CONCENTRATION OF MACRO-NUTRIENTS IN LEAVES OF SOME AGROFORESTRY TREE SPECIES IN THE FOREST ARBORETUM OF THE FEDERAL UNIVERSITY DUTSIN-MA, NIGERIA

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Abstract

Soil nutrient declining is considered to be a major threat to food security and natural resource conservation in Sub-Saharan Africa. The study assessed macro-nutrients contents of some selected agroforestry tree species in the Forest Arboretum of the Department of Forestry and Wildlife Management, Federal University Dutsin-Ma, Katsina State, Nigeria. A plot of 50 m by 50 m was measured from the 2.5 hectares of Arboretum land area. The leafy biomass pruned include; Faidherbiaalbida(FA), Leuceanaleucocephala (LL), Senna siamea(SS), Gliricidiasepium (GS), Albizialebbeck (AL). The data were analyzed using the Analysis of variance (ANOVA) while, means were separated using the Fishers' Least Significant Difference (LSD) at P=0.05. Gliricidiasepium was observed to have significantly higher value (41.0 g/kg) in nitrogen, lower values (117.2 g/kg and 61.7 g/kg) in carbon to nitrogen ratio (C: N) and cellulose respectively.The result also revealed that Gliricidiasepium among other species had significantly higher values (41.0 g/kg, 460.10 mg/kg and 15.00mg/kg) in the macro nutrients viz-a-viz; nitrogen, phosphorus and sodium respectively.In conclusion, Gliricidiasepiumcontained appreciable amount ofchemical concentration and macro nutrients embedded in it that can enhance faster decomposition of the leafy biomass and higher release of nutrients, and is therefore recommended in soil replenishment strategies for crop improvement.

Keywords: *leafy biomass, decomposition, nutrients, arboretum, soil replenishment*

Introduction

From the very beginning of agriculture, many farmers maintained and actively included trees as part of their agricultural landscapes. Trees provide shade, shelter, energy, food, fodder and many other goods and services that enabled the farmstead to prosper(Oyebamiji*et al.,* 2013). For the first roughly two decades of agroforestry research, agroforestry scientists were mostly concerned with the sustainable production of agricultural goods, especially food and this line of research has lost none of its relevance (Oyebamiji*et al.,* 2014).

However, over the last decade, scientists have also become interested in the environmental services that agroforestry practices may provide to local and even global society by maintaining watershed functions, retaining carbon in the plant–soil system, and, most recently, by supporting the conservation of biological diversity (McNeely and Scherr, 2003; Schroth*et al.,* 2004).Trees in agroforestry systems have important uses such as holding the soil against erosion and improving soil fertility. Soil nutrient declining is considered to be a major threat to food security and natural resource conservation in Sub-Saharan Africa (SSA). According to Bationo*et al*. (2006), Africa loses US$4 billion per year due to soil nutrient declination. The problem is pervasive among mixed crop and livestock farming systems of the northern region of Nigeria where competing uses for crop residues such as livestock fodder or household fuel means are embraced; these could not sufficiently be enough to serve the purpose of replenishing the soil.

Nutrient replacement using mineral fertilizers is a limited option for many smallholder farming households of Nigeria. It is observed that, region with lowest mineral fertilizer application rates will experience, much lower crop yields than those using organic fertilizer (Morris *et al.,* 2007).Therefore, to improve soil quality and its improvement on crop growth and yield, incorporation of leafy biomass or litter which are decomposed primarily by microbial activities, and also by environmental factors such as temperature and precipitation, as well as litter quality and soil chemistry and physical conditions (Liu*et al*., 2006;Ajayi *et al*., 2007; Oyebamiji*et al.,* 2017a). However, since many farmers in Nigeria for example, cannot afford chemical fertilizers and even those who can afford, cannot access the fertilizer when needed, because they are relatively unavailable or scarce (Oyebamiji*et al.,* 2017b). Hence, the use of agroforestry tree species which fix nutrients can at least alleviate some of the problems of declining soil fertility and be used to complement the improvement of soil for better yield of crops (Oyebamiji *et al.,* 2017c).

