

NET N MINERALISATION IN COCONUT/NITROGEN FIXING TREE-BASED SYSTEM

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ABSTRACT

To study the net N mineralisation rates of coconut/NFT plantations, a field incubation technique was carried out. In this study, four types of NFT i.e. *Acacia auriculiformis*, *Calliandra calothyrsus*, *Gliricidia sepium*, *Leucaena leucocephala* and coconut monocropping were selected. Forty plastic tubes were inserted into the soil, to a depth of 15 cm at a distance of 2 m and 1 m away from coconut palm, for field incubation period of 2 weeks. Similarly another set of forty tubes were inserted for a 4 week field incubation period, after removing the previous set of tubes. Fresh soil samples (same depth) were also taken close to the inserted tubes on the day on which tubes were inserted for the estimation of initial N concentrations in the soil. Mineralised N concentrations were extracted by 2 M KCl and the net N mineralisation rates were calculated.

Net N mineralisation was significantly higher ($P \leq 0.001$) 4 weeks after field incubation period than 2 weeks and also, the significant higher ($P \leq 0.001$) net N mineralisation was shown 2 m away from coconut than

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1 m away from coconut. The highest net N mineralisation (4.9 - 15.5 kg ha⁻¹) was found in *Gliricidia* site than in the other NFT sites, followed by *Leucaena* > *Calliandra* > *Acacia*. The lowest net N mineralisation (1.2 - 2.2 kg ha⁻¹) was recorded in the coconut monocrop, either 2 weeks or 4 weeks incubation period. This study clearly indicated that growing NFTs with coconut enhances N availability in coconut lands and *Gliricidia* being the most promising.

INTRODUCTION

The mineralisation of organic N in soils is mediated by microorganisms and is influenced by factors affecting microbial activity in soils. Nitrogen mineralisation depends on the transformation of N from organic state to the inorganic form NH₄⁺ or and NO₃⁻.

In the tropics, mineralisation is known to be enhanced by favourable soil temperatures in the rhizosphere (Blondel, 1971). The importance of the soil N mineralisation in meeting plant N needs has long been recognised. In nonfertilized ecosystems, the requirements for plant production is mainly derived from this source (Clark, 1981).

Nitrogen fixing trees (NFTs) are now being planted in some nutrient deficient coconut soils in Sri Lanka and these sites have shown a remarkable response in coconut tree growth due to N input. Nitrogen fixing trees have long been recognized as a source of N and addition of organic matter in coconut plantations (Gunaratne and Heenkende, 1994). In addition, NFTs provide a favourable microclimate to the coconut palm as well as coconut soils. However, their role as a source of nutrient for improving soil quality have been little understood.

The net N mineralisation in the coconut rhizosphere on lateritic gravel soil in the Low Country Wet Zone has been reported as 25-60 kg ha⁻¹ yr⁻¹ (Tennakoon, 1990). However, this value has increased when fertilizer,

either as inorganic or organic form is applied. When recommended inorganic fertilizers, for coconut are applied to soils, the net N mineralisation has been shown to be 73-495 kg ha⁻¹ yr⁻¹ while it was 106-625 kg ha⁻¹ yr⁻¹ after application of organic manure such as goat dung. These values differ according to season, due to changing rainfall and temperatures (Tennakoon, 1990). The net N mineralisation rates in some N fixing trees growing in Coniferous forest soils, have been reported to be 50-150 kg ha⁻¹ yr⁻¹ (Gosz, 1981).

MATERIALS AND METHODS

Site description

The experimental site was located at Rathmalagara estate, Madampe, Sri Lanka, situated in the Intermediate Zone receiving an average 1500 mm of annual rainfall with a mean annual temperature of 27° C. The soil belongs to Andigama series of Red Yellow Podzolic soils which is considered marginal for coconut cultivation. The soil is a well drained, moderately deep to deep and loamy with gravel on lateritic hardpan.

Four species of nitrogen fixing trees (NFTs) i.e. *Acacia auriculliformis*, *Calliandra calothyrsus*, *Gliciridia sepium* and *Leucaena leucocephala*, established in 1989, were selected for this study. All NFTs were planted between the coconut row at a distance of 2 m x 1 m.

These were planted in a block with four replicates. A coconut monocropping block (with 4 replicates) was considered as a control.

