International Scholars Journals

International Journal of Agricultural Extension and Rural Development ISSN 2756-3642 Vol. 10 (7), pp. 001-013, July, 2022. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Farmers' ethno-ecological knowledge of vegetable pests and pesticidal plant use in Malawi and Zambia

Stephen P. Nyirenda[1], Gudeta W. Sileshi[2]*, Steven R. Belmain[3], John F. Kamanula[4], Brighton M. Mvumi[5], Phosiso Sola[6], Greenwell K. C. Nyirenda[7] and Philip C. Stevenson[3,8]

[1]Department of Agricultural Research Services, Lunyangwa Agricultural Research Station, P.O. Box 59, Mzuzu, Malawi.
[2]World Agroforestry Centre (ICRAF), Southern Africa Programme, Chitedze Agricultural Research Station, P.O. Box 30798, Lilongwe, Malawi.
[3]Natural Resources Institute, University of Greenwich, Chatham Maritime, Kent, ME4 4TB, United Kingdom.
[4]Mzuzu University, P/Bag 201, Luwinga, Mzuzu 2, Malawi.
[5]Department of Soil science and Agricultural Engineering, University of Zimbabwe, P.O. Box MP167, Mount Pleasant, Harare, Zimbabwe.
[6]Southern Alliance for Indigenous Resources, Box BE 398, Belvedere, Harare, Zimbabwe.
[7]University of Malawi, Bunda College, P.O. Box 219, Lilongwe, Malawi.
[8]Royal Botanic Gardens, Kew, Surrey, TW9 3DS, United Kingdom.

Accepted 25 August, 2021

While pests are a major constraint in vegetable production in many parts of Southern Africa, little is known about farmers' knowledge and management practices. A survey was conducted among 168 and 91 vegetable farmers in Northern Malawi and Eastern Zambia, respectively, to evaluate their knowledge, attitudes and traditional management practices in tomato and crucifers (brassica). All respondents in Malawi and Zambia reported pest damage on tomato and crucifers, and 75% had used synthetic pesticides. The use of pesticidal plants, cultural practices and resistant varieties constituted a smaller portion of the pest control options in both crucifers and tomato. Over 70% of the respondents were aware of pesticidal plants, and more female (75%) than male (55%) respondents reported using them. While over 20 different plant species were mentioned by respondents, *Tephrosia vogelii* accounted for 61 and 53% of the pesticidal species known to respondents in Malawi and Zambia, respectively. Farmers with small landholdings were more inclined to use pesticidal plants than those with medium and large landholding highlighting the importance of this management alternative for poor farmers. Most respondents were willing to cultivate pesticidal plants, which indicate that farmers understand the potential value of these plants in pest management.

Key words: *Azadirachta*, brasicca, *Tephrosia*, *Tithonia*, tomato, *Vernonia*.

INTRODUCTION

African agriculture is largely traditional, and pest management is a built-in process in the overall crop production system rather than a separate, well-defined activity (Abate et al., 2000). By its nature, traditional agriculture is characterised by diversity of practices and genetic resources where farmers manipulate and derive advantages from local resources and natural processes (Altieri, 1995). It is often considered a step between the local practices, which provide communities with subsistence levels of food and modern agricultural practices, which are used to mass-produce food for

*Corresponding author. E-mail: sgwelde@yahoo.com. Tel: +265-999-642-149. Fax: +265-1-707-323, +265999642149

global distribution (Chhetry and Belbahri, 2009; Jeeva, 2006). In Southern Africa, vegetable production is fast transforming from the traditional backyard garden production to more intensive systems especially in areas with supplementary irrigation (Kuntashula et al., 2006). Nevertheless, it is still dominated by cultivation of the same field year after year, and heavy dependence on family labor and locally available inputs for soil nutrient replenishment and control of weeds, pests and diseases.

In Malawi and Zambia, vegetables are valuable as a relish, providing dietary vitamins and minerals in the largely maize-based diet of rural households. Vegetables also have high market value and generate income throughout the year (Kuntashula et al., 2006; Tschirley et al., 2009). According to a survey of consumption and purchasing habits of urban Malawians (Mwandira, 2003), the most commonly bought vegetables were mustard (35%), rape (31%), tomato (13%), Chinese cabbage (8%) and cabbage (6%). In a survey conducted in Zambia (Kabaghe et al., 2009), in 2004 the most valuable vegetables were tomato, rape and cabbage, with about 38, 23 and 12% share of the total value of sales, respectively. Similarly, in 2008 about 54, 18 and 7% share of the total value of vegetable sales was taken by tomato, rape and cabbage, respectively (Kabaghe et al., 2009). Rape is especially important for domestic consumption, and the annual per capita consumption has been estimated at 15 kg (Nkhungulu and Msikita, 1985; Tschirley et al., 2009) thus ranking first in terms of the percentage share of total food expenditure of vegetables. Rape also accounts for 95% share of the informal fruit and vegetable market in Zambia (Kabaghe et al., 2009).

Pest damage severely constrains vegetable production in many parts of Southern Africa (Grzywacz et al., 2010; Kuntashula et al., 2006; Obopile et al., 2008; Sibanda et al., 2000). The tolerance of pest damage on vegetables is often very low, and farmers have to control pests whether the vegetable is grown for home consumption or sale. So far, farmers' perception of vegetable pests and how they control pests are not yet fully understood in Malawi and Zambia. The effectiveness of farmers' control practices also needs to be evaluated so that suitable and affordable strategies can be developed. An understanding of traditional knowledge and practices may give an insight and understanding of local resources, different ways of controlling pests as well as the ecological knowledge of local communities.

A growing body of literature suggests that many farming communities possess traditional knowledge of pests that affect their crops and alternative approaches to their control (Altieri, 1993; Chhetry and Belbahri, 2009; Price and Björnsen, 2006; Sileshi et al., 2008) . Traditional ecological knowledge (Berkes et al., 2008) is likely to be accompanied by an equally informed knowledge of how pests can be controlled. The strong point of farmers' knowledge is that it is the product of frequent observation of crops during the whole cropping season, and it comprehends continuities within the diverse landscape. Documenting and validating this knowledge is especially useful to set research agenda, for developing messages for communication, planning campaign strategies and form the basis for constructive collaboration between researchers and farmers (Sileshi et al., 2009; Van Mele et al., 2001). Therefore, the objectives of this study were to (i) identify priority pest problems in crucifers (brassica) and tomato crops of resource-poor farmers in Northern Malawi and Eastern Zambia; and (ii) evaluate farmers' practices in vegetable pest management including use of pesticidal plants as a platform for the development of optimised application.

MATERIALS AND METHODS

The study areas

The study was conducted in Mzimba and Rumphi districts of northern Malawi and Chadiza, Chipata and Katete districts of Eastern Zambia (Figure 1). The majority of the people in the study area in Northern Malawi belonged to the Tumbuka and Ngoni ethnic groups, while those in Eastern Zambia belonged to the Ngoni and Chewa (Nyanja linguistic) ethnic groups. Knowledge of ethnic and linguistic groups is important because this assists in the understanding of the way local people view and define the specific issues in their area. Mzimba and Rumphi districts are located in the Northern part of Malawi in the Viphya (1300 m) and Nyika (1700 m) highlands. Mzimba district has a population of 724,873 mostly of Tumbuka and Ngoni tribes. Rumphi has a population of 169,112 predominantly of Tumbuka (NSO, 2008).

