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Evaluation of Two Indigenous Multipurpose Shrub Species for Agroforestry Practices in Nigeria

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Abstract

Trees integrated with crops in time and space help nutrient cycling on farms by increasing the supply and availability of nutrient in the crop root zone and reducing nutrient losses. An analysis to determine the nutrient composition of two indigenous multipurpose shrubs (Uvaria chamae p. beauv and Icacina *trichantha oliv) of Akwa Ibom State, Nigeria, was conducted in the lowland rainforest agro-ecological zone. The roots and leaves of the shrubs were collected from the three agro-ecological (mangrove, freshwater swamp and lowland rainforest) zones and analysed for nutrient contents including the soils. Nitrogen content was determined using Kjeldahl method while phosphorus and potassium were determined by flame photometry method. The results indicated a great variability in the nutrient composition of the two species. Nitrogen content in the leaves and roots of Icacina trichantha was 2.78% and 1.17% while that of Uvaria chamae was 1.85% and 0.65% respectively. The percentage phosphorus composition in the roots of Icacina trichantha was 0.09% while that of Uvaria chamae was 0.07%. Whereas in the leaves sample, Uvaria chamae had phosphorus content of 0.10%, the percentage composition of potassium in Uvaria chamae was 0.09% while Icacina trichantha had 0.05% respectively. In the roots, Icacina trichantha and Uvaria chamae had 0.11% and 0.09% potassium content respectively. The two indigenous multipurpose shrubs contained essential nutrient sources for growth and high crop yield. It is therefore recommended that farmers could intercrop these species with food crops in their farmland to improved soil fertility.*

Key words: Evaluation, indigenous, multipurpose shrubs, agroforestry, Nigeria

Introduction

Agriculture is the major form of land use in Nigeria which has led to soil erosion and depletion of nutrient, thereby causing problems in farming systems such as agroforestry. Nitrogen-fixing trees with high fixing potential can be used in agroforestry systems for replenishing nitrogen which is the most limiting growth factor in the soil (Griller and Wilson, 1991). In the process of conceptualization of agroforestry, a number of issues and attributes have been advanced in the recent past. One of the most significant and often repeated among these is the suggested potential of agroforestry as a major practical land management alternative for maintenance of soil fertility and productivity in a variety of situations in the tropics.

Most African farmers practice low- input agriculture that depends on organic matter in the soil to sustain production. Soil organic matter plays an important part in establishing the intrinsic properties of a soil, which make plant growth possible. Soil organic matter helps sustain soil fertility by improving retention of mineral nutrients, increasing the water holding capacity of soil and increasing the amount of soil flora and fauna (Sanchez, 2002; Young, 1987). One fundamental principle of sustainability is to return to the soil the nutrient removed through harvests, runoff, erosion, leaching, denitrification and other loss pathways. According to Palm (1995) and Sanchez (1995), agroforestry is the growing of trees with crops and/or livestock on the same piece of land to promote a more efficient cycling of nutrients from litter to trees in natural ecosystems and the assumption that trees will likewise transfer nutrients to intercropped plants.

Continuous cropping and erosion reduce the level of soil organic matter and ultimately diminish soil productivity, thus prompting call for inclusion of nitrogen-fixing trees and shrubs in farming systems (Young, 1987; Nair, 1987b; Nair, 1984; Kumwenda and Coe, 1996). Low soil fertility is the major problem to food production and one of the key biophysical constraints to increase agricultural growth in sub-Saharan Africa (Sanchez 2002; Kwesiga and Coe, 2003; Vanlauwe and Giller, 2006). In tropical areas, inclusion of legumes in land cultivation plays an important role in the maintenance and improvement of soil fertility. Among the legumes are some indigenous species which their roots network are said to have active potentials in fixing nitrogen through the nodules in association with *rhizobia.* Indigenous legumes have also been reported as good intensive fallowing cover crops to regenerate the soil (Nair *et al*., 1984; Lundgren and Nair, 1985).

