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Influence of Non-incineration System on Soil Carbon/Nitrogen Ratio Values of Yakonde (Y2) Series under Cassava Cultivation in Yangambi, D.R. Congo

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Abstract: *The objective pursued in this research was to assess the potential of cassava cultivation in the non-incineration of cut plant biomass in the management of the stock of organic carbon and its main component in the soil, namely its C/N ratio. . To do this, five cassava cultivars have been introduced including: Obama, M'vuazi, Disanka, Zizila and Sansi. These five cultivars were planted in forest fallow in plots each measuring 0.48ha and repeated four times on the Yakonde series (Y2) on the Isalowe plateau in Yangambi. These plots were developed in non-incineration of biomass and from where 108 disturbed soil samples were taken in two groups, one of 54 samples at one month and the other of 54 samples at six months. culture in soil slices 0-20 and 20-40cm deep. These 108 samples made it possible to evaluate the stock of organic matter (M.O.S), total organic carbon (TOC), total organic nitrogen of the soil in order to determine the values of the carbon/nitrogen ratio at one and six months of age of cultivation of five varieties of cassava. M.O.S under the varieties Disanka (21.2±1.0%), Obama (19.6±0.7%) and Sansi (19.5±2.1%) at six months of age in the 0 range -20cm. While under Obama and Disanka, they were lower and respectively 6.1±1.3% and 7.0±2.9% in the 0-20cm age group at one month. The highest average soil TOC values were observed at six months of age under the Disanka (12.3±0.6%), Obama (11.6±0.7%) and Sansi (11. 3±1.3%) in the 0-20cm range; while the weakest were at one month of age under the varieties Obama (3.5 ± 0.8%) and M'vuazi (4.1 ± 1.7%) in the 20-40cm range. The average values of soil Nt contents which vary from 0.4±0.0 to 1.0±0.0% at the surface and from 0.4±0.1 to 0.9±0.4% at depth under the five varieties of cassava were found to be numerically superior to those of the soil under the old secondary forest in the two slices of soil studied (respectively by 0.5±0.1% and 0.2±0.1%). For the two slices of soil studied, the highest values in Nt of the soil (0.9±0.1% and 1.0±0.0% for the slice of 020cm; 0.9±0.4% and 0.9±0.1% for the 20-40cm slice) are observed at six months of age respectively under the Sansi and Disanka varieties. As for the C/N ratio, it decreases with the depth of the soil, except for the Zizila and Disanka varieties at one month of age. The highest mean values are observed under Sansi (12.4±2.8) at one month of age and under Disanka (12.3±0.3) at six months of age in the 0-20cm range; the weakest are under Obama (7.7±7) at one month and under Zizila (7.5±0.6) at six months of age in the 20-40cm range. In fact, the highest mean value of the C/N ratio remains that of the control forest taken as the reference forest.*

Keywords: *influence; shifting cultivation; no incineration; cassava cultivation; soil C/N ratio; Yakonde series*

I. Introduction

The roving agriculture on the giblets-burnt lands as practiced traditionally in Yangambi is today prone to numerous critiques following the ecological mutations observed in this region and more especially inside the Reserve of the Biosphere of Yangambi (RBY) (Kombele F, 2004, Alongo and Litucha, 2007, Motondo, 2010, Kombele M, 2017et al.,).

Indeed, he/it is attested that, facing the demographic growth in full flight in the region of variable Yangambi of 76 habitants/Km2 in 1962 to 132 habitants/Km2 in 2009 and that

leads the increase of the needs in surface agricultural of the populations and the shortening of the length of the fallow, the roving agriculture practice on the giblets-burnt lands is there with the practice of the "Zongisa" the main reason of the fragmentation of the forest landscapes and the deterioration increased of the soil properties (Kombele M, 2017).

In addition, fire is the main instrument used in this shape of agriculture and has the disadvantage to decrease the quantity of the organic matter already weak of the tropical soils (Of Leenheer and al. 1952; Van Wambeke and al. 1954-1957; Kombele BF, 2004).

