Agronomic Potential of the Artificial Termite Mound of Senoufo Poultry Farmers in Northern Côte d'Ivoire

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Abstract : ***The negative impacts of the misuse of chemical fertilizers force farmers to seek sustainable solutions in the management of soil fertility that respect the environment. Notwithstanding the termite damage to crops and in relation to a Senoufo practice of trapping termites for poultry, this study was undertaken to produce an organo-mineral fertilizer derived from the activity of termites of the genus Macroterms. The negative impacts associated with the misuse of chemical fertilizers force farmers to look for sustainable solutions for soil fertility that respect the environment. In connection with termite damage to crops and a Senoufo practice of trapping termites for poultry, this study was undertaken to produce an organo-mineral fertilizer derived from termite activity of the genus Macrotermes. The use of corn residues (stalks, stalks and stubble), dry cattle droppings and terracotta canaries (traps) has made it possible, through the trapping of termites, to obtain a product resulting from the digestion of these residues and the raising of fine soil. This substrate consists essentially of an organic fraction and a mineral fraction with a significantly improved texture compared to the control soil. Similarly, the chemical properties (CEC, exchangeable bases, organic matter) are improved compared to the control soil. It is an organo-mineral substance with fertilizing activity that can be used as a soil amendment in agriculture.***

Keywords: Termites, digestion of agricultural residues, mineral rise, fertilizer, Daloa

1. Introduction

Soil fertility and soil management are two essential aspects of crop production. In the production process, farmers use chemical fertilizers because of their rapid action, which unfortunately acidifies the soil. Aware of the age of agriculture, which is as old as the Neolithic, we are led to seek natural practical solutions in human practices. Indeed, African farmers have for a long time produced without chemical fertilizers because of practices that facilitate either the regeneration of the soil (fallows) or the advance made to the soil by amendments based on the use of animal manure. In this last range of fertilizer products, the remains of termite mounds are recovered with poultry droppings. It is this dynamic management of fertility management and, taking into account research on termites and their role in fertility management, that this study is initiated to confirm this role under controlled conditions.

Agriculture occupies a predominant place in the economy of Côte d'Ivoire. However, high pressure on land due to population growth and lack of arable land, soil degradation and low crop yields are forcing farmers to intensify farming[1] and[2]. Indeed, fallow land, which for a long time remained a natural means of restoring soil fertility once practiced in this agriculture, is almost non-existent nowadays as soil fertility is depleted year after year. This is especially the case in the savannah region where farmers have long lived from subsistence farming through local practices based on the use of manure made from bovine, ovine and poultry manure, spread at the end of the dry season in the fields and which are however, neglected by farmers. In this context, savannah soils are depleted of organic matter and especially nitrogen when we know that farmers use very few mineral fertilizers[3] because of their high cost and low availability, which make them almost inaccessible to many[3]. Moreover, the use of these fertilizers, without soil analysis, has a negative impact on soil fertility (soil acidification) and the health of populations[4]. In a concern for sustainability and environmental protection, the above constraints are now prompting agricultural research to reconsider the place of organic resources and their management in agricultural techniques[5]. Indeed, the sustainable improvement of agricultural production requires a better understanding of the spatio-temporal dynamics of organic matter in soils. The use of local organic fertilizers such as droppings from hens of different ages[6] has been considered as a sustainable alternative for improving production with less impact on the soil and the consumer. Manure based on local organic products is a good traditional organic amendment. However, the decline in livestock production, the increase in cultivated land and the need for organic matter mean that manure production (about 300 Mt.yr-1)[7] is insufficient to restore and maintain the humic stock of cultivated silty soils[8]. Research into other organic and biological sources has made it possible to demonstrate the role of various organisms (earthworms, iules, termites, etc.), which are true bio-indicators of soil quality and in soil fertility without always seeking the means and factors that could allow its agricultural application [9]. The Isoptera are very abundant in the soils of tropical regions where they build often spectacular structures. Among termites, the social organization and involvement of their activities in the establishment of cover areas have been widely studied[10]. This work has mainly concerned the large termite termite mounds of Macrotermes spp. and has become a reference among the processes of the establishment of surface formations[11]. However, one of the characteristics that has not been sufficiently highlighted in Cubiterms is their ability to concentrate clays in their nests, even where the substrate does not seem a priori suitable[11]. As a result, very little work has been done to study termites outside their termite mounds, while African peoples have been developing captive development strategies for these arthropods for many years to develop poultry farming. This study is being initiated to confirm the role of termites in captivity in soil fertility for agronomic enhancement.