Materials and Methods

Study Area

The research area was forest Arboretum of the Department of Forestry and Wildlife Management, Federal University Dutsin-Ma, Katsina State,Nigeria. The area lies between Latitude 8^0 29' N and Longitude 4^0 35' E, and 307 meter (above sea level), during the 2018 dry seasons. Dutsinma is characterized by an annual rainfall of 1,186 mm while the mean annual temperature and relative humidity are 29^0 and 85% respectively. The soil is well drained, and the order is Alfisols belonging to the Tanke series (23).The underlying geologist is made of sand stone ranging from fine to coarse grained light brown colour. The dominant soil types include; sand, silt, clay textural class(Tukur *et al.,* 2013).

Procedure

The species of plant material that were collected include; *Faidherbiaalbida, Leuceanaleucocephala, Senna siamea, Gliricidiasepium, Albizialebbeck.* A plot of 50 m by 50 m was measured and the trees were counted in the Arboretum of 2.5 hectares in custody of the Department of Forestry and Wildlife Management, Federal University Dutsin-Ma, Katsina State, Nigeria. Five trees were randomly selected from each selected tree species out of which the leaves were pruned. Each pruned leafy samples were pooled together, while their composite samples were then taken as the original sample for each of the selected tree species. The leafy biomass pruned were air- dried at room temperature and the sample was ground and sieved in a 2 mm size dimension sieve. Then, 2.0 g of each sample from the selected species were put into a digestion flask which was washed with distilled water.10 ml of 4 % perchloric acid ($HCLO_4$) was added to the samples under a fume cupboard. The contents was mixed and heated strongly on digestion block under the $HCLO_4$ fume cupboard.

The contents were allowed to cool and then 50 ml of distilled water were then added. The solution was transferred into a 100 ml Pyrex volumetric flask. The volume was made up to mark with distilled water. Then the solution was stored in plastic bottles and labeled for analysis. The digested sample solutions of the plants were subjected to laboratory analysis to determine the Total Nitrogen (N), Potassium (K), Calcium (Ca), Magnesium (Mg) and Sodium (Na) and recorded in part per million (ppm)). Total Nitrogen was determined by Macro-Kjeldahl method as described by Jackson (1958).

Tissue Analysis of the Leafy Biomass

The air-dried samples were taken to laboratory for chemical analysis. The ground samples wereanalysed for organic carbon content which was determined by wet oxidation method of Walkley-Black as described by Allison (1965). Total Nitrogen was analysed by Macro-Kjeldahl digestion, followed by distillation and titration (Brandstreet, 1965; Anderson and Ingram, 1993). The C: N ratio was computed as ratio of N to C. Available P was extracted by Bray 1 method. The P concentration in the extract was determined calorimetrically by using the Spectronic 20 and absorption was read-off as described by Bray and Kurtz (1945) and modified by Murphy and Riley (1962). Exchangeable base, Na, K, Ca and Mg were extracted using ammonium acetate. K was determined on flame photometer and Ca and Mg by Atomic Absorption Spectrophotometer.

Data Analysis

The data wereanalyzed using the Analysis of variance (ANOVA) at P=0.05 with the use of Statistical Analysis System (SAS, 2003) computer package. The means were separated using the Fishers Least Significant Difference (LSD) at P=0.05.

Results

Chemical Composition of the Leaves of Selected Agroforestry Tree Species

Gliricidiasepium was observed to have significantly higher value (41.00 g/kgin nitrogen, lower values (117.20 g/kg and 61.70 g/kg) incarbon to nitrogen ratio (C: N) and cellulose respectively. However, *Faidherbiaalbida*also had significantly lower values (54.10 g/kg, 2.40 g/kg, 15.00 g/kg and 15.00 g/kg) in lignin (L), polyphenol (PP), lignin to nitrogen ratio (L:N) and lignin plus polyphenol to nitrogen ratio (L+PP):N, while *Senna siamea*alsohad significantly lower values (151.40 g/kg and 86.10 g/kg) in lignin to polyphenol ratio (L:PP) and polyphenol to nitrogen ratio (PP:N)respectively (Table 1).

