Nigerian Journal of Soil Science 23 (2013) 60 – 65

Nigerian Journal of Soil Science

Journal homepage:www.soilsjournalnigeria.com

QUANTITATIVE ANALYSIS OF HUMIC SUBSTANCES IN SOILS TREATED WITH DIFFERENT ORGANIC MANURES IN SUDANO-SAHELIAN SAVANNA, NORTH-EAST NIGERIA

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ABSTRACT

This work was carried out to study effect of organic manures on different fractions of soil organic matter. Field trials were carried out in 2008 and 2009 cropping seasons at the Teaching and Research Farm of the Department of Soil Science, University of Maiduguri, Maiduguri. The treatments consisted three types of organic manures (cow dung, city refuse and poultry droppings) applied at three rates (0.0, 2.5, and 5.0 tons/ha). The three organic matter fractions; (human (HN), fulvic acid (FA) and humic acid (HA) were significantly affected by the organic manures and their rates. Poultry droppings increased HA and FA contents but had a decreasing effect on HN content. Humic acid (3.65 g/kg) and FA (52.05 g/kg) contents were highest in soils treated with 5.0 tons/ha of cow dung, while it had the lowest content of HN (885.9 g/kg). Fulvic acid was higher in all the soils than humic acid.

INTRODUCTION

Humic substances are the most pronounced components of the passive highly stable soil organic matter pools and are the key factors in stabilization, accumulation and dynamics of organic carbon in the soil (Andreux, 1996). Andreux (1996) further stipulated that the strong association of humic substances with the inorganic soil components is regarded as a means by which carbon is protected against microbial degradation. Christl *et al*., (2000) also confirmed that humic fraction constitutes a large portion of the total organic carbon in the soil and aquatic environment and plays an important role in global carbon recycling and in the regulation of the mobility and fate of plant nutrients and environmental contamination. Leenheer *et al*., (2006), identified about fourteen different fractions of soil organic matter on the basis of size (particulate, colloidal and dissolved), volatility, polarity (hydrophobic, transphilic, hydrophilic), acid, base, neutral characteristics and precipitate or flocculates formation upon acidification. They also stated that humus or humic fraction is the most important portion of the soil organic matter because of its role on soil chemical properties. Classical scheme dividing soil humic substances into humin, fulvic acid and humic acid fractions is based on their solubility in sodium hydroxide [(NaOH), (humin)] and their subsequent solubility (fulvic acid) and their insolubility (humic acid) in acid solution (Brady and Weil, 2002)1. Christl *et al*., (2000) found that humic substances constitute a larger portion of organic matter and organic carbon in the soil. Although the chemical structures are not well studied, however, chemical differences in size is well established and that the smaller size fractions of soil humic acid contain more charges of aromatic carbon than the larger size ones and their fulvic acid counterparts as well. Jenkinson (1988) reported that the humic substances of humus have a very large influence on the cation exchange capacity of the soil, often contributing half or more and it becomes increasingly important as the seat of cation exchange.

Humic substances in particular or soil organic matter in general plays key roles in nutrient retention and availability and buffering effect. The contribution of soil organic matter to sustainable crop production is well recognized and established but little is known about its chemistry and different fractions in this sub-region. The primary objective of this study therefore was to assess the effect of each of the three sources of organic manure of the quantities of the different fractions of organic matter in the study area.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted in 2008 and 2009 cropping seasons at the Teaching and Research Farm of the Department of Soil Science, University of Maiduguri (11°53'N; 13°16'E), on the northern fringes of the Sudan savanna belt of Nigeria. The study is characterized by a short rainy season of 100 – 150 days with a long dry season of at least 7 months, and a mean annual rainfall of about 500 mm (Yunusa and Ikwelle, 1990).

The major soil type found in the study area is Typic ustipsament as described by Rayar (1987) derived primarily from the recent Aeolian sand deposits of the Sahel savanna. Thus, the soils are characterized by sandy texture with low organic matter content, low CEC and inherent low fertility status.

Experimental Design and Treatments

Field experiments were conducted in two successive cropping seasons, 2008 and 2009. The field was ploughed and harrowed to a fine tilth and marked out into plots of 4x4 m (16 m^2) during the first year. In the second year the plots were prepared by hand hoes so as not to disturb the plots. The treatments were three sources of organic manure (cow dung, city refuse and poultry droppings) at four rates each (0.0, 2.5 and 5.0tons/ha). The experiment consisting of nine treatments was laid out in a Randomized Complete Block Design (RCBD) replicated three times giving a total of 27 plots.

