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Full Length Research Paper

Chemical composition of green foliage biomass of three agroforestry shrub species grown in Dello-menna district of Bale Zone, Southeast Ethiopia

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The main objective of any agroforestry system is the use of foliage/pruning biomasses as source of nutrients for crop production. Foliage biomass sourced from woody component shows considerable quality variation among species. Hence, better productive agroforestry land use remains on the identification and use of the desirable species foliage biomass perceiving higher quality. Study was designed to examine the quality of three agroforestry shrub species foliage biomass based on macronutrient and common chemical quality index composition. The studied species were *Cajanus cajan*, *Sesbania sesban* and *Flemingia macrophylla*. To do so fully mature green foliage with petioles was collected from all crown parts of mother plants. The collected foliage biomass was analyzed for their macronutrient (N, P, K, Ca, Mg, C) and quality indices (Cellulose, Hemicellulose, Lignin, LCI and poly-phenol) compositions. Results from statistical analyses showed a significant (p<0.05) variations among species except for poly-phenol. In this respect the composition ranged from 2.13 to 2.74% for N, 0.33 to 1.28% for P, 0.4 to 1.04% for K, 0.3 to 1.72% for Ca, 0.21 to 0.24% for Mg, 45.08 to 47.25% for C, 13.7 to 23.6% for hemicellulose,1.85 to 14.53% for cellulose,7.71 to 22.3% for lignin, 0.33 to 0.38% for LCI, 0.6 to 0.86% for poly-phenol, 0.1 to 0.74% for tannin, 13.29 to 17.15% for crude protein and 16.44 to 22.43% for C/N ratios. The observed variation may be due to the species inherent physiological ability in the rate of nutrient uptake from soil. In the study foliage biomass sourced from S.sesban was identified as highly suitable species with regard to crop nutrient supply followed by C.cajan and F.macrophylla respectively.

Keywords: *Cajanus cajan, Flemingia macrophylla, Sesbania sesban*, Quality indices, Nutrient

BACKGROUND AND JUSTIFICATION

Population growth, natural resource degradation and the concomitant need to increase food production are the major challenges in the mid and low altitude areas of Bale. In order to meet the requirements of an increasing population natural resources have been exploited at an alarming rate. A notable example is the devastation of *Combretum- terminalia* woodland and fragmentation of *Harenna forest* of Berbere and Dello Menna districts, respectively. Due to this, the area is experiencing a decrease in overall agricultural land productivity being the decline of soil fertility as the fundamental problem. The integration of tree/shrub into agricultural landscape has long been suggested as an alternative approach to solve soil fertility problem (Madalcho and Tefera, 2016). The common mechanism in which tree/shrub species enrich soil fertility is via addition of their biomasses mainly prunings (foliage) and also roots.

Foliage of tree/shrub species are classified into high quality, intermediate-high quality, intermediate-low quality and low quality (Palm *et al*. 2001). According to the Authors high quality green biomass contains N > 2.5%, lignin < 15% and polyphenol < 4%; intermediate-high quality green biomass contains N > 2.5%, lignin > 15% or polyphenol > 4%; intermediate-low quality green biomass

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contains N < 2.5%, lignin < 15% and polyphenol < 4%; and low quality green biomass contains N < 2.5%, lignin > 15% or polyphenol > 4%. High quality foliage materials are directly incorporated in the soil as a nutrient source for annual crops, while materials of intermediate quality are applied together with high quality or are composted and low quality materials are applied to the soil surface for erosion control.

However, the composition strongly varied over environmental conditions under which the species are grown. Soil fertility in particular is considered as the most important environmental factor controlling chemical composition of plant tissue (Kindu *et al.,* 2008: Kiros *et al.,* 2015). This shows understanding foliage chemical composition of agroforestry species that are grown under certain environment is needed as this is helpful for the development of better productive agroforestry land use system. With this understanding, this study is designed to evaluate the chemical composition of three agroforestry species foliage grown in Dello-Menna district.

