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

N.A Tennakoon and M. de S, Liyanage [1]

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 l 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 soll 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= 0.001) 4 weeks after field incubation peniod than 2 weeks and also, the significant higher (P= 0.001) net N mineralisation was shown 2 m away from coconut than l m away from coconut. The highest net N mineralisation (4.9 - 15.5 $kgha^{-1}$) 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 $kgha^{-1}$) 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 promismig.

INTRODUCTION

The mineralisation of organic N in soils is mediated by microorganisms and is influenced by factors affecting rmicroblal activity in soils. Nitrogen minerallsation depends on the transformation of N from organic state to the inorganic form NH_4+ or and $N0_{3-}$

In the tropics, mineralisation is known to be enhanced by favourable soll temperatures in the rhizosphere (Blondel, 1971). The importance of the soil N mmeralisation 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) arc 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 kgha $^{-1}yr^{-1}$ (Tennakoon, 1990). However, this value has increased when fertilizer, either as inorganic or organic form is applied. When recommended inorgaruic fertilizers, for coconut are applied to soils, the net N mineralisation has been shown to be 73-495 kgha $^{-1}yr^{-1}$ while it was 106-625 kgh $^{-1}$ yr 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 nuineralisation rates mi some N fixing trees growing in Coniferous forest soils, have been reported to be 50-150 kgha $^{-1}$ yr^{-1} (Gosz, 1981).

---

[1] Coconut Research Institute, Lunuwila, Sri Lanka.

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 27^0C. The soil belongs to Andigarna series of Red Yellow Podzolic soils which is considered marginal for coconut cultivation. The soli is a well drained, moderately deep to deep and loamy with gravel on lateritic hardpan.

Four species of ruitrogen 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 l 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 dimeter 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. l m and 2 m away from coconut palms respectively. (2 m and l 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 (Tixne 2) at the same distances from the coconut and NFT's, after removing the l st set of plastic tubes.

Figure l is a diagrammatic representation of the sampling positions / sites m 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 sarnples at the same depth were collected following the same procedure for the detennination of initial N concentrations ((NH_4N and $N0_3N$) 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 $N0_3N$) was extracted by shaking soil samples (10 g fresh weight) for l hour with l00 ml of 2 M KCl (Mw and Cresser), 1983). Extracts were fiftered through Whatman number 42 filter metrically using RFIA Alpkem 300 (Rapid Flow Injection Analyzer). Measurements were made on field moist soil and results expressed on an oven dry basis (l 05^0C, 24h).

Calculation

The N mineralisation was calculated usm'g the following equations.

1. For 2 weeks incubation period

$$\text{Net N mineralisation } (\mu\text{ g g}^{-1}) = (NH_4N_{(TI)} - NH_4N_{(TO)}) + (N0_3N_{(TI)} - N0_3N_{(TO)})$$

Where:

$NH_4N_{(TO)}$	Mean NH_4N concentrations of initial (Time 0) non incubated soil samples
$N0_3N_{(TO)}$	Mean $N0_3N$of initial (Time 0) non-incubated soil samples
$NH_4N_{(TI)}$	Mean NH_4N concentrations accumulated in field incubated soil sampled at 15 days (Time 1).
$N0_3N_{(TI)}$	Mean $N0_3N$ concentrations accumulated in field incubated soll sampled at 15 days (Time 1)

2. For 4 weeks incubation period

Net N mineralisation (μ g g^{-1}) $(NH_4N_{(TI)} - NH_4N_{(TO}1_{)})$
$$+$$
$(NO_3N_{(T2)} - N0_3N_{(TO}1_{)})$

Where

NH_4N (TO')	Mean NH_4N conccntrations of initial (Time 0^1) non-incubated soil samples
$N0_3N$ (TO^1)	Mean $N0_3N$ concentrations of initial (Titne 0^1) non-incubated soil samples
NH_4N (T_2)	Mean NH_4N concentrations accumulated in field incubated soil sampled at 30 days (Time 2).
$N0_3N$ (T_2)	Mean NO_3 N concentrations accumulated in field iricubated soil sampled at 30 days (Time 2).

RESULTS AND DISCUSSION

Net N minerallsation of soil 1 m 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 (P= 0.001) between the soll samples taken from plots with different NFTs. The highest net N mineralisation was reported from die site (l m) *Gliciridia* trees followed by *Leucaena, Calliandra* and *Acacia.* The lowest net N minerallsation 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 micubation period than that of 2 weeks.

