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Evolution of the Stock of Total Organic Carbon of Soil under the Culture of Cassava (Manihot Crantz esculenta) Installed in no Incineration in a Forest Fallow of the Yakonde Set (Y2) in Relation to the One of the Old Surrounding Secondary Forest of the Reserve of the Biosphere of Yangambi, R.D. Congo

Kombele M[1]*, Motondo M[2], Motosia A[3], Kolela B[4], Ugencan D[5], Lifafu H[6], Kakuni J[7], Kombele F[8], Kombele FM[8]

Option Soil and Water, Institute of Agronomic Sciences of Yangambi, Yangambi, Democratic Republic of the Congo, B.P Kisangani1232

Chemistry department and Agro-Food Industry, Institute of Agronomic Sciences of Yangambi, Yangambi, Democratic Republic of the Congo, B.P Kisangani 1232

Department of Zootechny, Institute of Agronomic Sciences of Yangambi, Yangambi, Democratic Republic of the Congo, B.P Kisangani, 1232

Institute of Building and Public Works, Kisangani B.P. 517 Democratic Republic of Congo

Email: jeanmarckombele@gmail.com

Abstract:

The objective pursued in this work is to try to put in evidence the ecological role of the cassava culture installed by no burning of the biomass on the management of the stock of total organic carbon of soil. Thus, an extent of 0,48 ha has been delimited and has been subdivided in 24 parcels in which were installed 24 pedological pits and where 48 samples of soil that means 24 samples no - unsettled and 24 unsettled others, were appropriated in the slices of 0-20 and 20-40 cm of depth these samples served for the determination of the total organic matter, the total organic carbon, the obvious density and of the stock in carbon of soil to seven months of age of the culture of five varieties of cassava. Five cultivars of cassava to know Disanka, Obama, Zizila, Me vuazi and Nsansi have been installed in a fallow forest enhancement by no - incineration of the biomass and an old secondary forest taken like reference, situated in the Yakonde set (Y2) in the Tray Isalowe in Yangambi, RD Congo. The results gotten during our experimentation reveals a relative an impact in the management of the stock of soil carbon by the different cultivars of cassava, with the exception of the Zizila varieties (T3) and Nsansi (T5) in relation to the old secondary forest taken like witness even though that, the analyses statistical attest non meaningful differences between the worth of carbon stock observed so much in soil under the different varieties of cassava that under the old secondary forest. Nevertheless, the no - incineration decorated the most suitable fashion of enhancement of soil in general in the optics of the lasting management of the stock of organic carbon of soil in the agrosystèmes of the tropics and of the region of Yangambi in particular.

Keywords:

stock of total organic carbon of soil; no burning; manihot esculenta and yakonde set

I. Introduction

The roving agriculture on the giblets burnt lands stays until our days the unique agricultural shape of use of the earth in sub-Saharan Africa and particularly, in R.D Congo where the dense forest occupies the quasi-total of the Congolese central pan.

In this practice, fire is the main instrument used by the African nomadic agriculturist in the south of the Sahara for not only to clear his/her/its sowing but also to bring to soil the ash coming from the incineration (Kombele, 2004). fire has, among others disadvantages, the one to burn the organic matter of soil also in place on several centimeters of depth, decreasing the quantity thus already weak of his/her/its organic matter (Of Leenheer and al. 1952; Van Wambeke and al. 1954-1957; Kombele, op cit). Indeed, if one considers the state greatly altered and poor in organic matter of soils dominant ferrallitiques in the tropical region, one will understand why the use of fire returns the less and less lasting agriculture in this region.

The idea in this survey is that soil is disturbed least possible, to keep it covered, to mix and to conduct the rotation of the cultures so that the carbon is drawn of the atmosphere and is stocked in soils and vegetation. Such FAO/IFAD practices come close to 90% of the agriculture potential in the reduction or the elimination of the emissions of gas to greenhouse effect in the atmosphere, (1999). Number of these activities can also reduce the deforestation and the deterioration of the forests because of the gains of productivity partners.

In the reserve of the biosphere of Yangambi, demography constantly increasing in the region obliges his/her/its population to practice a shape of agriculture nearly sedentary (convenient of the "Zongisa") where fire is used too much, the fallow is not respected anymore and no shape of organic fertilization is adopted. This new shape of use of the earth has for consequences the reduction of the organic matter of soil to every agricultural country and the drastic fall of the agricultural production. (Kombele, 2004).