In the lasting agriculture, idea-strength is that soil as substratum is disturbed least possible and kept covered so that the carbon is drawn of the atmosphere and is stocked in soil via vegetation or the culture setting up. Besides, the management of matter suitable of the biomass to the surface of soil and in soil returned the extensive agriculture more productive and lasting, especially in the sub-Saharan region as Yangambi, since the unique source of elements nourishing of soils dominant ferrallitiques remained the content in organic matter of soil (Kombele BFS, 2004 and Kombele ATMS, 2015).

It is in this optics that this survey initiated and whose object is to be able to test the effects of the no incineration practice and the ecological role of the cassava culture on the dynamics of the carbon and the organic nitrogen of soil to the scale of the cassava fields in the Isalowe tray of Yangambi in RDC.

The present research matches the vision of research with regard to the alternatives adapted to the socio-economic and ecological conditions of the ecosystems of the tropical regions, as pursued by the department of Soil and Water in the Faculty institute of the Agronomic sciences of Yangambi (IFA-Yangambi).

II. Review of Literature

2.1 Environment

This research has been led in the region of Yangambi, situated to 100km to the west of the city of Kisangani (Of Heinzelin, 1952), in the territory of Isangi, province of the Tshopo. Van Wambeke and liben (1957) and Crabbe (1965) confirmed later than Yangambi is situated on the right strand of the Congo stream, in the part Northeast of the Congolese central pan. His/her/its geographical coordinates are: O° 49' North latitude and 24° 29' longitude is, to a middle altitude of 470m.

Soil having served to the application of different treatments is an oxisol of the Yakonde set (Y2) according to the classification of the INERA (National Institute for the survey and research Agronomic, in RDC).

2.2 Material

The material having served to the withdrawal of the pedological samples on land in Yangambi was constituted of the tools following: a machete for the opening of the land, a spade for the digging of the profiles, a knife for the withdrawal of the soil samples, a metric ribbon for the measure of the withdrawal depths, of the cylinders of Koppecky for the withdrawal of the no burning samples, of the book, laths, pens and papers, of the sachets for the transportation and the conservation of the samples.

To the laboratory in Kisangani, the used material counted a balance of precision for weighed them, a steam room for the drying of the samples, a rule stepped up for the measures on the cylinders of Koppecky, a desiccator to lower to dry the temperature of the samples after steaming and crucibles carrying the samples of soil during the steaming. The samples of soil appropriated in the slices of 0-20 and 20-40cm of depth in the pits dug in the different

parcels of the experimental field of cassava in the Yakonde set in Yangambi and under the surrounding vegetation have been dried, crumbled, sifted on a sifter of 2mm and bagged; conditioned thus, they served to the dosage of the total organic matter of soil, to the determination of the total organic carbon of soil, Nt of soil and the worth C/N report.

III. Research Methods

An old secondary forest and a grassy fallow constituted the previous cultivations of the experimental site. These two types of plant cover were used for the non-incineration installation of the experimental field consisting of several cassava plots. The cassava cultivars used: Disanka, Obama, Zizila, M'vuazi and Sansi) also served as the soil-applied treatments of the Yakonde series (Y2). And the different treatments applied were: T0: old non-incinerated secondary forest, surrounding vegetation; T1: Zizila variety cassava plot; T2: cassava plot of the M'vuazi variety; T3: Cassava plot of the Sansi variety; T4: cassava plot of the Obama variety and finally T5: cassava plot of the Disanka variety.

3.1 Layout of Plots and Taking of Samples

The six treatments together constituted twenty-four elongated plots of 50m x 16m (i.e. 800m2 or 0.08ha each) separated in all directions by alleys 2m wide. It is an overall area of 314m x 74m, i.e. an area of 23236m2 (i.e. 2.3236ha). A block comprising six treatments (plots) was 4,800m2 large (i.e. 0.48ha) and was repeated four times in space. In the center of each plot (under the cassava crop and the surrounding forest), a pit of 80cm x 80cm x 40cm oriented East-West was dug. The disturbed samples were taken using the knife by recovering a strip of soil of 0-20cm and 20-40 cm deep for the analyzes of the total organic matter of the soil.

