Journal of Applied Biosciences 49: 3394– 3405

ISSN 1997–5902

Perception of farmers' management strategies for termites control in Ghana

Akutse K. S [1, 2*], Owusu E. O. [1] and Afreh-Nuamah K. [1]

[1]African Regional Postgraduate Programme in Insect Science (ARPPIS), University of Ghana, P O. Box: PMB, L. 59 Legon-Accra, Ghana; [2] International Centre of Insect Physiology and Ecology (ICIPE), P. O. Box 30772-00100, Nairobi, Kenya.

*Corresponding Author: fakutse@yahoo.fr / +254 (0) 701177291

Originally Submitted on 17th November 2011. Published online at www.m.elewa.org on January 29, 2012.

ABSTRACT

Objective: Termites are serious pests in West Africa affecting crop production, buildings, books and wood conservation. Intensive use of insecticides which is of great environmental and health concerns was the most frequently control option. To make termites management environmentally friendly, there is a need to integrate indigenous knowledge about pest management techniques into the scaling-up process in order to improve farmers' pest management practices. This paper documents farmers' knowledge, perceptions and management practices against termites in Greater Accra and Volta Regions of Ghana.

Methodology and results: Traditional methods of controlling termites used by farmers, obtained from a survey include application of plant extracts (55.71% of the respondents), dead animals, toads and intestines of rat (42.86%), physical removal of the queen (64.29%), human urine (55.71%), wood ash (30%), and poultry (60%). These are mainly practiced by small-scale farmers and their efficiency needs to be studied, improved and promoted. Additionally, a total of thirteen plants traditionally used for termite control were identified from the survey. From the 70 farmers investigated, 44.29% depend on chemicals and other strategies, while 55.71% used plants as control strategy. About 67.67% combined plants with chemicals and other strategies.

Conclusion and application: Indigenous termite's taxonomic knowledge identified needs to be documented and promoted to facilitate communication between farmers, extension agents and scientists on specific pest problems. The efficiency of the various indigenous control practices reported by farmers in this study need to be verified, and the promising ones standardized and promoted with other IPM measures with the aim of reducing chemical pesticides application.

Key words: Termites, *Macrotermes* sp., Control strategies, Indigenous knowledge.

INTRODUCTION

The literature on smallholder agricultural development emphasizes the need for research institutions to understand indigenous knowledge systems in a bid to adapt their technologies to local farmers' situations in order to enhance the acceptance and adoption of these technologies (Chitere and Omolo, 1993; Norton *et al*., 1999). However, there continues to be very little information on farmers' perceptions of pests, management practices and decision-making processes in agriculture (Nyeko and Olubaya, 2005). As agricultural technologies are developed and promoted, there is a need to integrate indigenous knowledge about pest identification and management techniques into the scaling-up process in order to improve farmers' pest management practices (Nyeko *et al.,* 2004). Termites (Isoptera) have long been recognized as

important agricultural and domestic pests (Logan *et al.,* 1990). They are one of the major agricultural pests in the tropics (Wardell, 1987). Their efficiency in utilizing many food sources has meant that some species have become pests of crops or timber, and a few species have attacked a great variety of man- made materials. In semi-arid savannah of Kenya termites destroyed 800-1500 kg/ha of pasture per year (Lepage, 1981), while in the countries of Southern Africa, harvester termites are a serious pest of rangeland, removing 60% or more of the standing grass bio-mass during dry years (Coaston, 1958). In Uganda, for example losses of crop and tree stands ranging from 50 to 100% have been attributed to termite attack (Sekamatte, 2001). Because of their economic importance, the majority of studies of tropical termites have concentrated on the pest species and their control. There have been relatively few studies on the populations of tropical termites. In Ghana, in general and in Greater Accra and Volta Regions particularly, where the survey was based, termites cause serious problems. The degree of damage done by these pests to crops, trees, building and wood is so enormous that people fail to recognize or simply refuse to acknowledge the positive roles played by majority of the species in the soil ecosystem. To date no publication apparently exists on damaging termite species diversity and distribution on farmlands in these two regions in Ghana and all the various existing species are not documented. This information is essential in developing strategies for management of termites' populations since not all termite species are pestiferous (Cowie *et al.*, 1989). Control of termites has largely relied on broad spectrum and persistent organochlorine insecticides (Logan *et al*., 1990). However, serious limitations and increasing legal restrictions associated with the application and efficacy of these chemicals (Cowie *et al.,* 1989; Logan *et al.,* 1990) emphasize the need for alternative methods. Most non-chemical control of termites on farmlands revolve around good silvicultural or agronomic practices, physical destruction of termite mounds, biological control, and use of plant extracts and resistant species (Wardell, 1987; Logan *et al*., 1990). However none of these methods have been rigorously evaluated and their efficacy remains speculative. A key area that has yet to be adequately addressed in termite management is indigenous knowledge accumulated by local communities. Such information is essential for priority setting and also for development of pest management strategies that meet local aspirations and are thus likely to be adopted by local communities (Chitere and Omolo, 1993; Nyeko *et al*., 2002). This study examines farmers' indigenous knowledge of termites with the aim of developing and promoting integrated termite management in agriculture and other materials. The paper specifically documents the following information about termites: (i) farmers' perceptions of termite damage in relation to other problems; (ii) their knowledge of the diversity, identification and distribution of termite species; (iii) the perceived levels of termite damage on different crops; and (iv) the termite control practices they have attempted and constraints encountered.

