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FARMERS' EXPERIENCE IN TERMITE MANAGEMENT IN EASTERN UGANDA

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A B S T R A C T

This study was aimed at understanding farmer's perceptions about termite management in eastern Uganda. The study covered 84 villages located in seven districts of eastern Uganda involving 420 respondents. In addition to the individual interviews, the perception of push-pull technology adopters was determined from four districts through a focus group discussion. Quantitative and qualitative data were collected and analyzed using STATA (version 13). Respondents were diverse in terms of age, gender, level of education and marital status. In general, 95% of the respondents stated that termites can cause food insecurity and poverty. The level of infestation varied between districts, respondents from Bukedea and Iganga stated that the infestation of maize due to stemborer is between 70% and 80% while respondents from Tororo and Pallisa stated that the infestation could reach upto 50%. The prevalence of termites and damage potential varies across districts and the type of crop and growth stage. Some are vulnerable at germination, some at vegetative and some at maturity stages. Averaged over three districts, farmers claimed that maize is more vulnerable to termite attack causing about 40% yield loss followed by beans, soybeans, and sorghum. Push-pull technology adopters stated that green leaf desmodium intercropped with maize was vulnerable to termite attack. Although pesticide application can be an effective option, they claimed it is either expensive or not a lasting solution.

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INTRODUCTION

Termites have long been recognized as important agents of the ecological stability of semi-arid and sub-humid tropics (Logan *et al.*, 1990; Wardell, 1987). They are found in every type of soil in the world and have a broad range of species. Termites are recognized as serious pests in agriculture. In East Africa, damage due to termites is aggravated in areas where the land is degraded. They pose a serious threat to crops, forestry seedlings, rangelands, and wooden structures (Logan *et al.*, 1990; Taye *et al.*, 2013). In the semi-arid savannah of Kenya for instance, termites destroy 500-1500 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, losses of crops and tree stands ranging from 50 to 100% have been attributed to termite attack (Sekamatte, 2001b).

Because of their economic importance, most of the studies of tropical termites have concentrated on their control, especially the use of pesticides. The non-pesticide methods revolve around good silvicultural or agronomic practices, physical destruction of termite mounds, biological control, and the use of resistant/tolerant species (Logan *et al.*, 1990). Microbial biological control methods have also been used with the aim of suppression and management of insect populations (Mugerwa and Nyangito, 2011). It is imperative to understand the indigenous technical knowledge before the introduction of new or improved agricultural practices (Norton et al., 1999). Particularly true when it comes to termite management because most farmers are familiar with termites and in most cases, they have local names for the different species (Nyeko and Olubayo, 2005).

In the cereal production systems, damages are attributed to insect pests like cereal stem borers, termites, and parasitic weed Striga. Several improved agricultural practices and innovations have been developed to enhance crop production through the control of insect pests. One such innovation is the push-pull technology (PPT) (http://push-pull.net/) where maize is intercropped with a stem borer moth-repellent legume, Desmodium (Desmodium intortum & Desmodium unicinatum), surrounded with an attractant host plant, Napier (Pennisetum purpureum Schum.) or Brachiaria grass planted as a trap plant for stem borers (Khan *et al.*, 2002). Although termites are among the major pests of maize in Africa (Riekert and Van den Berg, 2003; Sileshi *et al.*, 2005; Sileshi *et al.*, 2009; Paul *et al.*, 2017) little is known about the termite management experience of push-pull technology adopters. Therefore, the objective of this study was to evaluate farmers' experience in termite management in eastern Uganda.

MATERIALS AND METHODS

Study area

The study was conducted across seven districts in eastern Uganda (Figure 1). These districts receive a bi-modal rainfall pattern with an annual mean daily maximum temperature of 30°C. Rainfall ranges between 800 to 1500 mm per annum with annual precipitation of around 1160mm. The main rain season (long rains) is between March/April to June/July while the second rain season (short rains) follows from August to October sometimes extending to November. A long dry season occurs from December to February while a short spell comes around July-August. The natural vegetation in the districts is dominantly open savannah grass and woodland. Farming is the main economic activity where crop production is more dominant. Crops such as maize, sorghum, beans, cassava as well as fruits, vegetables, and tuber crops are cultivated and livestock such as cattle, goats, sheep, pigs, and poultry are reared by some households. Maize, cassava, beans, and sweet potatoes stand out as the major staple crops in all three districts (Ministry of Agriculture Animal Industry and Fisheries, 2010).

Sampling and site selection

The termite survey was conducted in 2016 where three sub-counties were randomly selected using simple random sampling without replacement from each district. In each sub-county, two parishes were selected using simple random sampling without replacement. In each parish, two villages were selected using simple random sampling. Using this approach, 84 villages were reached, and five households were randomly selected in each village using a simple random sampling technique. Thus, a total of 420 interviews were conducted across seven districts. In each household, the head or any other adult member was interviewed. The gender of the household member interviewed was considered so that a representative number of male and female members could be interviewed.