(M.O.S), total organic carbon (C.O.T) and total organic nitrogen (Nt) of the soil; a total of 108 soil samples (including 54 at one month of age and 54 others at six months of age) were taken from the experimental cassava field on the Isalowe plateau in the Yakonde series at Yangambi.

Soil samples were taken at one and six months of planting age for the different varieties of cassava. The age of one month corresponds to the beginning of the observations and that of six months, to the first cutting of the cassava cuttings in this experimental field where the observations should continue over several cropping seasons.

3.2 Laboratory Analysis

The loss-on-ignition method (Bell, quoted by Alongo, 2011) was used to test the evolution of organic matter in the soil. This method consists in placing in the oven at 600°C and for sixteen hours a sample of approximately 10 g of soil previously dried (Ws). The sample is placed in a desiccator for cooling. The ashes are then weighed at room temperature (Wc).

The proportion of organic matter in the soil corresponds to the ratio of the mass lost during the stay of the soil sample in the kiln to the total mass dried before incineration. The organic matter content of the soil expressed as a percentage is given by the formula: %MOS = [(Ws-Wc) /Ws] x 100, in addition, the soil content of total organic carbon (TOC) expressed as a percentage is calculated using the conservation factor 1.724 generally accepted in the literature for tropical soils.

%CO. T = (%M.O. S) / 1.724

For the total organic nitrogen of the soil: introduce into a Kjeldahl flask 5g of fine earth, 1 spoonful of the mixture of 5g CuSO4, 5g of K2SO4 and 0.25g of selenium then 20ml of concentrated H2SO4. Bring the flask under the attack ramp placed under a hood, heat first gently then gradually, increase the intensity of the heating until the contents of the flask are

brought to a boil when the mixture discolors and takes a slightly greenish tint, note the time and continue the attack for an hour.

Remove the flasks and allow to cool when the temperature of the mixture is close to that of the laboratory, pouring from time to time, in small quantities taking precautions, distilled water to dilute the suspension contained in the Kjeldahl flask; filter the contained Kjeldahl flask into another 10ml volumetric flask. Also rinse the Kjeldahl flask; collect the 10ml filtrate and put in a flask on the distillation apparatus; add 10ml of 40% NaOH; distil, collect the drops of NH3 in a vial containing 10ml H3BO3 2% + mixed indicator (0.5ml); titrate as the distillation proceeds with 0.1 N H2SO4.

IV. Results and Discussion

4.1 Results

a. Soil Organic Matter (%M.O. S) and Total Organic Carbon (%C.O. T)

The average M.O.S and C.O.T contents in the slices of 0 – 20 and 20 – 40cm of soil depth under the influence of the cassava crop installed by non-incineration of the fallow biomass and under a surrounding old secondary forest are shown in Figure 1and 2 below

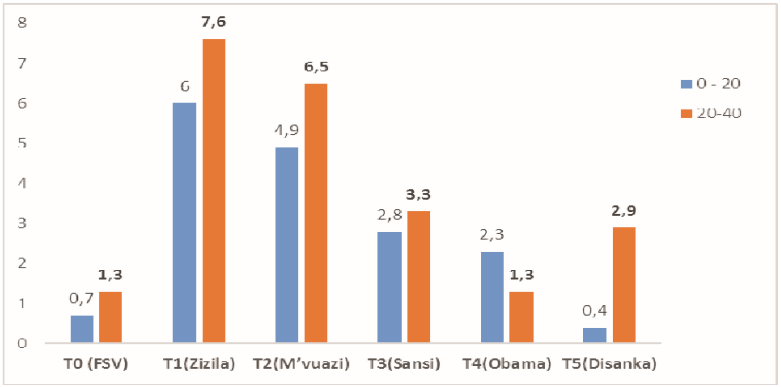

Figure 1. *Variation and Standard Deviations (%) M.O.S as a Function of Depth and Time in the Fallow Cassava Field and under the Control Forest at One Month of Age*

