academicJournals

Vol. 10(36), pp. 3625-3635, 3 September, 2015
DOI: 10.5897/AJAR2014.9283
Article Number: E6FDAAB55282
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Farmers' knowledge, perceptions and management practices of termites in the central rift valley of Ethiopia

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Received 28 October, 2014; Accepted 20 May, 2015

A high density of epigeal termite mounds is common in the Central Rift Valley of Ethiopia (CRVE). A survey of farmers' perceptions of termites was conducted in the CRVE using semi-structured questionnaires and in-depth interviews with farmers for documenting their knowledge about termites, identification of termite types, crops and crop growth stage susceptible to termites, perception of the role of termites, estimate of potential yield loss to the major crops, and termite management practices in field crops among others. A field survey was also conducted on maize and haricot beans on farmers' fields to assess termite damage. Farmers were knowledgeable about the existence of termites. However, they could not identify different types of termite (species). Farmers mentioned the existence of 19 different pre-harvest crop pests and 69% of them mentioned that termites are among the most important pests in their farming system after porcupine. Farmers considered termites as of no benefit to human nutrition and mound soil as fertilizer, but they acknowledged termites for the mound soil used in house construction. Maize and haricot beans were the major crops grown in the area and most of the farmers (87%) considered the crops as the most susceptible to termite damage and they estimated potential pre-harvest yield loss as 18.02 ± 2.67 and 10.58 ± 1.91 kg (mean ± SE) per hectare, respectively. Farmers complained about termite mounds as they reduce farmlands and stand as obstacle for ox cultivation. All the farmers reported that damage to the crops occurs from maturity stage onwards and this was also confirmed in the field survey. Lodging of maize plants recorded in the surveyed fields ranged between 3 and 33% which was mainly due to *Macrotermes* and *Microtermes*. Although the majority of farmers considered termites as pests, only few (9%) of them managed termites using cultural control practices such as removing lodged maize and prompt harvesting. The study has shown that farmers viewed termites as pests of crops at maturity stage.

Key words: Central Rift Valley, knowledge, maize, perception, termite, yield loss.

INTRODUCTION

A distinct dichotomy exits between the pest management literature that depicts termites as "pests" and the ecological literature demonstrating their crucial role in ecosystem services (Sileshi et al., 2009). Termites play a

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key role as decomposers of organic matter, nutrient cycling, and soil structure improvement in savannah as well as in subtropical and tropical ecosystems (Wood and Sands, 1978; Ackerman et al., 2009; Ayuke, 2010). Despite the potential beneficial role of termites, of the over 2800 described species, about 10% of these have been recorded as pests of crops, forestry, housing structures, and rangelands (Wood and Sands, 1978; Borer et al., 1981; Logan et al., 1990; Munthali et al., 1999; Culliney and Grace, 2000; Ackerman et al., 2009; Sileshi et al., 2009). However, not all timber, crops and trees are susceptible, and their resistance may vary with time or stage of growth (Pearce, 1997).

Susceptibility of crops and trees to termites is governed by several factors. In general, damage by termites is greater in rain-fed than irrigated crops, during dry periods or droughts than periods of regular rainfall, in lowland rather than highland areas, and in plants under stress (lack of moisture, disease or physical damage), rather than in healthy and vigorous plants. In particular, exotic crops and trees are more susceptible to termite attacks than indigenous crops (Logan et al., 1990; Pearce, 1997; UNEP, 2000).

Over 90% of the termite damage in agriculture, forestry and urban settings is attributed to members of the Macrotermitinae which build the large mounds that form the spectacular features of the African landscape (Sileshi et al., 2009; Adekayode and Ogunkoya, 2009; Abdurahman et al., 2010). The reputation of termites as pests is also associated with the presence of termitaria in crop fields and near trees (Sileshi et al., 2009; Abdurahman et al., 2010).

Despite the significant roles of termites in tropical ecosystems and the damage they cause mainly to crops and forestry is widely expressed in the scientific literature, yet less is known about farmers' perception and management of termites by small scale farmers (Ayuke, 2010). Farmers' perception is based on local experience and indigenous knowledge which can provide valuable insights not presently covered in scientific literature. Scientists can learn from farmers' knowledge about termites, their behavior, impact on crop production and their management under different agro-ecological conditions. Insights on farmers' perception may also provide scientists with some understanding on how research could be conducted so as to address the needs and constraints of farmers (Poubom et al., 2005; Sileshi et al., 2008; Ayuke, 2010).

The current philosophy in pest management is that if scientists have to work with farmers to improve crop protection and production, they should value farmers' indigenous technical knowledge systems (ethnoscience) and recognize farmers' constraints. Therefore, the first step towards the development of successful pest management strategies adapted to farmers' needs is an understanding of farmers' perceptions of the pests and their control methods. Farmers are, in general, good decision-makers; as such, their views should be considered when changes such as new technologies are to be introduced. The level of adoption of such technologies will therefore be high where farmers' perceptions are considered in their development (Poubom et al., 2005; Sileshi et al., 2008; Ayuke, 2010).

