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EFFECT OF LAND USE ON MICROBIAL BIOMASS, CARBON AND NITROGEN FROM FALLOW ON SANDY-CLAY OF SAVANNA, CONGO

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ABSTRACT

The study was carried out at the Agricongo center situated at seventeen kilometers from Brazzaville. The aim of the present study was to assessment the effects of land use on chemical and microbiological characteristics of soil. Seven sites were chosen in the study area : S1 grass fallow with legume grown; S2 grass fallow; S3 fallow with cowpea residues incorporated into soil; S4 soybean cultivation; S5 grass fallow (7-year-old); S6 coffee plantation; S7 Orchard, in which composite soil samples were taken at 0-10 and 10-20 cm depth for determination of pH, total organic carbon, total nitrogen and microbial biomass. The results showed that pH was different between the depth and between the sites. highest total organic carbon content was recorded in site 1 (16.7%) and site S2 (12.4%) of 0-10 and 10-20 cm respectively. While lowest content was recorded in site 6 in 0-10 cm depth and in Site 7 in 10-20 cm depth. In 0-10 cm depth, total nitrogen was higher in S1 and lower total nitrogen was in S7. Total nitrogen recorded in 10-20 cm was higher in S6 and lower in S7. Microbial biomass carbon of 0-10 cm was higher in S1 with 309.5 µg / g soil and lower in S7 with 147.3 µg/g soil. In 10-20 cm depth, microbial biomass carbon was 271,93 µg/g soil in S7 and 109.3 µg/g soil in S3 and S4. Microbial biomass nitrogen was ranged between 6.48 and 69.12 µg /g soil and between 9.36 to 55.6 µg /g soil respectively in0-10 and 10-20cm depth. The results obtained in the present study showed that land use had high impact on the characteristics of soil mainly on pH, organic matter and microbial biomass.

KEYWORDS: Microbial biomass, organic matter, pH, soil, soil use.

1. INTRODUCTION

Organic matter and nitrogen are important components and ecological factors that strongly influence the functioning of soils under cultivation and hence productivity. Quantity and quality of organic matter have an impact on mineralization and availability of soil nitrogen. All methods and techniques for improving the efficiency of nitrogen utilization are built on the understanding of mineralization processes. To develop cultivation practices that maximize the efficiency of plant utilization of these two elements, it is necessary to be able to predict the quantities made available during mineralization. According to several authors, changes in soil use modify the physical properties of soils and the environment of micro-organisms, the distribution of nitrogen, carbon and nutrients (Larney and Bullock, 1994; 2011, Kleber Trabaquini et al., 2013). These changes affect the release and degradation of organic matter, thus contributing to the reduction of organic carbon and microbial biomass in uncultivated soils (De Luca and Keeney, 1994). Several studies have shown that reduced soil working methods increase the organic carbon content five years after planting, and also a small increase but significance of the total nitrogen content of the soil resulting from the selective nitrogen mineralization. The soil bacterial community can be manipulated by changes in soil use, but plowing is unlikely to lead to substantial loss of diversity or impairment of functions caused by bacteria such as decomposition, nutrient mineralization. Or the contributions of bacteria to the stabilization of soil structure. Plowing does not lead to strong divergences between communities but suggests relatively subtle changes in the structure rather than losses of large taxa. For many years, the Agricongo Center of Kombé has set up a system of crop rotation and soil fertilization. In order to maintain an acceptable level of organic matter, animal droppings, straw and legume haulm are used. Long grass fallows as well as leguminous-cereal or legume-cassava rotations are also used to restore the mineral fertility of soils. To our knowledge, no studies have yet been carried out on the nutrient balance of these soils. The objective of this study is to assessment the effect of land use soil characteristics mainly pH, organic matter and microbial biomass.

2. MATERIAL AND METHODS

2.1. Site Location and Description

The present study was carried out at the Agricongo center situated at seventeen kilometers from Brazzaville. Latitude geographic coordinates: 4° 10’00’’S, 15° 20’00’’E, above sea level 313m. The climate of the area is characterized by a rainy season from October to May with an average annual rainfall of 1200 mm and a dry season from June to September. The average annual temperature is 28° C. The soil is sandy-clay type. The native vegetation is a shrub savannah dominated by *Hymenocardia acida* Tull.

2.1.1. Sites choice

The study sites were chosen after a survey of all the plots of agrosystems of Agricongo Center. Seven sites were chosen according to the characteristics described in Table 1.

