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Original Research Article

Farmers' Knowledge and Perception of the Pest Status and Management Options for Termites in Buikwe District, Central Uganda

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Abstract: Termites are known to be serious pests, particularly in tropical and sub-tropical countries, causing damage to crops, forestry and structures/buildings. To design and implement effective and environmentally-friendly termite management strategies, there is a need to consider farmers' knowledge and experience in defining and setting priorities. We therefore conducted a survey in the coffee agro-ecology of Buikwe district, central Uganda to determine farmers' knowledge on the damage caused and control options for termites. Farmers were aware of the damaged caused by the termites, with 85.8% of them mentioning damage to crops in the field as the most important. However, 43.4% of them were of the view that the proportion of the whole coffee garden damaged by termites was generally low (1-25%). More than half of the farmers mentioned that they first observed termites in their gardens in the last 15 years and maize was the most (97.1%) damaged crop. In addition to crops, farmers mentioned that termites were also attacking mulching material, particularly maize stover (47.2%) and buildings (66%). Most farmers mentioned that they observed highest termite damage in the dry season (30.2%), at hill top (35.8%) and in reddish soils (55.7%). Also, >70% of the farmers mentioned that termite damage was generally decreasing in their coffee gardens, mainly due to destruction of termite mounds and bushes (39.6%). Furthermore, 83% of the farmers mentioned that they had attempted to manage termites, with most of them (>70%) acknowledging using chemicals. In addition to chemicals, farmers also mentioned that they were using cultural-based options such as destroying termite nests or mounds (68.7%), queen removal (34.9%) and weeding (30.2%), among others to control termites. Furthermore, in attempting to manage the termites, farmers mentioned that they faced several challenges, with most (36.8%) of them claiming that termites are impossible to control. In conclusion therefore, farmers had knowledge on the pest status of termites, conditions and seasons that support high termite damage as well as control options and the constraints they face in managing the termites. However, there is need to develop effective, cheap and environmentally-friendly integrated pest management (IPM) packages for termites but also, to conduct biological studies to relate termite damage to crop yield loss and determine the economic injury level (EIL), the basis for decision-making in most IPM programs.

Keywords: Termites, forestry, farmers' knowledge, agro-ecology.

INTRODUCTION

Despite the ecological importance of termites in soil ecosystems such as decomposition, nutrient cycling and soil formation [1, 2, 3], they are collectively regarded as one of the most damaging pests in tropical countries, causing damage to crops, forestry and houses/structures [4, 5, 6, 7, 8, 9, 10]. This damage impedes food security, thus, threatening livelihoods of smallholder farmers [11]. However, serious damage to crop and trees is done by less than 5% of the existing 1,000 termite species in sub-Saharan Africa [12]. Generally, termites became pests with disturbance of their natural habitats [13, 14], due to human activities such as deforestation and overgrazing

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[14, 15, 16]. This results into a shift in biodiversity that causes the predominance of the termites in agro-ecosystems, due, to the disappearance and/or reduction of certain feeding groups from the ecosystems which often give way to other feeding groups that increase in abundance [17]. More research is therefore needed to understand why termites are still considered our "enemies" in agro-ecosystems [2, 18, 19].

Globally, a lot of energy and significant budgets have been spent to identify and improve methods for controlling or eradicating termite populations in human-impacted environments [2]. However, termite control is still a challenge because of their cryptic nature and unpredictable foraging patterns [20, 21]. Many farmers in sub-Saharan Africa mostly rely on chemicals for controlling termites [8, 16, 22, 23, 24]. However, chemicals have limitations and increasing legal restrictions associated with their application and efficacy [4, 25] due to health and environmental reasons [26]. Also, most of the smallholder farmers in sub-Saharan Africa cannot afford chemicals due to high costs [22, 27]. Nevertheless, several research studies have reported that farmers have also attempted to employ other cultural methods such as: physical removal of the termite queen, destruction of the termite mound, good agronomic practices, intercropping, mulching, and use of plant extracts, wood ash and animal or human urine, among others to manage termites [6, 8, 9, 10, 12, 16, 22, 23, 24, 28, 29, 30, 31]. However, most of these cultural methods have not been rigorously evaluated and their efficacy remains speculative, and, to a considerable extent, ineffective and ecologically unsustainable [18]. As a result, there exists no specific recommendations for their large-scale utilization [4, 30, 32].

Furthermore, modern science and philosophy in pest management advocate for scientists to closely work with farmers in improving crop protection and production by valuing their indigenous technical knowledge systems (ethnoscience) including constraints [33]. The ensemble of traditional crop protection practices used by indigenous farmers represents a rich resource for modern workers seeking to create IPM systems that are well adapted to the agro-ecological, cultural and socio-economic circumstances facing smallholder farmers [34]. Therefore, the first step towards the development of successful pest management strategies adapted to farmers' needs is to thoroughly understand their perceptions of the pests and the control methods they employ [12, 33]. This information is very vital for priority setting and development of termite management strategies that meet local aspirations and thus, more likely to be adopted by local communities [8, 16, 30].

Basing on this background we therefore conducted a survey in the villages surrounding Mabira forest, Buikwe district, central Uganda to assess farmers' indigenous knowledge on the damage and control options for termites. We specifically attempted to answer the following questions:

i) What is the pest status of termites?
ii) What conditions and season support high termite damage?
iii) What control measures do farmers employ?
iv) What constraints do farmers experience in managing termites?

MATERIALS AND METHODS

Description of the study area

A survey was conducted in the villages surrounding Mabira forest which is situated in Buikwe District, central Uganda (Fig. 1). The district is located at 00 21Nº, 33 02Eº at an average of 1,134 meters above sea level (m.a.s.l). The biggest part of Buikwe district lies along the shores of Lake Victoria which is characterized by sandy clay alluvial soils with moist semi-deciduous forest, savannas, and swamps. The area receives annual rainfall in the range of 1,750-2000 mm, with bimodal rains comprising of April to May for the first season and October to December for the second season rains. The climate is warm and wet with relatively high humidity and the temperature range is 11-33°C [35, 36, 37].

Agriculture serves as the basis for rural livelihoods in the region and households rely on crops, livestock, and fisheries to meet their food and income needs. The major food crops are banana, maize, cassava, beans, sweet potato, and rice. Most of the population earns income from coffee, banana, vanilla, maize, pineapple, tea, sugarcane, charcoal, fish and livestock products, small to medium industries, and petty trading [37, 38].

Sample selection and data collection

The results being presented herein are part of a big study entitled "Re-tooling conservation of termite biodiversity beyond protected areas and forest remnants in Uganda" that was conducted in Mabira forest reserve and the villages surrounding it. This project aimed at investigating the role of the various coffee agro-systems along a land use gradient, ranging from 'rustic' (forest) coffee, through coffee-banana-trees, coffee-trees, coffee-banana to 'open sun' coffee systems in conserving termites and the ecological functions and activities they mediate. The study was therefore purposively conducted in Najjembe sub-county because it is one the main sub-counties surrounding the biggest part of the reserve.

A total of 105 coffee growing households were randomly selected from 11 villages that were randomly selected from five (5) parishes. GPS readings of these households were recorded. A well-structured questionnaire was then administered to the selected households. It elicited the socio-economic characteristics of the households; their knowledge of the negative attributes and pest status of the termites; conditions supporting high termite populations; seasonality of termite attack; termite management options; and, constraints limiting termite control.

