NUTRIENTS (P, K AND Na) LEACHING FROM LEAF LITTER OF *DALBERGIA SISSOO* (ROXB.)

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Abstract

Dalbergia sissoo (Roxb.) is best known as a premier timber species of the rosewood genus. This species deserves greater consideration for agroforestry applications for its multiple uses, tolerance to light, frosts and long dry seasons. Nutrients (P, K and Na) leaching from leaf litter of *D. sissoo* were studied in the laboratory. About 20% of initial weight of leaf litter was lost, while conductivity and TDS (Total Dissolved Solid) of leached water increased to 239 µS/cm and 114 mg/l, respectively and pH decreased to 5.81 after 96 hours. Weight loss (%) of leaf litter, conductivity and TDS of leached water showed significant (NAOVA, $p<0.05$) curvilinear relationship with leaching time. During the leaching process, 71%, 75% and 36% of initial concentration of P, K and Na in leaf litter were decreased, respectively after 24 hours and they showed significant (NAOVA, $p<0.05$) negative curvilinear relationship with the leaching time.

Keywords: *Dalbergia sissoo*, Leaching, Nutrients, Weight loss.

Introduction

Agroforestry is an effective production system that ensures the optimum use of productive capacity of soil. In Bangladesh, agroforestry is not a new concept but mostly confined in homestead. Agroforestry practice is now an urgent issue to meet the ever increasing demand of agricultural and forest products and also minimizes the environmental degradation. However, sustainability of any agroforestry practice depends on the perfect combination of both tree and agricultural crops (Dwivedi, 1992). In agroforestry system, trees and agricultural crops use the same piece of land which may induce competition for both above and below-ground resources (Nair, 1984). Tree species being a perennial component, plays an important role to improve the site condition (Marschner, 1995). Tree species uptake nutrients from the deep layer of soil compared to agricultural crops and the up taken nutrients become available to the agricultural crops through leaching and decomposition of litter (Kimmins, 2004). However, the rate of nutrient addition to the soil varies with species, nutrient composition of litter and environmental conditions (Jones, 1998; Marschner, 1995). So, appropriate tree species is a vital issue for sustainable agroforestry practice. Different tree species have been used (*Azadirachta indica, Melia azaderach, Eucalyptus* spp., *Syzygium* spp. *Mangifera indica, Dalbergia sissoo, Albizia* spp. *Leucaena leucocephala, Litchi chinensis, Acacia* spp. etc.) in different agroforestry practices in Bangladesh, (Anon, 2006), but *D.*

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sissoo has got special interest due to its multipurpose use, faster growth and nitrogen fixing capability (Tewari, 1994).

So far, no attempt has been taken to screen agroforestry tree species on the basis of nutrient return capabilities, which can provide the complete picture of their suitability. In this context, tree species with efficient nutrient return is becoming the vital research interest in agroforestry practices. Leaf litter is the main and quick source of nutrient return to the soil through leaching and decomposition compared to other litter components (Mason, 1977; Park and Kang-Hyun, 2003). So, the present study focused to assess the pattern of nutrients (P, K and Na) leaching from the leaf litter of *D. sissoo*.

Materials and Methods

Experimental setup

Bulk of yellowish senescence leaves was picked from trees and air-dried at room temperature for one week. Leaves were then thoroughly mixed and accurately weighted to 2 g of leaves as individual sample. Similarly, a total 41 samples were prepared of which, thirty six samples were placed into individual beaker (500 ml) and 200 ml of distilled water was poured to each beaker and few drops of $HgCl_2$ solution (50 mg/L) (McLachlan, 1971; Otsuki and Wetzel, 1974) were added to each beaker to prevent from fungal decay. Five samples were kept into the oven at 80 °C until constant weight to get the air-dry to oven-dry conversion weight.

