establish registration schemes, conduct risk assessments, and collect data on the import and export of pesticides and cooperative with other governments in the establishment of harmonised pesticide registration procedures.

The Pesticides and Toxic Substances Regulations 1994

The Pesticides and Toxic Substances Regulations 1994 is Zambia's main pesticide regulatory instrument. The regulations seek to control the importation, exportation, manufacture, storage, distribution, sale, use, labelling, packaging, transportation, disposal and advertisement of pesticides. Control of the above is achieved through regulations No. 3 and 4 by registration and authorization through a certificate. A pesticide is registered after meeting requirements of other sections of the regulations (5 to 10). According to ECZ (1994), pesticide may be registered or denied registration based on information on some of the following:

- **Toxicity:** A pesticide that is highly toxic to man and the environment in general may not be registered specially if alternative less toxic pesticides exist.
- **Persistence:** It must not be very stable in the environment over a period of years.
- **Carcinogenic or Teratogenic:** It may be rejected if it is implicated that the pesticide may cause cancer or reproductive problems.
- **Shelf life:** It must have a reasonably long shelf life preferably two (2) years.
- **Safety Data:** This must include information on treating poisons

Handling of Pesticides Code of Practice

The Zambia Bureau of Standards is responsible for formulating all the standards governing trade in all products in Zambia and also ensuring that the standards are adhered to. ZABS is a statutory body established under an act of parliament, the Standard Act of 1994 of the laws of Zambia for the preparations and promulgation of Zambian Standards. ZABS in 2006 developed the '**Handling of pesticides code of practise'** that governs the production, processing storage, Marketing and disposal of pesticides in Zambia. The standard were compiled by a pesticide Committee which is comprised of the Food and Drug control Laboratory, National Institute for Scientific and Industrial Research, Zambia Agro Chemicals (now Crop Life), Zambia Cooperative Federation and the Zambia Bureau of Standards in. Though the standard above was developed by ZABS, pesticides are not one of the products that the body is regulating.

Implications for plant pesticides

According to FAO, a Pesticide is defined as "any substance or mixture of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm during or otherwise interfering with the production, processing, storage, transport or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or substances which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies'. Under the Pesticides and Toxic Substances Regulations 1994, a pesticide is defined as 'any substance or mixture of substances or organisms intended controlling, repelling or mitigating any pests, and a substance or mixture of substances intended for use as a plant regulator, defoliant or desfoliant'. It is clear that the definition

are based on the use of the chemicals and do not define pesticides in terms or ‘organic’ or ‘synthetic’. Therefore, it is evident that natural pesticides which are intended for the some cause as synthetic pesticide are also subject to the some legislation. It therefore, holds that natural pesticides should be registered just as synthetic pesticides before use. Although natural pesticides are generally perceived safer, emphasis should not only be on efficacy tests but include mammalian toxicity and general environmental effects (ECZ, 1994).

WORK PACKAGE 8

Activity 8.1 Build capacity in SADC scientists and institutes to evaluate, develop and promote the use of botanical pesticides

MALAWI: Mzuzu University and Lunyangwa Agricultural Research Station

A lecturer (Mr Fred Masumbu), two graduate technicians (Messers Rashid Chiposa and Charles Luhana) and two laboratory assistants (Mr Elvis Manda and Mr Treck Myaba) of Chemistry Department were involved in carrying out storage field trials data collection and phytochemical analysis of pesticidal plants and as such received training directly in the associated techniques an procedures.

One BSc (Education) student, Mr. Daniel Saka carried out his BSc degree research finished project on “Screening of indigenous plants for pesticidal activity against *Sitophilus* spp. in stored maize grain’’ as part of his BSc and was supervised by Mr John Kamanula.

Mr. J. Kamanula (Mzuzu University) and Stephen Nyirenda (Lunyangwa Agricultural Research station – DARS-Malawi) registered with NRI-University of Greenwich in UK for MPhil/PhD, and spent three months training in analytical chemistry in 2008, where they learnt the theory and standard operating procedures of analytical and preparative chemistry techniques particularly with respect to GC-MS, HPLC & LC-MS as well as laboratory safety. He also had training in advanced bioassay techniques for evaluating plant chemicals against insects. In 2009 (June to September) he spent a further 3 months in UK for advanced bioassay and analytical chemistry techniques. Mr Kamanula successfully upgraded through the formal process of MPhil viva exam on 29th September 2009 in UK.

A total of 4 technicians and 3 lab assistants have undergone hands-on-training in chemical analysis and bioassay techniques at Mzuzu University and Lunyangwa Research Station, respectively.

ZIMBABWE/ZAMBIA: University of Zimbabwe and SAFIRE.

At UZ, 7 technical staff members are working with pesticidal plants through preparing and or application of the plant material as well as sampling. Similarly, 2 SAFIRE staff members and 5 staff members of the Institute of Agricultural Engineering were involved. In each case, the SAPP project rationale and the objectives of the respective experiments were explained. This generated tremendous enthusiasm because it is a completely new area of research for most involved.

During the field surveys conducted using a standard questionnaire a total of 225 farmers were interviewed and this process itself raised considerable awareness of pesticidal plants and pesticide safety issues.

Five MSc and 4 BSc students did their research projects through SAPP and only one MSc student did not manage to complete the studies within the project time-frame (Table 8.2).

Table 8.2. University of Zimbabwe students who undertook their research projects on various aspects of the SAPP Project.

Name	Sex	Degree studied for	Comments
Simbarashe Muzemu	Male	MSc Crop Protection	Completed; Now Lecturer, Midlands State University, Zimbabwe
James Madzimure	Male	MSc Animal Science	Completed; Now PhD student, Fort Hare University, South Africa
Emmanuel Nyahangare	Male	MSc Animal Science	Completed; Now Lecturer, Animal Science Dept, UZ
Grace Ndoro	Female	MSc Agricultural Economics	Not yet completed. Had family problems
Larry Chikukura	Male	MSc Soil & Environmental Management	Completed
Tsitsi Mandaza	Female	BSc Applied Environmental Science	Completed
Alex Chigoverah	Male	BSc Agricultural Engineering	Completed
Kenias Nyevedzanai	Male	BSc Agricultural Engineering	Completed
Dennis	Male	BSc Animal Science	Completed

Other people who were worked on the project include those listed in Table 7. In addition **six** field staff in the Departments of Agricultural Technical and Extension Services and Veterinary Services helped in implementation of field trials. **Two** technicians in the Central Veterinary Laboratory provided technical assistance in setting up tick bioassays.

Table 8.2 Staff of various organizations who worked on various aspects of the SAPP Project.