Data collection

A mixed-method data collection approach involving the use of quantitative and qualitative methods was applied. The quantitative method involved the use of a household survey where a structured questionnaire with close-ended questions was administered. The questionnaire was pretested for consistency, clarity, and timing as well as revised based on feedback from enumerators. Data collected include socio-demographic characteristics of respondents, the major causes of termite infestation and the damage potential as well as their experience and knowledge about termite management.

Focus Group Discussions

The other component of the study focused on PPT adopters, termites being a landscape-level problem and PPT comprises perennial companion plants, it was very important to understand the effect of termites and its implication for technology dissemination. To collect this information qualitative approach was applied using Focus Group Discussions (FGDs). The participants of the FGDs were selected purposively. Eight FGDs were conducted with only PPT adopters in four districts including Tororo, Busia, Pallisa, and Bukedea. Two FGDs were conducted in each district with each group having 8-15 farmers. During the FGDs farmers were asked about the constraints of agricultural production in general and specifically about abundance and damage potential of termites in the PPT and their termite management experience.

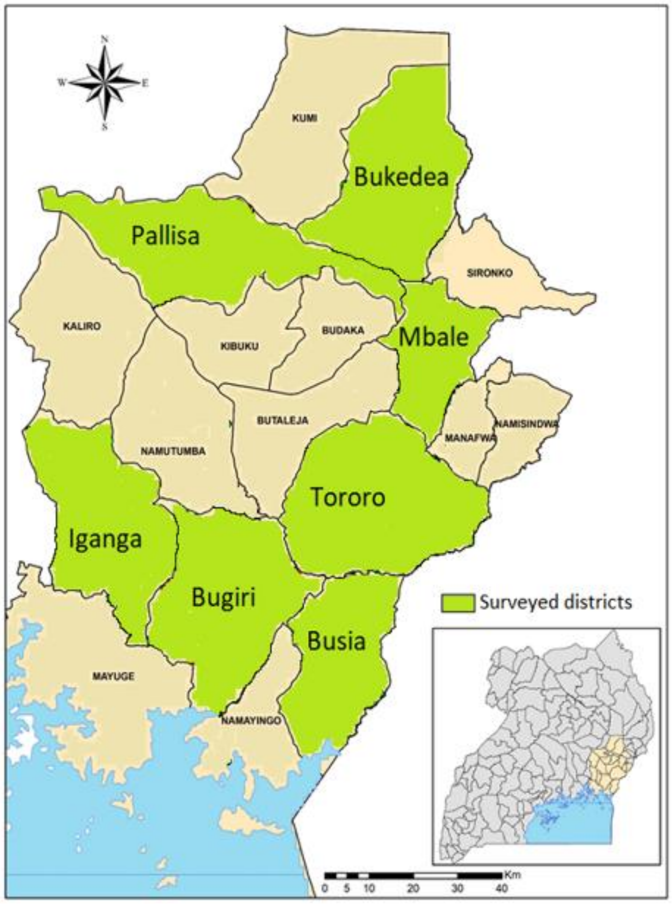


Figure 1. Map of surveyed districts in eastern Uganda.

Data analysis

The data were analyzed using *STATA (version 13)*. The analysis captured descriptive statistics including averages and standard deviations for selected variables, frequency tables, and graphs were presented. Cross tabulations between and among selected variables were performed.

RESULTS

Socio-demographic characteristics of respondents

A total of 420 respondents participated in the survey with 68% male and 36% female. The respondents had an average age of 43.3 years, ± 13.6. The age range included 28% above 50 years, 27% were between 41-50 years, 24% were 31 – 40 years while 19% were aged between 20-30 years. Most participants (88%) were married and only 12% were single. The results further showed that 69% of the participants were household heads. A greater proportion (62.4%) of the respondents attained primary level education while 23.0% attained secondary level education, only 12% did not attain any form of formal education (Table 1). The majority (95%) of the respondents were subsistent farmers (Table 1). FGD conducted with push-pull adopters involved 153 participants among which, 53% were female and 47% male.

Table 1. Socio-demographic characteristics of respondents.

Background characteristics (n=420)	Frequency	Percentage	Mean (SD)
Age of the farmer			
<20	4	1.0	43.3±13.57
20-30	81	19.4	
31-40	101	24.2	
41-50	113	27.1	
Above 50	118	28.3	
Sex of the farmer			
Male	268	63.8	1.36±0.48
Female	152	36.2	
Marital status of the farmer			
Single1	52	12.4	1.25±0.75
Married	367	87.6	
Household head			
Yes	290	69.0	1.31±0.46
No	130	31.0	
Education level			
None	49	11.7	2.17±0.66
Primary	261	62.4	
Secondary	96	23.0	
Tertiary	12	2.9	
Occupation			
Peasant farmer	379	90.5	1.27±0.99
Housewife	11	2.6	
Professional	11	2.6	
Casual laborer	2	0.5	
Business/self employed	12	2.9	
Ill/disabled	1	0.2	
Other	3	0.7	

Perceived consequences of termite infestation on the livelihoods of farmers

Respondents across the surveyed district consider termites as a threat to their livelihoods. For example, about 32% of the respondents stated that the damage causes poverty while 27% stated that it will reduce income and 26% said it causes food insecurity (Figure 2). Other consequences include an inability to send children to school and migration or abandoning the farm.

