OPTIMISED PEST MANAGEMENT WITH TEPHROSIA ON LEGUME CROPPING SYSTEMS IN MALAWI AND TANZANIA

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For

The McKnight Foundation's

Collaborative Crop Research Program

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INTRODUCTION

The common approaches to pest control on common beans (*Phaseolus vulgaris*) have been the use of inorganic pesticides which are usually effective, but they come with some severe constraints to users. These constraints are associated with high costs, health and safety, poor labeling and environmentally unfriendly (Pan Africa, 2009 in Alan Cork et al, 2009). Studies have further shown that though synthetic insecticides are effective Labreque, (1983); Golob, (1988); Pierce and Schmidt, (1992) and Bekele et al., (1996), majority of farmers in Africa and Malawi in particular are resource-poor. This entails that they have neither the means nor the skills to obtain and handle synthetic pesticides appropriately Saxena et al., (1990). Careful use of pesticidal plant products can deliver substantial benefits to the society: increasing the availability of good quality reasonably priced foodstuffs. However these pesticides can be harmful to living organisms so there are risks associated with their use. It is important that these risks are accurately assessed and appropriate measures taken to minimize them.

The final year, the project continued with farmer field trials using optimised procedures of application and a farmer post project evaluation survey was conducted to ccollect information that is comparable with the baseline data and can be used to examine the magnitude of changes in the following key areas; changes in the socio-economic status of households; proportional changes in the utilization, accessibility and availability of botanical insecticides in the study area; proportion changes in household income; proportional changes in household food security; proportional changes in households knowledge of botanicals; proportional changes in households crop productivity; changes in human capital; changes in households decision making.

Project Objectives

The overall goal of the project is to improve food security in Malawi through the development and optimization of plant-based pest management technologies that are simple, effective, low-cost and appropriate for the control of field and storage insect pests of beans.

Specifically:

- To determine mechanisms of activity in pesticidal plant species
- To optimize production, harvesting and application of pesticidal plant materials
- To develop of optimized techniques for field application through farmer participatory trials

Problem statement

Many African countries want to benefit from indigenous knowledge, particularly of native plants with useful properties. Indeed, local knowledge is highly prioritized in the natural resource sector of agricultural ministries. Despite its popularity among research institutions and universities across Africa, multidisciplinary research on pesticidal plants in Africa has been and continues to be limited. Few African research outputs are of sufficient quality to be published in internationally peer-reviewed journals and thus miss the opportunity for wide readership. An analysis of African based science journals indicates that many publications on pesticidal plants are often repeating work, and research progresses largely ignorant of the critical knowledge gaps (i.e. up-scaling, on farm efficacy, health and safety, propagation and cultivation characteristics or conservation issues) that are essential in addressing the constraints that restrict the development, uptake and promotion of pesticidal plants by small-scale farmers. Farmers are currently served inadequately by the agricultural sector and lack access to high quality commercial products so will benefit from new, affordable and effective protocols for the cultivation and optimised use of *T. vogelii* and other pesticidal plants for pest management. While the main aim of the project is to develop appropriate technologies based on pesticidal plants for farmers and facilitate them in the production of their own material the project will also engage with small enterprises to determine whether there is scope for their commercial production. This process will develop opportunities for business driven up-scaling so many more farmers can be reached with the technologies than the limited funds of the proposed work would otherwise allow.

RESEARCH DESIGN AND METHODS

To achieve the project outcomes, research was conducted through partnerships among the following organizations namely; The International Centre for Tropical Agriculture (CIAT) which operates in southern Africa as the Southern Africa Bean Research Network (SABRN), Department of Agricultural Research Services, (Lunyangwa) in Malawi, Natural Resources Institute, University of Greenwich and Royal Botanic Gardens, Kew, UK. On-farm trials were set in Rumphi-Nchenachena, Mzimba-Lodjwa and Kasungu-Chinseu in Malawi (Fig.,1).

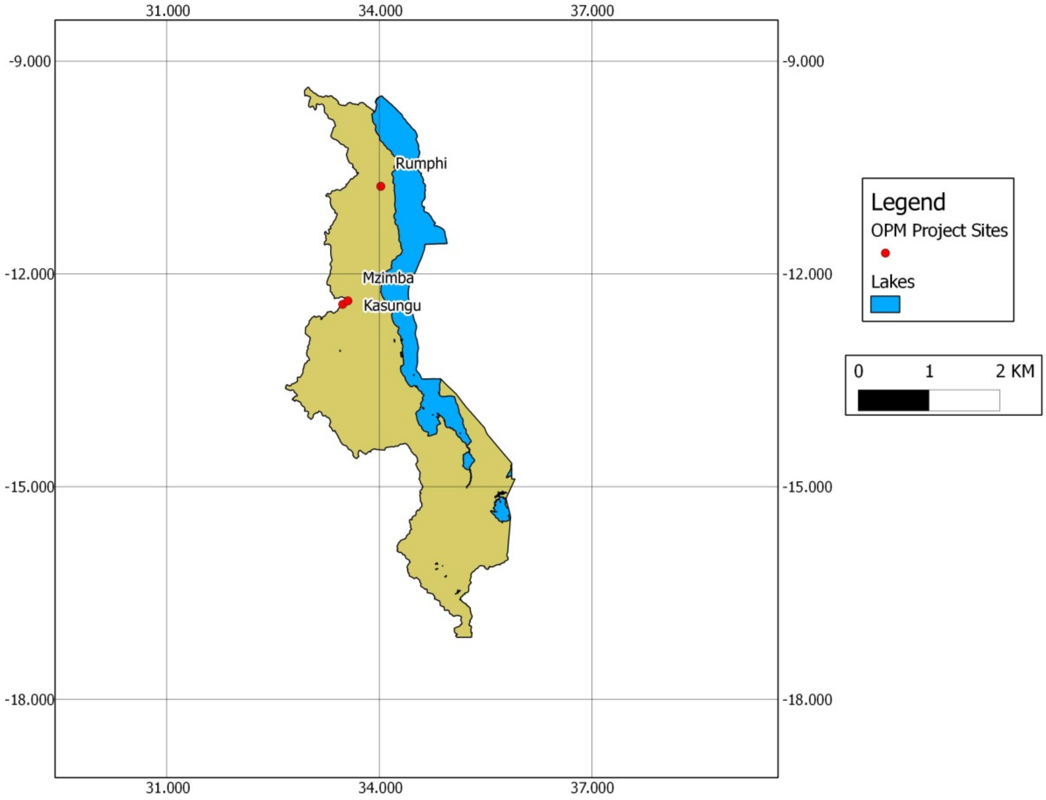

Figure 1: OPM project sites in Malawi

PREPARATION OF AQUEOUS EXTRACT

The extracts of the botanicals were prepared following the method of Rezaul Karim *et al.* (1992) where each of the plants extracts was prepared at a concentration of 5% w/v by weighing 300 g, 2% w/v weighing 120g, and 0.5% w/v weighing 30g of the powder respectively and then soaked in plastic bucket containing 2 litres of old water. The resulting solution was stirred continuously for 5 minutes and left to stand for 12 hrs. Filtration of the plant extracts was done shortly before application in the field using wire mesh of 0.2mm. The final volume of each plant extract filtrate was made up by diluting with 4 litres of distilled water. The enhancement of extraction of active ingredients, stickiness and adherence of each of the plant extract formulation was enhanced by the addition of 6 ml of 0.1 % soap solution as surfactant. Spraying of the plant extracts was done early in the morning or late in the afternoon because of the photodegradable nature of the extracts.

