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Carbon sequestration under different land cover in soils derived from sand stones in south western Nigeria

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Abstract

The trial was to determine the potentials of different land covers in carbon sequestration of soil derived from sand stone with low nutrient status in south western Nigeria. The land cover/use types included leucaena (*Leucaena leucephala)*, elephant grass (*Pennisetum purpureum*), guinea grass (*Megathyrsis maximus*), secondary forest (creepers) and arable farm land. Soil samples were collected in four replicates from each land cover from 0 – 30 and 30 – 60 cm depths for soil attributes. The soil organic carbon (SOC) was analysed using wet oxidation method. The SOC stock was calculated from bulk density, percent carbon and depth of sampling. The results of SOC stock for elephant grass, guinea grass and Leuceana land covers were 70.27 t C/ha, 64.86 t C/ha and 63.68 t C/ha, respectively. Whereas 24.51 and 17.39 t C/ha were recorded for arable land and secondary forest, respectively. The SOC stock for elephant grass, guinea grass and leuceana were more than arable crop by 183.72 %, 173.26%, 183.72% respectively. Thus, grasses can improve SOC stock in the tropics if well managed and ploughed back into the soil yearly. Elephant and guinea grass can serve as part of local sustainable agricultural system to minimize SOC losses and optimize inputs efficiency.

Keywords: Land cover, carbon sequestration, carbon stock, grasses, sustainable agriculture

Introduction, scope and main objectives

Sequestration of organic carbon is the panacea to soil fertility decline in the tropical environment. Tropical soils are characterized with inherent low fertility, low organic carbon, deforestation, and soil physical degradation rate caused by extreme climatic condition such as high rainfall intensity and temperature. To meet the food demand of the teaming population, large expanse of land is opened for cultivation in southwestern Nigeria without adequate soil protection against degradation. However, for soil carbon to be improved there must be increase in time the soil is vegetated, reduction in conventional tillage, boosting of primary production and return of organic carbon to soil, increase in soil fertility and increase in use of perennial grasses and legumes (Paustian et al., 1997 and Mehdi et al., 2000).Therefore this study was to investigate the potentials of elephant and guinea grass in carbon farming compared to leuceana in an agrarian low nutrient soils derived from sand stone in southwestern Nigeria.

Methodology

The study area

The study was conducted at Ikenne (6^{o} 51' N, 3^{o} 42' E), a Research Station of the Institute of Agricultural Research and Training (IAR&T.), Nigeria. The climate of the area is between the humid and sub humid tropical, with an annual rainfall of 1,436 mm, with two peak distribution pattern (June and September) and five dry months in the year. Mean temperature of 26.3^{0}C with February and March as the hottest months; mean relative humidity of 75% and potential evapotranspiration (PET) of 109 mm (IAR&T, 2011). These soils have been classified as Oxic paleustults and Dystric Nitosols under USDA and FAO classifications respectively [14].

Land use and fallow types

The study area include arable farm land, guinea grass fallow, secondary forest tree, elephant grass fallow, and Leucaena which have been existing for about 15 years. The arable plot has been under cultivation with crops such as maize and cassava. Inorganic fertilizer (NPK 20-10-10 or Urea, based on crops) is usually applied every year to improve the fertility of the soil. The elephant and guinea grasses were usually ploughed in at the beginning of the planting season to avoid pest infestation through them, and to avoid their encroachment on adjacent cultivated plots. The secondary forest has developed canopies but the canopies were not fully formed with underground thickets and herbs. The Leucaena plants were planted to improve the fertility of the soil after it had been cultivated at a spacing of 5 by 5 m.

Field work

Area under each land cover was divided into four (4) polygons of 20 m x 20 m. Three samples were collected from each polygon from which representative composite samples were taken. Minipits were dug at the sampling points for sub surface sampling to avoid contamination. A cylindrical corer of 5 cm diameter and 5 cm height was used to take soil samples for soil bulk density (BD) and determined as described by Grossman and Reinsh (2002).

