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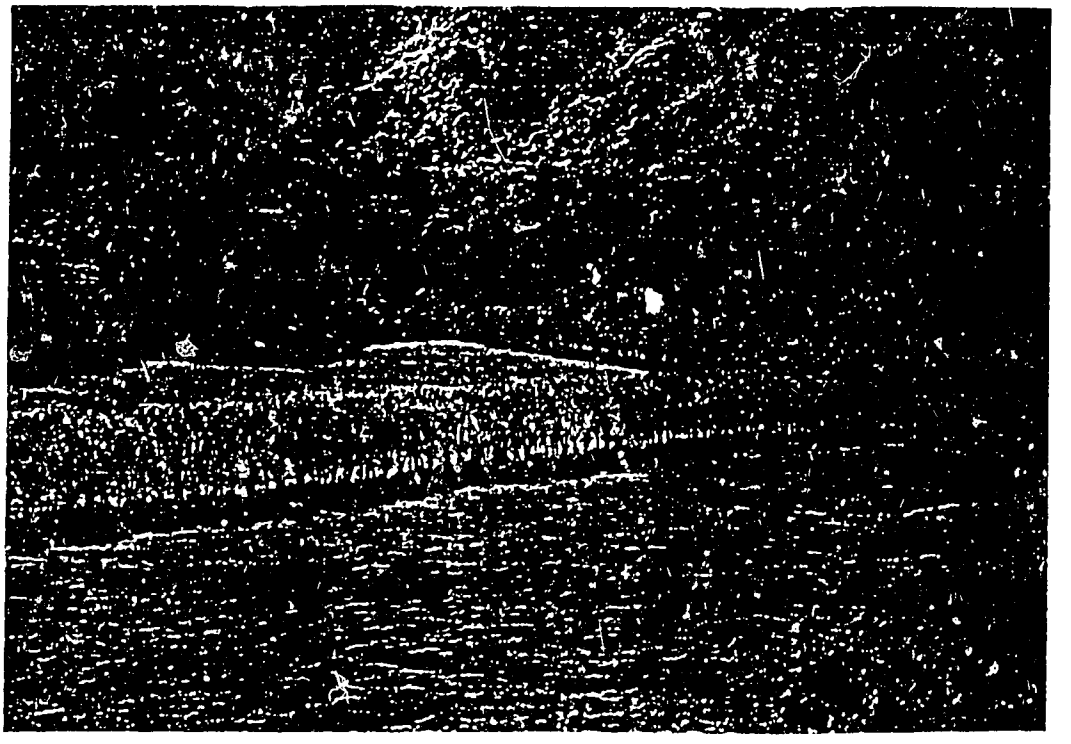

# *GLIRICIDIA SEPIUM* (JACQ.) WALP.: MANAGEMENT AND IMPROVEMENT

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# SCREENING OF LEGUMINOUS TREES FOR ALLEY CROPPING ON ACID SOILS OF THE HUMID TROPICS[3]

**Abstract**

Several factors need to be taken into account when selecting the appropriate tree for an alley cropping system. Some of these factors pertain to the environment and general adaptation to the climate and soils. Other factors are specific to characteristics of the trees, such as biomass production, response to pruning, rates of decomposition, and rooting patterns. In this paper we present preliminary results on screening for species for alley cropping on acid soils. Specific studies on decomposition and nitrogen mineralization and rooting patterns are described. In general, we have found that species native to the region perform better in terms of survival and biomass production than exotic species. Decomposition and nitrogen mineralization are greatly affected by leaf quality. This is important and should be taken into account for timing pruning applications to coincide with crop uptake patterns. Competition from the roots of the hedgerow can drastically reduce crop yields. The distribution patterns of tree roots should be determined for choosing appropriate alley widths.