Table 1: Characteristics of sites.

Sites	Characteristics	Sites	Characteristics
S1	grass fallow with legume grown	S5	grass fallow (7-year-old)
S2	grass fallow	S6	coffee plantation
S3	fallow with cowpea residues incorporated into soil	S7	Orchard.
S4	soybean cultivation		

2.2.2. Sampling and preparation

In each site five composite soil samples were taken using a drill of 30x5 cm at depths 0-10 and 10-20 cm. The samples collected were cleared of roots and stones then they were air dried, grounded and sieved with a 2 mm sieve. The sieved soil was analysed for pH, total organic carbon, microbial biomass, total nitrogen and ammonium.

2.2. 3. Determination of pH

The pH of the soil samples were measured in water using the « OHAUS STARTER 3000 » pHmeter.

2.2.4. Determination of total Organic Carbon

The total organic carbon contents of soil samples were determined using the Walkley-Black wet oxidation method (Nelson et Sommers, 1982).

2.2.5. Determination of Total Nitrogen

Total nitrogen was determined using the Kjeldahl method described by Bremner and Mulvaney (1982).

2.2.6. Determination of ammonium

The ammoniacal nitrogen is extracted over 10 g of soil after stirring for 30 minutes in 50 ml of a 1N KCl solution on shaker. After decantation and filtration on filter paper, the assay was carried out on a 10 ml aliquot of supernatant supplemented with 1 ml of Nessler's reagent (Bremmer and Mulvaney, 1982).

2.2.7. Determination of microbial biomass

The microbial biomass is determined by the fumigation-extraction method (Jenkinson, et al., 1976; Jenkinson, et al., 1996; Goma-Tchimbakala, 2003). The fumigation was carried out under vacuum for 72 h with chloroform with ethanol free on 10 g of field moist soil. The soluble carbon was extracted with a 0.5N K_2SO_4 solution after stirring for 1h on shaker. Another 10 g were directly extracted in 0.5N K_2SO_4 solution for 1h on a shaker. The difference between the organic carbon in the extract of fumigated and the non-fumigated soil was multiplied by the conversion factors 0.45 and 0.54 respectively for microbial biomass C and N and N (Wu, et al., 1990; Joergensen and Mueller, 1996).

2.3.Statistical Analysis

Statistical analysis of the data: analysis of variance (ANOVA), comparison of means and plotting of the graphs were carried out using Statview 5 software. Means were separated using Student-Newman-Keuls test at 5% probality level (p<0.0.5)

3. RESULTS

3.1. Soil pH

The pH of the sites was lower in the two depth, 0-10cm and 10-20cm. ANOVA showed significantly differences between horizon and between the sites ($p < 0.0001$). In the 0-10cm horizon, pH was from 4.41 to 5.31 with highest pH recorded in site 1 (grass fallow with legume grown). Site 3 (fallow with cowpea residues incorporated into soil) and site 4 (soybean cultivation) have similar pH values. Site 5 (grass fallow7-year-old) has a higher pH than the other sites. However, this pH is lower than that of site 1 (Figure 1). On the other hand, in the 10-20 cm horizon the pH varies between 4.81 and 5.08. The pH of sites 2, 4 and 7 are significantly different ($p < 0.0034$, figure). All other sites have similar pH (Figure 1).

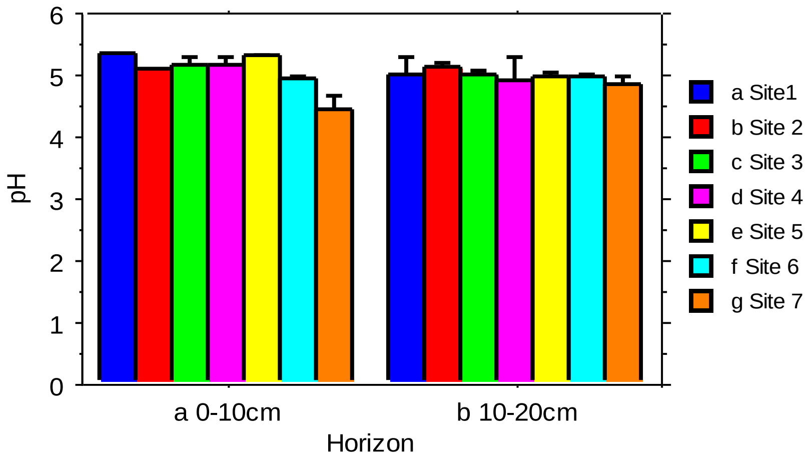

Figure 1: Effect of land use on soil pH.

