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Macronutrient release in Rajendrapur forest soils amended with tree leaf litters

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Abstract

Macronutrient release pattern in tree leaf litters amended Rajendrapur forest soils was studied during the period from 23 June to 24 September, 2005 by an incubation experiment over four months. Leaf litter viz. *Teak* (*Tecktona grandis*), *minjiri* (*Cassia stamea*), *sal* (*Shorea robusta*) and *mahogoni* (*Sweitenia macrophylla*) were added to the soil @ 1g 50 g^{-1} soil (dry wet basis). The experiment was laid out in a completely randomized design with three replications. Nutrients were significantly released upon decomposition of the leaf litters used. The highest NH_4^+-N and NO_3^--N was released from *minjiri* amended soil at day 5 and day 20, respectively. After an initial flash of available P there was a marked decrease in all the amended soils. The release of K into the available pool was higher in *mahogoni* and *mingiri* than other amendments. The highest release of Ca was observed in teak amended soil after two months and *mahogoni* amanded soil recorded the highest amount of Mg at day 5. Available S release followed almost the same trend as for N.

Keywords: Macronutrient, *Teak, Minjiri, Sal, Mahogoni*

Introduction

Nutrient release from decomposing litter is an important internal pathway for the nutrient flux in forest ecosystems. Nutrients may be released from litter by mineralization (Swift *et al.,* 1979). The rate at which nutrients are released depends on several factors as indicated by Seasted (1984) are the chemical composition of the litter, the structural nature of the nutrients in the litter matrix, the microbial demand for the nutrient and the availability of exogenous sources of the nutrients. Factors affecting nutrient release from litter are macro and microclimatic variables and microbial and faunal biotic activity (Reichle, 1977). Above ground litter plays a fundamental role in the nutrient turnover and in the transfer of energy between plants and soil, the source of the nutrient being accumulated in the upper most layers of the soil. This is particularly important in the nutrient budgets of forest ecosystems on the nutrient poor soil where to a large extent the vegetation depends on the recycling of the nutrients contained in the plant detritus (Singh, 1978). Litter quality affects not only the rates of mass loss but also the patterns and rates of nutrient immobilization or release. Unfortunately, there is no published report on the macronutrient release pattern from leaf litters of the study area of Bangladesh. Keeping the above facts in view, the present piece of research work was undertaken to examine the macronutrient release pattern from the leaf litters of some important tree species of Rajendrapur forest soils of Bangladesh.

Materials and Methods

An incubation experiment was carried out in the laboratory of the Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh, during the period from June to September, 2005. Leaf litters viz, *Teak* (*Tecktona grandis*), *minjiri* (*Cassia stamea*) *sal* (*Shorea robusta*) and *mahogoni* (*Sweitenia macrophylla*) were collected from Rajendrapur forest. Some properties of the collected leaf litters have been presented in Table 1.

Table 1. Some selected characteristics of *teak, minjiri, sal* and *mahogoni* used in the experiment

Leaf litter	Organic C (%)	Total N (%)	Total P (%)	Total K (%)	Total Ca (%)	Total Mg (%)	Total S (%)	C:N Ratio	C:P Ratio	C:S Ratio
Sal	50.54	0.96	0.19	0.79	0.82	0.76	0.07	52	266	722
Teak	52.81	1.12	0.44	0.53	1.72	0.61	0.06	46	96	812
Minjiri	48.91	1.20	0.30	0.93	1.01	0.56	0.08	41	188	611
Mahogoni	44.30	1.29	0.49	1.63	0.59	0.80	0.10	34	76	443

The soil collected for this experiment from the selected areas of Rajendrapur forest soil of Bangladesh was sandy loam with pH 4.20, 1.24 % organic matter, 0.02% total N, 13.31 $\mu g\ g^{-1}$ available P, 21.28 $\mu g\ g^{-1}$ S, 50 $\mu g\ g^{-1}$ Ca, 61 $\mu g\ g^{-1}$ Mg, and 19 cmol Kg^{-1} soil of exchangeable K. Undecomposed plant materials were removed by hand and the soil was sieved (<2mm). Samples were conditioned aerobically at room temperature and at 40% water holding capacity (WHC) for 10 days. This allowed the soil microbial population to stabilize, minimizing the effects of soil handling and preparation (Chowdhury, 2000). Immediate after conditioning, the soil was used for amendment. Oven dried and finely ground leaf litters were added to the soil at the rate of 1g 50 g^{-1} soil (dry weight basis) and placed in 100 mL glass jars. The experiment was laid out in completely randomized design (CRD) with three replications. Following amendment, glass jars were placed in 1L glass bottles, sealed and incubated at room temperature for 120 days. To trap CO_2, 20 mL of 1M NaOH solution was placed inside each jar. To maintain internal humidity of the 1L glass bottle, 10 mL distilled water was added at the bottom of each incubation bottle. Available NH_4^+ and NO_3^- -N, P, Ca, Mg, S and exchangeable K were determined after 5, 10, 15, 30, 60 and 120 days of incubation following standard methods of analyses (Page *et al.* 1989). Collected data were statistically analyzed by a computer using statistical package programme MSTAT-C developed by Russel (1986). A one way ANOVA was made by F variance test. The pair comparisons were performed by least significant difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

