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Weight loss, nitrogen content changes, and nitrogen release during decomposition of legume tree leaves on and in the soil

Introduction

In an agroforestry system, pruned leaves are mulched or incorporated into the soil, and trees periodically or continually drop their leaves on the ground. These fresh leaves and leaf litter decompose, releasing nutrients into the soil for growth and development of associated crops.

Most decomposition studies focus on nutrient release. Release of nutrients from forest litter through natural decomposition is recognized as an important part of the nutrient cycle, where essential mineral elements tied up in plant biomass are made available for further plant growth (David and Wein 1978). The release of nutrients is a basic and complicated process, especially true for N because of its different forms. The specific rate of decomposition plays an important role in the general assessment of the agricultural value of a leaf mulch, green manure or litterfall. If the release is very fast, nutrients may be lost through leaching and volatilization; if nutrient release is very slow, annual crops may not be able to utilize the nutrients (Budelman 1988).

Legume trees are an important component of agroforestry systems as a means of maintaining N levels. However, each species has its own decomposition characteristics. Information on the decomposition of leaf biomass and the pattern of N release is essential in species selection for sustainable agroforestry systems.

Farmers usually apply tree leaves to the soil by mulching or green manuring. Mulching is broadcasting leaves on the soil surface, while green manuring is incorporating leaves below the soil surface. Decomposition characteristics determine the best application method for supplying nutrients to associated crops. The present study of three popular agroforestry species was undertaken to evaluate their decomposition characteristics in terms of weight loss, to monitor changes in their N content, and to determine their rate of N release.

Materials and methods

This study was conducted in a randomized complete block design with six treatments replicated three times. The site was the farm of the Central Luzon State University's College of Agriculture at Munoz, Nueva Ecija, Philippines. The six treatments consisted of three commonly used legume tree leaves, *Gliricidia sepium* (Jacq.) Walp., *Acacia auriculiformis* A. Cunn., and *Acacia mangium* Willd., and two methods of placement, on and below the soil surface. The leaves came from a 10-month-old agroforestry trial involving these three species.

The experiment was based on the litterbag technique of Gilbert and Bocock (1962). About 110 g of fresh leaves of each species was sealed separately in each of 90 bags, making a total of 270 bags. To determine moisture percentage and N content, subsamples of the leaves of each species were oven-dried at 70°C for 48 hours. This amount of fresh leaves was equivalent to 30.47 g dry matter for *G. sepium*, 49.24 g for *A. auriculiformis*, and 38.5 g for *A. mangium*.

Before the experiment, the trial fields were hoed and raked. The soil was kept free of weeds during the period of observation. All bags were placed in the field on 4 June

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1991, half on the surface and the other half below the surface (in the top 7.5 to 10.0 cm) of the soil. Sample bags were collected at 30-day intervals for 150 days. Each collection consisted of six bags of each species, three from the surface and three from below the surface. After 90 days of decomposition, *G. sepium* leaves could not be traced. Bag collection continued with the other two species until the end of the study.

In the laboratory, the bags were cleaned to remove any adhering soil particles or other foreign materials, dried at 70°C for 48 h, weighed individually, ground, and analyzed for N. Nitrogen content was determined at the International Rice Research Institute Analytical Service Laboratories using the micro-Kjeldahl method.

The percentage of dry weight remaining was calculated using the following formula:

$$\% \text{ of dry weight remaining} = \frac{DWt}{DWi} \times 100$$

where DWt = mean oven-dry weight at time t and DWi = initial oven-dry weight. The percentage of N release at different times was calculated using the formulas:

$$\% \text{ of original N content} = \frac{\% \text{ N remaining at time t}}{\% \text{ N at time 0}} \times \% \text{ of original weight remaining}$$

$$\% \text{ of N released} = 100 - \% \text{ of original N content remaining.}$$

Total rainfall was 1664.8 mm during the study period. Rainfall and evaporation at the study site are shown in Figure 1. Soil properties are illustrated in Table 1.