Name	Sex	Qualification	Dates of appointment	Duties	Status
Brighton Mvumi	Male	PhD Stored Product Entomology	01 Jan 2007	National Coordinator/ Student Supervisor	Part-time
Thokozani Hove	Female	Associate Professor, Paraclinical Veterinary Studies	1 Aug 2007	Post-graduate Student Supervisor	Part-time
Humphrey Hamudikuwanda	Male	Professor, Animal Science	1 August 2007	Post-graduate Student Supervisor	Part-time
Elliot Zitsanza	Male	PhD Entomology	1 Aug 2007	Post-graduate Student Supervisor	Part-time
David Icishahayo	Male	MPhil	1 Jan 2008	Statistician	Part-time
Thembinkosi Siziba	Male	National Diploma, Applied Chemistry	1 July 2007	Research Technician	Part-time
Erikana Chitopo	Male	None	1 Dec 2007	Technical Hand/Driver	Part-time
Rodrick Kuseri	Male	"O" Level	Aug 2008	Research Hand	Part-time
Robert Tumbare	Male	"O" Level	Nov 2007	Field technician	Part-time
M. Munyangani	Male	BSc Hons Veterinary Science	Nov 2007	Vet Doctor	Part-time
Alfred Mare	Male	National Diploma	Aug 2008	Technician	Part-time

2.3 Activities that have not taken place

All activities have been undertaken as set out in the Project proposal although as a consequence of information that unfolded through project meetings some activities were modified to ensure the best use of available funds was made. In particular, the plants species that were identified by farmers, our own literature searches and planning meetings as priority species based on their potential value to farmers were mostly well known and of generally universal distribution within the botanical zone of the project. Consequently an in depth evaluation of the diversity of Caesalpiniod woodlands was not undertaken for all species

2.4 What is your assessment of the results of the Action?

The SAPP Project has successfully accumulated information on the use of pesticidal plants in Malawi, Zimbabwe and Zambia and forms a basis on which a regionwide change in their use should be based.

One of the assumptions at the outset was that the number of candidate botanical pesticides was very large and that it would only be possible to work on a limited number in much detail and this was born out. Prioritisation was based on discussions with farming communities and existing knowledge and as a results fourteen species of plants have been identified with real value to farmers in the region of which 8 have been proven effective under field conditions in trials conducted by the farmers themselves and should be considered for up-scaling. This has been an enabling process for the more than 1000 farmers who were directly involved in the project activities and has enriched their pest management options. There was much anecdotal evidence that many farmers who were not directly involved in our project activities were observant of them and we hope have assimilated important specific information about pesticidal plants but at the very least been sensitized to their use. This is all very important since our field surveys showed that while many farmers were aware of the existence of various plant based pest management options few had actually used them and the activities of the project have enhanced the profile of this technology.

In most cases our pre project expected outputs as set out in the log frame and the detailed work plan have been exceeded. For example, we predicted we would be able to conduct phytochemical investigations of at least three key botanical pesticides but in fact have produced significant and in some cases comprehensive analyses of the chemistry of *Tephrosia candida* & *T. vogelii*, *Bobgunnia madagascariensis*, *Tithonia diversifolia*, *Vernonioa amygdalina*, *Lippia javanica*, *Strychnos spinosa*, *Mucuna pruriens* . We proposed to determine vertebrate toxicity of 3 species a but managed to evaluate 6 species.

While we have engaged with local policy makers throughout the project it is not clear yet whether this impact has had sufficient impact on agricultural policy for the promotion of pesticidal plants to continue after the project has finished – however the project partners will be able to continue to monitor this under the scope of other projects that have followed on the present activity and are detailed below in 2. There was a strong community approach to the participatory trials and this is likely to ensure sustainability of project activities particularly if followed up under new projects by the current project partners.

One of the key risks at the project outset was whether the selected botanicals could show unacceptable hazards. This has not been born out. The most toxic material used was Tephrosia spp. which are considered in the US to be at the lowest level of toxicity and in any event are already used widely in the region. Otherwise the toxicity of the plant materials at the

concentrations at which they are used and without excessive consumption are safe. However, one subsequent issue that has arisen is the scope for government to legislate on the use of materials once any level of production beyond home made pesticides is started. For example, if some species are seen to have potential for cultivation and preparation could these then be considered to be 'pesticidal products' and have limited value without the prohibitively expensive safety trails associated with them normally associated with the more conventional synthetic pesticides. Currently the collection, basic prep and distribution of herbal remedies is not controlled in Southern Africa and this could be similar with pesticidal plants. A new project following on from the present one will investigate this.

2.5 *What has been the outcome on both the final beneficiaries &/or target group (if different) and the situation in the target country or target region which the Action addressed?*

The SAPP project had two main groups of beneficiaries. The ultimate beneficiary was of course the poor farmers for whom pesticidal plants offer an appropriate, affordable effective and environmentally benign pest management alternative to synthetic products. The main project outcome on these target beneficiaries was a dramatic reduction in pest damage by field and stored product pests and for livestock and changes to the way farmers perceive that these pests can be controlled or managed effectively and cheaply.
Evidence from participatory trials shows that some of the pesticidal plants are effective but also that some, identified by the farmers themselves were not and that care needs to be taken when using these materials since for some pests certain plants may be suitable but for others they are not.

The second group of beneficiaries were the students and research scientists who have carried out many of the experiments under supervision and guidance from project experts and benefitted from this training for both their immediate needs (project activities that are relevant challenging and sufficiently significant for their degrees) but also provide important information. The numbers of trainees involved is detailed elsewhere but again the predicted number of training beneficiaries has far exceeded predictions at the outset owing to the skill and hard work of the project partners.

The importance and potential value to pest management for poor farmers has been highlighted under numerous workshops and meetings that have ultimately raised awareness about pesticidal plants. However, this heightened perception needs to be maintained and increased to ensure that the role of pesticidal plants is exploited fully. This will be done during the course of the next 3-4 uyears through follow on projects through other donors (details below). The region has been

2.6 *Please list all materials (and no. of copies) produced during the Action on whatever format (please enclose a copy of each item, except if you have already done so in the past).*

One of the primary output target was the submission and publication of the research through international refereed journals. We aimed at the outset to submit 5 papers of this type. In fact, we have already submitted 6 and there are as many as 10 more papers that are in preparation from the research carried out in this project. The submitted papers are attached to the FTR as additional documents.

Papers submitted to international scientific journals.

1. Stevenson, P.C. Veitch, N.C., Jayasekera, T.K., Belmain, S.R., (**2009**). Bisdesmosidic saponins from *Securidaca longepedunculata* (Polygalaceae) with deterrent and toxic properties to Coleopteran storage pests. *Journal of Agricultural and Food Chemistry,* 57 (19), 8860–8867.

