



COMPARATIVE STUDY OF ORGANIC MATTER CONTENT OF A TROPICAL SOIL UNDER THREE AGROFORESTRY TREE SPECIES

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Abstract: This study was carried out to evaluate the effect of three fast growing agroforestry tree species; *Acacia crassica*, *Gliricidia sepium* and *Leucaena leucocephala*, litters on the organic matter content of the soil. The soil samples were collected from the plot supporting the ten years old tree species with the use of a soil hugger at three depths; 0-10cm, 10-20cm and 20-30cm and were analysed for percentage organic matter content. The data collected were subjected to analysis of variance (ANOVA) at 5% level of significant. The results indicate that organic matter was highest at 0-10cm under *leucaena leucocephala* followed by *Gliricidia sepium*, and least in *Acacia crassica*. Percentage organic matter was highest at depth 10-20cm in *Acacia crassica* followed by *Leucaena leucocephala* and least in *Gliricidia sepium*. At depth 20- 30cm, percentage organic matters was also found highest in *Acacia crassica* followed by *Leucaena leucocephala* and Least in *Gliricidia sepium*. The result shows significant difference in percentage organic matter under the different tree species and at different level.

Keyword: Nutrient cycling, soil, organic matter, agroforestry, tree species.

Introduction

Soil Organic Matter is diverse organic materials, such as living organisms, slightly altered plant and animal organic residues, and well-decomposed plant and animal tissues that vary considerably in their stability and susceptibility to further degradation (Magdoff, 2004). Soil organic matter is any soil material that comes from the tissues of organisms (plants, animals, or microorganisms) that are currently or were once living. Soil organic matter is rich in nutrients such as nitrogen (N), phosphorus (P), sulfur (S), and micronutrients, and is comprised of approximately 50% carbon (C) (Laura and Jodi, 2016). Soil organic matter serves as a reservoir of nutrients for crops, provides soil aggregation, increases nutrient exchange, retains moisture, reduces compaction, reduces surface crusting, and increases water infiltration into the soil (Wander, 2004). Low soil fertility is the most fundamental causes for low agricultural productivity, food insecurity, low income and poverty among farmers. The fertility of soil increases when organic matter is incorporated into the soil as it has been established that SOM is considered to be the single important indicator of soil quality because of its influence on the physical, chemical and biological properties of the soil (Karlen *et al.*, 1997; Asiamah *et al.*, 2001). In the tropics, the soils in general have an inherently low fertility, which decline rapidly after the conversion from natural forest or natural fallow to agricultural systems (Serrao *et al.*, 1979). Maintenance of soil quality is considered essential for ensuring sustainable land use; hence land resources management must aim at soil conservation (Parysow, 2001)

Population increase has led to massive conversion of forested land to other uses such as conversion to farmland, urban expansion as well as construction of roads; this in turn has reduced the span of land available for agriculture. Consequently, decrease in the length of fallow period, which in turn has led to serious decrease in the quantity of organic materials that could be incorporated into the soil for resuscitation of the loss fertility.

Agroforestry can be only viable option to alleviate the degradation and alleviation of loss of soil fertility from agricultural field (Adedayo and Sobola, 2014). Lundgren and Raintree (1982) gave the definition of agroforestry is a collective name for land-use systems and technologies

where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components. Trees significantly influence the fertility of tropical soils by maintaining soil organic matter. Increases in organic matter and improved microclimatic conditions under parkland (and savanna) trees enhance soil microbial and enzymatic activity, decomposition and physical characteristics. (FAO, 1995). The potential of trees to bring improvements in nutrition, income, housing, health, energy needs, etc environmental sustainability in the agricultural landscape cannot be overemphasized. Among all the benefits accrue to incorporating trees on agricultural landscape; an important element is the positive effect of trees on soil properties and consequently benefits for crops (Rachel *et al.*, 2012).

Tree legumes such as *Gliricidia sepium* and *Leucaena leucocephala*, are important for supplying organic matter with different characteristics, such as greater C/N ratios, polyphenol, or lignin contents (Recheal *et al.*, 2012). In addition, the yearly contribution of surface vegetation to soil, in the form of leaves, branches, twigs, etc, gradually decomposes and becomes a part of the soil. The decomposing plant tissues (above and below ground litter) are the main source of soil organic matter, which influences the physicochemical characteristics of soil such as, texture, water holding capacity, pH and nutrients availability (Semeneh, 2012). Organic matter with a low C/N ratio will decompose more quickly and rapidly releasing nutrients for use by crop plants, in certain situations a slower decomposition rate may be desirable, in order to maintain soil cover and control growth of weeds. It is widely reported that soils under tree canopy (i.e. within the crown zone) accumulate more organic carbon than the open field due to the direct influence of the tree canopy (Toma *et al.*, 2015). This study aimed at determining the variation in percentage organic matter under three agroforestry tree species.