Results and Discussion

The KCl extractable NH_4^+-N varied markedly with the types of leaf litter and period of incubation (Fig.1A).The release of NH_4^+-N was highest in *minjiri* amended soil at day 5. All amended soil showed decreasing trend of NH_4^+-N up to 30 days of incubation and thereafter a gradual increase of NH_4^+-N was noted up to the end of incubation *sal* amended soil where NH_4^+-N gradually decreased after day 60. *Minjiri* amended soil showed the maximum release of NH_4^+-N (54 $\mu g\ g^{-1}$ soil) at day 120 of the incubation which was followed by *Mahogoni* amended soil (Fig.1A). Toor *et al.,* (2001) reported that mineralization was highest at first sampling (5^{th} day of incubation). Avnimelech (1986) and Melillo *et al.*, (1982) reported that N mineralization rates were significantly correlated with the initial C: N or the initial lignin content of the substrate. Melillo *et al.*, (1989) found that in the early decomposition process, low quality litter will release N than high quality litter because available nutrient are immobilized more rapidly by microbes decomposing low quality, nutrient poor liter.

Incubation of soils amended with *teak, minjiri, sal* and *mahogoni* litters showed considerable variations in the release of NO_3^--N. The highest release was observed on day 15 from all the amended soils except *mahogoni* (Fig.1B). A maximum concentration of NO_3^--N was depicted in the soil amended with *minjiri* (89 μg g^{-1} soil) at day 15 of incubation and it decreased thereafter. Similar trend was observed in the *teak, sal* and *mahogoni* amended soils with some fluctuations. The concentrations of NO_3^--N at 120 days of incubations were 56.9, 62.8, 64.5 and 55.8 μg g^{-1} soil due to amendment with litter of *teak, minjiri, sal* and *mahogoni,* respectively, which were significantly higher over the control (38.4 μg g^{-1} soil). Melillo *et al.*, (1982) reported that some denitrification might also occur from anaerobic microsites probably developed due to application of organic residues in particular (Khalil *et al,*. 2001). Aulakh *et al.,* (1991) emphasized that denitrification increased with increasing N content and decreasing C to N ratio. The difference in available N content of soils among the leaf litter treatments can be attributed to N content of plant materials applied and their respective decomposition rates (Debnath and Hajra, 1972).

