Farmer perceptions on the effects of termites in Kwa Vonza Location, Kitui County, Kenya

Comment [cs1]: Farmer's perception
What is the meaning of "Location" here?
Kwa Vonza is primarily a town established by a British Settler. Since, the article is about farmers, the word "Location" must be changed to a term that indicate farming space. Location has no meaning otherwise.

ABSTRACT

Aims: ~~The aim of this study was~~This study aimed to assess~~: (i) the perception of Kwa Vonza farmers regarding the presence of termites in their land (ii) the perceived importance of termites~~ (i) the perception of Kwa Vonza farmers regarding the presence of termites in their land, (ii) the perceived importance of termites,and (iii) how they control termites in their properties.

Study design: This study is based on responses to ~~a questionnaires~~a questionnaire sent to farmers.

Place and Duration of Study: The study took place in Kwa Vonza Location, Yatta Sub County, Kitui County, Kenya, between April and November 2017.

Methodology: 60 questionnaires~~ each comprising 20 multiple choice questions were send~~, each comprising 20 multiple-choice questions, were sent out to farmers. Out of~~,~~ these, 54 responses were received. Where the response did not require a Yes or No answer, it elicited a response from a standardized five-point scale to demonstrate agreement ~~to~~ withthe provided proposition.Data analysis was done using descriptive statistics~~ in which percentages were tabulated and frequency tables~~ , in which percentages were tabulated, and frequency tables were generated using Microsoft Excel.

Results:73% of farmers perceived their land as infertile~~ with the causes of infertility ranging from soil erosion, drought, and mono-cropping. 87% of farmers acknowledged of termite infestation in their farms but perceived them as destructive. Termite infestation was attributed to deforestation, drought~~, with the causes ranging from soil erosion, drought, and mono-cropping. 87% of farmers acknowledged termite infestation in their farms but perceived them as destructive. Termite infestation was attributed to deforestation, drought, and flooding. Chemical control was the method of choice to manage termites.

Conclusion: Kwa Vonza farmers do not perceive termites ~~to be of any agronomic significance but view them as destructive agents. Further research to address the complex issue of soil management at the farm-scale level that involves farmers is necessary to fillgaps in scientific knowledge and producing~~as of any agronomic significance but view them as destructive agents. Further research to address the complex issue of soil management at the farm-scale level that involves farmers is necessary to fill gaps in scientific knowledge and produce advice for practical use.

Keywords: termites; soil fertility; tropical ecosystems; soil biodiversity; farmer perceptions

1. INTRODUCTION

Termites (*Isoptera*) are an order of insects consisting of 2,500 species, out of which 300 are considered pests (Ndiaye et al., 2004). Depending on their family or ~~sub-family~~subfamily, they build their nests underground, in wood or termite mounds (Heyde et al., 2021). Because termites display a high sensitivity to the biotic and abiotic environmental conditions they are exposed to, they can play a key role in tropical ecosystems (Jouquet et al., 2016) just like earthworms do in temperate ecosystems (Manono~~and~~ &Moller, 2015). These soil organisms play important roles in linking abiotic and biotic components of ~~soil ecosystem by supplying 'soil services' such as nutrient cycling, decomposition, and plant growth (Apori et al., 2020; Jouquet et al., 2016; Manono~~the soil ecosystem by supplying 'soil services' such as nutrient cycling, decomposition, and plant growth (Apori et al., 2020; Jouquet et al., 2016; Manono, 2016a).

Large amounts of essential nutrients in the soil are bound in organic form (Khasabulli et al., 2023; Manono, 2014). For these nutrients to be released and made available for plant absorption, they must undergo decomposition and mineralization (Marzi et al., 2021; Manono et al., 2019). Through their feeding and ~~barrowing~~ burrowingactivities, termites and earthworms directly influence the breaking down, mixing, and transportation of organic matter and mineral nutrients. They create macrospores that enhance infiltration, water storage, and air regulation while providing channels for root growth and penetration (Manono, 2019; Jouquet et al., 2016). On the negative side, they both contribute to the emissions of greenhouse gases (Quevedo et al., 2021; Manono, 2016b).

