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Ammonium Dynamics in a *Leucaena* Green Manure Incorporated Puddle Rice Soil

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ABSTRACT. Field studies were conducted for two seasons to evaluate the effect of Leucaena leucocephala (Lam) De Wit. green manure on the available ammonium-N in soil and grain yield of rice grown under lowland conditions. The treatments were 0, 4, 8 and 12 mt/ha Leucaena with 0, 44 and 88 kg N/ha as urea in a factorial combination. Available ammonium N in soil was evaluated at the time of transplanting, maximum tillering, panicle initiation and harvest.

During both seasons, incorporation of Leucaena increased the available ammonium-N throughout the experimentation irrespective of the level of mineral N. However significant differences in available ammonium-N were observed only at transplanting. Incorporation of 8 mt/ha of Leucaena green leaves to the soil two weeks before transplanting could produce available ammonium-N in soil which is comparable with the ammonium-N that is originating from the mineral N level recommended by the Sri Lankan Department of Agriculture, ie. 88 kg N/ha. There is a significant increase in the grain yield accruing to increased levels of Leucaena. In both seasons the application of 8 mt/ha of Leucaena was almost as effective as the highest mineral N application.

INTRODUCTION

Nitrogen is the most important nutrient element limiting growth in most rice growing soils (Savant and De Datta, 1982), and it should be adequately present for the proper function of metabolic processes in the plant (Russel, 1973). The mineralization of organic nitrogen in puddled soils is a crucial prerequisite for nitrogen nutrition; even in well fertilized

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paddy fields, the rice plant uses nearly 50 – 70% of soil nitrogen through mineralization (Broadbent, 1979).

In this study *Leucaena* was selected as the green manure for rice, since it is commonly found in many areas of Sri Lanka. The rapid growth and the relatively high nitrogen content of *Leucaena* make it an ideal green manure. Hence, this investigation was conducted to evaluate the effectiveness of using *Leucaena* green manure as a nitrogen supplement for rice soils.

The dominant form of mineral N in lowland rice soils is ammonium, which is found both in soil solution and at exchange sites (Mengel *et al.*, 1986). These two sources are readily available to the rice plants. In this experiment, therefore, the Nitrogen that exist in other forms was not considered.

MATERIALS AND METHODS

Field trials were conducted at the Regional Agricultural Research station, Girandurukotte, Sri Lanka during 1985/86 (*Maha*) and 1986 (*Yala*) seasons. Girandurukotte lies in the intermediate agroclimatic zone (96m above m.s.l.) receiving 2100 mm of annual rainfall distributed bimodally. The soil in this area is Tropaqualfs and some of the important characteristics are given in Table 1.

The treatments were in a randomized complete block design with three replicates.

Treatments comprised four levels of *Leucaena* green manure (0, 4, 8, 12 mt/ha) with three levels of mineral – N fertiliser (0,44,88 kg N/ha) applied in the form of urea in a factorial combination. P and K were added at the rate of 28 and 34 kg/ha respectively (Agriculture Department recommendation, 1980). Total P was applied at the time of transplanting while N and K were applied according to the following plan.

At transplanting	: N – 7 kg/ha, P – 28 kg/ha, K – 13 kg/ha
14 DAP	: N – 43 kg/ha
42 DAP	: N – 38 kg/ha, K – 21 kg/ha

Table 1. Soil characteristics of the experimental site.

Soil character	Depth (cm)	
	0 – 10	10 – 20
Sand (%)	77.60	77.40
Silt (%)	12.60	12.40
Clay (%)	9.80	10.20
pH (1:5 water)	7.04	7.06
EC ms/cm (1:5 water)	0.18	0.19
CEC (cmol/kg soil)	7.20	7.00
Exchangeable cations (cmol/kg soil)		
Na	0.52	0.47
K	0.08	0.06
Ca	1.24	1.26
Mg	4.78	4.54
Total N %	0.05	0.05
Organic C %	0.43	0.41
C:N ratio	8.60	8.20

The two levels of mineral – N treatments *viz.* 44 and 88 kg/ha represents the half and full recommended doses.

Leucaena green leaves were incorporated to th soil two weeks before transplanting and water movement to the plots were stopped.

Experimental plots were (4x5)m in size and separated by guard plots.

Rice variety BG 94 – 1 (105d) was chosen as the indicator plant. Three seedlings were planted at 20x15 cm per hill.

Soil samples were taken at transplanting, maximum tillering, panicle initiation and at harvest. The samples were drawn randomly from 6 locations at 0 – 20 cm depth from each plot and mixed thoroughly to get a composite sample. Available ammonium was extracted from fresh soil by using IN KCL (soil:Kcl, 1:10) and determined calorimetrically by using Indophenol blue complex method (Hesse, 1971).