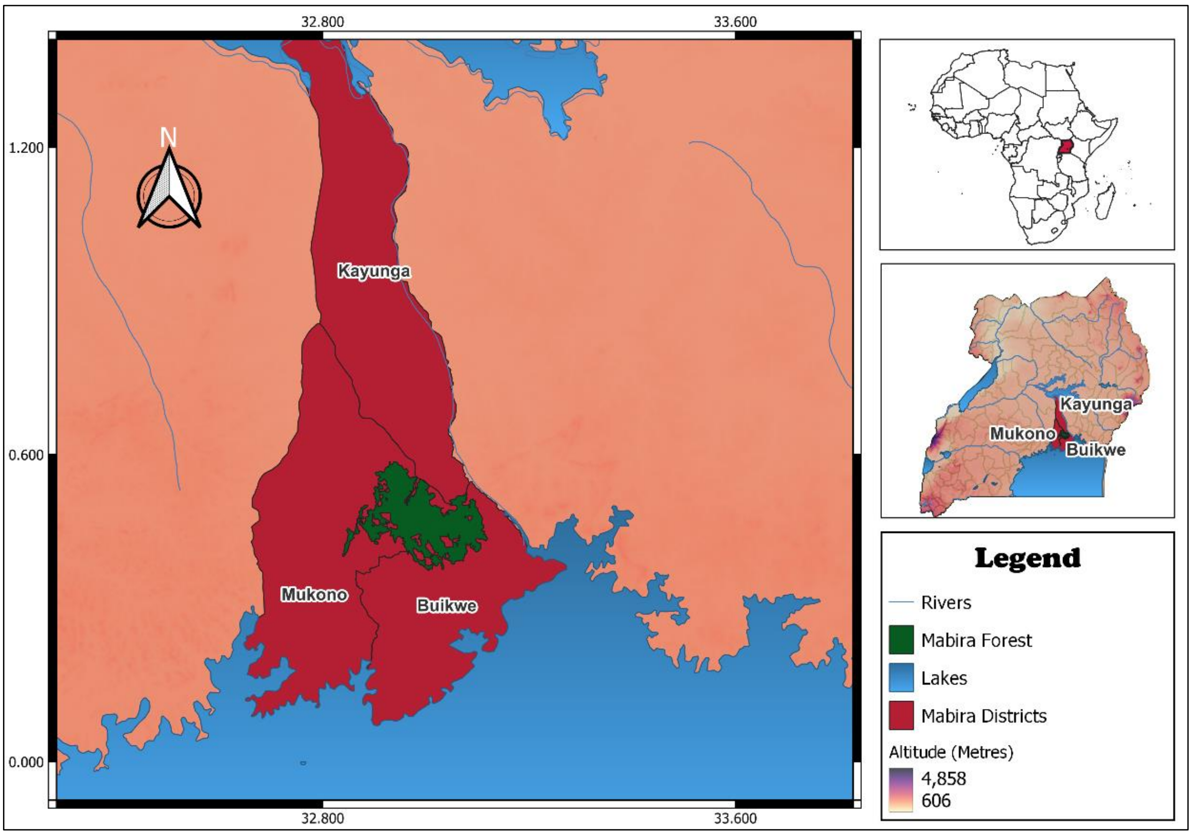

Figure 1: Map of Uganda showing the study area – Buikwe district, central Uganda

Statistical analysis

The data collected were cleaned, coded and then entered into Microsoft Excel spread sheet. They were then analyzed using descriptive statistics to calculate the frequency distribution and percentage of variables. SAS v. 9.1 for Windows [39] program was used to generate the analysis.

RESULTS AND DISCUSSIONS

Socioeconomic characteristics

The socioeconomic characteristics of the coffee farmers interviewed in Buikwe district, central Uganda are summarized in table 1 below. Results showed that the majority (60.4%) of farmers interviewed were males, as also reported in a number of coffee studies conducted in Uganda [40, 41, 42] and other coffee growing countries [43, 44, 45, 46, 47]. This could imply that coffee farming in most developing countries is mostly dominated by males [47], in part, because males have better access to resources [40, 48]. Women mostly participate in activities like weeding, harvesting, drying and sorting [47]. In fact, coffee is even termed as a "male" crop in these settings [40, 46, 48, 49]. The Government of Uganda should therefore develop strategies and interventions that aim at impacting women's empowerment using gender-transformative approaches of transforming gender norms and addressing structural barriers within households, communities and markets [47, 50, 51].

Furthermore, the majority (68.9%) of the farmers were 40 years and above, implying that coffee farming is mainly practiced by old people, with limited participation of the youth [50, 52, 53, 54]. Therefore, both public and private sectors need to create programs and initiatives that attract the youth to engage in coffee activities, not only in production but also in the upper end of the value chain [42, 50, 55]. This is because the youth are usually more dynamic in the adoption of new farming techniques, while older ones tend to avoid energy-demanding technologies [56]. Secondly, research shows that increasing the participation of young farmers in coffee production and creating an enabling environment for intensification can have a positive and sustainable effect on national production [56]. In addition, 42.5% of the farmers interviewed had attained secondary level of education, agreeing with [58]. Education level of a farmer increases his ability to obtain, process or synthesize and use information relevant to adoption of a new technology and then apply it to farming [56, 59, 60]. Also, 75.5% of the farmers interviewed in our study were married, agreeing with studies conducted in other coffee growing regions [58, 61, 62, 63]. Marital status of a farmer has been reported to show a positive and significant influence on adoption intensity of climate smart agricultural (CSA) practices in coffee production [63].

Our results further showed that 90.6% of the farmers mentioned that were involved in crop production as their main livelihood strategy, with 92.3% mentioning growing coffee as their main cash crop. This finding agrees with earlier studies in Uganda [54] and many other African countries [64, 65]. Coffee plays a major role in supporting the livelihood of Ugandans. The crop is grown by an estimated 1.7 million households located in 126 districts and more than 12 million people derive their livelihood from coffee-related activities along the value chain [66]. It also contributes substantially to the national economy - 20-30% of the country's foreign exchange earnings. For example, coffee exports for the Financial Year 2022/23, totaled to 5.76 million bags worth US$845.94 million [67]. Additionally, 73.6% of the farmers also mentioned that they were growing bananas as their main source of food. In fact, farmers in Uganda and in the Great Lakes region usually grow bananas (*Musa* spp.) and coffee together in order to provide shade as well as food and money [68, 69, 70, 71, 72].

Table 1: Socioeconomic characteristics of the coffee farmers interviewed (n=120) in Buikwe district, central Uganda

Variable	Respondents (%)
Gender	
Male	60.4
Female	39.6
Age group	
20-29 years	11.3
30-39 years	19.8
> 40 years	68.9
Educational level	
No formal Education	22.6
Primary Level	33.0
Secondary Level	42.5
Certificate	0.9
Diploma	0.9
Marital status	
Single	8.5
Married	75.5
Widowed	12.3
Divorced	3.8
Primary source of income	
Crop production	90.6
Trading	4.7
Casual laborer	2.8
Animal rearing	0.9
Formal employment	0.9
Most important cash crop	
Coffee	93.4
Banana	2.8
Maize	0.9
Sugarcanes	0.9
Beans	0.9
Pumpkins	0.9
Most important food crop grown	
Banana	73.6
Maize	12.3
Beans	6.6
Cassava	6.6
None	0.9

Pest status of termites

Figure 2 below summarizes farmers' responses on the negative attributes of termites. Farmers mentioned five (5) negative attributes of termites namely, causing damage to field and storage crops, trees, buildings and structures as well as causing stomach upset to humans.

Similarly, farmers in Kakamega, Western Kenya mentioned 8 (eight) negative attributes caused by termites [8]. This implies that farmers really recognize termites are a threat to their livelihood [31, 33]. Furthermore, 85.8% of the farmers mentioned that the most important negative attribute due to termite is damaging crops in the field, agreeing with earlier studies conducted elsewhere [e.g. 8, 9, 10, 31]. In fact, farmers usually associate crop losses with termite damage [31] and the reputation of termites as pests is in part associated with the presence of termitaria in crop fields and near trees [32]. Nevertheless, termites usually become pests in farming systems when humans alter their natural habitats [13, 14] through various activities such as deforestation and overgrazing [14, 15, 16].

