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Chemical Characteristics of Six Woody Species for Alley Cropping

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Summary

Leaves of six woody species (Leguminosae) for alley cropping have been chemically analysed in order to evaluate their potentiality in the restoration of soil fertility. These species are: Acacia mangium, Cajanus cajan, Flemingia grahamiana, F. macrophylla, Leucaena leucocephala *and* Sesbania sesban. *Nitrogen, carbon, cellulose, hemicellulose, lignin, active fraction and ash contents were determined as well as C/N and L/N ratios. All these species appear to be rich in N and C. Fiber contents (cellulose, hemicellulose and lignin) are globally low but variable from one species to another. C/N and L/N ratios are globally low. Among these species,* Leucaena leucocephala *and* Senna spectabilis *show the lowest C/N and L/N ratios. Such low values of C/N and L/N are normally found in species with rapid decomposition of organic matter.*

Résumé

Les feuilles des six espèces ligneuses de la famille des légumineuses utilisées dans les cultures en couloirs ont fait l'objet d'analyses chimiques afin d'évaluer leur potentialité dans la restauration de la fertilité du sol. Il s'agit d'espèces suivantes: Acacia mangium, Cajanus cajan, Flemingia grahamiana, F. macrophylla, Leucaena leucocephala et Sesbania sesban. *Les teneurs en azote, carbone et fibres (cellulose, hémicellulose et lignine) ainsi que la fraction active et les rapports C/N et L/N ont été déterminées. Toutes les espèces étudiées sont caractérisées par des teneurs élevées en azote et en carbone. Celles en fibres sont globalement basses mais variables d'une espèce à l'autre. Les rapports C/N et L/N sont globalement bas, ce qui implique des taux de décomposition de la matière organique très élevés. Toutefois, parmi ces espèces,* Leucaena leucocephala *et* Senna spectabilis *présentent les plus faibles rapports C/N et L/N. De telles valeurs caractérisent normalement les espèces végétales dont la matière organique se décompose très rapidement.*

Introduction

In Africa, shifting cultivation was an agricultural popular practice. In this traditional system, an area of forest was cleared and burned for cultivation. The area was cropped intensively for two or three years until its fertility began to decline. After this, the site was abandoned, giving the natural successional vegetation time to return and to restore soil fertility (9,10). Today, shifting cultivation appears as an unadapted agricultural practice because of increased pressure on land due to many factors such as increased population, mechanisation and a more commodity oriented economy. Farmers are now cultivating their land for longer periods, which progressively makes soil poor in mineral nutrients.

One of the ways to restore soil fertility and to exploit rationaly rain forest areas is to practise agroforestry. This represents an approach to integrated land use involving the combination of trees or shrubs with crops (4,5). The role of such trees or shrubs is both productive and protective. The productive role includes production of food, fodder, firewood and various other products. One of the most interesting agroforestry technologies is the hedgerow intercropping in crop production fields. This is known as alley cropping (4,15). This practice involves growing arable crops in the spaces or alleys between tree hedgerows. The trees are pruned periodically during the cropping season to prevent shade and provide green manure to the arable crop. Leaves and twigs are then applied to the soil as mulch and nutrient sources, and bigger branches used as firewood or stakes (12,13). Alley cropping is a cheaper and affordable technology by developing countries, fertilizers being more expensive (7). The protective role of woody

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species (trees or shrubs) in agroforestry results from their functions in soil fertility and conservation. There are several ways through which woody species could improve soil conditions: fixation of athmospheric nitrogen (especially leguminous woody species), addition of organic matter through litterfall and dead and decaying roots, modification of soil porosity and infiltration rates leading to reduced erodability of soil and improvement of the efficiency of nutrient cycling within the soil plant system (11).

Although all the trees have potential role in agroforestry, the leguminous woody species (Leguminosae) are the most important because of their economic uses as well as ecological adaptability. Moreover, they have the added advantage because of their capability for nitrogen fixation. In this study, six leguminous woody species which can be used for alley cropping are chemically analysed. The aim of the study was to compare the chemical characteristics of their leaves and evaluate their potentiality in the restoration of soil fertility.

Material and methods

Leaf samples of the following six legume woody species for alley cropping were chemically analysed: *Leucaena leucocephala, Flemingia grahamiana* and *Cajanus cajan* from Kisangani (R.D.C.-Kinshasa), *Senna spectabilis, Acacia mangium* and *Flemingia macrophylla* from Brazzaville (Congo-Brazzaville). These chemical analysis were carried out in the Laboratory of Soil Biology and Fertility of KUL (Katholieke Universiteit van Leuven, Belgium) in 1992. Nitrogen (N), carbon (C), cellulose, hemicellulose, lignin (L), active fraction and ash contents were determined. All the results are expressed in per cent of dry matter and summarised in Table 1.

Leaf samples were dried at 60°C until constant weight, then crushed before chemical analysis. Total carbon was analysed according to AMATO's method (1). Total nitrogen was analysed using Kjeldahl method, at the rate of three repetitions for each species. In each case, about 50 mg of powder was weighed. The determination of cellulose, hemicellulose and lignin was done following the method described by Van Soest and Wine (14). Ash content was determined by calcination at 550°C. The active fraction was calculated as follows:

Active fraction = 100%-(Cellulose + Hemicellulose + Lignin + Ash).