3.2. Total organic carbon

Total organic carbon rate varies between 9.25‰ and 16.7‰ in the 0-10 cm horizon while it was between 5.56‰ and 12.47‰ in 10-20 cm horizon. ANOVA shows that there were significant differences of total organic carbon rate between the sites p <0.0001. In the 0-10 cm horizon, the highest total organic carbon content was recorded in site 1 while the content was similar between site S3 and S4 (Figure 2). In the 10-20 cm horizon, highest total organic carbon was founded in the site 2. Figure 2 shows that sites 3 and 6 had similar total organic carbon content.

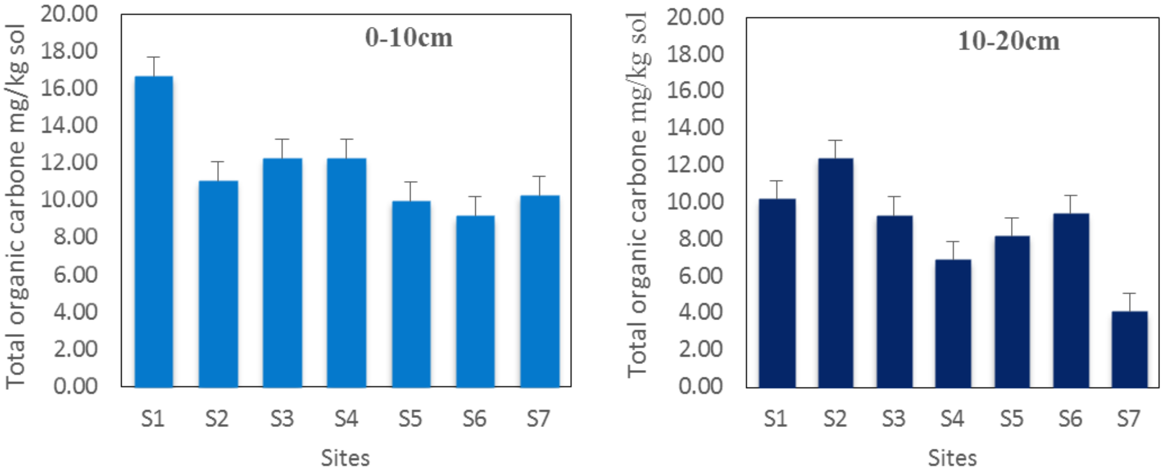

Figure 2: Effect of land use on total organic carbon.

3.3. Total Nitrogen

The total nitrogen rate was higher (2‰) in the 0-10 cm horizon of site 1 (grass fallow with legume grown) while the lowest rate (0.97‰) was recorded in the site 7 (orchard) (p <0.001).

Similar total nitrogen rate was noted in sites 2, 3 and 4 respectively (Figure 3). In the 10-20 cm horizon, total nitrogen rate varied from 0.76‰ to 1.36‰ with the highest rate in the site 6 (coffee plantation) and the lowest rate recorded in the site 3. On another hand similar total nitrogen rate was observed in site 1 and site 5 (Figure 3).