Data collection and analyses

Data were collected using a household survey conducted between November and December 2007 in Northern Malawi and Eastern Zambia. Semi-structured questionnaires were employed in interviews of randomly selected households. A total of 91 and 168 farmers were interviewed in Eastern Zambia and Northern Malawi, respectively.

The qualitative and quantitative data were summarized and contingency tables were drawn. The chi-square statistic was used to test for associations. A generalized linear model assuming binomial/multinomial error distribution of farmer responses was used to characterize respondents' awareness of pesticidal plants and their use of these plants for pest control. It was hypothesized that farmer's awareness and their use of pesticidal plants is a function of farmer-specific explanatory variables such as age, sex, education level and years of experience in growing vegetable crops. Parameters of the logit-linear model were estimated using the LOGISTIC procedure of SAS (SAS, 2001).

RESULTS

Characteristics of respondents

The majority (70%) of the respondents in both Northern Malawi and Eastern Zambia were men older than 25 years of age, and had undergone formal schooling (Table 1). Over 83% of the respondents were married in both

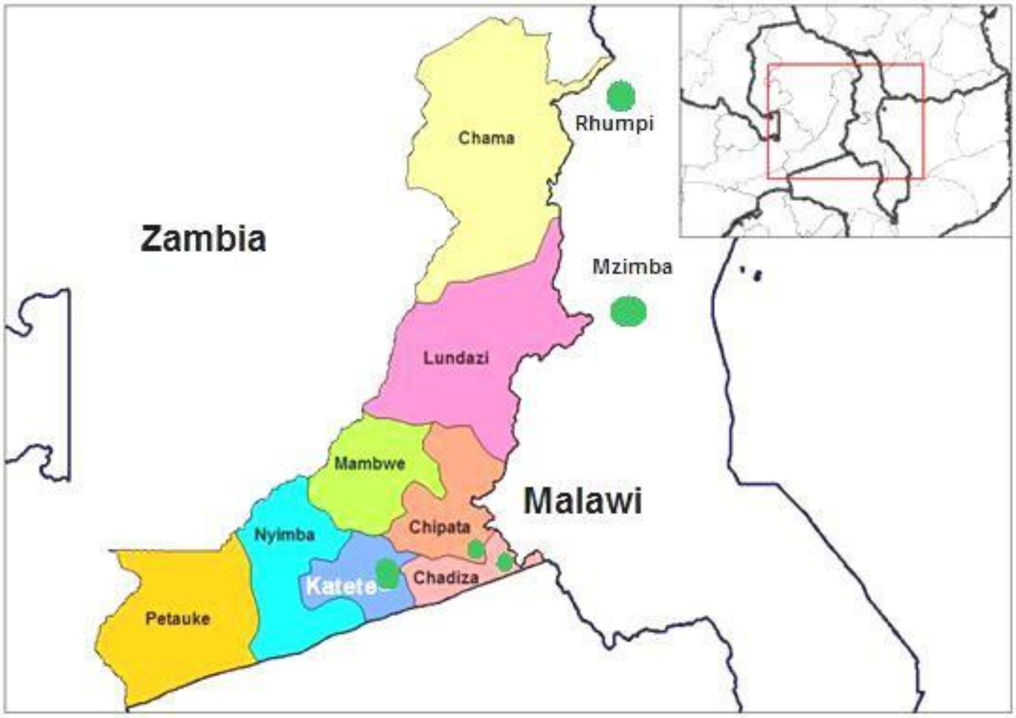


Figure 1. Map of the study areas in Malawi and Zambia. Approximate location of the districts is denoted by green oval mark.

Table 1. Percentage of respondents according to sex, age, education and household size in Northern Malawi and Eastern Zambia.

Variable	Category	Malawi (n=168)	Zambia (n = 91)
Gender	Female	25.6	16.5
	Male	74.4	83.5
Age	Young (<25 years)	17.9	12.0
	Middle (25-40 years)	48.2	44.0
	Old (>40 years)	33.9	44.0
Education	None	0.1	24.2
	Primary (up to Std 8)	64.1	57.1
	Secondary (>Std 8)	35.3	18.7
Marital	Divorce/Widow	10.1	2.2
	Married	83.3	96.7
	Single	6.6	1.1
Households	Small (<4 people)	39.9	16.4
	Medium (4-6 people)	42.2	30.8
	Large (>6 people)	17.9	52.8

countries. About 60% of the households in Malawi were medium to large (4-6 people per household). On the other hand 83.6% of the households in Zambia had 4-6 family members (Table 1). Most of the respondents (54% in Malawi and 70% in Zambia) had over 10 year of farming experience (Table 2). The majority of the

Table 2 Percentage of respondents according to their experience in farming, landholding size, land tenure and preference for tenure and appraisal of their land holding size in northern Malawi and eastern Zambia.

Variable	Category	Malawi (n = 168)	Zambia (n = 91)
Farming experience	Short (<10 years)	45.8	30.0
	Long (> 10 years)	54.2	70.0
Land size	Small (<0.4 ha)	65.5	-
	Medium (0.4-1 ha)	29.1	22.2
	Large (>1 ha)	5.4	77.8
Land ownership	Chief	4.9	17.6
	Borrow	4.9	0
	Inherit	80.8	76.9
	Rent	7.9	2.2
	Private	0.6	3.3
Preferred tenure	Customary land*	85.0	60.4
	Private/purchase	11.4	38.5
	Rent/lease	3.6	1.1
Landholding	Very small	20.2	18.7
	Small	28.0	31.9
	Perfect	51.8	49.4

*Customary land is land inherited from family members or given by the chief.

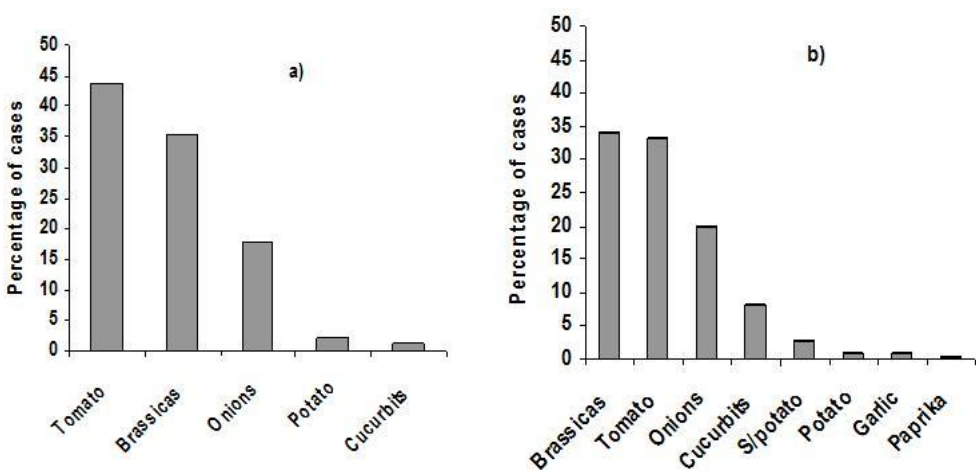


Figure 2. Vegetable crops mentioned by respondents in northern Malawi (a) and eastern Zambia (b). Percentage values were calculated as the proportion of all vegetable crop species mentioned by the respondents.

respondents (78%) in Zambia owned more than 1 ha of land, whereas, in Malawi, landholding size was relatively small with over 65% owning less than 0.4 ha. Over 76% of the respondents in both countries had inherited land, while less than 10% had either purchased or leased/rented the land (Table 2). About 50% of the respondents reckon their landholding is adequate for farming (Table 2).