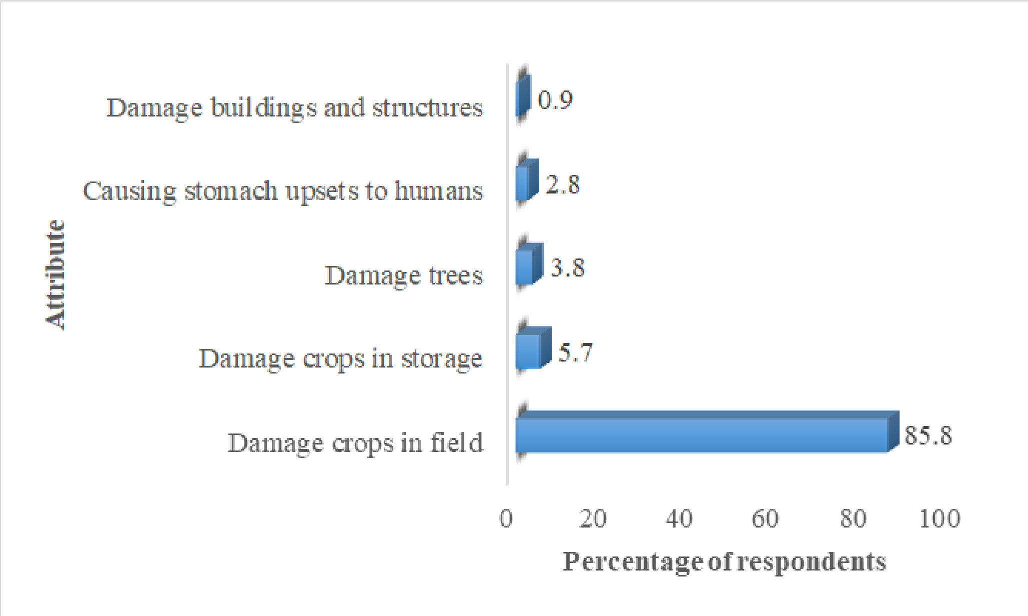

Figure 2: Farmers' responses on the negative attributes of termites in the coffee agro-systems of Buikwe district, central Uganda

Termite damage at plot level

Table 2 below shows farmers' responses on termite damage at plot level. Results showed that 96.2% of the farmers mentioned that they had ever observed termite damage in their coffee gardens, though, 43.2% of them were of the view that the proportion of the gardens damaged by termites was generally low (1-25%). Our finding is in line with various studies conducted in Uganda [22, 30, 73] and elsewhere [8] and this shows the economic importance of termites among farming communities of Uganda [16, 22, 30, 31]. Furthermore, more than half of the farmers mentioned that they first observed termite damage in their coffee gardens more than 10 years ago. Similarly, 45% of the farmers interviewed in Nakasongola rangelands of central Uganda, mentioned that the termite problem was first recognized as far as 10-20 years back [16]. Also, most farmers interviewed in Ethiopia, reported that the problem of termite was very serious in the study area for the last 10–15 years and its severity was increasing over time [76].

In addition, 50% of the farmers interviewed mentioned that termites were causing a decrease in crop production, agreeing with earlier research studies by [8, 74, 76]. This supports our earlier finding that farmers consider damage to crops as the most important negative effect of the termites. Farmers usually associate crop losses with termite damage [31] and farmers in Ethiopia relate the increase in cost of production of crops to termite damage [76]. Furthermore, 97.1% of the farmers mentioned that maize was the main crop attacked by termites, agreeing with various studies conducted in Uganda [22, 27, 30] and other African countries [8, 10, 24, 25, 28, 32, 33, 74]. Maize crop is susceptible to termite attack probably because it is exotic and thus lacks resistance to the African termites [4, 32, 75]. Indigenous plants are expected to be resistant to these termite species since these plant species have co-evolved with them [32]. However, farmers surveyed in Northern Benin by [10], reported that maize is preferred by termites because of its high moisture content and sweet taste. Thus implies that efforts should be geared towards developing effective and environmentally-friendly practices for managing these termites on maize [10, 33].

Table 2: Farmers' response on termite damage at plot level in the coffee agro-systems of Buikwe district, central Uganda

Variable	Respondents (%)
If the farmer has ever observed termites in the garden	
Yes	96.2
No	3.8
Proportion of the whole garden is damaged by termites	
0%	15.1
Low (1-25%)	43.4
Moderate (28-50%)	15.1
High (51-75%)	11.3
Very high (more than 75%)	10.4
Not applicable	4.7
First time of observing termites in your garden	
Never	1.9
Less than 5 years ago	8.5
5-10 years ago	27.4
11-15 year ago	28.3
16-20 years ago	9.4
More than 20 years ago	24.5
Change in crop production due to termites	
None	23.6
Decrease	50.9
Increase	24.5
Not applicable	0.9
Main crop affected by termites	
Maize	97.1
Coffee	2.9

Termite damage to mulching material

Farmers' knowledge of the effect of termites on mulching materials is summarized in table 3 below. Results showed that 47.2% of the farmers mentioned that maize stover was the type of mulching material most damaged by termites. This finding agrees with some scientists and farmers who are of the view that termites prefer dry maize stover to fresh biomass [27, 77]. This stimulated termite activity leads to decomposition of the mulch [78] and thus, generating nutrients for supporting coffee plant growth [79, 80]. In addition, termite activity also enhances rehabilitation of soil physical properties, especially on crust prone soils [81] as well as increasing infiltration, water storing capacity, and storage of carbon [2]. Furthermore, more than half of the farmers mentioned that termites take one month to decompose the mulching materials. These findings are in line with studies by [82] who reported that mass loss of maize residues is fast in the five weeks, with a 50% loss attained after 2-3 weeks from incubation. This could therefore result into fast release of nutrients for supporting coffee growth [79, 80].

Table 3: Farmers' responses on effect of termites on mulching materials in the coffee agro-systems of Buikwe district, central Uganda

Variable	Respondents (%)
Type of the mulch mostly damaged by termites	
Grass	32.1
Maize stover	47.2
Bean Husks	6.6
Banana leaves	1.9
No difference	5.7
Not applicable	6.6
Time taken by termites to decompose the mulch	
<1 month	11.3
1 month	53.8
1-3 months	21.7
>3 months	4.7
Not applicable	8.5

Termite damage to buildings

Table 4 below summarizes farmers' responses on the effect of termites on buildings. Majority (66%) of the farmers mentioned that they had ever observed termite damage on their buildings, with 71.5% of them claiming that this damage is high to very high. This finding agrees with studies in Kakamega, western Kenya where >80% of the farmers mentioned that damage to houses and structures was the negative attributes of termites [8]. Other scholars [e.g. 9, 76, 83, 84] also observed a similar trend though, with less percentages of farmers. Globally, termite damage to buildings is a serious problem as termite colony structurally compromises a building's integrity resulting in permanent damage and loss of value. This is more common in tropical and subtropical countries, due to the diversity of termites, favored by the good conditions in these geographical areas [85].

Table 4: Farmers' responses on effect of termites on the buildings in the coffee agro-systems of Buikwe district, central Uganda

Variable	Respondents (%)
If a farmer have ever observed termite damage on buildings	
Yes	66
No	34
Extent of termite damage on buildings	
Low (<25%)	28.6
High (51-75%)	22.9
Moderate (28-50%)	15.7
Very high (<75%)	32.9

Conditions supporting highest termite damage

Farmers' responses on the ecological conditions supporting the highest termite damage on crops are summarized in table 5 below. Most (30.2%) of the farmers mentioned that termites caused highest damage on crops during the dry seasons. This finding is in line with studies by [5, 9, 16, 23, 30, 32, 86, 87, 88. 89] and implies that water stress exacerbates termite damage to crops [4, 90, 91]. Most (35.8%) of the farmers mentioned that they observed highest termite damage in gardens located on hill tops while, 30.2% of them mentioned slopes. Similarly, >60% of the farmers in Nakasongola rangelands, central Uganda, rated damage caused by termites at upper- and mid-slope as very high and moderately respectively [16]. Results further showed that >50% of the farmers mentioned that they observed the highest termite damage under reddish soil type (locally termed as 'limyufumyufu'). Scientific research shows that the soil type influences the diversity of termites [92], depending on the species. For example, *Odontotermes obesus* termite species has been reported to be more abundant in the red soil of less than 75 μ particle size and minerals like kaolinite [93].