Materials and Methods

Study site

The experiment was conducted at the teaching and Research farm of the department of Forestry and Wood Technology, Akure. The site is located at latitude 7°17', longitude 5°10'E which lies in the tropical rain forest zone of Nigeria, and has a mean annual temperature of about 25°C. The elevation is about 350m with gently undulating landform with relative humidity that ranges between 85% and 100% during the raining season and below 60% in the harmattan period. The soil profile shows some medium to light textured materials near the surface and followed by sandy clay subsoil and a layer of sub angular quartz gravel below (Oke, 1995).

Experimental plots

The study was conducted in the 10 years old trial plots established to evaluate the effect of three fast growing agroforestry tree species; *Acacia crassica*, *Gliricidia sepium* and *Leucaena leucocephala*, litters on the organic matter content of the soil. The treatments consisted of three fast growing trees species as mentioned above and three soil depths which are: 0-10 cm, 10-20 cm and 20-30 cm soil depths. The experimental design was completely randomized design (CRD) with three replications. The plot size was 8 m by 10 m while the spacing was 2 x 2 m. The total land area for the study is 244m² and the total numbers of plot were 27.

Soil sampling

The soil sampling was carried out with the use of tube auger at the aforementioned depths for each of the tree species using 5 m by 5 m quadrat, which was centrally located in each plot and the collection was done within this quadrat to guard against plot- edge effect. Soil sample collected from same species at the same horizon were bulked and three composite samples were collected and placed in sample bags and moved to the laboratory for routing analysis.

Determination of soil organic matter

The organic matter content of soil was determined using the Walkley (1947) wet oxidation method. This method measures active or decomposable organic matter in the soil. The soil samples collected in triplicate were grounded and pass through 100µmesh sieve. 1g of soil sample was weighed in duplicate and transfer to 250 ml conical flask. 10 ml 1µ K₂Cr₂O₇ was added and then 20 ml of conc. H₂SO₄ rapidly and it was winked immediately until soil and reagents were mixed and it was swirled more rigorously for 1 min, the flask was rotated again and allowed to stand on a sheet of asbestos for about 30 min. After 30 min, 70 ml of distilled water was added and then 3 drops of ferroin indicator. This was titrated with 0.5% ferrous sulphate solution and percentage organic matter was calculated using Walkely (1947).

$$\frac{\% \text{ organic carbon and } \% \text{ matter}}{\% \text{ organic matter}} = 10 [(S \div B)] \times 0.06$$

Where: B = Blank titration; S = Sample titration

Results and Discussion

The results of the analysis for comparing soil organic matter under the woody species at depth 0 – 10 cm using Duncan Multiple Range Test revealed significant differences (P < 0.05) in % soil organic matter. The percentage soil organic matter under *Leucaena*

leucocephala was significantly higher than *Gliricidia sepium* and *Acacia crassica* (Table 1). At depth of 10 – 20 cm, the soil samples had no significant difference between *Acacia crassica* and *Leucaena leucocephala* but are different significantly from *Gliricidia sepium* (Fig. 1). There was no significant difference in percentage organic matter under the depth of 20 – 30 cm although *Acacia crassica* had higher mean value follow by *Leucaena leucocephala*, and least with *Gliricidia sepium* at P < 0.05 (Fig. 1).

Table 1: % soil organic matter in relation to depth under the tree species

Tree species	Mean % soil organic matter for depth		
	0 – 10 cm	10 – 20 cm	20 – 30 cm
<i>Acacia crassica</i>	2.63b ± 0.24	2.34a ± 0.05	1.87a ± 0.35
<i>Leucaena leucocephala</i>	3.59a ± 0.08	2.23b ± 0.11	1.85a ± 0.35
<i>Gliricidia sepium</i>	2.92b ± 0.03	1.98c ± 0.17	1.81a ± 0.25

a,b,c = Duncan multiple range test mean value showing different significant level at 5% level of probability

The result revealed a variation in (%) organic matter of the soil under the three different tree species significantly different from one another. This variation could be as a result of variation in the different rate of decomposition and nutrient release which are determined by the resource quality of the organic material, the environment and the decomposer organisms present. This support the findings of Mafongoya *et al.* (2000), that the litter quality controls the rates of decomposition and mineralization. Soil under *Leucaena leucocephala* has the highest (%) organic matter (Fig. 1) at 0-10 depth over a period of 10 years which could be due to higher accumulation of litter fall and increase decomposition rate which may be accounted for by high quality organic inputs as high content of Nitrogen, low lignin and polyphenol content present in *Leucaena leucocephala* (Palm, 1995; Mafongoya, 2000). *Gliricidia sepium* was also found to contain a higher level of soil organic matter which contains a greater proportion of decomposition and release of large proportion nitrogen content and lower lignin as well as lesser quantity of polyphenols. This support the findings of Reyes-Reyes *et al.* (2002) that legume species accumulate more organic matter, nutrients and microorganisms in the soil than do non-leguminous species, while the relatively lower soil organic matter under *Acacia crassica* tree species at the same level may be attributed to slow decomposition of its leaf litter despite the heavy litter fall as observed under its canopies.