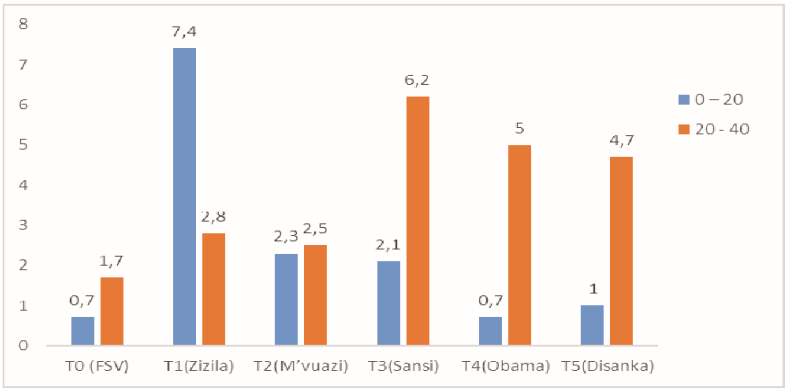

Figure 2. *Variation and Standard Deviations (%) M.O.S as a Function of Depth and Time in the Cassava Fallow Field and under the Control Forest at Six Months of Age*

It emerges from these two figures above that one month after installation of the cassava crop, the average M.O.S content varies from 11.7±0.4 to 18.4±2.8% in the soil of surface and from 6.1±1.3 to 11.5±6.5% in the 20 – 40cm range; i.e. 6.8±0.2 to 10.7±1.6% of organic carbon up to 20cm depth and 3.5±0.8 to 6.7±3.8% of soil organic carbon between 20 – 40cm deep. While under old surrounding secondary forest taken as a control, the average M.O.S

content reaches only 9.0 ± 0.7% or 5.3 ± 0.4% organic carbon in the surface soil (0 – 20cm) and barely 3.1±1.3% equivalent to 1.8±0.8 of organic carbon in the deep soil (20 – 40cm).

Although numerically we can observe a superiority of the values of the M.O.S and C.O.T contents of the soil under the cassava fields over that of the surrounding old secondary forest following the continuous effects of the decomposition of the non-incinerated biomass during the cultivation of fallow, the analysis of variance shows that there are no significant differences (p=0;9039 > 0.05) between the values of M.O.S and C.O.T observed in the soil of this agrosystem and the old secondary forest taken as a witness.

As for the evolution of these parameters after six months of exploitation of the soil by the cultivation of cassava, the results presented in these two tables show a gain in the contents of M.O.S and C.O.T in the soil under cassava cultivation compared to the control soil. and this gain varies according to the particularities of each of the varieties of cassava put in place. Indeed, although the Student's T test did not reveal any significant difference (p=0.07 >0.05) between the values of M.O.S and C.O.T observed at one and six months of installation of the cassava crop, it nevertheless emerges that a gain of at least 81.20% of M.O.S and C.O.T was observed under the Disanka variety, 21.29% under the M'vuazi variety, 17.36% under Obama, 6% under Sansi and 1.47% under Zizila while the control soil recorded a loss of M.O.S and C.O.T of about 6% between these two observation times.

This increase in the M.O.S in the soil under the crop reflects the effect of the stabilization of the humus formed following the gradual release of the carbon contained in the non-incinerated plant biomass. As for the loss of carbon or soil organic matter under the control forest, it may be due to disturbances of anthropic origin that these forest ecosystems undergo due to their proximity to dwellings.

The average Nt contents in the soil slices of 0 – 20 and 20 – 40cm depth in the soil under the influence of cassava cultivation and old secondary forest at the Yakonde series (Y2) at a and six months of age in Yangambi are shown in Figures 3 and 4 below:

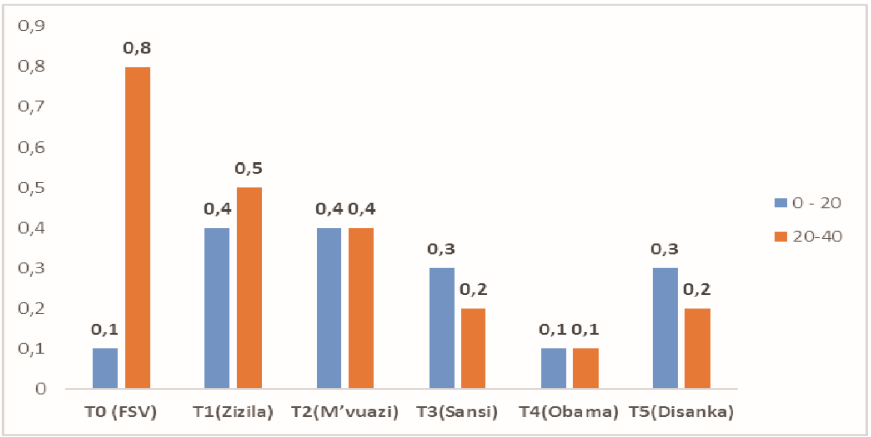

Figure 3. *Variation and Standard Deviations (%) Nt as a Function of Depth and Time in the Fallow Cassava Field and under the Control Forest at One Month of Age*

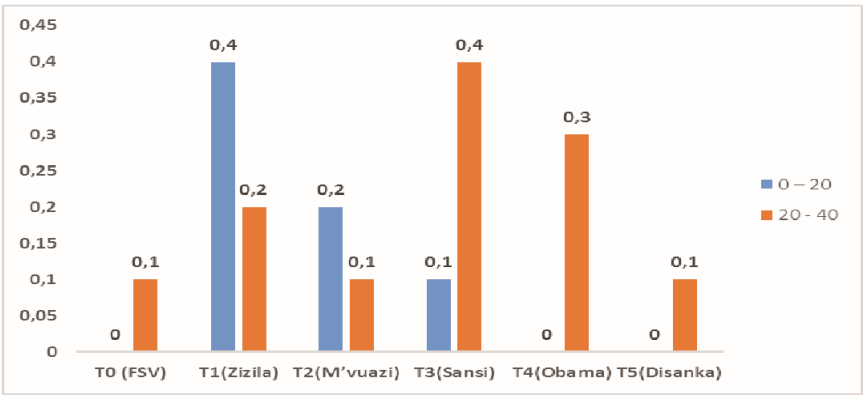

Figure 4. *Variation and Standard Deviations (%) Nt as a Function of Depth and Time in the Fallow Cassava Field and under the Control Forest at Six Months of Age*

The observation of the results as represented in Table 3 above shows that there is no significant variation in the average total nitrogen contents of the surface soil (0-20cm) between the two times of our observation (at one and six months of age of installation of the cassava crop), while slight variations are recorded in the depth slice. The ANOVA statistical test also reveals that there are no significant differences ($p=0.48 > 0.05$) between the values of total soil nitrogen content observed in these two ecosystems; the same observation was made regarding the comparison of nitrogen levels at one and six months after the cassava crop was established.

Considering the evolution of this element in the profile, we can see through these results that the total nitrogen content of the soil varies inversely with the depth of the soil. This confirms the purely organic origin of nitrogen in the soil.

b. Soil C/N Ratio

The average values of the C/N ratio in the slices of 0-20 and 20-40cm of soil depth under the influence of the cassava crop and the control forest of the experimental field installed in the Yakonde series (Y2) at a and six months of age are shown in Figures 5 and 6 below:

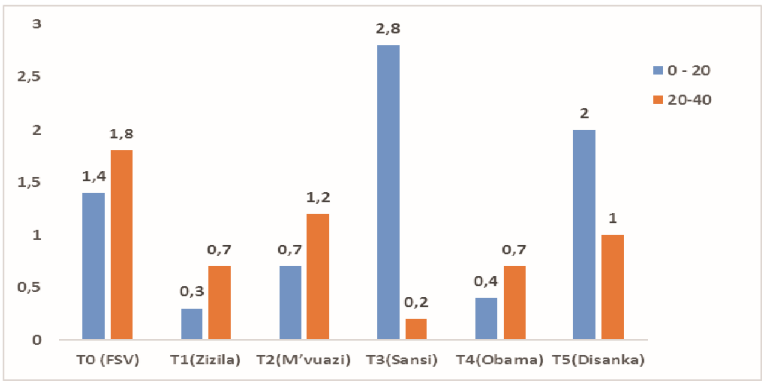

Figure 5. *Variation and Standard Deviations of the C/N Ratio as a Function of Depth and Time in the Fallow Cassava Field and under the Control Forest at one Month of Age*

