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RESEARCH ARTICLE **LIFE SCIENCE**

P, K AND Na LEACHING FROM LEAF LITTER OF *MELIA AZEDARACH* (LINN.)

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Abstract: Cations leaching from leaf litter of *Melia azedarach* (Linn.) was studied in laboratory. About 37% of initial dry weight of leaf litter was lost after 72 hours. Conductivity and total dissolved solid (TDS) of the leached water significantly ($p<0.05$) increased to 475 $\mu S\ cm^{-1}$ and 227 $mg\ l^{-1}$, respectively. pH of the leached water dropped to 5.64 at the end of the experiment. Conductivity and TDS showed significant ($p<0.05$, $r=0.99$) positive linear relationships with the weight loss of leaf litter. The concentration of P, K and Na in leaf litter significantly ($p<0.05$) decreased to 24 $\mu g\ g^{-1}$, 2247 $\mu g\ g^{-1}$ and 900 $\mu g\ g^{-1}$, respectively and PO_4, K and Na in leached water significantly ($p<0.05$) increased to 0.16 ppm, 5.44 ppm and 5.58 ppm, respectively. Nutrients (P, K and Na) in leaf litter showed significant ($p<0.05$, ranged from -0.92 to -0.99) negative relationship with the weight loss. But, nutrients (PO_4, K and Na) in leached water showed significant ($p<0.05$, ranged from 0.90 to 0.98) positive linear relationship with the leaching time.

Key words: Agroforestry, nutrient return, phosphorus, potassium, sodium

Introduction

Agroforestry practice involving *Melia azedarach* has been found in Bangladesh, China, India, Indonesia, Laos, Nepal, Philippines and Vietnam (French and Blicher, 1995; Khangia, 1997). *Melia azedarach* is of special interest in agroforestry practices in Bangladesh for its multiple uses and fast growth. It can successfully be grown in combination with a variety of crops. The agricultural crops like, maize, mustard, rapeseed, gram, peas, wheat, sugarcane, cotton etc. can be grown in combination with *M. azedarach*.

Optimum production from agroforestry is influenced by the soil condition, especially availability of nutrients, moisture condition and rate of organic matter decomposition (Nair, 1984). Thus maintenance of soil fertility under different agroforestry practices is of vital research interest. Various studies showed that trees considerably improve the soil condition by adding nutrients through mycorrhiza and other symbiotic association, leaching and litter decomposition (Marschner, 1995). Nutrients are taken-up by tree crops from a comparatively deep layer of soil and a portion of this is stored in plant biomass and the other is returned to the soil as litter. But the rate of nutrient addition to the soil varies with species, nutrient composition of litter and

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environmental conditions (Jones, 1998; Marschner, 1995). In this context, selection of an efficient tree species is a challenging issue in agroforestry.

Again, leaf litter contributes the bulk of nutrient return to the soil and nutrient leaching from leaf litter is the ready source of nutrient to the soil (Tukey, 1970; Mason, 1977; Park and Kang-Hyun, 2003). Information on nutrient leaching from leaf litter of different tree species will facilitate to incorporate the nutrient return efficient species with agricultural crops to maximize the total productivity in agroforestry. So, the present study aimed to assess the pattern of weight loss and P, K and Na leaching from the leaf litter of *M. azedarach*, being the prominent tree species used in agroforestry.

Materials and Methods

***Experimental setup*:** Senescent leaves were picked from trees and air-dried at room temperature for one week. Leaves were then thoroughly mixed and 35 samples (2 g each) were prepared. Thirty samples were placed in 30 beakers (500 ml). Distilled water (200 ml) was poured into each beaker and $HgCl_2$ was added at the concentration of 50 mg l^{-1} to prevent the fungal decay (McLachlan, 1971; Otsuki and Wetzel, 1974). Five samples were kept into the oven at 80 °C until constant weight to calculate the air-dry to oven-dry conversion factor.