Vegetable production patterns in the study areas

Tomatoes, crucifers, onions, cucurbits and potatoes were the most commonly grown vegetables in both countries (Figure 2). Tomatoes were grown by 94% of the respondents in Malawi and 83% of the respondents in Zambia. The most frequently mentioned tomato varieties were Rodade and Money Maker in both Malawi and

Table 3. Percentage of respondents growing different Brassica and tomato varieties in northern Malawi and eastern Zambia.

Country	Crop	Variety	Respondents (%)
Northern Malawi (n = 168)	Cabbage	Florida	37.5
		Maracanta	21.2
		Drum head	9.6
		Gloria	8.7
		Mayford	2.9
		Sugar loaf	1.0
		Inkuqueen	1.0
	Rape	Giant Essex	10.6
	Mustard	Unknown	4.8
	Tomato	Rodade	74.3
		Money maker	25.7
Eastern Zambia (n = 91)	Rape	Giant Essex	62.9
		Hobson	17.1
		Choumolier	2.9
	Cabbage	Drum head	2.9
		Gloria	2.9
		White rob	2.9
	Tomato	Money maker	37.5
		Rodade	23.2
		Tengelo	17.9
		Floridade	7.2
		Heinz	3.6
		Unknown	3.6
		Mkushi	3.6
		Monpale	1.8

Zambia (Table 3). About 51% of the Malawian and 40% of the Zambian respondents said that they produce two crops of tomatoes in a year. Cruciferous were grown by 75% of the respondents in Malawi and 85.7% of the respondents in Zambia. However, when values were calculated as the percentages of all vegetable crop mentioned by the respondents, crucifers accounted for 34 and 44% (Figure 2). Among the cruciferous crops, cabbage (*Brassica olerancea* var *capitata*), rape (*Brassica napus*), Chinese cabbage *(Brassica campestris* var *chinensis*) and mustard (*Brassica juncea*) were reportedly grown most frequently. Respondents from Northern Malawi mentioned seven varieties of cabbage, while those in Eastern Zambia reported three varieties (Table 3). Giant Essex was the most common variety of rape in both Malawi and Zambia (Table 3). The majority of Malawian respondents (91%) produced crucifers twice a year. About 66% of the Zambian respondents produced at least two different species/varieties of crucifers two to three times a year, indicating how important they were to the farmers surveyed.

Farmers knowledge of pests and management practices of vegetable pests

All of the respondents in Malawi and Zambia said they experienced pest damage on tomato and crucifers. According to respondents in both countries the major pests of tomatoes are the red spider mite (*Tetranychus evansi*), bollworms (*Helicorvepa armigera)* and aphids (Figure 3). The other pests of tomatoes mentioned included red ants, blister beetles, leaf- miners and variegated grasshopper mainly *Zonocerus variegatus*. The most important pests reported on crucifers were aphids (*Brevicoryne brassicae*), diamond back moths (*Plutella xylostella*), cutworms (*Agrotis* spp.), webworms (*Hellula undalis*), grasshoppers and beetles (Figure 3). Because of high disease incidence during the rainy season, most farmers grow vegetables during the dry season.

Over 75% of the respondents in Zambia and Malawi had used pesticides to control insect pests on crucifers and tomato crops (Figure 4). Respondents sometimes

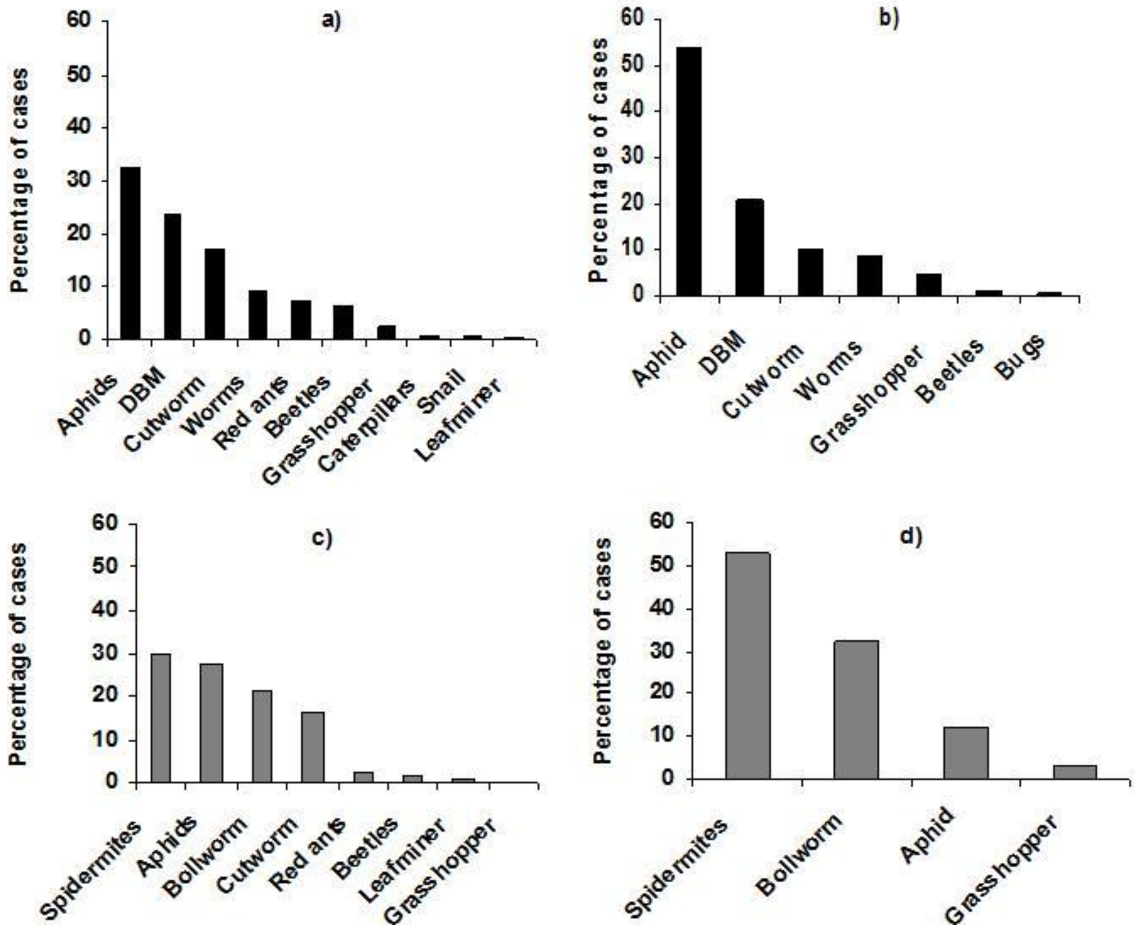
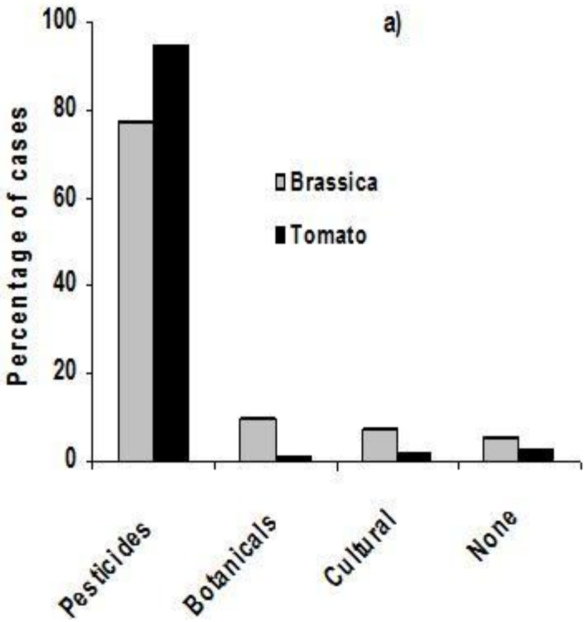