MATERIALS AND METHODS

Area of the survey: The survey, based on a questionnaire was made in two different Regions (Greater Accra and Volta Regions) where termites constitute serious problems for the populations. In Greater Accra, 10 villages (Dodowa, Matese, Pokuase, Amasaman, Mayera, Agbogba, Ashongman, Abladje, Parakou estate and Aburi) were visited. In Volta Region, two districts (Hohoe and Jasikan) were visited. Five and six villages were visited in Hohoe and Jasikan districts respectively. The villages visited at Hohoe district are Golokuati, Kolonu, Wegbe, Kpeta and Hohoe. For Jasikan district, Jasikan, Okadjakrom, Ayoma (New and Old Ayoma), Likpe-Kokrontumi and Lolobi were visited.A semi structured questionnaire on termites was discussed with randomly selected farmers and households in these villages.

Methods of the survey: A survey was carried out to determine the different types of plants traditionally used by farmers to control termites in Ghana. The survey was conducted within some communities in Greater

Accra and Volta Regions of Ghana. Samples of the plants were collected from the communities and sent to the Botany Department, University of Ghana for identification. A total of 21 villages cited above were selected for this study. The villages were randomly selected, using a list of those villages in the districts that had implemented agricultural and storage technologies. The list was obtained from IPM / FFS (Integrated Pests Management / Farmer Field Schools) in the different districts. The questionnaire focused mainly on general problems farmers had experienced in, with growing crops on their farms, in order to elicit their rating of termites as a constraint to agriculture. These included farmers termite species identification capacity, diversity, abundance and topographic distribution; termite damage to crops, buildings and other wood materials; termites as a source of food; termites in social arts and buildings / construction, patterns of rainfall and termite damage; and termite control practices and constraints. With special focus on termites' control, they were each asked: (i) what control methods (materials) they had attempted, (ii) how they applied them, (iii) on which termite species the control had been attempted, (iv) which effect the control strategy had on the termites and (v) how effective the control method had been.

At the beginning of every survey, the interview began with self introduction and stating the purpose of the study which was to generate information on problems affecting all materials and crops on their farms or houses. Mentioning of termites was avoided at first at the onset of the questions, to elicit the farmers' perceptions of termite damage in relation to other problems without biasing their responses. In addition, before collecting the responses from any farmer or people, he / she was asked to indicate his / her gender, ethnicity, farming experience or duration of farming experiment and highest level of formal education.

RESULTS AND DISCUSSIONS

Farmers' profiles: Overall, 70 farmers responded (30 people in Greater Accra and 40 in Volta Region) from the 21 villages, the respondents were composed of 81 and 19% of men and women respectively. The average year of respondents was 38 years, but varied markedly from 25 to 70 years. The majority (47%) of farmers was middle-aged (30 – 50 years) and only 17% of them were above 50 years old. Most farmers (86%) had some formal education, with equal proportions (69%) claiming to have stopped in primary or secondary school. There was not any diploma holder and no university graduates among the farmers during the survey. Several ethnic groups were represented, the majority of whom were Twi (52%) followed by the Gan (23%), Ewe (21%) and Shai (4%). Despite this ethnic diversity, all the farmers could speak Twi fluently; hence all the meetings were conducted in this language in addition to Ewe (in Volta Region).

Diversity, abundance, identification and distribution of termites: According to farmers, termites pose serious problems to their crops, buildings, woods and other home furniture. During the survey, all of the respondents were aware of the damages caused by termites. More than 75 % of them even consider termites to have any benefits in their life because of the great damages they caused. Farmers (87 %) were able to recognize and identify termites based on empirical knowledge. According to them they can easily identify the different type of termites based on characteristics listed in Table 1.