2. Materials and methods

2.1 Materials

2.1.1 Location of the study area

The study was carried out on the experimental site of the Jean Lorougnon Guédé University of Daloa (06° 54′ 33.1″ north latitude and a longitude 06° 26′ 06.4″ west) in the Upper Sassandra region of central-western Côte d'Ivoire (Figure 1). The climatic regime of this region is that of the Guinean domain characterized by an equatorial and sub-equatorial regime with two rainfall maxima[12]. However, in recent years, there has been a change in these characteristics [6]. The experimental field was characterized by grass dominance with few woody species. The soils in the study area are mostly typical ferralitic soils with high organic matter content

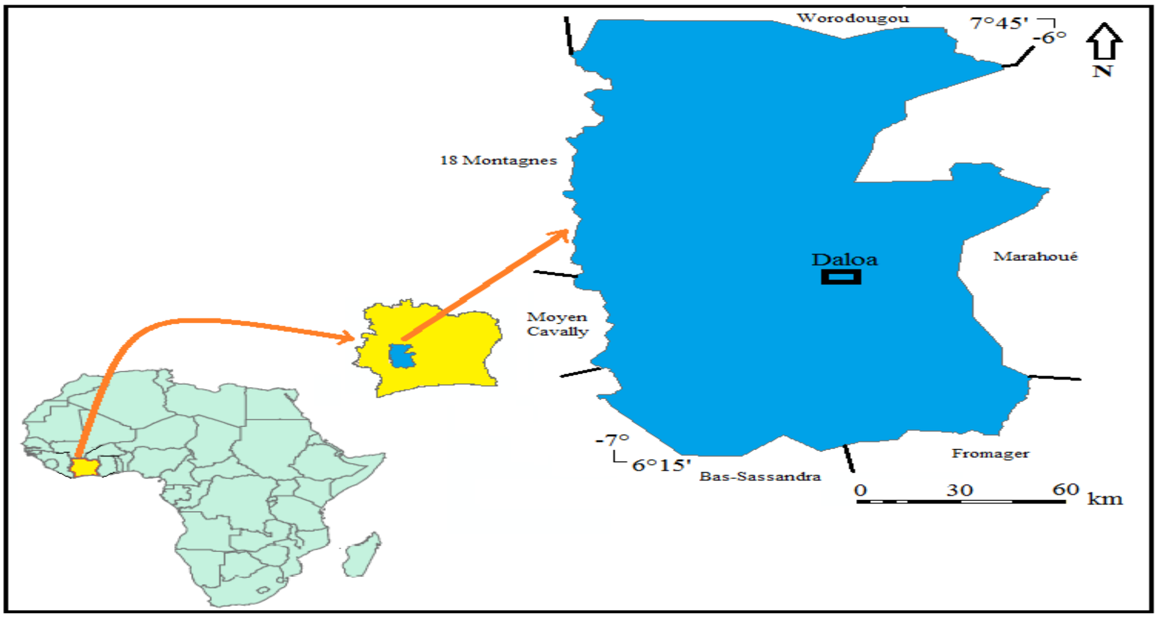

Figure 1: Location of the study area

2.1.2 Materials

The material used in this study consisted of biological and technical materials, the names and uses of which are summarized in table I.