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

Net N mineralisation showed highly significant difference (P= 0.001) between samples taken l 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.

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

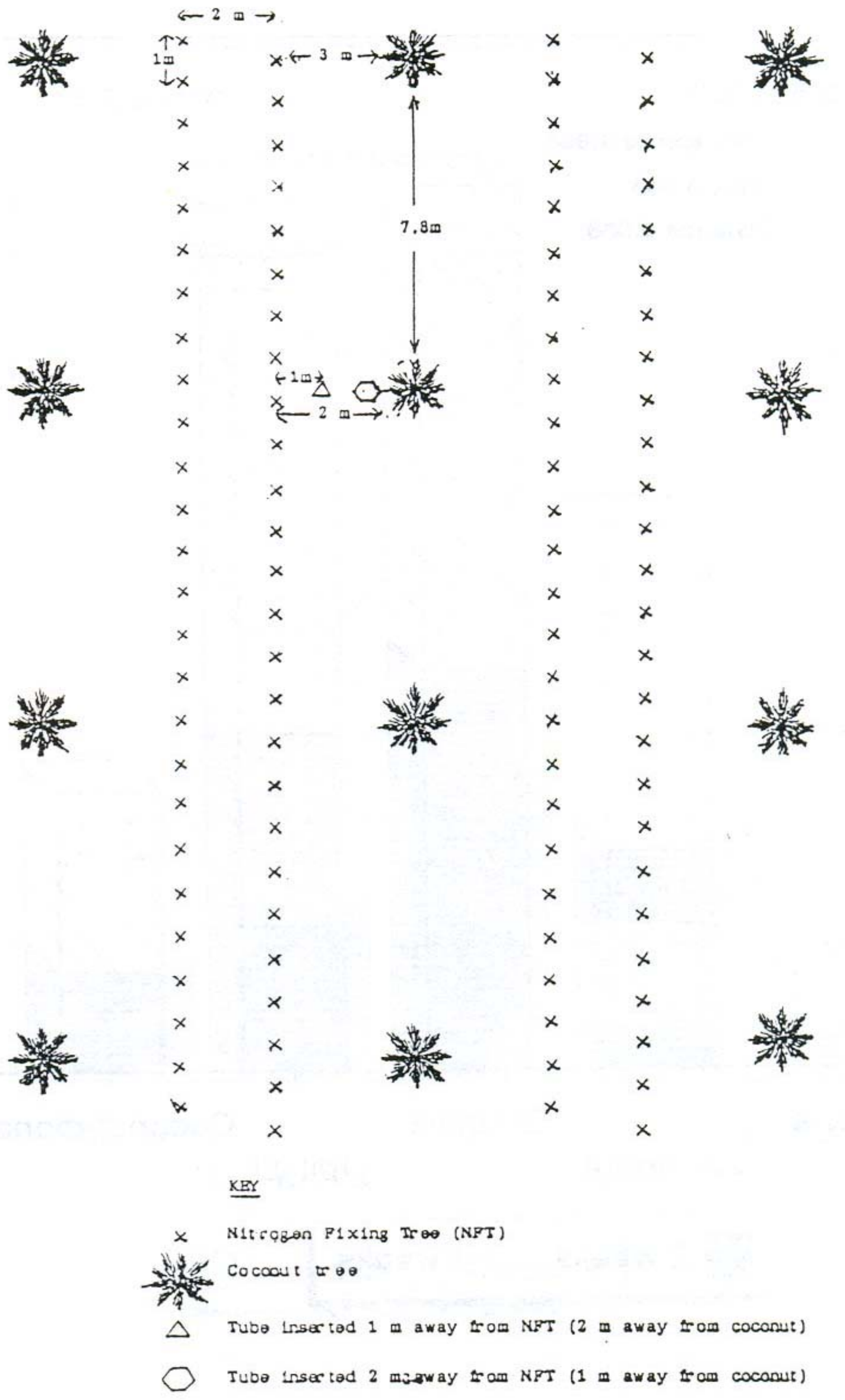


Figure 2: Net N Mineralisation rate in 1 m away from the coconut palm (2 m away from the NFT)