2. Nyahangare, E.T., Hove, T., Hamudikuwanda, H., Belmain, S.R. Stevenson, P.C., Mvumi, B.M. Toxicity of the pesticidal plants *Strychnos spinosa* Lam., *Bobgunnia madagascariensis* (Desv.)

J.H. Kirkbr. & Wiersama *Vernonia amygdalina* Del. and *Cissus quadrangularis* L. in BALB/c mice, *Human and Experimental Toxicology*, (**submitted**).

3. Madzimure, J., Nyahangare, E.T., Hamudikuwanda, H., Hove, T., Stevenson, P.C., Belmain, S.R., and Brighton M. Acaricidal efficacy against cattle ticks and acute oral toxicity of *Lippia javanica* (Burm F.) *Experimental and Applied Acarology*. (**submitted**).

4. Kamanula JF, Sileshi, G., Belmain, S.R., Sola, P., Mvumi, B., Nyirenda, G.K.C., Nyirenda, S.P.N. & Stevenson, P.C. Farmers' Pest management practices and pesticidal plant use for protection of stored maize and beans in Southern Africa. *International Journal of Pest Management*. (**submitted**).

5. Stevenson, P.C., Nyirenda, S.P.N. and Veitch, N.C. Highly glycosylated flavonoid glycosides from *Bobgunnia madagascariensis*. *Phytochemistry*. (**submitted**).

6. Nyirenda, S.P.N. Sileshi, G., Belmain, S.R., Kamanula, J.F., Mvumi, B., Sola, P., Nyirenda, G.K.C. & Stevenson, P.C. Farmers' Ethno-Ecological Knowledge of Vegetable Pests and their Management Using Pesticidal Plants in Northern Malawi and Eastern Zambia. *Agriculture and Human Values*. (**submitted**).

Paper to be submitted during 2010.

1. Toxicity and efficacy of pesticidal plants against livestock
2. Propagation of pesticidal plants.
3. Field evaluation of pesticidal plants in Malawi field crops.
4. Laboratory evaluation of pesticidal plants /chemistry.
5. Laboratory & field evaluation of pesticidal plants against stored product pests in Malawi
6. *Tephrosia* activity against *Callosobruchus maculatus* and *Sitophilus oryzae*
7. Novel flavonoids and rotenoids from *Tephrosia candida*.
8. Video capture of insect response to repellent pesticidal plants.
9. Up to 3 papers from field evaluation of pesticidal plants for stored products and field crop protection in Zimbabwe and Zambia.
    a) Combined farm trials (Zim/Zam) & lab bioassays
    b) Community surveys
    c) Station trials on vegetable pests.

Conference presentations:

XIII International Congress of Entomology held in Durban, South Africa from 6 to 12 July 2008
The following papers were presented

- Belmain, S.R.,_Stevenson, P.C., Simmonds, M.S.J., Mvumi, B.V., Sileshi, G.S., Sola, P., Nyirenda, S.P. and Kamanula, J. Can botanical pesticides be used safely and reliably in stored product protection?
- Mvumi B.M. et al., Botanical pesticides for stored grain protection: From the laboratory to the farm
- Madzimure J. et al. The Efficacy of *Strychnos spinosa* (Lam.) and *Solanum panduriforme* (*incanum*) Fruit-extracts in Controlling Ticks on Cattle

43rd South African Society for Animal Science, 28-30 July 2009 South Africa.

- Madzimure J. et al., The efficacy of *Lippia javanica* (Burm f.) leaf water-extract against cattle ticks in Zimbabwe (Oral presentation)

7th Conference of Toxicity in developing Countries (7CTDC), 6-11 September 2009 in South Africa

- Nyahangare, E., et al., Single - dose Acute Oral Toxicity of *Strychnos spinosa*, *Lippia javanica* and *Bobgunnia madagascariensis* in Balb/c mice (Oral and poster presentation)

8th Biopesticides Meeting of the Phytochemical Society of Europe 22-26th September 2009

- Stevenson P.C., T. K. Dayarathna, S.R. Belmain, P. Sola and N.C. Veitch. 2009. Bisdesmosidic saponins from *Securidaca longepedunculata* roots: Evaluation of deterrency and toxicity to Coleopteran storage pests. (Abstract – see additional documents)
- Stevenson, P. C. Belmain, S. R., S.P. Nyirenda, P. Sola, B.M. Mvumi, G. Sileshi, J.F. Kamanula and M.S.J. Simmonds. Optimizing sustainable use of pesticidal plants by subsistence farmers in southern Africa. (Abstract – see additional documents)

Policy Document.

We proposed to write a policy and strategy document that would be distributed among stakeholders to highlight and detail the importance of pesticidal plants as an appropriate alternative to synthetic products for farmers in Southern Africa. This was produced as a chapter in a McKnight Foundation Integrated Pest Management document that will be distributed widely in Southern Africa through pest management networks particularly those operated alongside McKnight Southern African Community of Practise and is available on their website as well as on the SAPP web site. This is attached im the additional documentation– strategies for Legumes Pesticidal plants but can also be found at http://mcknight.ccrp.cornell.edu/program_docs/general/NRI_Legume_IPM_review2009.pdf

We will continue to distribute this further via several follow on projects – (See 2.7 below)

Website www.nri.org/sapp

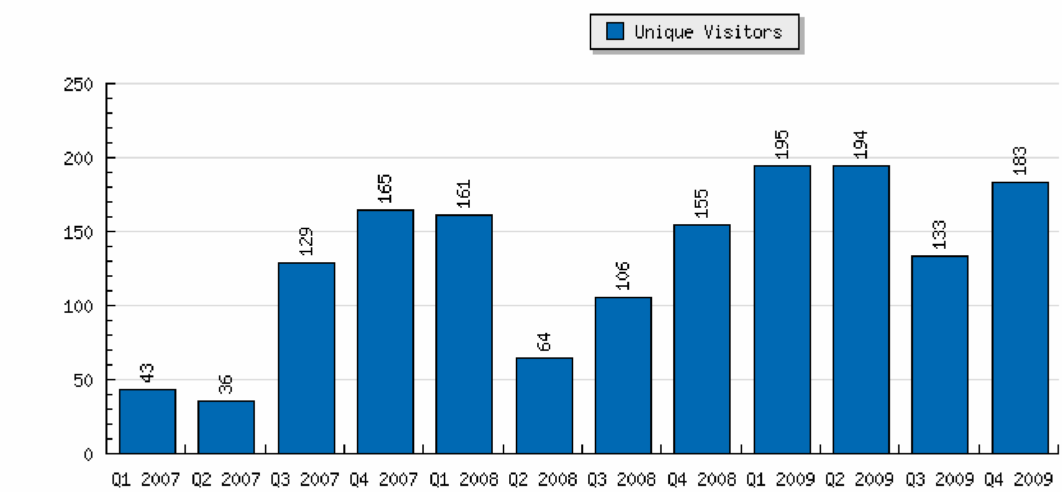
The website acts as a portal for all project related information, with project documents such as protocols, questionnaires, methods, minutes, press releases, etc. all available to download. Documents designated for internal use are password protected; however materials related to publicity and communication are freely available to download. In this regard, the website acts as a central information platform for sharing knowledge among the SAPP partners as well as with the wider public. Contact information for all the project partners can be found on the site as well as acknowledgements to the EC and SADC donors for the ICART programme funding, including links to their respective websites.