Figure 3. Major pests of Brassica and tomato mentioned by respondents in northern Malawi (a & c) and eastern Zambia (b & d). Values were calculated as the percentages of all insect pest species mentioned by the respondents.

reported using pesticides that are hazardous (class I) according to the WHO classification as well as products not recommended for control of pest in vegetable crops (Tables 4 and 5). In some instances, farmers only knew pesticides by their trade names, which vary widely. This was frequent in Eastern Zambia where the same product was known by different names.

The use of pesticidal plants, cultural practices and resistant varieties constituted a smaller portion of the pest control options in both crucifers and tomato. Cultural practices mainly involved hand-picking and destroying visible insects. Respondents reported over 20 different pesticidal plant species (Table 6). These included *Tephrosia vogelii*, neem (*Azadirachta indica*), *Mucuna pruriens*, *Bobgunnia (Swartzia) madagascarensis*, *Euphorbia tirucali*, *Vernonia amygdalina*, *Tithonia diversifolia*, *Solanum panduriforme* and tobacco (*Nicotiana tabacum)* (Table 6). Respondents in the study areas sometimes identified the same species with different local names. The values presented in Table 6 were calculated as the percentages of all species mentioned by the respondents. This was done to enable listing of priority species for further studies. Accordingly, *T. vogelii* accounted for 67% and 63% of the species known to the respondents as pesticidal plants in Northern Malawi and Eastern Zambia, respectively (Table 4). However, only 13.2% of the respondents had actually used *T. vogelii* for pest control despite most being aware of it. *T. diversifolia*, *V. amygdalina*, *E. tirucali* and *A. indica* were the other most frequently reported pesticidal plant species but there may be numerous others yet to be identified.

Awareness of pesticidal plants was associated significantly only with the educational level of respondents. The significant determinants of use of pesticidal plants were gender (^{2} = 6.0, P = 0.014), education (^{2} = 10.3, P = 0.006) and land holding size (^{2} = 15.9, P = 0.004) (Table 7). More female respondents (75%) were reported using pesticidal plants than their male counterparts (55%). The majority of respondents (73%) who attended secondary school had used pesticidal plants while 93% of those who did not go to



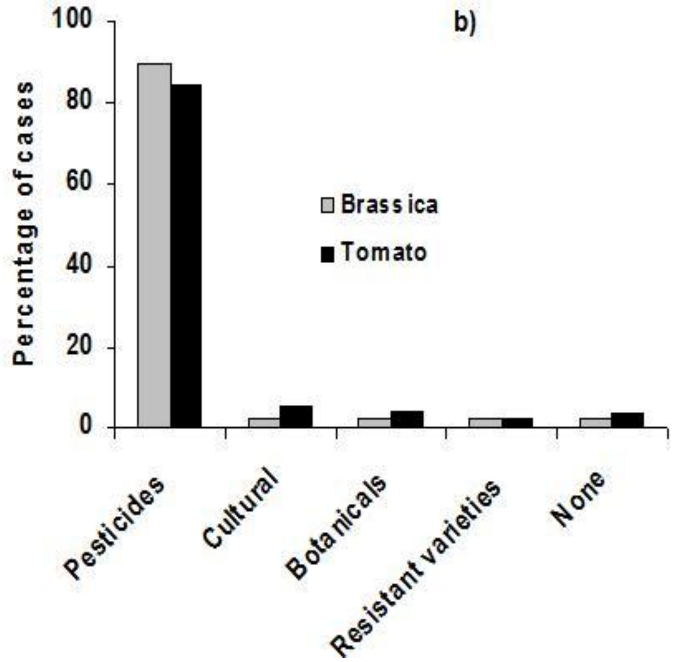


Figure 4. Control measures mentioned by respondents in a) northern Malawi and b) eastern Zambia. Values were calculated as the percentages of all control measures mentioned by the respondents.

Table 4. Percentage respondents using synthetic pesticides for vegetable pest control in Northern Malawi and their WHO classification.

Pesticide	Respondents (%)	WHO class*
Phoskil/Parathion/Protein C	25.2	I
Cypermethrin/Ripcord	22.7	II
Azodrin	13.6	I
Karate/Lambda cyhalothrin/Fenthion	10.9	II
Carbaryl	6.2	II
Dithane	5.6	0
Copper oxychloride	4.4	III
Bravo/Daconil/Chlorothalonil	3.9	U
Dimethoate	2.9	II
Actellic	1.4	I
Dursban/Chlorpyrifos	1.1	II
Funguran/Copper hydroxide	0.7	III
Novachlorvos	0.6	I
Acephate/Orthene	0.6	III
Metaphos/Methamidophos	0.1	I

*WHO classification found at http://www.who.int/ipcs/publications/pesticides_hazard/en/. (I = extremely or highly hazardous; II = moderately hazardous; III = slightly hazardous; U = unlikely to present acute hazard; 0 = basic).

school did not use pesticidal plants. Farmers with small landholdings were more inclined to use pesticidal plants than those with medium and large holdings. Less than 22% of respondents with small landholdings had not used pesticidal plants. On the other hand, 70% of those with large landholdings said they have not used them. There is clearly a strong association between relative wealth and interest in alternatives to synthetic pesticides that may simply be due to resource endowment and corroborates our assumption that they are most relevant to the poorest farmers. Table 7 shows the significant predictors in the logit-linear model relating knowledge

Table 5. Percentage respondents using specific synthetic pesticides in eastern Zambia and their WHO classification.