RESULTS AND DISCUSSION

The available ammonium−N in soil *Leucaena* treatments at each N−level in the *Maha* season are given in Table 2. At transplanting the application of *Leucaena* has resulted in an increase in available ammonium−N at all mineral N−levels. When compared with the control this increase was significant when 8 and 12 mt/ha of *Leucaena* was applied. This was true for all N levels. When *Leucaena* application was raised from 8 to 12 mt/ha, significant increase in available ammonium−N was observed only in 0 and 44 kg/ha treatments. It is shown that 8 mt of *Leucaena* in the absence of mineral N produced higher available ammonium−N than the highest mineral N application level ie. 88 kg/ha without *Leucaena*.

Since *Leucaena* was incorporated two weeks before transplanting, it could be said that a mineralization period of two weeks was adequate to produce available ammonium−N to cope with the nitrogen requirement of the rice crop which was comparable to N recommendation ie. 88 kg N/ha. According to Ponnamperuma (1972) much of the mineralisable organic nitrogen in flooded soils are released as ammonium in two weeks of flooding.

The yield data in the *Maha* season (Table 4) showed that the incorporation of green manure has improved the grain yield at all N levels. The incorporation of 12 mt of *Leucaena* increased the grain yield from 1.85 to 5.62 mt/ha. This was about 1 mt of grain than the highest mineral N level *i.e.* 88 kg N/ha.

Compared with the values at the time of transplanting, the available ammonium−N in soil in all treatments decreased up to panicle initiation. A rapid decrease in available ammonium−N from transplanting to maximum tillering could be mainly due to crop uptake. Watanabe and Inubushi (1986) observed a rapid decrease in available ammonium in the early stages of rice growth. They demonstrated that available ammonium almost disappeared within 40 days after transplanting due to crop uptake. At maximum tillering the effects of *Leucaena* green manure was not reflected on the available ammonium−N significantly. This could be due to the possible nitrification activities in surface oxidized soil layer. However, at the highest nitrogen level, available ammonium−N were slightly higher. This denotes that some of the mineral N applied

Table 2. Mean* available NH_4^+.N (ppm) in *Maha* season (1985/86).

Stage	*L. leucocephala* (mt/ha)	N(kg/ha) 0	44	88
Transplanting	0	4.85 a	5.72 a	7.07 a
	4	5.90 a	6.58 ab	7.83 a
	8	8.62 b	8.11 b	10.83 b
	12	11.53 c	11.54 c	12.37 b
Maximum tillering	0	1.49 a	1.63 a	5.42 ab
	4	2.05 a	2.22 a	6.15 a
	8	2.63 a	2.33 a	5.68 ab
	12	3.26 a	2.83 a	4.46 b
Panicle initiation	0	1.90	1.32	1.77
	4	1.84	2.48	2.62
	8	3.10	2.99	1.53
	12	2.37	1.40	1.81
Harvest	0	4.62	5.16	5.53
	4	4.24	4.57	5.91
	8	4.97	5.85	5.28
	12	5.05	5.22	5.84

* mean of 3 replicates
mean followed by common letters in columns at each stage are not significantly different at 5% level by DMRT.

as top dressings two weeks after transplanting have contributed to increase the available ammonium – N in soil.

No significant differences in exchangeable ammonium was observed at panicle initiation. A similar tendency could be seen at harvest even though there was an accumulation of available ammonium in soil. This accumulation could be due to less uptake of N at the latter part of rice growth and also possibly due to ammonification processes of native soil organic N. The pattern of available ammonium during the plant life was almost consistent for all levels of mineral nitrogen which exhibit typical changes of available ammonium – N in puddled soils. Khind *et al.*,

(1985) observed similar changes in available ammonium in irrigated rice with the incorporation of Sesbania aculeata two weeks before transplanting.

As in *Maha* similar results could be observed in the *Yala* season also (Table 3). At transplanting leucaena incorporation has significantly increased the available ammonium - N only at 44 and 88 kg N/ha applied treatments. Incorporation of *Leucaena* more than 4 mt/ha has a resulted greater available ammonium - N than that of the highest mineral nitrogen treatment. This confirms the findings of the previous experiment in *Maha* season. Ammonium - N levels were relatively higher in *Yala* than the *Maha* season at transplanting stage. The residual substances of incorporated *Leucaena* in the previous season, may have provided additional absorption sites for the retention of ammonium ions that were originated from mineral N as well as from *Leucaena* green manure.