Concentration of the Macro-Nutrient Content in the Selected Agroforestry Trees Leafy Biomass

*Gliricidiasepium*was noted to have significantly higher values (41.00 g/kg, 460.10 mg/kg and 15.00 mg/kg) in nitrogen, phosphorus and sodium respectively. Furthermore,*Leuceanaleucocephala*and*Albizialebbeck* also had significantly higher values (2.30mg/kg and 13.40 mg/kg) in calcium and potassium respectively.However,*Senna siamea*had significantly lower value (0.70mg/kg) in magnesium(Table 2).

Comparative Amount of Macro-Nutrients (Phosphorus, Calcium and Magnesium) in the Leafy Biomass of the Selected Agroforestry Tree Species

Gliricidiasepium had significantly higher value (460.10mg/kg) in phosphorus, followed by*Senna siamea*

(420.62mg/kg) and the least was observed in *Faidherbiaalbida*(353.07 mg/kg). Furthermore, *Leucaena leucocephala* had significantly higher value (2.30 mg/kg), followed by *Senna siamea*(2.00 mg/kg), while the least was found in *Gliricidiasepium* with lower value (1.10 mg/kg).However, *Senna siamea* had significantly lower value (0.70mg/kg) in magnesium among other biomass examined (Figure 1).

Table 1 : Mean chemical composition/concentration of the selected leafy biomass of agroforestry tree species

Species	N	C	C:N	L	PP	L:PP	L:N	PP:N	(L+PP):N	Cellulose
FA	36.0b	774.3a	215.1a	54.1e	2.4c	222.6d	15.0e	148.1a	15.0e	121.6c
LL	32.0c	507.3d	158.6d	122.6b	3.7b	381.9b	38.3b	99.7d	39.3b	200.0a
SS	36.0b	587.5c	163.2c	63.3d	4.1a	151.4c	17.6d	86.1e	18.7d	121.6c
GS	41.0a	480.4e	117.2e	111.1c	3.2c	297.1c	27.1c	109.6c	28.0c	61.7d
AL	37.5b	747.6b	199.4b	155.8a	2.4d	542.9a	41.5a	130.7b	42.2a	173.3b

a, b, c, d, e:indicates means within rows with different superscript are significantly different at 5 % level ofprobability using Least Significant Difference (LSD).**FA:** *Faidherbiaalbida*; **LL:** *Leucaena leucocephala*; **SS:** *Senna siamea*; **GS:** *Gliricidiasepium*; **AL:** *Albizialebbeck,***N:** Nitrogen; **C:** Carbon; **C:N:** Carbon to nitrogen ratio; **L:** Lignin; **PP:** Polyphenol; **L:PP:** Lignin to polyphenol ratio; **L:N:** Lignin to nitrogen ratio; **PP:N:** Polyphenol to nitrogen ratio; **(L+PP):N:** Lignin plus polyphenol ratio nitrogen.

Table 2 : Mean concentration of macro nutrient in the selected leafy biomass of agroforestry tree species

Species	N (g/kg)	P (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	Na g/kg
FA	[illegible]	353.07±1.330e	10.20±0.015b	1.40±0.001bc	1.00±0.002a	0.70±0.029c
LL	32.00±0.115c	380.70±0.115c	7.50±0.018c	2.30±0.011a	1.00±0.001a	5.60±0.012b
SS	36.00±0.058b	420.62±0.123c	8.40±0.023c	2.00±0.058b	0.70±0.012b	0.80±0.006b
GS	41.00±0.012a	460.10±0.058a	2.00±0.058d	1.10±0.001c	1.00±0.001a	15.00±0.115a
AL	37.50±0.115b	370.20±0.058d	13.40±0.017a	1.20±0.001c	1.00±0.001a	6.20±0.012b

a, b, c, d, e:indicates means within rows with different superscript are significantly different at 5 % level ofprobability using Least Significant Difference (LSD). *FA: Faidherbiaalbida*; *LL: Leucaena leucocephala*; *SS: Senna siamea*; *GS: Gliricidiasepium*; *AL: Albizialebbeck*; *N:* Nitrogen; *P:* Phosphorus; *K:* Potassium; *Ca:* Calcium; *Mg:* Magnesium; *Na:* Sodium.