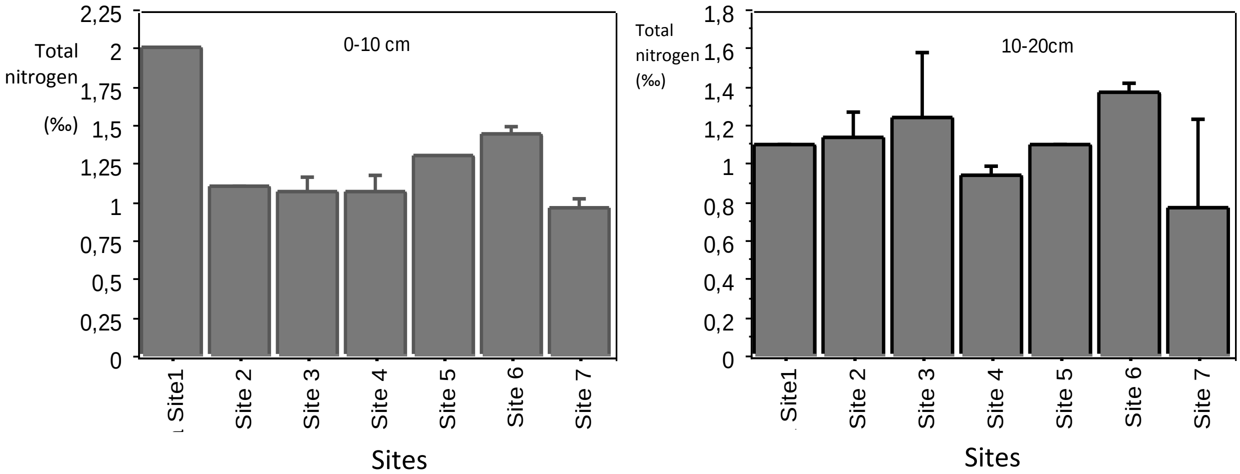

Figure 3: Effect of land use on total nitrogen.

3.4. Microbial biomass

The microbial biomass carbon varies between 147.3 and 309.50 µg /g soil (Figure 4, p < 0.0001). Microbial biomass carbon was significantly higher in site 1 than that other sites. Sites 3 (fallow with cowpea residues incorporated into soil) and 4 had similar microbial biomass. Site 7 (orchard) had a lower microbial biomass (Figure 4). In the 10-20 cm horizon, microbial biomass carbon varied from 109.35 to 271.95 µg/ g soil. In this horizon, highest biomass was recorded in site 7 while similar biomass was recorded in site 3 (fallow with cowpea residues incorporated into soil and site 4 (soybean cultivation). These sites had also lowest microbial biomass. Microbial biomass N varies between 6.48 and 69.12 µg /g soil in the 0-10cm horizon. ANOVA shows significant differences between sites (p <0.0001; Figure 4). Site S4 had significantly higher microbial biomass than that other sites. Lowest microbial biomass N was recorded in Site 7 (Orchard). Microbial biomass values ranged from 9.36 to 55.6 µg /g soil in the 10-20cm horizon. Sites showed significant difference (P <0.0001; Figure 4).

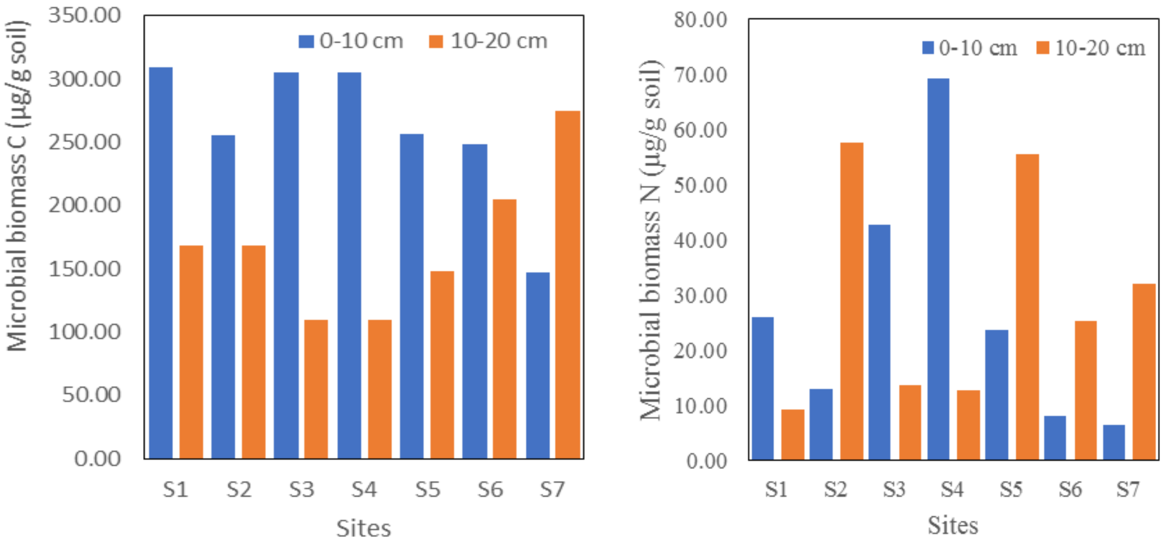

Figure 4: Effect of land use on microbial biomass.