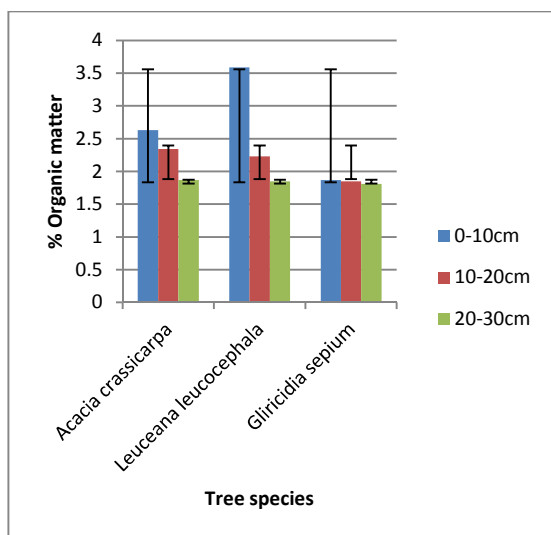


Figure 1: Variation in soil organic matter at three depths

Findings such as (Mafongoya *et al.*, 2000; Bot and Benites, 2005) have shown that leaf litter quality controls the rates of decomposition and mineralization and in order to maintain the nutrient replenishing cycle from the leaf litter the rates of decomposition must be equal to the rates of addition of organic matter. These corroborate the work of Makaza and Shoko (2013), that the level of inorganic N had a significant effect on decomposition rate of litters. The percentage organic matter was found lowest in *Acacia crassicaarpa* at the same horizon which may be accounted for by the present of higher level polyphenols and lignin which release nutrients slowly or even immobilize them (Palms, 1995)

The importance of soil organic matter in supplying nutrients, contributing to cation exchange capacity, and improving soil structure, is well recognized. It was also observe that percentage organic matter under *Acacia crassicaarpa* was the highest at depth 10 – 20 cm, (Fig. 1) this may be due to greater accumulation of organic matter at this level as a result of gradual release of nutrient over the period 10 years. This was followed by *Leucaena leucocephala* and least in *Gliricidia sepium*; this may be accounted for by increase rate of mineralization. The % soil organic matter was not significantly different at depth 20 -30 cm (Table 1) because the organic materials such as litters have much more effect at the surface level than at the lower level.

It was observed that as the soil depth increases there was a general decrease in the percentage of the soil decomposes organic matter under the selected tree species (Table 1). This decrease may be due to variation in the amount of organic material present at each horizon and the rate of aeration, this confirm the work of Thomson and Troeh (1978) that the organic matter content of any horizon of soil depends partly on how much organic matter decomposes are balanced as well as more decomposition occur in the upper layers and aeration is more adequate at the upper layer. The result of this paper shows variation in decrease in organic matter with increase in depth. *Gliricidia sepium* showed the highest decrease with depth 47.47%, (Table 1) followed by *Leucaena leucocephala* which decrease by 22.95% and least percentage decrease with depth in organic matter was found in *Acacia crassicaarpa*.

Conclusion

Multipurpose trees (MPTs) which are low in polyphenols, can provide a rapid flush of N during mineralisation, and may therefore be a good choice for use in agroforestry system. Trees can therefore play a great role in soil conservation especially in places characterized by steep slopes and farmers can benefit from trees on off farm uses. This study showed that percentage soil organic matter varies with selected tree species, which could be resulted from difference in the quality and quantity of litter fall which affect the rate of decomposition and mineralization. *Leucaena leucocephala* and *Gliricidia sepium* are recommended as the best suppliers of organic matter at the topmost layer and are thereby recommended for intercropping with arable crop with shallow root for accessibility for nutrient uptake. and could be used in agroforestry practices, incorporation with annual crops to boost the organic matter content of the soil because of the high level of decomposable Organic litters which tends to decompose faster and releases more carbon and other secondary compounds like nitrogen that reduces the accumulation of organic acids most especially at the uppermost layer which make it accessible for the root of crops. *Acacia crassicaarpa* on the other hand is as well suitable in agroforestry practice but it is recommended to be incorporated with agricultural crops with deep rooting system so as to access the organic matter at the deeper layer of the soil.

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