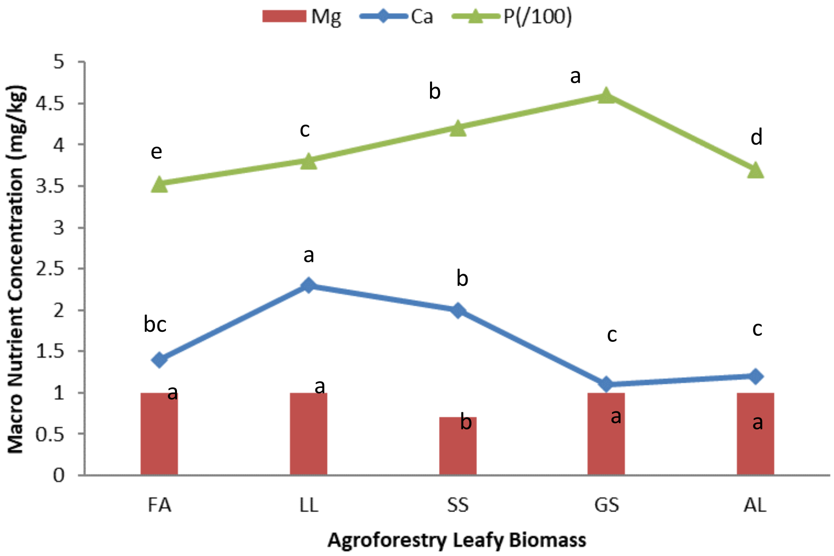

Figure 1. Comparison of amount of Macronutrients in the Selected Leafy Biomass Tree Species
FA: *Faidherbiaalbida;* ***LL:*** *Leuceanaleucocephala;* ***SS:*** *Senna siamea;* ***GS;*** *Gliricidiasepium; AL: Albizialebbeck.*

Discussion

The study revealed that the chemical composition of the selected leafy biomass showed that *Gliricidiasepium* among other biomass decomposed faster to release mineral nutrients due to its having more of nitrogen (N) contents and less carbon to nitrogen ratio (C:N) contents and cellulose respectively. The better performance of *Gliricidiasepium* in terms of nutrients release agrees with Oyebamiji*et al.* (2017a) who noted that the more the nitrogen content biomass or litter is having and the less its C:N the faster the decomposition of mineral nutrients and the faster the nutrient release for the use crop(s).The factors that are responsible for adequate decomposition and nutrient release of both the litter and leafy biomass in terms of lignin, polyphenol, cellulose etc revealed that, the lower the contents oflignin, cellulose, polyphenol, lignin to nitrogen ratio, lignin plus polyphenol to nitrogen ratio, lignin to polyphenol ratio and polyphenol to nitrogen ratio as it was observed both in *Faidherbiaalbida* and*Senna siamea* respectively resulted to their faster decomposition and nutrient release after *Gliricidiasepium*that was the leading biomass under this investigation to decompose and release nutrients faster. Decomposition and quick nitrogen release have been found to be enhanced by these factors (Liu *et al.,* 2006)

Though, the rate of nutrients release by the leafy biomass is established to differ from specie to species as it was earlier observed. This was equally found out when other agroforestry leafy biomass was used as test case in other ecological zones (Matheus *et al.,* 2013).Although, the results of the nutrients composition analysis of the leafy biomass were found to be significantly different from one biomass to another, however,*Gliricidiasepium, Leuceanaleucocephala* and *Albizialebbeck*were the excellent nitrogen fixers based on the litter quality among other biomass investigated(Budelman, 1990). The polyphenol content of the leafy biomass is generally low and still significantly different. Though, this might cause a faster release of the nitrogen content of the leafy biomass. Decomposition and quick nitrogen release have been found to be enhanced by lignin and polyphenol (Liu *et al.,* 2006). Furthermore,the higher macro nutrient experienced by *Gliricidiasepium*also borne out of its litter/biomass quality that is embedded in it as compare to other biomass examined. However, it is noteworthy that all the leafy biomass of the selected agroforestry species have significantly higher amount of the macro nutrient contents required to growth agricultural crops (Oyebamiji*et al.*, 2016).

Conclusion

In conclusion, Gliricidiasepium wasfound to be superior in terms of the chemical properties than other selected leafy biomass examined and contained significantmacro nutrients through biomass qualities embedded in it that enhance better and fasterdecomposition and higher nutrient release which are the factors necessary for consideration in soil replenishment and crop improvement programmes.

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