FIELD DESIGN AND DATA COLLECTION

Sampling of aphid was visually done three weeks after planting (WAP). Stand count data (net plot) at germination was also collected 3 weeks after planting. Aphid infestation and severity were assessed every fortnightly from the two central ridges as net plot. Ten plants per treatment in each replicate were sampled and scores for the presence and abundance of aphid were recorded. The two middle ridges (net plots) 10 plants were randomly selected and tagged. Each was observed for aphid infestation and the colony size was visually scored on a scale of 1-5 points (Table 1) where the number of plants infested and severity of infestation was recorded per plant in each plot.

Table 1 Scale for rating aphid infestation and severity

Rating	Number of Aphids	Infestation/severity
1	1	No infestation
2	≤ 100	Slightly infested
3	≥ 200 but less than 300	Moderate
4	≥300 but less than 400	High infestation
5	≥ 400	Severe infestation

Source: adopted from Litsinger *et al*. score in cowpeas

APHID INFESTATION AND ABUNDANCE

The effects of treatments on bean aphid were evaluated from the presence (infestation) and abundance (severity) of aphids after application. The results in Table 2A and 2B show that there were significant differences amongst treatments on aphid infestation and abundance on all three sprays. No significant differences however were observed in each treatment according to least significant difference (lsd) test.

Table 2A: Mean aphid infestation of two plant extracts at different concentrations

	Aphid infestation										
	unsprayed	soap	Tv1 30g	Tv1 120g	Tv1 300g	Tv1 300g wts	Karate	Tv2 30g	Tv2 120g	Tv2 300g	Tv2 300g wts
Initial	1.325^{d}	1.000^{ab}	1.275^{cd}	1.000^{a}	1.175^{bc}	1.175^{bc}	1.300^{cd}	1.100^{ab}	1.200^{bcd}	1.000^{a}	1.075^{ab}
2nd spray	1.864^{c}	1.795^{c}	1.591^{b}	1.500^{b}	1.318^{a}	1.273^{a}	1.227^{a}	1.205^{a}	1.205^{a}	1.205^{a}	-
3rd spray	1.909^{c}	1.909^{c}	1.886^{c}	1.886^{c}	1.864^{c}	1.818^{bc}	1.682^{ab}	1.659^{ab}	1.568^{a}	1.568^{a}	-

Means followed by the same letter are not significantly different according to Fisher's unprotected least significant difference test

Table 2B: Mean aphid population of two plant extracts at different concentrations

	Aphid abundance										
	unsprayed	soap	Tv1 30g	Tv1 120g	Tv1 300g	Tv1 300g wts	Karate	Tv2 30g	Tv2 120g	Tv2 300g	Tv2 300g wts
Initial	1.425^{d}	1.100^{ab}	1.275^{cd}	1.000^{a}	1.175^{bc}	1.175^{bc}	1.300^{cd}	1.100^{ab}	1.200^{ab}	1.000^{ab}	1.000^{ab}
2nd spray	2.295^{cd}	2.455^{d}	2.045^{cd}	1.818^{bc}	1.636^{d}	1.568^{abcd}	1.455^{abc}	1.250^{ab}	1.273^{a}	1.293^{ab}	-
3rd spray	3.114^{cd}	3.182^{d}	3.182^{d}	3.159^{d}	2.841^{bcd}	2.841^{abcd}	2.545^{abc}	2.500^{ab}	2.737^{a}	2.364^{ab}	-

Means followed by the same letter are not significantly different according to Fisher's unprotected least significant difference test

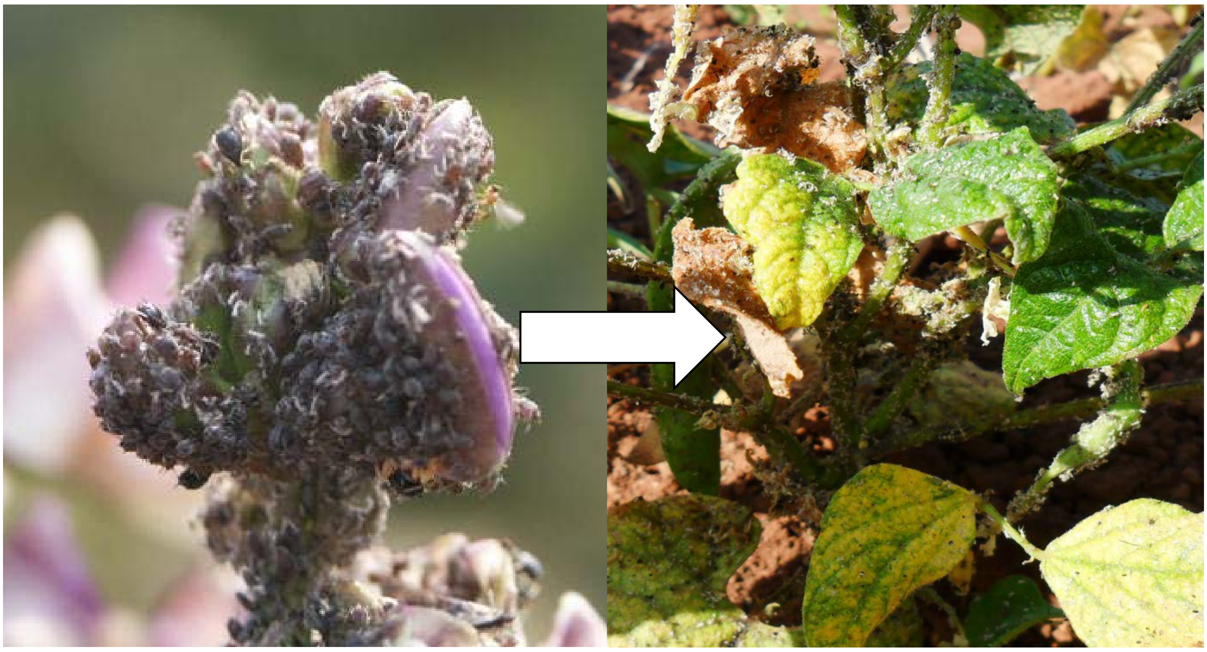

Figure 2: Foliage and flowers severely attacked by aphid in untreated plots

EFFECTS OF *TEPHROSIA VOGELII* AND *CANDIDA* ON YIELD

The results in Figure 3 show that there were significant differences amongst treatments on stem maggot on bean after establishment.