Table1: Identification features used by farmers in termites' reconnaissance

Characteristics	Farmers identification features	Names given by farmers in Ewe	% Respondents (X ± SE)
Colour	Some termites have red colour, others are almost black or brownish in colour and some are white. These referred to heads of soldier termites.	"Baba tadze" (red head termites), "Baba tayibor" (black head termites) or "Baba he" (white head termites)	67.2 ± 1.43
Head and mouth parts	The shape / structure and size of the head combine to the aspect of the mouth parts. For them, some have a big head but some have not. Some have big head and scissor-like type of mouth part (*Macrotermes* sp.) and some have small head with mouth parts	"Baba taga" (soldiers); "Baba tavi" or "Nugbletor" (workers)	97.5 ± 0.37

	not as developed as the case of *Macrotermes*.		
Body size	Some termites are small and some are big. They were also able to identify the reproductives: the king and the queen, the alates and the workers of different colonies based on the body size.	"Baba korfia" (queen or king); "Agbale" (alates)	97.5 **±** 3.43
Type of mounds	The size of mounds made by termites helps farmers to identify the kind of termites present at the area of their farms. Depending on the type of termites present in the area some mounds are huge (*Macrotermes* sp.); some small and others are under ground.	"Gbedoxor baba" (cathedral termites) equivalent to *Macrotermes* spp.; "Koklo or Gume baba" (underground termites or fowls feeding termites)	55.67 **±** 1.22
Feeding tunnels and sound production	Tunnels help farmers to identify the presence and the type of termites in an area. The size of the tunnels and how it is constructed help for identification. Sometimes however, they produce a sound "yaya" during dry or harmattan season which helps to identify the presence of termites in an area.	"Ati rubaba" (tree feeding termites); "Gberubaba" (grass feeding termites)	43.67 **±** 0.22
Effects on plants or crops	The damages caused or feeding effect of termites. The changes in colour of the crops sometimes show the farmers the presence of termites because their attack affects the development of different stages of the plant and the colour of the leaves become yellowish.	"Kpekoe" (tuber termites); "Ati rubaba" (tree destructive termites)	12.25 **±** 1.54

Benefits of termites: Generally in Ghana and in Greater Accra and Volta Regions particularly, where the survey was based, termites cause serious problems. People complained about termites' damages especially that by Macrotermitidae species which are very common. The degree of damage done by these pests to crops, trees, building and wood is so enormous that people fail to recognize or simply refuse to acknowledge the positive roles played by majority of the species in the soil ecosystem. Although majority (59.14%) of respondents describes the advantages of termites in the system in various domains of life, they will however prefer not having them in the system due to their level of damage they caused (50 – 100%). Table 2 below shows the proportions and percentage of frequency of the interviewed in the various uses of termites in their life in the study sites.

Table 2: Termites as beneficial in the study sites

Uses of termites in people life	**Greater Accra**		**Volta Region**		**Total % Frequency (X ± SE)**
	No. Respondents	**% Respondents (X ± SE)**	**No. Respondents**	**% Respondents (X ± SE)**	
Termites in Agriculture	13	43.33 ± 0.36	35	87.5 ± 1.12	68.57 ± 1.48
Termites in social art and buildings	9	30 ± 0.54	29	72.2 ± 0.22	54.29 ± 0.76
Termites as food source	17	56.67 ± 1.25	38	95 ± 1.79	78.57 ± 3.04
Termites in medicine	15	50 ± 0.80	31	77.5 ± 0.22	65.71 ± 1.03
Feeding fowl with termites	3	10 ± 1.88	17	42.5 ± 2.91	28.57 ± 4.79

Termites in soil and agriculture: Termites are observed to be the engineers of the soil. They contribute to the formation or constitution of the soil. According to farmers (68.57%), termites are also in charge of the decomposition of the organic materials and give aeration and humus to the soil, thus important in agriculture (Table 2). All these activities give to the soil a good fertility which provides suitable nutrients to plants. The texture and structure of the soil are seriously influenced by the activities of termites. The porosity and aeration are balanced because of the humus coming from the degradation of the plant residues and other organic materials. These new properties acquired by the soil from the activities of termites, facilitate easy migration of the nutrients and water of soil, and their fixation by the plants or crops. The activities of termites enable farmers to easily identify the level of fertility of the soil during their farming time. According to them (87.5% in Volta Region and 43.33% in Greater Accra), the structure and the texture of the soil are improved by the humus derived from the degradation of organic materials by termites (Table 2).

Farmers attest that the old mounds of termites are source of nutrients for crops; this result was also found by Stoops and Schaefer (2010) and Stoops (1964), who proved that the content of organic matter of the mounds was higher than in the soil samples. According to them, plants which are grown around these mounds do better because the soils around the mounds are found to be more fertile. This result confirmed the founding of Abe *et al*. (2009) and Robinson, (1958) in coffee fields in Kenya. Some plants such as vegetables especially pepper, garden eggs, tomato, and other crops such as corn, cassava are usually grown around the mounds. In such situations farmers break the mounds and scatter it to cover more surfaces before the planting or sowing time.When the *Macrotermes sp* vacate their mounds, farmers arrange the interior by making holes inside. They put fire inside to sterilize the mound and kill reptiles and use the place as storage for farm materials including water. The vacated mound can also serve as refuge place for people during rains or used as resting spots during the farming periods when the sun is too intense. The mounds of *Macrotemes sp.* also produce mushrooms which are important source of proteins for the farmers. About 95 % of the interviewed in Volta Region confirmed the importance of termites in mushroom production (Table 2). Where they occur, these mushrooms are cultured and periodically packed for domestic use or as a source of income when sold to interested customers.

