



Decomposition and Nitrogen Release of Prunings from Hedgerow Species Assessed for Alley Cropping in Haiti

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ABSTRACT

We studied decomposition and N release patterns of prunings of 8 tree species at a low and a high elevation site in Haiti. Leaves and stems (< 1 cm diam) from 4 year old hedgerows were sealed in separate bags and placed on soil surface. Leaves decomposed faster than stems and decomposition was best described by a two-pool exponential model. At low elevation, leaf carbon (C) loss was highest (82 %) in *Gliricidia sepium* (Jacq.) Kunth ex Walp. and lowest (42 %) in *Delonix regia* (Bojer ex Hook) Raf. after 48 weeks. At high elevation, leaf C loss after 48 weeks was 48 % in *Leucaena leucocephala* (Lam.) De Wit and 29 % in *Acacia angustissima* (Mill.) Kuntze. Initial N concentrations correlated with leaf C loss (phase 1) at low elevation while C:N and lignin:N correlated with leaf C loss (phase 2) at low and high elevations, respectively. Nitrogen release resembled C loss. At low elevation, *G. sepium*, *Leucaena shannonii* Donn. Sm. and *L. leucocephala* released > 50 kg N ha⁻¹ in 4-6 weeks, whereas at high elevation *A. angustissima* released < 40 kg N ha⁻¹ during the period. Leaf N release correlated negatively with (Lignin + Polyphenol):N at low elevation. At low elevation, *G. sepium*, *L. shannonii* and *L. leucocephala* provided adequate N for maize production in alley cropping. At the high elevation, *A. angustissima* contained adequate N, but N release rate may not meet peak N demands of an associated crop.

INTRODUCTION

Soil degradation and nutrient depletion on sloping lands are major constraints for crop production in the tropics. Alley cropping, which is production of food crops between rows of leguminous trees or shrubs is being used as a profitable alternative, owing to its potential for sustaining crop yields (Kang and Wilson, 1987). However, success of alley cropping depends upon its capacity to replenish or sustain reserves of nutrients removed or lost from soil through appropriate choice of woody species and proper hedgerow management.

Adaptation to environmental conditions combined with amount and rate of N released are important criteria in assessing hedgerow species for alley cropping. Research has shown that prunings of legume species can be an effective source of N (Kang and Wilson, 1987), but little is known regarding factors that govern N release patterns under different agroecological conditions. Concentrations of N, lignin and polyphenol are chemical factors influencing degradability of plant materials added to soil (Constantinides and Fownes, 1994; Fox et al., 1990). Hedgerow management and environmental conditions may affect chemical composition of hedgerow species altering the decomposition rates of their prunings. Understanding the impact of agroecological conditions on quality of plant materials and consequently on decomposition and N dynamics will result in better assessment of tree species suitable for alley cropping under specific environments

OBJECTIVES

- To evaluate suitability of *L. leucocephala*, *L. diversifolia*, *Leucaena* hybrid (*L. leucocephala* x *L. diversifolia*), *L. shannonii*, *G. sepium*, *D. regia*, *A. angustissima* and *Flemingia macrophylla* for alley cropping in terms of pruning decomposition and N release rates
- To determine effects of chemical composition of prunings on their decomposition and N release patterns under specific environments.

MATERIALS and METHODS

- Location:** Haiti, Low elevation (70 m), 18° 13' N, 73° 42' W, 1600 mm rainfall and High elevation (1150 m), 18° 29' N, 72° 15' W, 1200 mm rainfall
- Plot:** Hedgerows established in single rows of 5 m (low elevation) and 6 m long (high elevation) with 4 replicates in randomized block design.
- Procedure:** Decomposition and N release carried out on prunings of 4 month-regrowth (4 year old hedgerows)

Procedure:

- Species used (low elevation): *L. leucocephala* var. K636, *G. sepium* var. HYB, *Leucaena* hybrid var. KX3, *L. shannonii* and *D. regia*
- Species used (high elevation): *A. angustissima*, *L. leucocephala* var K636, *L. diversifolia* var K156, *Leucaena* hybrid var KX3 and *F. macrophylla*
- Hedgerows pruned to 50 cm height and separated into leaves and stems (<1cm diam)
- Air-dried leaves and stems (hectare basis) sealed in nylon mesh bags (20 x 10 cm, 50-60 µm openings) and placed on soil surface.
- Bags arranged in a randomized block design - 4 replicates within site.
- 4 bags per type of prunings and per species retrieved at 2, 4, 8, 16 and 48 weeks - Bags oven dried at 71° C for 36 hours
- Contents of bags analyzed for total C and N. Initial prunings analyzed for C and N, lignin, cellulose and polyphenol.