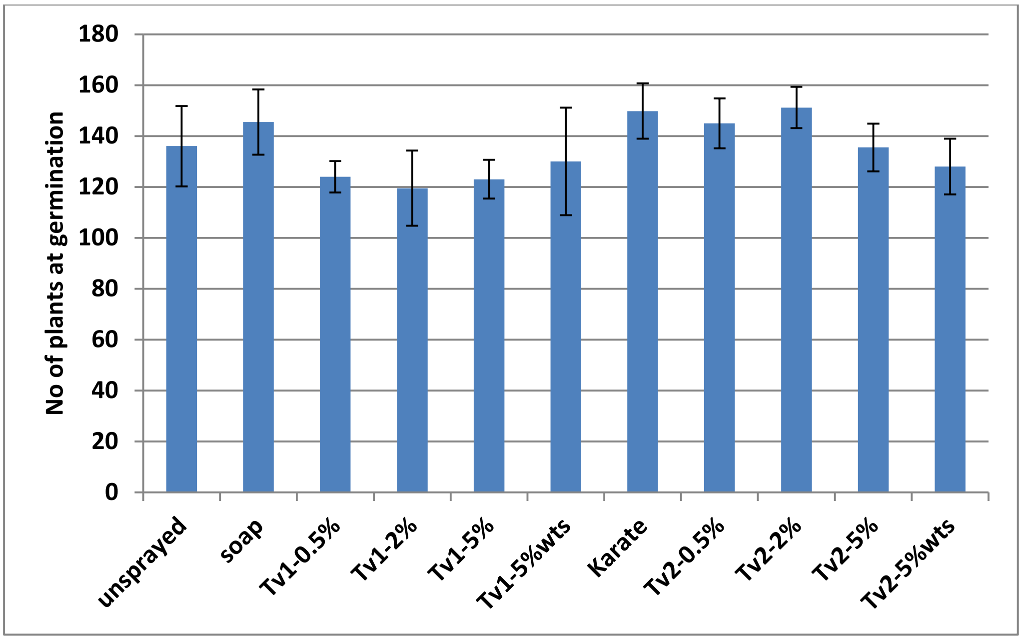

Fig 3: Effect of *Tv1 and Tv2* against bean stem maggot after establishment

The results in Figure 4 show that there were significant differences amongst treatments on number of pods harvested. The number of pods harvested in each plot treated with *Tephrosia vogelii* at 300g with and without soap was reasonably higher compared to karate. However, when weighed plots treated with karate registered highest (Figure 4).