Basic information on pesticidal plants and the project's objectives and activities are available through the website plants database, and many people throughout the world are visiting the website to obtain basic information about pesticidal plants. Freely available web-tracking software has been embedded into the SAPP website (www.statcounter.com), allowing detailed monitoring of people accessing the website, their time spent visiting the site per page, what keywords and search engines were used to find the site, their IP addresses, screen resolutions, etc.

The monitoring of access to the SAPP website has allowed the project team to improve the information provided, making it more relevant to those who are accessing it. The project now links directly to ICRAF pages providing more detailed about the priority plant species identified by the project and also to a new follow on network project funded through the Africa Caribbean and Pacific Science and Technology Programme (ACP S&T) www.nri.org/adappt about which there is more below under Exit Strategies.

The SAPP website also links to an independent web-based networking site hosted by GoogleGroups <http://groups.google.co.uk/group/pesticidal-plants> This pesticidal plants site acts as

an email forum where people can post announcements and queries related to the use of pesticidal plants in agriculture, particularly their use in vegetable gardens, in grain storage and against livestock ectoparasites (ticks, mites). Members of this group may be scientists or extensionists involved in research and promotion of pesticidal plants or end users wishing to share their experiences or learn more about pesticidal plants through discussion and sharing of information with other group members. Anyone can join the GoogleGroup, allowing them to email other members, create websites and upload files to the pesticidal plant group.



Unique visitors to the SAPP website per quarter over life of project.

List of countries and percentage frequency of hits

Perc.	Country Name	Perc.	Country Name
30.00%	United States	0.40%	Pakistan
22.20%	United Kingdom	0.40%	Malaysia
10.40%	India	0.40%	Ireland
6.80%	Canada	0.40%	New Zealand
4.20%	South Africa	0.40%	Bangladesh
2.20%	Sweden	0.40%	Finland
1.20%	Germany	0.40%	Vietnam
1.20%	Philippines	0.40%	Malawi
1.00%	Spain	0.40%	Hungary
1.00%	Kenya	0.40%	United Arab Emirates
1.00%	Zambia	0.40%	Singapore
0.80%	Greece	0.20%	China
0.80%	Benin	0.20%	Egypt
0.80%	Zimbabwe	0.20%	Colombia
0.80%	Hong Kong	0.20%	Sri Lanka
0.80%	Poland	0.20%	Mozambique
0.80%	Croatia	0.20%	Netherlands
0.80%	Italy	0.20%	Ghana
0.80%	Australia	0.20%	Indonesia
0.60%	Mexico	0.20%	Sudan
0.60%	France	0.20%	Argentina
0.60%	Nepal	0.20%	Belgium
0.60%	Nigeria	0.20%	Slovenia
0.60%	Denmark	0.20%	Lithuania
0.60%	Brazil	0.20%	Jamaica
0.60%	Portugal	0.20%	Norway
0.60%	Czech Republic	0.20%	Romania

Location of sapp visitors from last six months of sapp project Jul-Dec 2009, map generated by www.statcounter.com

Public Media

A major communication strategy during the project has been through interviews by radio and TV stations and electronic media. An orientation trip was organised for the media personnel to one Vegetable site at Champhira in order to sensitize them on the activities of SAPP project in Malawi during year 2. Three radio interviews were aired on Zodiak Radio Station (Private Radio) and 3 interviews by Mr Wesley Kumwenda with Dr P.C Stevenson (Project Leader), Prof. Landson Mhango (Vice Chancellor, Mzuzu University) and John Kamanula were aired on national radio by the Malawi Broadcasting Corporation (MBC) Station on 7 AM English News and 6 AM Chichewa News on 10th December 2008. The electronic media has been slow in coming up with articles such that only one article came out (27th December, 2008) in Daily Times of Malawi by Mr Benson Makhuyula to report SAPP activities after our Annual planning meeting in 2008 (***scanned example provided below).***

On 12th February (Morning basket from 7.45 to 8 AM) and 17th December 2009, (7 PM and 8 PM main bulletin, in Chichewa and English, respectively) the Malawi Broadcasting Corporation (MBC) aired the interview which Mr J. Kamanula had with Mr Sangwani Phiri of MBC in Mzuzu. The same interview was also on TVM on 18th December 2009.

During another orientation trip to our project sites in Champhira and Nchenachena members of Malawi national media were sensitized of SAPP project activities in Malawi. As a result radio scripts both in Tumbuka and English were aired on Zodiak Radio Station (Private Radio) from 12th January to 2nd February, 2010. These radio scripts are available and will be posted on the project website (www.nri.org/sapp)

Two field days were organised in Champhira and Nchenachena among vegetable farmers. Over 400 smallholder farmers attended these and expressed interest, confidence and zeal in taking up pesticidal plant use further to a wider community in the study area. The guest of honour at the field day was the representative of the Traditional Authority Mwalweni for Rumphi district. He indicated his belief that SAPP work was by far the most powerful way to divert farmers away from using synthetic pesticides which tend to be harmful to the environment and humankind. About 500 copies of newsletter were published by DARS to facilitate dissemination of our work to more farmers in Malawi.

THE DAILY TIMES, Friday, December 26, 2008

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urther said the illegal ants did not pass the border post but chartered routes.
he time of the arrest, igration publicist said victs pretended as if re still in Tanzania.

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Sapp researchers share skills on pesticidal plants

BY BENSON MAKHUYULA

SOUTHERN African Pesticidal Plants (Sapp) researchers recently held a weeklong annual meeting in Mzuzu where they shared notes on how best to assist small-scale farmers to make optimum use of pesticidal plants in combating insects that attack both crops and livestocks.

Sapp Project team leader Philip Stevenson of Greenwich University in Britain said use of pesticidal plants such as neem and tephrozia could effectively help to kill insects that destroy crops in the fields as well as in storages.