The decline in soil fertility has been caused by the breakdown of the traditional natural fallow system that farmers use to naturally replenish the fertility of their soils and low rate of the use of mineral fertilizer due to unaffordability and lack of timely access of the inputs by most small holder farmers. The problem of accessibility to fertilizer becomes more acute in Nigeria following the removal of fertilizer subsidies and the collapse of public farm inputs distribution channels. To tackle the problems associated with fertilizer subsidy removal, nitrogen fixing trees/shrubs in an agroforestry-based soil fertility replenishment practices have been integrated in farming systems in most African countries. These trees and shrubs have important role to play in the maintenance of soil fertility in agroforestry systems of which they form a part (Dommergues, 1987). The study therefore, was conducted to evaluate the nutrient contents in two indigenous multipurpose shrub species, with the ultimate aim of recommending them for incorporation in agroforestry practices.

Material and Methods

The Study Area

This study was conducted in the lowland rainforest agro-ecological zone of Akwa Ibom State, Nigeria. Akwa Ibom State lies within the tropical rainforest zone of Nigeria on latitude $4^o30^{'}$ and $5^o30^{'}$N and longitudes $7^o31^{'}$ and $8^o20^{'}$E (AKS, 1989). Rainfall of the area ranges from 2200mm to 3200mm per annum. The rain begins in March and continues till October with its peak in July and September. The dry season starts from November till February, while annual temperatures vary between 22.48^oC and 30.13^oC (AKS, 1989)

Sampling Technique and Sample Collection

Fresh leaves and roots sample of *Uvaria chamae p. beauv and Icacina trichantha oliv* samples was collected from fallow plots in three randomly selected local Government Areas of Akwa Ibom State, Nigeria. Three set of the samples were collected from each of the species and replicated in three sample Local Government Areas. The samples were taken to the faculty of basic medical (biochemistry) laboratory of university of Uyo for analysis. They were washed with distilled water without mixing them, and oven dried at 80^oC with Stuart-scientific oven 252 for 24 hours. After drying, the sample was ground with a grinder into powdery form and store in glass bottles, well labelled for analysis.

Statistical Analysis

All nutrient data were compared by analysis of variance using a randomized complete block design (RCBD). The variation among nutrient in both species were compared using ANOVA table to test for significant different at p=0.05.

Laboratory Procedure

Nitrogen Determination

One gram of the sample was accurately weighed into a standard 250ml kjeldahl flask containing 1.5g $CuSO_4$ and 1.5g of $NaSO_4$ as catalyst and 5ml concentrated H_2SO_4. The kjeldahl flask (digestion) was placed on a heating mantle and was heated gently to prevent frothing for some hours until a clear bluish solution was obtained.

The digested solution was allowed to cool and this was quantitatively transferred to 100ml standard flask and made up to the mark with distilled water. 20ml portion of the digest was pipetted into a semi micro kjeldahl distillation apparatus and treated with equal volume of 40% NaOH solution. The ammonia evolved was steam distilled into a 100ml conical flask containing 10ml solution of saturated boric acid to which two drops of tashirus indicator (double indicator) had been added.

The tip of the condenser was immersed into the boric acid double indicator solution and then the distillation continued until about 2/3 of the original volume was obtained. The tip of the condenser was rinsed with a few millilitres of distilled water in the distillate which was then titrated with 0.1MHCl until a purple-pink end point was observed. The blank determination was also carried out in the similar manner as described above except for the omission of the sample. The percentage nitrogen obtained by using the formula

Sample titre- blank titre/ weight of sample

Therefore, the chemical equation for the reaction to obtain nitrogen by Kjeldahl method was given as:

$2N\ (Leaf) + 4H_2SO_4 \rightarrow (NH_4)_2SO_4$

$(NH_4)_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O + 2NH_3\nearrow$

$2NH_3 + 2H_3BO_3 \rightarrow 2NH_4H_2BO_3$

Ammonium borate

$NH_4H_2BO_3 \rightarrow NH_4Cl + HBO_3$

I mole HCl= I mole of N=14gN

Analysis of Micro Nutrients

Micro nutrients were determined by flame photometry as outlined by (Associated of Official Analytical Chemists) AOAC (2004). Trioxonitrate (v) acid (HNO_3) and perchloric acid ($HCIO_4$) were used. Weighed ground samples of 1kg were put into digestion flask and 20ml of concentrated trioxonitrate (v) acid and 10ml of perchloric acid was added for digestion to take place in a hot plate until the colour turned white. The white colour indicated that the digestion was completed. The solution was allowed to cool, and then 30ml of distilled water was added. Visible spectro-photometer-cam-spec wavelength

325-900 was used for phosphorus determination while flame photometer-jenway was used for potassium determination.

Soil Analysis

Soil samples were collected from where the species were located using soil auger at the depth of 0-15cm. The soil samples were put in the polythene bags and labelled accordingly for laboratory analysis for soil pH, soil organic matter, EC, and the total nitrogen as described by (Bates and Navano, 1954; Murphy and Riley, 1962). In addition, exchangeable bases such as Ca, Mg, Na, K, exchangeable acidity, ECEC and base saturation was determined accordingly as described by Melean (1966). Subsequently, soil particle sizes of sand, silt, and clay was determined as described by Bouyoucous (1951). After, the samples were evenly spread out for air drying. The samples were sieved and put in a well labelled container for laboratory analysis.

Results

Table 1 shows the differences in nutrient (NPK) composition between *Uvaria chamae* and *Icacina trichantha.* The average total nitrogen composition obtained from the three replicated local government was 1.85% and 2.78% for *Uvaria chamae* and *Icacina trichantha* respectively. The percentage phosphorus content in the leaf were 0.10% and 0.07% for *Uvaria chamae* and *Icacina trichantha* respectively, while the percentage potassium composition in the leaf of *Uvaria chamae* and *Icacina trichantha* were 0.09% and 0.05% respectively. There were no significant difference ($p>0.05$) in NPK composition between the two plant species under consideration.

Table 1: Nutrients (NPK) composition of leaf of Two Indigenous Multi-purpose shrubs

SPECIES	NITROGEN%	PHOSPHORS%	POTASSIUM%
Uvaria chamae	1.85	0.10	0.09
Icacina trichantha	2.78	0.07	0.05

N/B values are means of three replicates of the two samples species.

Table 2 shows variation in nutrient (NPK) composition in the roots of two indigenous multipurpose shrubs species. The total nitrogen percentage obtained for *Uvaria chamae* and *Icacina trichantha* were 0.65% and 1.17% respectively. The percentage phosphorus was 0.07% and 0.09%, while potassium in percentage was 0.09% and 0.11% for *Uvaria chamae* and

Icacina trichantha respectively. There were significant differences ($p<0.05$) in the NPK composition between the two plant species under consideration.

Table 2: Nutrients (NPK) Composition in roots of two indigenous multipurpose shrubs

SPECIES	NITROGEN%	PHOSPHORUS%	POTASSIUM%
Uvaria chamae	0.65	0,07	0.09
Icacina trichantha	1.17	0.09	0.11

N/B values are means of the three replicates of the two sample species.

Table 3 indicates that the pH of the soil were 5.52 and 5.67 for *Uvaria chamae* and *Icacina trichantha* respectively whereas, exchange acidity were 2.64 and 2.52 while those of ECEC were 5.08 and 4.60 for *Uvaria chamae* and *Icacina trichantha*. The soil contain 1.27% and 1.02% of Ca, 0.11% and 0.14% of K, 0.93% and 0.88% of Mg, 0.05% and 0.05% of Na respectively for *Uvaria chamae* and *Icacina trichantha*. The organic matter content in the soil for *Uvaria chamae* and *Icacina trichantha* were 1.46% and 1.87% while those of available P were 144.44 and 161.93 for *Uvaria chamae* and *Icacina trichantha*. The contents of base saturation in the soil were 46.31% and 45.82% for *Uvaria chamae* and *Icacina trichantha* respectively. The quantity of sand silt and clay were 82.18% and 82.09%, 4.69% and 4.65% respectively while clay had 13.14% and 12.60% for *Uvaria chamae* and *Icacina trichantha* respectively.