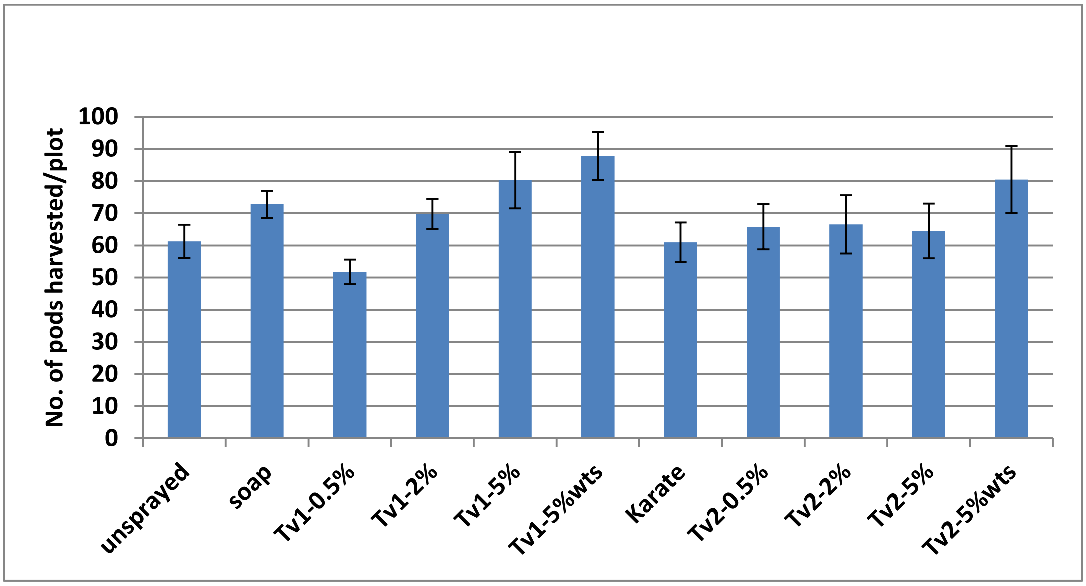

Fig 4: Effect of *Tv1and Tv2* on pod establishment

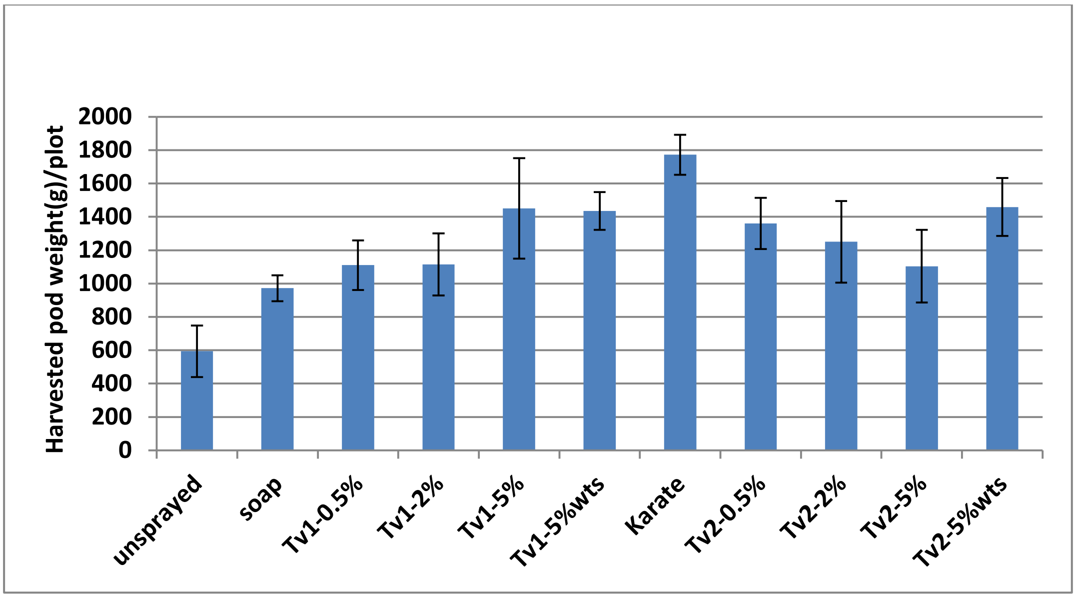

Fig 5: Effects of *Tv1 and Tv2* against pod borers

DEMOGRAPHIC FACTORS FOR THE ENDLINE STUDY

Gender of household head has a bearing on the decisions a household makes. There is now a growing recognition of gender-differentiated interactions among welfare, efficiency, and the success of technology transfers. A number of studies have documented differences in productivity between female and male-headed households (Addis et al., 1999). Other studies have shown gender differences in the adoption of improved technologies. In many male dominated countries like Malawi, it is the man who makes the ultimate decision in a household. Results from the follow up study indicated that majority (72.5%) of the households were headed by men. This indicates that in many farming households, it is the man who will be taking a leading role in making decisions regarding use of bio pesticides option for bean pest control. Results indicate that there is a significant difference between married and unmarried farmers with 76.5% of the household heads being married.

Table 3: Socio-economic characteristics of sampled household heads

Sex of household head	**Marital status of household head**		
	Married	**Unmarried**	**Total**
Male	104	4	108
	96.3	3.7	100
	91.2	11.4	72.5
Female	10	31	41
	24.4	75.6	100
	8.8	88.6	27.5
Total	114	35	149
	76.5	93.2	100
	100	100	100

Pearson chi^2 (1) =85.5****

Age has a negative influence on the levels of inefficiency in that the older the farmer gets, the less willing they are to adopt new skills and technologies. Results in Table 4 show that there is a significant difference between male and female headed households. Nevertheless in both groups the mean ages fell within the productive age group hence potential for more adoption of plant based pest management technologies. Apart from this, education plays a very critical role in making farm and marketing decisions at a household. Results have revealed that there is a significant different in schooling years of male and female headed households. Furthermore, most farming households in Malawi rely on family labour as opposed to hired labour. More often than not, household size determines the availability of family labour, results are further showing that the mean household size for male headed household is 6 while for female headed households is 5. However there is no significance difference between the two.

Table 4: Socio-economic factors of sampled household heads

Category for household head	**Male (n=108)**	**Female (n=41)**	**p-vale**
Mean age	44 (1.498)	52 (2.285)	0.007
Mean number of schooling years	8.4 (0.311)	6.1 (0.542)	0.000
Mean household size	6 (0.318)	5 (0.454)	0.177

*figures in parenthesis are standard error of the means

KNOWLEDGE AND USE OF PEST MANAGEMENT OPTIONS

Many non-variety technologies for crop improvement have been released and disseminated to farmers. For the past decades, farmers have been advised by government extension agents, NGOs to use different industrial pesticides for bean pest control in addition to other agronomic practices. Results from the baseline study indicated that 77% of the farmers knew use of bio pesticides as one way of pest control. In this follow up study, 87.9% of the farmers now know that bio pesticides can help in pest control.

Table 6: Farmer knowledge of different pest management options

Pest Management option	Yes		No	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Crop rotation	147	98.7	2	1.3
Cover cropping	116	77.9	33	22.1
Early ploughing	145	97.3	4	2.7
Timely planting	144	96.6	5	3.4
Timely weeding	147	98.7	2	1.3
Bio pesticides	131	87.9	18	12.1
Introducing beneficial insects	26	17.4	123	82.6
Industrial pesticides	139	93.3	10	6.7

Knowing a technology and using the technology are two different things; from the total sampled households 102 (68.5%) farmers of 149 sampled household used bio pesticides with 5 that introduced beneficial insects to their farms. This is slightly higher compared to baseline results where 96 (68.1%) of the sampled 150 households used bio pesticides for pest control.

Table 7: Use of different pest management options

Pest Management option	Yes		No	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Crop rotation	135	90.6	14	9.4
Cover cropping	94	63.1	55	36.9
Early ploughing	133	89.3	16	10.7
Timely planting	139	93.3	10	6.7
Timely weeding	143	96.0	6	4.0
Bio pesticides	102	68.5	47	31.5
Introducing beneficial insects	5	3.4	144	96.6
Industrial pesticides	130	87.2	19	12.8

Results from Table eight indicate that most households are using Tephrosia and Tithonia for both field pest control and post- harvest handling.

Table 8: Type of bio pesticide used by place of application

Type of bio pesticide	Field application (n=72)		Postharvest handling (n=40)	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Tobacco			1	2.5
Securidaca			5	12.5
Venonia	5	6.9	6	15
Ash			8	20
Tephrosia	30	41.7	9	22.5
Tithonia	37	51.4	11	27.5
Total	72	100.0	40	100.0

Results further showed that majority of the farmers used Cypermethyline (28%) and Dythen (24.4%) for field pest control as industrial pesticides. These are being used by many because they are also advocated by extension staff.

Table 9: Type of Industrial pesticide used for field pests

Type of Industrial pesticide	Frequency	Percentage
Actellic	1	1.2
Cypermethyline	23	28
Dimethoate	1	1.2
Dythen	20	24.4
Karate	13	15.9
Phoskill	2	2.4
Protein C	1	1.2
Round up	3	3.7
Seven	1	1.2
Soluba	13	15.9
Spear	3	3.7
Superguard	1	1.2
n	82	100.0

HUMAN CAPITAL DEVELOPMENT AND FARM DECISION MAKING

To ensure sustainability of any project there is need to develop the capacity of the target group. Results from the end-line study show that majority of the farmers did not attend any form of training as compared to 45% and 45.6% who attended forma training in bean production and pest management.

Table 10: Human capital development

Type of training	Bean production		Pest management	
	Frequency	Percentage	Frequency	Percentage
None	82	55.0	81	54.4
Training	66	44.3	65	43.6
Training and study tour	1	0.7	3	2.0

End-line results on the involvement of the respondents in carrying out various on-farm and marketing activeities are presented in Table 10. Observations from the table reveal that in most of the activities both men and women equally take part in executing the selected farm and marketing activities. In most sub-Saharan countries including Malawi, beans are considered a women crop results from baseline evidenced this by the role women took in transporting beans to the market (33.3%), doing the actual marketing (34.8%) as well as keeping the money from the bean sales (34.1%). In the end-line after the projects intervention results in Table 10 are showing that both men and women are now almost equally doing the activities together. Results are showing that 37.5% of transporting, 26.1% of actual marketing is being done by both men and women. This may be so because gender mainstreaming activities that are considered when doing on-farm participatory trials. However, looking at spraying insecticides, it is the men who are still taking a greater responsibility. This is evidenced by a proportion (34.1% from baseline and 45.4% from the end-line) of men only involved in the spraying. These results indicate that if pesticidal plant products are to go commercial it will be mostly dominated by men who appear to be less scared of handling poisonous materials.