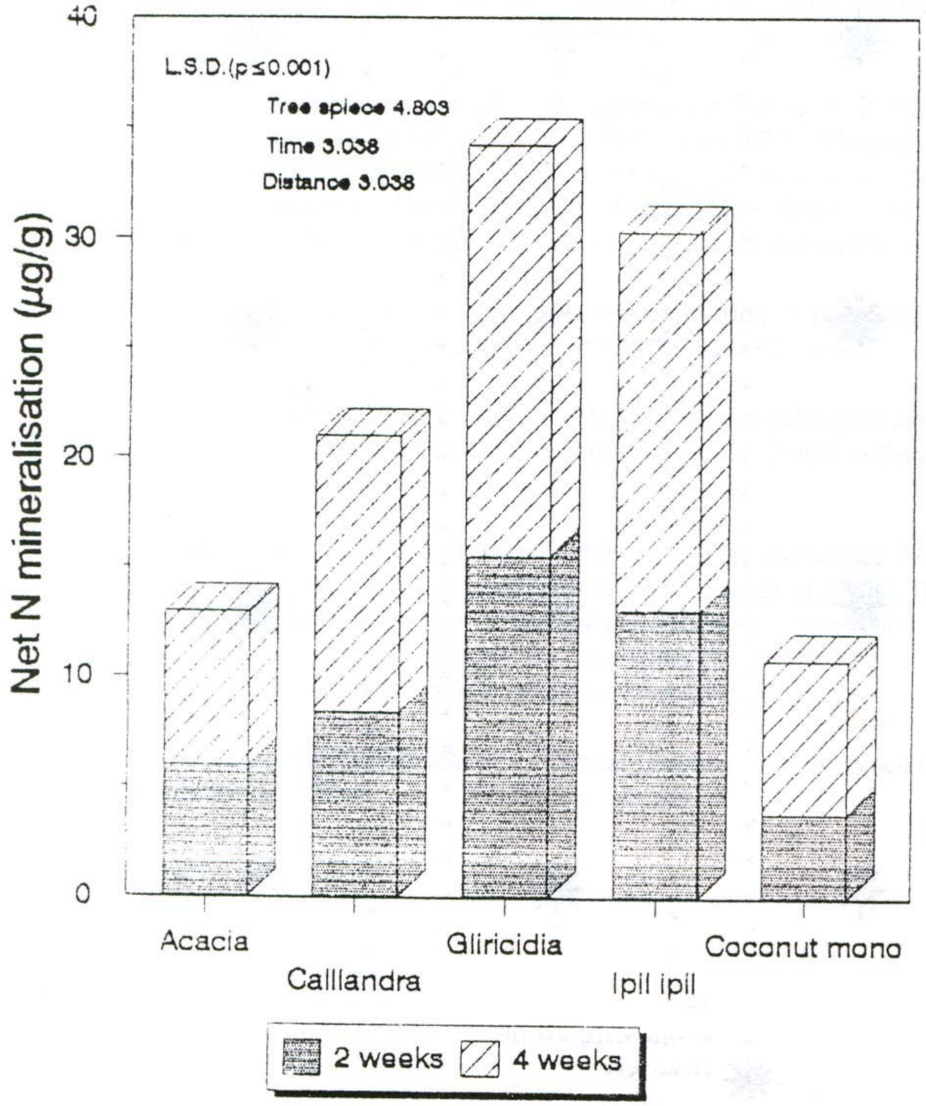
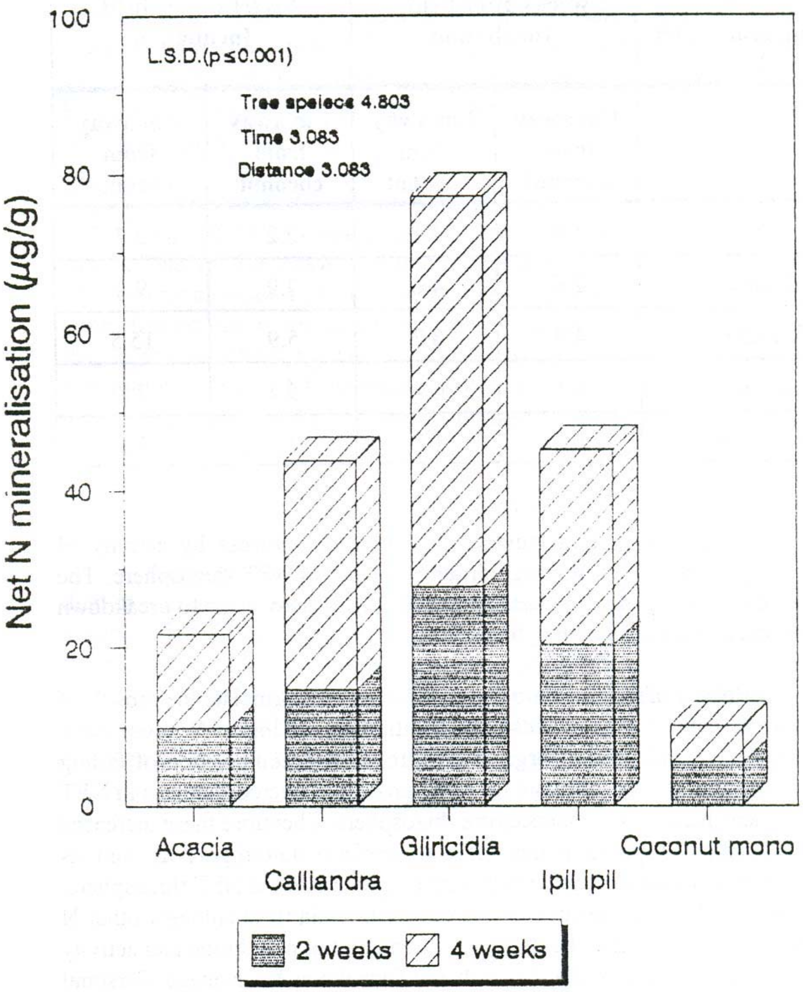