The practice of the "Zongisa" exhausts the organic matter of soil so in place so that cassava considered like being the main culture of the region of Yangambi, product only of the numerous small not viable tubers even for the local consumption and soil becomes practically poor, the resumption of vegetation and the organic fertility of soil becoming problematic (FAO, 2003; Kombele, op cit).

It is in this optics that we wanted to test the practice of the no burning and the ecological role of the cassava culture on the storage of the organic carbon in soil to the scale of an agrosystem of the Yakonde set (Y2) in the reserve of the biosphere of Yangambi.

II. Review of Literature

2.1 Environment

Our survey is led in the region of Yangambi, situated to 100 km in the west of the city of Kisangani (Of Heinzelin, 1952), county seat of the 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 with as geographical coordinates: 0° 49' North latitude and 24° 29' longitude is, to a middle altitude of 470 meter.

2.2 Material

The material having served to the withdrawal of the pedological samples on the land in Yangambi was constituted of the following tools:

- A machete for the opening of the land and the preparation of the cassava cuttings, a spade and hoe for the digging of the profiles and the seedling of the cassava cuttings, a knife for the withdrawal of the samples disrupted of soil, A metric ribbon for the measure of the withdrawal depths, Of the cylinders of Koppecky for the withdrawal of the no unsettled samples, Of the notebooks, laths, pens and papers and of the sachets for the transportation and the conservation of the samples.

To the laboratory in Kisangani, the used material included a balance of precision for weighed them, a steam room for the drying of the no unsettled samples, having served to the analyses of the obvious density by calcination, a rule stepped up for the measures on the cylinders of Koppecky, a desiccator to lower to dry the temperature of the samples after the steaming and calcination, of the crucibles (molds) structural the samples of soil during the calcination.

III. Research Methods

An old secondary forest and a forest fallow constituted the previous cultural of the experimental site. The old secondary forest was dominated by *Musanga R. Br cecropioides., Ricinodendron heudelotii (Baill.)* Pierre & Heckel., *Pycnanthus Warb angolensis. Alstonia bonei Of Wild.,* etc. The forest fallow was dominated, as for it, by *Panicum maximum Jacq., Diodia Sw sarmentosa., Paspalum conjigatum*, etc. These two types of plant cover served to the installation in no burning of the experimental field constituted of several parcels of cassava. The cultivars of cassava used (Disanka, Obama, Zizila, M'vuazi and Nsansi) served as the different treatments applied to the soil of the Yakonde set (Y_2) in the Tray Isalowe of the IFA/Yangambi. The different treatments thus applied to soil were the next one:

1. T0: old secondary forest non incinerated: surrounding vegetation taken like witness,
2. T1: parcels of cassava of the Disanka variety, installed in the no burning forest fallow,
3. T2: parcels of cassava of the Obama variety, installed in the no burning forest fallow,
4. T3: parcels of cassava of the Zizila variety, installed in the no burning forest fallow,
5. T4: parcels of cassava of the variety M'vuazi, installed in the no burning forest fallow and
6. T5: parcels of cassava of the Nsansi variety, installed in the no burning forest fallow.

The experimental field of cassava had for measurements 314m X 74m, either a total surface of 2,3ha. This surface was subdivided in four blocks of six treatments each and was separated by alleys of 2m of width; the treatments were applied to soil in stretched out parcels of 50m x 16m, either a surface 0,08ha by experimental parcel. The methods of analysis to the laboratory and treatment of the analytic data have been made of the following manner:

3.1 Treatment of the Data and Calculation of the Studied Parameters

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

The method by loss to fire (Bell, mentioned by Alongo, 2011) was used to value the quantity and the evolution of the organic matter in soil. This method consists in placing to the oven to mitten in 600º C and during sixteen hours a sample of about 10 g of soil previously dried to 105°C (Ws). The sample is placed to the desiccator for his/her/its cooling. The ashes are weighed some following the ambient temperature (Wc). The proportion of organic matter of soil corresponds to the report of the mass lost at the time of the stay of the soil sample in the oven on the dried total mass and weighed before the incineration in the oven. The content of soil in organic matter expressed in percentage is given by the formula:

% M.O.S = [(Ws – Wc)/Ws] x 100

Otherwise, the content of soil in total organic carbon (C.O.T) expressed in percentage is calculated with the help of the factor of conversion 1,724 generally admitted in the literature for the tropical soils.

