



NUTRIENTS (N, P AND K) DYNAMICS ASSOCIATED WITH LEAF LITTER OF *Albizia saman* AND *Leucaena leucocephala* OF BANGLADESH

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Abstract: *Albizia saman* and *Leucaena leucocephala* are not native to Bangladesh, but they are widely planted in agroforestry and households for their commercial value. Selection of tree species with efficient return of nutrients is a vital challenge to maintain soil fertility for sustainable crop production. Therefore, a comparative study was conducted on nutrients (N, P and K) leaching from leaf litter of *A. saman* and *L. leucocephala* in laboratory condition. The initial dry weight of leaf litter of *A. saman* and *L. leucocephala* were significantly ($p < 0.05$) decreased to 17% and 26%, respectively at the end (after 96 hours) of the experiment. *Leucaena leucocephala* showed comparatively (t-test, $p < 0.05$) higher rate of weight loss, conductivity and TDS (Total Dissolved Solid) of leaching water. Comparatively, higher amount of N and K was released from leaf litter of *A. saman* and higher amount of P from leaf litter of *L. leucocephala*. Both the species showed similar pattern ($K > N > P$) of nutrient release during the leaching process and nutrients (N, P and K) concentration in leaf litter of these species showed significant ($p < 0.05$) negative curvilinear relationships with the weight loss.

Keywords: *Albizia saman*, *Leucaena leucocephala*, leaching, nutrient cycling, weight loss

Introduction

Use of chemical fertilizer for sustaining crop production is well known (Kang and Spain, 1986; McIntire, 1986) though it is expensive and has negative environmental impacts (Good *et al.*, 2004). However, most farmers in developing countries have limited access to affordable fertilizer (McIntire, 1986; Vlek, 1993; Sanchez, 2002). Maintenance of soil productivity is a critical issue in a tropical agroecosystems. Reducing fertilizer inputs can be achieved by inclusion of N-fixing leguminous species, which can contribute biologically fixed nitrogen to the production system (Balasubramanian and Blaise, 1993; Kang *et al.*, 1990). In Bangladesh, presently, farmers prefer *Albizia saman* and *Leucaena leucocephala* due to their multipurpose use capability within a short period of time among the leguminous tree species for agroforestry practices (NAS 1979; Nair *et al.*, 1984; von Carlowitz 1991; Roder and Maniphone 1998; Roder *et al.*, 1998; Roder 2001). Both the species can tolerate salinity and has disease infestation (Dutta and Iftekhar, 2004; Hossain *et al.*, 2006).

Agroforestry, being a people oriented program, farmer's preference should be acknowledged, but the performance of these species is needed to be scientifically assessed with due attention in terms of nutrient return efficiency for further promotion. Litter decomposition is an important

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component in nutrient cycling and leaf litter is the main and quick source of organic matter and mineral elements to the soil which becomes readily available to plants and soil micro-organisms (Tukey, 1970; Wetzel and Manny, 1972; Mason, 1977; Dahm, 1981; Gray and Schlesinger, 1981; Waring and Schlesinger, 1985; Vitousek and Sanford, 1986; Regina *et al.*, 1999; Guo and Sims, 1999; Ukonmaanaho and Starr, 2001; and Park and Hyun, 2003). However, nutrient return from a tree through leaf litter is influenced by micro- and macro-climates (Edwards, 1975), chemical composition and physical state of the leaf litter (Swift *et al.*, 1979; Anderson, 1991; Aerts, 1999), the quantity (Knutson, 1997), diversity of leaf litter (Ball *et al.*, 2008) and rate of leaching and decomposition of leaf litter (Senevirante *et al.*, 1998; Kwabiah *et al.*, 2001, Bossa *et al.*, 2005). The present study aimed to assess the pattern of nutrients leaching (N, P and K) from the leaf litter of *A. saman* and *L. leucocephala* in laboratory condition.

Materials and Methods

Leaf litter selection and leaching Experiment: Bulk of yellowish senescent leaves of *A. saman* and *L. leucocephala* were collected during March 2008 (maximum leaf fall period). Leaves were air-dried at room temperature for one week. Air-dried leaves of each species were thoroughly mixed and weighted to two grams as an individual sample and thus a total 38 samples were prepared. Each sample was placed at room temperature into individual beaker (500 ml) and 250 ml of distilled water was poured to each beaker and few drops of HgCl₂ solution (50 mg l⁻¹) (McLachlan, 1971; Otsuki & Wetzel, 1974) were added in each beaker to prevent fungal decay. Five samples were kept into an oven at 80°C until constant weight to get the air-dry to oven-dry conversion weight.