Table 5: Farmers' responses on effect of termites on trees in the coffee agro-systems of Buikwe district, central Uganda

Variable	Respondents (%)
Season	
Does not know	2.8
Wet season	21.7
Dry season	30.2
Transition between wet to dry season	24.5
Transition between dry to wet season	13.2
No difference	7.5
Topography	
Does not know	3.8
Hill top	35.8
Slope	30.2
Low land	4.7
No difference	25.5
Soil type	
Does not know	2.8
Black (liddugavu)	17.9
Sandy (lusenyusenyu)	1.9
Clay (lubumbabumba)	0.9
Reddish (limyufumyufu)	55.7
Gravelly (luyinjayinja)	0.9
No difference	18.9
Not applicable	0.9

Trends in termite damage

Table 6 below shows the responses of farmers on trends of termites over the years in Buikwe district. Results showed that 72.6% of the farmers mentioned that termite damage in farmers' gardens was generally decreasing over the years. However, this finding contradicts farmers' responses in other parts of Uganda and Zambia that showed that termite problems are more serious now than in the past years [12, 14, 16, 94]. In addition, results further revealed that most (39.6%) of the farmers attributed the decrease in termite damage to the destruction of termite mounds and bushes. Destruction of the nests or mounds has been reported to be frequently employed by farmers as traditional methods for controlling mound-building termites [9, 10, 16, 24, 28, 30], because their nests are readily identified and the royal chamber easily located [4]. Despite this controversy, efforts should be geared towards developing and implementing an Integrated Pest Management (IPM) measures to controlling the termites [22, 24, 30].

Table 6: Farmers' responses on trends of termite damage over time in the coffee agro-systems of Buikwe district, central Uganda

Variable	Respondents (%)
Trend of termite damage	
No change	6.6
Decrease	72.6
Increase	20.8
Why termites are decreasing	
Does not know	4.7
Application of chemicals to destroy termites	34.0
Presence of anthills in the neighborhood	5.7
Destruction of anthills and bushes	39.6
No control practices of termites	2.8
Haven't bothered to destroy them	3.8
Increased rainfall	1.9
Not applicable	7.5

Termite control

Farmers' knowledge of the methods employed for controlling termites in Buikwe district, central Uganda is summarized in table 7 below. Results showed that 83% of the farmers mentioning that they had ever attempted to control termites in their coffee agro-systems. This finding agrees with earlier reports of studies conducted in other districts of Uganda [22, 30, 31] and elsewhere [8, 24] but also contradicts other studies that reported that majority of the farmers were not applying any type of method to control termites [23, 30, 33]. In addition, farmers mentioned 19 options they use to manage termites in their agro-settings. Related studies conducted in Uganda [22, 30] and elsewhere [8, 23, 24] have also reported that farmers mentioned more than 10 options they use to manage termites. This implies that farmers are aware of the management options for termites [33].

Our results further showed that chemical control was the most mentioned (77.4%) method used by farmers, agreeing with several earlier studies [e.g. 8, 16, 22, 23, 24, 31]. This emphasizes the fact that, even though chemicals are hazardous to the environment, humans and animals [26], farmers all over the world use them extensively for the management of agricultural pests including termites [26, 95]. More than half of the farmers who were using chemicals mentioned that the method was very effective for managing termites, agreeing with [8, 8, 31]. However, most of the smallholder farmers in Uganda cannot afford these chemicals for termite control [22, 27]. There is therefore a need to develop alternative non-chemical methods for managing the termites [7, 10, 12] and also to train farmers on the use of pesticides in termite management [22]. The onus is therefore on the extension service providers and researchers to provide adequate and quality information to farmers [8] so that they have a more objective basis for decisions about pesticide use in their local systems [30, 96].

Furthermore, 68.6% of the farmers mentioned that they were controlling the termites by destroying their nests or mounds. Similarly, 54.26% of the farmers interviewed in Northern Benin were using this method for controlling termites. Systematically destruction of termite mounds in and around farmers' gardens is a common practice in Africa [23, 24]. Of the farmers who were using this method, 47.3% of them mentioned that it is not effective. Our finding contradicted studies by [8] who reported that 66.7% of the farmers in Kakamega, Western Kenya mentioned that this method was effectively in managing termites. This could in part due to the fact that the farmers using this method in Kakamega (n=3) was far less than that in our study (n=72). Nevertheless, though this method has been advocated for by researchers, it might be difficult to eradicate termites because the mound is constructed deep in the ground, requiring a lot of labor to break the hard material [32, 95]. Secondly, termite species that do not build mounds (e.g. many *Odontotermes* and *Microtermes* spp.) are not often targeted [16, 32]. But also, many farmers may resist destroying the mounds [29] because termites are a source of food for humans in Africa [30, 32, 97, 98, 99] as well as animal feed [100, 101]. Also, these mounds serve as burying places and are often associated with the spiritual world (especially containing the spirits), among many communities in Africa [102].

In addition, 34.9% of the farmers mentioned that they control the termites by removing the queen. Our finding is in line with several studies that have reported almost similar percentages of farmers who use this method for managing termites [6, 16, 31]. Removal of the queen have frequently been used by farmers as traditional methods for control of mound-building termites, apparently because their nests are readily identified and the royal chamber easy to locate [4]. Of the farmers who mentioned that they were using this method, 27.9% of them claimed that it was effective. Similarly, 36.8% of the farmers who were using this method for managing termites in Kakamega, Western Kenya claimed that it was effective [8]. However, effectiveness of this method has been reported to depend on the termite species in question [30]. For example, it was reported to be the most effective method for controlling *Macrotermes subhyalinus*, but not *Eutermes arborum* [22]. It has also been reported that sometimes this method is effective for a short period of time because there might be re-colonization of the de-queened mounds [6, 30, 32], if nymphs or alates are present at the time of de-queening, replacement reproductives may develop [30].

Also, 30% of the farmers mentioned that they do clean weeding as a method of managing termites, with 40 of them claiming that the method was effective. Similarly, a few studies in other country have reported that farmers use weeding as a method of managing termites [e.g. 23, 33]. Bad cultural practices that result in abundance of weeds are important factors responsible for termites' proliferation [23]. Research studies conducted in Zambia [103] and India [104], pointed out that weeds favor the abundance of termites in agricultural farms because the former compete with plants for food, light, water and space which may leave the plant susceptible to termites [95]. Secondly, weeding and tillage may have adverse effects on termite activity because of the physical disruption of their feeding as well as exposure to predators and, alteration of soil environment and food resources [4, 105].

Cementing houses was also mentioned by 22.6% of the farmers as one of the methods they use to manage termites, with, 46.2% of them claiming that the method was effective. However, studies conducted in Central Rift of Ethiopia and Western Kenya, reported fewer percentage of farmers who mentioned cementing as a method of managing termites – 1.9 and 2% respectively [8, 106]. Nevertheless, cementing foundations of houses or use of concrete will create a barrier to termites and thus reduce termite attacks on the former [8, 107]. Furthermore, 16% of the farmers mentioned that they practice treatment of poles and removal of crop residues in order to control termites. Similarly, farmers in Ghana mentioned that they were treating their wood with Sologram (Borates (disodium octaborate tetrahydrate [Tim-bor®, Bora-Care®, Jecta®], Impel®)) against termites [9] whereas, those in Zimbabwe were removing and burning crop residues [108] so as to reduce termite infestations. However, some scientists urgue that the application of dry crop residues under conservation agriculture (CA) may actually reduce termite attack on growing crops as they prefer dry stover as compared to fresh biomass [108, 109, 110]. Infact, studies in Nakasongola rangelands of central Uganda showed that farmers heaped organic residues such as maize stover, tree branches, and grass mulch to attract termites as well as to localize termite activity in specific places [16].

Lastly, the other 12 methods were mentioned by less than 10 of the farmers and were mainly cultural-based, revolving around good agronomic practices [4]. However, these methods need to be rigorously evaluated so as to determine their efficacy for managing termites [9]. There is also a need to verify, standardize and promote these practices with the other Integrated Pest Management (IPM) measures for controlling termites. This will not only result into control of the termites, but also reduction in application of chemical pesticides in the coffee agro-systems of Uganda [30].