Finally, C/N and L/N ratios were calculated in order to assess the rate of leaf decomposition.

Results

Ash content

As shown in Table 1, ash content does not vary much from one species to another (low coefficient of variation). It ranges between 4% and 5.7% in *Flemingia*.

Nitrogen and carbon contents

Nitrogen and carbon contents are globally high and less variable from one species to another. Nitrogen content ranges from 3.04% in *Acacia mangium* to 4.18% in *Senna spectabilis*, whereas carbon content ranges between 49% in *Leucaena leucocephala* and 55.6% in *Senna spectabilis*.

Cellulose, hemicellulose and lignin contents

Cellulose content is highly variable from one species to another. Of the species studied, *Leucaena leucocephala* is the poorest in cellulose (7.5%) while *Flemingia grahamiana* is the richest (28.0%). Hemicellulose content also varies from one species to another. The least content was found in *Senna spectabilis* (3.6%), whereas the highest in *Leucaena leucocephala* (17.4%). As for cellulose and hemicellulose, lignin content is also variable from one species to another, ranging from 4.1% in *Senna spectabilis* to 24.1% in *Cajanus cajan.*

Active fraction content

The active fraction does not vary much with species. It is particularly high in *Leucaena leucocephala, Flemingia grahamiana, Acacia mangium* and *Senna spectabilis* with content values ranging between 53.1% and 73.0%. Such high values indicate that the organic matter of these species can decompose rapidly. The lowest *spectabilis* with content values ranging between 53.1% and 73.0%. Such high values indicate that the organic matter of these species can decompose rapidly. The lowest values are found in *Flemingia grahamiana* (42.7%) and *Cajanus cajan* (40.9%). In these cases, the decomposition rate of organic matter is comparatively low.

Table 1
Chemical characteristics of leaves of six woody species of Leguminosae for alley cropping

Species	Cellulose	Hemi-cellulose	Lignin	Ash	Active fraction	C	N	C/N	L/N
	Contents in % of dry matter								
Leucaena leucocephala	7.5	17.4	13.1	9.2	53.1	49.0±3.55	4.06±0.30	12.1	3.2
Flemingia grahamiana	28.1	6.3	18.9	4.0	42.7	54.3±3.72	3.28±0.02	16.6	5.8
Flemingia macrophylla	21.4	5.2	7.4	4.7	61.3	49.8±1.39	3.48±0.04	14.3	2.1
Acacia mangium	20.6	7.3	4.7	4.6	62.8	53.9±2.76	3.04±0.03	17.7	1.5
Senna spectabilis	13.8	3.6	4.1	5.5	73.0	55.6±1.50	4.18±0.04	13.3	1.0
Cajanus cajan	22.5	10.4	24.1	5.7	40.9	51.7±1.27	3.59±0.04	14.4	7.0
Average	19.0	8.4	12.1	5.6	55.6	52.4	3.6	14.7	3.4
Coefficient of variation (cv)(%)	38	59	67	33	22	5	12	14	71

For Cellulose, Hemicellulose and Lignin, n=6; for Ash, C and N, n=3 (n = number of analysis).

C/N and L/N ratios

C/N ratios are globally low and less variable from one species to another, ranging from 12.1 to 17.7. The lowest values are found in *Leucaena leucocephala* and *Senna spectabilis* whereas the highest in *Flemingia grahamiana* and *Acacia mangium*.
L/N ratios are also globally low but variable from one species to another, lying between 1.0 and 7.0. Such C/N and L/N values indicate high decomposition rates of organic matter, especially for *Senna spectabilis* of which L/N ratio is very low.

Discussion and conclusion

This study aimed at analysing chemical characteristics of leaves of six legume woody species used in alley cropping agricultural system. All the species studied are characterised by high nitrogen (≥3%) and carbon (±50%) contents but low C/N ratios. High nitrogen contents can be explained by the fact that all of these species belong to the family Leguminosae which includes numerous nitrogen fixing tree species, as pointed out by Nair et *al.*(11). Nitrogen content is however higher in *Senna spectabilis* (4.18%) and *Leucaena leucocephala* (4.06%) while carbon content is higher in *Flemingia grahamiana* (54.3%) and *Senna spectabilis* (55.6). Likewise, chemical analysis done one *Leucaena leucocephala* in Nigeria (6) and Tanzania (8) also showed high contents in nitrogen: 4.33% and 4.3% of dry matter respectively.

Cellulose, hemicellulose and lignin contents are highly variable from one species to another. L/N ratios are globally low and highly variable with species, while the active fraction is high and less variable. Such results indicate that organic matter from all the species studied decompose rapidly. However, the decomposition rate of organic matter varies from one species to another.
It appears, from this study, that all the species studied can play a great role in alley cropping agricultural system. They show globally high nitrogen and carbon contents and low C/N and L/N ratios. This, consequently, indicate their potential use as natural organic fertilizers, essentially in developing countries. Because of their high decomposition rate of organic matter, they can release rapidly mineral nutrients to the soil and restore its fertility (5,6). Among the species studied, *Leucaena leucocephala* and *Senna spectabilis* appear qualitatively as the most interesting ones because of their high nitrogen content and low C/N and L/N ratios.

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