% C.O.T = (% M.O.S) /1,724

b. For the Obvious Density of Soil

With the help of the cylinders of Koppecky, the no unsettled pedological samples have been appropriated in the slices 0-20 and 20-40cm and it, in the three agrosystèmes (FS, JH and RF) of the Yakonde set (Y2). The obvious density, expressed in g/cm3, has been determined with the help of the weight of soil contained in the cylinder of Koppecky and his/her/its volume. The obvious density of soil was determined by the method to the cylinder of Koppecky:

$$Da \frac{m}{v} \rightarrow \quad m = Da \times V$$

c. For the Stock in Carbon of Soil

The quantity of determined carbon corresponds to the one being in the cylinder of Koppecky that must be driven vertically to soil within the slice to study. For the stock of total organic carbon of soil calculates itself by the following formula:

$$\text{Stock of carbon} = \frac{m \times \% COT}{100}$$

d. For the Statistical Treatment

The parameters of position and scattering to know, the average and the gap-type have been calculated in view of a better understanding of the results. In all calculations and statistical analyses, the software Excel has been used.

IV. Discussion

4.1 Matter Organic Total of Soil (M.O.S)

The results of the analysis of the soil samples by loss to fire (Bell, mentioned by Alongo, 2011) on the organic matter of soil (% M.O.S).

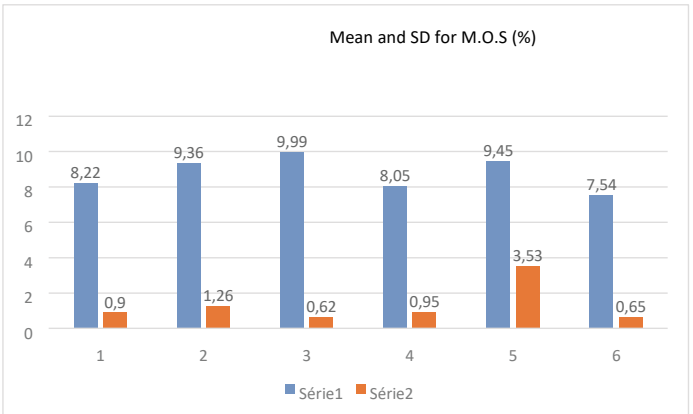

Figure 1. *Variations of the Middle Contents in M.O.S and SD (%)*

One notices that in the I face here high under the culture of Cassava, the contents in total organic matter of soil (M.O.S) observed vary between 6,15 (T4) and 15,35% (T4), with middle contents going from 7,54 ± 0,65 (T5) in 9,99 ± 0,62% (under T_2) of matter under the different cultures of cassava, whereas under the old surrounding secondary forest they vary between 6,9 and 9,2% with an average of 8,22 ± 0,9% (T_0) of total organic matter of soil (M.O.S).

Considering the middle values of contents in total organic matter of soil (M.O.S), the different varieties of cassava the impact differently. The most elevated impact is observed under the Nsansi variety (T_5) with the content in weakest organic matter of the soil (7,54 ± 0,65%), while the weakest impact is under the Obama variety (T_2) with the most elevated content in organic matter of soil (9,99 ± 0,62%).

This observation means that the Obama variety (T_2) possesses a maintenance elevated potential of the total organic matter of soil contrary to the Nsansi variety (T_5) that exhausts it more in spite of the practice of the biomass non incineration. Following their different types of weariness of the total organic matter of soil, the different varieties of cassava can be classified by order of size of the biggest to the weakest weariness observed of the total organic matter of the soil of the Yakonde set (Y_2) in Yangambi:

4.2 T_5 (Nsansi) > T_3 (Zizila) > T_1 (Disanka) > T_4 (M'vuazi) > T_2 (Obama)

In relation to the old secondary forest taken like witness (T0), two varieties of cassava present an impact of weariness of the total organic matter of the more elevated soil; it is about the Nsansi varieties (T5) with 7,54 ± 0,65% and Zizila (T3) with 8,05 ± 0,95% of total organic matter of soil. The three other varieties of cassava present each a positive impact on the total organic matter of soil in relation to the witness (T0); it is about the Disanka varieties (T1) with 9,36 ± 1,26%, Me vuazi (T4) with 9,45 ± 3,53% and Obama (T2) with 9,99 ± 0,62% of total organic matter of soil that the witness (T0) with 8,22 ± 0,90%. in relation to the old secondary forest taken like witness, the varieties of Cassava Obama (T2), Me vuazi (T4) and Disanka (T1) presented a relative improvement of the content in total organic matter of soil (M.O.S) that the Nsansi varieties (T5) and Zizila (T3).