# SELECCION DE ARBOLES LEGUMINOSEOS PARA CULTIVOS EN CALLEJON SOBRE SUELOS ACIDOS DE LOS TROPICOS HUMEDOS

**Resumen**

Varios factores tienen que ser tomados en cuenta, cuando se seleccionan los árboles apropiados, para un sistema de cultivos en callejón. Algunos de esos factores, están relacionados al medio ambiente, y adaptación general al clima y suelos. Otros factores son específicos a las características de los árboles, tales como producción de biomasa, respuesta al podado, grados de descomposición y patrones de desarrollo de raiz. En este papel, presentamos los resultados preliminares de selección, para especies usadas en cultivos de callejón, sobre suelos ácidos. Son descritos, estudios específicos sobre la descomposición y mineralización de nitrógeno y patrones de desarrollo de la raiz. En general, hemos encontrado, que las especies nativas de la región, se comportan mejor en términos de supervivencia y producción de biomasa que las especie exóticas. La descomposición y mineralización del nitrógeno son grandemente afectadas por la calidad de las hojas. Esto es importante, y debe ser tomado en cuenta para escoger el mejor tiempo de la aplicación del podado, para que coincida con los patrones de recogido de la cosecha. Competencia originada por las raices de las filas de los bordes, puede reducir drásticamente el rendimiento de cosechas. Los patrones de distribución de las raíces de los árboles, debe ser determinada, escogiendo en forma apropiada el ancho de los callejones.

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[3] Contribution of the Tropical Soils Program conducted jointly by the Instituto Nacional de Investigacion y Promocion Agropecuaria of Peru (INIPA) and North Carolina State University with funding from TropSoils and the International Development and Research Centre of Canada.

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## Introduction

Nitrogen-fixing trees are being screened throughout the tropics for potential use in agroforestry systems (Nair et al., 1984). *Leucaena leucocephala* has proven itself in terms of biomass and nitrogen production for alley cropping, forage and fuelwood production (NAS, 1977). However, this success was not realized on acid soils, which comprise 93% of the soils of the humid tropical America (Cochrane and Sanchez, 1982). Recent research has revealed several species, including *Gliricidia sepium*, that may be productive on acid, infertile soils. Undoubtedly, several more useful species will be discovered.

The choice of the appropriate N-fixing tree to use will depend on several factors such as climate, soil type, and the particulars of the agroforestry system. Characteristics to consider in selecting species for alley cropping include biomass production, response to pruning, nitrogen content, rate of decomposition, nitrogen mineralization, and root distribution and biomass.

This paper presents a summary of work being conducted in Yurimaguas, Peru, on the selection and use of nitrogen-fixing trees for alley cropping systems. In addition to general screening trials for tolerance to acid, infertile soils, above-ground biomass production and response to pruning, we have specific studies on the rates of decomposition of the leaves and root distribution of the leguminous trees.

## Site Description

Yurimaguas Experiment Station is located at an altitude of 182 m in the upper region of the Peruvian Amazon (longitude 76° 5' W, latitude 5° 45' S). The climate is humid tropical with an average annual temperature of 26.3° C. Rainfall averages 2100 - 2300 mm annually and is fairly evenly distributed, although a short dry season often occurs in June, July and August.

Soils of the Yurimaguas area are predominantly Ultisols which are acid and nutrient poor (Table 1). This soil type is representative of much of the Amazon Basin (Cochrane and Sanchez, 1982).

**Table 1. Soil chemical characteristics of study site (Yurimaguas series; fine, loamy, siliceous isohyperthermic Typic Paleudult).**

| Depth | pH | K | Ca | Mg | Al | ECEC | %Al | P |
|---|---|---|---|---|---|---|---|---|
| -cm- | | ----------cmol (+) $kg^{-1}$---------- | | | | | | ppm |
| 0-15 | 4.4 | .07 | 0.73 | 0.15 | 2.89 | 3.84 | 75 | 8.5 |
| 15-30 | 4.4 | .06 | 0.47 | 0.08 | 4.31 | 4.92 | 88 | 5.2 |
| 30-45 | 4.4 | .06 | 0.46 | 0.07 | 5.14 | 5.73 | 90 | 3.6 |

## Selection Trials

Methods - A completely randomized block design with two replications was installed to evaluate 11 leguminous tree species for potential use in alley cropping. Both native and exotic

species were included. Each species is considered a treatment (Table 2). Although it is generally believed that members of the genus Cassia do not fix nitrogen, they were included in this study as a comparison for total N production. Each treatment consisted of a row of 10 trees planted 1 m apart. Five meters separate each row. Seedlings were planted after a three-month establishment phase in the nursery.