At maximum tillering and panicle initiation similar trend could be observed as in previous season. At harvest the available ammonium - N in soil were very low. Neither the application of *Leucaena* nor the mineral N fertiliser were reflected at this stage. This was possible due to the high nitrification activity under oxidized conditions. Therefore whatever the ammonium ions produced could have transformed into nitrates. The available ammonium mobility was comparable to wet season confirming the general release pattern of ammonium in wet land rice soils.

The yields obtained in *Yala* season is fairly comparable with the available ammonium - N levels in the soil. In the control plot the grain yield in *Yala* season was greater than that of *Yala*. This could be due to higher nitrate concentration in irrigation water in the *Yala* season (Kendaragama, 1988).

The results of this experiment indicate the suitability of *Leucaena* green manure as a substitute for mineral N application. The most effective application level was 8 mt/ha which was in par with the highest mineral nitrogen application. Further studies have to be undertaken to ascertain the efficiency of green manure in practically feasible quantities and the times of application of mineral nitrogen fertiliser as well as *Leucaena* green manure.

Table 3. Mean* available NH_4^+.N (ppm) *Yala* season (1986).

Stage	L. leucocephala (mt/ha)	N(kg/ha) 0	44	88
Transplanting	0	5.15 a	5.27 a	6.82 a
	4	8.49 a	7.51 a	15.60 b
	8	8.81 a	13.37 b	15.79 b
	12	10.43 c	21.34 c	17.79 b
Maximum tillering	0	2.95	5.62	3.94
	4	3.82	6.01	4.24
	8	4.55	6.72	5.31
	12	3.81	5.37	6.32
Panicle initiation	0	3.30	3.79	3.74
	4	3.72	3.44	4.90
	8	5.31	4.47	5.97
	12	5.51	5.35	8.72
Harvest	0	0.48	0.85	1.09
	4	1.16	0.85	1.23
	8	1.14	1.11	1.93
	12	2.01	1.57	3.73

* mean of 3 replicates
mean followed by common letters in columns at each stage are not significantly different at 5% level by DMRT.

Table 4. Mean* rice grain yield (mt/ha) in *Maha* (1985/86) and *Yala* (1986) seasons.

Season	L. leucocephala (mt/ha)	N (kg/ha) 0	44	88
Maha	0	1.85 a	4.06 a	4.54 a
	4	3.70 b	4.31 a	4.79 ab
	8	4.99 c	5.27 b	4.83 b
	12	5.62 c	5.62 b	5.46 b
Yala	0	2.43 a	3.92 a	4.40 a
	4	4.11 b	4.35 ab	4.50 a
	8	4.64 b	5.28 b	4.74 a
	12	4.02 c	4.11 b	4.67 a

* mean of 3 replicates
means followed by common letters in columns at each seasons are not significantly different at 5% level by DMRT.

It would be appropriate to test the performance of rice with *Leucaena* application in other soils too.

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REFERENCES

Broadbent, F.E. and Tusneem. (1971). Losses of nitrogen from flooded soils in tracer experiments. soil Sci. Soc. Am. Proc. 35: 922–926.

Broadbent, F.E. (1979). Mineralization of organic nitrogen in paddy soils. *In* Nitrogen and Rice. Intl. Rice Res. Inst., Los Banos, Laguna, Phils. pp 105–115.

Hesse, P.R. (1971). A text book of soil chemical analysis. John Murrey Publ. Ltd., London. pp 197–203.

Kendaragama, K.M.A. (1988). Evaluation of nitrogen nd potassium in Non Calcic Brown soils under irrigated rice in Mahaweli System – B. M.Phil. Thesis. Postgraduate Inst. of Agriculture, Peradeniya.

Khind, C.S., Josan, A.S. and V. Beri. (1985). Nitrogen release from green manure and effect of time of application of nitrogen fertiliser on lowland rice. Intl. Rice Res. Inst. 4 August pp 26–27.

Mengle, K., Schon, H., Keerthisinghe, G. and S. K. De Datta. (1986). Ammonium dynamics of puddled soils in relation to growth and yield of lowland rice. *In* Economy of flooded rice soils, Washington D.C. pp 117–129.

Ponnamperuma, F.N., (1972). The chemistry of submerged soils. Adv. Agron. 24: 29–96.

Reddy, K.R. (1982). Nitrogen cycling in a flooded soil eco system planted to rice (Oriza sativa L), Plant soil 67: 209 – 220.

Russell, E.W. (1973). Soil conditions and plant growth, 10th ed. Longman group Ltd., London.

Savant, N.K. and S.K. De Datta. (1982). Nitrogen transformation in wet land rice soils. Adv. Agron. 35: 241 – 302.

Watanabe, I and Inubushi. (1986). Dynamics of available nitrogen in paddy soils. 1. Changes in available nitrogen during rice cultivation and origen of nitrogen. Soil Sci. Plant Nutr., 32: 37 – 50.