Table 11: Percentage Distribution of Respondents According to Involvement in Various Farm Management and Marketing Activities (n=137)

Activity	Husband only	Wife only	Husband mostly	Wife mostly	Husband and wife equally	children	Hired labor	Total
Land prep	16.1	21.9	13.1	2.9	36.5	3.6	5.8	100.0
Planting	5.8	29.2	5.1	11.7	43.1	2.9	2.2	100.0
Weeding	5.4	22.3	5.4	2.3	56.2	4.6	3.8	100.0
Spraying	45.4	10.3	11.3	2.1	22.7	8.2	-	100.0
Harvesting	2.9	29.2	1.5	8.8	51.1	4.4	2.2	100.0
Post-harvest	10.3	32.4	2.9	12.9	36.8	4.4	0.7	100.0
Transporting	13.4	19.6	8.0	8.9	37.5	11.6	0.9	100.0
Marketing	16.5	29.6	7.0	13.1	26.1	7.8	-	100.0
Keeping sales	20.7	35.3	4.3	17.2	21.6	0.9	-	100.0

Results from the end-line line show that the mean bean yield is 117.17 kg per acre with mean seed planted of 18.77kg per acre. There is a high significance difference between yields of respondents across the three sites. Further results show that on average bean yield lasts within the first six months after harvest and maize within the first nine months. Farmers indicated that they get additional foods from dimba production. Beans are attacked more when grown under irrigation but now farmers are able to plant beans under irrigation knowing that pesticides are available at their hands.

Table 12: Bean and Maize crop production

Category	n	Mean	Std error	p-value
Amount bean seed planted (kg)	136	18.8	1.44	0.000
Amount of fertiliser applied to beans (kg)	97	5.0	2.23	0.028
Amount of bean yield harvested (kg)	136	117.2	14.4	0.000
Amount of maize harvested (kg)	149	1338.5	124.01	0.000
Period bean lasted (months)	133	6	0.3	0.000
Period maize lasted (months)	147	9	0.24	0.000

INCREASING EFFICACY BY INVESTIGATING THE POTENTIAL FOR SYNERGISTIC EFFECTS WHEN COMBINING PESTICIDAL PLANT SPECIES AND THUS REDUCING RISK BY ENABLING THE USE OF LOWER CONCENTRATIONS.

Some farmers which have much experience and knowledge in using pesticidal plants report that they sometimes mix plants together. Sometimes this is done simply to make up the required amounts, but some farmers claim it can improve efficacy. Indeed, research on synergistic effects between different bioactive constituents has been reported[1], and the practice of adding synergists to commercial products is well-established, e.g. the addition of sesame oil to pyrethrum as sesame contains sesamolin which increases efficacy of pyrethrins.

Research was carried out at NRI to investigate whether admixing *Tephrosia vogelii* and *Dysphania (Chenopodium) ambrosioides* could improve efficacy above that achieved when either plant is used alone. To do this, dose response curves were generated for each plant species, using adult mortality of the model test insect, *Callosobruchus maculatus*. Glass vials were coated in plant extracts at different concentrations, and adult insects were introduced to the vials after the acetone solvent had completely evaporated *T. vogelii* was significantly more toxic than *D. ambrosioides*, and the LC_{50} value for *T. vogelii* was determined as 0.3% (Fig 6) and for *D. ambrosioides* as 1% (Fig 7). Linear regressions of the dose response curves were significant for both plant species, with *T. vogelii* data presenting less variability (r^2 = 0.646, Fig 8) than the mortality data recorded for D. ambrosioides (r^2 = 0.201, Fig 9), which may suggest that toxicity is not linear with increasing concentration for *D. ambrosioides*.

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[1] Miresmailli S., Bradbury R., and Isman M.B. 2006. Comparative toxicity of *Rosmarinus officinalis* L. essential oil and blends of its major constituents against *Tetranychus urticae* Koch (Acari:Tetranychidae) on two different host plants. *Pest Management Science*, **62**: 366-371

To evaluate potential synergy, extracts of the LC_{25} concentrations of the two plant species were made separately and as a mixture of the two, both at the LC_{25} concentrations. Extracts were applied to glass vials, recording adult bruchid mortality as before, 5 replicates per treatment. The experiment was repeated on three separate occasions and data were analysed to determine the effects of treatment. Figure 5 shows that the mortality of each plant species on its own is in agreement with observed values obtained from the dose response trials, with 26% mortality for *T. vogelii* at 0.15% and 8% mortality for *D. ambrosioides* at 0.5%. When the two plant materials were combined, mortality increased to 75%, indicating a synergistic effect of nearly 40% increase in mortality. Further research is planned to confirm these results. If this effect holds true for other test insects and under field conditions, it could be a way to dramatically increase efficacy whilst reducing potential exposure to pesticidal plant materials.