In general, over 95% of the respondents attributed termite damage as a cause of poverty since reduced income, food insecurity, and inability to educate children results in the same consequence.

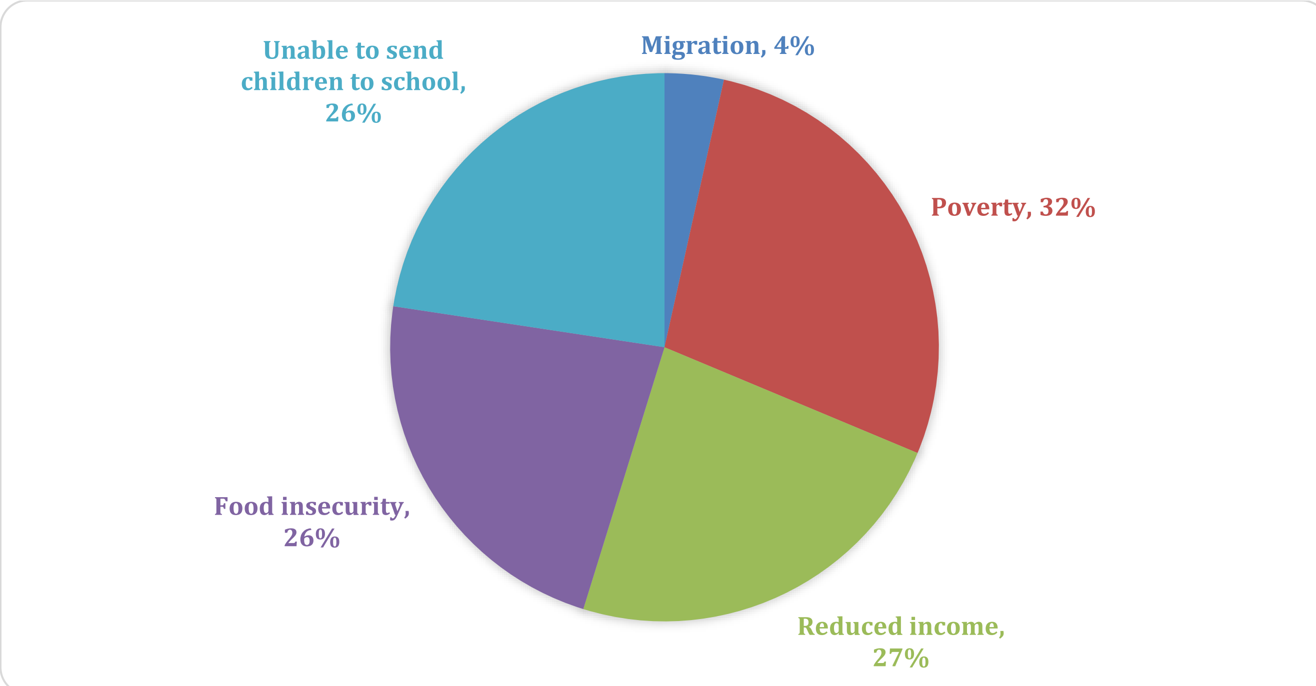
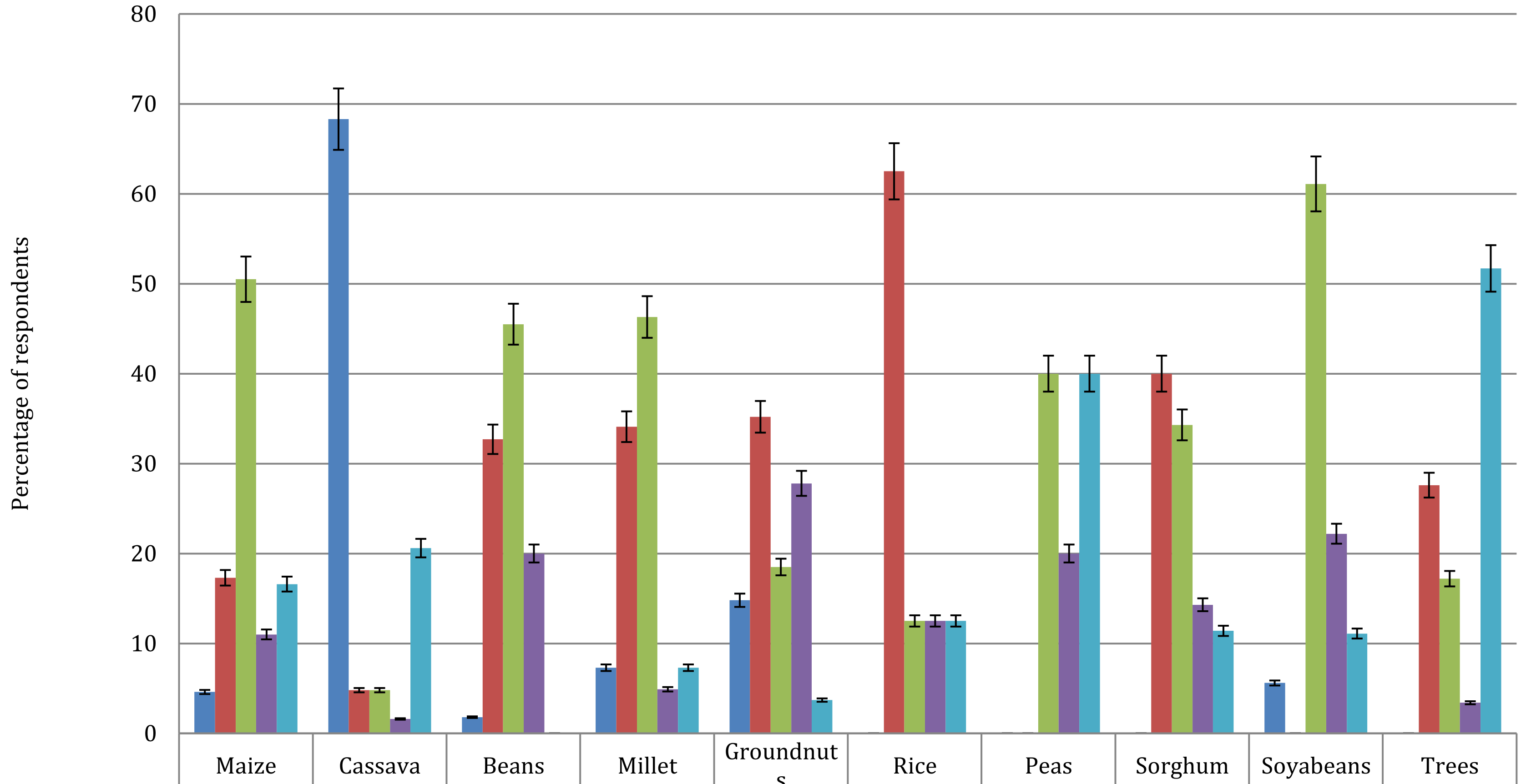