Termites in social art and buildings: In some localities farmers build their houses with the old mound of termites. This is more frequent in Volta Region where 72.2% revealed the importance of termite mounds in building and social art (Table 2). What is special about the soil from the mounds is that, termite mounds are elaborate structures made using a combination of soil, mud, chewed wood/cellulose, saliva, and faeces. Higher amounts of clay, silt, and fine sand, and lower amounts of coarse sand occurred in termite mounds than in adjacent soils of all rainfall zones. Extractable cations (Ca, Mg, and K), calcium carbonate, pH, electrical conductivity, and organic carbon were also higher in termite mounds than adjacent soils. These chemical and physical properties and mineralogical composition of the mounds contribute a lot in constructions (Abe *et al*., 2009 and Stoops and Schaefer, 2010). They first dig and break the mounds and mix it with water. After 24 hours, they make bricks with it. These bricks are then used to build houses, stored products structures and fences or hedges for domestic animals. About 54.29 % interviewed used this technique for traditional buildings. This result confirmed the finding of Logan (1991) and Iroko (1996) who attested that soil from termite mounds is used in constructing mud walk, brick making and pottery. Sometimes, the mounds are directly used when mixed with water to build the houses, stored products' structures and fences without first making bricks. The same techniques can also be used to make traditional oven, cooking pots, plates and other pottery materials.

Termites in feeding of fowl or poultry: Termites are also used as poultry feed. Farmers (28.57% interviewed) collect the small mounds of *Nasutermites* sp. containing alive termites and even other termites' species and seal them home for the fowl. Sometimes, they collect directly the termites from the mounds and put wet soil on it before carrying them to the house .In the house, remains of the termites are put into a pot covered by soil or may be put into a hole underground and watered to conserve the humidity. These termites are later removed and fed to fowl / chicken. This technique is used in Volta Region (42.5 %) more than Greater Accra (10 %) (Table 2) and it is a very important source of protein for fowl.

Termites as food for human being: Termites are sources of proteins for human being. In some parts of Ghana, they form part of food chain. About 95 % of interviewed in Volta Region and 56.67 % in Greater

Accra have attested that they consumed termites (Table 2). After rains, farmers use water traps sometimes combined with light traps to collect a lot of alates. These alates are then fried and eaten sole or sometimes with cassava flour or gari. It is very much appreciated by great number of farmers (78.57 %) interviewed during the survey (Table 2). Atu (1993) has also found that fried or dried termites as an important source of food which contains 32 – 36% protein. The queen and the king are also consumed raw when they are captured.

Medical aspect of termites: About 65 % of the farmers indicated that termites have various medicinal effects (Table 2). Some said that the mounds can be used to treat abscess or boils. This is done by collecting the mound and mixing it with water and the mixture applied to the boil. This cures the boil within two days. This result was attested by 77.5% interviewed in Volta Region and 50% in Greater Accra. In addition, these farmers said that the queen has several medicinal values. When ground and mixed with an ointment especially shea oil/pomade, the mixture can be applied to skin of children to enhance healthy growth and avoidance of skin diseases. The skin of the child becomes smooth and feels strong. The king has the same effect when used. A total of 46 interviewed (65.71 %) knew this medicinal value of termites (Table 2). Soldiers are charred to make ash and used to treat wounds. This ash is mixed with an ointment, shea oil/pomade in preference before applying to the wound.

Termites as pests: Although termites provide a lot of benefits, they are also source of serious concerns. They are serious pests of crops, stored products' structures, buildings and other home furniture. More than 50% of the respondents mentioned termites as one of the most important constraint in their agricultural activities.Overall, farmers (68.57 %) considered termite damage to be higher in the dry months (November to March, and April to May) than in the wet ones (Table 2). They attributed high termite damage in dry seasons mainly to the fact that several crops, especially maize, millet, groundnuts and sorghum, matured and were harvested in these months. According to them, the crops are most susceptible to termite attack at maturity. About 87.5 % of the farmers in Volta Region attested the susceptibility of these crops to termites attack (Table 2). Termite damage in February, March, May and August was generally rated to be low to moderate because, according to farmers, these are the months for field preparation and planting with relatively fewer crops, mostly perennials and trees, available for termites to attack. This same result has also been observed by Nyeko and Olubaya (2005), in Uganda. According to the farmers interviewed (95 %) both in Volta Region and Greater Accra, termites prevent germination of the seeds or other planting materials. They also destroy the crops by destroying the roots and making some feeding tunnels through the stem. The whole plant becomes stunted and eventually dies. At Okadjakrom in Volta Region, a farmer attested that his farm of about one (1) hectare of maize was completely destroyed by termites. According to information obtained from this Region, termites cause serious problem to the farmers in their agricultural production and conservation/storages. More than 60% respondents in Volta Region attested that, harvested produce could be damaged within 24 - 72 hours before they are transported from the farm for storage.