Despite playing these important roles, termites are one of the most damaging pests in the tropics and can cause considerable problems in agriculture (Kagezi et al., 2023; Govorushko, 2019). They feed on dead organic matter, but when not available, they will eat live plant material, including crops. In arid and semi-arid lands, termites build underground nests and collect live green plant material such as living grass, crops, seedlings, and weak wilting plants (Lopez-Hernandez, 2023; Lepage et al., 1993). Because of the beneficial roles these organisms play in agroecosystems, they should be carefully managed, considering their benefits against the rate of loss to the ecosystem (Manono, 2016c; Nyeko ~~and~~ &Olubayo, 2005).

Individual farmers are the stewards and ~~decision-makers about what happens on their land (Kalovoto et al., 2020; Manono, 2016c; Sileshi,~~decision-makers about what happens on their land (Kalovoto et al., 2020; Manono, 2016c; Sileshi et al., 2008). It ~~therefore~~, therefore, follows that sustaining agricultural productivity depends on maintaining and enhancing the abundance and functional activities of these soil organisms (Manono, 2016c; Sileshi~~,~~ et al., 2008). Farmers could benefit from more quantitative evidence of their perception and knowledge ~~on~~ ofthese organisms and their activities in soil fertility and crop production (Manono, 2016c). For example, improved farmer understanding of the importance of these organisms could enable the development of suitable decision support tools that emphasize their management in contributing to agricultural sustainability. This is particularly important in systems that are susceptible to changing land use and management pressures associated with persistent drought~~ like Kwa-Vonza location,~~ , like the Kwa-Vonza location in Kitui County, Kenya. It is with this background that this study explores how small-scale farmers in Kwa-Vonza perceive termites in relation to soil fertility and crop production. Thus, ~~the aim of this study was~~this study aimed to assess~~: (i) the perception of Kwa vonza farmers regarding the presence of termites in their land (ii) the perceived importance of termites~~ (i) the perception of Kwa Vonza farmers regarding the presence of termites in their land, (ii) the perceived importance of termites, and (iii) how they control termites in their properties.

Comment [cs2]: The author must inform the reader about the nature and extent of termites' activities in the studied area. How far are the farmers influenced positively or negatively by the termites' actions? It is logical to think that if termites significantly impact the soil quality, the farmers must have developed a symbiotic relationship with them since arming is a traditional and century-old practice among these people.
On the basis of such context, the present investigation finds its ground. Keeping the context uncovered as to why the issue of the beneficial action of termites has to be assessed according to the perception of the farmer, the basic premise of the research or the inquiry will be illogical and irrational.

2. MATERIAL AND METHODS

2.1 Study area

This study is based on responses to a questionnaire sent to farmers in Kwa Vonza Location, Yatta Sub County, Kitui County, Kenya, between April and November 2017. The coordinates of the study area are 44°38′ to 44°54′ S and 170°59′ to 171°08′ E. Kwa Vonza is located at 130 Kilometers South East of Nairobi on the Machakos – Kitui road. It is part of the Yatta Plateau, which stretches from the north to the south of the county and lies between Rivers Athi and Tiva. The area experiences a semi-arid climate with very erratic and unreliable rainfall. Annual temperatures range between a minimum of 14 to 22° centigrade and a maximum of 26 to 34° centigrade. There are two rainfall seasons: long rains between March and May and short rains between October and December. The area's soils are low in fertility and range from sedimentary rocks, red sandy soils, to clay black cotton soils.