Though a high density of *Macrotermes* termite mounds making spectacular feature of the rural landscape of the Maki-Batu area was reported, no systematic studies exist on farmers' perceptions of termites and farmers-termite interactions. Therefore, the main objective of this study was to investigate and document farmers' indigenous knowledge and their perceptions of beneficial and detrimental roles of termites.

MATERIALS AND METHODS

Description of the study sites

The study was conducted at nine sites in five Kebele Administrations (KAs) in the three districts of East Shawa Zone of Oromia Regional State. Kebele is the lowest administrative level. Descriptions of the districts and the KAs are shown in Table 1.

Data collection methods and analyses

Farmers' perceptions of termites

Data were collected through semi-structured questionnaires and individual interviews held between July and December 2012. The questionnaires were first prepared in English and then translated into the local Afan Oromo language before administration. The questionnaires were administered to 51 household farmers in four KAs selected randomly from lists obtained from the Development Agents of the respective KA. The questionnaires had focused on identification of termite types, major crops grown in the area, farmers' perceptions of the benefits of termite mound soil and termites and detrimental roles of termites. A total of 32 farmers were purposively selected based on recommendation from Development Agents and interviewed individually on crops susceptible to termites, crop growth stage susceptible to termite damage and the average yield losses to the major crops grown in the area, termite management practices in field crops and to list different pests of standing cereal crops.

Farmers' crop yield loss estimate data of five major crops grown by farmers: maize, haricot bean, teff, wheat, barley, and sorghum were gathered carefully by reading the questionnaire to the respondents by the first author. The respondents were asked to estimate for an individual crop potential yield in kilograms they would harvest in the absence of any attack by termites per one *qarxii* of land which is equivalent to 50 m × 50 m (0.25 ha), followed by asking to estimate the quantity they would get in case of termite severe damage. The local people were knowledgeable about measurements in kilograms.

Farmers' yield loss estimate was then calculated as:

$$\text{Yield loss (\%)} = \frac{Y}{X} \times 100\%$$

Where X = Farmers' estimated potential yield without termite attack, and Y = Farmers' estimate yield loss due to termites.

Table 1. Some information about the Kebele Administrations in which the study sites were located.

District	Kebele Administrations	Coordinates*	Elevation (m.a.s.l.) *	Study sites
Bora	Tuqa Langano	8°16'N, 38°55E	1686	$Bora_1$
	Barta Sami	8˚14'N, 38˚53'E	1683	$Bora_2$
Dugda	Oda Boqota	8°10'N, 38°50'E	1666	$Dugda_1$ and $Dugda_2$
ATJK	Warja Washgula	7°56'N, 38°41'E	1652	$ATJK_1$ and $ATJK_2$
	Garbi Widana Boramo	7°53'N, 38°41'E	1650	$ATJK_3$

*Kebele Administrations' coordinates and elevations were recorded using GPS during the study period.

Termite damage and yield loss assessment on haricot beans and maize

Maize and haricot beans were selected for the study because they were identified by farmers as the most important major crops grown in the area and the most susceptible crops to termites. This was also confirmed by East Shawa Zone of Agricultural and Rural Development Office.

Haricot bean

Haricot bean (*Phaseolus vulgaris* L.), seeds were planted at three sites: Garbi Widana Primary School (GWPS), Warja Washgula Kebele Administration Farmers Training Center (WWKAFTC) and Oda Baqota Kebele Administration (OBKA) in the 2012 cropping season. Each site contained two blocks each divided into 4 plots measuring 3 m × 3 m. Seeds were planted on each 6 rows of each plot at a spacing of 40 cm between rows and 15 cm between plants. Two plots of each block were randomly treated with Diazinon 60%EC at field application rate of 2 l/ha as soil spray and the other two were left as untreated control. Two weeks after seedling emergence, the number of standing plants per plot was determined and termite damage to different plant parts was assessed in two weeks interval until harvest. At harvest, all plants in each plot were pulled out by hand, sufficiently dried and then threshed separately. The grains were weighed and the yields from the plots of the same treatment of each site were combined. The percentage yield loss was calculated for each treatment using the formula below as the difference between the treated and untreated plots.

$$\text{Yield loss (\%)} = \frac{(U - V)}{U} \times 100\%$$

Where U = mean grain yield of chemical treated plots and V = mean grain yield of untreated plots

Maize

Six plots of 3 m × 3 m were delineated at a certain distance-interval (depending on the size of the field) along the diagonal of the field on seven volunteer farmers' fields which had been cultivated by oxen in the traditional way and managed under farmers' conditions. Three weeks after emergence, the number of standing plants per sample plot was determined and plants in each plot were assessed for termite damage at two weeks interval until harvest.