Name	Respondents (%)	WHO class*
Phoskil/Monocrotophos	41.4	I
Copper oxychloride	9.1	III
Fenkil	4.5	I
Karate	3.5	II
Kanoma/Canon/Yakanona/Lakanona(Milky)	8.0	-
Cotton pesticides	2.8	-
Diefen/Dithane	4.2	0
Spear	2.1	-
Doom	1.7	-
Malathion/Marazone	2.4	III
Soluba	2.4	II
Decitab	1.4	I
Delta-x 100EC	1.4	II
Fortis k	1.4	-
Sailax	1.4	II
Acetan	1.0	III
Batha	1.0	II
Mathioruz	1.0	III
Surf	1.0	-
Twatonge	1.0	-
Cypermethrin/ Sepermefin/Fastac	2.4	II
Nicotine sulphate	0.7	
Red spider killer	0.7	I
Spur acetamirids	0.7	
Vagila	0.7	-
Dikof	0.3	II
Dursban	0.3	II
Logo/Dimethoate/Rogor	0.3	II
Sylesc	0.3	-
Tetex	0.3	-

*WHO classification found at http://www.who.int/ipcs/publications/pesticides_hazard/en/. (I = extremely or highly hazardous; II = moderately hazardous; III = slightly hazardous; U = unlikely to present acute hazard; 0 = basic).

Table 6. Species of pesticidal plants known to respondents (in %) in Eastern Zambia and Northern Malawi.

Species name	Local name (s)	Zambia	Malawi
Tephrosia vogelii	Ububa, Mtetezga, Gulinga, Muthuthu	60.7	53.4
Vernonia amygdalina	Soyo, Mluluzga, Futsa	NM	10.2
Tithonia diversifolia	Belibeli, Heji	3.3	7.1
Euphorbia tirucali	Nkadze, Nkhadzi, Mduzi	3.3	6.8
Solanum panduriforme	Nthula, Nthuma	NM	4.8
Azadirachta indica	Neem	5.0	2.7
Bobgunnia madagascarensis	Mchelekete, Mulundu, Ndale, Kasokosoko	3.3	2.7
Mucuna pruriens	Chitedze	5.0	NM
Sesbania sesban	Jerejere	3.3	NM
Euphorbia ingens	Mlangale	NM	2.0
Terminalia sericea	Mjoyi	NM	2.0
Dolichos kilimandscharicus	Dema, Dindya	NM	1.7
Nicotiana tabacum	Tobacco, Fodya, Hona	1.7	1.7

Table 6. Contd.

Toona ciliate	Senderera	1.0	1.4
Alium cepa	Onion, Anyezi, Hanyezi	1.7	NM
Capcicum spp	Pepper, Sabola, Tsobola	1.7	NM
Aloe vera L.	Chinthembwe	NM	0.3
Cassia abbreviate	Mubabani	NM	0.3
Cussonia spp	Chibwabwa	NM	0.3
Alium sativum	Garlic, Adyo	NM	0.3
Lantana camara L	Maluwa	NM	0.3
Parinari spp	Mwambula, Mbula, Muula	NM	0.3
Erythrophleum suaveolens	Mwayi, Mwavi	NM	0.3
Agave sisaliana	Sisal, Kholokoto, Khonje	NM	0.3
Tagetes minuta	Welensky, Marigold	NM	0.3

NM = Not mentioned.

Table 7. Logit-linear model results on determinants of farmers' knowledge and use of pesticidal plants in northern Malawi and eastern Zambia.

Parameter	Category	Estimate (s.e.)	Wald χ^2	Probability
Northern Malawi		-1.12 (0.23)	24.82	<0.0001
Gender	Female	0.02 (0.19)	0.01	0.9341
Education	None	1.08 (0.31)	11.84	0.0006
	Primary	-0.19 (0.22)	0.69	0.4057
Experience	Long	0.29 (0.17)	2.95	0.0857
Eastern Zambia		0.16 (0.39)	0.16	0.6854
Gender	Female	-0.57 (0.23)	5.96	0.0146
Education	None	2.00 (0.75)	7.08	0.0078
	Primary	-0.65 (0.40)	2.60	0.1068
Experience[1]	Long	0.07 (0.18)	0.17	0.6805
Household size[2]	Large	0.10 (0.25)	0.15	0.6985
	Medium	-0.05 (0.23)	0.04	0.8355
Landholding size[3]	Large	0.84 (0.26)	10.05	0.0015
	Medium	0.03 (0.23)	0.01	0.9049

[1]Experience: Long (more than 5 years of farming experience), short (less than 5 years of farming experience); [2]Household size: large (more than 6 people), medium (4-6 people), small (less than 4 people); [3]Landholding size: large (more than 1 ha), medium (0.5 to 1.0 ha), small (less than 0.5 ha).

and use of pesticidal plants. Respondent's knowledge was described by models with gender, education level and farming experience giving 59.1% correct classification (25.4% discordant). Respondent's use of pesticidal plants was adequately described by a model with gender, education level, farming experience, household size and landholding size that gave 76.8% correct classification (20% discordant).

About half of respondents in Malawi believe that pesticidal plants were abundant, whereas only 5% of Zambian participants thought this to be the case; suggesting strong regional difference in perception (Figure 5) . Friends/parents, researchers and extension staff were the major sources of information on pesticidal plants (Figure 6) and despite its oft lauded value for the promotion of agricultural technologies, the radio contributed the least to farmers' knowledge in both countries. Respondents said they were willing to cultivate pesticidal plants such as *T. vogelii*, neem and *Vernonia* (Figure 7).

DISCUSSION

The study has revealed that tomatoes and crucifers are cropped two to three times a year. This is in agreement with reports from other parts of Zambia (Kuntashula et al., 2006) and Malawi (Mwandira, 2003) showing that