Objectives

- To study the macro-nutrient composition (C, N, P, K, Ca, Mg) of the species foliage biomass
- To study quality indices composition of the species foliage biomass

MATERIALS AND METHODS

Study area

The experiment was conducted at Burkiti kebele located in Dello-Menna district of Bale zone, Southeast Ethiopia. Dello-menna receives mean annual rainfall and temperature 986.2mm and 22.5^{o}C respectively. Nitisols is the dominant soil in the area, and is characterized by its color, reddish brown clay towards the higher altitudes and tends to red-orange sandy soil towards the lower altitudes.

Experimental Procedures

Foliage collection and sample preparation

The collection and preparation of foliage biomass was undertaken to employ a standard woody perennial's plant tissue sampling procedure (Benton, 1998). Representative of most recent and fully developed live foliage biomass was collected from identified mother plant. Collected samples labeled with code and kept separately in paper bags. Then, samples are taken to laboratory, to where they were further processed and prepared for chemical analyses.

Chemical Analyses

The analyses were undertaken following standard analytical procedures for each parameter. Accordingly, Cellulose, Hemicellulose and Lignin contents are determined by using three sequential heating fiber extraction methods (Anderson and Ingram, 1963). The methods sequenced as neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid determined lignin (ADL). With this NDF method separates the soluble and insoluble fibers, providing a total of cellulose, hemicellulose and ADL. The ADF method was used to estimate cellulose and ADL. The difference between NDF and ADF provides the amount of hemicellulose. Lignin was extracted from ADL after being heated in strong acid (72% H_2SO_4) as this fractionates ADL into ash and lignin. Thereafter Lignocellulosic index (LCI) estimated using Herman *et al.* (2008) mathematical equation as shown below whereas total phenol and tannin determined by Folin-Denis (Claudia *et al.,* 2008) and Vanillin (Hagerman, 2002) methods, respectively.

$$\mathrm{LCI} = \frac{(\mathrm{Lignin})}{\mathrm{Lignin} + \mathrm{Cellulose} + \mathrm{Hemicellulose}} \qquad \text{equation (1)}$$

For the determination of cations dry ashing of plant tissue technique is used. In the course one gram milled foliage biomass was then weighed in to a crucible and precalcinated in hot plate. Then it was transferred into Muffle Furnas and calcianted at 450 o C for 3 hours followed by cooling and dissolving in 20ml, 20% nitric acid while it was in the crucible. Then, it was heated to boil, stirred carefully, and then filtered into 100ml volumetric flask making up to the mark with distilled water. Phophorus in the extract was determined by Uv-spectrophotometer whereas was by flame photometre. Quantities of Ca and Mg determined by atomic absorption spectrophotometer, and N and CP by the Kjeldahl distillation method (CP = N * 6.25). In the study fifty percent of the ash free dry matter was considered as organic carbon (Wassie and Abebe, 2013).

Statistical Analyses

Data collected from the experiment was analyzed using Genstat (15th ed.) software. The method used to compare treatment means was Fisher's protected least significant difference (LSD). Results declared as statistically different at 5% level of error tolerance.

RESULTS AND DISCUSSION

Macronutrient Composition of the Studied Species Foliage Biomass

As the results obtained from Analysis of variance (ANOVA) the macronutrient composition of foliage biomass significantly ($p < 0.05$) varied among the species. The level of Carbon composition was found maximally in *F.macrophylla* foliage followed by *C.cajan* and *S.sesban* respectively (table 1). Amount of Nitrogen in foliage materials of the species ranged from 2.13 to 2.74% indicating the lowest composition in *F.macrophylla.* The reported N composition in *F.macrophylla* is also below the critical level (N< 2.5%), in

Table 1. Nutrient composition of the species foliage biomass (n = 9).

Chemical parameters	Species		
	C.cajan	*S.sesban*	*F.macrophylla*
Carbon	45.8b	45.08a	47.25c
Nitrogen	2.65b	2.74b	2.13a
Phosphorus	1.28c	0.404b	0.33a
Potassium	0. 9b	1.03c	0. 4a
Calcium	1.72c	0.50b	0.30a
Magnesium	0.124b	0.123b	0.121a

Means with different letters within a row are significantly different ($p < 0.05$).

which N immobilization is expected during decomposition process (Munthali *et al.,* 2015). However, the overall mean composition of N (2.506%) of the tested species was tended to be higher than overall mean composition of N (0.25%) recorded for most legume cover crops (Gachene *et al.,* 2012). The variation may attribute to species, stage of sampled material, soil type and climatic factors.