2.2 Farmer recruitment and analysis.

Respondents were farmers in Kwa Vonza Location with over ~~3~~ three years of farming experience. The questionnaire comprised 20 ~~multiple choice~~multiple-choice questions designed after trials to take no longer than 25 min to complete. Where the response did not require a Yes or No answer, it elicited a response from a standardized five-point scale to demonstrate agreement ~~to~~ with the provided proposition. A blank space was left after each question ~~for respondents to~~ so that respondents could give an open-ended response or clarification. Participating farmers were given informed written consents, had their anonymity guaranteed, and were reminded that they did not have to participate and that they could stop participation at any stage or refuse to answer certain questions. Sixty questionnaires were sent, out of which 54 responses were received. Some respondents did not answer every question. Therefore, the percentages reported in the analysis are for individual questions. Data analysis was done using descriptive statistics ~~in which percentages were tabulated and frequency tables~~, in which percentages were tabulated, and frequency tables were generated using Microsoft Excel.

3. RESULTS AND DISCUSSION

3.1 Farmer's perception of their land's fertility

Farmers perceive their land's fertility differently ~~with a majority saying theirs is neither fertile nor infertile followed by those saying theirs are~~, with a majority saying theirs is neither fertile nor infertile, followed by those saying theirs is infertile (Figure 1). The two categories combined comprised ~~of~~ 73% of the respondents. When asked what they perceive to be the cause of the infertility, the farmers gave a mix of results, ranging from soil erosion, drought, and mono-cropping (Figure 2). This observation was ~~consisted~~ consistent with (Okoba ~~and~~ & De Graaff, 2005). Although the majority of farmers perceived termites to be destructive (Figure 4), only 14% of the farmers attributed soil infertility to termites (Figure 2). This was so~~, even when a greater percentage (87.5%) of the farmers acknowledged of termite infestation in their lands, with a majority of these farmers comprising of 65% not attribute~~ even when a greater percentage (87.5%) of the farmers acknowledged termite infestation in their lands, with a majority of these farmers, comprising 65%, not attributing termites to any soil benefits (Figure 3).

Comment [cs3]: The methodology reveals that the researcher did not visit the study sites personally. So, the contexts of the field are not mentioned in the article, which is one of the shortcomings of the inquiry. The methodology thus could not be precise because the problem setting was not properly identified or delineated. It seems that the researcher came up with an idea and sent the questionnaires to the selected respondents without knowing whether there was a significant presence of termites in the farmland or not.
It is natural that if the farmers do not notice the significant presence of termites in their fields, their knowledge or ideas about the ill effects or bad effects will be imaginary and perceptual, not based on significant practical situations.
This implies the importance of describing the study's context or problem settings in relation to the field situations.
So, I suggest that if the researcher knows the significant presence of termites in the fields of the farmers under study, he/she must discuss it in the introduction to set the problem setting or the research argument.

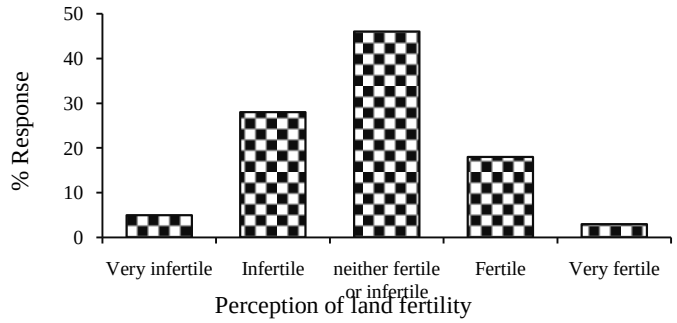

Fig.1. ~~Farmers~~ Farmers'perception ~~on~~ ofsoil fertility.