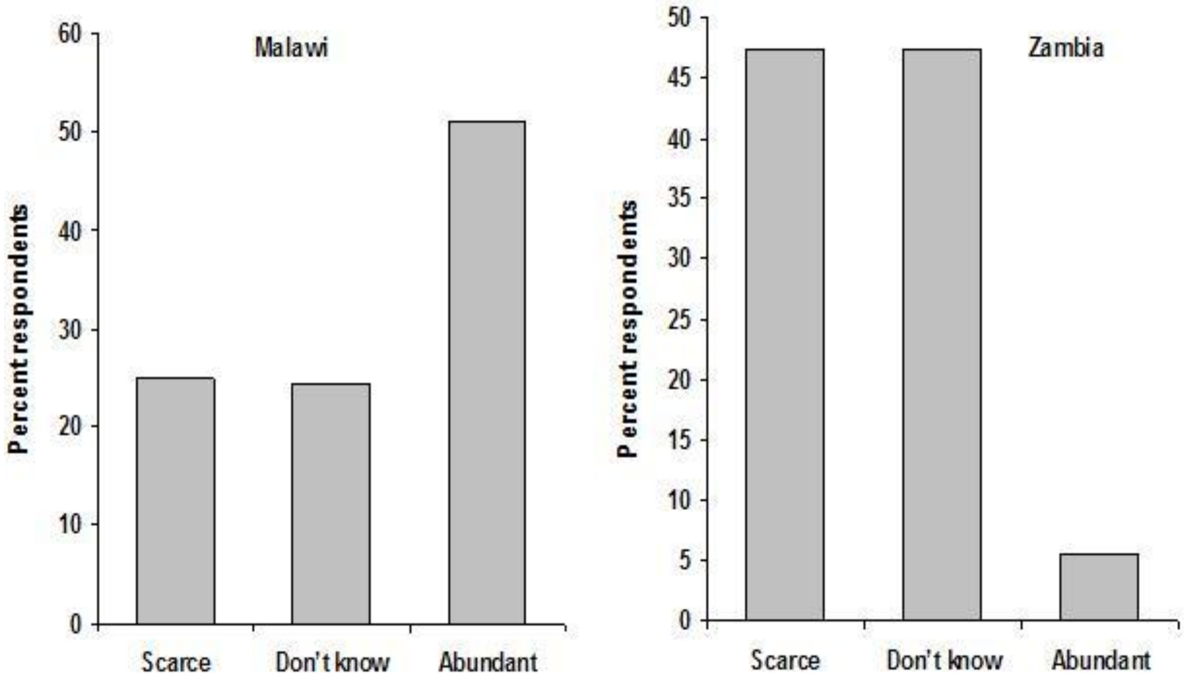


Figure 5. Perception of availability of pesticidal plants among Malawian and Zambian respondents.

farmers grow vegetables during both the wet season (in the up-land fields) and dry season (in the wetlands). With the availability of heat-tolerant cultivars, crucifers such as cabbage are now cultivated throughout the year in southern Africa (Kfir, 2003). This has implications on the build-up of pest populations. The results of this study also support earlier reports that tomatoes and crucifers are the main vegetables grown widely in the two countries (Nkhungulu and Msikita, 1985; Obopile et al., 2008; Theu, 2008). This indicates how important these vegetables are to the subsistence farmers in the study areas.

According to the farmers' perceptions, red spider mite and bollworms are the major insect pests of tomato, while the diamond back moth, webworms and aphids are major pests of crucifers in Northern Malawi and Eastern Zambia. This is consistent with the literature from other parts of Southern Africa (Grzywacz et al., 2010; Obopile et al., 2008; Sibanda et al., 2000). The red spider mite is an invasive species in Africa and the present findings highlight its increasing importance in the region. Wide expansion of the mite to new areas in Africa has been predicted (Migeon et al., 2009), thus new technologies to manage this pest that are particularly relevant for resource-poor farmers need to be identified and promoted. The diamond back moth and aphids (*B. brassicae*, *Lipaphis erysimi* and *Myzus persicae*) have been identified as the most damaging pests of crucifers in most of Eastern and Southern Africa (Grzywacz et al., 2010; Kfir, 2003; Sibanda et al., 2000) and the present survey confirms this to be the case for Malawi and Zambia too. Other major pests of crucifers include caterpillars such as the cabbage webworm that seriously damage cabbage in Eastern Zambia (Kuntashula et al., 2006).

Results of this study are also in agreement with reports of the growing dependence on synthetic insecticides for the control of vegetable crop pests (Grzywacz et al., 2010; Obopile et al., 2008; Orr and Ritchie, 2004). For example, Orr and Ritchie (2004) reported up to 19 applications to tomato and 14 applications to cabbage per year in the wetlands of Southern Malawi. Most of the pesticides applied are potent toxins and their intensive use poses potential hazards to humans, livestock and the environment (Chambers et al., 2001; Ngowi et al., 2007). The fact that farmers applied insecticides that were not recommended for vegetable pest control is indicative of the poor knowledge associated with pesticide use and the potential problems this can cause. Incorrect use can be ineffective and even exacerbate the problem by encouraging the emergence of resistant pest populations. For example, the diamond back moth has developed resistance to a wide range of common insecticides in Africa and Asia (Grzywacz et al., 2010). With the widespread use of insecticides in Southern Africa, local populations of this pest have started developing resistance to synthetic pyrethroids, organophosphates and carbamates (Kfir, 2003). The indiscriminate use of chemical pesticides to achieve higher vegetable yields could lead to disruption of natural control systems, increase the risk of contamination of the farm environment, pesticide residues in fresh produce and

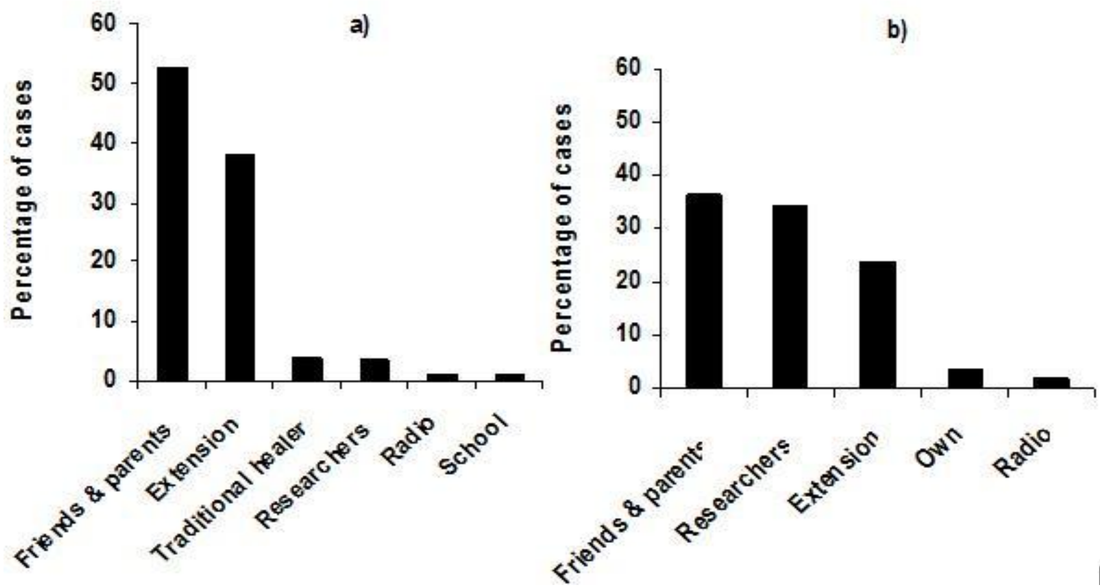


Figure 6. Source of information on pesticidal plants in a) Northern Malawi and b) Eastern Zambia. Values were calculated as the percentages of all information sources mentioned by the respondents.

increase health risks to consumers. This highlights the importance of identifying and promoting safer and low-cost alternatives to the synthetic products.