This improvement of the content in total organic matter of soil (M.O.S) is owed to the practice of no burning used like fashion of soil preparation on the one hand and on the other hand, to the individual contributions in total organic matter of soil (M.O.S) of these three varieties of Cassava (abundant production of the leaves, better cover of soil, abandonment on the soil of a great deal of products of the decomposition, etc.).

As for the weak content of the total organic matter of soil (M.O.S) observed under the Zizilas entertainment and Nsansi in relation to the three other varieties of Cassava and also in relation to soil under the surrounding vegetation, she/it can explain herself/itself by the fact that, the quantity of biomass gangway and no burning was not uniform on all the experimental parcels, but also and especially by the fact that these two varieties would have a weak capacity of production in biomass to maintain the organic matter of soil.

The set of these observations already indicates a good management of the total organic matter of soil (M.O.S) by the no burning of the biomass during the preparation of the land. As one can notice it beyond the half of the vegetative cycle of the culture (to 7 months of age), the processes of decomposition of the biomass to soil are only to his/her/its beginning because the incorporation of the organic matter is there gradual.

4.3 Total Organic Carbon (C.O.T) of Soil

The contents in total organic carbon (C.O.T) in the slices of 0-20 and 20-40cm of soil depth and their variations under the five varieties of cassava in culture and under the old secondary forest are presented below in the figure 2.

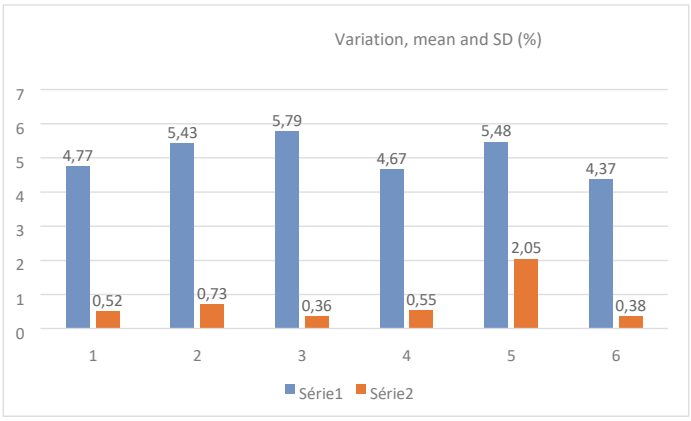

Figure 2. *Variations of the Middle Contents in C.O.T of Soil and Gaps-types (%)*

He/it is evident from this face 2 that the contents in total organic carbon (C.O.T) of soil follow the same pace that the total organic matter of soil (M.O.S) under the culture of cassava and under the old secondary forest. Thus, they vary between 3,57 (T4) and 8,90% (T4) with middle contents going from 4,37 ± 0,38 (T5) in 5,79 ± 0,36% (T2); whereas under the old secondary forest, they go from 4,00 (T0) to 5,34% (T0) with an average of 4,77 ± 0,52%. He/it goes in the same way with regard to the importance of the degree of weariness impact on the carbon.

Although some strong variabilities exist between the values of total organic carbon (C.O.T) observed under the different treatments, the middle values in C.O.T (%) in the figure 2 show a clean numeric superiority of the T2 treatments, T4 and T1 However in relation to those of T3 and T5, the results of the test of ANOVA showed non meaningful differences between the contents in total organic carbon (C.O.T) of soil observed under the culture of cassava and the one of soil under the old surrounding secondary forest.

4.4 Obvious Density of Soil (Da)

The values of the obvious density (Da) of soil in the slice of depth 0-40cm and their variations under the culture of cassava and the old secondary forest are consigned below on the figure 3:

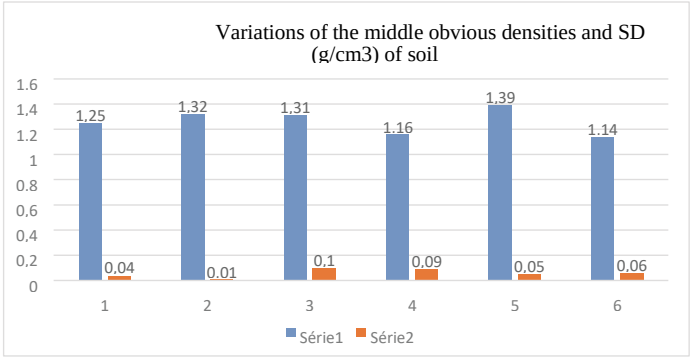

Figure 3. *Variations of the Middle Obvious Densities and SD (g/cm3) of Soil*

As one notices it above on the face 3, the values of the obvious density of soil (Da) observed under the different cultures of cassava vary 1,07 (T5) to 1,48 g/cm3 (T4) with middle values going from 1,14 ± 0,06 (T5) 1,39 ± 0,05 g/cm3 (T4); whereas those of the witness go from 1,21 to 1,31 g/cm3 with an average of 1,25 ± 0,04 g/cm3.

In relation to the witness (T0) with a middle value of obvious density of 1,25 ± 0,04 g/cm3, the varieties of Zizila cassava (T3 with middle Da = 1,16 ± 0,09 g/cm3) and Nsansi (T5 with middle Da = 1,14 ± 0,06 g/cm3) furnishing relatively well soil; they present weak values of obvious density in relation to the witness. As for the three other varieties, Obama (T2 with middle Da = 1,31 ± 0,10 g/cm3), Me vuazi (T4 with middle Da = 1,39 ± 0,05 g/cm3) and Disanka (T1 with middle Da = 1,32 ± 0,01 g/cm3), they show values relatively raised of the obvious density, what indicates a degree of elevated compaction of soil making difficult the blossoming of the roots tuberoses and the setting up of the big very interesting cassava tubers for the trade.

4.5 Stocks in Carbon of Soil

The middle results of calculation of the organic carbon stock and their variations observed in decides them of 0 - 20 and of 20-40cm of soil depth and expressed in term of quantity of carbon (g) in relation to the mass of soil appropriated are presented below on the figure 4:

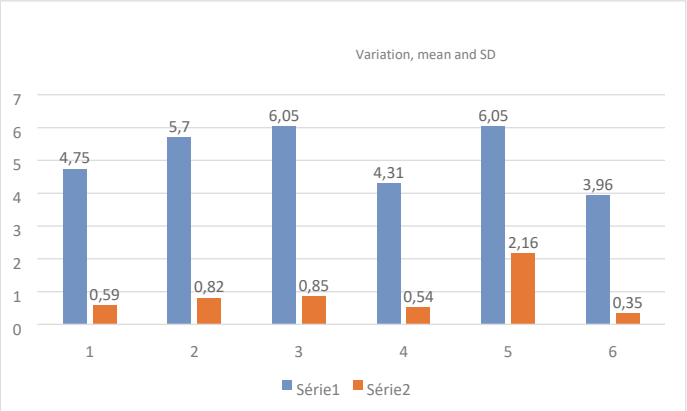

Figure 4. *Variations and Gaps-Types of The Stock Values (G) In Total Organic Carbon of Soil in Relation to The Mass of Soil Appropriated Under the Culture of Cassava by No Burning and Under the Old Secondary Forest of the Yakonde set (Y2) in Yangambi, RDC*

He/it is evident from the face 4 that the middle values in organic carbon stocked in the mass of soil appropriated under the culture of cassava vary between 4,84 ± 0,54 in 6,53 ± 2,3g of carbon, whereas soil under the old surrounding secondary forest stocks 4,99 ± 0,62g of carbon on average. As for the stock of carbon expressed by unit of surface, the values consigned in the picture 4 permit to indicate that the carbon stocked in soil under the culture of cassava by no burning oscillates on average between 22,53 ± 3,3 and 36,28 ± 12,5 t/ha, whereas a hectare of the old surrounding secondary forest stocks 24,99 ± on average 3,6 tons of carbon in the 40 cm of depth of the studied soil.

Considering the observed middle values, the stock of carbon in soil varies according to the cultivated and following varieties of cassava the type of soil occupation. One can notice however in this same picture 4 a relative improvement in the management of the stock of soil carbon by the different varieties of cassava, with the exception of the Zizila variety (T3) in relation to the old surrounding secondary forest.

Since the organic carbon storage in soil under the culture of cassava doesn't defer itself of carbon stock under the old surrounding secondary forest, we can affirm thus that the results of this work put on the one hand in evidence the effects positive of the practice of no burning of the biomass in the storage of soil carbon and on the other hand, the potentiality of the cassava culture to increase the stock of soil carbon.