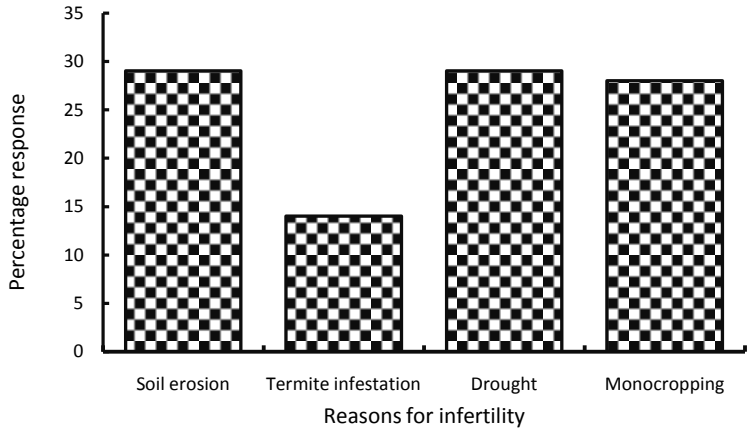

Fig. 2. The reasons for soil infertility.

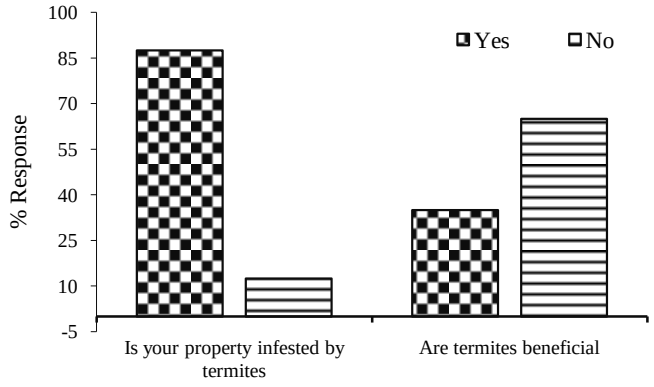

Fig. 3. Termite infestation in the farms and perception of benefit.

3.2 Effect of termite infestation in farms.

~~Majority of farmers comprising 40% associated termites with crop destruction~~y,,The majority of farmers, comprising 40%, associated termites with crop destruction, while 33% associated their presence with lower yields (Figure 4). A further 16% associated termites with house destruction. Only 5% of the ~~farmers' perceived termites has~~farmers perceived termites as playing a role in enhancing soil fertility (Figure 4). From this perspective, it would be noted that a majority of farmers, comprising 89% of respondents, perceived termites as destructive, ~~in~~ consistent with other studies (Govorushko, 2019; Lepage et al., 1993). It should be noted that the arguments put forward by scientists on the beneficial roles of ~~termite~~ termitesas a result of their bioturbation activities ~~that~~ lead to the breaking up of surface crusts, reducing soil compaction, increasing soil porosity, improving water infiltration and enhancing water holding capacity~~, and litter~~. Litter degradation (Jouquet et al., 2016) may be invisible to farmers and ~~therefore, were not able to be recognize~~, therefore, are not able to recognize these roles and associate them with termites.

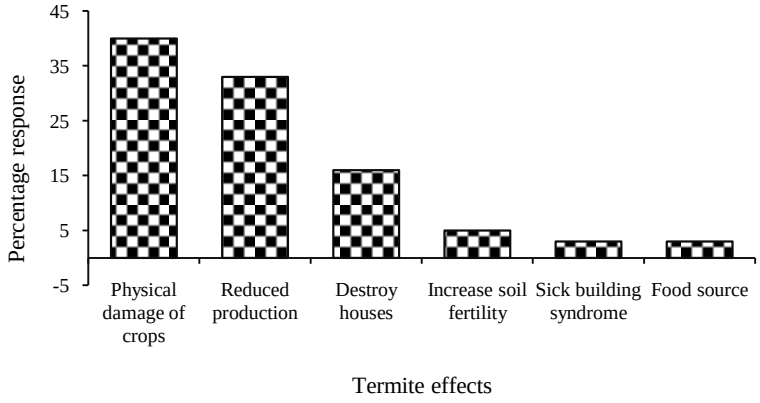

Fig. 4. Effects of termite infestation in the farms.