***Sample collection and measurements*:** Three replicates of leaf samples (2 g each) were collected at 0, 2, 4, 8, 12, 18, 24, 36, 48 and 72 hours, respectively. These samples were than rinsed in distilled water and oven-dried at 80 °C until constant weight. The oven-dried samples were then weight to calculate the weight loss (%) due to leaching from the initial converted oven-dried weight. The samples were processed according to Allen (1974), conductivity (µS cm^{-1}), total dissolved solid (TDS) (mg l^{-1}) and pH of leached water sample were measured by a conductivity and TDS meter manufactured by Ciba-Corning Diagnostic Ltd., England and a temperature compensated pH meter manufactured by Ciba-Corning Diagnostic Ltd., respectively.

***Nutrients in leaf litter and leached water*:** The processed leaf samples (0.1 g each) were acid digested according to Allen (1974). Potassium and Na concentration in extracts of leaf samples and leached water samples of different time intervals were measured by flame photometer (PFP7, Jenway LTD., England). While, P concentration in extracts of leaf samples and PO_4 in leached water samples were measured according to Timothy *et al.* (1984) by using UV-Visible Recording Spectrophotometer (SHIMADZU, UV-160A, JAPAN).

***Statistical analysis*:** Percentage of weight losses at different time intervals of leaching process were transformed to arcsine. Conductivity, total dissolve solid (TDS), pH, PO_4, K and Na concentration of leached water samples and P, K and Na concentration in leaf litter at different time interval were compared by one way analysis of variance (ANOVA) followed by Duncan Multiple Range Test (DMRT) using SAS 6.12. Correlation and regression analysis were conducted among weight loss (%); conductivity and TDS of leached water; nutrients in leaf litter and leached water; and leaching time intervals by using SAS 6.12.

Results

***Weight loss of leaf litter, and conductivity, TDS and pH of leached water sample*:** The initial dry weight of leaf litter was significantly ($p<0.05$) reduced to 13% after 12 hours, and 37% after 72 hours through leaching (Fig. 1). Conductivity of leached water significantly ($p<0.05$) increased to 475 µS cm^{-1} after 72 hours (Fig. 2). TDS showed similar pattern to conductivity and significantly ($p<0.05$) increased to 227 mg l^{-1} at the end of this experiment (Fig. 3). pH of leached water samples was significantly ($p<0.05$) dropped to 5.64 at the end of this experiment from the initial (7.57). Significant ($p<0.05$) positive linear relationships were observed among leaching time and weight loss of leaf litter, conductivity, TDS (Fig. 1 to 3). Irrespectively, significant positive relationship was observed between weight loss and conductivity (y = 0.0825x - 2.955, r=0.99, $p<0.05$); weight loss and TDS (y = 0.1724x - 2.8504, r=0.99, $p<0.05$).

Cations in leaf litter and leached water: The concentration of P, K and Na in leaf litter significantly ($p<0.05$) decreased to 24 µg g^{-1}, 2247 µg g^{-1} and 900 µg g^{-1}, respectively (Fig. 4 to 6). Phosphorus loss from leaf litter showed significant ($p<0.05$) negative linear relationship with leaching time, while K and Na exhibited a significant ($p<0.05$) negative curvilinear relationship (Fig. 4 to 6).

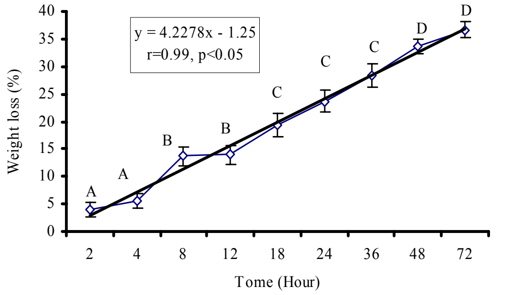


Fig. 1. Weight loss of leaf litter due to leaching at different time intervals. Means with similar alphabet are not significantly (p>0.05) different.

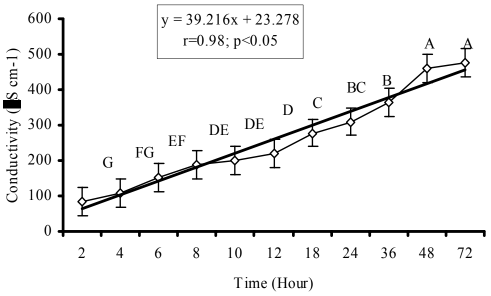


Fig. 2. Conductivity of leached water at different time intervals. Means with similar alphabet are not significantly (p>0.05) different.

