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Suitability of Termite Infested Soils in the Guinea Savanna Region of Nigeria for Arable Crop Production

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Abstract: Effects of termite infestation results in highly modified soil profile and characteristic that could affect soil fertility and crop production. This study therefore assessed the suitability of termite-infested soils for maize (*Zea mays* L.), guinea corn (*Sorghum bicolor*), millet (*Pennisetum glaucum*) and cassava (*Manihot esculenta*) production. The study was conducted in Mokwa and Kontagora area of Niger State, Nigeria. Soil profile samples were analysed in the laboratory for physical and chemical parameters. The soil and environmental characteristics generated were used for parametric suitability evaluations. It was observed that all the plots were not suitable for maize production except the non-infested at Kontagora that was marginally suitable. All the plots were marginally suitable for millet and guinea corn production with the exception of non-infested plots that were potentially moderately suitable for millet production. Both Termite-infested and non infested plots were marginally suitable (actual) and potentially moderately suitable for cassava production. Major constraints were coarse sandy texture and low CEC for all crops in addition to rainfall for cassava. *Macrotermitinae nigeriensis* dominant in the area characteristically deplete soil organic matter that could form organic matter-clay complex, improve soil structure, enhance CEC, ability to adsorb and make plant nutrients available.

Key words: Termite infestation, *Macrotermitinae nigeriensis*, soil suitability, crop production, Guinea savanna

INTRODUCTION

Land is a complex and dynamic concept that caries the ecosystem and itself part of the ecosystem (Vink, 1975), comprising the entire elements of the physical environment of which soil is a major component and include geology, landform, climate, hydrology, fauna and flora (Dent and Young, 1980). Land therefore, comprises the entire element of physical environment that influence potential for use, which could be evaluated.

Various methods of land evaluation exist and it involves the rating of selected land qualities and characteristics relevant for a particular use type. The determination of suitability of a piece of land for a specified use involves the matching of land use requirement for a particular crop with the supply of the requirements by the land. Some of the land characteristics required to evaluate suitability of a pedon for a particular land utilization type include climate, topography, drainage, soil physical properties and fertility status. Within a particular area or ecology that enjoys similar climatic condition, some extraneous factors could introduce variation in the suitability class of pedons.

Prominent in this regard is the influence of termite infestation whose activities to a large extent influences soil formation, subsequently characteristics and use (Ekundayo and Aghatise, 1997; Ndiaye *et al.*, 2004; Jouquet *et al.*, 2005; Obi, 2007). Termite is widely distributed over the world but with high concentration in the savanna region (Lobry de Bruyn and Conacher, 1990; Baba, 1993; Myles, 2002) as compared to earthworms in the humid region (Lal, 1988; Lavelle *et al.*, 1997). Termites modify the landscape of the savanna region to a large extent that their effects manifest on the soil characteristics, fertility status and subsequently productivity. They feed, build and repair their nest and galleries out of soil fabrics and organic material and therefore influencing soil fertility especially of the tropics that depends to a large extent on organic matter.

This is more important in *Macrotermitinea nigeriensis* dominated areas. *Macrotermitinea nigeriensis* have been reported to feed on organic materials and store same in the fungus comb (Lavelle *et al.*, 2001; Mora *et al.*, 2003; Jouquet *et al.*, 2005), hence depriving the soils of organic matter to which it largely depend on for fertility and virility. In southern guinea savanna of Nigeria, termites remove 60% of annual wood litter per year.

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It has been reported that these locations with high termite infestation is also agrarian therefore increasing the problems of soil fertility and crop yield. Research has shown that the major crops grown in this area comprises maize, guinea corn, cowpea and millet grown by 82.0, 75.3, 63.3 and 31.9% of the farmers respectively (Obi *et al*. 2007). Additionally, cassava is not a major crop in the area, grown by 21.9% (Obi *et al*., 2007), but as it is gaining popularity among Nigerian farmers because of its increased demand.

Therefore, the objective to this study is to assess the suitability of termite infested soil for maize, guinea corn, millet and cassava in the guinea savanna region of Nigeria.

