

# Distribution of organic carbon and total nitrogen in aggregate size fractions in a southern Nigeria Ultisol under different agricultural land use

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## Abstract

We studied the effect of different land uses on organic carbon and total nitrogen content in soil and soil size fractions. A range of land uses was selected, that included tree plantings, pasture and soil tilled at different intensity. Soil organic carbon and total N were significantly higher under forest and tree crops in comparison to pasture, no tilled and tilled plots. Converting conventional tillage to no tillage lead to significant increase of the soil organic matter content. Organic carbon and total nitrogen contents generally decreased with increasing size of soil aggregates, whilst the C:N ratio was directly related to the aggregate size. The presence of higher amounts of organic C associated with lower C:N ratio in the finer fractions suggests that these aggregate size classes protect the soil organic matter and make it inaccessible to degrading agents.

## Key Words

Soil organic matter, C:N ratio, organic matter protection.

## Introduction

The contribution of soil organic matter to aggregate stability is well known. To describe soil aggregate stabilization Oades (1993) proposed the hierarchical model, based on the hypothesis that macro-aggregates are collections of micro-aggregates and that different binding agents are active at different hierarchies of soil aggregation. However this model has not been clearly confirmed by studies on aggregate fractionation (de Sa *et al.* 2000), maybe due to variations in methods employed for soil fractionation (Ashman *et al.* 2003). Soils with different clay mineralogy were observed to respond differently to fractionation, and aggregate hierarchy exists only in soils where aggregate stability is controlled by organic materials (Oades and Water 1991). This paper examines the effect of land use on organic carbon distribution in soil aggregate fractions and implications to carbon protection in soil.

## Materials and methods

The experimental area was in the Teaching and Research Farm of Obafemi Awolowo University, Ile Ife (7°25'N, 4°39'E), Nigeria. The soil (Oxic Haplustult according to USDA Soil Taxonomy) derived from coarse gneiss and granite and varied from sandy loam to sandy clay loam (table 1). Seven land use type were selected: forest, cocoa, teak, oil palm, pasture, no tillage and conventional tillage. Forest was a control secondary forest site left undisturbed for 30 years, while the ages of cocoa, teak and oil palm ranged between 24 and 27 years. The conventionally cultivated plot had been tilled for 15 years using disk plough and harrows, while the no tillage plot was converted from conventional cultivation 3 years prior to this study. The pasture was established 15 years prior to this study and it had been under cattle grazing since then. Composite soil samples (40 subsamples) were taken in the different land use types at depths of 0-15 cm (topsoil) and 15-30 cm (subsoil). They were air dried, gently crushed by hand, and carefully sieved into size fractions of 1-2, 0.5-1, 0.25-0.5, 0.125-0.25, 0.05-0.125, and <0.05 mm. Organic C and total N were determined in each size class using the Multiphase LECO RC-412 C analyzer and the FP-528 N analyzer respectively.

## Results and discussion

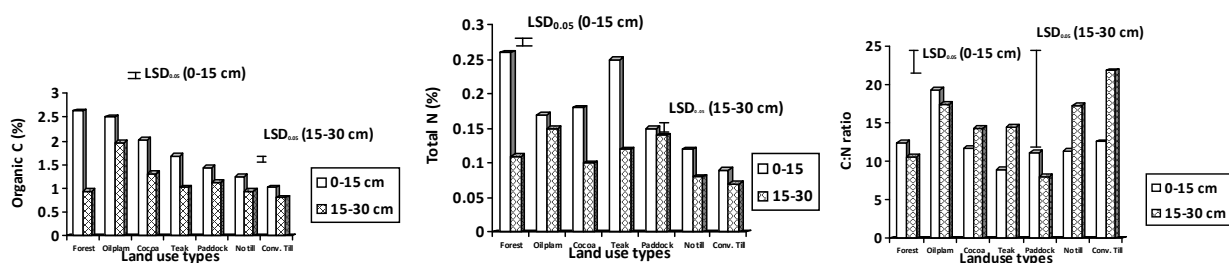
Soil organic carbon (SOC) was significantly higher under forest and tree crops in comparison to pasture, no tilled and tilled plots (Figure 1). There is a noteworthy difference between tilled and no

tilled plots, showing a significant increase of SOC three years after the soil management was changed. Soil N also followed a similar pattern of distribution with slight variations among the crops. The mean C:N ratio in the topsoil was 10.9, considering the all the land use types, except oil palm, whose ratio was 19.5. This may be attributed to the low N content of the fibrous roots of the oil palm tree. The C:N ratio in subsoil was not significantly