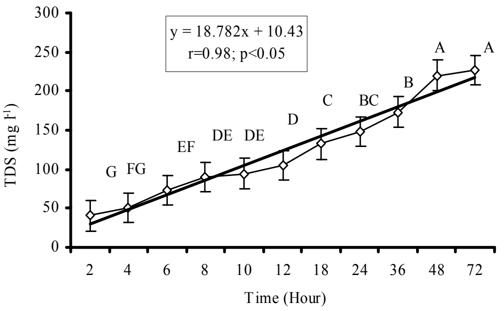


Fig. 3. Total dissolved solid of leached water at different time intervals. Means with similar alphabet are not significantly (p>0.05) different.

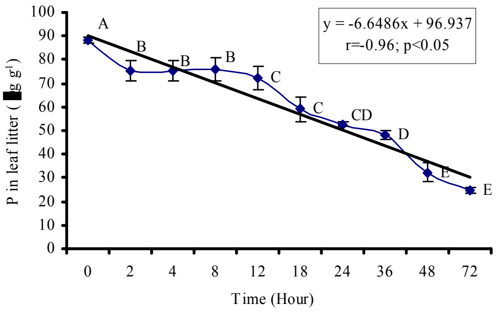


Fig. 4. Phosphorous concentration in leaf litter at different time intervals during the leaching experiment. Means with similar alphabet are not significantly (p>0.05) different.

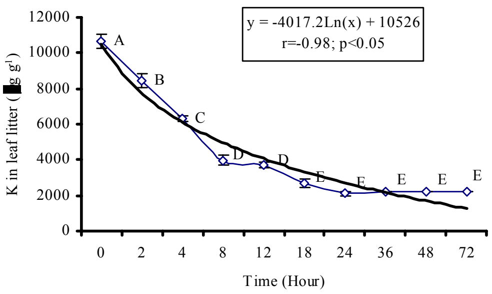


Fig. 5. Potassium concentration in leaf litter at different time intervals. Mean with similar alphabet are not significantly (p>0.05) different.

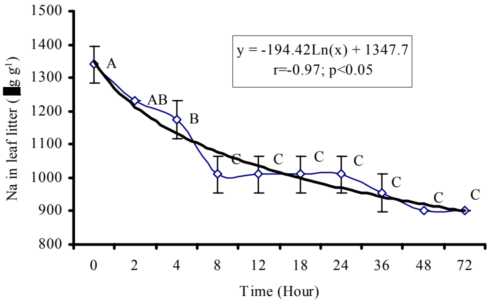
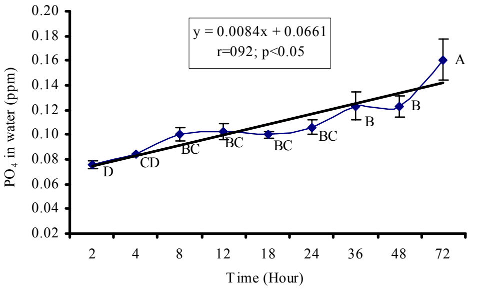


Fig. 6. Sodium concentration in leaf litter at different time intervals. Mean with similar alphabet are not significantly (p>0.05) different



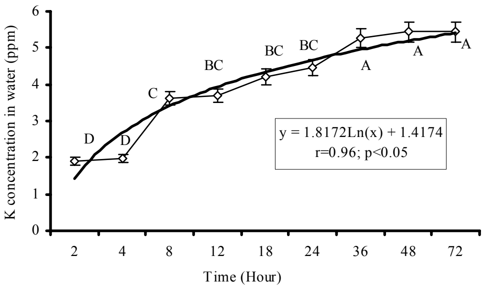


Fig. 7. PO_4 concentration of leached water samples at different time intervals. Means with similar alphabet are not significantly ($p<0.05$) different..