MATERIALS AND METHODS

Study site: Giant termite mounds are common features of the rural landscape of Niger State. These mounds are particularly numerous and cover Mokwa, Gbako, Bida, Agaie, Kontagora, Magama and Wushishi Local Government Areas of Niger State, Nigeria measuring about 51,756.96 km^2. It is located between latitudes 8° 30'N and 11°N and longitudes 4° 30'E and 6° 30'E (Fig. 1).

The soils of the area are dominantly Alfisols (USDA), Lixisol (FAO/UNESCO) and Kulfo series (Moss, 1957). The environmental conditions of the study area include precipitation (1175 mm year^{-1}), temperature (28°C), sunshine period (3.8 h in August to 8 h in November), wind velocity (44 km day^{-1} in January to 133 km day^{-1} in April) and evapotranspiration (about 2149 mm). The soil moisture regime is ustic and soil temperature regime is hyperthermic. The area falls within the Southern Guinea savanna region covered with either wooded bush land or wooded grassland. The study area is on a relatively flat terrain with slope of less than 4%. Parent material is Nupe sandstone. The soil texture class of B-horizon of the pedons is dominantly sandy loam, with clay that ranged between 102 and 182g kg^{-1}.

Soil sampling and analysis: Mokwa in the south and Kontagora in the northern part of the infestation zone

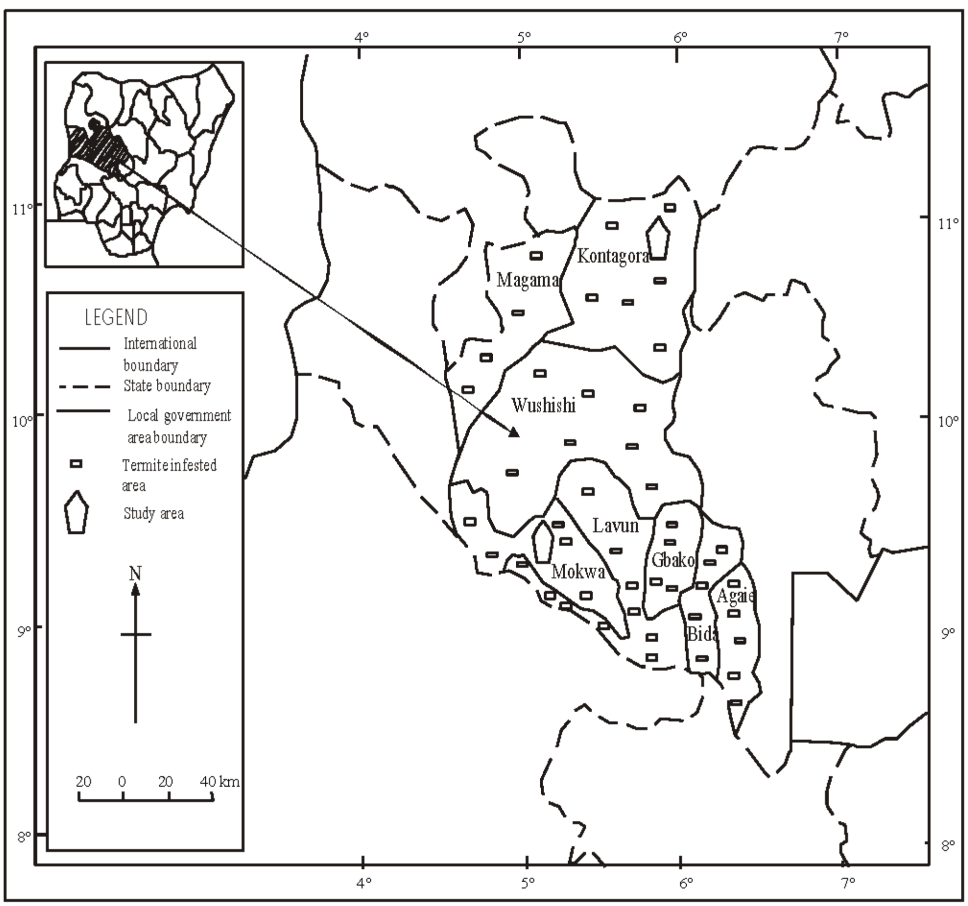

Fig. 1: Location map showing infestation area and study sites

Table 1: Land characteristics and qualities of the termite infested and non-infested soils of Mokwa and Kontagora for suitability rating