Sampling procedure

Plastic tubes (50 mm diameter and 30 cm long) were inserted to a depth of 15 cm near to (in two distances) nitrogen -fixing trees and coconut palms in treatment plots. Total of 40 plastic tubes were placed at two distances i.e. 1 m and 2 m away from coconut palms respectively. (2 m and 1 m away from NFT respectively) and tubes were removed 2 weeks (Time 1) afterwards. The same procedure was followed by inserting another set of (40)

plastic tubes for the period of 4 weeks of field incubation period (Time 2) at the same distances from the coconut and NFT's, after removing the 1st set of plastic tubes.

Figure 1 is a diagrammatic representation of the sampling positions/sites in one treatment plot. The same number of fresh soil samples at the same depth (15 cm) were also collected close to the tubes inserted (5 cm away) on the same day (T_0). These soil samples were analysed to determine the initial N (NH_4N and NO_3N) concentrations in plots. Similarly, another set of fresh soil samples at the same depth were collected following the same procedure for the determination of initial N concentrations (NH_4N and NO_3N) for a 30 day incubation period (T_0)1.

Chemical Analysis

Fresh soil samples were allowed to pass through 2mm sieve prior to analysis. Mineralized N (NH_4N and NO_3N) was extracted by shaking soil samples (10 g fresh weight) for 1 hour with 100 ml of 2 M KCl (Marr and Cresser), 1983). Extracts were filtered through Whatman number 42 filter paper. The NH_4N and NO_3N concentrations were determined spectrophotometrically using RFIA Alpkem 300 (Rapid Flow Injection Analyzer). Measurements were made on field moist soil and results expressed on an oven dry basis (105 °C, 24h).

Calculation

The N mineralisation was calculated using the following equations.

1. For 2 weeks incubation period

$$\begin{aligned} \text{Net N mineralisation} &= (\text{NH}_4\text{N}_{(T1)} - \text{NH}_4\text{N}_{(T0)}) \\ (\mu \text{ g g}^{-1}) &+ (\text{NO}_3\text{N}_{(T1)} - \text{NO}_3\text{N}_{(T0)}) \end{aligned}$$

Where

$\text{NH}_4\text{N}_{(\text{T}0)}$ Mean NH_4N concentrations of initial (Time 0) non-incubated soil samples

$\text{NO}_3\text{N}_{(\text{T}0)}$ Mean NO_3N of initial (Time 0) non-incubated soil samples

$\text{NH}_4\text{N}_{(\text{T}1)}$ Mean NH_4N concentrations accumulated in field incubated soil sampled at 15 days (Time 1).

$\text{NO}_3\text{N}_{(\text{T}1)}$ Mean NO_3N concentrations accumulated in field incubated soil sampled at 15 days (Time 1)

2. For 4 weeks incubation period

$$\begin{aligned} \text{Net N mineralisation } (\mu \text{ g g}^{-1}) &= (\text{NH}_4\text{N}_{(\text{T}2)} - \text{NH}_4\text{N}_{(\text{T}0)}^1) \\ &\quad + \\ &= (\text{NO}_3\text{N}_{(\text{T}2)} - \text{NO}_3\text{N}_{(\text{T}0)}^1) \end{aligned}$$

Where

$\text{NH}_4\text{N} (\text{T}_0^1)$ Mean NH_4N concentrations of initial (Time 0¹) non-incubated soil samples

$\text{NO}_3\text{N} (\text{T}_0^1)$ Mean NO_3N concentrations of initial (Time 0¹) non-incubated soil samples

$\text{NH}_4\text{N} (\text{T}_2)$ Mean NH_4N concentrations accumulated in field incubated soil sampled at 30 days (Time 2).

$\text{NO}_3\text{N} (\text{T}_2)$ Mean NO_3N concentrations accumulated in field incubated soil sampled at 30 days (Time 2).

RESULTS AND DISCUSSION

Net N mineralisation of soil 1m away from coconut palm (i.e. 2m away from the NFT) 2 weeks and 4 weeks after field incubation period is shown in Figure 2.

Net N mineralisation showed highly significant difference ($\leq P 0.001$) between the soil samples taken from plots with different NFTs. The highest net N mineralisation was reported from the site (1 m) *Gliciridia* trees followed by *Leucaena*, *Calliandra* and *Acacia*. The lowest net N mineralisation was recorded in samples taken from coconut monoculture.