Termite damage to crops is generally expressed as percentages of plants attacked or plant mortality, and degree of plant damage (UNEP, 2000). Thus, during each assessment the number of wilted, unhealthy looking, dead or lodged plants were checked for termite presence and damage. When present, termites were collected and preserved in 80% ethanol for later identification. When termites were not found, termite species were determined by damage symptoms. For damaged plants which were not cut either totally or partially at ground level, damage was assessed by pulling out the plants and checking the roots for the presence of termites or their damage symptoms. Plants were considered attacked when termites were seen feeding inside the root system or when root damage showed subterranean termite damage symptoms (Abdurahman, 1990). *Microtermes* species enter and consume the roots and continue their excavation into the stem, which can be excavated and packed with soil, while *Macrotermes* species cut the base of well-established plants (Abdurahman, 1990). Damage was assessed based on the method of Gudeta et al. (2005) by recording the number of lodged plants in each plot. At harvest the total numbers of plant lodged in all plots were combined and the mean percentage of lodged plants per site (field) was calculated.

Farmers' responses were summarized and analyzed as percentages using simple descriptive statistics. Farmers' estimate of percentage yield losses was analyzed using SPSS computer program version 17.0 for Windows.

RESULTS

Farmers' identification of pests of crops

Farmers mentioned 19 major different kinds of pest problem they faced in growing crops irrespective of pest ranks (Table 2). Without giving any hint about termites earlier in the questionnaires, the majority of the farmers considered porcupine (94%) followed by termites (69%) and foxes (56%) as the major pests of crops. Besides, warthogs, dogs and stem borers were also considered as important pests by some of the farmers and these were reported mainly as pests of maize. The major and devastating birds in the area were *Quelea* birds. Cutworms affected different types of crops at seedling stage. Farmers mentioned armyworms as occurring occasionally, but when they occur they cause economic damage on cereal crops. A farmer in Oda Boqota Kebele Administration (OBKA) considered aardvarks as pests for two reasons. First, aardvarks damage crops and cover them with soil, while digging the soil/mound to feed on termites. Second, they feed on maize which is an unusual recent phenomenon.

Table 2. Percentage of respondents' response to pests of standing cereal crops in Bora, Dugda, and Adami Tullu Jido Kombolcha districts of Central Rift Valley of Ethiopia (n = 32).

Pests of standing cereal crops	Percent (number)
Porcupines	94 (30)
Termites	69 (22)
Foxes	56 (18)
Stem borers	47 (15)
Dogs	34 (11)
Birds (mainly *Quelea*)	34 (11)
Cutworms	28 (10)
Armyworms	25 (8)
Warthogs	25 (8)
Fungi (diseases)	13 (4)
Shootfly	9 (3)
Rats	9 (3)
Domestic animals	9 (3)
Weeds	9 (3)
Mole rats	6 (2)
Antelopes	6(2)
Wild pigs	3 (1)
Aardvark	3 (1)
Grasshoppers	3 (1)

Number in the parenthesis indicate the number of respondents farmers.

Farmers' knowledge about the existence of termites and identification of termite types

All farmers were aware of the existence of termites and termite damage to crops and wooden construction. Farmers mentioned that termites were not uniformly distributed in their areas and that they were more abundant in relatively drier areas than wet areas and absent on vertisols. They also pointed out that the termite mounds were very old, no one knew the age of the mounds or when termites appeared in the area.

Farmers were not aware of the existence of different types (species) of termites, and they simply knew termites as a single entity. Even they were not aware of the existence of the minute species, *Microtermes*, which were common in their crop fields and also cause some damage. However, they recognize that a colony consisted of different castes which they could mention some of them using certain features as: the queen (*haadhoo* - the mother), soldiers (*diimtuu kan nama ciniintu* - the red-coloured which bites humans), and alates by flying behaviour (*roobaan jireettii* - the ones which appear during rain). All farmers reported the presence of epigeal mounds on their farmlands and that mounds were constructed by termites. Some also mentioned that termites could be found in non-moundy areas.

Farmers' perception of the benefits of termites

The utilization of mound soil and termites by the community is shown in Table 3. The majority of farmers mentioned that termite mound soil and termites are used for different purposes. About 90 and 78% of the respondents mentioned that mound soil was used for painting of walls of house and making mud bricks for house construction, respectively. Only very few (6%) farmers used termite mound as fertilizer and no one mentioned the use of termites as food for humans.

Farmers' perceptions of susceptibility of crops and crop growth stage susceptible to termite damage

Most of the farmers (78%) considered haricot beans and maize as the most susceptible crops to termites in the area (Table 4). The majority of respondents (99%) and all the participants (interviewees) mentioned that damage on maize plants (lodging) commences at maturity stage and continues until harvest and this was also confirmed by the surveys made on farmers' fields. Farmers reported that damage to haricot beans starts after physiological maturity and they associated damage to unpredictable cloudy weather which may be followed by rain. Farmers mentioned further that termites cause yield loss not by

Table 3. Percentages of respondents about the benefits rendered by termite mound soil and termites in the Central Rift Valley of Ethiopia (n = 51).