	Mokwa			Kontagora		
	Termite infested		Non-infested	Termite infested		Non-infested
Land qualities	Plot 1	Plot 2	Plot 3	Plot 1	Plot 2	Plot 3
Climate (C)						
Annual rainfall (mm)	1175	1175	1175	1175	1175	1175
Length of growing season (months)	5	5	5	5	5	5
Mean Temp. (°C)	28	28	28	28	28	28
Length of dry season (months)	7	7	7	7	7	7
Topography (T)						
Slope (%)	2	2	2	2	2	2
Wetness (W)						
Drainage	good	good	good	good	good	good
Soil Physical Properties						
*Texture/Structure (0-15 cm)	CS	CS	CS	CS	CS	CS
Volume of coarse fragments (S)	none	none	none	none	none	none
Soil depth (cm)	>200	>200	200	>200	>200	>200
Soil fertility (f)						
CEC (cmol/kg clay)	8.07	6.22	2.53	5.31	5.98	9.70
Base saturation (%)	83.88	93.57	72.36	84.92	72.92	69.06
Organic matter (%) 0-15cm	0.74	0.69	0.98	0.60	0.38	0.41

*CS = Coarse sand

Table 2: Suitability evaluation of the termite infested and non-infested soils of Mokwa and Kontagora for maize production.

Climate (c)		Length of growing season	Topo graphy (l)	Wetness (d)	Soil physical properties (s)			Soil fertility (f)			
Rainfall	Temperature	season	Slope	Drainage	Texture	Coarse fragment	Soil depth	CEC	Base saturation	OM	SI* (class)
Kontagora											
Termite infested (Plot 1)											
100	100	100	100	100	40	100	100	60	100	60	14 (NSsf) a
100	100	100	100	100	40	100	100	60	100	100	24 (NSsf) p
Termite infested (Plot 2)											
100	100	100	100	100	40	100	100	60	100	60	14 (NSsf) a
100	100	100	100	100	40	100	100	60	100	100	24 (NSsf) p
Non-infested (Plot 3)											
100	100	100	100	100	40	100	100	85	100	85	29 (S3sf) a
100	100	100	100	100	40	100	100	85	100	100	34 (S3sf) p
Mokwa											
Termite infested (Plot 1)											
100	100	100	100	100	40	100	100	85	100	60	20 (NSsf) a
100	100	100	100	100	40	100	100	85	100	100	34 (S3sf) p
Termite infested (Plot 2)											
100	100	100	100	100	40	100	100	60	100	60	14 (NSsf) a
100	100	100	100	100	40	100	100	60	100	100	24 (NSsf) p
Non-infested (Plot 3)											
100	100	100	100	100	40	100	100	40	100	85	14 (NSsf) a
100	100	100	100	100	40	100	100	40	100	100	16 (NSsf) p

SI* = suitability index, a and p= actual and potential suitability respectively when characteristic s and f were limiting and may not be easily corrected, Suitability index class rating, 75-100 = S1 (Highly suitable), 50-74 = S2 (Moderately suitable), 25-49 = S3 (Marginally suitable), <25 = NS (Non Suitable)

were chosen for the study (Fig. 1). In each location, three (100×100 m) plots were selected for study. Two plots had termite mounds while the third had neither sign of present nor previous occurrence of mounds. The entire plots studied had been under similar land use but presently cropped to maize and relay cropped with cowpea. None of the plots had been cropped for more than 5 years.

Six representative profile pits were established at the rate of one per plot. Soil morphological and site characteristics were described using FAO guidelines (FAO, 2006a). Soil samples were collected according to genetic horizons. All samples were bagged and labeled. Soil samples were air-dried, partially ground and made to pass through 2 mm sieve. The pedons were classified using Soil Survey Staff (2006), FAO (2006b) and Moss (1957).