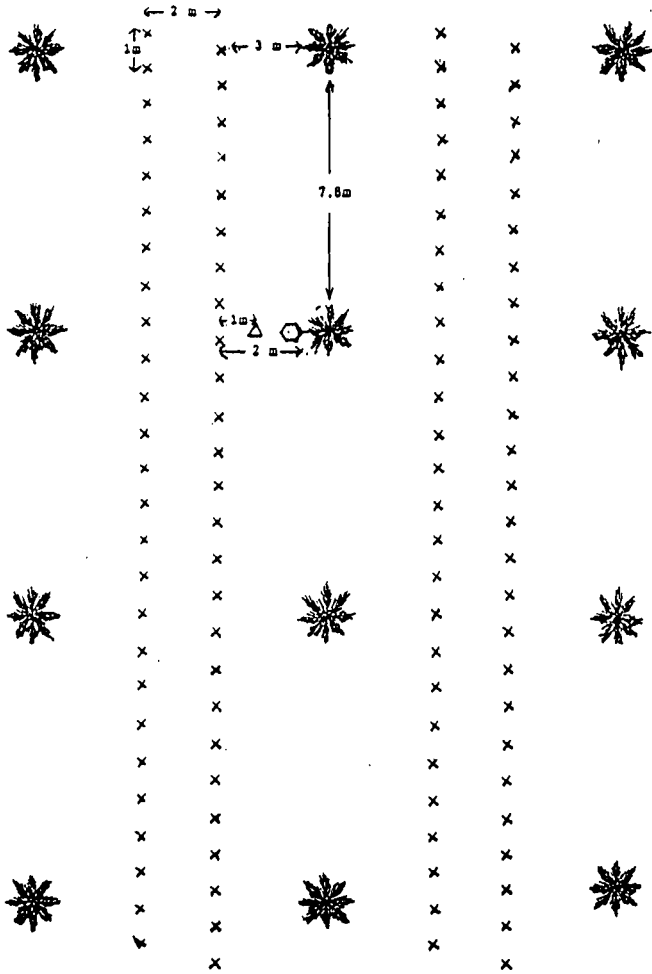
Figure 2 clearly showed that net N mineralisation is significantly higher ($P < 0.001$) at 4 weeks incubation period than that of 2 weeks.

Net N mineralisation 2 m away from the coconut palm (1m away from the NFT) after 2 and 4 weeks field incubation period is shown in Figure 3.

Net N mineralisation showed highly significant difference ($P < 0.001$) between samples taken 1 m away from different species of NFTs. The highest net N mineralisation occurred in plots with *Gliciridia* trees followed by *Leucaena* > *Calliandra* > *Acacia*. The lowest net N mineralisation was recorded in coconut monoculture after 4 weeks incubation period.

Net N mineralisation as kg/ha in different N-fixing trees and coconut trees are shown in Table 1.

Figure 1: Diagrammatic representation of sampling positions in one treatment plot



- KEY**
- x Nitrogen Fixing Tree (NFT)
 - ★ Coconut tree
 - △ Tube inserted 1 m away from NFT (3 m away from coconut)
 - Tube inserted 2 m away from NFT (1 m away from coconut)

Figure 2: Net N Mineralisation rate in 1 m away from the coconut palm (2 m away from the NFT)