One such alternative is the use of botanicals. The present study has documented farmers' traditional use of various toxic or insect repellent plants. Such plants may provide environmentally benign and low cost alternatives with high potential efficacy that is particularly relevant to the farming systems of sub-Saharan Africa (Isman, 2008). Some of the plant species reported in the study area are known to be used by farmers elsewhere (Mugisha-Kamatenesi et al., 2008). Based on the results of farmers' previous use and willingness to cultivate, it can be concluded that *T. vogelii* is the species with the greatest potential for development and optimisation in the region. *T. vogelii* has been used by farmers in other parts of Africa (Blommaert, 1950; Mugisha-Kamatenesi et al., 2008; Sileshi et al., 2008; 2009). In Northern Zambia, the Adaptive Research Planning Team (ARPT) assessed *T. vogelii* for control of cabbage pests, and showed it to be as effective as the synthetic pyrethroid -cypermethrin. Recently, *T. vogelii* has been tested on a variety of field insects including those damaging vegetable crops (Kuntashula et al., 2006). *T. vogelii* is known to be a source of rotenoids, which have non-residual insecticidal activity (Barnes et al., 1967; Blommaert, 1950). However, the specific roles of the different rotenoids have not been confirmed or proven against many insect species and it needs evaluating before it is widely promoted. This is because some studies suggest that rotenoids may not be responsible for the insecticidal activity of this species (Koona and Dorn, 2005). Also the chemistry of this species may be highly variable (Lambert et al., 1993) and this requires studies on field grown material since the use of plant species requires that the raw material is reliable and provides consistent efficacy to farmers.

The advantage of *T. vogelii* is that it is widely used for soil fertility improvement in agroforestry systems in the study area (Sileshi and Katanga, 2002; Sileshi et al., 2008). Therefore, promotion of this species as a pesticidal plant will not require additional investments in terms of seed sourcing and farmer training. One major bottleneck to its promotion for local use has been the lack of information on its safety to humans, although farmers do not regard use of *T. vogelii* as hazardous to their health. This has been based on the belief that historically they eat fish which had been poisoned by *T. vogelii* and never become ill (Karlsson, 1995).

Similarly, *Tithonia diversifolia* has been widely used for soil fertility improvement and it is easily accessible to most farmers as it is found in most parts of Eastern and Southern Africa as an invasive species. The limitation of this species is that it is rapidly invading natural ecosystems. At present it has been declared as a Category I weed in South Africa, and its planting is restricted (Henderson, 2001). *Tithonia* can colonize farmlands quickly and if uncontrolled it can become an environmental weed. Therefore, planting this species on farm land is not recommended although its invasive nature could be combated in small part by using it as a pesticidal plant.

Most respondents were willing to cultivate pesticidal plants. This indicates that farmers value pesticidal plants, and that they are willing to set aside a portion of their cultivatable land to grow them. Land tenure is probably one of the bottlenecks to planting trees (German et al., 2009) even if farmers may be willing to grow pesticidal plants since it may take a long time for the pesticidal

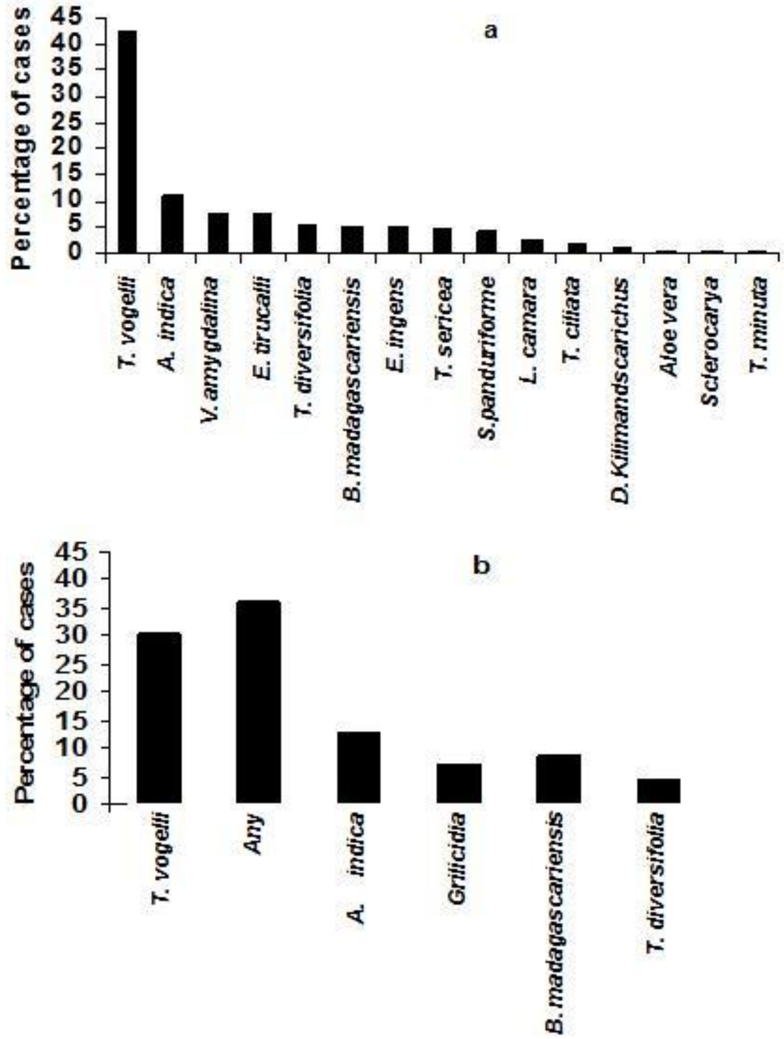


Figure 7. Pesticidal plants that respondents are willing to plant in Northern Malawi (a) and Eastern Zambia (b). Values were calculated as the percentages of all pesticidal plant species mentioned by the respondents.

material to be produced (e.g., if it is fruit), by which point the land tenure may expire or circumstances change. The majority of respondents in the study area inherited land and also preferred customary land tenure. This is probably because the existing land user-rights provided smallholder farmers much freedom in land utilization. Initial appropriation of customary land both in Malawi and Zambia is often undertaken through treaties with local chiefs who allocate land as per customary law. So the extent to which this could influence the willingness of farmers to cultivate pesticidal plants needs to be investigated. Future studies need to establish this aspect as most land holding capacity in the two countries is very small.

In conclusion, the use of pesticides (including many classified as toxic) without protective gear and sufficient training highlights the urgent need for promotion of safer and low cost pest management tools as alternatives to the synthetic products. This study has revealed that smallholder farmers are well aware of pesticidal plants as one alternative even though relatively few farmers currently admit to using them. Although advocacy for the use of pesticidal plants has increased, there is no clear validation of their efficacy against the specific pests reported in this survey. This study formed the basis for prioritizing plant species for evaluation of their efficacy and their safety to users and provides a platform for technical research and farmer participatory activities.

ACKNOWLEDGEMENTS

This work was financed by the European Union through the Southern African Development Community (SADC)

Secretariat's Implementation and Coordination of Agricultural Research and Training (ICART) project and the African, Caribbean and Pacific (ACP) Science and Technology programme. The contents of this document are the sole responsibility of the authors and can under no circumstances be regarded as reflecting the position of the SADC Secretariat or the European Union.