Table 7: Farmers' response on managing termites in the coffee agro-systems of Buikwe district, central Uganda

Method	Usage (%)	Level of effectiveness of the method (%)			
		Not effective	Effective	Very effective	Does not know
Chemical	77.4	4.7	21.7	56.6	17.0
Digging or destruction of mound	68.9	47.3	35.1	2.7	14.9
Queen Removal	34.9	37.2	27.9	18.6	16.3
Weeding	30.2	42.9	40.0	0.0	17.1
Cementing houses	22.6	26.9	46.2	23.1	3.8
Treating poles	16.0	10.5	84.2	5.3	0.0
Removal of crop residues	16.0	35.3	58.8	0.0	5.9
Sealing vents	8.4	57.9	0.0	0.0	42.1
Hot water	7.5	77.8	22.2	0.0	0.0

Method	Usage (%)	Level of effectiveness of the method (%)			
		Not effective	Effective	Very effective	Does not know
Diesel or grease or used oil	7.5	44.4	44.4	0.0	11.1
Wood ash	7.4	57.1	7.1	0.0	35.7
Fire, heat or smoke	6.6	62.5	12.5	12.5	12.5
Paraffin	5.7	25.0	50.0	25.0	0.0
Local concoction of herbs	4.7	33.3	16.7	33.3	16.7
Trapping with sticks	2.8	0.0	100.0	0.0	0.0
Cow dung	1.9	50.0	50.0	0.0	0.0
Intercropping	0.9	100.0	0.0	0.0	0.0
Baiting with crop residue	0.9	100.0	0.0	0.0	0.0
Flooding with running water	0.9	100.0	0.0	0.0	0.0

Reasons for failure to control termites

Despite of the numerous control options reported by the farmers, they also mentioned nine (9) challenges limiting their efforts to manage these termites (Table 8), agreeing with studies conducted in eastern Uganda [30] and Benin [23]. The main challenge mentioned by the farmers was that termites are impossible to control (36.8%), agreeing with studies in eastern Uganda [31]. This could in part be due to lack of effective control methods that can eradicate the termites [10] which was one of the major constraints mentioned by 11.3% of the farmers in our study. Furthermore, the same percentage of farmers (12.3%) mentioned that their main challenge was that the control practices are expensive or they lacked knowledge and skills on control practices, as also reported by [8, 9, 10, 31]. This implies that much of the indigenous control knowledge is limited to a few individuals [9]. Research efforts should therefore be geared towards developing control methods that are effective and cheap for smallholder farmers [9]. But also, information flow on termite control amongst farmers should be made more adequate [8]. This should be supported by strong and efficient mechanisms and strategies for promoting farmer-to-farmer information transfer [30, 111, 112].

Our results further showed that termite control practices were time consuming (8.5%) and labor intensive (0.9%). This is particularly true in case of some of the cultural-based practices such as the physical destruction of the mounds and queen removal [8, 30, 32, 77]. In addition, only 1.9% of the farmers mentioned that they were not controlling termites because they are a source of food for humans and animal. Similarly, farmers in Kakamega, Western Kenya and other part of Africa, reported that they resisted controlling termites or destroying their termitaria because of being a source of food [8, 32].

Table 8: Farmers' response on reasons for failure to control termites in the coffee agro-systems of Buikwe district, central Uganda

Reason	Farmers (%)
Termite control impossible	36.8
Control practices are expensive	12.3
Lack of knowledge and skills on control practices	12.3
Just not controlling	11.3
Control practices not effective	11.3
Control practices are time consuming	8.5
Not applicable	3.8
Termites are important as food for humans and animals	1.9
Control practices are labor intensive	0.9
Chemical are not available	0.9

CONCLUSIONS

Results of our study clearly showed that farmers had knowledge on the pest status of termites as well as the conditions and seasons that support high levels of termite damage. However, even though farmers regarded termites as pests, they viewed the damage termites caused on crops in the field as low and generally decreasing over the years. There is therefore a need to conduct biological studies to establish the real damage caused by termites and then relate it to crop yield losses so as to determine the economic injury level (EIL) which forms a basis for decision making in most integrated pest management (IPM) programs. Farmers also had knowledge on the control options they had attempted against termites. However, most farmers mentioned that 'termites are impossible to control' as the main challenge they face in their effort to manage these termites. This could in part be due to lack of effective control options for the termites. Therefore research efforts should be geared towards developing an effective and cheap IPM package for the termites in the coffee agro-systems of Uganda. In addition, the indigenous control options for termites reported by farmers in our study need to be verified, standardized and integrated into the IPM package. Another constraint faced by farmers in their effort to control termites was lack of knowledge on the control options, implying that this indigenous knowledge might be limited to few individuals. Efforts should therefore be geared towards making information flow amongst farmers more efficient through various mechanisms and strategies, for example, Farmer Field Schools (FFS').

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REFERENCES

1. Jouquet, P., Traoré, S., Choosai, C., Hartmann, C. & Bignell, D. (2011). Influence of termites on ecosystem functioning. Ecosystem services provided by termites. *European Journal of Soil Biology*, 37(4), 215-222.
2. Jouquet, P, Chaudhary, E. & Kumar, A.R.V. (2018). Sustainable use of termite activity in agroecosystems with reference to earthworms. A review. *Agronomy for Sustainable Development*, 38, 11.
3. Khan, M.A., Ahmad, W. & Paul, B. (2018). Ecological impacts of termites. In Khan, M. A., & Ahmad, W., Eds. Termites and Sustainable Management, Sustainability in Plant and Crop Protection, Springer International Publishing.
4. Logan, J.W.M., Cowie, R.H. & Wood, T.G. (1990). Termite (Isoptera) control in agriculture and forestry by non-chemical methods: a review. *Bulletin of Entomological Research*, 80, 309–330.
5. Pearce, M.J., Logan, J.W.M. & Tiben, A. (1995). Termites (Isoptera) from the Darfur region of the Sudan with comments on their pest status. *Journal of Arid Environment*. 30, 197-206.
6. Kiwuso, P., Maiteki, G. & Okorio, J. (2004). Indigenous methods of controlling termites in agroforestry systems in Uganda. *Uganda Journal of Agricultural Sciences*, 9, 893-895.
7. Sileshi, G., Mafongoya, P.L., Kwesiga, F. & Nkunika, P. (2005). Termite damage to maize grown in agroforestry systems, traditional fallows and monoculture on nitrogen-limited soils in eastern Zambia. *Agriculture and Forest Entomology*, 7, 61-69.
8. Kagezi, G.H., Kaib, M., Nyeko, P. & Brandl R. (2010a). Pest status and control options for termites (Isoptera) in the Luhya community of western Kenya. *Sociobiology*, 55, 815-829.
9. Akutse, K., Owusu, E. & Afreh-Nuamah, K. (2012). Perception of farmers' management strategies for termites control in Ghana. *Journal of Applied Biosciences*, 49. 3394-405.
10. Loko, L.E.Y., Orobiyi, A., Agre, P., Dansi, A., Tamò. M. & Roisin, Y. (2017). Farmers' perception of termites in agriculture production and their indigenous utilization in Northwest Benin, *Journal of Ethnobiology and Ethnomedicine*, 13, 64.
11. Demissie, G., Mendesil, E., Diro, D., & Tefera, T. (2019). Effect of crop diversification and mulching on termite damage to maize in western Ethiopia. *Crop Protection*, 124, 104723.
12. Sileshi, G.W., Kuntashula, E., Matakala & Nkunika, P.E. (2008). Farmers' perceptions of pests and pest management practices in agroforestry in Malawi, Mozambique and Zambia. *Agroforestry Systems*, 72, 87-101.
13. Pearce, M.J. (1997). Termites: Biology and Pest Management. CAB International, New York.
14. Sekamatte, M.B. & Okwakol, M.J.N. (2007). The present knowledge on soil pests and pathogens in Uganda. *African Journal of Ecology (Supplement)*, 45, 9–19.
15. Kekeunou, S., Messi, J., Weise, S. &Tindo, M. (2006). Insect pests' incidence and variations due to forest landscape degradation in the humid forest zone of Southern Cameroon: farmers' perception and need for adopting an integrated pest management strategy. *African Journal of Biotechnology*, 5(7), 555-562.
16. Mugerwa, S. (2011). Indigenous Knowledge and Ecology of Subterranean Termites on Grazing Lands in Semi-arid Ecosystems of Central Uganda. PhD thesis. University of Nairobi, Kenya. 103 pp.
17. Dawes, T.Z. (2010). Reestablishment of ecological functioning by mulching and termite invasion in a degraded soil in an Australian savanna. *Soil Biology & Biochemistry*, 42(10), 1825–1834.
18. Mugerwa, S. (2015a). Infestation of African savanna ecosystems by subterranean termites. *Ecological Complexity*, 21, 70–77.
19. Mugerwa, S. (2015b). Magnitude of the termite problem and its potential anthropogenic causes in Nakasongola district of Uganda. *Grassland Science*, 61(2). 75–82.
20. Su, N.Y. & Scheffrahn, R.F. (1998). A review of subterranean termite control practices and prospects for integrated pest management programmes. *Integrated Pest Management Reviews*, 3, 1-13.
21. Debelo D.G. (2020). Economic importance of termites and integrated soil and water conservation for the rehabilitation of termite degraded lands and termite management in Ethiopia. *Journal of Soil Science and Environmental Management*, 11, 65-74.
22. Orikiriza, L.J.B., Nyeko, P. & Sekamatte, B. (2012) Farmers' knowledge, perceptions and control of pestiferous termites in Nakasongola district, Uganda, *Uganda Journal of Agricultural Sciences*, 13 (1), 71-83.
23. Loko, Y.L., Agre P., Orobiyi, A., Dossou-Aminon, I., Roisin, Y., Tamo, M. & Dansi A. (2015). Farmers' knowledge and perceptions of termite as pests of yam