Table I: Equipment used in termite trapping

Material		Use
Bait (corn crop residues and cattle droppings)		Dry plant and animal material used as bait to trap termites
Terracotta canary		Serve as a container for the bait and define the cockpit, the artificial termite mound
Termites		Biological material of the study
2-4 mm mesh sieve		Screening of crops to separate useful and coarse fractions

2.2 Methods

2.2.1 Principle of the artificial termite hill

The principle of the artificial termite mound is to trap termites in a gambit called*"Doungbône"* (in Senoufo language) or artificial termite mound made by Senoufo poultry farmers in northern Côte d'Ivoire. This principle is based on the ability of termites to digest agricultural residues. This practice, which valorizes agricultural residues, offers termites a collection of agricultural waste (corn stubble, millet, mango kernels, beef droppings, etc.) crumbled and moistened. This set is placed in terracotta pots and transported to the fields in the termite living space where evidence of their presence, such as soil veneers on plant and/or animal residues, is identified (Figure 2). At these locations, the traps loaded with the bait (Figure 3) are closed under a shade box. Termites colonize it, degrade the material for their needs and bring up the soil in, creating the artificial termite mound (Figure 4). Traps are generally harvested every two (2) to three (3) days around 10 a.m. to collect as many termites as possible before the effect of temperature causes them to return to the ground.

Figure 2: Indicators of the presence of termites in an area

Figure 3: Artificial termite hill before its implantation

Figure 4: Artificial termite mound

2.2.2 Experimental design

The collection design was an isosceles rectangular triangle with 50 x 50 x 70.7 m sides and an area of 1/8 ha (Figure 5). This triangle has been subdivided into 6 smaller rectangular isosceles triangles. Soil pits were opened at the corners of the triangles. In total, seven (7) traps rated P1 to P7 were implanted in the device. Each trap was a repetition and the individual harvests represented the treatments.

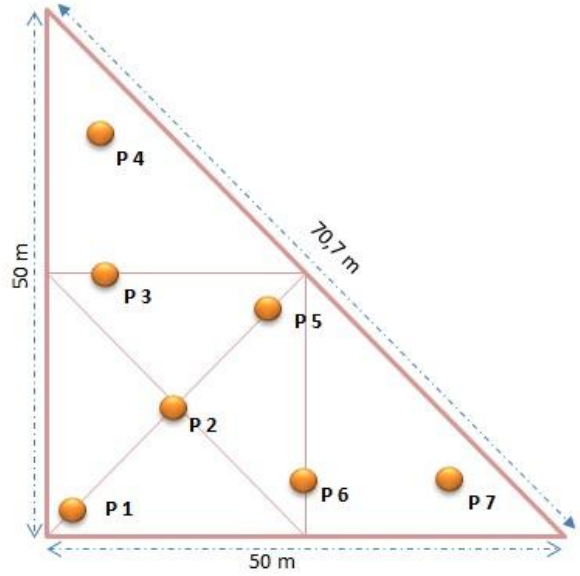

Figure 5: Design for collecting termites and waste products

2.2.3 Harvest of termites and waste product collection

The traps were harvested and processed every three (03) days to feed the chickens. The trap is turned over to discover its contents and harvested. During this harvest, the masses of the loaded trap and then the mass of the entire detritus removed from the trap were determined. The entire harvest was trapped to dry (Figure 6a) and then sieved to separate undigested residues (refusal) and possible EGs (coarse elements) from the soil, the fine fraction and the sieve (Figure 6b). This sieve was the organo-mineral waste product (Figure 6c) that was subjected to physico-chemical analyses to determine its quality.

2.2.4 Production parameters

The essential parameters that were collected in the organo-mineral material production activity were the dry mass of the crop, coarse element levels (EG), moisture, digestion and organo-mineral material composition elements, rejection and sieve quantity (Table 2).

2.2.5 Data analysis

An analysis of variance was performed on the averages obtained and a T test was used to rank them. At the end of a preliminary analysis giving no trap effect, a second analysis was carried out on the basis of composites of the products from the traps, free digestion and control soil.

3. Results

3.1 Production of TWP

3.1.1 Tailings digestion and mineral rising

The digestion rate of agricultural residues by termites varied significantly from trap to trap ($p = 0.0051$; $\alpha < 0.05$) and from crop to crop ($p < 0.0001$; $\alpha < 0.05$) (Figure 6). Residue digestion was different from trap to trap and low, varying between 3.03 $g.day^{-1}$; at 7.62 $g.day^{-1}$. In terms of mineral rising, trap production was also different from one trap to another.