Soil Organic Carbon stock determination

Soil samples were crushed and allowed to pass through a 2 mm to obtain uniform subsamples and further ground with mortal and pestle to pass through 0.5 mm sieve. Organic carbon was obtained after soil oxidation with a dichromate-sulfuric acid mixture using Walkley Black method (1934). The SOC stock was obtained from Bulk density (BD) and organic carbon concentration with the following equation:

$$\text{SOC stock (kg m}^{-2}\text{)} = \frac{OC\ concentration\ (g\ kg^{-1})\ x\ BD\ (Mg\ m^{-3})\ x\ soil\ layer\ thickness\ (m)\ x\ fine\ earth\ content}{100}$$

$$\text{Where BD} = \frac{total\ soil\ mass\ (Mg)}{Sample\ volume\ (m^{-3})}$$

Results

Tables 1 and 2 show the soil properties of surface and subsurface soils from the different land cover investigated. The lowest bulk density (0.84g/cm^3) was recorded under the secondary forest soil follows by Leucaena (0.87g/cm^3) where tillage was not involved. Highest bulk density was obtained under elephant grass but not significantly different from cultivated soil. Highest carbon percentage (2.44%) and Nitrogen (0.25%) were recorded in both elephant grass and Leucaena plots. The N contents in Leucaena, elephant grass and guinea grass were higher and significantly different from cultivated and secondary forest. The soil properties under elephant grass, guinea grass and Leucaena plots had comparable performance in terms of % C and %N.

Table 1: Soil chemical properties in the surface soil (0-30 cm) under different land cover

Soil property	cultivated	Elephant grass	Guinea grass	Leucaena	Secondary Forest	CV %
BD (Mg m^{-3})	0.95^b	0.96b	0.92b	0.87a	0.84a	6.23

Carbon (%)	0.86b	2.44a	2.35a	2.44a	0.69b	28.98
SOC t C/ha	24.51b	70.26a	61.35a	63.69a	17.40b	
Total N %	0.08b	0.25a	0.24a	0.25a	0.07b	26.16

Mean with the same letter are not significantly different from each other (P<0.05).

Table 2: Differences in soil chemical properties Among Fallow type sub soil (30-60cm)

Soil property	cultivated	Elephant grass	Guinea grass	Leucaena	Secondary Forest	C V %
B.D (g/cm3)	0.94a	0.96a	0.90a	0.84b	0.84b	6.23
Carbon%	0.61c	1.70a	1.50a	1.96a	1.04b	28.12
SOCt C/ha	17.19c	48.96a	40.50a	49.38a	26.22b	

Mean with the same letter are not significantly different from each other (P<0.05

Discussion

Grasses such as elephant and guinea grass are common and have always been seen as problems in agricultural land in south western Nigeria. Their potential in improving SOC has not been exploited compared to legumes such as leuceana. High bulk density under cultivated land and elephant grass fallow could be attributed to effect of intensive mechanized cultivation and trampling of livestock during grazing. Higher carbon and Nitrogen percentages recorded under elephant grass and leucaena plant could be attributed to yearly large biomass being added to the soil. The operation was usually done to avoid pest and further infestation on adjacent arable land. The lowest SOC sequestration under secondary forest is attributed to its vegetation (creepers/thickets) which does not easily decompose. The yearly incorporation of the grasses resulted to significantly higher content of SOC stock than arable farm land. It has been reported that grasses add large amount of SOM in the soil (Scopel et al 2004) Soil organic C stock decreased in the subsoil except in the secondary forest where it appreciated by 50.72% (from 17.39 to 26.22t C/ha). It has been reported that keeping vegetation for a long time is essential to the improve SOC (Mehdi et al 2000). However, SOC stock from the grasses and Leuceana in the subsoil were significantly higher than SOC in cultivated land and in secondary forest. SOC in secondary forest increased above SOC stock in arable land by 70.49% in the subsoil. This confirms the findings that highly weathered soils of the tropics are characterized by a rapid decline in SOM when land is cleared for cultivation on a slash-burn crop sequence (Ogle et al., 2005; Jimenez& Lal, 2006)

Conclusions

The study shows that not only legumes can build SOC stock in the tropics but grasses also if well managed and ploughed back into the soil yearly. For SOC sequestration and maintenance, improved fallow or land cover types that are capable of recycling nutrient taken from the soil and atmosphere to build SOC should be an essential part of cropping systems. Elephant and guinea grass can serve as part of local sustainable agricultural system to minimize SOC losses and optimize inputs efficiency.

References

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