Survival and growth rate was monitored at 1, 2, 5, and 7 months after planting to evaluate pre-adaptation to soil and climate and susceptibility to insect attack and diseases. Trees were pruned to a height of 70 cm when they attained a height of 2 m and were subsequently pruned every 3 months to evaluate biomass production and sustainability of production.

**Results**

Survival and growth: Except for Albizia procera, Flemingia congesta, and Acacia auriculiformis, which could not survive several replantings, survival was high (Table 2). The main problem in field establishment was leaf-cutter ants. Gliricidia sepium was attacked by aphids and a root fungus that resulted in 15% mortality. Cassia sp (1), Inga sp. (pacae) and Calliandra calothyrsus exhibited the highest growth rates (Table 3).

**Table 2. Species under investigation and their % survival for the first 7 months.**

| Species | % survival |
|---|---|
| Cassia sp. (1) | 100 |
| Cassia sp. (2) | 100 |
| Inga sp. (pacae) | 100 |
| Samanea saman | 100 |
| Pithecellobium dulce | 100 |
| Gliricidia sepium | 85 |
| Calliandra calothyrsus | 80 |
| Schizolobium amazonicum | 70 |
| Acacia auriculiformis* | 70 |
| Albizia procera* | 0 |
| Flemingia congesta* | 0 |

* Not native to Tropical America

**Table 3. Growth rate (ranked from the fastest to the slowest.**

| Species | Growth rate |
|---|---|
| | -cm/mo- |
| Cassia sp. (1) | 40.90 |
| Inga sp. (pacae) | 30.92 |
| Calliandra calothyrsus | 23.00 |
| Samanea saman | 20.31 |
| Gliricidia sepium | 15.92 |
| Cassia sp. (2) | 12.40 |
| Schizolobium amazonicum | 10.13 |
| Pithecellobium dulce | 9.54 |
| Acacia auriculiformis* | 7.56 |
| Flemingia congesta* | 6.02 |
| Albizia procera* | 2.28 |

* Not native to Tropical America

Biomass production: Only five species have been pruned. Trees were pruned 10 months after planting, when they had at least 2 m in height. In practice it would be possible to prune 1.5 m tall trees. Inga sp (pacae) and Cassia sp (1) produced practically twice as much pruning biomass than the other species (Table 4). Yields could be up to 5 t/ha/3 mo if tree rows were 4 m apart and trees within rows staggered in two rows at 25 cm spacing.

**Table 4 Pruning yields (Dry Weight).***

| Species | Average | Leaves |
|---|---|---|
| | -g/tree/3 mo- | -%- |
| Inga sp. | 515 | 59 |
| Gliricidia sepium | 338 | 54 |
| Samanea saman | 243 | 59 |
| Calliandra calothyrsus | 158 | 54 |
| Cassia sp. (1) | 443 | 55 |

* Average of 3 prunings

It is interesting to note the proportion of prunings which is leaves versus stems, since leaves are the important part for providing nitrogen. We have found a species of Erythrina which produces only 40% leaves at the same pruning interval. It is also interesting to note that species obtained locally perform best overall in terms of establishment, growth, and biomass production.

**Leaf Quality, Decomposition, and Nitrogen Availability**

Nitrogen-fixing trees are usually included as a component of agroforestry systems as a means of maintaining nitrogen obtained from the decomposition of litter, prunings, and roots from these trees. The rate at which litter, leaves, and roots decompose is determined, at least in part, by the chemical composition (litter quality) of the material (Swift et al., 1979). A material with high lignin content is defined as low quality and decomposes slowly (Melillo et al., 1982). High polyphenolic content may also influence the rate of decomposition (Swift et al., 1979). Preliminary work done at Yurimaguas with leaves from N-fixing trees has indeed shown that decomposition is affected by both lignin and polyphenolics (Table 5). A laboratory experiment was designed to show the patterns of release of nitrogen from leaves of N-fixing trees which exhibit different litter quality.

**Table 5. Effects of litter quality on rate of litter disappearance on an Ultisol of Yurimaguas, Peru.** (Source: C.A. Palm, NCSU, preliminary data)

| Parameters | Organic input: Inga edulis | Organic input: Erythrina sp. |
|---|---|---|
| % N | 3.3 | 3.6 |
| % Lignin | 17.0 | 8.3 |
| L/N ratio | 5.2 | 2.3 |
| % Sol. polyphenolics | 4.5 | 1.0 |
| % Dry matter remaining after 20 weeks | 68 | 27 |

Methods - Dried and ground leaves (0.88 g) were added to 500 g of soil. The species used and the chemical composition of their leaves are given in Table 6. The soil was kept at 11% water content (w/w). The leaf-soil mixture was stored in the dark at room temperature (approximately 28° C) in ziplock plastic bags.