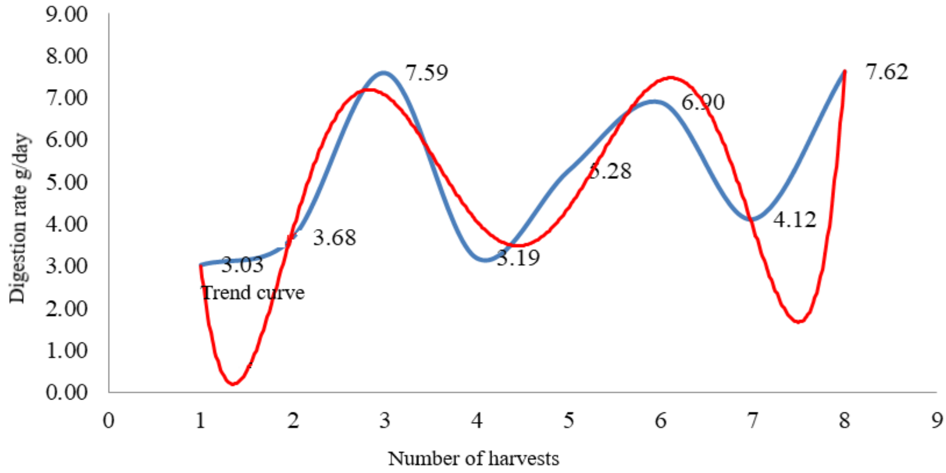

Figure 6 : Variation in digestion and rising rates in traps

Soil component rising

Termite wasterising varied from trap to trap and harvest to harvest ($p<0.0001$; $\alpha = 0.05$) (Figure 7). The fine soilrising, initially low (6.31 $g.day^{-1}$), gradually increased to reach maximum values between 12 and 15.92 $g.day^{-1}$ where it evolved according to a sinusoidal pace (Figure 7). Following the order of harvests, tailings digestion also followed a sinusoidal evolution with a parallel pace under the curve of the mineral ascent. While initially the two activities evolved in the opposite direction, they seemed synchronous beyond the 5th harvest.

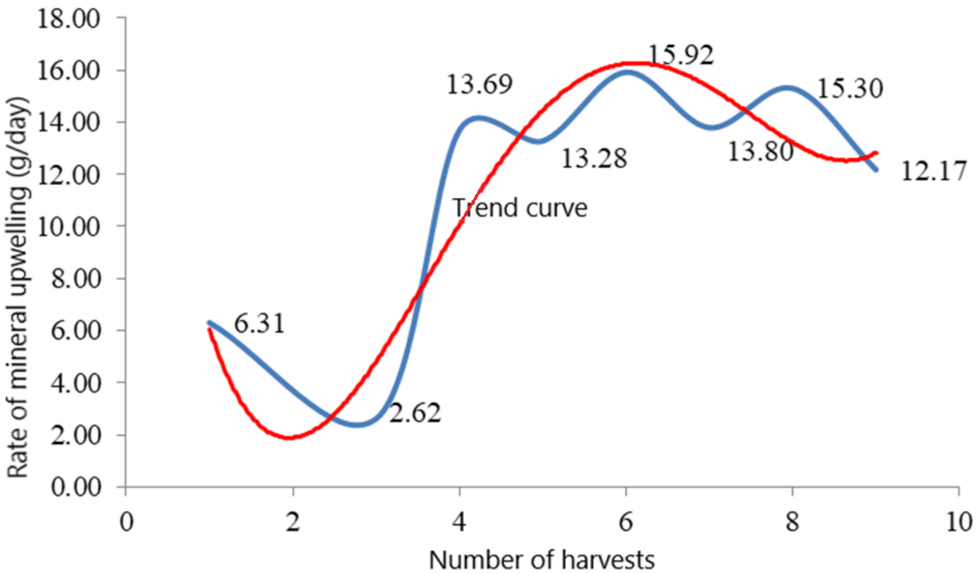

Figure 7 : Variation in digestion and uptake rates according to crops

Obtaining the termites waste product (TWP)

Figure 8: Obtaining the organo-mineral waste product from termites (TWP)

3.2 Species of termites in the traps

The main species responsible for activity in traps during identification was the *Bellicosus Macroterms*. This species corresponds to the species harvested for poultry in Senoufo countries.

