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STUDIES ON MINERALISATION OF NATIVE SOIL ORGANIC NITROGEN IN RUBBER GROWING SOILS OF TRIPURA

D.V.K. NAGESWARA RAO. A.K. KRISHNA KUMAR, AND S.N. POTTY*

Rubber Research Institute of India, Research Complex, North Eastern Region, Agartala (Tripura)
* Rubber Research Institute of India, Kottayam (Kerala).

ABSTRACT

Total mineralizable nitrogen in surface soil varied from 677 ppm to 1167 ppm in plantations, and from 599 ppm to 1142 ppm outside the plantation. In the subsoil the range of the mineralizable nitrogen was 506 ppm to 902 ppm for plantations and 498 ppm to 887 ppm outside the plantations. Ammoniacal nitrogen varied from 77 to 187 ppm in surface samples from inside the plantation and 61 to 108 ppm from the field under shifting cultivation at the start of incubation. For subsoil, these values were 68 to 99 ppm and 43 to 82 ppm for plantations, and outside the plantations, respectively. The trend in ammoniacal nitrogen concentration change over a period of incubation was, an increase followed by a decrease in surface soil under plantation. However, outside the plantation it decreased initially followed by an increase. The concentration of ammoniacal nitrogen in plantations samples prior to incubation increased with depth whereas it decreased in the case of samples from outside the plantation. After four weeks of incubation the concentration of ammoniacal nitrogen decreased with depth.

The rate of nitrification was lower in the plantation of higher age group, indicating build up of organic matter. Due to extreme deficiency of available P, the growth of mineralizing organism was also affected thereby affecting the rate of mineralization. The samples from the plantation showed higher mineralization as compared to corresponding samples from adjacent shifting cultivation fields.

INTRODUCTION

The cultivation of <u>Hevea</u> tree crop (deciduous tropical forest) was extended to the North Eastern states (Tripura) in early sixties. It requires specific nutrient management practices in the region (Krishna Kumar and Potty, 1989). For successful growth, nitrogen is one of the major element and is required at all stages of plant growth. The tree has a different ecological system wherein large amount of organic matter is recycled by way of leaf-fall, addition of roots, and cover crops during immature phase. A zero-tillage system coupled with marginal removal of nutrients by the crop, makes an ecosystem very close to a natural one in a steady state. Since cultivation of this tree crop is mainly confined to the humid tropics where nitrogen could be highly unstable, ammonification and nitrification need indepth study. Mineralisation of nitrogen in soils under Hevea in Malaysia is reported by Tan (1983) and in the other tropical soils by Haque and Walmsley (1972), Ishaque and Cornfield (1972) and Conforth (1971). Studies on soils under Hevea in the north eastern region are limited. Therefore present work was undertaken.

MATERIAL AND METHODS

Five plantation sites were selected in North, South and West Tripura covering 17000 ha under Hevea plantation. The soils were classified as Typic Dystrochrults and Typic Paleochrults'. An adjacent area under jhumming was also selected for comparison. Soil samples in triplicate from 0-30 and 30-60 cm depths were collected from inside and outside the plantations. They were analysed for total N, available N, and total P, ($HClO_4$ and HNO_3 extractable) available P (Bray II) and K, Ca and Mg, CEC, pH (1:2.5 H_2O), mechanical composition and Organic Carbon using standard methods.

The incubation was carried out for 4 and 7 weeks period (Tan, 1983). After the specified period the soil was extracted with 2N KCl (1:10 soil : KCl ratio) to determine ammoniacal and nitrate nitrogen (Bremner, 1965). The basic properties of soils are given in table 1.

RESULTS AND DISCUSSION

The total mineralisable nitrogen in surface layer varied from 677 to 1167 ppm for plantation and from 599 to 1142 ppm for outside the plantations (Table 2). In subsoil (30 to 60 cm), the range of the mineralisable nitrogen was 506 ppm to 902 ppm for plantation and that of 498 ppm to 887 ppm for outside the plantation. At the start of incubation, the ammoniacal nitrogen varied widely from 77 to 187 ppm in the surface layer for inside the plantation and from 61 to 108 ppm for outside the plantation. These values were 68 to 98 ppm, and 43 to 82 ppm for inside and outside the plantation respectively in subsoil. In the soils from inside the plantations (5 year old), the ammoniacal nitrogen concentration in surface layer increased after four week and decreased after 7 weeks of incubation. From outside the plantations there was decrease throughout. In subsoil samples from inside the plantations, slight decrease followed by a sharp decrease was observed. Similar results were also obtained from outside the plantations. Prior to incubation ammonical nitrogen also was found to decrease with depth for inside as well as for outside the plantations. After four weeks of incubation the concentration of ammoniacal nitrogen decreased with depth. The decrease could be attributed to partial fixation of inorganic ammonium ions by clay (Kowalenko and Cameron, 1976). There was also an increase in clay content with depth.