He said, according to research done in some university colleges in Zimbabwe and Zambia, use of pesticidal plants greatly checks down crop damage caused by such insects as aphids, weevils and spidermites and that it eliminates ticks that prey on livestocks.

Stevenson, therefore, said there was need for research scientists to equip small-scale farmers with technical know-

livestocks.

Stevenson, therefore, said there was need for research scientists to equip small-scale farmers with technical know-how of growing, harvesting and applying plant insecticides so that they benefit from the project.

The Sapp project team leader further said growing of pesticidal plants would provide poor small-scale farmers with additional income besides crop and animal protection.

In his speech, Mzuzu University Vice Chancellor Landson Mhango, who graced the meeting, hailed Sapp project, saying it was a solution to controlling pests because of the low cost involved.

"The major challenge in crop protection is to come up with low cost technologies for farmers' use. Currently, farmers rely on high cost technologies like use of synthetic pesticides whose source is sometimes very questionable. It is pleasing to note that Sapp project is addressing these important issues," said Mhango.

John Kamanula, a Mzuzu University Chemistry lecturer, who is coordinating Sapp activities in Malawi, said the project would help to make agriculture more competitive among small-scale farmers as it would keep crop and animal pests under check.

The Sapp project, which was launched last year, is being implemented in Zambia, Zimbabwe, Botswana, South Africa and Malawi with financial support from European Development Fund.

The project is geared towards generating appropriate technology for enhancing small scale farming.

Extract from newspaper coverage of project activities (Dec 2008)


EDITORIAL

EVALUATION OF PESTICIDAL PLANTS FOR MANAGEMENT OF VEGETABLE PESTS IN TOMATO AND RAPE

FIELD DAYS

PROCEDURE FOR PREPARING PESTICIDAL PLANTS INTO POWDER

PREPARATION OF PESTICIDAL PLANTS INTO POWDER FORM

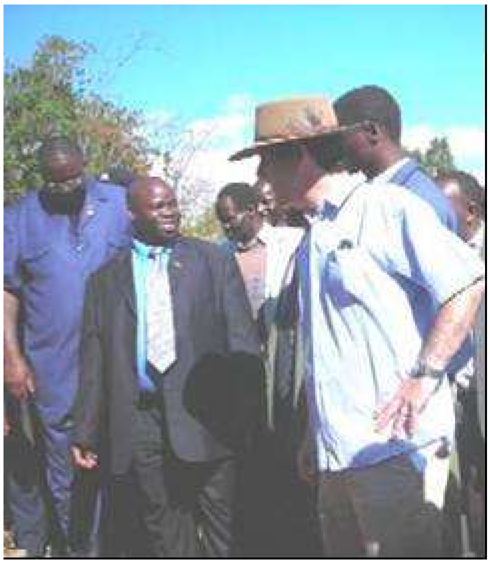
PREPARATION OF PESTICIDAL PLANTS POWDER READY FOR SPRAYING

This Issue Contains

Four page newsletter published by DARS (500 copies) on pesticidal plants and the SAPP Project for distribution to all Agricultural Development Divisions in Malawi, though much distribution targeted our working areas to inform public and policy makers and provide useful application details to extension workers.

The SAPP Project has sought to influence the public and policy makers through various forms of engagement to enhance the profile of and promote pesticidal plants.

SAPP project leader being interviewed for Malawi National Radio



SAPP project leader, and Honourable Deputy Agriculture Minister, Mr Binton Kuntsaira, Malawi

Plant information sheets

Plant Information sheets have also been produced including one on *Tephrosia vogelii*. (See attached in additional documents).

2.7 *Please list all contracts (works, supplies, services) above 10.000€ awarded for the implementation of the action since the last interim report if any or during the reporting period, giving for each contract the amount, the award procedure followed and the name of the contractor.*

None.

2.8 *Describe if the Action will continue after the support from the European Community has ended. Are there any follow up activities envisaged? What will ensure the sustainability of the Action?*

This is action is continuing through several new projects.

a) A DelPHE proposal (http://www.britishcouncil.org/delphe.htm) was sought during the course of Year 2 and led by one of the partners – John Kamanula and includes inputs from Stephen Nyirenda and Phil Stevenson formally and will benefit from the network of scientists established during the project. The project has a value of **£90,000** over 3 years and will enable John Kamanula to continue his research towards his PhD degree (which would not have been possible within the time limits of the SAPP Project. The title is OPTIMISATION OF PESTICIDAL PLANTS FOR THE CONTROL OF INSECT PESTS IN STORED MAIZE AND VEGETABLES

b) A McKnight Foundation project has also been funded through Southern African Community of Practise. The project entitled OPTIMISED PEST MANAGEMENT WITH *TEPHROSIA* ON LEGUME CROPPING SYSTEMS IN MALAWI AND TANZANIA is led by another Malawi based partenr from SAPP project Stephen Nyirenda and is a collaboration between 4 institutes – Department of Agric Research Services (Malawi), International Centre for Tropical Agriculture (CIAT – Malawi) (Roland Chirwa), Natural Resources Institute (Steve Belmain) and Ro6yal Botanic Gardens, Kew (Phil Stevenson). Roland Chirwa is a new partner for collaboration to the SAPP team. The overall aim is to take forward work initiated on the SAPP project specifically on optimising Tepohrosia vogelii and developing opportunities to commercial for small enterprise the production and distribution of the plant materials. As with John Kamanula above this will allow him to continue his research towards his PhD degree (which would not have been possible within the time limits of the SAPP Project. The project is worth **US$400,000 over 4 years**. (Sept 2009 – August 2013).

c) A new EU funded project through the African Caribbean and Pacific Science and Technology program and which is led by Phil Stevenson (SAPP Project leader) will consolidate and expand the network of scientists developed under the SAPP project. The project title is AFRICAN DRYLAND ALLIANCE for PESTICIDAL PLANTS TECHNOLOGIES and is funded to a value of **€1,000,000 over 3 years**. The new project is a network of Universities, NGOs and Institutes in 8 African countries – Egerton University (Kenya), National Botanical Institute (Namibia), University of Zimbabwe (Zimbabwe), Southern Alliance for Indigenous Resources (Zambia), National Agricultural Research Institute - Naliendele (Tanzania), Ministry of Food and Agriculture, Tamale (Ghana), Mzuzu University and Department of Agricultural Research Services – Mzuzu (Malawi) and Plant Protection Research Institute, Pretoria (South Africa) along with Natural Resources Institute, University of Greenwich and Royal Botanic Gardens Kew (UK) and includes ALL the SAPP project partners but also new partners from the new partners countries. The project will concentrate on consolidating and expanding the network of scientist but develop training and research activities and upgrade the output quality of the African partners through the development of the multidisciplinary teams of scientists. The project will continue the outstanding publication record established on the SAPP project and ultimately will host an international conference on pesticidal plants in Africa in 2013. www.nri.org/adappt

d) SAPP Partners have submitted 3 additional DelPHE proposals in the last round/call of funding (Feb 2010) from Malawi (ICRAF), Zimbabwe (University of Zimbabwe) and Zambia (The Copperbelt University).