REFERENCES

Abate T, van Huis A, Ampofo JKO (2000). Pest management strategies in traditional agriculture: An African perspective. Annu. Rev. Entomol., 45: 631-659.

Altieri MA (1993). Ethnoscience and biodiversity: key elements in the design of sustainable pest management systems for small farmers in developing countries. Agr. Ecosyst. Environ., 46: 257-272.

Altieri M (1995). Agroecology: The Science of sustainable agriculture, Boulder, Colorado: Westview Press.

Barnes DK, Freyre RH, Higgins JJ, Martin JA (1967). Rotenoid content and growth characteristics of *Tephrosia vogelii* as affected by latitude and within-row spacing. Crop Sci., 7: 93–95.

Berkes F (2008). Sacred Ecology: Traditional ecological knowledge and resources management, 2nd ed, New York: Routledge, p. 336.

Blommaert KLJ (1950). The plant *Tephrosia vogelii* Hooker as a fresh water fish poison. Roy. Soc. South Afr. Trans., 32: 247-263.

Chambers HW, Boone ZS, Carr RL, Chanbers JE (2001). Chemistry of organophosphorus insecticides. In: Robert I.K. (ed) Handbook of Pesticide Toxicology, Academic Press, CA, pp. 913–917.

Chhetry GKN, Belbahri L (2009) Indigenous pest and disease management practices in traditional farming systems in north east India: A review. J. Plant Breeding Crop Sci., 1: 028-038.

German G, Akinnifesi FK, Edriss AK, Sileshi G, Masangano C, Ajayi OC (2009) Influence of property rights on farmers' willingness to plant indigenous fruit trees in Malawi and Zambia. Afr. J. Agr. Res., 4: 427-437.

Grzywacz D, Rossbach A, Rauf A, Russell DA, Srinivasan R, Shelton AM (2010). Current control methods for diamond back moth and other brassica insect pests and the prospects for improved management with lepidopteran-resistant Bt vegetable brassicas in Asia and Africa. Crop Prot., 29: 68-79.

Henderson L (2001). Alien weeds and Invasive plants: A complete guide to declared weeds and invaders in South Africa, Paarl printers, Cape Town.

Isman MB (2008). Botanical Pesticides: for richer or poorer. Pest Manage. Sci. 64: 8-11.

Jeeva SRDN, Laloo RC, Mishra BP (2006). Traditional agricultural practices in Meghalaya, North East India. Indian J. Trad. Knowl., 5: 7-18.

Kabaghe C, Hichaambwa M, Tschirley D (2009). Fruit and vegetable production, marketing and consumption in Zambia: Overview of empirical analysis. Paper presented at the ZNFU Fruits and Vegetables Annual General Meeting, Mulungushi International Conference Centre, Lusaka. 13 October 2009.

Karlsson T (1995). Plant derived pesticides - field trials and farmers experience in Laupula province. In: Proceedings from the first National Symposium in Zambia held in Lusaka, 2nd-5th August of 1994.

Kfir R (2003). Biological control of the diamond back moth *Plutella xylostella* in Africa. In: Neuenschwander P, Borgameister C, Langewald,J (eds) Biological control in IPM systems in Africa, CAB International, Wallingford, pp. 363-375.

Kuntashula E, Sileshi G, Mafongoya PL, Banda J (2006). Farmer participatory evaluation of the potential for organic vegetable production in the wetlands of Zambia. Outlook Agr., 35: 299-305.

Koona P, Dorn S (2005). Extracts from *Tephrosia vogelii* for the protection of stored legume seeds against damage by three bruchid species. Ann. Appl. Biol., 147: 43-48

Lambert N, Trouslot MF, Nefcampa C, Chrestin H (1993). Production of rotenoids by heterotrophic and photomixotrophic cell-cultures of *Tephrosia vogelii*. Phytochemistry, 34: 1515-1520**.**

Migeon A, Ferragut F, Escudero-Colomar LA, Fiaboe K, Knapp M, Gilberto J, de Moraes GJ, Ueckermann E, Navajas M (2009). Modelling the potential distribution of the invasive tomato red spider mite, *Tetranychus evansi* (Acari: Tetranychidae). Expl. Appl. Acarol., 48: 199-212.

Mugisha-Kamatenesi M, Deng AL, Ogendo JO, Omolo EO, Mihale MJ, Otim M, Buyungo JP, Bett PK (2008). Indigenous knowledge of field insect pests and their management around Lake Victoria basin in Uganda. Afr. J. Environ. Sci. Tech., 2: 342-348.

Nkhungulu IC, Msikita W (1985). Importance and development of rape (*Brassica napus* L.) as a vegetable in Zambia. Acta Hort., 153: 163-168.

Ngowi AVF, Mbise TJ, Ijani ASM, London L, Ajayi OC (2007). Smallholder vegetable farmers in Northern Tanzania: Pesticides use practices, perceptions, cost and health effects. Crop Prot. 26: 1617–1624.

NSO (2008). Population and housing census preliminary report. Zomba, Malawi: National Statistical Office.

Obopile M, Munthali DC, Matilo B (2008). Farmers' knowledge, perceptions and management of vegetable pests and diseases in Botswana. Crop Prot., 27: 1220-1224.

Orr A, Ritchie JM (2004). Learning from failure: Smallholder farming systems and IPM in Malawi. Agr. Syst., 79: 31-54.

Price LL, Björnsen Gurung AB (2006). Describing and measuring ethno-entomological knowledge of rice pests: tradition and change among Asian farmers. Environ. Dev. Sustain., 8: 507-517.

Sibanda T, Dobson HM, Cooper JF, Wanyangarirwa W, Chiimba W (2000). Pest management challenges for smallholder vegetable farmers in Zimbabwe. Crop Prot., 19: 807-815.

Sileshi G, Katanga R (2002). The many uses of *Tephrosia*, Africa's wonder species. Ground Up, 1: 14-17.

Sileshi G, Kuntashula E, Matakala P, Nkunika PO (2008). Farmers' perceptions of pests and pest management practices in agroforestry in Malawi, Mozambique and Zambia. Agrofor. Syst., 72: 87-101.

Sileshi GW, Nyeko P, Nkunika POY, Sekamatte BM, Akinnifesi FK, Ajayi OC (2009). Integrating ethno-ecological and scientific knowledge of termites for sustainable termite management and human welfare in Africa. Ecol. Soc., 14(1): 48 [Online].

Theu MPKJ (2008). Diseases and nematodes as vegetable problems. In: Chadha ML, Oluoch MO, Saka AR, Mtukuso AP, Daud AT (eds) Vegetable Research and Development in Malawi, AVRDC (The World Vegetable Center) AVRDC Publication No. 08-705.

Tschirley D, Hichaambwa M, Mwiinga M (2009). Assessment of the tomato, onion, and rape supply chains serving Lusaka: Insights for research and investment priorities. FSRP Working Paper 44.

Van Mele P, Cuc NTT, van Huis A (2001). Farmers' knowledge, perception and practice in mango pets management in the Mekong Delta, Vietnam. Int. J. Pest Manage., 47: 7-16.