Figure 2. Perceived consequences of termite infestation on the livelihoods of farmers.

Table 2. The expected loss of yield (t/ha) due to termites as perceived by farmers in three districts of eastern Uganda.

District	Bugiri (n=11)			Bukedea (n=11)			Tororo (n=11)			Average (n=33)		
	Expected yield	Estimated yield loss	% Yield loss	Expected yield	Estimated yield loss	% Yield loss	Expected yield	Estimated yield loss	% Yield loss	Expected yield	Estimated yield loss	% Yield loss
Maize	1.91	0.85	44.7	1.83	0.76	41.6	1.85	0.67	36.2	1.86	0.76	41.0
Beans	1.30	0.53	40.5	1.16	0.42	36.2	1.27	0.51	40.0	1.24	0.48	38.9
Soybeans	1.40	0.55	39.2	1.27	0.44	34.9	1.37	0.49	35.3	1.35	0.49	36.5
Cassava	4.76	1.40	29.5	4.40	1.28	29.1	4.75	1.26	26.5	4.64	1.31	28.3
Groundnuts	4.02	1.08	26.8	2.83	0.71	25.0	3.48	0.73	21.0	3.44	0.84	24.4
Sorghum	1.40	0.53	37.6	1.21	0.43	35.2	1.40	0.51	36.3	1.35	0.49	36.2
Millet	1.17	0.39	33.7	1.27	0.38	30.1	1.24	0.41	33.1	1.22	0.39	32.2
Rice	1.77	0.66	37.3	1.53	0.46	30.2	1.74	0.61	35.4	1.68	0.58	34.5



	Maize	Cassava	Beans	Millet	Groundnuts	Rice	Peas	Sorghum	Soyabeans	Trees
Germination	4.6	68.3	1.8	7.3	14.8	0	0	0	5.6	0
Vegetative	17.3	4.8	32.7	34.1	35.2	62.5	0	40	0	27.6
Maturity	50.5	4.8	45.5	46.3	18.5	12.5	40	34.3	61.1	17.2
Harvesting	11	1.6	20	4.9	27.8	12.5	20	14.3	22.2	3.4
All stages	16.6	20.6	0	7.3	3.7	12.5	40	11.4	11.1	51.7

Figure 3. Stage of growth at which crops are attacked by termites.

Termite infestation of companion plants in push-pull technology

Almost all participants in the FGDs mentioned that termites attack the companion plants such as Napier and desmodium. According to their statement, the most affected is green leaf desmodium which is vulnerable after maize harvest resulting in poor performance during the subsequent season. Farmers in Bukedea and Iganga stated that the infestation can reach up to 80% and 70% respectively (Table 3). Respondents from Tororo and Pallisa also stated that the infestation could reach up to 50% and 40%, respectively. Although a lot less,

Silverleaf desmodium was also affected by termites during the dry spell, and farmers estimated about 60% in Bukedea, 50% in Iganga, and Tororo (Table 3). Among the grass components, Napier was mentioned but the level of infestation was only 9% on average and recovers at the onset of rain. Termite infestation of Brachiaria was mentioned only in Iganga and Tororo where the perceived infestation level by farmers was about 10% and 5%, respectively (Table 3).