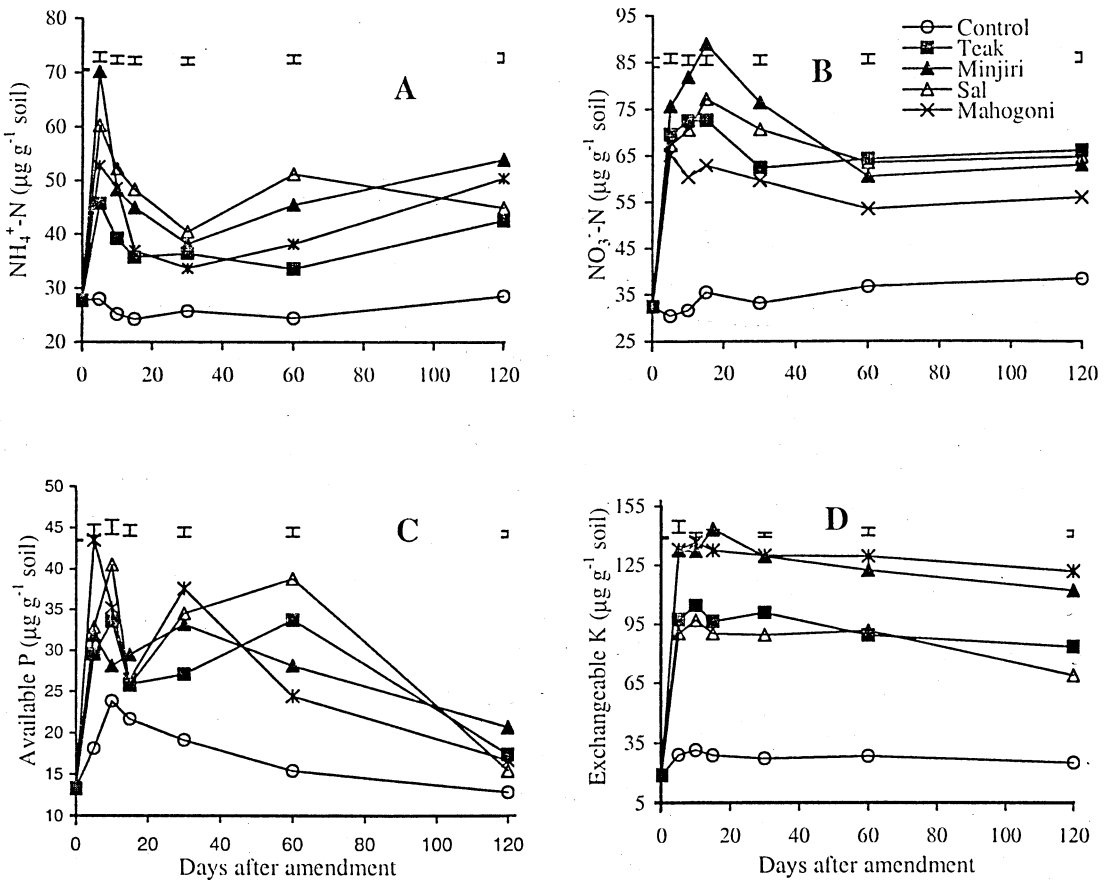

Fig. 1 Release of NH_4^+-N (A), NO_3^--N(B), available P (C) and exchangeable K (D) in *teak, minjiri, sal* and *mahogoni* leaf litters amended soil during 120 days incubation. Bars indicate LSD <0.05

Available P contents in litter treated soils were significantly higher compared to control (Fig.1C). After the initial release of available P, there was a marked decrease in all the amended soils. This might be due to either fixation by Fe, Al, or Mn ions present in the forest soils of low pH or immobilization by microbial biomass. Iltutmish *et* al., (2006) observed P mineralization in Chittagong evergreen forest was of the order *gamar> eucalyptus> jam> garjan* leaf litter amended soils. Microbial immobilization of available P during organic mater decomposition may be beneficial since it may lead to a decrease in the fixation of inorganic P. Mineralization of organic matter is likely to play a major role in P availability for plant growth. Release of several organic acids during decomposition might have reduced metal ions by chelation (Joseph *et al.*, 1952). Further, these organic acids being anionic could enhance P-release competing for the exchange sites. Initial low release of inorganic P during decomposition of leaf litter matter in the present experiment provided a continuous supply of P with a minimal exposure to the different fixation mechanisms. The presence of organic matter in the soil effectively decreases the P fixation by the soil through the acidifying and chelation mechanisms (Avnimelech, 1986).

The release of K to soil pool was more dependent on the quality of the litter. Potassium release varied making a peak at day 10 in soils amended with leaf litters except *minjiri.* After day 60, K release was almost stable in *mahogoni, minjiri* and *teak* amended soils. But in *sal* amended soil it decreased. However, exchangeable K contents in all the leaf litter treated soils were significantly higher compared to control (Fig. 1D). The increase in exchangeable K of soil may be attributed to the fact that K is not strongly bound in organic structures, unlike that of N and S. Hence, microbial action is not critical for K-release as it was for the mineralization of organic bound elements. This could be one of the reasons for no immobilization as indicated by large release to the available pool (Chemide, 1995).

Sulphur mineralization followed almost the same trend as for N mineralization. It was observed that the amount of extractable S in soil varied with the source of leaf litter and peroid of incubation (Fig. 2A). Sulphur availability decreased at 5 days of incubation in case of *sal* and *minjiri* amended soil and thereafter a gradual increase was recorded. The availability of S after 30 days of incubation increased up to end of the incubation period in *teak* amended soil (Fig. 2A). Available S contents in all the leaf litter treated soils were significantly higher compared to control. Fitzgerald and Andrew (1984) have shown that methionine-S is rapidly converted to SO_4-S and soil organic-S in 2 days following its addition to soil. Strickland *et al.*, (1986) have shown that most (70-100%) of the organic-S derived from forest litter can be mineralized or converted into other forms of organic-S after 7 days exposure in soil. Furthermore, results of the present study showed that once S was immobilized probably by the microbial biomass, S was directly transformed into the soil organic fraction. This suggests that the S immobilization by the microbial biomass and subsequent transformation into soil organic matter is not available for plant until it is remineralized.