Damages caused by termites to living forest trees / fruit trees and other materials: *Macrotermes* species also cause serious damage to plants and trees. They make tunnels on the trees and try to feed on the bark or skin of the tree. This reduces the photosynthetic area of the plant and causes considerably yield loss (Plate 1a, b). About 13.33 % of the farmers interviewed in Volta Region have attested the negative effect of termites on even their fruits trees.

a b

Plate1: Effect of termites (Macrotermes sp.) on trees and the preference of termites: Morinda lucida (infested) near Antiaris africana (b)

Plate 2: Pronounced effect of termites on live trees found in Volta Region

In severe attack, they cause the death of some branches of the tree or the death of the whole tree as found in Volta Region during the survey (Plate 2). It's been also observed that they sometimes have preference for some trees more than others (Plate 1b). Stored product structures are also destroyed by termites, which subsequently lead to easy attack of the stored products. Almost 100 % of the farmers interviewed have been complained about these negative effects of termites either in Volta Region or Greater Accra. Brick buildings are easily destroyed by termites. In most houses, the wood structures on the wall (doors and windows) are also destroyed by termites (Plate 3). For example at Jasikan in the Volta Region, termites destroy beds by making huge mounds under the beds before they are noticed. Termites destroy also fruits which fall under trees (Plate 4).

a b c

Plate 3: Effect of termites on windows (a) and doors (b, c) at Amasaman

Plate 4: Effect of termites on the fruits of Adonsonia digitata at University of Ghana campus

Strategies used by farmers to control termites: To avoid, prevent and control termites, farmers adopt different strategies. Chemical and non chemical control methods are used.

Table 3: Proportions of farmers using the different control / management strategies identified during the survey

Management options	Greater Accra		Volta Region		Total % Frequency
	No. Respondents	% Respondents	No. Respondents	% Respondents	
Insecticides	20	66.67 ± 0.86	11	27.5 ± 0.71	44.29 ± 0.15
Plant materials	9	30 ± 0.11	30	75 ± 0.60	55.71 ± 0.70
Insecticides + plant materials	13	43.33 ± 0.38	37	92.5 ± 1.08	71.43 ± 1.46
Physical control	15	50 ± 0.52	30	75 ± 0.60	64.29 ± 1.12
Water in which fresh fish is dissected	4	13.33 ± 0.06	2	5 ± 1.33	8.57 ± 1.57
Urine / Carbon	12	40 ± 0.31	27	67.5 ± 0.39	55.71 ± 0.70
Sand / Camphor	2	6.67 ± 0.38	10	25 ± 0.78	17.14 ± 1.16
Wood ash	5	16.67 ± 0.17	16	40 ± 0.37	30 ± 0.54
Toads	1	3.33 ± 0.45	29	72.5 ± 0.53	42.86 ± 0.08
Intestines of rat or died animals	1	3.33 ± 0.45	29	72.5 ± 0.53	42.86 ± 0.08
Salt/Magic powder	7	23.33 ± 0.03	13	32.5 ± 0.57	28.57 ± 0.61
Tyre	2	6.67 ± 0.38	14	35± 0.51	22.86± 0.88
Fowl / poultry	11	36.67 ± 0.24	31	77.5 ± 0.67	60 ± 0.91
Irrigation / Sologam	3	10 ± 0.31	22	55 ± 0.05	35.71± 0.26
Fire/Kerosene/Diesel oil/Hot water	7	23.33 ± 0.03	19	47.5 ± 0.16	37.14 ± 0.19

Chemical control methods: Different chemicals are used by the farmers for the control of termites. Among these, are DDT® (Dichloro-diphenyl trichloroethane), Dursban® (Active ingredient = Chlorpyrifos ethyl), Pyrinex 48 EC ®(Chlorpyrifos 480 GR/LT; O, O-Diethyl O-3,5,6-trichloro-2-pyridyl phosphorothioate), Terminus® (Chlorpyrifos ethyl), Neemol® (Azadirachtin), Perfekthin® (Dimethoate), Cymethoate (Dimethoate cypermethrin), and other chemicals (insecticides) are also used to spray. Some farmers even use herbicides to spray termites when they are lack of insecticides. The use of insecticides in Greater Accra (66.67%) is more pronounced than Volta Region (27.5%) (Table 3). During this survey, about 70 % of the farmers interviewed indicated that they use DDT for the control of termites and other insects, though the use of this insecticide is prohibited. This is a cause for concern because this organochlorine has greater toxicity and residual action levels than other groups or classes of insecticides. This is likely to expose farmers to contaminations and accumulations of the residues of the product in their bodies and crops; because they don't even have appropriate application equipment and protective clothing. Apart from these chemicals, salt is also used by some farmers (30 %) for the control of this pest (Table 3). Some quantities (from one to two "Olonka", approximately 1 to 3 kilograms according to the size of the mounds) of salt are inserted into the termites' mounds. This forces the termites to leave the mound after 2 to 5 days. Camphor (17.14 % interviewed) can also be used in a similar manner (Table 3). Sologram (Borates (disodium octaborate tetrahydrate [Tim-bor®, Bora-Care®, Jecta®], Impel®)) is always used by farmers to treat wood against termites before their storage (Table 3). About 55 % of the farmers during the survey confirmed the use of sologram to prevent or control termites (Table 3). It was attested by certain farmers that "magic powder" or "magic chalk" is used to control termites. This is used in the rooms against termites and other insects. The powder is sprinkled around the room, under beds and under the support of stored products. According to these patricians, the powder has repellent effect on the termites when it's applied.Carbon (the black material of batteries) is also used as control material. The carbon is collected and diluted in water and the solution used