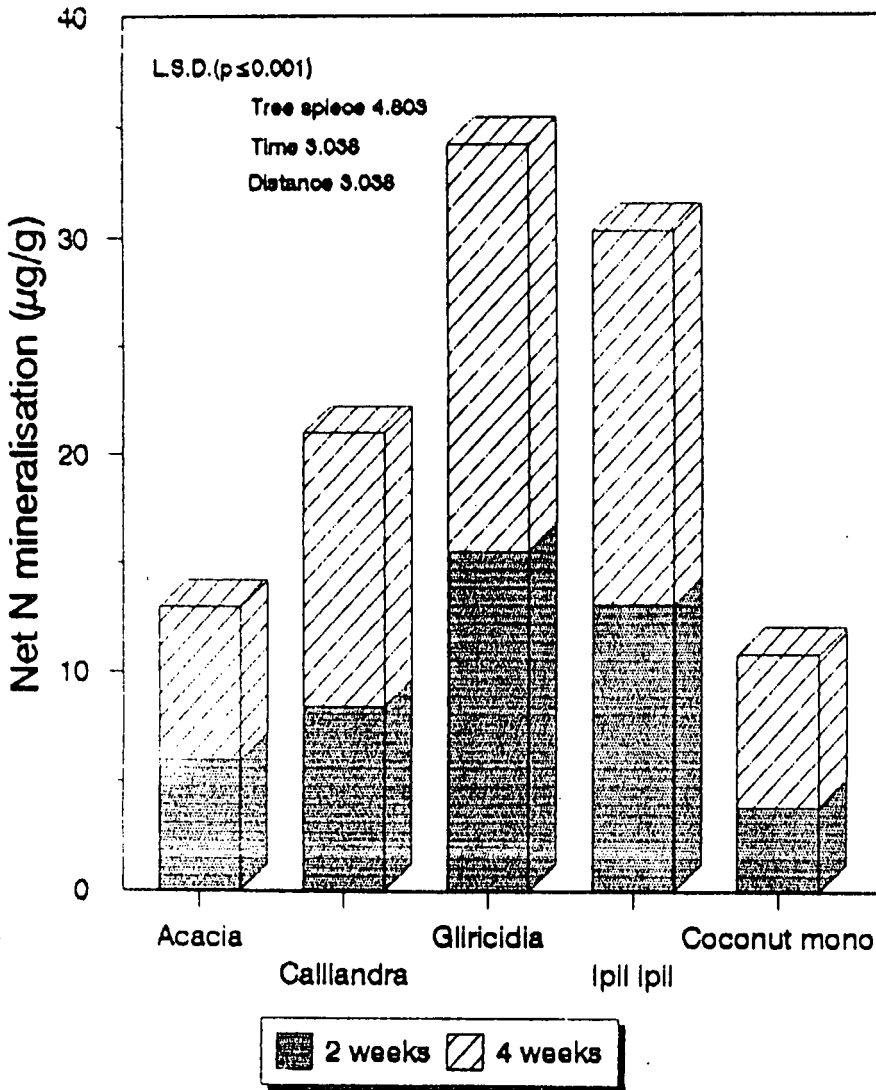


Figure 3: Net N mineralisation rate in 2 m away from the coconut palm
(1 m away from the NFT)