The three sources of organic manures used were cow dung (CD), city refuse (CR) and poultry droppings (PD). Cow dung was collected from the animal farm of the Borno College of Agriculture, Maiduguri in June, 2008 and 2009. City refuse was collected from the refuse dump within the Staff Quarters of the College in the same years of experiment. Poultry dropping was collected from the poultry production unit (PPU), a division of the Borno State Ministry of Agriculture, Maiduguri in the same years of experiment. Complete doses of organic manures (2.5 t/ha or 4.0 kg/ net plot, 5.0 t/ ha or 8.0 kg/net plot) and 10.0 tons/ha or 16 kg/ net plot were applied at land preparation An extra-early variety of maize (SAMMAZ 28) was used as a test crop, obtained from the Agronomy Department, International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria through the project, Promoting Sustainable Agriculture in Borno State (PROSAB), Maiduguri was used as a test crop. Weeds were controlled manually using a hand hoe at 3, 6, and 9 WAS.

Soil Sampling and Analysis

Soil samples were collected from surface (0-20 cm) using soil auger. Fifteen (15) samples were randomly collected across the farm, thoroughly mixed and a representative composite sample was taken before the experiment. After each harvest three (3) soil samples were collected from each plot, thoroughly mixed and neatly packed and carried in new polythene bags. The soil samples were air-dried, crushed separately using wooden mortar and pestle and passed through 2 mm for pH, CEC and available P and 0.5 mm sieves for organic carbon, total N and organic matter fractions. Each sample was analyzed for some selected properties of the soil.

Organic Matter Fractionation

Soil organic matter was fractionated for their different fractions following the dilute acid (HCl) method described by Schnitzer (1987).

Ten grams (10g) of air – dry soil was weighed into a 200ml propylene flask. One hundred milliliters of the extractants was added (0.1 N NaOH). The air in the flask was displaced by N_2. The flask was closed and shaken for 24 hr at room temperature. The dark colour supernatant solution was separated from the residual soil by filtration. The soil residues were suspended in 50ml of distilled water and the phase separated by filtration as before. The washing was added to the supernatants.

The alkaline extracts and washing was acidified to pH 2 with 2 N HCl. Then it was allowed to stand at room temperature for 24hr, and the soluble materials (Fulvic Acid) was separated from the coagulate, humic acid (HA) by filtration. Both fractions were frozen – dry on a rotary evaporator at about 40^{O}C.

RESULTS AND DISCUSSION

The soil of the study area was sandy loam in texture. This implies that basic cations such as Ca, K, Na and Mg would be leached more easily as texture determines the degree of retention or ease of leaching of basic cations. There was low organic carbon content, total nitrogen, cation exchange capacity and available P but high in percentage base saturation. Low organic carbon and organic matter in the soil of the experimental site was probably as a result of high proportion of sand content of the soil. Low organic carbon is attributed to inadequate supply of organic litter, bush burning, long dry season and intensive mineralization during the rainy season (Dugje *et al*., 2008).

The soil was slightly acidic in pH (6.20) and low EC (0.0173 dS/m). The contentS of different organic matter fractions showed that fulvic acid was higher than humic acid. Nwaka and Denissof (1981) also found that the content of fulvic acid is higher than that of humic acid in all the soils of the savanna and the content increases with depth.

Although, all the three organic manures were neutral in pH, yet the pH was slightly alkaline in city refuse and lowest in poultry droppings. On the other hand nitrogen content was highest in poultry droppings and lowest in city refuse. The higher content of nitrogen in poultry droppings might be as a result of higher content of uric acid in the poultry droppings. Delin (2011) reported that poultry manure differs from that of mammals because of its content of uric acid, which is rapidly converted to ammonium and therefore has a higher fertilizer value than other organic nitrogen in manures. Nahm (2003) earlier observed that the amount of N that mineralizes from poultry manure after application depends on the amount of uric acid that has already been transformed during storage.

Among the three fractions of organic matter, poultry droppings showed the highest content of fulvic acid but lowest content of humin than the other two organic manures. City refuse had the highest content of humin but lowest content of fulvic acid.