to spray. In some situations the carbon is buried in the soil or inserted into the mound of the termites. The battery carbon can also be used to treat seeds before sowing. Using this strategy or treatment, they have attested that the rate of germination is always better than sowing without this carbon. About 55.71 % of the farmers are using this control strategy (Table 3).Diesel oil and kerosene are also used to control termites by 37.14 % of the interviewed (Table 3). These are used to treat wood against termites or directly on the termites or inside their mounds. Some farmers also used soap water to spray against termites.

Non chemical control methods: Several non-chemical strategies are used by the farmers. Some used these because of lack of easy access to the synthetic insecticides (termiticides) and even where there were accessible the prices of these products were too expensive for the farmers. Some farmers (55.71 %) also indicated that, the traditional products are less toxic than the synthetic chemicals (Table 3). In addition these indigenous products were found to be easily available and could be obtained even without paying for them. Among these non chemical methods, are:

Physical control: This method consists of breaking the mounds of the termites and removing the queen and the king. This control strategy is used by 64.29 % of the interviewed in the both study sites. However, this practice is more pronounced in Volta Region (75 %) than Greater Accra (50 %) (Table 3). Sometimes, it is very successful but in some cases, it can fail. When it fails, the neotenics or supplementary reproductives take the place of the main reproductives to continue future generations. Some farmers (37.14 %) use fire to control termites (Table 3). They break the top of the mounds and put fire inside after gathering some dry materials inside the mounds. Sometimes the dry materials are gathered on the feeding tunnels and lit to burn the termites. Some farmers (22.86 %) even use car tyres to control them (Table 3). They ignite the tyres inside the mounds or on the feeding tunnels. Hot water can also be used to kill termites and treat the soil before planting or sowing. This technique is even used to prevent their activities on the seed or planting materials for better germination and most of the times in nursery.

Indigenous materials used in termites' control: Some indigenous materials are also used to target termites. Use of these was mentioned to be more common during the survey. Table 4 bellows, exposed the methods of applications of these various indigenous materials.

Table 4: List of indigenous materials mentioned during the survey and their methods of application

Indigenous materials	% Frequency (X ± SE)	Methods of application used by farmers
Human urine	55.71 ± 0.70	Mixed matured urine (stored for 1 to 2 weeks) with carbon and used to spray or pour directly into the mounds. Sometimes, only matured urine is used for this purpose. It is claimed to have killing (toxic) and repellent effect on the termites.
Toads, Intestines of rat, dead animals or shell / scallop of tortoise	42.86 ± 0.08	They kill the toads and bury them around different parts of the farm or inserted directly into the mounds. Intestines of rat or other dead animals and the shell / scallop of tortoise can also be used in the same way. These have repellent effects on termites which will leave the mounds some days after the application.
Water in which fresh fish is dissected	8.57 ± 1.57	Water in which fresh fish is washed or dissected is poured directly into the mound by breaking the top of the mound. After at least one week of this application, termites will leave the mound.
Fowl / poultry	60 ± 0.91	Fowl or poultry is carried to farm and when farming, the fowls chase termites which come out of the soil. This provides food for the fowl and helps the farmers to control this serious pest.
Wood ash	30 ± 0.54	Wood ash is used to control termites by putting it inside the mounds or sprinkling around different parts of the farm. Some farmers also dilute this ash in water and use it as spray solution on the termites.
Sand	17.14 ± 1.16	Dry sand is mixed with soil of the termites when they start building their mounds. Pouring this sand inside the initial new mound, termites will immediately abandon the mound.