Results and discussion

Weight loss and decomposition. The differences in weight loss among the three species at various sampling dates and under two soil environments were significant (Figure

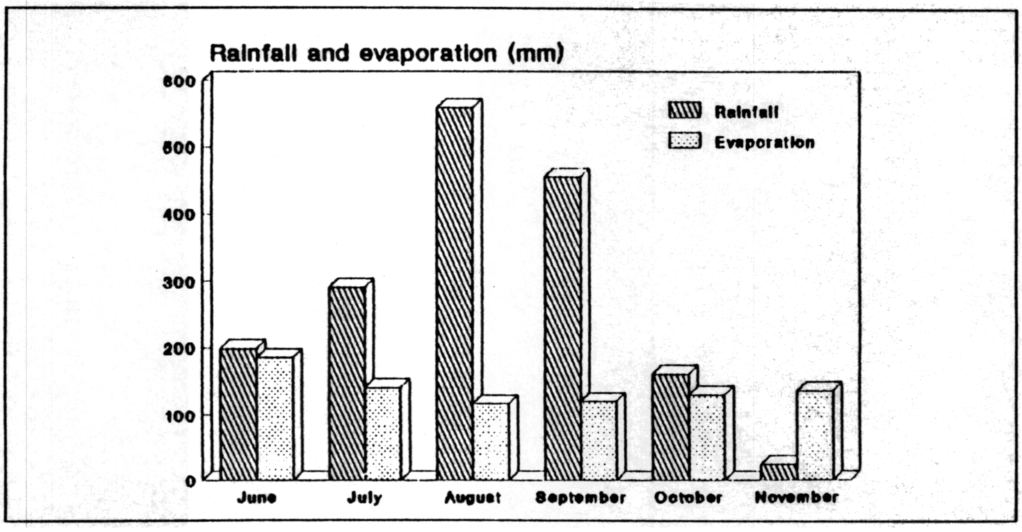

Figure 1. Mean monthly rainfall and evaporation at the study site at CLSU, Philippines, 1992.

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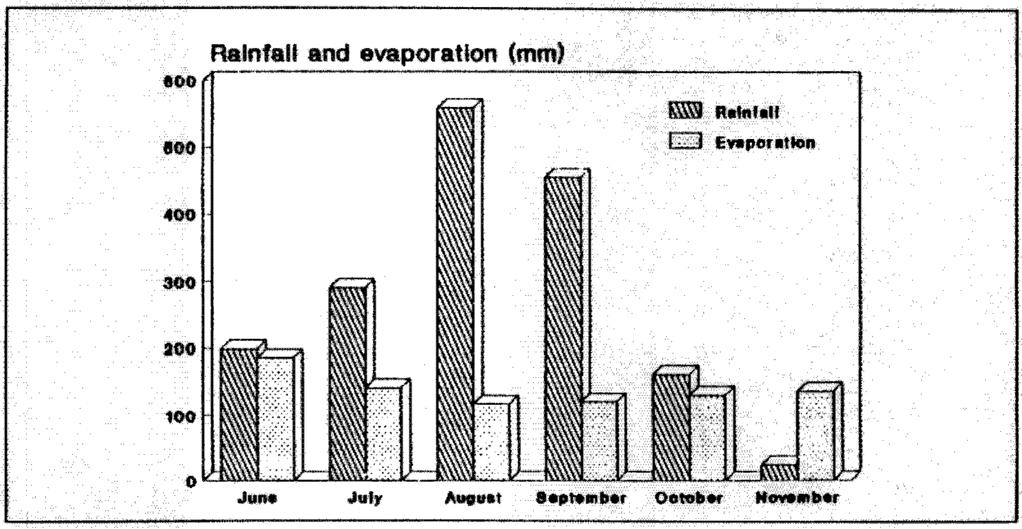

Figure 1. Mean monthly rainfall and evaporation at the study site at CLSU, Philippines, 1992.

Table 2. Nutrient composition of *Gliricidia sepium*, *Acacia auriculiformis* and *Acacia mangium* leaves (%).

	N	P	K	Ca	Mg
Gliricidia sepium	3.00	0.16	2.10	2.18	0.46
Acacia auriculiformis	2.29	0.10	1.10	1.46	0.22
Acacia mangium	2.04	0.14	1.18	0.93	0.23

of 76% after 16 weeks, while *A. auriculiformis* (N content 1.63%) had a decomposition rate of 33%. The second factor that could have influenced the rate of weight loss was the size of the leaves or leaflets. *G. sepium* leaflets were the smallest among the three species. Higher weight loss in *G. sepium* might have also been influenced by the succulent nature of its leaves.

The rapid weight loss from *G. sepium* leaves was supported by field observations regarding the absence of leaf litter on the ground. An accumulation of leaf litter would be expected if weight loss were slow, and indeed Leaf litter accumulation was observed in the plots of *A. auriculiformis* and *A. mangium*.