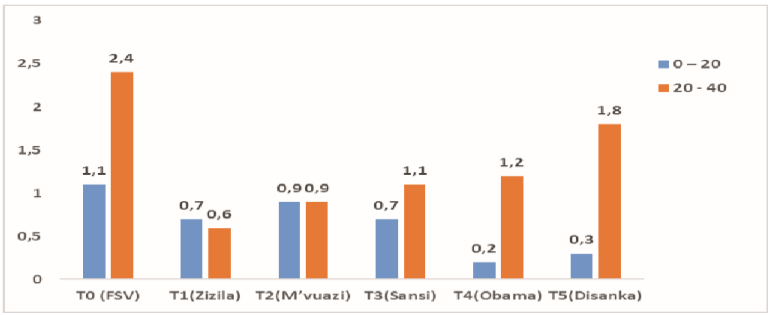

Figure 6. *Variation and Standard Deviations of the C/N Ratio as a Function of Depth and Time in the Fallow Cassava Field and under the Control Forest at Six Months of Age*

Figures 5 and 6 show that, in general, the average values of the C/N ratio in the soil vary from 7.1±2.0 to 12.4±2.8 at one month and from 7.5± 0.6 to 12.6±1.1 at six months of age. The highest values are observed in the surface soil compared to the deep soil, which then reflects the receptacle effect of the surface horizons benefiting from the decomposition products of the non-incinerated plant biomass at the soil surface.

The ANOVA statistical test to detect the influence of each cassava variety on the C/N ratio in the soil reveals that there is no significant difference ($p=0.06 > 0.05$) between the values of the C/N ratio observed under the five cultivated cassava varieties and even in the control soil. In all faith, these results have made it possible to highlight the potential of the practice of non-incineration on the dynamics of organic carbon in the soil. Indeed, it emerges here that this practice by making it possible to control the speed of decomposition of the non-incinerated biomass, essentially promotes humification than mineralization in the slices of soil studied.

The comparison of the carbon dynamics between the two sampling phases using the Student's T test revealed no significant difference between the values of the C/N ratio observed at one and six months of age of installation of the culture. cassava.

4.2 Discussion

The carbon contained in soil organic matter represents the majority of terrestrial carbon. It is the main indicator of soil quality for the physical, chemical and biological properties of the organic matter that contains it. Soil organic matter constitutes a real or potential reservoir (depending on the saturation rate) of nutrients in the soil by forming chelates therein, organic matter is capable of fixing and inhibiting undesirable compounds (pesticides, xenobiotics) or traces of acidifying mineral elements (Al, Fe, Mn) (Robert, 1996).

From a chemical point of view, the mineralization of soil organic matter releases fertilizing elements (such as N, S and P) which are associated with carbon in organic compounds. The recycling of these nutrients (N, P and S) by the gradual decomposition of non-incinerated plant residues is the main factor of sustainability in extensive agriculture (Mayuni Tokura et al., 2002).

The M.O.S content of soils or C.O.T is determined on a soil sample which passes through a sieve with 2 mm mesh and which brings together a set of very varied components. In the soil sample considered, the heterogeneity of the material and the interactions between the physical, chemical and biological processes that take place in the soil allow the fluctuation of the turnover of the different components of organic matter.

Most of the soil nitrogen reserve is in an organic form that cannot be assimilated by plants (except for the NH+ ion) either in fresh organic matter or in the form of humic compounds. However, the form directly assimilated by plants is mineral. It is therefore necessary for organic nitrogen to be mineralized in order to be assimilated by the roots of

plants in the soil. The nitrogen nutrition of plants is therefore closely related to the rate of mineralization of nitrogen contained in organic matter.

The decomposition of organic matter releases nitrogen stored in organic form and is one of the processes by which the soil can become enriched in nitrogen. During these processes, organic matter loses more carbon than nitrogen, a significant part of which is incorporated into the humus molecules. The C/N ratio of all the humus horizons reflects both a rapid evolution of the plant matter that has fallen to the ground, therefore a rapid return of nutrients to the soil and good possibilities for nitrogen supply by the plants. The values of the C/N ratio observed in this research generally fluctuate around the value of 12 at one and six months of age.