Use of	Variables	Percent (number)
Mound soil	Soil fertility/fertilizer	6 (3)
	Pottery making (traditional oven, pots, etc)	71 (36)
	Painting the wall of houses	90 (46)
	Making bricks to build houses	80 (41)
	Construction of stored products' structures	61 (31)
Termites	Food for humans	0 (0)
	Fishing bait*	51 (26)
	Chicken feed†	78 (40)

Number in the parenthesis indicate number of respondents; * Only those farmers who live around Lake Dambal use termites for fishing as baits or sell termites nesting in mounds found in their premises or farmlands to fishermen. †Chickens feed on alates only during alate flight; ‡Responses do not add up to 100% because multiple responses were possible.

Table 4. Crops reported by farmers as susceptible to termites and farmers' estimate of percentage yield losses of standing crops and harvested crops in the Central Rift Valley of Ethiopia.

Crop	% of respondents considered standing crops as susceptible	Yield loss (%)	
		Standing crops (mean ± SE)	Harvested crops (mean ± SE)
Maize	87	10.58 ± 1.91	6.78 ± 1.32
Haricot bean	87	18.02 ± 2.67	17.92 ± 3.54
Teff	39	4.67 ± 1.53	10.93 ± 2.15
Wheat	32	2.81 ± 0.96	4.49 ± 1.45
Barley	16	1.49 ± 0.66	1.49 ± 0.64
Sorghum†	0	0 ± 0.00	0.27 ± 0.27

*The figures are averages of several careful interviews by the researcher; †Sorghum was not mentioned by farmers in the list of susceptible standing crops to termites and this is in agreement with literature.

eating the seeds, but by eating the pods after which the seeds are scattered on the soil. This was also confirmed by observations made on farmers' fields (Plate 1). Under such conditions farmers even estimated high yield loss. Moreover, they reported that damage was highly localized even in the same field and some farmers could identify specific places where termites damage crops in their farmlands.

Farmers' perception of termites as pests and farmers' estimate of yield loss

The majority of respondents (94%) complained about the presence of termite mounds in their farmlands and thus they would like if these mounds are removed from their fields because of certain problems created by the mounds (Table 5). Only few respondents (6%) appreciated the presence of the mounds for their soil used in house construction, derive financial benefits from the sale of the soil, and soil in the perimeter of the mounds was more fertile than adjacent soil which increases production. Farmers also mentioned that termites damage crops and they were able to estimate yield loss to certain major crops (Table 4).

Crop damage and yield loss assessment

Yield loss assessment on haricot bean

No termite damage to standing haricot bean plants was recorded. The yield losses were very low and are shown in Table 6. Haricot beans planted at OBKA site were totally damaged by disease at pod formation stage and thus there are no results for the site.

Assessment of termite damage on maize on farmers' fields

Lodging of maize plants between 3 and 33% was

Plate 1. Haricot seeds scattered on the soil after the pods were damaged by termites on farmers' field.

Table 5. Farmers' perceptions of problems caused by termite mounds found on farmlands in the Central Rift Valley of Ethiopia (n = 51).

Variables	Percent (number)
Narrow farm land and decrease production	90 (34)
Used as nests for animals like rats, foxes, and hyenas which damage crops and/or attack domestic animals	3 (1)
Create obstacle for ox cultivation	21 (8)
Contain termites which eat crops	18 (7)
Source of weeds as weeds grow on mounds and then spread to adjacent area	3 (1)

*Responses do not add up to 100% because multiple responses were possible.

Table 6. Mean haricot bean yield loss due to termites at GWPS and WWKAFTC sites in the 2012 cropping season.

Site	Weight of seeds of treated plots (kg)	Weight of seeds of untreated plots (kg)	% loss (kg)
GWPS	9.006	8.949	0.632
WWKAFTC	9.577	9.563	0.146

GWPS = Garbi Widana Primary School; WWKAFTC = Warja Washgula Kebele Administration Farmers Training Center.

recorded (Table 7). *Macrotermes* were the most common termites responsible for the lodging which cut the plants at ground surface (Plate 2). *Microtermes* were also sampled from roots of some lodged plants. *Odontotermes* were found attacking plants rarely and *Amitermes* were also sampled from few lodged plants.

Farmers' termite management practices in field crops

Only few farmers used cultural management practices and no farmer used chemicals (Table 8). During the interviews, farmers noted that termites rarely damage standing crops on fields to which decomposed animal

Table 7. Mean percent of lodged maize plants and termite species responsible for the lodging at seven sites in the Central Rift Valley of Ethiopia in the 2013 cropping season.