Table 3. Perceived level of termite infestation in push-pull farms.

Crop	Perceived percent infestation				
	Bukedea (%)	Iganga (%)	Tororo (%)	Pallisa (%)	Average (%)
Green leaf desmodium	80	70	50	40	60
Silver leaf desmodium	60	50	50	30	47
Brachiaria	0	10	5	0	4
Napier	0	10	20	5	9

Farmers experience on termite management

The various termite management practices implemented by respondents from different districts are presented in Table 4. Overall, 62% of the respondents have ever tried to control termites, while 35% have never attempted to manage termites. Among the participants who tried to control termites, 57% used insecticides.

The removal of the queen was mentioned by 31% of the respondents. Other control strategies such as the use of cow dung, wood ash, use of boiled water, flooding the termite mounds were reported by about 5% of the respondents (Table 4). For respondents who have not tried to control termites, 36% claimed the lack of money to purchase insecticides. 18% of the respondents cited a lack of knowledge/skills as a limiting factor to control termites. About 14% of the respondents claimed that termites cannot be controlled (Table 4). Regarding institutional interventions in helping them to control termites, 98% of the respondents claimed that there was no institutional support. Only 2% (9/420) stated that they received help/advice on termite management. Some of the institutions cited include NGOs (4/9), government (3/9), academic institutions (1/9), and research body/researchers (1/9). The kind of support provided were insecticides, extension support on termite management, credit provision for farming and/or termite management, information sharing on termite management (Table 4).

Table 4. Farmers experience in the management of pestiferous termites in eastern Uganda.

Termite management experience (n=420)	Frequency	Percentage	Mean (SD)
Tried to control termite			
Yes	260	62.4	1.37±0.48
No	157	34.6	
Control strategy used			
Use of pesticides	211	56.9	1.39±0.49
Queen removal	115	31.0	1.66±0.47
Boiled water	16	4.3	
Use of wood ash	18	4.9	1.99±0.05

Cow dung/goat residue	2	0.5	1.99±0.07
Flooding	7	1.9	1.98±0.15
Mixed strategies	1	0.3	1.99±0.05
Reason for not controlling termites			
Termites cannot be controlled	39	14.1	1.85±0.35
Available control mechanisms not effective	21	7.6	1.92+0.27
Lack of labor to apply control mechanisms	11	4.0	1.96±0.20
Lack of money to buy pesticides	93	33.6	1.64±0.48
Lack of knowledge/skills to apply control mechanism	50	18.1	1.81±0.39
Pesticides not available	22	7.9	1.91±0.27
Natural occurrences	41	14.8	1.84±0.36
Institutional support to control termites			
Yes	9	1.9	1.98±0.14
No	403	98.1	
Institutions that have intervened4			
Government	3	0.7	
NGO	4	1.0	
Academic institutions	1	0.2	
Research body/researchers	1	0.2	
Control mechanism used by institutions			
Credit provision for farming/ termite management	1	12.5	
Extension support on termite management	1	12.5	
Provision of termite control pesticides	4	50.0	
Information sharing on termite management	1	12.5	
Collected termite specimen for research	1	12.5	

Farmers experience of termite management disaggregated by gender and age

The survey data disaggregated by gender revealed that 52% (77 out of 149) female and 68% (183 out of 268) male respondents attempted to control termites (Table 5). The predominant control strategy applied by was the use of insecticides. Among the respondents, 84% male and 81% female claimed to apply insecticides which was significantly greater compared to all the management methods applied (Table 5). More females (8%) than male (7%) used ash as a control strategy for termites. The reasons for not controlling termites varied between the male and female respondents; however, common to both was the lack of money to buy insecticides (Table 5). More female than male respondents stated that termites cannot be controlled, they lack knowledge/skills to apply control mechanism, while more male than female respondents stated that the available control mechanisms not effective, they lack labor to remove the queen. What was common was lack of money to purchase insecticides and natural occurrences. There was no significant association between gender of respondents and their reasons for not controlling termites (Table 5). Close to all male (98%) and female (99%) respondents stated that they never received support on termite management from any institution.

The control of termites by many farmers was significantly associated with the different age categories ($\chi2=15.119$, $p<0.01$). About 34% of the respondents aged 50 years and above tried to control termites while 26%, 23%, and 18% of the respondents in the age categories of 41 – 50 years, 31 – 40 years, and 21-30 years respectively, attempted to control termites (Table 5). The termite control strategies used by the respondents were not significantly affected by age for most of the control strategies while significant differences are observed for the use of queen removal ($\chi2=10.142$, $p<0.05$) and the use of chemicals ($\chi2=9.775$, $p<0.05$). Over 30% of the respondents in the different age categories except for respondents less than 20 years cited the use of queen removal as a control strategy while over 80% of the respondents in the different age categories except for respondents less than 20 years used chemicals for termite control (Table 5). The control mechanisms of termites identified by the PPT adopters in the FGDs also confirmed the findings of the household survey. Participants in the FGD also stated that they practiced queen removal, flooding, and smoking though the method was not effective. The participants also reported that they have used some pesticides; however, they have limited access and knowledge about effective insecticides and even if they are available, they were highly priced.