Fig. 8. Potassium concentration of leached water samples at different time intervals. Means with similar alphabet are not significantly ($p<0.05$) different.

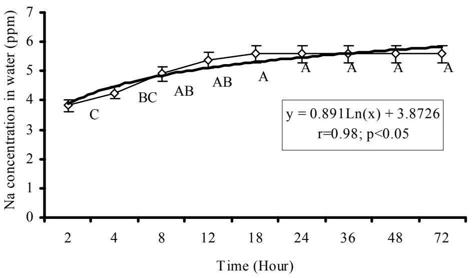


Fig. 9. Sodium concentration of leached water samples at different time intervals. Means with similar alphabet are not significantly ($p<0.05$) different.

Moreover, P, K and Na concentration in leaf litter showed significant negative relationships with the weight loss of leaf litter and the relationships were $y = -0.5874x + 53.361$, $r= -0.97$, $p<0.05$; $y = -19.461\mathrm{Ln}(x) + 177.99$, $r= -0.93$, $p<0.05$ and $y = -0.0798x + 102.03$, $r= -0.92$, $p<0.05$, respectively. PO_4, K, Na concentration in leached water significantly ($p<0.05$) increased to 0.16 ppm, 5.44 ppm and 5.58 ppm, respectively after 72 hours and exhibiting a significant ($p<0.05$) positive linear relationship with the leaching time (Fig. 7 to 9). Again, PO_4, K and Na concentration in leached water showed significant positive relationship with the weight loss of leaf litter and the relationships were $y = 439.72x - 27.503$, $r=0.92$, $p<0.05$; $y = 1.2998x^{1.899}$, $r=0.99$, $p<0.05$ and $y = 0.0034x^{5.1937}$, $r=0.95$, $p<0.05$, respectively.

Discussion

The initial rapid weight loss of leaf litter is associated with the leaching loss of both inorganic and organic compounds (Tukey, 1970). The conductivity and TDS values of a solution are the rough estimation of cations and dissolved organic substances (Allen, 1974). The positive relationships among the weight loss of leaf litter; conductivity; TDS and leaching time may narrate the similar findings of Park and Kang-Hyun (2003), where weight loss (%), subsequent loss of inorganic and organic substance from the leaf litter increased with longer leaching time. Moreover, the positive linear relationships among weight loss of leaf litter, conductivity and TDS of leached water indicated that the weight loss of leaf litter could be the result of leaching of cations and other soluble organic substances.

Different cations showed different rate of leaching, which depends on the characteristics of individual cations, environmental factors, initial concentration in litter (Tukey, 1970; Marschner, 1995) and cations involvement in the structural properties of respective plant cell (Meyer *et al.*, 1973). Phosphorus is most abundant in meristematic tissue and reproductive components (seeds and fruits) (Meyer *et al.,* 1973), but K and Na are accumulated in physiologically active tissues (leaves, buds and roots) (Marschner, 1995) and this could be the reason for observing comparatively lower concentration of P in leaf litter. The negative relationship among (P, K and Na) in leaf litter and leaching time explain that cations concentration significantly ($p<0.05$)

decreased with longer leaching time. Conversely, the positive relationship among the leaching time and PO_4, K and Na, conductivity, TDS of leached water were the evidences of cations leaching from leaf litter. Leaching is the preliminary stage of litter decomposition and it ceases at certain stage (Mason, 1977), this could be the reason for observing negative curvilinear relationship with the weight loss and cations concentration in leaf litter and positive curvilinear relationship among weight loss and cations concentration in leached water with the progress of time. Park and Kang-Hyun (2003) also observed similar negative relationships among the rate of weight loss and subsequent loss of inorganic substance from the leaf litter during the leaching process.

Conclusion

The amount of nutrient addition to the soil is the combined action of leaching and decomposition of litter, which might ensure the sustainability of soil fertility. In this study, the knowledge of K, P and Na leaching from the leaf litter might help the agroforestry practitioners to add a new criterion to choose potential tree species for their farming system. For limited lab facility and time constraints, other important nutrients could not be measured. However, to get a complete picture about the cations release efficiency, decomposition of leaf litter of this species should be investigated.

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