Sites	Lodged plants		Termites caused lodging of plants
	Number	Percent	
$Bora_1$	15	8	*Macrotermes, Odontotermes* and *Microtermes*
$Bora_2$	9	7	*Macrotermes* and *Microtermes*
$Dugda_1$	24	15	*Macrotermes* and *Microtermes*
$Dugda_2$	12	7	*Macrotermes* and *Microtermes*
$ATJK_1$	12	10	*Macrotermes*
$ATJK_2$	4	3	*Macrotermes*
$ATJK_3$	51	33	*Macrotermes*, *Microtermes* and *Amitermes*

ATJK = Adami Tulu Jido Kombolcha.

Plate 2. Lodged maize plants by *Macrotermes* at $ATJK_3$ study site.

Table 8. Termite management practices mentioned by farmers to protect standing crops from termite damage (n = 32).

Indigenous management methods	Percent (number)
Wood ash	3 (1)
Wood ash + Cow dung + Mound destruction	3 (1)
Proper weeding	3 (1)
Collecting lodged maize	9 (3)
Prompt harvesting	19 (6)

dung was applied for soil fertility improvement. However, except collecting lodged maize plants, the use of these practices were not witnessed in the area applied for managing termites during the study period.

DISCUSSION

The inclusion of termites by the majority of the respondents (69%) in the list of pests of standing crops is indicative that termites are important pests in the area. Farmers were aware of the existence of termites for a long time in the area. Elders who were in their seventies, born and lived in the study area to date said that "*Akaakayyonni keenyallee akkanumatti argine jedhanii dubbatu.*" which means "Even our grandfathers said that they saw the mounds from their childhood as they are nowadays." The elders also mentioned that some mounds still existed which they knew during their childhood. Mr. Bariso Karu, a 76 year old indigenous elder, reported that termite mounds had existed in the area before his grandfather was born. Reconstructing the time, his grandfather was born in 1820, about 194 years ago. From this information, termite appearance in the area dates back at least about 200 years. However, to date, there is no evidence of the time termites appeared in the area before the aforementioned time. Termites appeared in western Wallaga (part of western Ethiopia) in about 1938 around a small town known as Qiltu Kara, and termite damage to crops was noticed in 1953 in the same area (Gauchan et al., 1998).

Farmers in the area did not have much knowledge on the presence of diverse species of termites. The lack of knowledge of termite diversity may be attributed to the absence of any benefit gained from termites as food and/or medicine contrary to elsewhere in some African countries. In those countries where termites are used as food, different termite species may be delicious and have better odor/taste than others and thus the people are able to identify termites based on such features.

Farmers of some African countries like Uganda, Kenya, Somalia, Zambia, Malawi and Ghana can identify different types of termites (species) in their areas by local names (Sileshi et al., 2009; Akutse et al., 2012). In Tororo district of Uganda, for instance, farmers identify a total of 14 species of termites in the local language and these are markedly consistent with scientific identifications. The farmers' identification of termites is based on a number of characteristics: (i) Mound building, (ii) Size of mound; (iii) Presence or absence of vents on mounds; (iv) Size, colour, odour and taste of alates (winged reproductives), soldiers or workers and (v) Seasonal and diurnal flight periods of alates (Nyeko and Olubayo, 2005).

In the current study farmers considered maize and haricot beans as the major crops grown in their area and also the most susceptible crops to termite damage. Among cereal crops, maize is the most often damaged by termites (UNEP, 2000). In western Kenya 97 and 3% of the farmers rate maize and sorghum as the most susceptible crops, respectively, whereas in eastern Zambia, all farmers rate maize as the most susceptible crop (Sileshi et al., 2009). Maize is susceptible because it was introduced recently into Africa by the Portuguese explorers in 1502 and has not been exposed to the range of termite life-history strategies of those species occurring in Africa (Ayuke, 2010). In parts of Africa, indigenous crops such as sorghum and pear millet, cowpea, arabica coffee and teff are more resistant to termite damage because of co-evolution and selection by farmers over many centuries (Pearce, 1997; Ayuke, 2010).

Over 98% of farmers reported that damage (lodging) to maize plants starts at maturity stage and continues until harvest and this was confirmed by the intensive field studies conducted on farmers' fields and both were in agreement with most literatures. Maize seedlings are rarely attacked by termites while plants are growing vigorously and lodging commences at physiological maturity (Gudeta et al., 2005). In Ghana farmers also reported that crops are most susceptible to termite attack at maturity stage and they attribute high termite damage in dry seasons mainly to the fact that several crops, especially maize, millet, groundnuts and sorghum, mature and are harvested in these months (Akutse et al., 2012). Several crops are most susceptible to termite attack at maturity (from tasselling/seed set to harvest) (Nyeko and Olubayo, 2005) and plants under stress, such as in drought conditions and those near ripening stage are most vulnerable to termite attack, and younger seedlings can contain repellent compounds such as phenols and cyanides (Pearce, 1997).