With respect to Phosphorus (P) significantly higher amount was reported in *C.cajan* foliage biomass followed by *S.sesban* and the least in *F.macrophylla*. The P content of the studied species is higher than the P content (0.15 - 0.29%) reported for leguminous trees (Palm *et al.,* 2001). Other studies conducted on *Erythrina abyssinica and H.abyssinca species* P content was higher than of P content of tropical woody plant species (Wassie and Abebe, 2013). Moreover calcium and magnesium composition recorded for the three species followed an increasing order of *F.macrophylla*, *S.sesban and C.cajan.*

Quality indices characteristic of the Three Species Foliage biomass

Quality index composition of foliage biomass was also characterized. Indeed, with the exception of total-phenol ANOVA test has showed significant differences ($p < 0.05$) in cellulose, hemicelluloses, lignin, LCI, tannin, crude protein and C/N ratio among species. The composition of Cellulose, lignin, LCI and tannin were found significantly higher in *F.macrophylla* foliage biomass as they were the least in the case of *S.sesban* foliage (table 2). Oppositely crude protein and Nitrogen compositions in *S.sesban* foliage biomass was significantly higher of than *C.cajan* and *F.macrophylla* species. Such a higher amount of protein and nitrogen in *S.sesban* foliage is likely to be highly suitable as feed sources beyond crop-nutrient supply. Considerably lower tannin composition in *Sesbania* foliage is also an indication of the species potential as feed supplement for livestock production. This is because tannins at higher concentration affect the enzyme activities of rumen bacteria (Gebeyew *et al.,* 2015).

Depending upon nitrogen, lignin and polyphenol composition the quality of *S.sesban* foliage biomass was classified as high (N>2.5, Lignin <15 and Polyphenol <4%) quality class whereas *F.macrophylla* was confirmed as the lowest quality among the species. This has shown in line with the decision guideline developed by Sanginga and Woomer (2009) on how to use organic materials for integrated soil fertility management, foliage of *S.sesban* should be directly incorporated into the soil prior composting against to *F.macrophylla* and *C.cajan*.

Summary

In agroforestry system crop-nutrient demand can be achieved via the addition of tree/shrub species biomass input, mainly foliages. The relative quantities of nutrients in these materials vary greatly depending on species type, management practices, soil characteristics and climate. Therefore, understanding tree and shrub species biomass quality based on their chemical composition is needed as this enhance the productivity of agroforestry land use. A study was planned to evaluate the chemical composition of foliage biomass of three Agroforestry shrub species grown in Dello-Menna district of Bale zone, Southeast Ethiopia. In the study, thirty six mother plants from each species (108 mother trees in total) randomly selected and identified as experimental plot. Then, fully mature green leaves with petiole (foliages) collected from all crown parts of identified mother plants. Following the identification samples of foliage biomass were collected, labeled with codes and kept in a separate paper bags. Thereafter samples taken to laboratory, to where they were further processed and prepared for chemical analyses. Then, the analysis was undertaken employing standard of woody perennial's plant tissue analytical techniques.

Results showed the levels of chemical composition considerably ($p < 0.05$) varied among the three species except for Phenol. In this regard, the composition ranged

Table 2. Quality index characteristics of the studied species foliage biomass (n = 9).

Quality index parameters	Species		
	C.cajan	*S.sesban*	*F.macrophylla*
Hemicellulose	19.88b	13.70a	23.60b
Cellulose	13.94b	1.85a	14.53b
Lignin	16.63b	7.71a	22.30c
LCI	0.33b	0.329a	0.388c
Polyphenol	0.86 a	0.6 a	1.47a
Tannin	0.215b	0.103a	0.736c
Crude protein	16.57b	17.15b	13.29a
Carbon/Nitrogen	17.66a	16.44a	22.43b

Means with different letters within a row are significantly different ($p < 0.05$).