Analysis:

- Percent C and N remaining (ash-free basis) analyzed for a randomized block design and regressed on time - nonlinear regression models
- Decomposition and N release constants (k) determined after Wieder and Lang (1982):

$$Y = A + B e^{-k_1 t} + \text{Error} \quad (1)$$

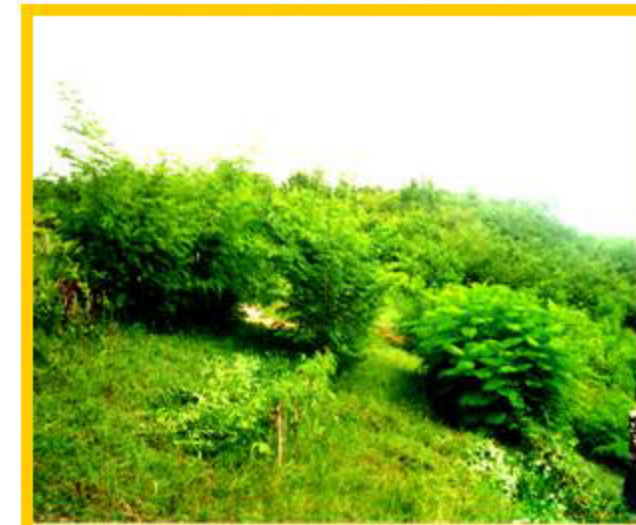
$$Y = A e^{-k_1 t} + B e^{-k_2 t} + \text{Error} \quad (2)$$
 Y = % initial C or N remaining at time t, A = fraction of recalcitrant pool (Eq. [1]) or fraction easily decomposable (Eq. [2]), B = 100 - A, k₁ and k₂ are rate constants, and t = time in weeks.



Acacia angustissima



Gliricidia sepium



Leucaena K636, L. shannonii and D. regia



Delonix regia

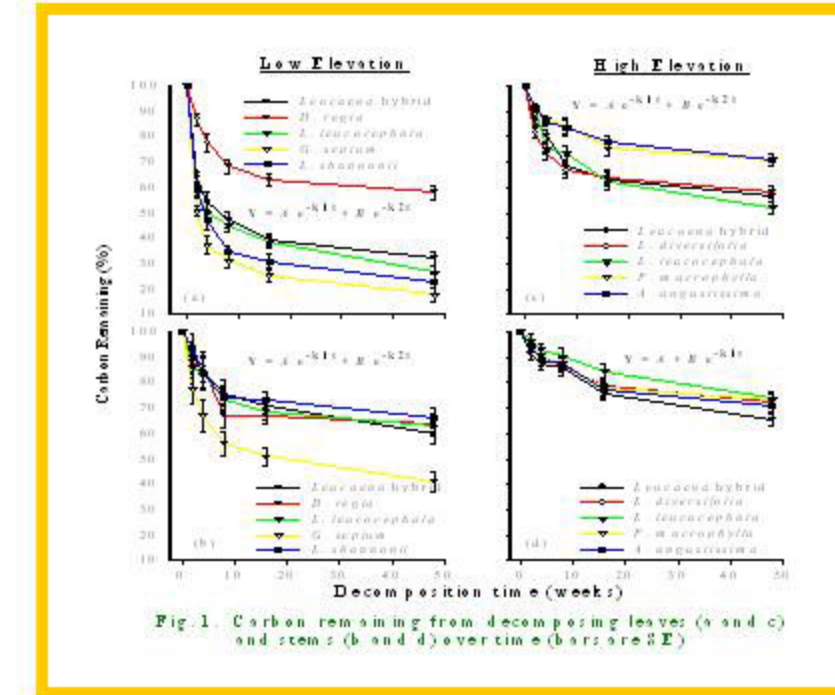


Fig. 1. Carbon remaining from decomposing leaves (a and c) and stems (b and d) over time (weeks) at low and high elevations.

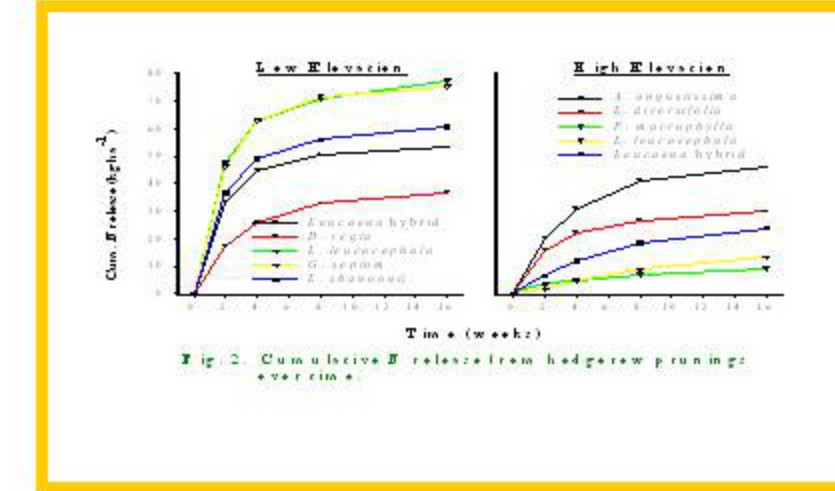


Fig. 2. Cumulative N release from hedgerow prunings over time.