Table 5. Farmers experience in the management of pestiferous termites in eastern Uganda.

Termite management experience (n=420)	Gender		Age group				
	Male	Female	<20 years	21-30 years	31-40 years	41-50 years	Above 50 years
Tried to control termite							
Yes	183 (68)	77 (52)	0 (0.0)	46 (17.8)	59 (23)	66 (26)	87 (34)
No	85 (32)	72 (48)	4 (2.6)	35 (22.4)	42 (27)	44 (28)	31 (20)
Control strategy used							
Boiled water	12 (7)	4 (5.2)	0 (0.0)	2 (4.4)	1 (2)	7 (11)	6 (7)
Queen removal	85 (47)	32 (42)	0 (0.0)	25 (55.6)	26 (46)	20 (30)	45 (52)
Use of pesticides (insecticides)	151 (84)	62 (81)	0 (0.0)	37 (82.2)	48 (84)	55 (84)	71 (82)
Use of wood ash	12 (7)	6 (7.8)	0 (0.0)	1 (2.2)	3 (5)	6 (9)	8 (9.2)
Cow dung/goat residue	1 (0.6)	1 (1.3)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2)	1 (1.1)
Flooding	7 (3.9)	1 (1.3)	0 (0.0)	2 (4.4)	1 (2)	2 (3)	3 (3.4)
Mixed strategies	1 (0.6)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2)	0 (0.0)	0 (0.0)
Reason for not controlling termites							
Termites cannot be controlled	20 (25)	19(28)	0 (0.0)	8 (21.1)	8 (21)	16 (42)	6 (15.8)
Available control mechanisms not effective	12 (15.2)	9(13)	3(15.0)	7 (35.0)	3 (15)	1 (5)	6 (30.0)
Lack of labour to apply control mechanisms	7 (8.9)	4 (6.0)	0 (0.0)	0 (0.0)	3 (27)	2 (18)	6 (55)
Lack of money to buy pesticides (insecticides)	52 (65.8)	41 (61)	4 (4.3)	17 (18.5)	23 (25)	26 (28)	22 (24)
Lack of knowledge/skills to apply control mechanism	26 (33)	24 (36)	0 (0.0)	16 (32.0)	15 (30)	10 (20)	9 (18)
Pesticides not available	11 (14)	11 (16)	2 (9.1)	8 (26.4)	7 (32)	1 (5)	4 (18)
Natural occurrences	25 (32)	16 (24)	2 (4.9)	10 (24.4)	9 (22)	12 (29)	8 (20)
Intervention of institutions in controlling termites							
Yes	6 (2.3)	2 (1.3)	0 (0.0)	1 (12.5)	2 (25)	0 (0.0)	5 (63)
No	256 (98)	147 (99)	4 (1.0)	79 (19.8)	97 (24)	110 (28)	110 (28)

Farmers' testimony on the effectiveness of termite management methods they applied

Several termite management options were listed by farmers including conventional options like insecticide application and indigenous technical knowledge such as queen removal, applying boiled water, sprinkling red pepper, wood ash, flooding, and cow dung (Table 6). In general, out of 420 respondents about 172 claimed to have used insecticides to control termites. Among which 13% considered it as highly effective and 28% as moderately effective. 84 out 420 respondents claimed to apply queen removal as a control method where 7% of respondents stated it as highly effective and 13% of considered as a moderately effective method (Table 6). Other opinions include the use of insecticides is only effective in the short run because termites still come back even after insecticide application. The cultural methods were also effective only for a short time.

Table 6. Level of success of different control strategies employed by farmers.

Strategy used	Highly successful	Moderately successful	Termite vernacular names	Scientific name*
Use of insecticides	56 (13.3)	116 (27.6)	Ripo, Agoro, sisi, Rudho,	Ripo =Macrotermes
Queen removal	29 (6.9)	55 (13.1)	Ripo and Agoro	bellicosus (Smeathman)
Boiled water	7 (1.7)	3 (0.7)	Ripo, Agoro, Rudho	Agoro = Macrotermes
Wood ash	1 (0.2)	12 (2.9)	Agoro	subhyalinus (Rambur)
Red pepper	0 (0.0)	1 (0.2)	Agoro, Ripo	Rudho = Amitermes (?
Flooding	0 (0.0)	4 (1.0)	Ripo and Agoro	truncatidens Sands)
Cow dung/goat residue	0 (0.0)	2 (0.5)	Sisi, Ripo and Agoro	Sisi = Pseudacanthotermes
Others	3 (0.7)	7 (1.5)		militaris (Hagen)

Numbers in parentheses are percentages; n=420 *Scientific name (Nyeko, 2005)

DISCUSSION

The consequences of termites cited in this study varied considerably across the surveyed districts. In general, termite damage was considered a threat to farmers' livelihood. Like this study, farmers associated termites to be responsible for crop yield loss (Ewetola *et al.*, 2018). Legesse *et al.* (2013) also stated that termites are affecting farmers' livelihoods because of the damage caused to their crops. In this study, a decrease in their farm income was reported as a result of termite infestation and correspondingly almost all the interviewed farmers in the Diga district of Ethiopia believe that termites have decreased their farm income (Legesse *et al.*, 2013). Some farmers interviewed in this study cited migration (abandoning farm) because of termite damage which was a similar incident of an outmigration due to termite infestation coupled with soil fertility decline was reported in Ethiopia (Legesse *et al.*, 2013).