2.9 Explain how the Action has mainstreamed cross-cutting issues such as promotion of human rights[3], gender equality[4], democracy, good governance, children's rights and indigenous peoples, environmental sustainability[5] and combating HIV/AIDS (if there is a strong prevalence in the target country/region).[6]

The main of the focus of the project from its outset has been food security - not simply with respect to stored products but also securing crops in the field and livestock) which is a particular concern for female and child headed families which are becoming increasingly abundant due to HIV/AIDS and changing male employment patterns. This was particularly apparent from surveys although in north Malawi and eastern Zambia the majority of rural families were still represented by men. The importance of women to the development of strategies for up-scaling the use of pesticidal plants was highlighted by the significant association between women and the greater inclination to use pesticidal plants.

Women may be empowered by pesticidal plants since there are no barriers to their access provided the appropriate information on their ID and collection is available or better still on their cultivation e.g., *Tephrosia*. Female headed homesteads are on the increase and they normally have no alternative source of livelihood other than agriculture. Increasingly, rural families in southern Africa are often run by women as men look for jobs in cities, and the majority of beneficiaries directly involved in the SAPP project have been women.

HIV/AIDS. As a strategy this project has been implemented by SAFIRE in Zimbabwe as an intervention in broader livelihood projects mostly funded by the EU through partnerships with HIVOS http://www.bcoalliance.org/node/320 and TDH. Specifically

- Improvement of agricutlural production through food for work in Provinces of Manicaland and Matabeleland South (German Agro Action) in which farmers get inputs and training from GAA.

- HIV/AIDs and nutrition: EC funds through TDH which support the establishment of 4 gardens in the area where field trials are undertaken

- SAFIRE Livelihoods programme funded through HIVOS Livelihood project facilitating agricultural development

2.10 How and by whom have the activities been monitored/evaluated? Please summarise the results of the feedback received, including from the beneficiaries.

The activities have been monitored and evaluated in several ways.

External Advisory Board. At the project outset the project partners invited external advisors to the inception meeting-who were introduced to the project activities and work plans and ambitions of the project. Their feedback was instrumental in setting out clear and achievable work plans

3 Including those of people with disabilities. For more information, see "Guidance note on disability and development" at http://ec.europa.eu/development/body/publications/docs/Disability_en.pdfhttp://ec.europa.eu/development/body/publications/docs/Disability_en.pdf

4 http://www.iiav.nl/epublications/2004/toolkit_on_mainstreaming_gender_equality.PDF

5 Guidelines for environmental integration are available at: http://www.environment-integration.eu/

6 To refer to EC Guidelines on gender equality, disabilities…

while contributing their expertise about botanical institutes and conservation priorities for the Southern African region. Subsequent meetings to evaluate activities were attended by External Advisors from southern Africa and provided continual support and analysis of the projects field objectives while advising on new sources of pesticidal plant that had otherwise not been encountered and contributing invaluable knowledge about key pests in the target agricultural systems.

International peer review. Ultimately it is the intention of the project to publish all the research outcomes as research papers in refereed journals. Already 7 papers have been submitted or published from this work with as many as 10 additional papers are under preparation. Indeed publication of research is itself a process of monitoring of quality since the submitted papers are evaluated by independent review. One paper has so far been published and has been through this rigorous process already – a process that is particularly robust for the particular target *Journal of Agricultural and Food Chemistry* (ISI Impact Factor 2.8). Furthermore, one other paper was actually invited by the journal directly as a result of a presentation made at an international conferences which again demonstrates that peer evaluation has indicated the work of the SAPP Project to be of high quality, relevant and of international standard for publication.

ICART Management team. We invited the ICART project team to our first mid year meeting and 2 annual meeting both in Malawi and which was an opportunity to demonstrate to them what the project was doing but also to receive feedback about the activities. One particularly important piece of feedback at our end of year 2 meeting in Mzuzu from the project coordinator was the emphasis on exit strategies for the projects. We took this on board and from that moment considered how we could continue the work beyond its lifetime and this resulted in sourcing new funds from 3 different funding bodies based in UK (British Council), Brussels (ACP S&T) and USA (McKnight Foundation) to a total value of approximately 1.5million euros. Otherwise feedback at these meetings with ICART team was positive and indicated that the project was on track.

Beneficiaries. All the 1,500 farmers were co –researchers and worked in close collaboration with SAFIRE, University of Zimbabwe and Department of Agricultural Research Services in Malawi. The feedback from target farmers has invariably been positive with all farmers appreciating the potential benefits of using pesticidal plants instead of synthetic pesticides. However, in several field trials the effects of the plant materials were not as profound as had been expected and in some cases simply did not work. Indeed the number of participatory farmers went down to 993 from 1100 in Zambia since the commencement of the 2008/09 trials as farmers felt there were no immediate benefits in this action. This highlighted the importance of a full understanding of the mechanisms of activity to ensure that plant materials promoted to farmers were active against the specific target pest and that the application was optimised.

Other stakeholders. In Malawi the project has received positive support from Director of Research Services as well as the programme Manager for MZADD. We have had cordial support from smallholder farmers in project sites with excellent backup from the District Agricultural Development Offices of Rumphi and Mzimba.

2.11.What has your organization/partner learned from the Action and how has this learning been utilised and disseminated?

Partners learned about many new techniques from each other and the processes of operating a large multi national and multi institutional project in Africa. The skills and knowledge gained have helped to consolidate a network of scientists and this is born out by our success in winning three more substantial projects over the coming three to four year.

There is still scope for more regular communication by email among the partners. Some partners suggested exploiting the use of other communications media including skype which allows prompt and direct e-discussion amongst partners whenever necessary. However, perhaps the most reliable communication device was the telephone. Mobile phone networks in Africa are extensive and even in the field, project partners were easier to contact by phone tan by email when at their desks owing to problems with the internet.

Slow turn around of co-authored papers held up work for longer than necessary. Processes of fast tracking or prioritising by lead or corresponding authors could assist in the process. Mentoring can address this through bringing authors/contributors together and applying pressure for outputs. Two surveys papers for example really came together through a specific and dedicated slot of time at which the three key players in Malawi came together to thrash out the information. Deadlines, even unofficial ones, also help to move things along as well as regular meetings.