Sample collection and measurements

Three replicates of samples were collected at 0, 2, 4, 6, 8, 10, 12, 18, 24, 48, 72 and 96 hours, respectively. The collected samples were ringed by distilled water and oven dried at 80 °C until constant weight. The oven-dried samples were weighted accurately to calculate the weight loss due to leaching and samples were processed according to Allen (1974). Conductivity (μS/cm), total dissolve solid (TDS) (mg/l) and pH of leached water samples at different time intervals were measured by a conductivity and TDS meter manufactured by Ciba-Corning Diagnostic Ltd., England and a pH meter with automatic temperature compensator manufactured by using Ciba-Corning Diagnostic Ltd., respectively.

Nutrients in leaf litter

The processed samples were accurately weighted to 0.2 g and put into digestion flask to acid digest according to Allen (1974). Potassium and Na concentration in the leaf at different time intervals were measured by Flame photometer (PFP7, Jenway LTD, England). While, P concentration was measured according to Timothy *et al.* (1984) by using UV-Visible Recording Spectrophotometer (SHIMADZU, UV-160A, JAPAN).

Statistical analysis

Weight losses (%) due to leaching were transformed to arcsine; conductivity, Total Dissolve Solid (TDS) and pH values of leached water samples; and P, K and Na concentration in leaf litter at different time interval were compared by ANOVA followed by DMRT using SAS 6.12 statistical software. The relationship among weight loss, conductivity and TDS of leached water, P, K and Na in leaf litter and time intervals were calculated by using SAS 6.12 statistical software. Moreover, relationships among weight loss (%) and conductivity, TDS, P, K and Na concentration in leaf samples were calculated by using SAS 6.12 statistical software.

Results and Discussions

Weight loss of leaf litter, Conductivity, TDS and pH of leached water samples

The initial dry weight of leaf litter significantly (ANOVA, DMRT, $p<0.05$) decreased to 9% after 6 hours, but 20% of weight loss was observed after 96 hours and weight loss (%) showed significant (ANOVA, $p<0.05$) positive curvilinear relationship with the leaching time (Figure 1). Conductivity of leached water significantly (ANOVA, DMRT, $p<0.05$) increased to 239 µS/cm after 96 hours (Figure 2). Irrespectively, total dissolve solid (TDS) showed similar pattern to conductivity, which significantly (ANOVA, DMRT, $p<0.05$) increased to 114 mg/l after 96 hours (Figure 3). pH of leached water samples was significantly (ANOVA, DMRT, $p<0.05$) varied with leaching time and fall to 5.81 after 96 hours.

The initial rapid weight loss of leaf litter is associated with the leaching 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 result of this study showed a significant (ANOVA, $p<0.05$) positive curvilinear relationship among the weight loss; conductivity; TDS and leaching time intervals (Figures 1 to 3). Similarly, Park and Kang-Hyun (2003) reported that the rate of weight loss, subsequent loss of inorganic and organic substance from the leaf litter varied with time. Moreover, the positive linear relationship between weight loss and conductivity ($y = 0.0879x - 4.7898$, $r=0.91$, $p<0.05$); weight loss and TDS ($y = 0.1851x - 4.7266$, $r=0.91$, $p<0.05$) indicated the weight loss of leaf litter could be the result of leaching of cations and other soluble organic substances, which increased with time.

Nutrients in leaf litter

The initial P, K and Na concentration significantly (ANOVA, DMRT, $p<0.05$) decreased to 25 μg/g, 2642 μg/g and 2576 μg/g, which were 71%, 75% and 36%, lower concentration, respectively. Initial rapid decrease of P concentration was observed after 4 hours, while K and Na concentration were rapidly decreased after 2 hours (Figures 4 to 6). Higher concentration of K and Na than P at initial stage of leaf litter could be the reason for observing higher initial leaching of K and Na compared to P.