The findings of this study showed that different crops are vulnerable at different growth stages while trees are at risk throughout. Cereal crops such as maize are most attacked at the maturity stage. Similar to this study, farmers in eastern Zambia stated termite attack to crops mostly occurred at the maturity stage (Wood *et al.*, 1980). A study by Akutse *et al.* (2012) reported that over three-quarters of the farmers interviewed attributed crops to be most susceptible to termite attack at maturity. Just like Akutse *et al.* (2012), Nyeko and Olubayo (2005) stated that termite infestation low to moderate in February and march with trees mostly affected. They attribute this to be months of field preparation and planting where relatively fewer crops are available for termites. At the germination and vegetative stages of crops, termites destroy the roots and for some crops, the stems making the plants look stunted and eventually die (Akutse *et al.*, 2012; Nyeko and Olubayo, 2005). Studies by Mugerwa and Nyangito (2011) in Nakasongola district of Uganda show that termites caused severe damage to pasture seedlings. Moreover, Mugerwa *et al.* (2008) observed that termites damaged all pasture seedlings in few days just after germination.

This study has demonstrated the importance of termites as major limiting factors for crop production. The findings showed that farmers perceive yield losses of 32 - 41% in cereal crops (sorghum, rice, and maize) and yield loss of 25% to 39% in grain legumes (groundnuts, soybeans, and beans). In Uganda, a study by Sekamatte (2001a) estimated crop losses due to termite attack could reach up to 100%. Particularly vulnerable are crops such as maize, sorghum and trees, and fruits. Akutse *et al.* (2012), showed that about 13% of the farmers from the Volta region of Ghana attributed fruit trees damage to termites. A study by Legesse *et al.* (2013) revealed that termite damage was reported for all crops and trees with differences in tolerance to termite attack. For instance, maize, coffee, sugarcane, and eucalyptus were the most susceptible, while crops such as sorghum, finger millet, sesame, and common beans appeared relatively less susceptible. Other studies by Nyeko and Olubayo (2005), Mugerwa and Nyangito (2011), Mugerwa *et al.* (2008) also reported high susceptibility of maize, groundnuts, grasses, sugarcane, eucalyptus, and fruit trees.

Various termite control strategies have been used by farmers across the five districts. The use of pesticides and non-pesticide control methods appeared to be common for example the use of insecticides, removal of the queen, the use of cow dung, use of wood ash, boiled water among others were cited. This study also highlighted that farmers' termite management practices have mostly relied upon the use of indigenous control practices (non-chemical control methods) even when the use of pesticides appears a common practice. For example, Nyeko and Olubayo (2005) in Uganda, Malaret and Njogo (1989) in Kenya, Akutse *et al.* (2012) in Ghana highlight different strategies used by farmers to destroy termite colonies including digging nests and removing the queen; burning wood or grasses, use of cow dung and urine, pouring hot water or paraffin, flooding the nest with rainwater to kill the colony. Furthermore, the use of wood ash as a control measure is also highlighted in eastern and southern parts of Zambia (Sileshi *et al.*, 2009) and Nigeria (Banjo *et al.*, 2003).

An experimental study conducted at the cattle corridor of Uganda, stated that the use of cow dung contributed to the reduction in termite damage to rangelands (Tenywa, 2008). However, the use of cow dung as a termite control mechanism pointed in this study was disregarded by some farmers in Benin (Yêyinou Loko *et al.*, 2017) who pointed out that fields fertilized with cow dung were the most attacked by termites. This assertion is also confirmed by Karbo *et al.* (1999) stating that some farmers in Ghana considered cow dung as the most suitable bait for trapping termites especially during the dry periods while Ferrar and Watson (1970) in Australia report the use of termites as a means to remove dry dung pads from pastures. The use of mixed methods to control termites is in tandem with Legesse *et al.* (2013) who highlighted that farmers in the Diga district of Ethiopia commonly applied mixed approaches such as fumigation and digging mounds, use of chemical pesticides and flooding among others to manage termite infestation. Besides, farmers were reported to cultivate local varieties instead of the improved ones due to its relatively better tolerance to lodging and termite attack (Legesse *et al.*, 2013).