Partner organizations learned new techniques of biological evaluation of plant materials in laboratory and field trials and their chemical analysis from other partners and the experience of working within an international network has been extremely beneficial to building the capacity of expertise. The project has been able to bring experts together in order to share strengths and improve weaknesses. The knowledge generated has been directly applied within the project and has led to a number of output

3 Partners and other Co-operation

3.1 How do you assess the relationship between the formal partners of this Action (i.e. those partners which have signed a partnership statement)? Please specify for each partner organisation

The relationship has been excellent among the partners. Meetings were characterized by constructive dialogue where partners were open to criticism and also provided sincere criticism of the progress. Because of the rapport built among partners planning and execution of project activities moved with ease. One particular aspect was the fact that each partner was responsible for a specific work package which encouraged interaction among the partners and a sense of role and responsibility of each partner to the overall aim and ambition of the project.

UZ worked more closely with SAFIRE on a day to day implementation of some of the components and the combination of the 2 organisations has been synergistic. Similarly partners in Malawi, worked closely together but the interaction among All the partners was overall very good. SAFIRE also conducts a close working relationship with University of Zambia through its Lusaka office. All partners communicated frequently and effectively with the lead institute NRI.

3.2 Is the partnership to continue? If so, how? If not why?

Yes. Three new projects have been won that overlap with the current project and these are detailed elsewhere as required in the report. Briefly these are a DelPHE British council grant awarded to John Kamanula (Malawi partner) for £90,000, a McKnight Foundation Southern Africa Community of Practise project awarded to Stephen Nyirenda worth US$400,000 and an ACP S&T project worth €1,000,000 awarded to Phil Stevenson NRI. In all cases SAPP project partners are involved to a greater or lesser degree and in the case of the ACP project ALL current proj4ect partners continue to work together.

3.3 How would you assess the relationship between your organisation and State authorities in the Action countries? How has this relationship affected the Action?

Zimbabwe:

University of Zimbabwe: UZ gained a lot of support from state authorities such as Henderson Research Station which provided animals and research facilities. Mazowe Veterinary College is another government institute that helped with blood sample collection and analysis for work at University of Zimbabwe. All these institutions contributed towards good quality research with no cost.

The Institute of Agricultural Engineering in the Ministry of Agricultural Engineering, Mechanisation and Irrigation, located at Hatcliffe provided grain storage facilities for the on-station storage experiments. The staff also participate in the experiment. The Crop Breeding Institute, Department of Agricultural Research for Development (DAR4D) provided bean weevils that have been used to start bean cultures to be used in the bioassays at UZ. The Chiredzi Research Station, DAR4D in collaboration with Agro forestry officer (Mrs Mwenye) allowed the project to harvest neem leaves from their plots. Plant Protection Research Institute and National Herbarium Botanic Gardens experts in DAR4D helped to positively identify the species of vegetable pests and pesticidal plants respectively.

In 2007 and 2008, state authorities were reluctant to share information about the regulatory aspects of pesticides and tended to withhold information or release it late even after seeking permission to acquire it. It was not possible to acquire secondary data especially on the structure of the pesticide industry before prior to 2007 (as part of the market structure study) which have made a trend analysis impossible.

SAFIRE has a long standing relationship with the Ministry of Tourism and SAPP is the 3rd project currently being implemented with the ministry in Zimbabwe. IN Zambia the relationship has a long standing relationship with Ministry of Agriculture to collaborate in environmental activities and this has made it easy for the project to be understood and accepted at policy level. Implementation of SAPP is being implemented with co-facilitation with ward level based Agricultural Research and Extension staff which has increased contact time. At the district level in Zimbabwe SAFORE have coordinated activities in conjunction with Environmental Management Agency staff thus the project has benefitted from legal backing and in Muzurabani and Nyanga districts SAFIRE attends all Rural district Council meetings and gives progress reports. This has made the action relevant and has the support of the local leaders. A similar outcome has arisen in Choma districts (Zambia) where the project is being implemented. Finally Forest Department in Zimbabwe and participation of the Joint Forest management initiative in Zambia have facilitated the harvesting of plant materials and the related issues and has helped highlight the action as a strategy to enhance the benefited of non timber forest products.

Malawi:

The relationship between ICRAF and State authorities relevant to this project was very strong. Historically, ICRAF has been hosted by the Ministry of Agriculture and Cooperatives (MAC) over the last 20 years at Msekera Regional Research Station. The Msekera Research Station is now being managed by the Zambia Agricultural Research Institute (ZARI), which had also strong ties with ICRAF when it was under MAC. This long history of relationship between ICRAF and MAC and ZARI and the commitment of the relevant staff has helped the actions in this project to be carried out smoothly. The activities in this project were carried out in collaboration with Dr Smart Lungu, who is a staff of MAC and also the national secretary of the Zambia National Agroforestry Steering Committee.

In addition, this project is now incorporated into ICRAF global research priority 2, “Diversification on Farm”, demonstrating institutional ownership and commitment.

It was possible for SAPP members to interact with Bunda College on a Bilateral project between South Africa and Malawi. We had a great input in the pesticidal plants project set up of South Africa and Malawi for training of post graduate students in the two countries.

Mzuzu: *Ministry of Agriculture, Mzuzu ADD* The relationship with Mzuzu ADD is very good. They allowed their extension workers to work with us in this project during and after surveys of pesticidal plants. The field officers at Nchenachena and Champhira helped us in organising farmers for workshops and storage trials and helped the project to run smoothly.

Professor G.K.C. Nyirenda of Bunda College has always been helpful in providing information on pesticidal plants and is now part of the Steering group. .

3.4 Where applicable, describe your relationship with any other organisations involved in implementing the Action:

- Associate(s) (if any)

MALAWI: The project brought together different staff members of various stakeholders such as The Mzuzu Agricultural Development Division (MZADD), Mzuzu University, Mzuzu Smallholder Coffee Planters Cooperative Union (MSCPCU) and Bunda College. Major staff contacts during the project included staff below.