Lodging was the only damage symptom recorded caused mostly by *Macrotermes*, to a less extent by *Microtermes* and rarely by *Odontotermes*. *Amitermes* were also sampled from few lodged plants. Although *Microcerotermes* were recorded from farmlands in the area (Daniel and Emana, 2014), they were not sampled from damaged maize plants. Lodging is considered to be the most symptom of termite attack and may entail in further attack by rodents and fungi, in post-harvest decay and aflatoxin contamination (Gudeta et al., 2005, 2008; Ayuke, 2010). Prompt harvest of such crops may therefore reduce yield loss (Nyeko and Olubayo, 2005).

Besides, their perception of the commencement of termite damage to crops at maturity stage, farmers also viewed that damage was highly localized even in the same field and this was confirmed during the intensive field studies on maize on farmers' fields. The results imply that termite damage showed both spatial and temporal variation governed by certain factors. Abdurahman (1990) also noted that the extent of *Microtermes* spp. damage varies from location to location and from year to year and generally plants growing under poor agronomic conditions are more prone to termite damage than those growing under optimum conditions.

In contrary to the finding of the current study, Abdurahman (1990) recorded greater stand loss of maize due to *Macrotermes subhyalinus* at the vegetative growth stage (and more damage to the seedling stage) of the crop as compared to post-tasselling period in western

Wallaga and attributed this to the foraging behavior of the termites. Similarly, UNEP (2000) also reported that in Africa *Macrotermes* spp. cause damage to maize at seedling stage. The differences between these reports and the current study could be attributed to firstly, differences in termite pest species which attack crops at different stages and availability of wood litter and/or crop residues during the early crop growth stage from the previous cropping season which attract termites. There would be more crop residues during the early crop growth stage and these deplete gradually which coincide with crop maturity and then termites will shift to crop plants. Secondly, in the current study, the lack of crop damage during vigorous growth stage and damage incident during crop maturity stage can also be related to the foraging ability of termites governed by rainfall. The heavy rainfall during the vigorous plant vegetative growth stage, that is, rainy season, prevents termites from foraging because termites can hardly construct foraging tunnels and the flood suffocates the termites (the area is generally flat) and thus they stay in their nests. Therefore, during the rainy period the colony's food reserve will become less and thus workers start foraging to feed the hungry colony as soon as the rain decreases (the onset of dry season) and finally stops which coincides with crop maturity stage during which crops start facing moisture stress and become more susceptible to termite damage.

Farmers in the area mainly acknowledged termites for their mound soil used in house construction in making mud bricks and plastering of walls. In wooden wall houses, farmers used a combination of different wood species in building their houses and some of these woods are very sensitive to termite attacks resulting in a decreased lifespan. The replacement of damaged wood and rebuilding of new houses is uneconomical for the farmers and has serious impacts on natural vegetation as it demands additional use of wood. It is therefore of high importance to further spread the knowledge regarding the use of mound soil in making bricks as construction material in a sustainable approach for the future (Emana and Daniel, 2014). The high clay content, the chemical and physical properties and mineralogical composition of termite mound soils which are different from adjacent soils make them useful for making bricks for buildings and contribute a lot in constructions (Pearce, 1997; Akutse et al., 2012). Mound soil is also used for pots, plastering walls, making ovens and is spread for growing plants (Pearce, 1997).

In the current study, the local people did not use termites as food and even there were no available document on the use of termites as food in Ethiopia. However, in the country some local people in Benishangul Gumuz Zone eat swarming alates (Expert of Crop Protection of Agricultural and Rural Development Office of Asosa Zone; Manager of Asosa Plant Health Clinic, pers. comm.). In some African countries, however, some termite species in the subfamily Macrotermitinae are eaten and farmers have extensive knowledge of the value of termites in human nutrition. For instance, the use of termites as food was reported in Uganda (Nyeko and Olubayo, 2005), Namibia (Yamashina, 2010), Kenya (Ayuke, 2010), and Ghana (Akutse et al., 2012). In these countries, the local people can easily identify edible termites from those unsuitable for consumption (Sileshi et al., 2009).

Although farmers reported crops grow better around mounds and fields on which mound soil was spread during mound destruction and all of them had termite mounds in their fields, only few of them (6%) used mound soil as fertilizer contrary to reports elsewhere in Africa. In other parts of sub-Saharan Africa farmers have been seen to leave the mounds and plant crops around them or spread termite-modified soils on their fields (Sileshi et al., 2009; Ayuke, 2010; Akutse et al., 2012). Farmers' use of termite-modified soil in crop production has been documented in Uganda, Zambia, Zimbabwe, Tanzania, Niger, and Sierra Leone (Sileshi et al., 2009) and Laos (Shuichi et al., 2011). Farmers in Ghana attested that the old mounds of termites were source of nutrients for crops. Some vegetables especially pepper, garden eggs, tomato, and other crops such as corn, cassava are usually grown around the mounds. Farmers break the mounds and scatter it to cover more surfaces before the planting or sowing time (Akutse et al., 2012).

Although, farmers acknowledged termites especially for their mound soil in house construction, they considered termites as serious pests of wooden construction and crops, and other problems created by the occurrence of high mound density on the fields. In the interview made with a farmer in the current study about the benefits of termites, the farmer said "*akkamittiin diinni bu'aa qaba*?" which means "How can an enemy have benefits?"