Sample collection and measurements: Three replicates of each samples were collected at 1, 2, 3, 4, 8, 12, 24, 36, 48, 72 and 96 hours of intervals and the collected samples were ringed by distilled water and oven-dried at 80 °C to constant weight. The mass loss (%) due to the leaching process was calculated from the differences between initial and final oven-dried weights and was expressed as a percentage of initial loss. The rate of mass loss was obtained from mass loss (%) and leaching time. Conductivity (μs cm⁻¹), total dissolve solid (TDS) (mg l⁻¹) of leaching water sample were measured by a conductivity and TDS meter manufactured by Ciba-Corning Diagnostic Ltd., England.

Nutrients (N, P and K) measurements in leaf litter: The leaf samples were processed and acid digested according to Allen (1974). Nitrogen (N) and Phosphorus (P) concentration in the sample extracts were measured according to Weatherburn (1967) and Timothy *et al.*, (1984), respectively using UV-Visible Recording Spectrophotometer (SHIMADZU, UV-160A, Japan). Potassium concentration in the sample extracts at different time intervals were measured by Atomic Absorption Spectrophotometer (PERKIN ELMER 4100, USA). The released amounts of these nutrients from leaf litters were calculated as differences between initial and final absolute amounts and also expressed as percentage of initial amounts.

Statistical analysis: The rate of mass loss and nutrients (N, P and K) concentration in leaf litter of each species at different time intervals was compared by two way analysis of variance using SAS 6.12 statistical software. Rate of mass loss, conductivity, TDS and nutrients (N, P and K) concentration in leaf litter between two species were compared by unpaired 't' test using SPSS (11.5) Statistical Software. For each species relationships among the mass loss and nutrients (N, P and K) concentration with leaching time were calculated.

Results

The percent change in dry weight varied between treatment and litter type. Litter mass loss displayed characteristic decomposition patterns, which appeared to approximate a negative logarithmic relationship for the species measured. The initial dry weights of leaf litter of *A. saman*

and *L. leucocephala* were sharply decreased to 7% and 13% after 8 hours (Fig. 1). Higher rate of mass loss was observed for *L. leucocephala* in comparison to (t-test, $p < 0.05$) *A. saman* (Fig. 2). Conductivity and TDS of leaching water of both the species were significantly ($p < 0.05$) increased at the end of the experiment and comparatively (t-test, $p < 0.05$) higher conductivity and TDS were observed for *L. leucocephala* (Fig. 3-4). Mass loss of leaf litter, conductivity and TDS of leaching water of both the species showed significant ($p < 0.05$) positive logarithmic relationships with the leaching time (Fig. 1, 3-4).

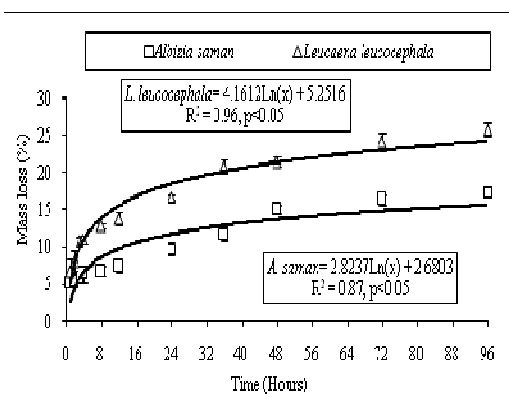


Fig. 1. Mass loss of leaf litter of *Albizia saman* and *Leucaena leucocephala* at different time intervals

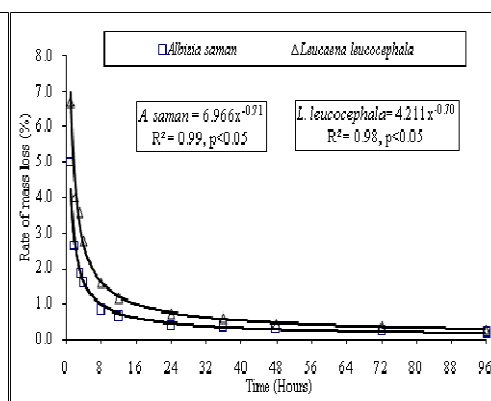


Fig. 2. Mass loss rate of leaf litter of *Albizia saman*, and *Leucaena leucocephala* at different time intervals.

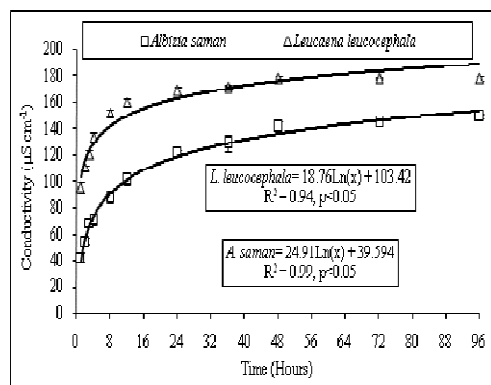


Fig. 3 Conductivity ($\mu\text{S cm}^{-1}$) in leaching water samples *Albizia saman*, and *Leucaena leucocephala* at different time intervals.