3.3 Amount of fresh and dry harvest

According to the ANOVA carried out, the quantity of fresh harvest varied with the number of harvests ($p < 0.0001$, $\alpha = 0.05$) with $r^2 = 0.89$. However, it is independent of the amount of residue from the traps. After drying, the mass of the dry gross residual product also varied significantly with the number of harvests ($p < 0.0001$) with $r^2 = 0.75$.

3.4. Rate of coarse elements

Termites have been responsible for the dynamics of various soil components including coarse elements larger than 2 mm. However, the EG rate in the crops was not influenced by the trap ($p = 0.18$) or the number of crops ($p = 0.09$).

However, the moisture content of the residues and the environment varied according to the number of harvests ($p = 0.0021$) with $r^2 = 0.49$. However, it remained similar from one trap to another.

3.5. Digestion rate, refusal and residual product amount

Termites digest between 3.18 and 16.5 $g.day^{-1}$ (table II). The digestion rate was influenced by the location of the trap ($p = 0.0051$; $\alpha = 0.05$) and highly modifiable depending on the crop ($p < 0.0001$; $\alpha = 0.05$). The amount of refusal varied greatly with the harvest ($p < 0.0001$; $\alpha = 0.05$) without influence of the trap ($p = 0.30$; $\alpha = 0.05$). The development of the organo-mineral waste product by termites was influenced by the trap ($p = 0.0003$; $\alpha = 0.05$) and the number of harvests ($p < 0.0001$; $\alpha = 0.05$).

Table II: Some parameters measured and calculated by harvest

N° of Harv.	Charge (g)	Dry Weight (g)	% Coarse Elements	Humid (%)	Digestion ($g.j^{-1}$)	Refusal (g)	Sieve (g)	Rising (%)
1	802.77^{d}	1126.77^{b}	2.96^{a}	22.18^{c}	3.18^{c}	573.70^{a}	536.31^{bc}	7.45^{bc}
2	601.23^{a}	690.14^{a}	2.40^{a}	30.25^{a}	16.50^{a}	575.04^{a}	135.65^{c}	5.88^{c}
3	1002.57^{b}	1699.14^{b}	5.43^{a}	22.10^{bac}	9.24^{b}	337.00^{cb}	986.00^{a}	13.69^{a}
4	1075.71^{cbd}	1709.14^{a}	6.14^{a}	26.03^{bac}	10.84^{b}	295.57^{cb}	956.29^{ba}	13.28^{ba}
5	1020.29^{b}	1872.57^{a}	5.14^{a}	22.30^{c}	10.04^{b}	297.57^{cb}	1146.57^{a}	15.92^{a}
6	1007.14^{cbd}	1876.71^{a}	4.57^{a}	24.64^{bc}	8.21^{b}	416.00^{b}	993.29^{a}	13.80^{a}
7	1047.57^{cb}	1796.00^{a}	1.86^{a}	20.59^{c}	10.13^{b}	318.00^{cb}	1101.86^{a}	15.30^{a}
8	809.43^{cd}	1611.86^{a}	1.29^{a}	29.54^{ba}	8.62^{b}	260.57^{c}	876.43^{ba}	12.17^{ba}
CV	11.02	21.02	103	18.53	15.2	21.02	32.84	32.8
LSD	198.29	560.64	5.70	6.69	2.87	133.65	497.54	6.91
Pstar	**	**	ns	*	**	**	**	**

In the same column, the values followed by the same letters are not significantly different. * Significant effect at the threshold α=5%; **: Significant effect at the threshold α=1%.

3.5.1 Quality of the organo-mineral waste product

Granulometry of termite waste product (TWP)

At the physical level, only the soil texture was studied by carrying out the granulometry because the harvesting method destructured the rising. The results of this analysis are presented in Table III below.

The soil at the experimental site was sandy, characterized by an abundance of fine sand (74.4%) and poor in fine elements, clay (A) + silt (L), representing only 25.6%. ANOVA revealed a significant difference ($p = 0.0452$; $\alpha = 0.05$) in A+L and Sand content. Termite activity contributed to the development of an organo-mineral waste product with an improved texture compared to the control soil within a period of three (3) to fifteen (15) days by raising fine elements (A+L) at the surface. This effect was evident when the residues were digested in the open air with a 43.2% improvement in the A+L rate compared to the control soil. When termites were active in the artificial termite mound, they improved the A+L content by 49.3 to 87.7% compared to the control soil. Isolated harvests improved the A+L content by more than 100% (harvest #2 of trap 1 contributed 161%) to a silty-clay texture. The T-test made it possible to distinguish substrates into three (3) classes according to A+L content.