The study has shown that the majority of the respondent farmers regarded termites as the worst pests because termites damage both pre- and post-harvest crops, wooden construction and furniture unlike any other organism. Besides they reported that the high density of termite mounds in their farmlands limits the area available for cultivation and create obstacle during ox-cultivation.

Farmers considered haricot beans and maize as the most susceptible crops and estimated yield loss to these crops before harvest as 18.02 ± 2.67 and 10.58 ± 1.91 (mean ± SE), respectively. According to the farmers, termites cause economic damage to these crops. In the field study 3 to 33% lodging of maize plants was recorded on farmers' fields. However, lodging of maize after senescence may not result in yield loss, if the number of cobs is less, sufficiently matured and all can be used as food by the family and picked daily before they are further attacked by termites and other animals. Generally, farmers considered lodged maize used as food as a loss or wastage because it is used without their intention and also not all is consumed immediately or stored for later use if it is not physiologically matured. It was observed that not all the lodged maize plants were further attacked by termites and other animals and these would add to the farmers' yield. Therefore, physiologically matured lodged plants may not necessarily result in considerable yield loss when they are collected daily for food and also as harvesting in the area is not mechanized. Abdurahman (1990) reported that, when harvesting is mechanized, collecting individual lodged maize from the ground during harvesting can make inconvenience and may demand additional labour to the farmer. Incomplete harvesting of lodged plants in commercial agriculture where the crop is mechanically harvested leads to high loss of yield (up to 100%) unless cobs are harvested by hand incurring added costs.

Contrary to the current study, from surveys they conducted in Maki-Batu area about 25 years ago, and report from local farmers' and area crop protection staff, Cowie and Wood (1989) and Abdurahman (1990) reported that there is no intensive crop damage even on highly susceptible crops such as maize and hot peppers despite the high density of *Macrotermes* mounds. The difference between these reports and the current study may imply that termites have achieved pest status over time. This is also evidenced by the majority (67%) of the respondents perceived that termite severity increased from time to time to standing crops and 52% of them considered termites as serious pests to especially susceptible crops like maize and haricot beans and thus control measure would be necessary. Similarly, Sileshi et al. (2009) reported that farmers in Uganda and Zambia perceive that termite problems are more serious now than in the past. They attribute the increasing severity of termite damage on trees and crops to the depletion of the usual termite food due to deforestation and overgrazing.

Although, farmers in this study considered termites as pests, they did not abandon growing any crop or have not left their lands. Contrary, in western Wallaga farmers abandoned farm fields or abandoned growing certain crops like field pea, faba bean, and chickpea and to some extent millet and migrated to other areas due to termite problems (Sanna, 1973; Abdurahman, 1990; EECMY-WS, 1997).

Whether termite pest problem in the area justifies control or not, detail crop yield loss assessment has to be carried out for a number of years at different sites. In line with this, Logan et al. (1990) reported that the first principle of control is to decide whether control is both desirable and economically feasible. For the latter, yield loss estimates are essential but have been rarely assessed in detail; damage levels may be only poor indicators of ultimate yield loss. For instance, in maize, compensatory growth by surviving plants following early season attack, harvest of cobs on the ground from plants lodged late in the season, and damage to vegetative parts occurring after cob formation will result collectively in over-estimates of yield loss if they are based only on attack or damage scores.

Although most of the farmers perceived termites as crop pests and farmers' average potential crop yield loss estimate, especially losses of maize and haricot beans sounds high, only few (9%) of them reported the use of few management practices. Of these, prompt harvesting of haricot beans and collecting of lodged maize cobs for family food were witnessed during the field study.

All the respondents reported that termites attack of haricot beans after senescence (towards harvest) and associated damage to incident of unpredictable cloudy weather which may be followed by rain. According to them, prompt harvesting of haricot beans and placing the harvested crop in a well protected place is the only means of termite management. However, if the crop is harvested before senescence and heaped, total crop loss results because of decay.

Conflict of Interest

The authors declared that they have no conflict of interest.

ACKNOWLEDGEMENTS

The authors are grateful to Adama Science and Technology University (ASTU) for funding the research. Special thanks go to the communities participated in this research. We also thank field research assistants.

REFERENCES

Abdurahman A (1990). Foraging Activity and Control of Termites in Western Ethiopia, Ph.D. Thesis, University of London. P. 277.

Abdurahman A, Abraham T, Mohammed D (2010). Importance and Management of Termites in Ethiopia. Pest Manage. J. Ethiop. 14:1–20.

Ackerman IL, Constantino R, Gauch HG, Lehmann J, Riha SJ, Fernandes ECM (2009). Termite (Insecta: Isoptera) Species Composition in a Primary Rain Forest and Agroforests in Central Amazonia. Biotropica 41(2):226–233.