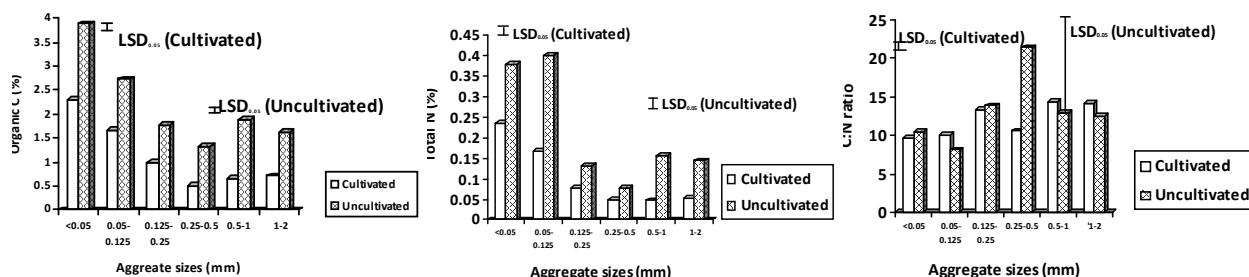
**Table 1. The soil physical properties for different land use types.**

Land use	0-15 cm					15-30 cm				
	pH	Sand (0.02-2 mm)	Silt (0.002-0.02 mm)	Clay (<0.002 mm)	Texture	pH	Sand (0.02-2 mm)	Silt (0.002-0.2 mm)	Clay (<0.002 mm)	Texture
No tillage	6.36	69.54	20.15	10.31	LS	6.20	76.68	13.74	9.58	LS
Conv.	5.88	77.88	14.27	7.85	LS	5.82	86.88	10.74	2.38	LS
Tillage										
Forest	6.76	65.54	21.06	13.4	L	6.76	63.65	22.57	13.78	L
Oil palm	5.95	62.63	22.02	15.35	L	6.00	63.98	22.71	13.31	L
Teak	6.12	68.45	20.81	10.74	LS	6.26	66.71	18.78	14.51	L
Cocoa	6.98	63.97	21.92	14.11	L	6.95	67.03	19.74	13.23	L
Pasture	5.65	64.13	22.48	13.39	LS	5.71	66.53	23.65	9.82	LS

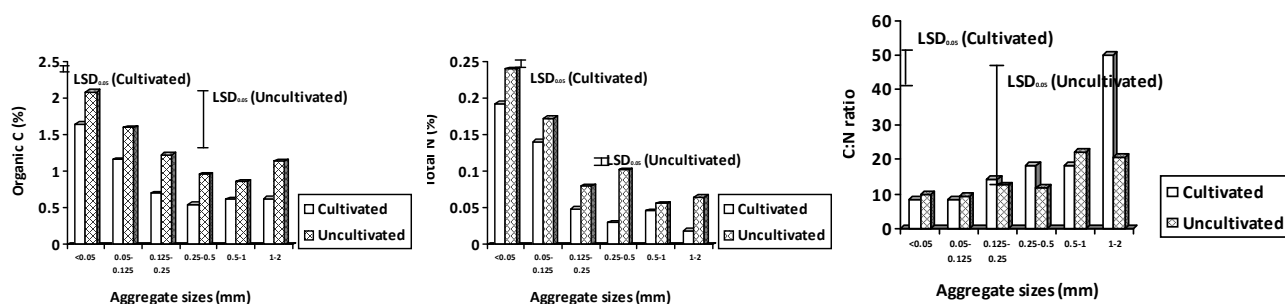
LS = Loamy sand, L = Loam.



**Figure 1. Topsoil (0-15 cm) and subsoil (15-30 cm) distribution of (a) organic C, (b) total N and (c) C:N ratio under different land use types.**



**Figure 2. Topsoil (0-15 cm) distribution of (a) organic C, (b) total N and (c) C:N in aggregate size fractions as influenced by cultivation**



**Figure 3. Subsoil (15-30 cm) distribution of (a) organic C, (b) total N and (c) C:N in aggregate size fractions as influenced by cultivation**

different among land use types, with the exception of the pasture. This result and the high amount of N in the pasture soil can be related to the presence of fresh animal manure left during the grazing. Data of SOC and N in different size fractions are reported in Figure 2, where values from forest, cocoa, teak and oil palm are grouped as “uncultivated” and tilled and no tilled plots are grouped as “cultivated”. SOC and N contents generally decreased with increase in the size of soil aggregates, with the highest values in the <0.05 mm class and the lowest in the 0.25-0.5 mm class. This trend is consistent across land use types and the two soil depths investigated. The C:N ratio in the cultivated topsoil was directly related to the aggregate size; no clear trend was shown by the uncultivated soil, even though the lowest values were those of the smallest size classes. In the subsoil only the largest classes showed significant higher C:N ratio, namely 1-2 mm in cultivated soil and 0.5-1 and 1-2 mm in uncultivated soil.

## Conclusions

As expected, tillage and cultivation reduce the organic carbon in the soil. The trend can be inverted with proper soil management using no tillage. The consistently higher C and N in the fine particle size fractions may indicate lower decomposition rates of the organic matter associated with clay and fine silt size particles and aggregates. This suggests a measure of protection of soil organic matter by the fine sized soil particles. The lower C:N ratio of the fine sized particles could suggest that this soil fraction offers protection to soil organic matter, while the coarse fractions were readily accessible to microbial degradation thus leaving the recalcitrant organic materials with high C:N ratio.

## References

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