4.6 Impacts of Anthropization (IA)

The different impacts of anthropization (IA) of the culture of cassava in relation to the witness and their variations on the M.O.S, the C.O.T, the Da and the stock of soil carbon are illustrated below by the figure 5.

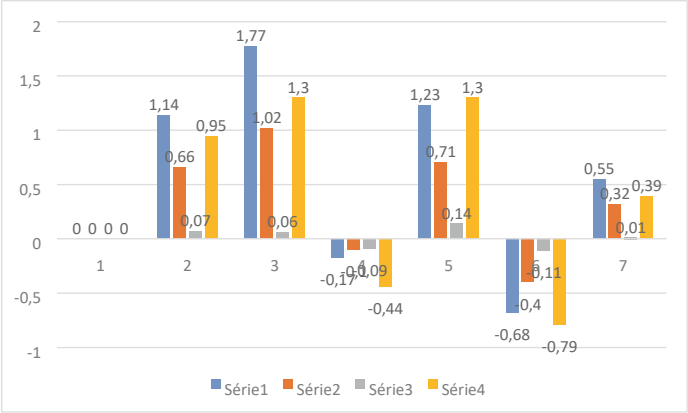

Figure 5. *Variations of the Values of Impacts of Anthropization (I.A) of the Culture of Cassava in Relation to the Witness on the M.O.S, the C.O.T, the Da and the Stock of Carbon of the soil of the Yakonde set (Y2) in Yangambi, RD Congo*

He/it is above evident from elements of the face 5 that a weak impact is positive, while an elevated impact is negative. The values gotten by the T1 treatments, T2 and T4 being positive in relation to the one of witness T0, these treatments improved the values of the parameters studied in soil, to know, therefore: the total organic matter (M.O.S), the total organic carbon (C.O.T), the obvious density (Da) and stock of carbon. Instead for example to decrease the content of soil in C.O.T, these treatments increased it in relation to the witness. However, the positive impact on the obvious density (Da) duct to the compaction of soil, what doesn't loosen soil in favor of the plants, roots and the tubers.

The values gotten by the T3 treatments and T4 being negative in relation to the one of witness T0, these treatments decreased the values of the parameters studied in soil, to know the M.O.S, the C.O.T, the Da and the stock in carbon, therefore quantitatively. Instead for example to increase the content of soil in total organic carbon of soil, these treatments rather drew in the stock of carbon beyond the existing quantity; these treatments encourage the broadcast of the carbon therefore in the atmosphere in spite of the agricultural practice of the no burning of the biomass cut. However, the reduction of the value of the Da by report indicates a furnishing in soil, improving the structure of the soil favorable to production of the tubers and plants roots thus.

4.7 Discussions

According to FAO, the changes of soil use are classified among the factors affecting short-term the content in carbon of soil (www.fao.org/waicent/agri, 2013). The management of soils and cultures can improve the time of resistance and a new storage of carbon considerably in soil, that that in accordance with the protocol of Kyoto, is worthwhile to be

considered (Buyanovshi and Wagner, 1998). In the setting of this work, the fragmentary scale of which a field of cassava cultivated by the method of no burning of the biomass to soil has been experimented.

The choice carried on this culture has been motivated by the fact that on the one hand, cassava constitutes the culture food crop important of the region of Yangambi where it is considered as the food hydrocarbon of basis; and on the other hand his/her/its capacity to adapt to the exhausted soils and unfit to receive other cultures (Raffaillac and Second, 1997), what makes of cassava a culture adapted to the processes of struggle against the climatic changes and the management of the carbon in the agrosystèmes.

The dosage of soil carbon can make itself by several methods, each with his/her/its advantages and inconveniences and according to the type of soil given. The choice been about the method of loss of weight, is often due to his/her/its weak demand in chemical non available to the local market of the region of Yangambi.

Although meaningful differences don't exist between the contents in total organic carbon (C.O.T), in total organic matter (M.O.S) and the stock of the carbon in soil under the culture of cassava and under the old surrounding secondary forest, the results of the analysis of the solum biodynamic reveal a certain accumulation of the quantities of the organic carbon under three varieties of cassava of which Obama, Me vuazi and Disanka in relation to the two other varieties of which Zizila and Nsansi and to soil under the old surrounding secondary forest.