Adekayode FO, Ogunkoya MO (2009). Comparative study of clay and organic matter content of termite mounds and the surrounding soils. Conference Proceedings. African Crop Science, Uganda. 9:379–384.

Akutse KS, Owusu EO, Afreh-Nuamah K (2012). Perception of Farmers' Management Strategies for Termites Control in Ghana. J. Appl. Biosci. 49:3394– 3405.

Ayuke FO (2010). Soil macrofauna functional groups and their effects on soil structure, as related to agricultural management practices across agroecological zones of Sub-Saharan Africa. Ph.D. Thesis, Wageningen University, Wageningen. P. 211.

Borer DJ, Delong DM, Triplehorn CA (1981). An Introduction to the Study of Insects (5th ed.) CBS College Publishing, USA.

Culliney TW, Grace JK (2000). Prospects for the Biological Control of Subterranean Termites (Isoptera: Rhinotermitidae), with Special Reference to Coptotermes formosanus. Bull. Entomol. Res. 90:9–21.

Daniel GD, Emana GD (2014). Termite species composition in the Central Rift Valley of Ethiopia. Agric. Biol. J. N. Am. 5(3):123-134.

Emana G, Daniel G (2014). Preliminary studies of termite damage on rural houses in the Central Rift Valley of Ethiopia. Afr. J. Agric. Res. 9(39):2901-2910.

EECMY-WS (Ethiopian Evangelical Church Mekana Yesus-Western Synod) (1997). A Strategy for a Sustainable Control of Termites in Manasibu Woreda (West Wallaga). B and M Development Consultants PLC. Addis Ababa.

Gauchan D, Ayo-Odongo J, Vaughan K, Lemma G, Mulugeta N (1998). A Participatory Systems Analysis of the Termite Situation in in West Wallaga, Oromia Region, Ethiopia. Working Document Series 68, ICRA, Wageningen. Netherlands P. 158.

Gudeta S, Mafongoya P, Kwesiga F, Nkunika P (2005). Termite damage to maize grown in agroforestry systems, traditional fallows and monoculture on nitrogen-limited soils in eastern Zambia. The Royal Entomological Society. Agric. For. Entomol. 7:61–69.

Logan JWM, Cowie RH, Wood TG (1990). Termite (Isoptera) Control in Agriculture and Forestry by Non-chemical Methods: A Review. *Bul. Ent. Res.* 80:309-330.

Munthali DC, Logan JWM, Wood TG, Nyirenda GKC (1999). Termite Distribution and Damage to Crops on Smallholder Farms in Southern Malawi. Insect. Sci. Appl. 19:43- 49.

Nyeko P, Olubayo MF (2005). Partcipatory Assessment of Farmers' Experiences of Termite Problems in Agroforestry in Tororo District, Uganda. Agricultural Research and Externsion Network Paper No.143:13.

Pearce MJ (1997). Termites: Biology and Pest Management. CAB International, New York. P. 172.

Poubom CFN, Awah ET, Tchuanyo M, Tengoua F (2005). Farmers' perceptions of cassava pests and indigenous control methods in Cameroon. Int. J. Pest Manage. 51(2):157-164.

Sanna E (1973). Termites as Agricultural Pests in: A literacy Abstract Mainly from W. V. Harris' book, "Termites: their Recognition and Control" and a Report from Henna Project, Wallaga. P. 10.

Shuichi M, Yusaku K, Mika K, Yuichi M, Yoshinao A, Sengdeaune S, Nobumitsu K, Shinya O (2011). Indigenous Utilization of Termite Mounds and their Sustainability in a Rice Growing Village of the Central Plain of Laos. J. Ethnobiol. Ethnomed. 7:24. doi: 10.1186/1746-4269-7-24.

Sileshi GW, Elias K, Patrick M, Philip ON (2008). Farmers' Perceptions of Tree Mortality, Pests and Pest Management Practices in Agroforestry in Malawi, Mozambique and Zambia. Agroforest. Syst. 72:87–101.

Sileshi G, Nyeko P, Nkunika P, Sekematte B, Akinnifesi F, Ajayi O (2009). Integrating ethno-ecological and scientific knowledge of termites for sustainable termite management and human welfare in Africa. Ecol. Soc. 14(1):48.

SPSS Inc (2008). SPSS Statistics 17.0, SPSS Inc., Chicago IL.

UNEP/UNEP/ Global IPM Facility Expert Group (2000). Finding alternatives to Persistent Organic Pollutants (POPs) for termite management.http://www.chem.unep.ch/pops/termites/termite_full document.pdf

Wood TG, Sands WA (1978). The role of termites in ecosystems, pp. 245-292. In: Brian M.V. (ed.), Production ecology of ants and termites. Cambridge University Press, Cambridge, Great Britain.

Yamashina C (2010). Interactions between Termite Mounds, Trees, and the Zemba People in the Mopane Savanna in Northwestern Namibia. African Study Monographs Suppl. 40:115-128.