The three organic matter fractions (HN, HA and FA) were significantly affected by the organic manure types and their rates. Poultry droppings increased HA and FA contents but had a decreasing effect on HN content. Humic acid (3.65 g/kg) and FA (52.05 g/kg) contents were highest in soils treated with 5.0 tons/ha of cow dung, while it had the lowest content of HN (885.9 g/kg). The higher content of fulvic acid in soils treated with poultry droppings might be due to the fact that poultry dropping contained more nitrogen than the other manures. As the rate of organic manure increased the content of fulvic acid also significantly increased. Contrarily, humin decreased with increase in organic manure levels and the content of humin was lowest in poultry droppings.

Generally, irrespective of treatment factor or rate of application, fulvic acid was higher in all the soils than humic acid fraction. This was in line with the report of Krieger (1975), which indicated greater quantities of fulvic acid than humic acid fraction and attributed this possibly to the greater percentage of nitrogen (protein) in fulvic acid than in humic acid. Carbon was higher in humic acid than in fulvic acid. Nwaka and Denissof. (1981) also found higher amount of fulvic acid than humic acid in soils of northern Nigeria. .Bohn *et al* (2001) reported that the low molecular weight fulvic acid had higher oxygen content and low carbon content than the higher molecular weight humic acid. This is responsible for the higher solubility of the former.

CONCLUSION AND RECOMMENDATION

It was found that poultry droppings significantly increased and improved the quantity of fulvic acid fraction of organic matter more than the other fractions and the quantity increased with increasing the rate of application. While humin fraction (insoluble in both dilute acid and NaOH) was significantly higher in soils treated with city refuse, while the quantity decreased with the application of poultry droppings.

To increase and improve the quantity and quality of fulvic and humic fractions of organic matter in the sub Sahelian savanna, application of poultry manure and cow dung is recommended. However, to reduce organic matter decomposition which is very high in the study area due to high temperature, application of city refuse should also be encouraged because of its high content of humin fraction.

Table 1: Physico-chemical characteristics of the soil of the experimental site

Soil properties	Value
pH (1:2.5 H_2O)	6.20
EC (dS/m)	0.01
Exch. Acidity (H^+ + Al^{3+} Cmol/kg)	0.20
ECEC (Cmol/kg)	4.66
Percentage Base Saturation (PBS %)	95.71
Organic carbon (g/kg)	19.0
Total Nitrogen (g/kg)	1.0
C : N Ratio	19.0
Available Phosphorus (Bray-1 P mg/kg)	2.80
Exchangeable Potassium (Cmol/kg)	0.24
Humin (g/kg)	983.14
Humic Acid (g/kg)	7.58
Fulvic Acid (g/kg)	56.94
Percentage Sand (g/kg)	762.0
Percentage Silt (g/kg)	116.0
Percentage Clay (g/kg)	122.0
Textural class	Sandy loam

Table 2: Some Chemical Characteristics of the Different Organic Manures used

Sample	pH (1:2.5 H_2O)	Org. C (%)	N (%)	C : N Ratio	P (g/ kg)	K (g/kg)	HN (g/kg)	HA (g/kg)	FA (g/kg)
Cow dung	7.31	14.63	0.39	37.52	2.9	19.7	883.19	15.77	83.03
City refuse	7.34	6.83	0.34	20.08	0.5	6.0	907.19	23.54	7.13
Poultry droppings	6.85	11.31	0.45	26.13	0.5	5.7	773.47	11.17	93.05

Table 3: Effects of Different Organic Manure Source on soil organic matter fractions (HN, HA and FA g/kg) after Two Years of Application

Treatment	HN	HA	FA
Control	985.5^{a}	2.60^{c}	38.99^{ab}
CD at 2.5 t/ha	953.8^{ab}	3.43^{ab}	39.72^{ab}
CD at 5.0 t/ha	900.7^{b}	3.65^{a}	52.05^{ab}
MW at 2.5 t/ha	946.7^{ab}	1.99^{c}	25.21^{b}
MW at 5.0 t/ha	956.1^{ab}	2.50^{c}	64.92^{a}
PD at 2.5 t/ha	899.2^{b}	2.74^{bc}	52.97^{ab}
PD at 5.0 t/ha	885.9^{b}	3.99^{a}	65.68^{a}
SE±	392.63*	0.381**	18.285*

Means in a column followed by similar letters are not significantly different at 5% level of probability by DMRT test.
* = significant at 5% level of the F-test
** = significant at 1% level of the F-test
NS = Not significant

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