Table 3: The Psycho-Chemical Properties of the soil at depth of 0.15cm

Soil Properties	*Uvaria chamae*	*Icacina trichantha*
Total N (%)	0.04	0.04
Organic Matter (%)	1.46	1.87
Avail. P (mg/kg)	144.44	161.93
K (Cmol/kg)	0.11	0.14
Ca (Cmol/kg)	1.27	1.02
Mg (Cmol/kg)	0.93	0.88
Na (Cmol/kg)	0.05	0.05
Exchange acidity (cmol/kg)	2.64	2.52
pH (ds/m)	5.52	5.67
ECEC (cmol/kg)	5.08	4.60
Base Saturation (%)	46.31	45.82
Sand (%)	82.18	82.09
Clay (%)	13.14	12.60
Silt (%)	4.69	4.65

Indigenous shrubs species of *Uvaria chamae* and *Icacina trichantha* had high percentage of nitrogen being 1.85% and 2.78% respectively, exotic species of *Leucaenae leucocephala* and *Gliricidia sepium* had 1.78% and 1.75% respectively (Table 4). These exotic species have traces of phosphorus (0.12%) and potassium (0.05%). However, both the exotic and indigenous tree species have the capacity to fix nitrogen. There were no significant difference ($p>0.05$) between the nutrient (NPK) contents of exotic and those of indigenous shrubs species

Table 4: Variation in nutrient content in the leaves between indigenous (sample spp.) and exotic species.

Exotic Leguminous tree Species				**Indigenous (Sample) Shrubs**			
Species	N	P	K	Species	N	P	K
Leucaenae leucocephala	1.78	0.12	0.55	*Uvaria chamae*	1.85	0.10	0.09
Gliricidia sepium	1.75	0.11	0.52	*Icacina trichantha*	2.78	0.07	0.05

Discussion

The comparison of the nutrient concentration results between indigenous multipurpose agroforestry shrubs species studied and values of exotic species obtained from literature indicated that *Icacina trichantha* contain the highest quantity of nitrogen. The implication of this is that, of all the tree species, *Icacina trichantha* could be utilized for the supply of N to augment soil nutrient through pruning. Leaf pruning from leguminous agroforestry tree species adds nutrients to the soil and improve soil fertility status to increase crop yield (Udofia, 2011). Young (1991) also stated the usefulness of multipurpose trees in soil fertility and soil conservation. The soil was low in total nitrogen, organic matter, available K except available P. this implies low soil fertility, and could have been caused by plant absorption. The pH of the soil indicates that the soil was slightly acidic. The nutrient released from roots was generally lower than from leaves as seen from the two shrubs (*Uvaria chamae and Icacina trichantha*) in West Africa by Lehmann *et al*., (1995). For efficient recycling, the leaves have to be returned through continuous pruning from indigenous multipurpose shrubs species but for P and K the roots could be more supportive under on-farm conditions. Thus there is need for farmers to understand how to manage these two plant species for nutrient fixation from above ground and below ground.

As reported by Ibedu *et al*., (1988), an increase in soil pH could adversely cause the unavailability of nutrient elements to crops. This can be corrected by liming using organic manure. However, maintaining high yield on a long-term could be feasible if agroforestry farms are permanently integrated with nutrient fixing trees such as *Uvaria chamae and Icacina trichantha* species.

Conclusion

Results of the study have evaluated that indigenous tree species could be used as fertilizers tree over the exotic ones. It also brought to the fore that indigenous plants can even contribute higher nutrient or recycle more nitrogen in the soil to improve crop yield than the so much talked-about exotics. The study also revealed that the leaves and roots do not supply same values of the different nutrients.

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