(*Dioscorea* spp.) in Central Benin. *International Journal of Pest Management*, 62, 75–84.
24. Loko, LEY.. Orobiyi, A.. Toffa, J.. Fagla, SM., Gavoedo, DM. & Manuele, T. (2019). Farmers' knowledge, perceptions and management practices for termite pests of maize in Southern Benin. *Open Agriculture*, 4(1), 554-574.
25. Cowie, R.H. & Wood, T.G. (1989). Damage to Crops, Forestry and Rangeland by Fungus-Growing Termites (Termitidae: Macrotermitinae) in Ethiopia. *Sociobiology*, 15(2), 139-153.
26. UNEP /FAO/Global IPM Facility (2000). Workshop on termite biology and management. 1-3 February. Geneva. Switzerland. 60pp.
27. Sekamatte, M.B. (2001). Termite situation on crops and rangelands in Nakasongola district. A report submitted to Environmental Protection and Economic Development (EPED) Project. 20pp.
28. Umeh, V.C. & Ivbijaro, M.F. (1997). Termite abundance and damage in traditional maize- cassava intercrops in southern Nigeria. *Insect Science and Its Application*, 17. 315-321.
29. Nkunika, P.O.Y. (1998). Termite identification, damage and control options in southern province, Zambia. Land Management and Conservation Farming, (SCAFE). Soil Conservation and Agroforestry Extension Report, Lusaka, Zambia. 14pp.
30. Nyeko, N. & Olubayo, F.M. (2005). Participatory assessment of farmers' experiences of termite problems in agroforestry in Tororo district, Uganda. Agricultural Research and Extension Network Paper No. 143, Overseas Development Institute, London, UK.
31. Hailu, G., Ochatum, N., Nyeko, P. & Niassy, S. (2020). Farmers' experience in termite management in eastern Uganda. *International Journal of Agricultural Extension*, 8(3), 49-162.
32. Sileshi, G.W., Nyeko, P., Nkunika, P.O.Y., Sekamatte, B.M., Akinnifesi, F.K. & Ajayi, O.C. (2009). Integrating ethno-ecological and scientific knowledge of termites for sustainable termite management and human welfare in Africa. Ecology and Society 14(1):
33. Debelo D.G & Degaga E.G. (2015). Farmers' knowledge, perceptions and management practices of termite in the central rift valley of Ethiopia *African Journal of Agricultural Research*, 10(36), 3625-3635,
34. Altieri, M.A. (1993). Ethnoscience and biodiversity: key elements in the design of sustainable pest management systems for small farmers in developing countries. *Agriculture, Ecosystems and Environment*, 46(1–4), 257-272.
35. Akodi, D., Komutunga, E., Agaba, C., Oratungye, K.J. and Ahumuza, E. (2016). The Effect of Land Use on Soil Organic Carbon Stocks in Lake Victoria Crescent Agro-Ecological Zone, Uganda. *Journal of Agricultural Science and Technology*, 6, 154-160. doi: 10.17265/2161-6256/2016.03.002.
36. Bongomin, L., Acipa A., Wamani S., Sseremba G. and Opio, S.M. (2020). Evaluation of maize (*Zea mays* L.) performance under minimum and conventional tillage practice in two distinct agroecological zones of Uganda. *African Journal of Agricultural Research*, 16(5), 600-605. DOI: 10.5897/AJAR2020.14768.
37. Kabugo, Y. (2022). Effect of sugarcane production on land use land cover change and nutritional status of children in Buikwe district, Uganda. MSc thesis. Uganda Martyrs University, Nkozi. 108pp.
38. Gwali, S., Agaba, H., Balitta, P., Hafashimana, D., Nkandu, J., Kuria, A., Pinard, F. and Sinclair, F. (2015). Tree species diversity and abundance in coffee farms adjacent to areas of different disturbance histories in Mabira forest system, central Uganda, International *Journal of Biodiversity Science, Ecosystem Services and Management*, 11:4, 309-317, DOI: 10.1080/21513732.2015.1050607.
39. SAS Institute Inc. (2008). SAS/STAT Users' Guide version 9.2, SAS Institute Inc., Cary, NC, USA.
40. Ochago, R., Mangheni, M.N. and Miiro, R.F. (2017). Which socio-economic factors matter in farmer group participation? Evidence from coffee pest management learning groups in Mt Elgon region. Uganda. *International Journal of Agricultural Extension*, 5(1), 23-38.
41. Kagezi, G.H., Kucel,, P., Kobusinge J., Olango, D.N., Nakibuule, L., Nanjego, W., Nambozo, P.B., Olal, S. and Wagoire, W.W. 2018. Farmers' knowledge and perception of the use of pesticides in Arabica coffee, *Coffea arabica* agro-ecologies of Uganda. *Journal of Agriculture and Environmental Sciences*, 7(2), 173-188.
42. Kagezi, G.K., Kyalo, G., Kobusinge, J., Nkuutu, E., Baluku, J., Arinaitwe, G. and Niyibigira, E.I. (2021). A rapid assessment of the invasive dodder weed, *Cuscuta* Spp. on Robusta coffee, *Coffea robusta* in Busoga coffee growing sub-region, Eastern Uganda. *East African Scholars Journal of Agriculture and Life Sciences*, 4(3), 55-66.
43. Ncube, N., Fogo. C., Bessler, P., Jolly, C.M. and Jolly, P.E. (2011). Factors associated with self-reported symptoms of acute pesticide poisoning among farmers in northwestern Jamaica. *Archives of Environmental and Occupational Health*, 66, 65-74.
44. Henry, D. and Feola, G. (2013). Pesticide handling practices of smallholder coffee farmers in Eastern Jamaica. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 114(1), 5967.
45. Lekei, E.E., Ngowi, A.V. and London, L. (2014). Farmers' knowledge, practices and injuries associated with pesticide exposure in rural farming villages in Tanzania. *BMC Public Health*, 14, 319.
46. Akiri, M., Boateng, D. and Agwanda, C. (2015). Mainstreaming gender and youth in smallholder sustainable coffee supply chain in Kenya. *Journal of Economics and Sustainable Development*, 6(18), 76-86.
47. Kangile, J.R., Kadigi, R.M.J., Mgeni, C.P., Munishi, B.P., Kashaigili, J. and Munishi, P.K.T. (2021). The role of coffee production and trade on gender equity

and livelihood improvement in Tanzania. *Sustainability*, 13, 10191.