The concentration of NO_3-N increased after four weeks and seven weeks of incubation in the surface and subsurface sample under plantation and outside the plantation. It suggested a state of active nitrification. This is in conformity with the observation made by Ishaque and Cornfield (1972) from East Pakistan Tea soils. At existing pH of the

Table 1. Physical and chemical properties of soil

Depth (cm)	O.C. (%)	pH	Total N	Total P	Avail. N	Avail. P	Avail. K	Avail. Ca	Avail. Mg	CEC meq/ 100g	C/N ratio	Sand	Silt	Clay
			<--------	--------	--------	(ppm)	--------	-------->				<------	(%)	------>
						West Tripura (5th yr.)								
Inside														
0-30	0.67	4.1	677	342	220	1	42	140	74	5.8	9.9	68.2	10.5	19.9
30-60	0.60	4.1	506	535	130	36	31	130	74	4.2	11.9	64.3	8.9	25.7
Outside														
0-30	0.59	4.2	599	276	141	3	62	114	61	2.5	9.9	70.3	5.6	22.9
30-60	0.54	4.0	498	298	130	0.1	55	104	63	2.5	10.8	64.7	6.1	28.2
						West Tripura (10th yr.)								
Inside														
0-30	0.83	4.2	832	535	130	0.1	21	103	70	7.3	10.0	60.4	11.1	27.1
30-60	0.78	4.2	560	357	127	0.1	21	92	77	9.1	13.9	60.9	10.2	27.5
Outside														
0-30	0.90	4.1	762	328	142	7	26	92	59	6.9	11.8	54.3	14.3	29.8
30-60	0.75	4.1	646	491	122	27	23	81	59	8.8	11.6	45.3	17.2	36.0
						South Tripura (15th yr.)								
Inside														
0-30	0.72	4.1	770	164	140	0.1	29	103	52	10.3	9.4	60.6	13.8	24.2
30-60	0.57	4.1	622	90	112	0.1	34	70	50	9.1	9.2	55.5	14.1	29.4
Outside														
0-30	0.42	4.3	926	75	113	17	50	92	66	8.4	4.5	62.4	12.1	24.6
30-60	0.35	4.3	653	283	105	19	27	77	66	7.8	5.4	57.1	14.3	28.6
						North Tripura (20th yr.)								
Inside														
0-30	0.95	4.2	887	313	158	27	86	85	45	10.0	10.7	53.0	12.0	33.3
30-60	0.82	4.3	723	209	129	7	28	84	46	8.8	11.3	48.1	11.0	39.4
Outside														
0-30	0.55	4.8	638	101	105	19	26	328	64	5.6	8.6	68.8	7.6	21.7
30-60	0.39	4.7	630	90	116	8	22	354	90	4.6	6.2	65.4	11.1	22.8
						South Tripura (25th yr.)								
Inside														
0-30	1.17	4.4	1167	491	152	2	64	201	115	8.1	10.0	52.0	19.9	25.9
30-60	0.88	4.50	902	228	146	0.1	59	160	102	7.6	9.8	45.3	22.7	30.5
Outside														
0-30	1.06	4.5	1142	491	133	0.1	61	488	144	7.8	9.2	42.9	21.6	33.7
30-60	0.86	4.4	887	535	133	0.1	62	364	142	9.1	9.7	30.3	11.5	56.7

Table 2. Concentrations of NH_4-N and NO_3-N at initial, 4th and 7th weeks of incubation (ppm)

Location of soil with depth (cm)		Initial		4th week		7th week	
		NH_4-N	NO_3-N	NH_4-N	NO_3-N	NH_4-N	NO_3-N
5th year plantation							
Inside :	0-30	119	50	131	93	68	129
	30-60	98	48	96	82	61	102
Outside:	0-30	61	33	49	64	29	79
	30-60	42	29	34	42	19	59
10th year plantation							
Inside :	0-30	118	38	102	47	75	92
	30-60	97	22	62	42	53	69
Outside:	0-30	92	26	68	67	47	82
	30-60	72	37	62	60	49	67
15th year plantation							
Inside :	0-30	77	22	63	65	32	93
	30-60	68	31	49	51	42	67
Outside:	0-30	64	20	47	61	32	69
	30-60	71	32	58	55	46	61
20th year plantation							
Inside :	0-30	126	63	97	96	74	132
	30-60	98	48	79	62	76	78
Outside:	0-30	78	36	64	53	54	70
	30-60	81	37	75	49	54	67
25th year plantation							
Inside :	0-30	186	32	146	79	102	148
	30-60	94	30	87	51	48	96
Outside:	0-30	107	39	77	74	62	90
	30-60	81	44	56	71	49	81

soil (4.1 to 4.9), autotrophic nitrification cannot be considered substantial theoretically. Present results however indicate active nitrification. The rate of nitrification is also observed to be large in inside the plantation which could be attributed to the role of heterotrophic organisms (Aynaba and Omaynli, 1975). The role of acid adapted autotrophs in nitrification cannot also be ruled out. In tree crops, the role of mycorrhizal association has been reported to lead to such observation. In case of rubber plantations, besides parts above ground, the underground plant parts also contribute much which would favour mycorrhizal association. Increased mineralisation in the soils of rubber plantation in the North and East could be due to these factors.