Irrigation is also used to minimize the effect of the termites. When the farm is regularly irrigated, the activities or damages of termites are reduced. Irrigation is always used by farmers (35.71 %) in vegetables production or gardens (Table 3). Fertilizer application can also minimize termites' damage on crops. Among these indigenous materials, plants also play an important role in the control of termites. About 55.71 % of the interviewed use plant materials to control termites in the both study sites (Table 3). Several plants were collected and tested for their efficacy in termites control during the survey (Tables 5). These plants were identified by the curator at Botany Department of the University of Ghana – Legon. The collected plants were even tested at laboratory and field conditions for their efficacy (Owusu *et al.,* 2008). Some farmers (71.43 %) used to combined insecticides and plant materials to control termites. This technique of controlling termites was more pronounced than the other control measures identified during the survey (Table 3). The extracts of these plants are sprayed in the morning. They are usually applied on vegetables. Farmers apply the extract with broom instead of sprayers.

Table 5: List of plants collected from the survey and their methods of preparation

Names of the plants	No. Respondents	% Frequency (X ± SE)	Methods of preparation
Azadirachta indica (Neem) (Spindales: Meliaceae)	14	35.89 ± 1.65	Crush or wash the leaves in water and leave the extract for 2-3 days and spray. Some add hot pepper to the extract before spraying. Extracts of seeds are also used.
Jatropha curcas / *Jatropha gossypiifolia*(Malpighiales: Euphorbiaceae)	16	41.03 ± 2.06	Planting them around the farm or house and they have repellent effect. Some even plant it to make fence.
Chromolaena odorata (Siam weed) (Asterales: Asteraceae)	8	20.51 ± 0.42	Same method as in the case of Neem leaves. Some farmers add hot pepper to the mixture before spraying.
Carica papaya (pawpaw) (Brassicales: Curicaceae)	3	7.69 ± 0.59	Crush or wash the fresh leaves in water and leave for 2-3 days before spraying.
Senna siamea (Fabales: Fabaceae)	2	5.13 ± 0.80	Same method as for Neem leaves. The fresh wood can also be inserted into the mound.
Manihot exculentus (Cassava) (Euphorbiales: Euphorbiaceae)	5	12.82 ± 0.19	Crush or wash the leaves in water and leave it for 1-2 hours and pour it into the mound.
Sporobolus pyramidalis (Cyperales: Poaceae)	3	7.69 ± 0.59	Put some plants into the mound and they will leave after some days.
Ocimum canum (Green basil) (Lamiales: Lamiaceae)	9	23.08 ± 0.63	The seeds are put into the mound and they will leave after some days. Leave extract also is used to spray them.
Philodendron corsinianum (Alismatales: Araceae)	4	10.26 ± 0.39	It is planted as ornamental plant and has repellent effect.
Ocimum gratissimum (Lamiales: Lamiaceae)	3	7.69 ± 0.59	Crush or wash the leaves in water and use the solution / extract to spray.
Allium sativum (Garlic) (Asparagales: Alliaceae)	2	5.13 ± 0.80	Bulbs are used for extraction and spray.
Zanthoxylum xanthoxyloides (Candle wood) (Sapindales: Rutaceae)	3	7.69 ± 0.59	The extract of the root and bark in water is used to spray.

From the 70 farmers investigated, 31 of them (44.29 %) depend on chemicals and other strategies. However, 39 of them (55.71 %) used plants as control strategy. Some also (71.43 %) combined this method with chemicals and other strategies (Table 3). Thus, the survey clearly indicates that greater percentage of the respondent farmers use plants or indigenous materials to control termites (Table 3). The following reasons were given for the choice of traditional methods:

- Availability of the chemicals in the communities (more available in towns or villages around towns than those which are far from supplying sites).
- The revenue or income of farmers too low so that they are not able to buy synthetic insecticides which are always expensive.
- Availability of indigenous materials, collection facilities and easy plant extracts preparation for spraying is more beneficial than the use of synthetic products.
- Unavailability of insecticide application equipment. In some cases farmers like to use broom or brush to apply their plant extract.
- Some of the farmers said that the synthetic pesticides are found to be more toxic.
- The use of plant extracts or indigenous materials is more economical than the use of synthetic pesticides (Owusu *et al*., 2008).

CONCLUSION

Overall, farmers rated termites as one of their most important constraint in agriculture. This suggests that solving termite problems is high on their agenda and that they will be receptive to innovative termite control measures. This study has provided some basic information about farmers' knowledge of the biology, ecology and management of termites that could aid the development and promotion of sustainable termite control measures in agriculture. With the aid of their indigenous identifying characteristics, local termite taxonomists identified different types of termite, which may be remarkably consistent with scientific identifications. Such indigenous pest taxonomic knowledge needs to be documented and promoted to facilitate communication between farmers, extension agents and scientists on specific pest problems. The farmers had attempted a number of control methods against termites and the majority of which they claimed was effective. However, they rated their lack of termite control knowledge and skills as their most important problem in termite management. This is apparently because much of the indigenous control knowledge is limited to a few individuals. Clearly, mechanisms are needed to educate farmers on appropriate termite management strategies and to encourage farmer-to farmer transfer (Nyeko and Olubayo, 2005) of such information. The efficacy of various indigenous control practices reported by farmers in this study need to be verified, standardized and promoted with other IPM measures with the aim of reducing application of synthetic chemical / pesticides.