The values of the content in total organic matter of soil (M.O.S) gotten in this survey (7,54% - 9,99%) are extensively superior to those found by Byamnobe (2012) in the same ecosystem that is the Yakonde set (Y_2). This difference would be bound to the dynamic state of individual soil in the space but also, because the previous survey has been led under a young fallow enhancement by incineration of the soil biomass.

As for the obvious density, the values gotten in this survey come closer of those gotten by Motondo (2010). Indeed, valuing the obvious density under the forest, the fallow and in the border forest fallow of the same set of soil, this author identified middle values of the active obvious density of 1,14 g/cm3 under the structures closed to 1,44 g/cm3 under open structures. The middle values of the obvious density of soil recorded during our survey (1,24 to 1,39 g/cm3) enroll in the fork of the cultivated and no cultivated tropical soils (Brady and al., 2002).

The values of the carbon stock gotten in this survey are extensively superior to those valued for the soils ferrallitiques (Post and al., 1982; Kimble and al., 1990). According to these authors, the Ferralsols can sequestrate until 5,7t/ha carbon between 0-30cm of depth and until 10,7t/ha between 0-100cm of depth.

However, these values are lower to the one gotten by Barthes and al., (1996) of the order of 50t/ha while analyzing the stock of carbon in the first 20 cm of one soil depth clayey ferralitic in central Africa. Indeed, the methods of dosage of carbon and the obvious density as well as the depth of the soil slice considered on the one hand and on the other hand the variability of the ecosystems would be to the basis of this diversity of the numbers. Besides, the quantities of carbon gotten in this survey translate the effect of the no incineration of the forest biomass cut at the time of the enhancement of soil in the first seven months of observation of the vegetative cycle of the studied varieties of cassava.

V. Conclusion

Soils are indispensable natural resources to the development, they are submitted to the outside actions (erosion, human action,) and interior (transformations physicochemical and biologic). Their constitution is slow and, to this title, they don't form a resource easily renewable. Yet, the history of the humanity is inseparably.

Bound to soils. Of agriculture to the exploitation of the mineral layers, soils constitute as many surroundings on which the man knew or no to adjust. His/her/its neighbor challenge is to keep this fragile wealth but indispensable.

The objective pursued in this work was to try to put in evidence the ecological role of the cassava culture installed by no incineration of the biomass on the management of the stock of organic carbon of soil. The results of the laboratory analyses showed the following tendencies:

- In relation to the content in total organic matter of soil (M.O.S), the most elevated value is observed under the Obama variety (9,99 ± 0,62%) consistent of M'vuazi (9,45 ± 3,53) and Dinsaka (9,36 ± 1,26). The middle contents in total organic matter of soil observed under the Zizila varieties and Nsansi are weak in relation to the old surrounding secondary forest taken like witness. The same tendency has also been observed for what is the total organic carbon (C.O.T) of soil since this last is the emanation of the total organic matter of soil.
- With regard to the obvious density of soil, the values raised of this pedological parameter have been observed under the Obama varieties, Me vuazi and Dinsaka whereas soil under Zizila and Nsansi is stayed piece of furniture. However, no tendency to the compactness of soil has been observed so much in soil under the different cultivars of cassava that under the adjacent forest. The middle values of the obvious density observed thus and variable between 1,14g/cm and 1,39g/cm don't present a meaningful difference between them.
- As for the stock in organic carbon of soil, quantities relatively raised of organic carbon have been valued so much in the 40cm of depth under the culture of cassava that under the adjacent forest. On average the carbon stocked in soil under the culture of cassava by no incineration has been estimated between 22,53 ± 3,3 t/ha and 36,28 ± 12,5 t/ha, whereas a hectare of the old surrounding secondary forest can stock 24,99 ± on average 3,6 tons of carbon in this 40 cm of soil depth.
- Besides and had look to these results, the no - incineration decorated the most suitable fashion of enhancement of soil in general in the optics of the lasting management of the organic carbon stock in the agrosystèmes of the tropics and of the region of Yangambi in particular.

To be more complete this survey has need of another way of research, the one to value the synergy so much between the improvement of the carbon stocks and the dynamics of fertility chemical, physical that biologic of soil as well as his/her/its impact on the agricultural production on the one hand and on the other hand to widen the range of culture to value the potentialities in order to increase the alternatives in the process of resilience and climatic attenuation and the food security in the most vulnerable zones; such is in general the case of the tropical regions and of the region of Yangambi in particular.

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