3.3 Causes of termite infestation

A majority comprising ~~of 72% of respondents~~72% of respondents, attributed termite infestation to three factors, viz, deforestation, drought, and flooding (Figure 5). Out of these, deforestation and drought,they accounted for 52%. Only 2% of respondents considered termites to be food, a contradiction to the majority who consider termites as food in western Kenya (Kinyuru et al., 2013). Kwa-Vonza ~~being a drought prone area, when~~is a drought-prone area; when it rains, it causes flooding in the termite mounds. This forces them out of their mounds to avoid drowning, just like earthworms do (Manono, 2014). In such circumstances, people are able to see them easily~~easily see them~~. However, during droughts and deforestation, termites tend to be all over the place (Charles et al., 2021).

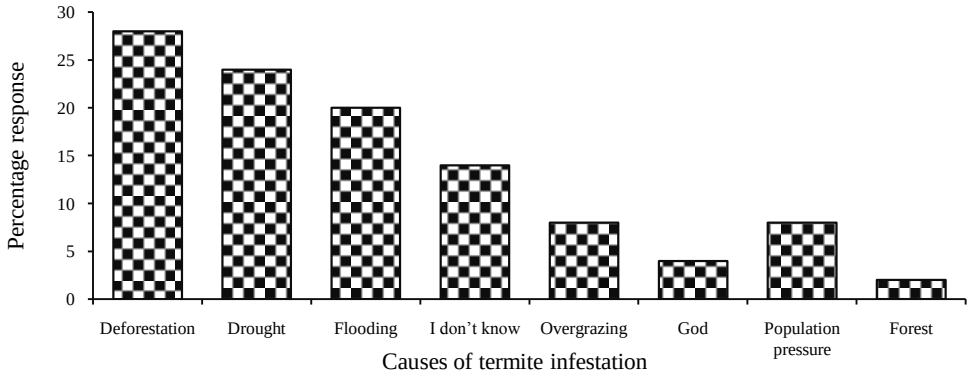

Fig. 5. Causes of termite infestation.

3.4Strategies ~~of~~ forcontrolling termites

Because farmers perceived termites to be destructive, it was prudent to enquire how they controlled them. ~~Majority of the respondents, comprising 45% controlled termites by chemicals while 26% physical~~The majority of the respondents, comprising 45%, controlled termites with chemicals, while 26% physically destroyed termite mounds to remove the queen (Figure 6). Chemical control is used as a termite control strategy in many places (Ahmad et al., 2021; Ejomah et al., 2020). Another 22% used wood ash from their kitchen. This method has been reported to be used in other studies (Oliver-Villanueva et al., 2013).

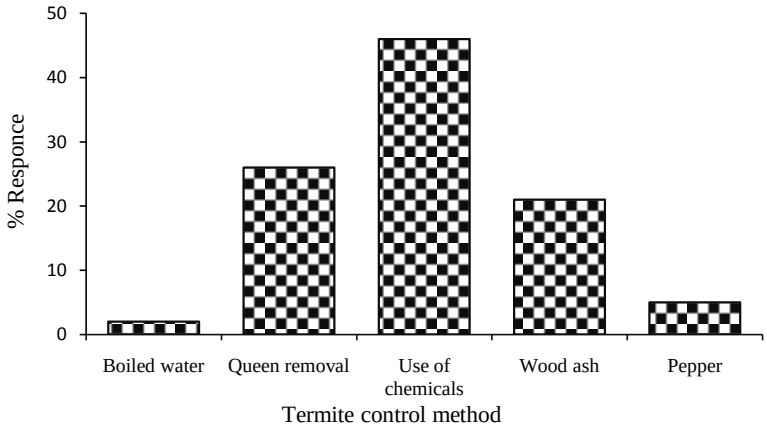

Fig. 6. Methods used to control termites.

3.4Methodological constraints

Caution should be taken when interpreting the outcome of this study because of the small sample size and homogeneous ~~properties of the farmer respondents. Nevertheless, 90% of farmers contacted responded to questionnaires and this should be considered as~~ characteristics of the farmer respondents. Nevertheless, 90% of farmers contacted responded to questionnaires, and this should be considered a model study that should be expanded to other regions.