4. DISCUSSION

pH is an important parameter which impact mainly chemical and microbiological reactions in the soil (Brady and Weil, 2002). According to Landon (1991), most cultivated plants grow properly in neutral or slightly acidic soil, pH between 5 and 7. All the soils studied in this work have a water pH <5.4. The results show that the soils on the 10-20 cm horizon are strongly acidic while those on the 0-10 cm horizon are moderately acidic. Land use impact weakly pH of soil. These results are in accordance with reported the observations of Koy (2009). The different land uses have effects on the amount of total organic carbon in the two horizons explored. Indeed, the values of the carbon rate vary between horizons in the same site and between sites. The vegetation composition on the sites could explain this phenomenon. It has been reported by several authors (Taylor et al., 2012; Mulaji Kyela, 2011; Dilly, et al., 2005) that vegetation positively influences the level of organic matter in the soil. In soils subjected to conventional agriculture, there is a loss of C while, under no-till or grassland agriculture, there is an increase in the C content which is extremely important for the bioavailability of nutrients in the soil for plants and microorganisms but also the main source of leached nitrates (Chabbi, et al., 2007). In the present study, the carbon level of the 0-10 cm horizon is higher than that of the 10-20 cm horizon regardless of the different land uses. Grass formations with previous legume crops have the highest carbon content (Naitormbaide, 2007; Taylor et al 2012). Measurements of the amount of total soil nitrogen at the seven (7) sites showed variability between sites and between horizons. In general, the nitrogen level follows that of organic matter. Indeed, the nitrogen level is high in the sites where the total carbon levels are the highest. In sites 4 (soybean cultivation) and site 5 (grass fallow 7-year- old), on the other hand, the nitrogen level is high while the carbon level is low. This fact can be explained either by a chain over several years of poor management of nitrogen fertilization, or by poor mineralization of organic matter. Another explanation can come from the difference in quality of the organic matter inputs due to the disparity of floristic composition of the sites. A comparison of the quality effects of previous crops shows that the total nitrogen levels are greater in the surface horizon (0-10 cm) than in the 10-20cm horizon. The work carried out in Chad and in South Africa has led to equivalent results (Naitormbaide, 2007; Taylor et al., 2012).

The microbial biomass carbon and microbial biomass nitrogen provide information on the mineralization of organic matter, its quality and the changes that take place in the fertility of the soil. The values of carbon and microbial nitrogen, which reflect the state of microbial biomass in the soil, are high and differ depending on the nature of the sites and the horizons. The microbial biomass C values found in this study are in the range of those generally found in cultivated tropical surface soils (Dilly, et al., 2005; Anonymous, 2002). These values are strongly influenced by the change in land use as shown by the results obtained. Indeed, fallow sites with a previous “legume” or under legume cultivation have high amounts of microbial carbon, as noted also Anonymous (2002) under permanent meadows as under annual crops. According to this author, the explanation lies in the contributions of rhizodepositions which provide energy substrates throughout the year. This type of observation was also made during crop rotations (Loiseau, et al., 1994; Anonymous, 2002). According to Massenssini et al (2015), in cultivated soils the chemical properties of the soil are the main factor which conditions the structuring of the microbial community.

REFERENCES

1. Anonyme. 2002. *Activité biologique et fertilité des sols. Intérêts et limites des méthodes analytiques disponibles.* [éd.] ITAB. cedex 12 : 1ere Ed, 2002; 27.
2. Brady, N.C. and Weil, R.R., 2002. The nature and properties of soils. *Pearson Education, Inc., New Jersey, USA.* 2002; 13: 960.
3. Bremner, J.M. and Mulvaney, C.S. Nitrogen-Total. In: Methods of soil analysis. Part Chemical and microbiological properties, Page, A.L., Miller, R.H. and Keeney, D.R. Eds., American Society of Agronomy, Soil Science Society of America, Madison, Wisconsin, 1982: 595-624.