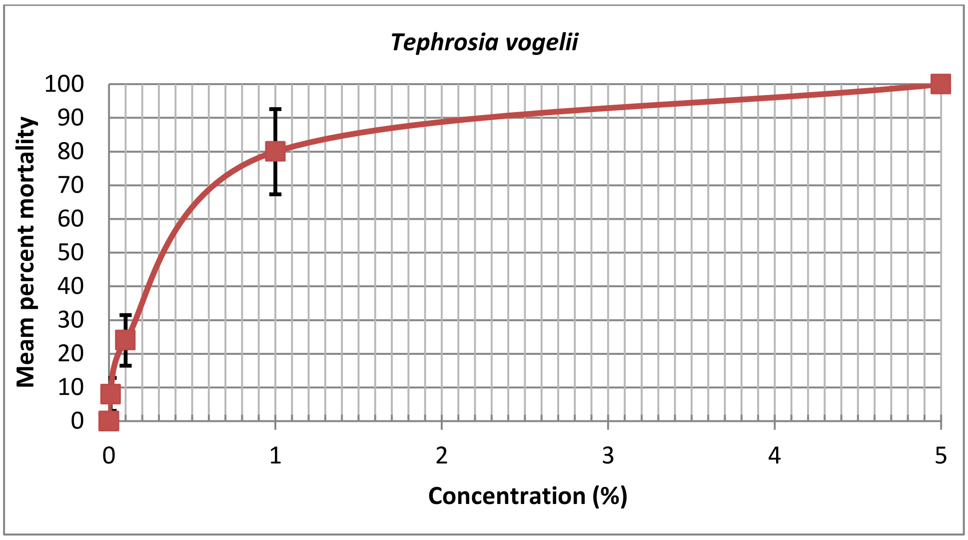
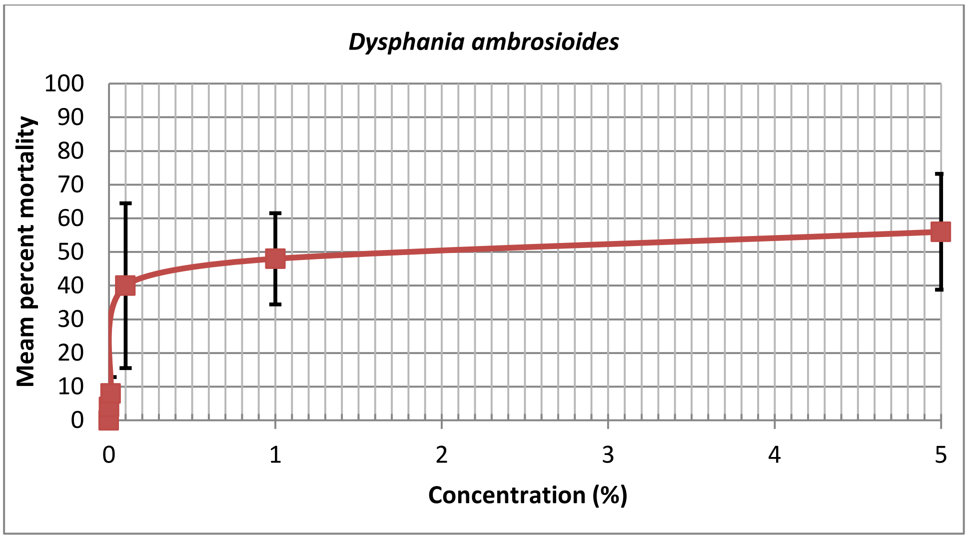


Figure 6. Dose response curve showing mean mortality (n = 5) of adult *Callosobruchus maculatus* exposed to *Tephrosia vogelii* extract-treated surfaces of glass vials after 72 hours.



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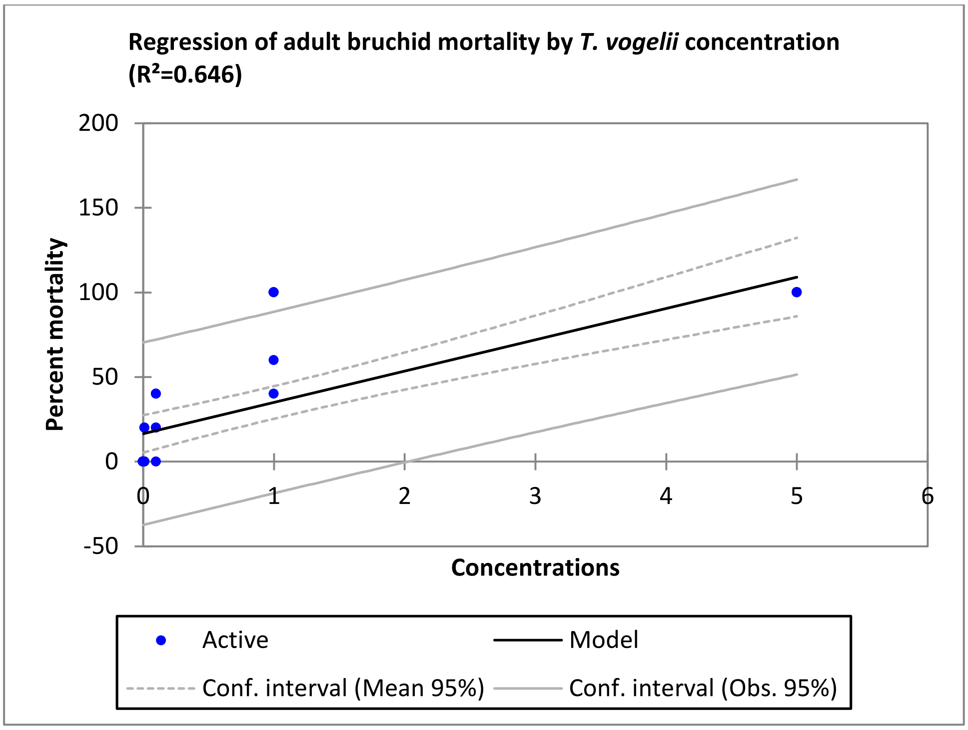


Figure 8. Linear regression of adult *C. maculatus* mortality when exposed to different concentrations (0, 0.001, 0.01, 0.1, 1.0, 5.0) of *T. vogelii* extract-treated glass surfaces.

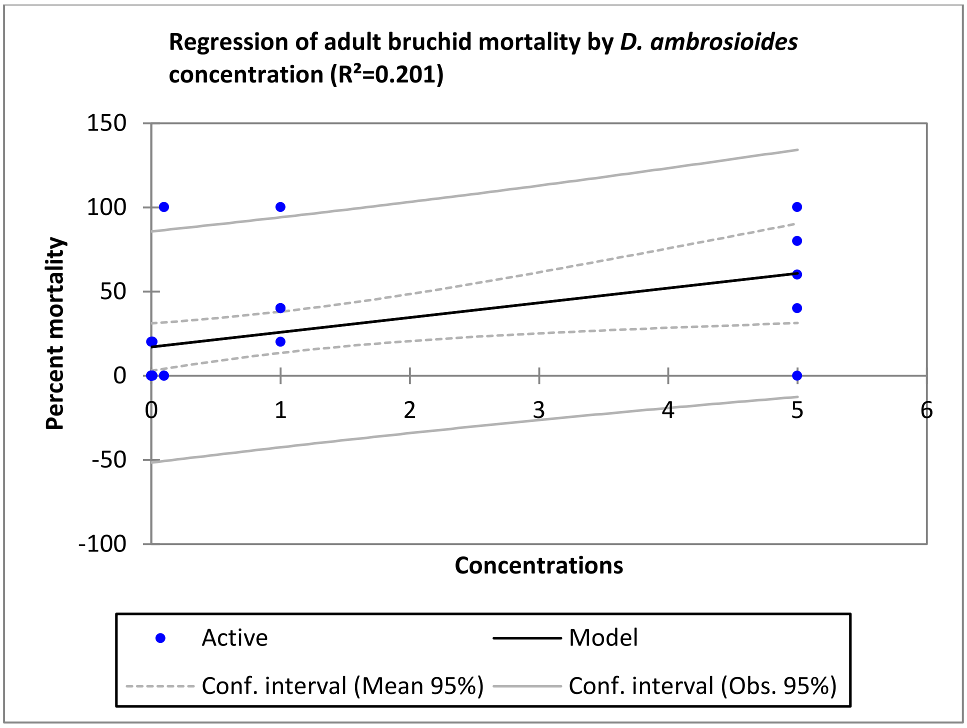


Figure 9. Linear regression of adult *C. maculatus* mortality when exposed to different concentrations (0, 0.001, 0.01, 0.1, 1.0, 5.0) of *D. ambrosioides* extract-treated glass surfaces.