Laboratory analysis: The soil samples were processed and analysed in the laboratory for physical and chemical properties. Particle size analysis was performed using Bouyoucous hydrometer method (Day, 1953). Exchangeable bases were extracted with Mehlick No. 3

Table 3: Suitability evaluation of the termite infested and non-infested soils of Mokwa and Kontagora for millet (*Pennisetum glaucum*)

Climate (c)		Length of growing season	Topo graphy (l)	Wetness (d)	Soil physical properties (s)			Soil fertility (f)			
Rainfall	Temperature		Slope	Drainage	Texture	Coarse fragment	Soil depth	CEC	Base saturation	OM	SI* (class)
Kontagora											
Termite infested (Plot 1)											
95	95	95	100	85	60	100	100	95	100	85	35 (S3cdsf) a
100	95	100	100	100	60	100	100	95	100	100	54 (S2s) p
Termite infested (Plot 2)											
95	95	95	100	85	60	100	100	95	100	85	35 (S3cdsf) a
100	95	100	100	100	60	100	100	95	100	100	54 (S2s) p
Non-infested (Plot 3)											
95	95	95	100	85	60	100	100	95	100	95	39 (S3cdsf) a
100	95	100	100	100	60	100	100	95	100	100	54 (S2s) p
Mokwa											
Termite infested (Plot 1)											
95	95	95	100	85	60	100	100	95	100	85	35 (S3cdsf) a
100	95	100	100	100	60	100	100	95	100	100	54 (S2sf) p
Termite infested (Plot 2)											
95	95	95	100	85	60	100	100	95	100	85	35 (S3cdsf) a
100	95	100	100	100	60	100	100	95	100	100	54 (S2sf) p
Non-infested (Plot 3)											
95	95	95	100	85	60	100	100	95	100	95	39 (S3cdsf) a
100	95	100	100	100	60	100	100	95	100	100	54 (S2sf) p

SI* = suitability index, a = actual suitability when either characteristic c, d s and f were limiting, p = potential suitability when characteristic c and d was corrected with irrigation, Suitability index class rating, 75-100 = S1 (Highly suitable), 50-74 = S2 (Moderately suitable), 25-49 = S3 (Marginally suitable), <25 = NS (Non Suitable)

Table 4: Suitability evaluation of the termite infested and non-infested soils of Mokwa and Kontagora for guinea corn (*sorghum bicolor*)

Climate (c)		Length of growing season	Topo graphy (l)	Wetness (d)	Soil physical properties (s)			Soil fertility (f)			
Rainfall	Temperature		Slope	Drainage	Texture	Coarse fragment	Soil depth	CEC	Base saturation	OM	SI* (class)
Kontagora											
Termite infested (Plot 1)											
100	95	100	100	85	60	100	100	85	100	95	39 (S3dsf) a
100	95	100	100	85	60	100	100	85	100	100	41 (S3dsf) p
Termite infested (Plot 1)											
100	95	100	100	85	60	100	100	85	100	95	39 (S3dsf) a
100	95	100	100	85	60	100	100	85	100	100	41 (S3dsf) p
Non-infested (Plot 3)											
100	95	100	100	85	60	100	100	85	100	85	35 (S3dsf) a
100	95	100	100	85	60	100	100	85	100	100	41 (S3dsf) p
Mokwa											
Termite infested (Plot 1)											
100	95	100	100	85	60	100	100	85	100	95	39 (S3dsf) a
100	95	100	100	85	60	100	100	85	100	100	41 (S3dsf) p
Termite infested (Plot 2)											
100	95	100	100	85	60	100	100	85	100	95	39 (S3dsf) a
100	95	100	100	85	60	100	100	85	100	100	41 (S3dsf) p
Non-infested (Plot 3)											
100	95	100	100	85	60	100	100	85	100	100	41 (S3dsf) a
100	95	100	100	85	60	100	100	85	100	100	41 (S3dsf) p

SI* = suitability index, a and p= actual and potential suitability when characteristic c, d, s and f was limiting and could not be corrected, Suitability index class rating, 75-100 = S1 (Highly suitable), 50-74 = S2 (Moderately suitable), 25- 49 = S3 (Marginally suitable), <25 = NS (Non Suitable)

extraction (Mehlick, 1984). K and Na content were read with the aid of flame emission spectroscopy, while Ca^{2+}, Mg^{2+} and micronutrients were read with the aid of Atomic Absorption Spectroscopy (AAS). Exchangeable acidity was extracted with un-buffered potassium chloride solution and titration with 0.01 M-solution of sodium hydroxide to the first permanent pink endpoint (Anderson and Ingram, 1993). Total organic carbon was determined by "wet" oxidation in acidified dichromate (Nelson and Sommers, 1982). CEC was determined as described in Anderson and Ingram (1993).