Table III: Physical characteristics of the soil and waste products

Récolte	%A	%L	A+L	%S	pH	%C	C/N	MO	Nt	Pass	CEC	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}
Piège 1	21.8a	17.9b	39.7a	60.2b	6.2a	2.7a	11.1a	4.6a	0.2a	103.2a	12.6c	1.7a	1.4a	0.24a	0.70a
Piège 2	21.0a	27.1a	48.1a	51.8b	6.2ba	1.9b	11.2a	3.3b	0.1cb	78.0b	12.8cb	1.2cb	0.9d	0.24a	0.51b
Piège 3	19.8a	18.4b	38.2ba	61.7ba	6.0b	1.8b	12.2a	3.1b	0.1cd	69.7b	14.0b	1.1c	0.7e	0.20a	0.50b
Hors Piège	22.5a	14.2b	36.7ba	63.3ba	6.2ba	2.3a	11.8a	4.0a	0.2b	56.6b	16.8a	1.4b	1.2b	0.18a	0.47b
Sol Témoin	7.0b	18.6ba	25.6b	74.3a	6.2a	1.3c	11.2a	2.3c	0.1d	60.0b	8.4d	1.2c	1.1c	0.06b	0.10c
CV	32.93	23.86	19.37	11.72	1.43	10.12	6.83	10.15	11.41	18.03	5.52	9.35	4.87	21.78	11.46
LSD	11.43	8.66	13.75	13.75	0.17	0.39	1.49	0.67	0.04	24.96	1.35	0.24	0.10	0.08	0.10
Pstar	ns	ns	*	*	ns	**	ns	**	**	*	**	*	**	*	**

In the same column, the values followed by the same letters are not significantly different. * Significant effect at the threshold α=5%; ** : Significant effect at the threshold α=1%. A: clay ; L : silt ; S : sand ; pH : hydrogen potential ; C : carbon : carbon ; C /N : carbon nitrogen ratio ; Nt : total nitrogen ; MO : organic matter ; P.ass : assimilable phosphorus ; CEC : cation exchange capacity ; Ca^{2+} : calcium ; Mg^{2+} : magnesium ; Na+ : sodium : potassium.

Chemical properties of the soil

The chemical properties of the soils studied that have been determined in the laboratory are summarized in Table III. The chemical properties taken into account in this analysis are pH; organic matter; the absorbent complex and the elements carbon (C), nitrogen (N) and phosphorus (P).

a) pH

The pH of the control soil (pH = 6.26) and that of the various waste products have remained relatively close (Table III). Termite activity remained almost unaffected by pH variation.

b) Organic matter, carbon (C) and nitrogen (N)

The initial level of OM in the soil was moderately good (2.33%) (Table III). This rate was raised by termite activity, placing waste products in the good soil range with values of

4.07% and 4.67% for free and captive termite activity respectively. This maximum improvement during the first harvest gradually decreased to reach the lowest value at the third harvest with a rate still higher in the PROMs compared to the control soil. Total carbon and nitrogen production rates (Table III) were weakly influenced by the environment and harvest frequency (p = 0.02 and p = 0.01 for and N) in the same trap. Indeed, organic matter production varied according to crops (p = 0.02, α = 0.05) within the same trap in relation (r2 = 0.93) to carbon and total nitrogen production.