4. CONCLUSION

This study revealed that farmers in Kwa Vonza do not perceive termites ~~to be of any agronomic significance but view them as destructive agents. This calls for further social science research to address the complex issue of soil management at the farm-scale level. Farmer involvement may help in prioritizing~~as of any agronomic significance but view them as destructive agents. This calls for further social science research to address the complex issue of soil management at the farm-scale level. Farmer involvement may help prioritize options for filling gaps in scientific knowledge and producing advice for practical use.

~~ACKNOWLEDGEMENTS~~ACKNOWLEDGEMENTS

We thank all the individual farmers who participated in this study.

COMPETING INTERESTS

“Authors have declared that no competing interests exist.”

AUTHORS' CONTRIBUTIONS

~~Authors contributed equally in the design, data collection, analysis~~The authors contributed equally to the design, data collection, analysis, and writing of this article. All authors read and approved the final manuscript.

REFERENCES

1. Ahmad, F., Fouad, H., Liang, S. Y., Hu, Y., & Mo, J. C. (2021). Termites and Chinese agricultural system: applications and advances in integrated termite management and chemical control. Insect ~~science~~Science, 28(1), 2-20.

2. Apori, S. O., Murongo, M. F., Hanyabui, E., Muli, G. K., & Wamuyu, B. (2020). Role of military termites (Pseudocanthotermesmilitaris) in improving soil productivity in tropical agroecosystems.

3. Charles, G. K., Riginos, C., Veblen, K. E., Kimuyu, D. M., & Young, T. P. (2021). Termite mound cover and abundance respond to herbivore-mediated biotic changes in a Kenyan savanna. Ecology and Evolution, 11(12), 7226-7238.

4. Ejomah, A. J., Uyi, O. O., &Ekaye, S. O. (2020). Exposure of the African ~~mound building~~mound-building termite, Macrotermesbellicosus workers to commercially formulated 2, 4-D and atrazine caused high mortality and impaired locomotor response. Plos one, 15(3), e0230664.

5. Govorushko, S. (2019). Economic and ecological importance of termites: A global review. Entomological Science, 22(1), 21-35.

6. Heyde, A., Guo, L., Jost, C., Theraulaz, G., & Mahadevan, L. (2021). Self-organized biotectonics of termite nests. Proceedings of the National Academy of Sciences, 118(5), e2006985118.

7. Jouquet, P., Bottinelli, N., Shanbhag, R. R., Bourguignon, T., Traoré, S., & Abbasi, S. A. (2016). Termites: the neglected soil engineers of tropical soils. Soil Science, 181(3/4), 157-165.

8. Kagezi, G. H., Twesigye, V., Musasizi, J. K., Ssebugenyi, I., Namara, E., Ssenoga, G., ... & Arinaitwe, G. (2023). Farmers' Knowledge and Perception of the Pest Status and Management Options for Termites in Buikwe District, Central Uganda.

9. Kalovoto Damariis, M., Kimiti Jacinta, M., & Manono Bonface, O. (2020). Influence of women empowerment on the adoption of agroforestry technologies to counter climate change and variability in semi-arid Makueni County, Kenya. International Journal of Environmental Sciences & Natural Resources, 24(2), 47-55.

10. Khasabulli, B. D., Mutisya, M. D., Anyango, S. P., Manono, B. O., & Odhiambo, D. G. (2023). Soil Microbial Biomass, Microbial Population and Diversity in Maize-Banana Based Agroforestry System in Kisii County, Kenya. Asian J. Res. Crop Sci, 8(4), 230-239.

11. Kinyuru, J. N., Konyole, S. O., Roos, N., Onyango, C. A., Owino, V. O., Owuor, B. O., ... & Kenji, G. M. (2013). Nutrient composition of four species of winged termites consumed in western Kenya. Journal of food composition and analysis, 30(2), 120-124.