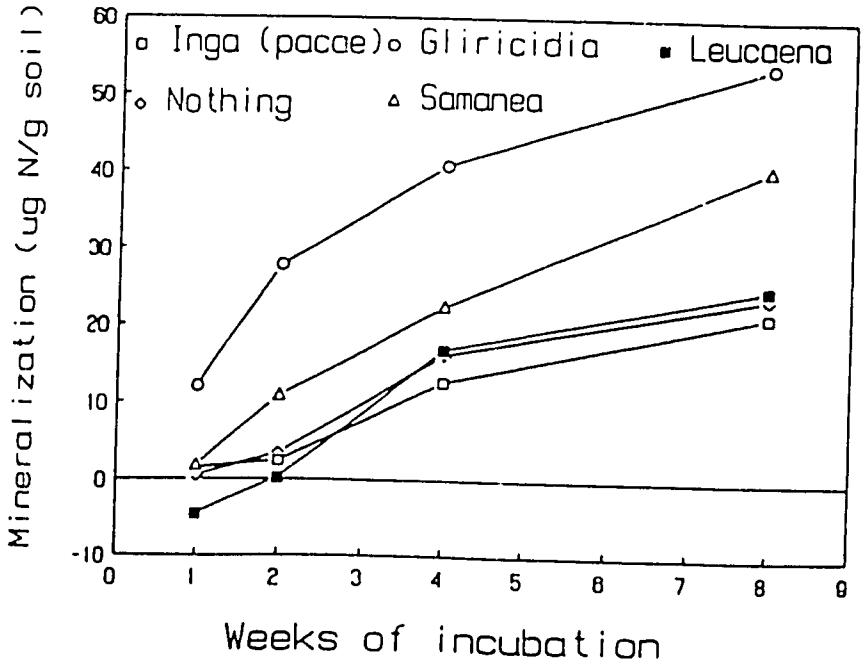
**Table 6. Selected chemical characteristics of leaves.**

| Species | N | Lignin | Soluble phenolics |
|---|---|---|---|
| | -%- | -%- | -%- |
| Gliricidia sepium | 3.74 | 8.0 | 1.02 |
| Inga sp. (pacae) | 2.93 | 18.6 | 1.61 |
| Samanea saman | 3.20 | 5.8 | 1.48 |
| Calliandra calothyrsus | 3.03 | 11.3 | 2.20 |
| Cassia sp. (1) | 2.50 | 6.7 | 3.90 |
| Leucaena leucocephala | 3.94 | 7.1 | 2.94 |

The amount of $K_2SO_4$ extractable nitrate and ammonium was measured on subsamples at 1, 2, 4, and 8 weeks (Keeney and Nelson, 1982). Net mineralization is defined as the change in the sum of inorganic nitrogen between each sampling.

Results - Figure 1 clearly illustrates that litter quality affects the rate of release of nitrogen. Gliricidia sepium which has a low lignin and polyphenolic content, released 59% of its total nitrogen, whereas Inga sp. (pacae), which has a high lignin content immobilized nitrogen. Leucaena leucocephala, which has low lignin but high polyphenolic contents, surprisingly mineralized less than 2% of its total nitrogen.

**Figure 1. Cumulative nitrogen mineralization of leaves of four nitrogen fixing tree species.**



**Competition and Root Distribution**

Much information is still necessary in order to design an efficient alley cropping layout that optimizes the spacing between tree hedgerows to maximize crop yields. This optimization requires finding a balance between maximizing biomass production per area by the trees, but minimizing competition between the trees and food crops. The first dictates close spacing between tree rows, whereas the second dictates broader spacing. The optimal spacing will differ with different tree species according to their biomass production and rooting patterns.

A study of root biomass and distribution was conducted in alley cropping systems, one with Inga edulis as the hedgerow and the other with Erythrina sp. Root biomass and distribution of the hedgerow species were measured in order to determine effects on the yield of crops in the alley. Hedgerows were separated by 8 m and rows of corn within alleys by 0.5 m.