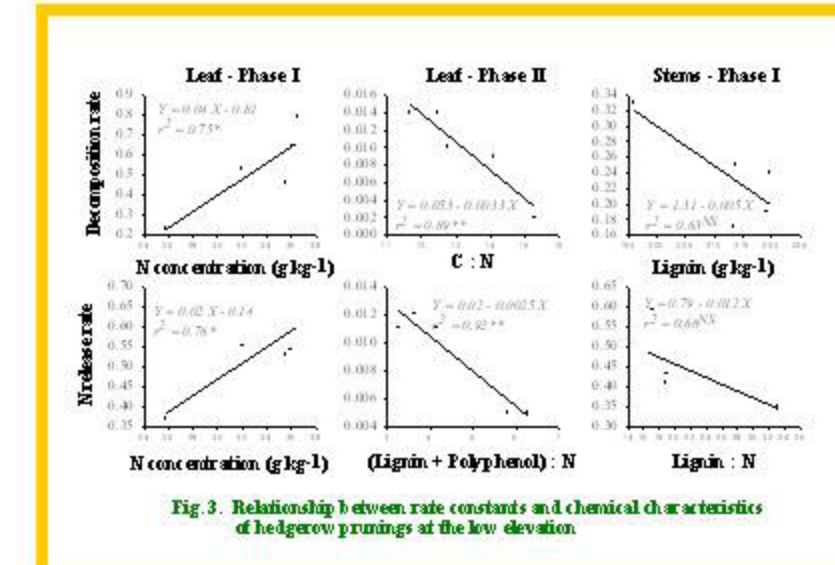


Fig. 3. Relationship between rate constants and chemical characteristics of hedgerow prunings at the low elevation.

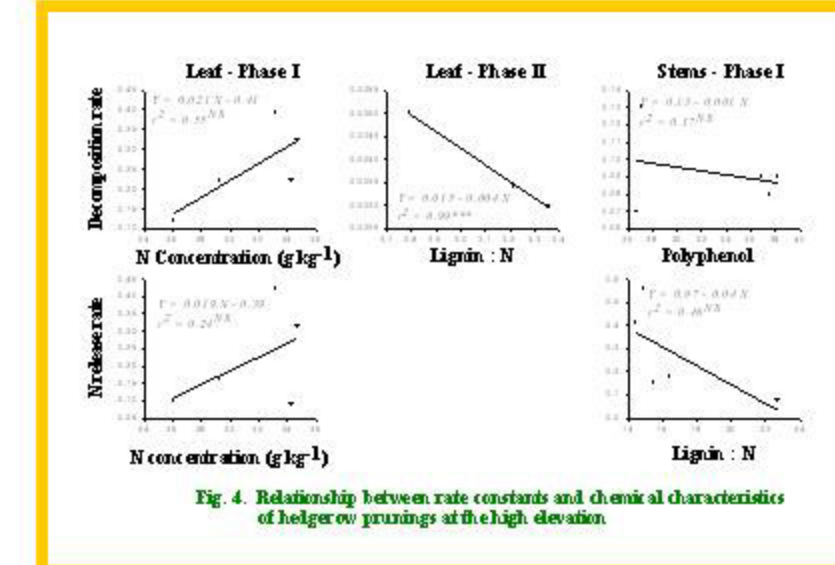


Fig. 4. Relationship between rate constants and chemical characteristics of hedgerow prunings at the high elevation.

RESULTS and DISCUSSION

- At low elevation, leaf C loss ranged from 82 % (*G. sepium*) to 42 % (*D. regia*) at the end of 48 weeks (Fig. 1a).
- At high elevation, leaf C loss was 48 % in *L. leucocephala* and 29 % in *F. macrophylla* and *A. angustissima* after 48 weeks (Fig. 1b)
- Leaf C loss was described by the two-pool model (both sites) with k₁ ranging from 0.12 to 0.79 and k₂ from 0.002 to 0.014.
- Stems decomposed slower than leaves. Highest stem C loss was 59 % in *G. sepium* (low elevation) and 35 % in *Leucaena* hybrid (high elevation) after 48 weeks (Fig. 1c and d)
- Leaf N remaining followed a pattern similar to C loss (low elevation) while % N release was greatest for *L. diversifolia* and *A. angustissima* (high elevation) after 48 weeks.
- At low elevation, *G. sepium* released 71 % (75 kg ha⁻¹) of its N content over 16 weeks while *L. leucocephala* released 46 % (78 kg ha⁻¹) - *D. regia* was lowest (36 kg N ha⁻¹) over 16 weeks (Fig. 2)
- Initial N correlated with leaf C loss (phase 1) at low elevation; C:N and lignin:N correlated with leaf C loss (phase 2) at low and high elevations, respectively.
- Leaf N release correlated negatively with (Lignin + Polyphenol) : N at low elevation (Fig 3 and 4)

CONCLUSIONS

- At low elevation, pruning decomposition was fast - *G. sepium*, *L. shannonii* and *L. leucocephala* released adequate N for a maize crop under these conditions
- At high elevation, decomposition occurred slowly - *A. angustissima* contained adequate N, but N release rate may not meet peak N demands of an associated crop.
- Initial N, C:N and (lignin + polyphenol):N influenced leaf C loss and N release while lignin:N seemed to regulated stem decomposition

Literature Cited

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