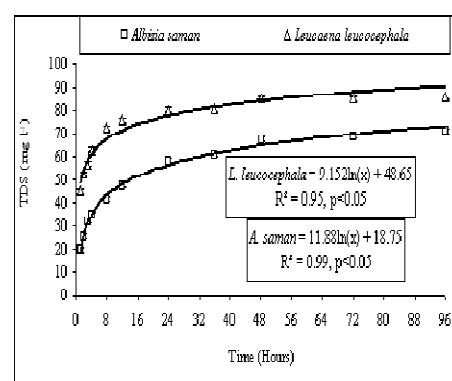


Fig. 4 Total dissolve solid (mg l^{-1}) in leaching water samples of *Albizia saman*, and *Leucaena leucocephala* at different time intervals.

In case of *A. saman* initial concentrations of N, P and K in leaf litter were significantly ($p < 0.05$) decreased to $25.67 \mu\text{g g}^{-1}$, $0.64 \mu\text{g g}^{-1}$ and $1.06 \mu\text{g g}^{-1}$ respectively after 24 hours whereas N, P, and K concentration in leaf litter of *L. leucocephala* were significantly ($p < 0.05$) decreased to $3.35 \mu\text{g g}^{-1}$, $0.52 \mu\text{g g}^{-1}$ and $1.19 \mu\text{g g}^{-1}$ respectively after 24 hours (Fig 5-7). At the end of the

experiment (after 96 hours) 26%, 67% and 85% of the initial amount of N, P and K was lost for *A. saman* that were 78%, 76% and 71% for *L. leucocephala* respectively (Table 1).

Table 1. Absolute amount of nutrients released from leaf litter during the leaching process (Values in the parenthesis indicate released nutrient amounts expressed as percentage of initial nutrient amount)

Species	Nitrogen (µg)	Phosphorus (µg)	Potassium (mg)
<i>Albizia saman</i>	34.68 (25.98)	1.91 (66.49)	7.06 (84.99)
<i>Leucaena leucocephala</i>	15.05 (77.74)	2.16 (75.92)	4.15 (71.33)

Comparatively (t-test, $p < 0.05$) higher concentrations of N and K was observed in leaf litter of *A. saman* (Fig. 5 and 7) whereas *L. leucocephala* contained higher (t-test, $p > 0.05$) concentration of P (Fig. 6). Higher amount of N and K was released from leaf litter of *A. saman* whereas higher amount of P was released from *L. leucocephala*; both the species showed similar pattern of nutrient ($K > N > P$) release during the leaching process (Table 1). Concentration of nutrients (N, P and K) in leaf litter of these species showed significant ($p < 0.05$) negative exponential curvilinear relationships with the mass loss (Table 2).

Table 2. Concentration of nutrients (N, P and K) in leaf litters

Relationships among mass loss and nutrients			
Species	N	P	K
<i>Albizia saman</i>	$y = -5.47\ln(x) + 40.60$ $R^2 = 0.79$	$y = -0.73\ln(x) + 2.702$, $R^2 = 0.81$	$y = -2.65\ln(x) + 8.190$ $R^2 = 0.79$
<i>Leucaena leucocephala</i>	$y = -5.65\ln(x) + 23.14$ $R^2 = 0.91$	$y = -1.09\ln(x) + 4.17$ $R^2 = 0.96$	$y = -1.95\ln(x) + 7.225$ $R^2 = 0.88$

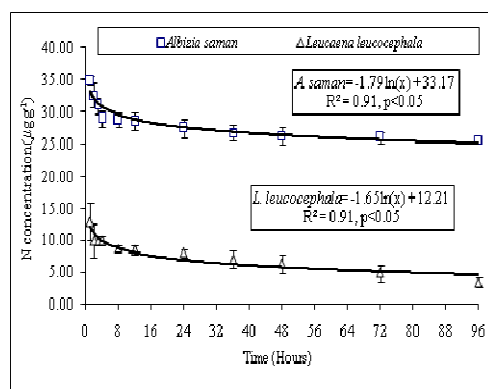


Fig. 5. Nitrogen concentration ($\mu\text{g g}^{-1}$) in leaf litter of *Albizia saman*, and *Leucaena leucocephala* at different time intervals

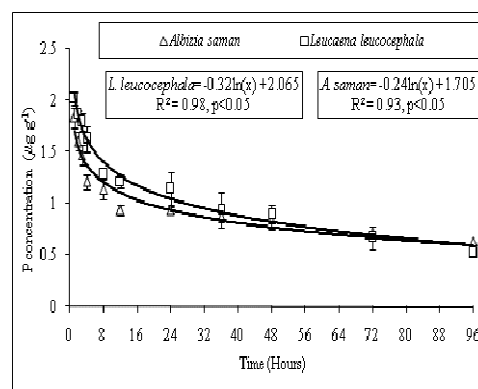


Fig. 6. Phosphorus concentration ($\mu\text{g g}^{-1}$) in leaf litter of *Albizia saman*, and *Leucaena leucocephala* at different time intervals