The rate of nitrification was observed to be lower in higher age group plantations, indicating the build up of organic matter. Low organic matter oxidation rates in soils under rubber plantations can be attributed to the microclimate and the influence of allophanes and oxides existing in tropical and sub-tropical soils. Due to extreme deficiency of available P, the growth of mineralising organisms is affected thereby affecting the mineralisation rate. It is noticed in 25 years of plantations that there is build up of organic carbon and total mineralisable nitrogen and lowering of nitrification rate which may be attributed to the above factors. In general, samples from the plantations showed higher percentage of mineralised nitrogen as compared to corresponding samples drawn from adjacent shifting cultivated field.

Ammoniacal nitrogen contribution to total N was found to be 4 to 13 per cent in the samples from outside the plantation and 4 to 20 per cent from inside the plantation at various stages of incubation (Table 3). Similarly NO_3-N constituted 2.9 to 20.3 per cent and 2.3 to 13.3 per cent of the total N in samples from inside and outside the plantations, respectively at various stages of incubation.

Table 3. NH_4-N and NO_3-N contents (as % total N) at initial, 4th week and 7th week of incubation and mineralised Nitrogen (as % available N)

	Ammoniacal nitrogen						Nitrate nitrogen					
	Initial		4th week		7th week		Initial		4th week		7th week	
	In-side	Out-side	In-side	Out-side	In-side	Out-side	In-side	Out-side	In-side	Out-side	In-side	Out-side
5th year												
0-30	17.5	10.2	19.3	8.3	10.1	4.9	7.4	5.6	13.8	10.7	19.1	13.3
30-60	19.5	8.6	19.0	6.9	12.0	3.9	9.4	5.9	16.2	8.5	20.3	11.9
10th year												
0-30	14.2	12.1	12.3	9.0	9.1	6.1	4.5	3.4	5.7	8.9	11.1	10.8
30-60	17.3	17.3	11.1	9.7	9.6	7.6	4.0	5.8	7.6	9.3	12.3	10.4
15th year												
0-30	10.0	6.9	8.1	5.0	4.1	3.4	2.8	2.2	8.5	6.6	12.1	7.4
30-60	10.9	10.9	8.0	8.9	6.8	7.1	5.0	4.9	8.3	8.4	9.2	9.4
20th year												
0-30	14.2	12.2	11.0	10.1	8.4	8.5	7.2	5.7	11.0	10.1	14.8	11.0
30-60	13.5	12.9	10.9	12.0	10.5	8.6	6.7	5.9	10.9	12.0	10.8	10.7
25th year												
0-30	15.9	9.4	12.5	6.7	8.7	5.4	2.7	3.4	12.5	6.7	12.7	7.9
30-60	10.5	9.2	9.6	6.3	5.3	5.5	3.4	5.0	9.6	6.3	10.6	9.1

It is indicated (Table 4) indicated that there was a significant positive correlation between ammoniacal nitrogen and NO_3-N after the 4th and 7th week of incubation. The correlation, however, was not significant at the initial stages suggesting NO_3-N production was dependent upon the production of ammonical nitrogen.

Correlation of mineralised Nitrogen with available nitrogen and available Calcium was positive and significant for samples inside the planations (Table 4). A negative correlation existed between clay and C/N ratio, which could be due to fixation of ammoniacal nitrogen by clay. There was a sharp decrease in ammoniacal nitrogen content with increase in incubation period. The ammonium ion fixation could be attributed to higher illitic clay suburface. Organic nitrogen plays an important role in Hevea nutrition. The results of this study will help in understanding the dynamics of nitrogen for refinement of management practices. A low mineralisation rate outside the plantations show reduced activity of microorganisms. *Influence of pH per se* would be more in case of soils from outside the plantations

Table 4. Corelation coefficients

NH_4-N Vs NO_3-N	Sample Inside Plantation	Sample Outside Plantation
Initial state	0.24	0.387
4th week	0.60*	0.377
7th week	0.64	0.546
Mineralised Nitrogen Vs. soil properties		
Available N	0.64*	0.104
Available Ca	0.72*	-0.746**
Total N	0.53	0.093
Organic Carbon	0.30	-0.118
C/N ratio	-0.57	-0.09
Clay	-0.58	-0.448

* Significant at 5 per cent level ; ** Significant at 1 percent level

rather than inside where the ecosystem permits the growth of microorganisms which could bring about mineralisation thereby alleviating the harmful effect of pH.

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