ACKNOWLEDGEMENTS

The authors would want to express special thanks to African Regional Postgraduate Programme in Insect Science (ARPPIS) and the German Office for Academic Exchange / Deutcher Akademischer Austauschdienst in Germany (DAAD) for their various supports.

REFERENCES

Abe SS, Yamamoto S, Wakatsuki T, 2009. Physicochemical and morphological properties of termite (*Macrotermes bellicosus*) mounds and surrounding pedons on a toposequence of an inland valley in the southern Guinea savanna zone of Nigeria. *Soil Science and Plant Nutrition* 55, 51 4–522.

Atu UG, 1993. Cultural practices for the control of termite (Isoptera) damage to yams and cassava in south-Eastern Nigeria. *Journal of International Pest Management* 39, 446-462.

Chitere PO. and Omolo BA, 1993. Farmers' indigenous knowledge of crop pests and their damage in western Kenya. *International Journal of Pest Management*, Vol. 39, pp. 126–32.

Coaston WGH, 1958. The Hototermitid Harvester Termites of South- Africa. Union of South Africa, Department of Agriculture, Entomological series No. 43, Bull. 375.

Cowie RH, Logan JWM, Wood TG, 1989. 'Termite (Isoptera) damage and control in tropical forestry with special reference to Africa and

Indo- Malaysia: A review', *Bulletin of Entomological Research*, Vol. 79, pp. 173–84.

Iroko AF, 1996. L'homme et les termitières en Afrique. Editions Karthala, Benin.

Lepage MG, 1981. The impact of foraging populations of *Macrotermes michaelseni* (Sjostedt) (Isoptera: Macrotermitinae) in a semi-arid ecosystem (Kajiado-Kenya). II- Food gathered, in comparison with large herbivores. *Insects sociaux* 28, 309-319.

Logan JWM, 1991. Damage to sorghum by termites (Isoptera: Macrotermitinae) in the lower Sire Valley, Malawi. *Sociobiology* 19, 2.

Logan JWM, Cowie RH, Wood TG, 1990. 'Termites (Isoptera) control in agriculture and forestry by non-chemical methods: A review', *Bulletin of Entomological Research*, Vol. 80, No. 3, pp. 309–30.

Norton GW, Rajotte EG, Gapud V, 1999. Participatory research in integrated pest management: Lessons from the IPM CRSP. *Agriculture and Human Values*, Vol. 16, No. 4, pp. 431–9.

Nyeko P, Gareth-Jones E, Day RK, Thomas R, 2002. 'Farmers' knowledge and perceptions of pests in agroforestry with specific reference to *Alnus* species in Kabale District, Uganda', *Crop protection*, Vol. 21, No. 10, pp. 929–41.

Nyeko P, Stewart J, Franzel S, Barklund P, 2004. 'Farmers' experiences in the management and utilisation of *Calliandra calothyrsus*, a fodder shrub, in Uganda' *Agricultural Research and Extension Network Paper* No. 140. London: Overseas Development Institute.

Nyeko P. and Olubayo FM, 2005. Participatory assessment of farmers' experiences of termites problems in agroforestry in Tororo District, Uganda**.** *Agricultural Research & Extension Network*. Paper No. 143.

Owusu EO, Akutse KS, Afreh-Nuamah K, 2008. Effect of some traditional plant components on the control of termites, *Macrotermes* spp. (Isoptera: Termitidae). *African Journal of Science and Technology (AJST) Science and Engineering Series Vol. 9, No. 2, pp. 82 - 89.*

Robinson JBD, 1958. Some chemical characteristics of "termite soils" in Kenya coffee fields. *J. soil sci.* 9, 58-65.

Sekamatte MB, 2001. Options for integrated management of termites (Isoptera: Termitidae) in smallholder maize-based cropping systems in Uganda. PhD thesis. Kampala: Makerere University.

Stoops G, and Schaefer CEGR, 2010. Pedoplasmation: formation of soil material. In Stoops. G., Marcelino, V. and Mees, F. (eds.), Interpretation of Micromorphological Features of Soils and Regoliths. Elsevier, Amsterdam, pp. 69 – 79.

Stoops 1964. Microbiology of some characteristic soils of the lower Congo (Kinshasa). Pedologuie 18, 110-149.

Wardell DA, 1987. Control of termites in nurseries and young plantations in Africa: Established practices and alternative courses of action. *Commonwealth Forestry Review*, Vol. 66, No. 1, pp. 77–89.

Wood TG. and Thomas RJ, 1989. The mutualistic association between Macrotermitinae and *Termitomyces*. In: Insect-fungus interactions (Wilding N, Collins NM, Hammond PM, Webber JF, eds). New York: Academic Press; 69-92.