Different nutrients showed different rate of leaching, which depends on the characteristics of individual nutrient, environmental factors, initial concentration in litter (Tukey, 1970; Marschner, 1995) and nutrients involvement in structural properties of respective plant cell (Meyer *et al*., 1973). Phosphorus is most abundant in meristematic tissue and accumulated in the reproductive components (seeds and fruits) (Meyer *et al.,* 1973) and leaf contained lower amount of P. But, K is highly mobile in plant and accumulated in physiologically active tissues (leaves, buds and roots) (Marschner, 1995). The concentration of P, K and Na in leaf litter showed significant (ANOVA, $p<0.05$) negative curvilinear relationship with the leaching time interval (Figures 4 to 6), which explains that nutrients concentration significantly (ANOVA, $p<0.05$) decreased with longer leaching time. Moreover, the negative relationship between P concentration and weight loss ($y = -0.2105x + 19.136$, $r= -0.98$, $p<0.05$); K concentration and weight loss ($y = -7.2628Ln(x) + 71.918$, $r= -0.96$, $p<0.05$); Na concentration and weight loss ($y = -30.097Ln(x) + 248.89$, $r= -0.90$, $p<0.05$) gave the evidences of weight loss caused by the leaching of nutrients 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 concentration of P, K and Na in leaf litter with longer leaching time. Similar types of negative relationships were also observed among the weight loss and subsequent loss of inorganic substance from the leaf litter during the leaching process (Park and Kang-Hyun, 2003).

Conclusion

Litter releases nutrients to the soil through leaching and decomposition and resulting return of considerable amount of nutrients to the soil. Thus, soil become enriched for sustainable crop production with minimum application of fertilizer in agroforestry system, but all trees are not be able to release equal amount of nutrients from litter. In this context, we should know the pattern of nutrient leaching from litter for selecting potential tree species in agroforestry practices. The knowledge of nutrient leaching will thus help us to select the best tree species for agroforestry practices in terms of nutrient return efficiency.

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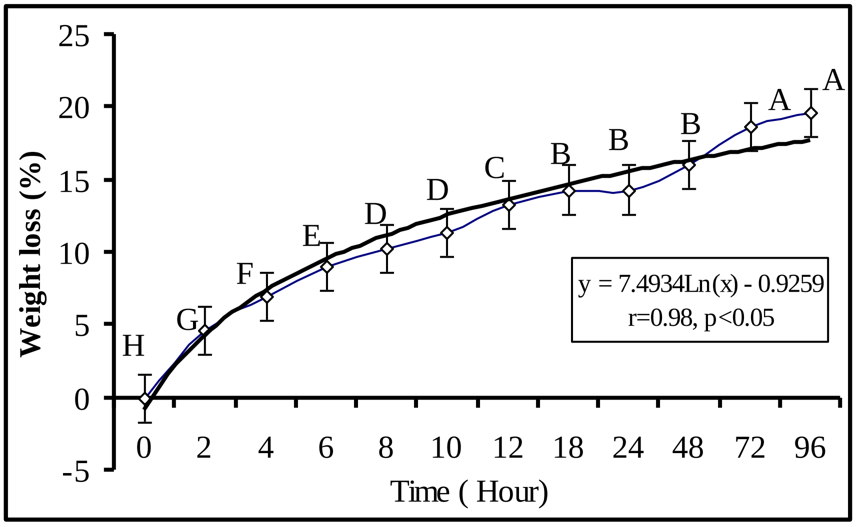

Fig.1. Weight loss (%) pattern of leaf litter due to leaching at different time intervals. Means (± SD, n=3) with similar alphabet in the line (according to time interval) are not significantly (ANOVA, DMRT, p>0.05) different.