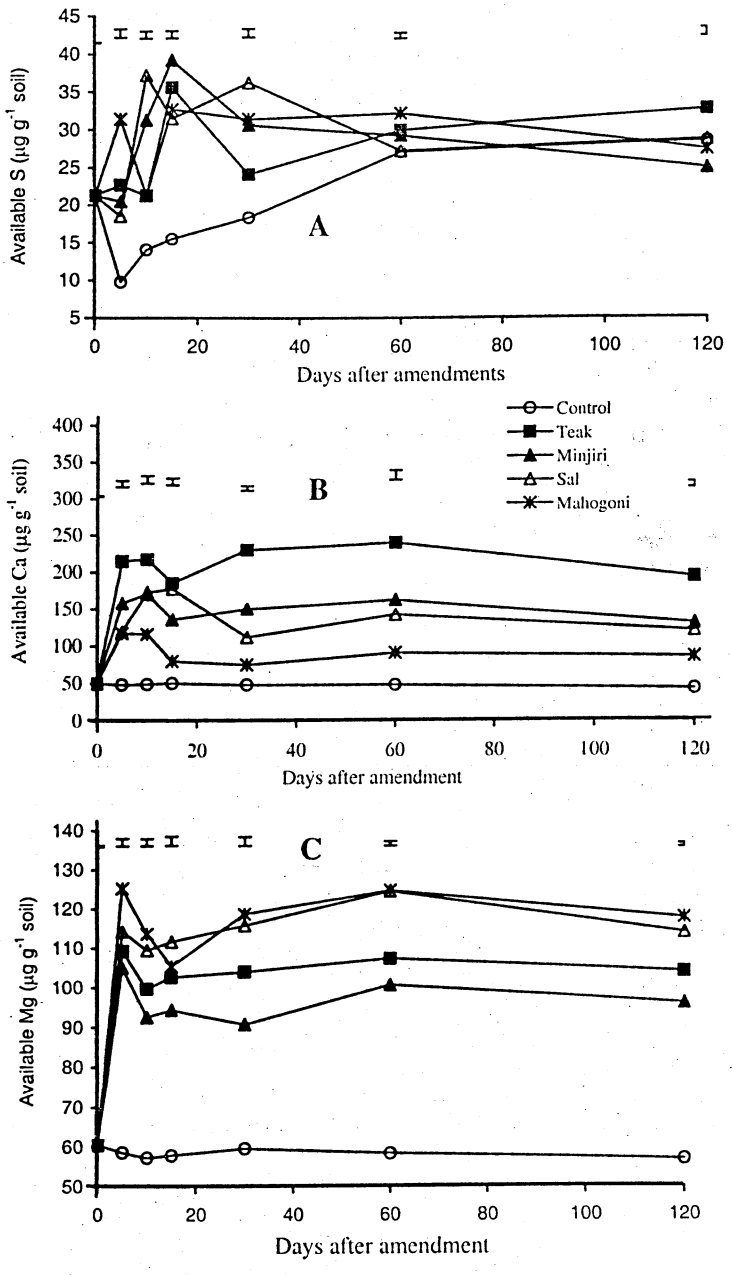

Fig:2. Release of available S (A), Ca (B) and Mg (C) in teak, minjiri ,sal and mahogoni leaf litters amended soil during 120 days incubation. Bars indicate LSD <0.05

The available Ca content in all the leaf litter treated soils was significantly higher compared to control. Calcium content varied widely after 5 days of incubation but later on it's availability ranked in the order of *teak* > *minjiri* > *sal* > *mahogoni* (Fig. 2B). Higher amounts of Mg were recorded in *mahogoni* and *sal* amended soil than *teak* and *minjiri* amendment. A large amount of Mg was released from *mahogoni* (125 µg g^{-1} soil) at day 5 and afterwards it

decreased slightly (Fig.2C). At 120 days of incubation, the concentration of Mg was 104, 96, 114 and 118 μg g^{-1} soil amended with *teak, minjiri, sal* and *mahogoni,* respectively, which were significantly different from control (57 μg g^{-1} soil)(Fig. 2C) .Tantos and Paioannon, (2000) stated that the effect of the forest species and the site quality on the amount of organic matter and nutrients accumulated in different parts of the forest floor were found to be significant.

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