48. Isoto, R.E., Kraybill, D.S. and Erbaugh, M.J. (2008). Impact of integrated pest management technologies on farm revenues of rural households: The case of smallholder Arabica coffee farmers. *African Journal of Agricultural and Resource Economics*, 9(2), 119-131.
49. Farm Africa (2018). Gender and the coffee value chain in Kanungu, Uganda. Study report, 7.
50. Mbowa, S., Odokonyero, T., and Munyambonera, E. (2014). The potential of coffee to uplift people out of poverty in Northern Uganda. EPRC Research Report No. 11.
51. Singh, S., Mohan, A., Saran, A., Puskur, R., Mishra, A., Etale, L., Cole, S.M., Masset, E., Waddington, H.S., MacDonald, H. and White, H. (2022). PROTOCOL: Gender transformative approaches in agriculture for women's empowerment: A systematic review. *Campbell Systematic Reviews*, 18, e1265. https://doi.org/10.1002/cl2.1265.
52. Kitakaya, L. (2011). Building coffee farmers alliances in Uganda. Café Africa Uganda (CFAU) Project Baseline Study Report. 46 pp.
53. Mbowa, S., Ahaibwe, G. and Mayanja, L.M. (2013). Coffee Production a Golden Opportunity for rural youth employment. Economic Policy Research Centre, Policy Brief No. 36 September 2013.
54. Bart, A.L. (2019). The wellbeing of smallholder coffee farmers in the Mount Elgon region: a quantitative analysis of a rural community in Eastern Uganda. *Bio-based and Applied Economics,* 8(2), 133-159.
55. FAO (2020). Promoting rural youth employment in Uganda’s coffee sector. Food and Agriculture Organization (FAO) Agricultural Development Economics Policy Brief 29.
56. Mugisha, J., Ogwal, O.R., Ekere, W., and Ekiyar, V. (2004). Adoption of IPM groundnut production technologies in Eastern Uganda. *African Crop Science Journal*, 12, 383–391.
57. Wairegi, L.W.I., Bennett, M., Nziguheba, G., Mawanda, A., Rios de los Rios C., Ampaire, E., Jassogne, L., Pali P., Mukasa, D. and van Asten, P.J.A. 2018. Sustainably improving Kenya’s coffee production needs more participation of younger farmers with diversified income. *Journal of Rural Studies,* 63, 190–199.
58. Kabita, E., Kwanya, T. and Mbenge-Ndiku, T. (2021). Knowledge sharing strategies between coffee farmers and Coffee Research Institute: A Case Study of Gitwe Farmers’ Co-Operative Society. *International Journal of Management, Knowledge and Learning*, 10, 157-175.
59. Chaves, B. and Riley, J. (2014). Determination of factors influencing integrated pest management adoption in coffee berry borer in Colombian farms. *Agriculture, Ecosystems and Environment,* 87, 159-177.
60. Luzinda, H., Nelima, M., Wabomba, A., Musoli, P.C. and Kakuru, A. (2018). Factors influencing adoption of improved Robusta coffee technologies in Uganda. *Uganda Journal of Agricultural Sciences* 18(1), 33-41.
61. Ngeywo, J., Basweti, E. and Shitandi, A. (2015). Influence of gender, age, marital status and farm size on coffee production: A Case of Kisii County, Kenya. *Asian Journal of Agricultural Extension, Economics and Sociology,* 5(3), 117-125.
62. Mugaga, F. (2017). Perceptions and response actions of smallholder coffee farmers to climate variability in montane ecosystems. *Environment and Ecology Research,* 5(5), 357-366.
63. Salad, A.F., Zziwa, S., Talengera, D., Nabatanzi, L., Makumbi, O., Najjuma, V. and Nafula, M. (2021). Adoption intensity of climate smart agricultural practices in Arabica coffee production in Bududa District. *International Journal of Multidisciplinary Research Updates* 1, 16–25.
64. Tadesse, T., Tesfaye, B. and Abera, G. (2020). Coffee production constraints and opportunities at major growing districts of southern Ethiopia. *Cogent Food and Agriculture*. 6(1).
65. Cuni-Sanchez, A., Twinomuhangi, I., Berta Aneseyee, A., Mwangi, B., Olaka, L., Bitariho, R., Soromessa, T., Castro, B. and Zafra-Calvo, N. (2022). Everyday adaptation practices by coffee farmers in three mountain regions in Africa. *Ecology and Society*, 27(4), 32.
66. UCDA (2020). Draft Coffee Sub-Sector Strategy (FY2020/21 – FY2024/25). Uganda Coffee Development Authority (UCDA). 116 pp.
67. UCDA (2023). UCDA Monthly Report June 2023. Uganda Coffee Development Authority (UCDA). Report CY 2022/23 Issue 9.
68. Okech, S.H.O., Gold, C.S., Abele, S., Nankinga, C.M., Wetala, P.M., van Asten, P., Nambuye, A. and Ragama, P. (2004). Agronomic, pests and economic factors influencing sustainability of banana-coffee systems of Western Uganda and potentials for improvement. *Uganda Journal of Agricultural Sciences*, 9, 415-427
69. Ouma, G. (2009). Intercropping and its application to banana production in East Africa: A review. *Journal of Plant Breeding and Crop Science* 1(2), 013-015.
70. van Asten, P.J.A., Wairegi, L.W.I., Mukasa, D. and Uringi, N.O. (2011). Agronomic and economic benefits of coffee–banana intercropping in Uganda’s smallholder farming systems. *Agricultural Systems*, 104, (4), 326-334.
71. Sebatta, C., Mugisha, J., Bagamba, F., Nuppenau, E.A, Domptail, S,E., Kowalski, B., Hoeher, M., Ijala, A,R. and Karungi, J. (2019). Pathways to sustainable intensification of the coffee-banana agroecosystems in the Mt. Elgon region. *Cogent Food and Agriculture*, 5:1, 1611051. DOI: 10.1080/23311932.2019.1611051.
72. Nibasumba, A., Jassogne, L., VanAsten, P., Nduwayo, G., Nkurunziza, C., Bielders, C. and Delvaux, B. (2021). Coffee-banana systems in