Land suitability assessment: Land evaluation is the process of estimating the potential of land for alternative uses. It involves the rating of selected land qualities/characteristics relevant for a particular land use

Table 5: Suitability evaluation of the termite infested and non-infested soils of Mokwa and Kontagora for cassava (*Manihot esculenta*)

Climate (c)		Length of growing season	Topo graphy (l)	Wetness (d)	Soil physical properties (s)			Soil fertility (f)			
Rainfall	Temperature		Slope	Drainage	Texture	Coarse fragment	Soil depth	CEC	Base saturation	OM	SI* (class)
Kontagora											
Termite infested (Plot 1)											
95	95	60	100	100	60	100	100	95	100	85	28 (S3csf) a
100	95	100	100	100	60	100	100	95	100	100	54 (S2s) p
Termite infested (Plot 1)											
95	95	60	100	100	60	100	100	95	100	85	28 (S3csf) a
100	95	100	100	100	60	100	100	95	100	100	54 (S2s) p
Non-infested (Plot 3)											
95	95	60	100	100	60	100	100	95	100	85	28 (S3csf) a
100	95	100	100	100	60	100	100	95	100	100	54 (S2s) p
Mokwa											
Termite infested (Plot 1)											
95	95	60	100	100	60	100	100	95	100	85	28 (S3csf) a
100	95	100	100	100	60	100	100	95	100	100	54 (S2s) p
Termite infested (Plot 2)											
95	95	60	100	100	60	100	100	95	100	85	28 (S3csf) a
100	95	100	100	100	60	100	100	95	100	100	54 (S2s) p
Non-infested (Plot 3)											
95	95	60	100	100	60	100	100	95	100	95	29 (S3csf) a
100	95	100	100	100	60	100	100	95	100	100	54 (S2s) p

SI* = suitability index, a = actual suitability when characteristic c was limiting, p = potential suitability when characteristic c was corrected with irrigation, Suitability index class rating, 75-100 = S1 (Highly suitable), 50-74 = S2 (Moderately suitable), 25-49 = S3 (Marginally suitable), <25 = NS (Non Suitable)

type (LUT). The determination of the suitability of a piece of land for a specified use involves the matching of land use requirement with the supply of these requirements by the land (Bennema *et al.*, 1981). Land suitability evaluation was done as described by Oluwatosin and Ogunkunle (1992).

Application of rating: The Land Characteristics (LC) for each plot shown in Table 1 were matched with Land Use Requirements (LUR) for cassava, maize, millet and guinea corn (Table 2-5, respectively) derived from rating. Suitability class was derived from matching using parametric approach (Sys, 1985).

Land indices were calculated before converting them to suitability classes using the equation:

$$IS = A.\frac{B}{100}.\frac{C}{100}......\frac{n}{100}$$

Where,

IS = Index of suitability.
A = Index of the most limiting characteristic.
B = Index of topography.
C = Index of moisture availability.
n = Index of nth characteristics.

The Index of Suitability (IS) was then converted to suitability class using Sys (1985) Conversion table:

Index 75-100 = S1 (Highly suitable)
Index 50-75 = S2 (Moderately suitable)
Index 25-50 = S3 (Marginally suitable)
Index <25 = NS (Non Suitable)

RESULTS AND DISCUSSION

Suitability of the study area was assessed parametrically for cassava, maize, millet and guinea corn production. The suitability assessment considered both actual (present status) and potential suitability of the soil. Potential suitability looks at possible ways of amelioration especially if the present suitability rating was low. The parametric assessment of land suitability for crop production considers both environmental factors and soil characteristics utilizing climate, topography, drainage, soil physical properties and soil fertility as factors of evaluation (Sys, 1985; Oluwatosin and Ogunkunle, 1992).