4. Chabbi, A. and Lemaire, G. 2007. Rôle des matières organiques des prairies dans le cycle de l'azote et impacts sur la qualité de l'eau. *Fourrages,* 2007; 192: 441-452.
5. Chaussod, R., Nialardot, B. et Catroux, G. 1986. Relations entre les caractéristiques physico-chimiques et microbiologiques de quelques sols cultivés. *Sci. du sol,* 1986; 2: 213-226.
6. Clutterbuck, B. et Yallop, A.R. 2010. Land management as a factor controlling dissolved organic carbon release from upland peat soils 2: Changes in DOC productivity over four decades. *Science of the Total Environment,* 2010; 408(24): 6179-6191.
7. Dilly, O. 2005. Microbial energetic in soil. [auteur du livre] F. Buscot et A. Varma. *Microorganisms in soils: roles in genesis and functions.* s.l. : Springer-Verlag Berlin, Heidelberg, 2005; 123-138.
8. Dilly, O., Gnaβ, A. et Pfeiffer, E. M. 2005. Humumus accumulation and activities in calcari-epigleyic fluvisols under grassland and forest diked in 30 years. *Soil Biology & Biochemestry,* 2005; 37: 2163-2166.
9. Goma-Tchimbakala, J. 2003. Dynamique de la matière organique et de l'azote en plantation de limba (Terminalia superba Engler et Diels) au Congo: Comparaison avec une forêt naturelle. *thèse de doctorat; Univ. Pièrre et Marie Curie Paris,* 2003; *6:* 180.
10. Hassan, , A.M., et al. 2007. Effect of hydrated lime on growth of maize at Federal Capital Territory, Abuja. *Interna., J. of Agri. Research,* 2007; 2(5): 495-499.
11. Jenkinson, R. G. et Mueller, T. 1996. The fumigation-extraction method to estimate soil microbial biomass : calibration of the KEN value. *Soil. Biol. Biochem,* 1996; 28: 33-37.
12. Jenkinson, R.G. et Powlson, D.S. 1976. The effect of biocidal treatments on metabolism in soil-V. A method for measuring soil microbial biomass. *Soil. Biol. Biochem,* 1976; 8: 209-213.
13. Joergensen, R.G. et Mueller, T. 1996. The fumigation-extraction method to estimate soil microbial biomass : calibration of the KEN value. *Soil. Biol. Biochem,* 1996; 28: 33-37.
14. Koy, K.R. 2009. Amélioration de la qualité des sols sableux du plateau de Batéké (R D Congo) par application des matériels géologiques et des déchets organiques industriels locaux. *Thèse de doctorat, Sciences de la Terre, Université de Gand, Gent,* 2009; 323.
15. Krave, A.S., van Straalen, N.M. et van Verseveld, H.W. 2002. Potential nitrification and factors influencing nitrification in pine forest and agricultural soils in Central Java, Indonesia. *Pedobiologia,* 2002; 46: 573–594.

16. Landon, J.R. 1991. *Booker Tropical Soil Manual. A handbook for soil survey and agricultural land evaluation in the tropics and subtropics.* s.l. : Longman, Booker Take limed, Oxon, UK, 1991; 474.
17. Loiseau, P., Chaussod, R. et Delpy, R. 1994. Soil microbial biomass and in situ nitrogen mineralization after 20 years of different nitrogen fertilization and forage cropping systems. *European Journal of Agronomy,* 1994; 3: 327-332.
18. Massenssini, A.M., et al. 2015. Relative importance of soil physico-chemical characteristics and plant species identity to the determination of soil microbial community structure. *Applied Soil Ecology,* 2015; 91: 8–15.
19. Mulaji Kyela, C. 2011. Utilisation des composts de biodéchets ménagers pour l'amélioration de la fertilité des sols acides de la Province de Kinshasa (Rép. Dém. du Congo). *Thèse de Doctorat, Univ. Liège, Gembloux, Agro-Bio Tech,* 2011; 172.
20. Naitormbaide, M. 2007. Effets des pratiques paysannes actuelles de gestion de la fertilité sur les caractéristiques physico-chimiques et la productivité des sols de savanne du Tchad: cas de Nguetté I et Gang. *Mémoire de DEA, Univ. Polytechnique Bobo-Dioulasso,* 2007; 62.
21. Rutherford, P.M. et Juma, N.G. 1992. Influence of soil texture on protozoa-induced mineralization of bacterial carbon and nitrogene. *can. j. soil. Sci,* 1992; 72(3): 183-200.
22. Taylor TS., Titshall LW., Hughes JC.,Thibaud, GR. 2012. Effect of tillage systems and nitrogen application rates on selected physical and biological properties of clay loam soil in KwaZulu-Natal, South Africa. *South Africa Journal of Plant and Soil,* 2012; 47-52.
23. Vong, P.C. 1987. Contribution à l'étude cinétique des différents fertilisants minéraux et organiques. *Thèse de Docteur Es-Sciences de L'INPL,* 1987; 217.
24. Wu, J., et al. 1990. Measurement of soil microbial biomass C by fumigation-extraction, an automated procedure. *Soil. Biol. Bioch,* 1990; 22: 1167-1169.
25. Yallop, A.R. et Clutterbuck , B. 2009. Land management as a factor controlling dissolved organic carbon release from upland peat soils 1: Spatial variation in DOC productivity. *Science of the Total Environment,* 2009; 407(12): 3803-3813.