At this stage, the evolution of the values of the other parameters (total soil organic carbon and nitrogen), values from which those of the C/N ratio are determined, is only at the beginning. It is a question of the observations being continued over several agricultural campaigns (crop seasons) to judge the positive impact of the agricultural practice of non-incineration on the capture of carbon and its storage in the soil and, by extension, on the improvement of the physical-chemical and biological properties of ferralitic soils in the Yangambi region in particular and in the central Congolese basin in general.

V. Conclusion

Our research has set as its main objective the determination of the influence of cassava cultivation in a non-incineration system on the values of the C/N ratio of the soil in the Yakonde series (Y2) in Yangambi, DR Congo.

In the process of combating climate change and food insecurity in developing countries, certain cultural practices that capture carbon and store it in agricultural soils offer some of the most promising options for early and effective action. protective, effective and low cost (FAO 2009).

The ultimate goal in this research was to seek to highlight the ecological role of cassava cultivation installed in non-incineration of biomass on the management of the stock of organic carbon in the soil. Five exotic cultivars of cassava, namely Disanka, Obama, Zizila, M'vuazi and Sansi, were installed in a forest fallow enhanced by the practice of non-incineration of biomass and adjoined to a secondary forest taken as forest. reference and located in the Yakonde series (Y2) on the Isalowe plateau in Yangambi.

Thus, a block of 0.4 ha was delimited and subdivided into 24 plots in which 24 soil pits were installed and where 108 soil samples were taken, including 54 at one month and 54 others at six months of age of the cassava crop. in soil slices 0-20 and 20-40cm deep.

The results of the laboratory analyze showed the following trends:

- Compared to the organic matter content of the soil (MOS in %), the highest average value is observed under the Disanka variety (21.2±1.0) followed by the Obama variety with (19.6±0 .7) and Sansi (19.5±2.1). The average soil organic matter content observed under the Zizila and M'vuazi varieties is low compared to the other cassava varieties. The same trend was also observed for soil total organic carbon (TOC), since the latter is the emanation of soil organic matter. However, the ANOVA test at the 5% threshold did not reveal any significant differences between the MOS and TOC values observed both under the cassava crop and under the surrounding vegetation, i.e. an old forest. secondary.
- Regarding the total soil nitrogen (%), the high average values of nitrogen were observed under the varieties Disanka (1.0±0.0), Obama (1.0±0.0) and M'vuazi (0.9±0.2), all at surface level in the 0-20cm soil slice, while the lowest mean values are observed under the Zizila variety (0.8±0. 4) compared to other varieties. At depth (20-40cm) however, high average nitrogen values are observed under Sansi (0.9±0.4) and Disanka (0.9±0.1)

varieties. The ANOVA statistical test also reveals that there are no significant differences between the values of the total nitrogen content of the soil observed in these two ecosystems; the same observation was made with respect to the comparison of nitrogen levels at one and six months of installation age of the cassava crop.

- The highest value of the C/N ratio is at the level of the secondary forest taken as a control with an average value of 12.6 ± 1.1 at the surface between 10.8 ± 1.1 in depth under the Sansi variety after six months of age, the lowest average value being recorded under the Zizila variety with 10.4 ± 0.7 at the surface compared to the old secondary forest taken as a control and the lowest average value in depth is observed always under the same Zizila variety with 7.5±0.6 compared to the control forest. Thus, the only highest average value of the C/N ratio remains that of the control forest (12.6±1.1 quoted above). Nevertheless, in general, the average values of the C/N ratio decrease with depth in all the land uses studied.
- In addition, and in view of these results, non-incineration appears to be the most appropriate mode of soil reclamation with a view to the sustainable management of the stock of organic carbon in agrosystems in the tropics in general and in the region of Yangambi in particular. To be more complete, this study needs another direction of research, that of evaluating the synergy between the improvement of carbon stocks in the soil and the dynamics of its chemical, physical and biological fertility of the soil as well as its impact on agricultural production on the one hand and on the other hand, to widen the range of crops to assess the potentialities in order to increase the alternatives in the process of climate adaptation and mitigation in favor of security food in the most vulnerable areas such as tropical regions.

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