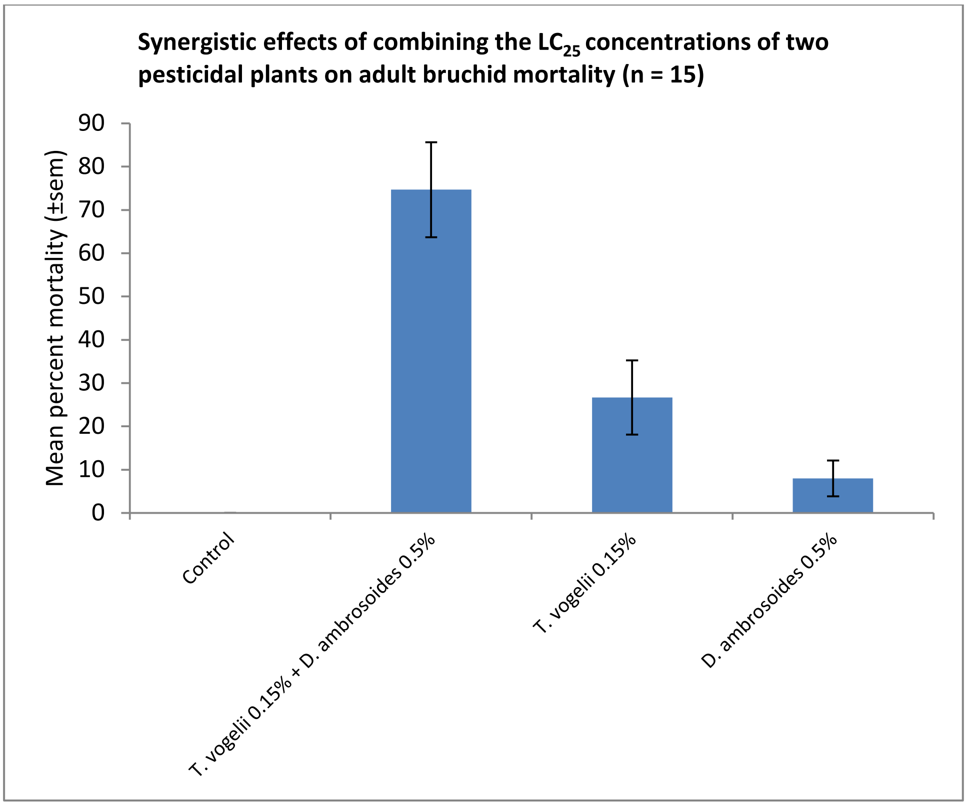
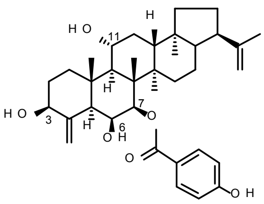


Figure 10. Effect of combining two pesticidal plant materials on adult bruchid mortality indicates a dramatic increase in efficacy, when compared to either plant species used on its own.

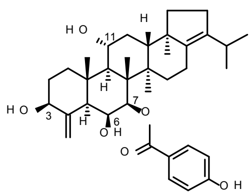
Preliminary analysis of the pesticidal plant, *Zanha africana*: Chemical constituents and their potential bioactivity.

Seven hopanes were isolated from the root bark of *Zanha africana* by semi preparative HPLC over a C18 column packing in a 10mmi.d. by 150mm column using a Waters Alliance system sepearting compounds using a gradient elution with three solvents A (MeOH): B (Water) and C (1%Fromic acid in MeCN) with A = 0, B=90 and C=10 at T=0 and A=90, B=0 and C=10 at T=20.

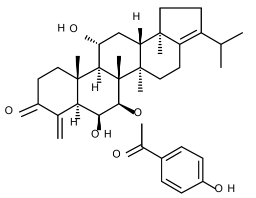
Seven hopanes were isolated by repeated separation of the extract to yield a few milligrams of the hopanes pure. These pure components were subjected to analysis by NMR spectroscopy in d-MeOH on a Bruker 400MHz instrument and their structures determined to be hopanes (Fig 11). The 4-hydroxybenzoyl moiety is responsible for the UV absorbance at c.255 nm seen in HPLC chromatograms. All compounds are new to science (have not been reported in the literature before) with the exception of Kew 1314 which is published as compound **2** in *J. Nat. Prod.* (1997) 60, 909; from *Diatenopteryx sorbifolia* (Sapindaceae) the same plant family as *Zanha africana*.



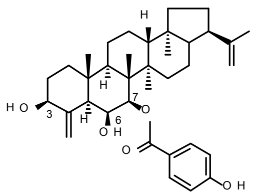
Kew1310



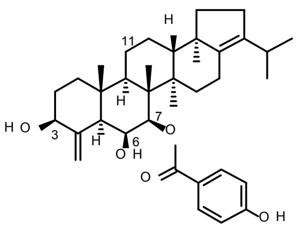
Kew 1311



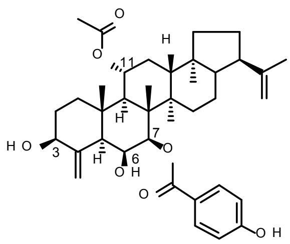
Kew 1312



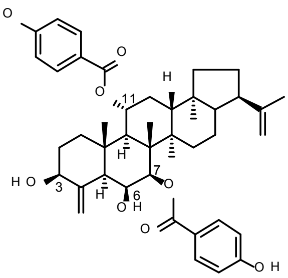
Kew1314*



Kew 1315



Kew 1349



Kew 1350

Fig 11. Structures of hopanes isolated from *Zanha africana*.

Hopanes were isolated in small quantities. While this was adequate for structural elucidation there was not sufficient material to test all compounds in bioassays. Kew 1314 and 1315 were selected to evaluate their potential toxic effects on adult bruchids, *Callosobruchus maculatus*. Generally their toxicity was quite low and considerable variation was observed among treatments (Fig 12). It is not yet clear whether these compounds are responsible for the observed efficacy reported by farmers in Tanzania who use this plant species to protect their beans from insect attack however one explanation for the lower concentration being more active is that the compounds could also be deterrent at higher concentrations so insects avoid them, as they become more concentrated rather than interact with them and get poisoned. Further work will determine how these compounds contribute to the effect observed by farmers and this may depend upon interactive effects with other compounds such as saponins.