12. Lepage, M., Abbadie, L., & Mariotti, A. (1993). Food habits of sympatric termite species (Isoptera, Macrotermitinae) as determined by stable carbon isotope analysis in a Guinean savanna (Lamto, Côte d'Ivoire). *Journal of Tropical Ecology, 9*(3), 303-311.

13. Lopez-Hernandez, D. (2023). Termite mound as nutrient hot-spots in savannah with emphasis in P cycling and the potential use of mounds as soil amendment. *Pedobiologia*, 150888.

14. Manono, B. O., Moller, H., Benge, J., Carey, P., Lucock, D., & Manhire, J. (2019). Assessment of soil properties and earthworms in organic and conventional farming systems after seven years of dairy farm conversions in New Zealand. Agroecology and Sustainable Food Systems, 43(6) 678-704.

15. Manono, B. O. (2016c). New Zealand dairy farm effluent, irrigation, and soil biota management for sustainability: Farmer priorities and monitoring. Cogent Food & Agriculture, 2(1), 1221636.

16. Manono, B. O. (2016b). Carbon dioxide, nitrous oxide and methane emissions from the Waimate District (New Zealand) pasture soils ~~as~~ areinfluenced by irrigation, effluent dispersal and earthworms. Cogent Environmental Science, 2(1), 1256564.

17. Manono, B. (2016a). Agro-ecological role of earthworms (Oligochaetes) in sustainable agriculture and nutrient use efficiency: a review. Journal of Agriculture and Ecology Research International, 8(1), 1-18.

18. Manono, B. O., & Moller, H. (2015). Effects of stock type, irrigation and effluent dispersal on earthworm species composition, densities and biomasses in New Zealand pastures. Pedobiologia, 58(5-6), 187-193.

19. Manono, B. O. (2014). Effects of irrigation, effluent dispersal and organic farming on earthworms and soil microbes in New Zealand dairy farms (Doctoral dissertation, University of Otago).

20. Marzi, M., Shahbazi, K., Kharazi, N., & Rezaei, M. (2020). The influence of organic amendment source on carbon and nitrogen mineralization in different soils. Journal of Soil Science and Plant Nutrition, 20, 177-191.

21. Ndiaye, D., Lepage, M., Sall, C. E., & Brauman, A. (2004). Nitrogen transformations associated with termite biogenic structures in a dry savanna ecosystem. Plant and Soil, 265, 189-196.

22. Nyeko, P., & Olubayo, F. M. (2005). Participatory assessment of farmers' experiences of termite problems in agroforestry in Tororo District. University of Nairobi.

23. Okoba, B. O., & De Graaff, J. (2005). Farmers' knowledge and perceptions of soil erosion and conservation measures in the Central Highlands, Kenya. Land Degradation & Development, 16(5), 475-487.

24. Oliver-Villanueva, J. V., Gascón-Garrido, P., & Ibiza-Palacios, M. D. S. (2013). Evaluation of thermally-treated wood of beech (Fagus sylvatica L.) and ash (Fraxinus excelsior L.) against Mediterranean termites (Reticulitermes spp.). Eur. J. Wood Wood Prod, 71, 391-393.

281 25. Quevedo, H. D., Brandani, C. B., Bento, C. B., Pitombo, L. M., Ferreira Filho, P. J., & do
282 Carmo, J. B. (2021). Greenhouse gas emissions from termite mounds in a transition
283 area between the Cerrado Savanna and the Atlantic Forest in Brazil. Acta Oecologica,
284 110, 103690.

285 26. Sileshi, G., Akinnifesi, F. K., Ajayi, O. C., Chakeredza, S., Mng'omba, S., & Nyoka, B. I.
286 (2008). Towards sustainable management of soil biodiversity in agricultural landscapes
287 in Africa. Biodiversity, 9(1-2), 64-67.

288