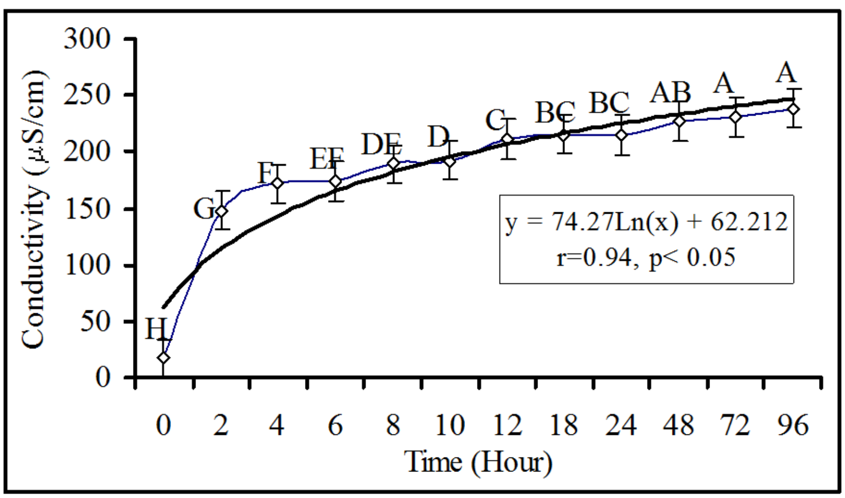

Fig.2. Pattern of conductivity (µS/cm) of leached water at different time intervals. Means (± SD, n=3) with similar alphabet in the line (according to time interval) are not significantly (ANOVA, DMRT, p>0.05) different.

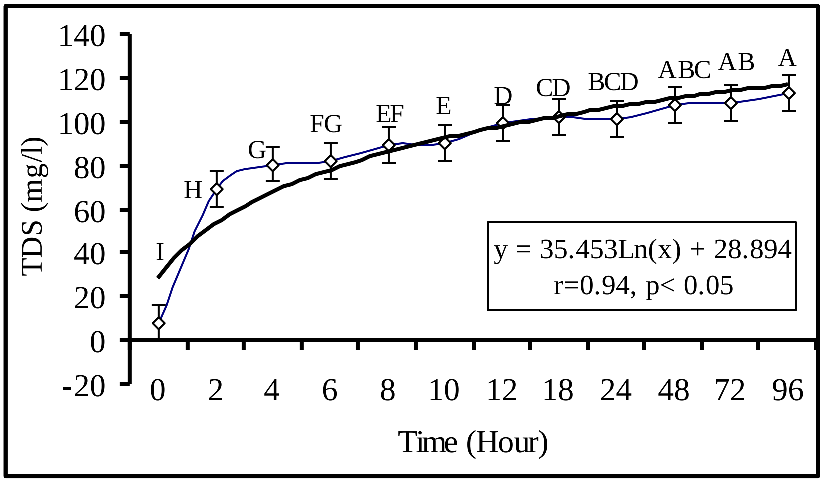

Fig.3. Pattern of total dissolve solid (mg/l) of leached water at different time intervals. Means (± SD, n=3) with similar alphabet in the line (according to time interval) are not significantly (ANOVA, DMRT, p>0.05) different.