Figure 3: Net N mineralisation rate in 2 m away from the coconut palm (1 m away from the NFT)



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

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 frorn 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 micreased microorganism population may help to perform autotrophic as well as hcterotrophic nitrification and mineralisation process in the NFT rhizosphere. The highest N mineralisation is shown in Glificidia 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 $N0_3N$ in the soil varied with time (i.e. 2 weeks and 4 weeks) and distance from the NFT's sites. Many workers (Bnich, 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 soll.

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

REFERENCES

BRICH, H.F. 1964. Mmieralisation of plant N following alternate wet and dry conditions Plant and Soil 20: 43-50.

BLONDEL, D. 1971. *Rolle de la mateie're organique libredaus la mineralisation en sol sableurx relation aral' alimentation azotee dn mil* Agronomy. In: Microbiological considerations of the N cycle in West African Ecosystem (ed T. Rosswall) pp 55-72 500 PE/UNDP, Royal Swedish Academy of Sciences.

CLARK, F. E. 1981. The N cycle viewed with poetic license. In: Terrestrial N cycles (eds F.E. Clark and T. Rosswall). Ecological Bulletin (Stockholm) 33:13-24.

GHEY, T.J. YAVITT, J.B. PERSON JA, and KNIGHT, D.H. 1985. The nitrogen cycle in lodegepole pine forests, South Eastern Wycomin. Biogeochemistry 1:257-275.

GOSZ, J.R. 1981. Nitrogen cycling mi coniferous ecosystems In: Terrestrial N cycles (eds F.E. Clark and T. Rosswall). Ecological Bulletin (Stockholm) 33:405-426.

GUNARATNE, W.D.L. and HEENKENDE, A.P. 1994. Evaluation of leguminous tree species for biomass production and on soil properties in coffee based cropping systems. In: Mulipurpose tree species in Sri Lanka (ed. H.P.M. Gunasena), p 57-63, Sri Lanka.

KILLHALM, K. 1994. Soil Ecology. Cambridge University Press UX.

MARR, I.L. and CRESSOR, M.S. 1983. Enviromental Chemical Analysis. International Textbook Company, New York.

NADELHOFFER, K.J., ABEF, J.D. and MELILLO, J.M. 1983. Leaf litter production and soil organic matter dynamics along a nitrogen availability gradientmi Southern Wisconsin (USA). Canadian Journal of Forest Research 13:12-2 1.

TENNAKOON, NA. 1990. Effed of organic and inorganic fertilizer combinations on soil biological and chemical properties and the nutrient status of the coconut palm M.Phil. Thesis, University of Kelaruiya, Sri Lanka.

WHITE, C.S., GOSH, J.R., HOMER, J.D. and MOORE, D.I. 1988. Seasonal annual and treatment induced vaniation of available N pools and N cycling processes in solls of two douglas-fir stands. Biological Fertility and Soil 6: 93-99.