Name	**Sex**	**Qual**	**Further study prospects**	**Dates of appointment**	**Duties**	**Status**
Louis Mwalima	M	Diploma	BSc	1/1/2008	Undergraduate Research Student	Part time
Hastings Nyasulu	M	JCE	None	1/1/2008	Lab Attendant	Part time
Paulus Maluwa	M	MSCE	Diploma	1/1/2008	Research Technician	Part Time
Chicco Kayange	M	MSCE	Diploma	1/1/2008	Research Technician	Part Time
Mercy Tembo	F	MSc	None	1/1/2008	Crop Protection Officer	Part time
Victor Kumwenda	M	BSc	None	1/1/2008	Horticulture Extension Officer	Part time
M.L. Banda	M	Certificate	None	1/1/2008	Extension	Full Time
Festus Mghogho	M	MSCE	Diploma	1/1/2008	Research Technician	Part Time
George Munthali	M	MSCE	Diploma	1/1/2008	Research Technician	Part Time
Mytot Mhango	M	MSCE	Diploma	1/1/2008	Extension	Part Time
Robert Chirwa	M	PSLC	None	1/8/2008	Research Driver	Full Time
Maria Hojane(Mrs)	F	MSCE	None	1/8/2008	Office Assistant	Part Time

The project has facilitated participation of other scientists through BSc & MSc supervision: Prof Thokozani Hove, Faculty of Vet. Sci.; Prof Humphery Hamudikuwanda, Animal Sci. Dept & Dr. Elliot Zitsanza, Crop Sci. Dept. and facilitated access to resources in the different departments. Links made with Prof Zaranyika, Mr Tendaupenyu (Chemistry Dept, UZ) and Prof Nike of National University of Sci. and Tech. in developing a protocol for the mode of action of the pesticidal plants.
The project has brought together scientists and students of different disciplines within the various partner organisations. For example an Animal Science MSc student worked on the vertebrate toxicity studies in collaboration with the Faculty of Veterinary Science at UZ. Two UZ BSc honours students

have been engaged (one per site) to work on the field storage trials. A Crop Science MSc student is undertaking vegetable field pest control experiments with assistance from an Applied Environmental Science undergraduate student. Another Animal Science MSc student is working on this component of acaricidal plants for tick control in cattle. The studies are being undertaken in collaboration with Faculty of Veterinary Science at University of Zimbabwe. The full list of University of Zimbabwe staff involved is as follows,

Name	Sex	Qualification	Further study prospects	Dates of appointment	Duties	Status
University of ZIM						
Thokozani Hove	F	PhD Veterinary Studies	N/A	1 Aug 2007 – current	Post-graduate Supervisor	Part-time
Humphrey Hamudikuwan	M	Assoc Prof, Animal Science	N/A	1 Aug2007 – current	Post-graduate Supervisor	Part-time
Elliot Zitsanza	M	PhD Entomology	N/A	1 Aug 2007 – current	Post-graduate Supervisor	Part-time
Simbarashe Muzemu	M	BSc Crop Science	MSc Crop Protection	1 Augu 2007 – current	Post-graduate Student	Full-time
James Madzimure	M	BSc Animal Science	MSc Animal Science	1 Aug 2007 – current	Post-graduate Student	Full-time
Emmanuel Nyahangare	M	BSc Animal Science	MSc Animal Science	1 Aug 2007 – current	Post-graduate Student	Full-time
Grace Ndoro	F	BSc Agric Econ	MSc Agric Economics	1 Jan 2008 - current	Post-graduate Student	Full-time
Tsitsi Mandaza	F	N/A	BSc Applied Env Science	1 Oct 2007 – current	Under-grad Student	Part-time
Alex Chigoverah	M	N/A	BSc Agric Engineering	1 Sept2007 - current	Under-grad Student	Part-time
Kenias Nyevedzanai	M	N/A	BSc Agric Engineering	1 Sept 2007 - current	Under-grad Student	Part-time
Thembinkosi Siziba	M	National Dip Appl Chem.	N/A	1 July 2007 – current	Research Technician	Part-time
Erikana Chitopo	M	None	N/A	1 Dec2007 - current	Technical Hand	Part-time

- Sub-contractor(s) (if any) *None*
- Final Beneficiaries and Target groups

- Considerable interaction with farmers (>1500) during the project as farm based trials (PRAs) of some pesticidal plants have been initiated.
- All farmers are co–researchers and work in closely with partners which is empowering.
- Familiarisation meetings held with communities, farmers, technical stakeholders and other significant parties. Field trials (gardens and storage) have generated lots of interest in the beneficiary communities as evidenced by their active involvement at all stages of the trials eg collection and preparation (pounding/crushing) of the pesticidal plant for ease of application. Support of local leadership secured. Other third parties involved.

  UZ/SAFIRE: In Zimbabwe the project has more recently not been able to reach out to communities in the project sites because of the political situation on the ground.

  ICRAF: Farmers in three districts of eastern Zambia.

  Researchers: The activities in this project were carried out in collaboration with Dr Smart Lungu, a botanist (taxonomist) by training with a keen interest in medicinal plants. He has personally supervised most of the activities and will continue to do so. Researchers and students from Mzuzu University and other scientists from ICRAF are also beginning to be involved in the propagation of the species selected.Agroforestry MSc program at University of Wales, at Bangor. A Masters student and his supervisor are closely working with me in the development of protocols for the micro propagation study **DARS**: Smallholder Farmers have had a great interest in conducting field trials with project members. Over 400 farmers have been in touch with project staff in the two sites.Mzuzu: Extension workers and over 150 farmers from Nchenachena

and Champhira (Jenda) were willing to work with us in surveys and storage trials and have benefited from the knowledge gained.

- Other third parties involved (including other donors, other government agencies or local government units, NGOs, etc).

  None not already mentioned above.

3.5 Where applicable, outline any links you have developed with other actions

In all cases partners have used collaborations and facilities to help move the project forward. For example, in Malawi, the rural appraisals interviews and trials leant heavily on support from local agricultural offices The major outreach tool to the community has been the MZADD extension staffs who are vested with all responsibilities of extension services in the area. UZ have developed links with FAO, which is providing more information on Laboratory bioassays using the Larval Packet Test in tick bioassay work. SAFIRE also recognizes that although the work under the SAPP project was time consuming the funds are limited so this project is being implemented as an intervention in broader livelihood projects mostly funded by the EU through partnerships with HIVOS and TDH. These have already been outlined above under 2.9.
IN the final year work in Mzuzu was additionally supported by a new DelPHE fund through the British Council.

3.6 If your organisation has received previous EC grants in view of strengthening the same target group, in how far has this Action been able to build upon/complement the previous one(s)? (List all previous relevant EC grants). **N/A**

4 Visibility

All outputs either acknowledge the source of funding in a written statement or publicise the EU using the flag/logo on outputs such as press statement and perhaps most importantly the website at www.nri.org/sapp

All interviews with press make clear that funding is EU. It is not possible to ensure that this information is presented in the final report. Details are listed elsewhere in the report.

The European Commission may wish to publicise the results of Actions. Do you have any objection to this report being published on EuropeAid Co-operation Office website? If so, please state your objections here.
No objections

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Signature: 

Location: Natural Resources Institute

Date report due: 31 March 2010

Date report sent: 31 March 2010