The soil analytical and climatic parameters were used to assess the suitability of the termite infested and non-infect plots for maize, millet, guinea corn and cassava production through comparison with land utilization ratings. The suitability ratings of the plots were as shown in Table 2-5. It was observed that all the plots were not currently suitable for maize production except the non-infested at Kontagora that was marginally suitable (Table 2). All the plots were marginally uitable (S3) for millet and guinea corn production with the exception of non-infested plots that were potentially moderately suitable (S2) for millet production (Table 3 and 4). The results also showed that both termite-infested and non infested plots of the study area were marginally (S3) suitable for cassava production (actual) and potentially moderately suitable (S2) for cassava production (Table 5). These showed that termite infestation may have significant effect on the suitability of soils of the study area for crop production as moderately suitable class was recorded only on non-infested plots while the termite infested plots fall into lower classes of either non suitable or marginally suitable.

The major limitations that commonly affect the suitability of the plots were soil physical properties, which was as a result of dominantly coarse sandy texture of the soils. Another major constraint was the poor nutrient retention capacity of the soils that manifested in poor CEC of the soils. These constraints may be difficult to ameliorate, hence some of the soils had potential and actual suitability ratings to be the same or close to each other. It was only in cassava that climatic factor (duration of dry season) constituted a major constraint apart from texture. The low CEC could have been partly as a result of removal of organic matter, which is normally stored away as either body protoplasm, fungus comb or in mound construction and repairs, depriving the soil of the organic matter that would have enhanced the CEC, structure and fertility status of the soil.

Comparing the infested with non-infested plots, it was observed that the potential suitability of the non-infested was improved to moderately suitable from marginally suitable. This was an indication that the infestation could be a factor coupled with the fact that it was due to the low organic matter status of the infested soil. This is as a result of removal of organic matter from the soil fertility dynamics (Lavelle *et al*., 2001; Mora *et al*., 2003; Jouquet *et al*., 2005). This was because the organic matter content of the non-infested was higher than the observed in the infested plots, but also up to the critical level required for optimal crop production in savanna region (FAO, 1976). This corresponds with the reports that *Macrotermitinae nigeriensis* deplete soil organic matter that has been shown to be able to form organic matter-clay complex with increased CEC and ability to adsorb and make plant nutrients available. Potential suitability of the plots was found to be moderately suitable for cassava production in the non-infested. If the shortfall in moisture (water) supply from the rains will be supplied through irrigation and the organic matter situation improved with the supply of manure or organomineral fertilizer, then the soil could be marginally suitable for cassava production. Manure and organomineral fertilizer does not only improve the chemical fertility status of the soil but also raises the CEC and improves the soil structure, infiltration rate and water holding capacity of the soil. The major limitation that may not be easily improved in the soils is the texture that is dominantly sandy. Generally it could be imagined that the activities of termites could include the destruction of cassava cuttings as a factor in the reduction in productivity of cassava but Umeh *et al.* (1999) reported that adoption of proper cleaning of the farm reduces destruction as a result of the activities of termites as farms littered with farm waste has higher incidence of termite attack compared with those in which cultural practices ensured proper disposal of waste. Additionally utilization of vetivar grass in farms could help in keeping termites away and in organic matter build up.

REFERENCES

Anderson, J.M. and J.S.I. Ingram, 1993. Tropical Soil Biology and Fertility. A Handbook of Methods. 2nd Edn. CAB Int., pp: 221.

Baba, J.M., 1993. Niger State. Nigeria giant in the tropics, State survey. In: Udo, R.K. and A.B. Mamman (Eds). Heritage Edition. Gabumo Publishing Co. Ltd. Ikoyi, Lagos, Nigeria, 2: 329-346.

Bennema, J., H.F. Gelena and P. Laban, 1981. Principles, basic concepts and procedures in land evaluation considered from a forestry angle Laban, P. Procedure of Land Evaluation for forestry. Publication. 28, International Livestock Research Institute, Wageningen, pp: 181-202.

Day, P.R., 1953. Experimental confirmation by hydrometer theory. Soil Sci., 75: 181-186.