The nitrogen content varied slightly despite termite activity. This rate at the limit just sufficient for the control soil (0.12%) is significantly improved by termite activity and reaches a maximum of 0.26% in captivity. In relation to the mineralization of organic matter, this rate had the best values also for first harvests. Through their digestion action, termites have helped to increase the soil's organic carbon and total nitrogen content. The C/N ratio, an indicator of the mineralization rate, was variable within normal limits (9 - 12) both on the ground and in the residual products of termite activity. The T-Test defined three clear classes of substrate in relation to carbon and organic matter content (ppds = 0.54).

c) Phosphorus (P)

Termite activity has reduced phosphorus levels in the soil from poor (56 to 60) to good availability (103% and 126.5%) (Tables III). The action of termites did not significantly affect the phosphorus content of the sieve, despite a change in this content compared to the control soil regardless of the trap (p = 0.55, α = 0.05) and the number of harvests (p = 0.11, α = 0.05). Phosphorus levels were average in the control soil and the variation induced by termite activity was low although this activity seems to induce its production in the soil.

d) Cation exchange capacity

The quality of the absorbent complex was improved by termites in captivity (12.61 ≤ CEC ≤ 14.08) or in free activity (CEC = 16.80 cmol.kg-1) in the soil depending on the crop (P = <0.0001: α = 0.05) while it remained ineffective in the same trap (p = 0.27 ; r2 = 0.98). This improvement in CEC was due to an overall improvement in the absorbent complex (Ca^{2+}, Mg^{2+} and K+ and Na+).

The T test separated the sieves into three (3) distinct classes (Table III): (i) the organo-mineral product derived from the activity of free termites in nature, (ii) the control soil and (iii) an intermediate class for PROM derived from traps. In captivity, termites had less effect on CEC compared to free activity.

Calcium, magnesium and potassium production varied with harvest (P = <0.001 : α = 0.05) but without environmental impact. In all cases, the first harvest offered the best production of calcium, magnesium and potassium.

4. Discussion

4.1 Termites activities

The results showed the degradation of agricultural residues by termites and the rise of fine mineral constituents from the soil to form a substrate with organic and mineral composition. The presence of a fine fraction consisting of sand, silt and clay is justified by the construction of the nest as the termites feed on the agricultural residues available in the termite mound, confirming the work of [13], which pointed out that the termite digs a cavity which it immediately fills with soil soaked in saliva or better and more often and more often with clay, set in depth when it is fed. Both digestion and rising were initially low due to a gradual colonization of the new environment (trap) and the gradual habituation to the residues, which will last about 9 to 12 days, i.e. 3 to 4 harvests. The waiting time between two harvests was three (3) days and the time between peaks ranged from three to nine days for digestion when it was three (3) days for the mineral run.

The sinusoidal evolution leads to periods of work and rest for termites. But it can also correspond to a renewal of the termite working class because each harvest constituted a loss of non-renewed individuals. The rate of degradation would be related to the number of active individuals. This evolution could not be maintained in regular increase because of the harvest which took away each time the trapped individuals justifying the waiting period between two periods of high activity.

These arthropods have thus contributed to the reworking of the soil, everything that contributes to its dynamics [14]. Thus, the role played by termites in the genesis of tropical soils concerns both humification according to the work of [15] and soil morphology according to [16]. Termites are positioned as privileged actors in pedogenesis by positively modifying the physical quality of the soil in accordance with [17]. If human action has so far had no effect on the textural composition of the soil, termites, through their capacity as building snoopers, explore depth horizons and transport fine fractions; clay, silt and even fine sand to the surface horizons. This ability can be exploited by humans to effectively influence the texture of some sandy soils to improve their agronomic abilities. Indeed, [13] already established that in coastal areas, by drawing from depth horizons, termites increased the clay content of sandy soils. In addition, building materials are collected at different depths from the soil and include saliva used as cement and stercoral substances [18], certainly contributing to enriching the waste product. In addition, the action of termites could help to improve locally the retention capacity and permeability of the soil through the galleries. Indeed, the humification and development of galleries not only facilitate the circulation of water, but also its retention by improving the organic matter content of the soil [18].

These substances, which mainly play a role as colloids in the soil, will lead to an improvement in the structure of the termite residue structure following the textural improvement. Indeed, the captive life of termites developed by man favours the production of organo-mineral waste products dominated by the earth and termite excreta.