Hossain, M., Rahman, M.M., Shamim, M.H., Siddique, M.R.H., Saha, S., Hossain, M.Z. and Kibria, M.A. 2010. Nutrients (N, P and K) dynamics associated with leaf litter of *Albizia saman* and *Leucaena leucocephala* of Bangladesh. *Khulna University Studies* 10 (1&2): 137-144

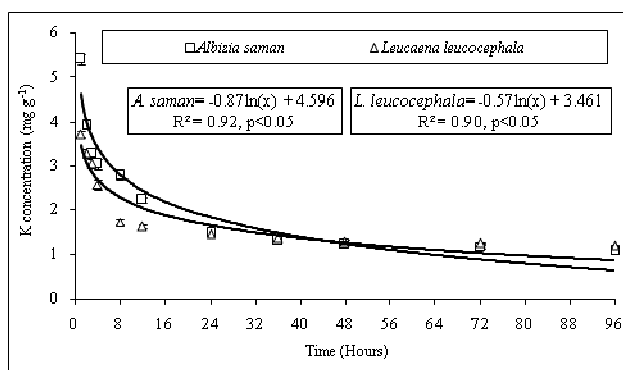


Fig.7. Potassium concentration (mg g^{-1}) in leaf litter of *Albizia saman*, and *Leucaena eucocephala* at different time intervals

Discussion

The relationships among leaching time and mass loss, conductivity and TDS were significantly positive (Fig. 1, 3 and 4) which indicate that water-soluble organic and inorganic substances are leached from leaf litter. The rates of leaching were initially high and slower rates were observed with the increasing leaching time. Similar relationships among leaching time and mass loss of leaf litter, conductivity and TDS of leaching water were observed by Park & Hyun (2003), Kongkon *et al.*, (2006), Hasan *et al.*, (2006), Ibrahim *et al.*, (2008) and Mahmood *et al.*, (2009). The higher rate of mass loss up to eight hours (Fig. 2) may be due to initial rapid loss of soluble inorganic and organic substances (Tukey, 1970; Maclean and Wein, 1978; Ibrahim *et al.*, 1995; Parsons *et al.*, 1990; Prescott 2005). Comparatively higher rate of nutrient loss was occurred for *L. leucocephala*. The average rate of mass loss of *A. saman* and *L. leucocephala* leaf litter of the present study were $1.28\% \text{ hr}^{-1}$ and $2\% \text{ hr}^{-1}$, respectively which were higher than *Acacia auriculiformis* ($0.25\% \text{ hr}^{-1}$), *Vitex madiensis* ($0.25\% \text{ hr}^{-1}$), *Syzygium guineese* var. *guineese* ($0.03\% \text{ hr}^{-1}$) (Kongkon *et al.*, 2006, Ibrahim *et al.*, 2008), *Eucalyptus camaldulensis* ($0.92\% \text{ hr}^{-1}$) and *Swietenia macrophylla* ($0.41\% \text{ hr}^{-1}$) (Mahmood *et al.*, 2009) and *Melia azedarach* ($1.15\% \text{ hr}^{-1}$) (Hasan *et al.*, 2006). The observed differences in the mass loss rate among different species may be due to the variation in the concentration of different soluble inorganic and organic substances, the physical, chemical and morphological characteristics of leaf litter (Nykqvist, 1963; Taylor & Parkinson, 1988; Saini, 1989 and Ibrahim, 1995). Moreover, the higher rate of mass loss also emphasizes the potentiality of species to provide readily available organic and inorganic compounds for microbiota (Wetzel, 1995).

Chemical differences in initial litter quality of the species reflect the combined effect of chemical content in living tissues and the efficiency of retranslocation mechanisms before abscission (Moro and Domingo, 2000). The significant variation of N and K concentration in the leaf litter of *A. saman* and *L. leucocephala* during the leaching process (Fig. 5 and 7) may depend on their initial concentration (Tukey, 1970), characteristics, mobility, and involvement in structural properties of the respective plant cell (Meyer *et al.*, 1973). Potassium (K) is highly mobile in comparison to N and P and at the same time K is not structurally bounded (Marschner, 1995). This could be the reason for observing higher amount of K release for the leaf litter. The significant negative exponential curvilinear relationship among N, P and K concentration, leaching time and mass loss of leaf litter (Table 2, Fig. 5-7) explains that mass loss of leaf litter could be associated with the release of these elements (Bernhard-Reversat, 1993).

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