The reasons enlisted for failure to control varied considerably, for example, the lack of money to purchase insecticide was cited as a major reason. Others cited the lack of knowledge/skills to control termites and some claimed that termites cannot be controlled. Similar to the findings of this study, farmers in Ethiopia highlight that they had limited access and capacity to use chemicals to manage termites while others cite the lack of effective control mechanisms and shortage of labour for queen removal that hindered them to control termites (Legesse *et al.*, 2013). Moreover, Yêyinou Loko *et al.* (2017) stated that the lack of effective insecticide for the control of termites as a limiting factor. Besides, they stated that the lack of knowledge for control methods recommended as the main constraints to termite management which are relatively related to the findings of the current study. The findings in this study also agree with Orikiriza *et al.* (2012) who reported that farmers who did not attempt any termite control methods cited reasons such as; high costs of termite control; and not aware of any effective chemicals against termites.

Common control strategies adopted by both the male and female respondents include queen removal and the use of insecticides. However, more male respondents were involved in termite management. A study by Legesse *et al.* (2013) highlights gender roles in termite management, for example, women were reported to have a limited role in selecting and applying control mechanisms in the farms and grazing lands. Furthermore, decisions on which mechanisms to use was solely the responsibility of the male. Women, however, were reported to have better access and control over termite management around the homestead with control measures such as the use of boiled water, gasoline, salt, fumigations and other spices commonly applied.

Concerning institutional interventions to control termites, the findings of this study show that there is limited support from institutions in controlling termites. Where there is support, intervention such as the supply of insecticides, extension support on termite management, credit provision for farming and/or termite management, information sharing on termite management, and more research on termite species are highlighted. A study by Legesse *et al.* (2013) reported that chemicals were used by the agricultural department in the Diga district of Ethiopia to control termites were high severity was reported. Moreover, the government also distributed chemicals freely to farmers who reported severe termite attack on their farmlands (Legesse *et al.*, 2013). Farmers in Benin recommend the development of termites control strategies that can be disseminated through government structures (Yêyinou Loko *et al.*, 2017). Sileshi *et al.* (2009) reported that smallholder farmers applied traditional termite control methods including queen removal, intercropping, crop rotation, and use of plant extracts with limited success.

The effectiveness of the cited termite control and management options shows that control methods were generally not effective. Although some farmers felt that some of the methods were moderately effective, the use of insecticides is only effective in the short run, because termites still came back even after applying pesticides. Similarly, cultural methods were also effective only for a short time. In a similar study carried out in Ethiopia, Cultural methods were reported to be more effective when applied in combination specifically for sedentary termites as found by Legesse *et al.* (2013). The use of chemicals was reported for termites that did not have mounds or queen in one place (Legesse *et al.*, 2013) thereby using chemicals and digging mound and queen removal were thus mentioned as the most effective mechanisms. However, in some cases, interviewed farmers classified their effectiveness to be moderate. In the Volta region of Ghana, interviewed farmers ranked the use of chemicals to be highly effective while the use of non-chemical control methods was relatively effective with some cases of failure reported by Akutse *et al.* (2012). Tenywa (2008) reported that some success was registered in termite control in the treatments where cow dung was used. While farmers in this study rated queen removal to be moderately successful, farmers in the Nakasongola district of Uganda reported queen removal to be the most effective method for controlling termite species *M. subhyalinus* (Orikiriza *et al.*, 2012). However, the same farmers reported queen removal was not effective in the control of the termite species *Eutermes arborum* (Orikiriza *et al.*, 2012). The use of boiled water, wood ash, and flooding was generally rated to be low by farmers in Nakasongola district of Uganda (Okirizia et al, 2012) which does not correspond with some farmers in this study who reported that this method to be relatively successful. Very few farmers in Benin, however, reported the use of chemical pesticides to control termites because most of them were considered inefficient (Yêyinou Loko *et al.*, 2017). This assertion is also pointed by Okiriza et al, 2012 who reveal that farmers rated the effectiveness of chemicals to be generally low in controlling several termite species.

The infestation of companion plants such as desmodium and Napier starts during the dry spell after maize harvest. The crop residue attracts termite activities and the twigs of desmodium become vulnerable at this stage particularly if desmodium is trimmed. Severe infestation, particularly to green leaf desmodium, reduces plant population during the subsequent planting season. Farmers are advised to leave the desmodium and not to trim the ground level. Napier always recovers from the infestation while infestation on Brachiaria is negligible.

CONCLUSION AND RECOMMENDATION

It was evident from this study that farmers do understand the damage caused by termites that contributes to poverty. Moreover, the termite problem is a cross-cutting issue across the surveyed districts. Moreover, almost all of the crops are vulnerable to termite attack at a specific growth stage or throughout. Queen removal and insecticide application seemed effective; however, labour and money were the major constraints for farmers not to adopt the methods. None of the farmers were using an integrated termite management approach. Push-pull technology adopters are also challenged by termites where Greenleaf desmodium one of the companion plants is affected during the dry season. This results in poor performance during the subsequent cropping season. Termite management should be a concerted effort of various stakeholders to develop and promote IPM for termites that have an impact at landscape level bearing in mind the agro-ecological benefits that this insect provides. The study, therefore, showed that there is a great need specifically geared towards different farming systems.

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