transition: Resource allocation and crop interactions in smallholder farms of Burundi. *Journal of Agricultural and Crop Research*, 9. 250-263. 10.33495/jacr_v9i11.21.167.
73. Mali, B., Okello, S., Ocaido, M., Nalule, A.S. and Celsus, S. (2018). Ethno charaterisation of termite species in the rangelands of central Uganda. *Livestock Research for Rural Development* 30, (1):
74. Gebeyehu, T.G. (2018). Assessments of termites' impact on vegetation, crops and buildings in Lalokile district, Kellem Wollega zone, western Ethiopia. MSc thesis. Addis Ababa University. 55pp.
75. Abate, T., van Huis, A. & Ampofo, J. (2000) Pest management strategies in traditional agriculture: An African perspective. *Annual Review of Entomology*, 45, 631-659. https://doi.org/10.1146/annurev.ento.45.1.631.
76. Legesse, H., Taye, H., Geleta, N., Swaans, K., Fikadu, D., Zziwa, E. and Peden, DG. (2013). Integrated termite management in degraded crop land in Diga district, Ethiopia. In: Wolde Mekuria. (ed). Rainwater management for resilient livelihoods in Ethiopia: Proceedings of the Nile Basin Development Challenge science meeting, Addis Ababa, 9–10 July 2013. NBDC Technical Report 5. Nairobi, Kenya: International Livestock Research Institute.
77. Mugerwa, S., Mpairwe, D., Zziwa, E., Swaans, K., and Peden, D. (2014). Integrated termite management for improved rainwater management: A synthesis of selected African experiences. NBDC Technical Report 9. Nairobi, Kenya: ILRI.
78. Mando, A. (1998). Soil-dwelling termites and mulches improve nutrient release and crop performance on Sahelian crusted soil. *Arid Soil Research and Rehabilitation*, 12(2), 153-163, DOI: 10.1080/15324989809381505.
79. Nzeyimana, I., Ritsema, C., Mbonigaba, J. & Geissen, V. (2019). Mulching effects on soil nutrient levels and yield in coffee farming systems in Rwanda. *Soil Use and Management*, 36, 10.1111/sum.12534.
80. Petit-Aldana, J., Rahman, M.M., Parraguirre-Lezama, C., Infante-Cruz, A. & Romero-Arenas, O. (2019). Litter decomposition process in coffee agroforestry systems. *Journal of Forest and Environmental Science*, 35(2), 121-139.
81. Mando, A. & Miedema, R. (1997). Termite-induced change in soil structure after mulching degraded (crusted) soil in the Sahel. *Applied Soil Ecology*, 6, 241-249. https://doi.org/10.1016/S0929-1393(97)00012-7.
82. Mubarak, A. R., Rosenani, A. B., Anuar, A. R., & Zauyah, S. (2002). Decomposition and nutrient release of maize stover and groundnut haulm under tropical field conditions of malaysia. *Communications in Soil Science and Plant Analysis*, 33(3-4), 609–622. doi:10.1081/css-120002767.
83. Mitchell, J.D. (2002). Termites as pests of crops, forestry, rangeland and structures in Southern Africa and their control. *Sociobiology*, 40(1), 47-70.
84. Fenetahun, Y., Xu , X. & Wang, Y. (2019). An evaluation of the effect of termites on rangeland degradation: The case of Yabello, Southern Ethiopia. *Journal of Resources and Ecology*, 10(5), 525–529.
85. James, S., Ndakidemi, P.A. & Mbega, E.R. (2019). Termite diversity, damage on crop and human settlements and their potential sustainable management strategies in Africa. *Research Journal of Agriculture and Forestry Sciences*, 7(1), 24-36.
86. Mugerwa, S., Nyangito, M., Nderitu, J., Bakuneta, C., Mpairwe, D., & Zziwa, E. (2011). Farmer's ethno-ecological knowledge of the termite problem in semi-arid Nakasongola. *African Journal of. Agricultural Research*, 6, 3183–319
87. Milton, J.E., Patel, B.V. & Mukwaya, S. (2014). Agriculturists' ethno-biological learning of the termite issue in semi-parched Nakasongola. *African Journal of Ecology and Ecosystems*, 1(2), 029-036.
88. Ohiagu, C.E. (1979). A quantitative study of seasonal foraging by the grass harvesting termite, *Trinervitermes geminatus* (Wasmann), (Isoptera, Nasutitermitinae) in Southern Guinea savanna, Mokwa, Nigeria. *Oecologia*, 40, 179-188.
89. Braack, L.E.O. (1995). Seasonal activity of savanna termites during and after severe drought. *Koedoe*, 38(1), 73–82.
90. Evans, T.A. & Gleeson, P.V. (2001). Seasonal and daily activity patterns of subterranean, wood-eating termite foragers. *Australian Journal of Zoology* 49, 311–321.
91. van den Berg, J. & Riekert, H.F. (2003). Effect of planting and harvesting dates on fungus-growing termite infestation in maize. *Suid-Afrikaanse Tydskrift Plant en Grond*, 20, 76–80.
92. Srinivasa, M.K. (2020). Diversity and abundance of subterranean termites in South India. *International Journal of Pure and Applied Bioscience*, 8(5), 141-149.
93. Kandasami, R.K., Borges, R.M. & Murthy, T.G. (2016). Effect of biocementation on the strength and stability of termite mounds. *Environmental Geotechnics*, 3, 99–113.
94. Tenywa, G. (2008). Thousands homeless as termites turn Nakasongola into a desert. The New Vision, 24 June 2008. [online] URL: http://www.newvision.co.ug/D/9/36/635585?highlight&q=termite.
95. Ahmad, F., Fouad, H., Liang, S., Hu, Y., & Mo, J. (2019). Termites and Chinese agricultural system: applications and advances in integrated termite management and chemical control. *Insect Science*, doi:10.1111/1744-7917.12726.
96. Banjo, A.D., Lawal, A.O., Fapojuwo, O.E., Songonuga, E.A. (2003). Farmers' knowledge and perception of horticultural insect pest problems in

Nigeria. *African Journal of Biotechnology*, 2(11), 434-437.

97. Kagezi, G.H., Kaib, M., Nyeko, P. & Brandl, R. (2010b). Termites (Isoptera) as food in the Luhya community (Western Kenya). *Sociobiology*, 55(3), 831-845.
98. Nyukuri, R.W., Mwale, R.E., Kirui, S.C., Cheramgoyi, E. & Koskei, C.G. (2014). Food Value of Termites (Ioptera: Termitidae) in Western Kenya. A Comparison with Tilapia fish and red meat. *International Journal of Scholarly Research Gate*, 2(4), 176-181.
99. Chulu, M.C. (2015). Nutrient composition of the termite *Macrotermes falciger*, collected from Lusaka district, a potential agent against malnutrition. Dissertation for Master of Clinical Pharmacy Degree. University of Zambia, Zambia.
100. Sankara, F., Pousga, S., Dao, N.C.A., Gbemavo, D.S.J.C., Clottey, V.A., Coulibaly, K., Nacoulma, J.P., Ouedraogo, S. & Kenis, M. (2018). Indigenous knowledge and potential of termites as poultry feed in Burkina Faso. *Journal of Insects as Food and Feed*, 4(4), 211-218.
101. Boafo, H.A., Affedzie-Obresi, S., Gbemavo, D.S.J.C., Clottey, V.A., Nkegbe, E., Adu-Aboagye, G., & Kenis, M. (2019). Use of termites by farmers as poultry feed in Ghana. *Insects*, 10(3), 1– 13.
102. van Huis, A. (2017). Cultural significance of termites in sub-Saharan Africa. *Journal of Ethnobiology Ethnomedicine*, 13(8), 1-12.
103. Sileshi, G. & Mafongoya, P.L. (2003). Effect of rotational fallows on abundance of soil insects and weeds in maize crops in eastern Zambia. *Applied Soil Ecology*, 3, 211–222.
104. Sharma, R.K., Babu, K.S,, Chhokar, R.S. & Sharma, A.K. (2004). Effect of tillage on termites, weed incidence and productivity of spring wheat in rice–wheat system of North Western Indian plains. *Crop Protection*, 23, 1049–54.
105. Black, H.I.J. & Okwakol, M.J.N. (1997). Agricultural intensification, soil biodiversity and agroecosystem function in the tropics: the role of termites. *Applied Soil Ecology*, 6(1), 37–53.
106. Debelo DG and Degaga EG. 2014. Preliminary studies on termite damage on rural houses in the Central Rift Valley of Ethiopia. *African Journal of Agricultural Research*, 9(39), 2901-2910, DOI: 10.5897/AJAR2014.8670.
107. Mahapatro, G.K., Debajyoti, C. & Gautam, R. (2017). Indian Indigenous Traditional Knowledge (ITK) on termites: Eco-friendly approaches to sustainable management. *Indian Journal of Traditional Knowledge*, 15(2), 333-340.
108. Mutsamba, E.F., Nyagumbo, I. & Mafongoya, P. (2016). Termite prevalence and crop lodging under conservation agriculture in sub-humid Zimbabwe. *Crop Protection*, 82, 60-64.
109. Nhamo, N. (2007). The Contribution of Different Fauna Communities to Improved Soil Health. A Case of Zimbabwean Soils under Conservation Agriculture. PhD thesis. University of Bonn. 131 pp.
110. Nyagumbo, I., Munamati, M., Mutsamba, E.F., Thierfelder, C., Cumbane, A. & Dias, D. (2015). The effects of tillage, mulching and termite control strategies on termite activity and maize yield under conservation agriculture in Mozambique. *Crop Protection*, 78, 54– 62.
111. Tiruneh, S., Yigezu, Y.A. & Bishaw, Z. (2015). Measuring the effectiveness of extension innovations for out-scaling agricultural technologies. *African Journal of Agricultural Science and Technology*, 3(7), 316-326.
112. Shikuku, K.M. (2018). Information exchange links, knowledge exposure, and adoption of agricultural technologies in northern Uganda. *World Development*, 115, 94-106.

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