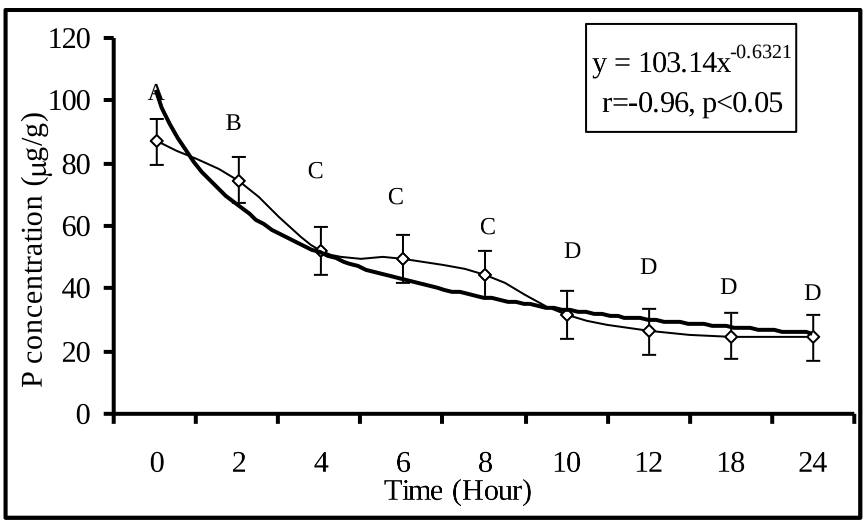

Fig.4. Phosphorus concentration (µg/g) in leaf litter at different time intervals. Mean (± SD, n=3) with similar alphabet in the line (according to time interval) are not significantly (ANOVA, DMRT, p>0.05) different.

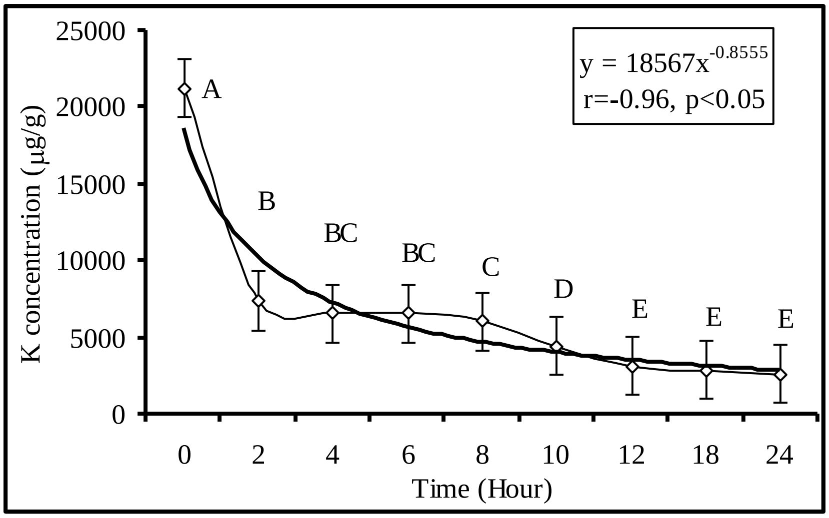

Fig.5. Potassium concentration (µg/g) in leaf litter at different time intervals. Mean (± SD, n=3) with similar alphabet in the line (according to time interval) are not significantly (ANOVA, DMRT, p>0.05) different.

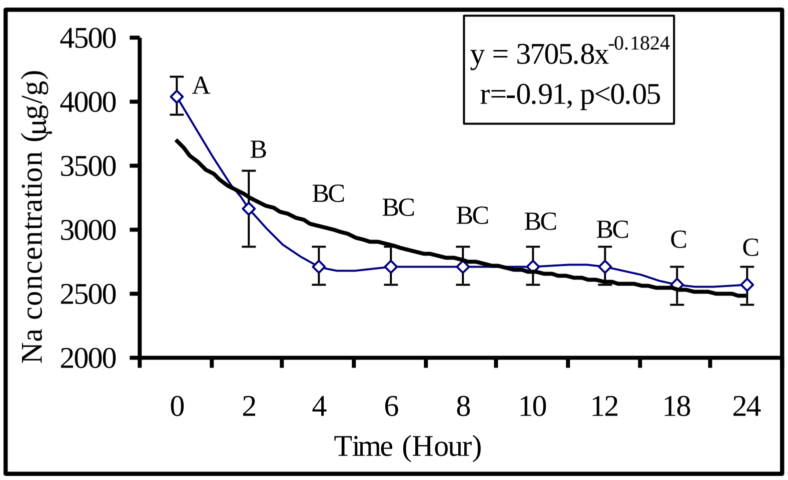

Fig.6. Sodium concentration (µg/g) in leaf litter at different time intervals. Mean (± SD, n=3) with similar alphabet in the line (according to time interval) are not significantly (ANOVA, DMRT, p>0.05) different.

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