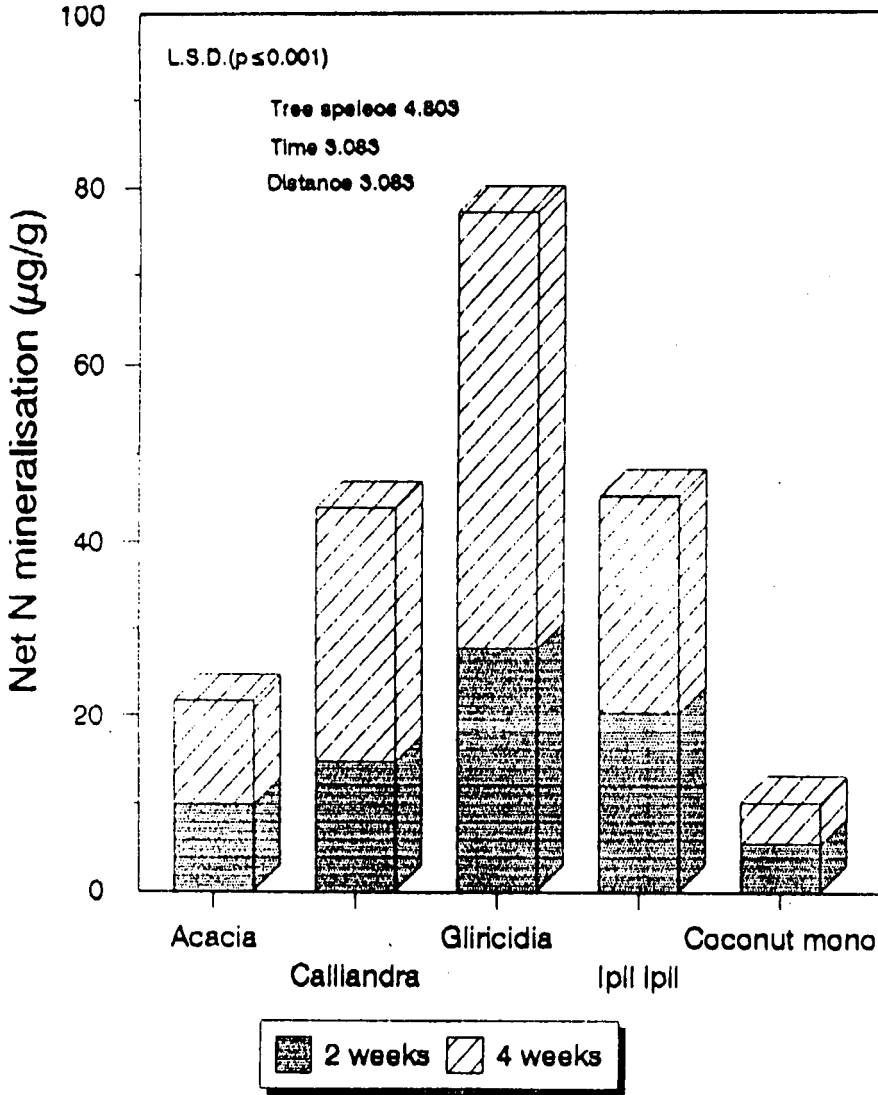


Table 1 Net N mineralisation (kg/ha) in different N fixing trees and coconut tree

N mineralisation kg/ha	2 weeks after field Incubation		4 weeks after field Incubation	
	1 m away from coconut	2 m away from coconut	1 m away from coconut	2 m away from coconut
Acacia	1.9	3.1	2.2	3.7
Calliandra	2.6	4.6	3.9	9.2
Gliricidia	4.9	8.7	5.9	15.5
Leucaena	4.1	6.4	5.4	7.8
Coconut-mono	1.2	1.7	2.2	1.5

In general, NFTs enhance soil mediated process by activity of microorganisms due to the high organic content of NFT rhizosphere. The increase of density of microorganisms in soil rhizosphere, helps to breakdown organic materials in the NFT rhizosphere.

Release of root exudate from NFT may also stimulate the growth of microorganisms (Killham, 1994). In addition, to fixing of N, those NFT palms with the addition of organic manure, after decomposition of falling leaves etc also supply nutrients for rapid growth of microorganisms in NFT rhizosphere than coconut monoculture rhizosphere. Therefore these increased microorganism population may help to perform autotrophic as well as heterotrophic nitrification and mineralisation process in the NFT rhizosphere. The highest N mineralisation is shown in Gliricidia trees amongst other N fixing trees, and this may be due to higher microbial population and activity occurrence in the Gliricidia rhizosphere (Tennakoon & Liyanage, Personal Communication).

Net N mineralisation and pool of NH_4N and NO_3N in the soil varied with time (i.e. 2 weeks and 4 weeks) and distance from the NFT's sites. Many workers (Brich, 1964; Nadelhoffer and Aber, 1984; White et al., 1988) have reported differences in N mineralisation due to time and environmental changes. In this study, the dynamics of N mineralisation was investigated 6 years after establishment of N fixing trees. Therefore, it is likely that the process of nineralisation would have been influenced by residual organic N from the NFT rhizosphere and that the main flush of N mineralised from the NFT rhizosphere soil.

Typical rates of N mineralisation varied from 50 to 150 kg $\text{Nha}^{-1}\text{yr}^{-1}$ in N-fixing coniferous forest plants (Gosz, 1981) although rates as high as 225 kg $\text{N ha}^{-1}\text{yr}^{-1}$ 1yr-1 have been reported (Fahey et al., 1985). In this study, net N mineralisation rates varied from 49 to 227 kg $\text{N ha}^{-1}\text{yr}^{-1}$. Nitrogen mineralisation rate in 'monoculture' coconut plantation was reported to be in the region of 25-60 kg $\text{ha}^{-1}\text{yr}^{-1}$. (Tennakoon, 1990). The observed N mineralisation in the NFT rhizosphere would have involved a combination of mineralisation of residual organic N derived from leaf litter and mineralisation of native soil organic N.

CONCLUSION

Net N mineralisation was found to be higher in the NFT rhizosphere than in monoculture coconut plantations. The rhizosphere microorganisms around NFT's stimulated N mineralisation process than in monoculture coconut plantation. Therefore, integration of NFT's with coconut, would increase N mineralisation and thereby supply the required N to the coconut palm. The coconut/NFT tree based integrated system helps to minimise additional input of N fertilizer in coconut plantations, thus saving on N fertilizer.

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