Dent, D. and A. Young, 1980. Soil Survey and land Evaluation. Georgia. Allum and Unwin. London. pp: 117.

Ekundayo, E.O. and V.O. Aghatise, 1997. Soil properties of termite mounds under different land use types in a typic paleudult of Midwestern Nigeria. Environ. Monitoring and Assessment, 45: 1-7.

FAO, 1976. A Framework for land evaluation. Soil Bulletin, 42. FAO. Rome, pp: 79.

FAO., 2006a. Guideline for Soil Description. 4th Edn. Rome.

FAO, 2006b. World Reference Base for Soil Resources. World Soil Resources Report No.103 FAO, Rome.

Jouquet, P., P. Barrë, M. Lepage and B. Velde, 2005. Impact of subterranean fungus-growing termites (Isoptera, Macrotermitinae) on chosen soil properties in West African savanna. Biol. Fert. Soils, 41: 365-370.

Lal, R., 1988. Effect of Macrofauna and soil priorities in tropical savanna. Agric. Ecosyst. Environ., 24: 101-106.

Lavelle, P., E. Barros, E. Blanchart, G. Brown, T. Desjardins, L. Mariani and J.P. Rossi, 2001. SOM management in the tropics: why feeding the soil macrofauna. Nutr. Cycl. Agroecosyst., 61: 53-61.

Lavelle, P., D. Bignell, M. Lepage, V. Wolters, P. Roger, P. Ineson, O.W. Heal and S. Dhillion, 1997. Soil Function in a changing World. The Role of Invertebrate Ecosystem Engineers. Eur. J. Soil Biol., 33 (4): 159-193.

Lobry de Bruyn, L.A. and A.J. Conacher, 1990. The role of termites and ants in soil modification: A review. Aus. J. Soil Res., 28: 55-93.

Mehlick, A., 1984. Mehlick 3 Soil Test Extractant: A Modification of Mehlick 2. Commun. Soil Sci. Plant Anal., 15: 1409-1416.

Mora, P., C. Seuge, J.L. Chotte and C. Rouland, 2003. Physicochemical typology of the biogenic structures of termites and earthworms: A comparative analysis. Biol. Fert. Soils, 37: 245-249.

Moss, R.P., 1957. Report on the classification of the soils found over sedimentary materials in Western Nigeria. Soil Survey Report. No. 67. Institute of Agricultural Research and Training, University of Ife, Ibadan.

Myles, T.G., 2002. Termite Biology, Termite Taxonomy, Termite Phylogeny, Beneficial uses of Termites and Distribution of Northern Termites. Urban Entomology Program. Faculty of Forestry, University of Toronto.

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

Nelson, D.W. and I.E. Sommer, 1982. Total Carbon, Organic Carbon and Organic Matter. Methods of Soil analysis. Part II. 2nd Edn. Page, A.I. Ed. Agronomy Monograph. No 9. Agronomy Society of America and Soil Science Society of America Madison W1, pp: 961-1010.

Obi, J.C., A.O. Ogunkunle and N.T. Meludu, 2007. Effect of Termite Infestation on the Farming System Characteristics of an Endemic Area in the Guinea Savanna Region of Nigeria. Am. Eurasian J. Scientific Res., 2 (2) (in Press).

Oluwatosin, G.A. and A.O. Ogunkunle, 1992. Suitability rating of some soils of the savanna zone of south western Nigeria for rain fed maize. Nig. J. Soil Sci., 10: 1-24.

Soil Survey Staff, 2006. Keys to soil taxonomy. 10th Edn. Washington, DC, Natural Resources Conservation Services, United States Department of Agriculture.

Sys, C., 1985. Land evaluation. International Training Centre for Postgraduate Soil Scientist Vol. I, II and III. State University of Ghent, Belgium.

Umeh, V.C., M.F. Ivbijaro and F.K. Ewete, 1999. Relationship between characteristics of *Macrotermes* sp. Mound material and their surrounding soils. Insect Sci. Appl., 19 (2/3): 251-255.

Vink, A.P.A., 1975. Land use: In Advancing Agriculture. Springer Verlag, Berlin. H. Fiderlberg, New York, pp: 344.