Methods - Root sampling was done during the anthesis stage of corn. Samples were taken every 0.5 m along a transect perpendicular to the hedgerow so that position 1 is between the hedgerow and first row of corn, Position 2 is between the first and second rows of corn, etc. Samples were taken from 0 - 30 cm depth with a cylindrical corer. Roots were separated from the soil by elutriation, sorted into corn or legume roots, dried and weighed.

Corn grain yields were also taken from the same position to see if there was a correlation between legume root distribution and crop yield.

Results - Figures 2 and 3 show root biomass with distance from the hedgerow and grain yields, respectively. Inga edulis showed significantly higher root production near the hedgerow than Erythrina sp., but maize yields close to the hedgerows were not significantly different for the two species. In both species there is a dramatic increase in grain yields as one moves away from the hedgerow, even up to 4 m.

**Figure 2. Root production of two tree species at different distances from the hedgerow in an alley cropping system.**

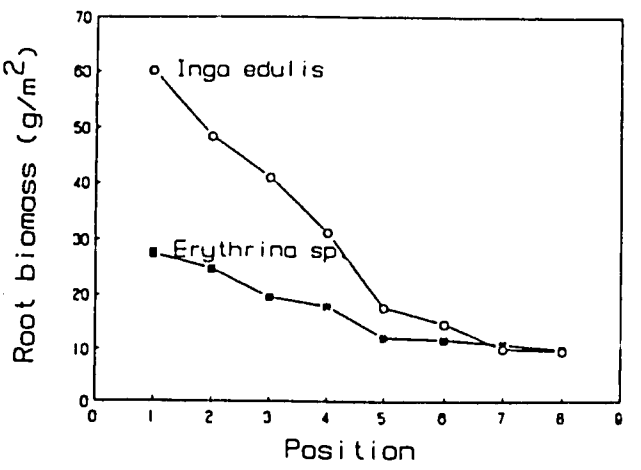
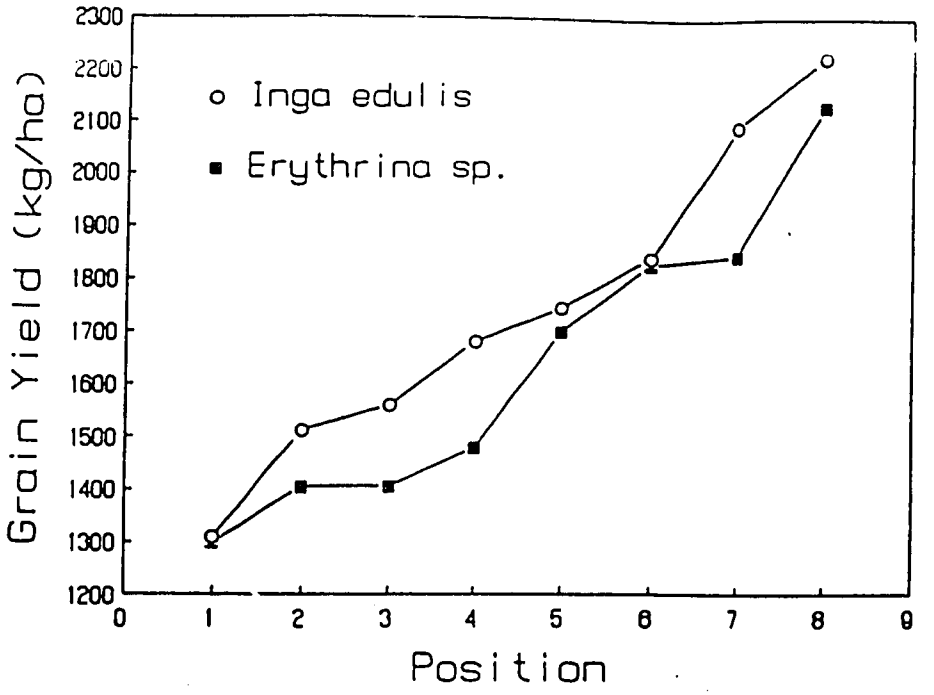


**Figure 3. Corn yields at different distances from a hedge in an alley cropping system.**

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