4.2 Fertilizing value of the PROM

The termites identified on the study plot and trapped in the traps were mainly constituted by the species Macrotermes bellicosus. The main activities highlighted in this study are the digestion of crop residues[19] and the rising of the mineral fraction composed of clay, sand and silt. The action of termites has allowed the soil to be enriched with fine soil, especially clay. This enrichment in fine elements is confirmed by[20] This result is consistent with that of[21], who argue that termite mounds are generally constructed from clay materials, fine sands collected at depth and brought to the surface, and plant debris is incorporated. The variation in digestion rate and ascent rate from one trap to another is related to the dynamics of termites, which determine the biological activity of the trap and especially the humidity conditions inside the trap. These two termite activities seem to control each other. Indeed, a negative correlation is established between digestion and mineral rising so that the high digestion activity is coupled with a low rising and vice versa.

The negative correlation between clay and sand on the one hand and silt and sand on the other hand, reflects the relative importance of each fraction for termites and that clay and silt are collected in the same way. In addition, the good correlation of A+L with CEC confirms the fertilizing capacity of these two portions with larger specific surfaces. [22] noted that in the semi-arid savannahs of Burkina Faso, termite activity in the presence of herbaceous and woody litter contributed to improved humification. This leadsto a chemical enrichment of the soils associated with these two phenomena of plant decomposition and mineral rising in accordance with[20]. By incorporating the residual product from their activity, termites have modified the granulometric composition of the soil by increasing the content of fine elements in the soil.

The evaluation of the physical, chemical and biological parameters of the soil makes it possible to understand how it works and how it evolves. The MO rate of termite waste products is generally higher than that of the control soil as observed [23] and [24] with Cubitermes materials. This result is confirmed by [25] and [26] who have shown that termite activity increases the organic matter content in the soil. Recycling this organic matter is an important parameter in the biological functioning of the soil. The increase in its content is related to the digestion of residues by termites and the excreta they deposit in the trap. Indeed, termites host bacteria which, through their different metabolic activities, produce carbon compounds not assimilated by them. These insoluble compounds bind to colloids and soil minerals to form humus that improves soil fertility [27]. They thus contribute to the decomposition of organic matter and the evolution of the physico-chemical structure of soils [24] and [28].

CEC is higher in the organo-mineral waste product than in the control soil. This enrichment is not only due to the fine fraction (A+L), but also to the organic matter that is the largest contributor to the CEC according to the work of [24]. This result is also consistent with those of [29]. In addition, [30] placed more emphasis on the accumulation of magnesium (Mg^{2+}) and calcium (Ca^{2+}).

Thus, according to [20], the increase in cation exchange capacity in termite mounds appears to be mainly due to the increase in clay content, while enrichment in exchangeable bases (Ca, Mg, K, Na) and phosphorus comes from the incorporation of faeces into the mound.

The phosphorus enrichment of soils resulting from termite activity is related to the dynamics of fine soil that passes through the termite digestive tract. Indeed, the intestinal transit of fine soil favours the release of phosphorus, which is released by termite excreta [30].

These physico-chemical characteristics of termite mounds have a positive effect on the fertility of tropical soils, particularly those poor in phosphorus and exchangeable bases. However, due to the low spatial distribution of humivorous termite mounds, these changes are limited, giving meaning to research on termite breeding strategies.

5. Conclusion and prospects

Ivorian agriculture, which is subject to fertility loss, is a source of many agricultural by-products whose valorization can contribute to reducing this loss of soil productivity and revitalizing various agricultural sectors. The recovery of these by-products cannot be achieved without the intervention of organizations involved in the genesis and evolution of soils. The study carried out made it possible to determine the fertility potential of residual products resulting from the activity of termites in captivity, confirming their role in soil fertility.

Termites improve the texture of the soil on the surface by enriching it with their excreta rich in organic matter and fine constituents (A+L) which promote a cation exchange capacity. Termites can thus contribute to the restoration of degraded soils by digesting agricultural by-products such as maize and millet stubble, cocoa shelling by-products that clog plantations.

6. Future Scope

The application of the termite activity product as a soil amendment can be used to determine fertility parameters. However, the major constraints to the use of TWP remain the control of these social insects as well as the quantities of crop residues necessary to produce the applicable doses. These constraints could be overcome by improving and disseminating the artificial termite mound technology developed during this study to reduce the damage caused by these arthropods, clean up the environment and manage soil fertility in a sustainable way.

7. Acknowledgment

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