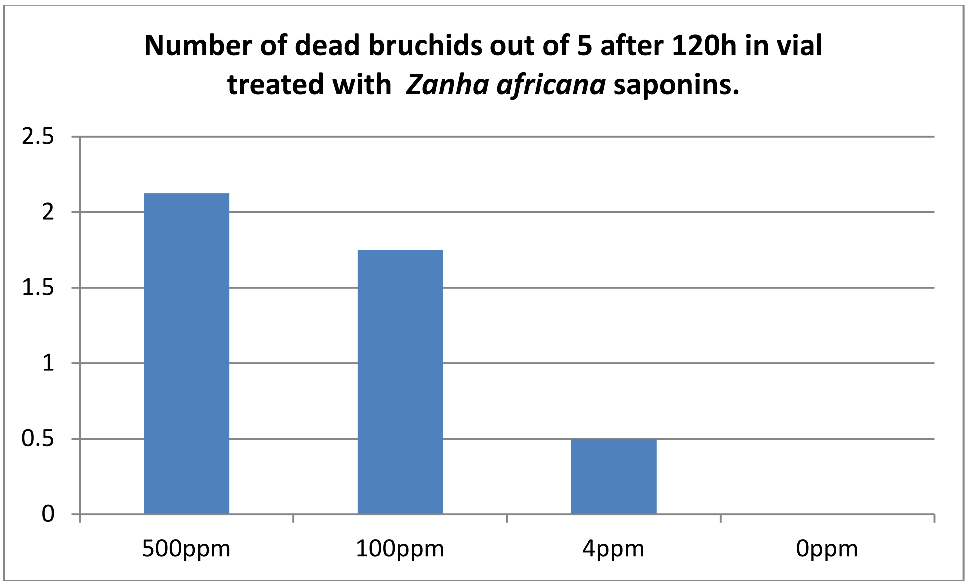


Figure 22 Concentration dependent effects of saponins from *Zanha africana*

Generally their toxicity was quite low and considerable variation was observed among treatments (Fig 13). It is not yet clear whether these compounds are responsible for the observed efficacy reported by farmers in Tanzania who use this plant species to protect their beans from insect attack. Other compounds such as saponins have also been found in *Z. africana*, and as saponins from other pesticidal plant species have been shown to be toxic, these may account for some of the farmer-observed effects. Further studies are planned to isolate and characterise the bioactive constituents in *Z. africana*.

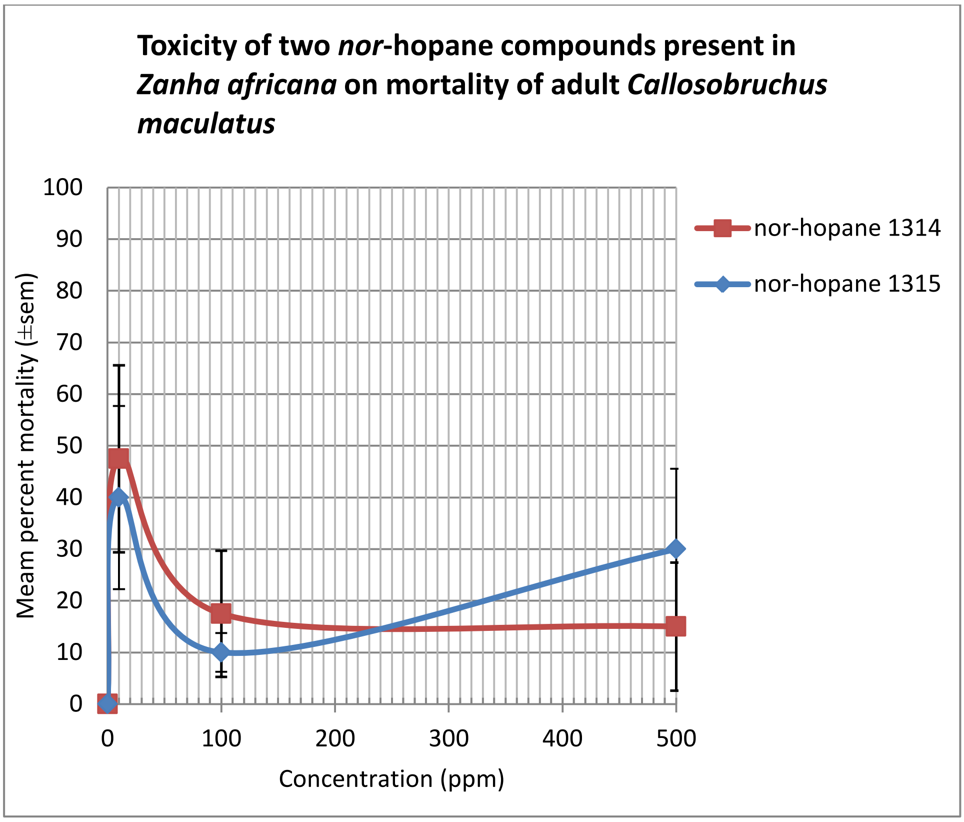


Figure 13. Dose response curve showing mean mortality (n = 5) of adult *Callosobruchus maculatus* after 72 hours exposure to two compounds isolated from *Zanha africana* applied to the surface of glass vials.

CONCLUSION

Results have shown that use of optimized pesticidal plant technologies provides poor farmers with effective, low cost and environmentally benign pest management tools for specific pest species. For some insects, including storage pests, there are various approaches that can be used as seen from the survey results however proportional use of bio-pesticides is still on the lower side hence there is need for further human development so that farmers are aware of what it takes to use bio pesticides. Pesticidal plant species namely *Tephrosia vogelii*, *Tephrosia* candida, *Zanha africana* and *Lippia javanica* have been identified as potential pesticidal plant species for use by farmers. Active ingredients and mechanisms for their activities have also been determined. *Tephrosia vogelii* offers the greatest potential for up-scaling of a proven technology that is familiar to farmers. Two chemotypes among plants used by farmers in Malawi have been identified: Chemotype 1 contains pesticidal compounds required for pest control efficacy while chemotype 2 does not have pesticidal activity. Sampling estimates that up to 25% of stands of the plant sampled from central and northern Malawi are non-pesticidal, so a blanket recommendation to farmers will not work. Pesticidal compounds have also been demonstrated from the tree *Zanha africana* in Tanzania and the herb *Lippia javanica* from Malawi, with highest levels of active substances of the latter produced from June to October.

The endline survey results have shown that there is an improvement in number of farmers who now know and use pesticidal plants across the three sites. Further improvement has been seen where now men and women share responsibilities and roles in bean farming. Finally farmers are now able to plant more beans under irrigation to support them in times of bean food shortage.