The same factors could explain the higher rate of weight loss in *A. auriculiformis* than *A. mangium*. *Acacia auriculiformis* had a higher N content than *A. mangium* (Table 2), while *A. mangium* had thicker leaves (weight per leaf). A much thicker layer of leaf litter was noticed in plots of *A. mangium* than in those of *A. auriculiformis*. Hiroshi et al. (1984) found that thicker, tougher leaves decompose more slowly, as indicated by a significant relationship between leaf thickness index (weight per unit leaf area) and decomposition rate.

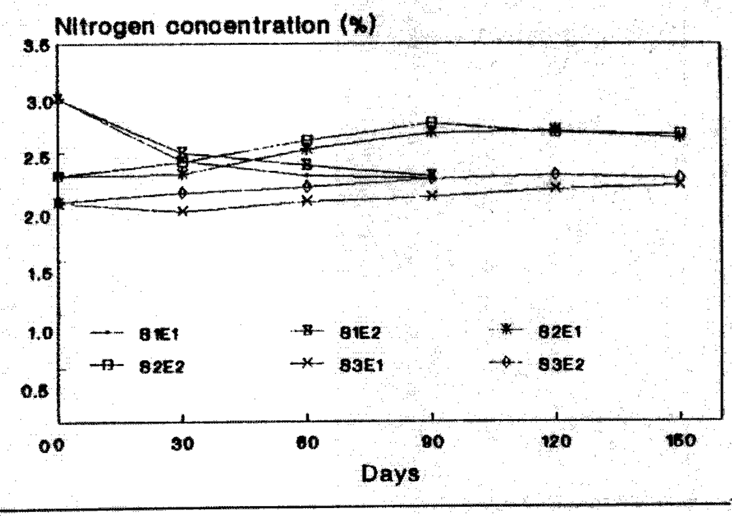

Figure 3. Changes in nitrogen content in decaying leaves of tree legumes over time. S1 = *Gliricidia sepium*; S2 = *Acacia auriculiformis*; S3 = *A. mangium*; E1 = surface; E2 = subsurface.

is well known (Gilbert and Bocock 1962, Bocock 1963, Gosz et al. 1973, Anderson 1973, Howard and Howard 1974, Yavitt and Fahey 1986). This increased concentration requires an addition of N from exogenous sources, which could be due to N fixation (Granhall and Lindberg 1977), uptake by fungal hyphae from the surrounding leaves (Berg and Soderstrom 1979), atmospheric N, or insect frass (Bocock 1963).

N release upon decomposition. Nitrogen release pattern varied significantly among the three species. The rate of N release was highest in *G. sepium* (94.70% in 90 days), lowest in *A. mangium* (34.24%), and intermediate in *A. auriculiformis* (41.81%) (Figure 4). *Acacia auriculiformis* released significantly higher amounts of N than did *A. mangium* except on the last sampling date. However, even after 150 days of decomposition, release of N from *A. auriculiformis* and *A. mangium* was much lower than that from *G. sepium*. After 150 days of decomposition, the rate of N release was 72.94% from *A. auriculiformis* and 69.21% from *A. mangium*. A similar trend in N release from *G. sepium* was reported by Angel and Palm (1987), Yamoah et al. (1986), and Soriano (1991).

Surface and subsurface soil showed N released from decomposing *G. sepium* and *A. auriculiformis* leaves at almost identical rates. *Acacia mangium* leaves released a significantly higher rate of N below the surface than at the surface during 30 to 120 days of decomposition.

Conclusion

This decomposition study revealed that *G. sepium* leaves lose weight more quickly than leaves of *A. auriculiformis*, and these in turn lose weight more quickly than leaves of *A. mangium*. Faster weight loss was associated with high N content and leaf characteristics. No significant variations in weight loss were exhibited between the two soil environments except for *A. mangium*, whose leaves lost weight more quickly below the surface that at the surface.

Nitrogen content declined progressively in *G. sepium*, initially increased then declined in *A. auriculiformis*, and increased gradually in *A. mangium*. The pattern of change depended on the original amount of N in the leaves. Nitrogen release was quickest in *G. sepium* and slowest in *A. mangium*. These findings suggest that crops in an agroforestry system might benefit more from *G. sepium* leaves, either at or below the soil surface, than from leaves of the other two species.

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