from 2.13 to 2.74% for N, 0.33 to 1.28% for P, 0.4 to 1.04% for K, 0.3 to 1.72% for Ca, 0.21 to 0.24% for Mg, 45.08 to 47.25% for C, 13.7 to 23.6% for hemicellulose,1.85 to 14.53% for cellulose,7.71 to 22.3% for lignin, 0.33 to 0.38% for LCI, 0.6 to 0.86% for poly-phenol, 0.1 to 0.74% for tannin, 13.29 to 17.15% for crude protein and 16.44 to 22.43% for C/N ratios. These infer the studied species have sufficient crop-nutrient provision potential falling within different quality class categories. Indeed, foliages biomass of *S.sesban* was found as high quality organic material whereas *F.macrophylla* foliage biomass confirmed in the lower quality category. Therefore, if foliage biomass sourced from *S.sesban* aimed to be used as source of crop nutrients in agroforestry land use, it has to be directly incorporated into soil prior composting.

REFERENCES

Anderson, J. M. and Ingram, J. S., 1993. Tropical soil biology and fertility: A handbook of methods, 2nd ed. Wallingford, UK: CAB International.

Benton Jones, 1998. Field sampling procedures for conducting a plant analysis. In: Yash Kalra (ed.); Handbook of reference methods for plant analysis: 25 - 34.

Claudia Anesini, Graciela Ferraro and Rosana Filip, 2008. Total polyphenol content and antioxidant capacity of commercially available tea in Argentina. *Journal of Agricultural and Food Chemistry*, 56: 1925 - 1929.

Gachengo. C., Vanlauwe.B., and Palm, 2012. Mineralization pattern of selected organic materials.

Gebeyew K, Beriso K, Mohamed A, G/silassie G, and Melaku S, 2015. Review on the Nutritive Value of Some Selected Acacia Species for Livestock Production in Dryland Areas. J Adv Dairy Res. 3: 139. doi:10.4172/2329-888X.1000139

Hagerman, 2002. Tannin extraction Hand book, Miami University, Oxford.

Herman, J., Moorhead, D., Berg, B., 2008. The relationship between rate of lignin and cellulose in aboveground litter. *Journal of Soil Biology and Biochemistry*, 40: 2620 - 2626

Jiregna Gindaba, Mats Olsson and Fisseha Itanna, 2004. Nutrient composition and short term release from *Croton macrostachyus* and *Millettia ferruginea* leaves. *Journal of Biology and Soil Fertilit*y, 40: 393 - 397

Kindu, M., Glatzel, G., Sieghardt, M., Birhane, K. & Taye, B. 2008. Chemical Composition of the Green Biomass of Indigenous Trees and Shrubs in the Highlands of Central Ethiopia. Journal of Tropical Forest Science 20(3): 167–174

Kiros Getachew, Fisseha Itanna and Abraham Mahari, 2015. Evaluation of locally available fertilizer tree/shrub species in Gozamin Woreda, North Central Ethiopia. *Research Journal of Agriculture and Environmental Management*, 4(3): 164 - 168.

Madalcho AB and Tefera MT, 2016. Management of Traditional Agroforestry Practices in Gununo Watershed in Wolaita Zone, Ethiopia. Journal of Forestry Research 5(1):163

Munthali, M.G., Gachene, C. K., Karanja, N.K. and Sileshi, G.W., 2015. Decomposition rate and nutrient release pattern of *Tephrosia vogelii* and *Tephrosia candida* residues in Malawi. *Journal of Plant Science and Ecology*, 1(2): 26-35.

Palm, Gachengo, Delve,Cadisch and Giller, 2001. Organic inputs for soil fertility management in tropical agroecosystem. Journal of Agriculture, Ecosystem and Environment, 83:27- 42

Sanginga, N. and Woomer, PL.(eds), 2009. Integrated Soil Fertility Management in Africa: Principles, Practices and Developmental Process. Tropical Soil Biology and Fertility Institute of the International Center for Tropical Agriculture, Nairobi. 263 PP.

Wassie Haile and Abebe Abay, 2013. Potential of local plants as a source of N P K on small holder fields in southern Ethiopia: Working paper.4