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DISTRIBUTION OF TOTAL AND DIFFERENT FRACTIONS OF NITROGEN IN RUBBER GROWING SOILS UNDER DIFFERENT AGE AND FERTILISER MANAGEMENT PRACTICES

MERCYKUTTY JOSEPH, V. K. SHYAMALA, E. S. GEORGE, K. I. PUNNOOSE,
M. KARTHIKAKUTTY AMMA and M. MATHEW
Rubber Research Institute of India, Kottayam - 686 009, Kerala

ABSTRACT

Soil samples from the selected treatments from the N P K trial and adjoining rubber plantations of different age were analysed for the total nitrogen and different fractions of nitrogen, viz., ammoniacal (NH_4-N), nitrate (NO_3-N), Organic (Org. N) and total hydrolisable nitrogen (total hydron N). Also organic carbon (OC) and potentially mineralisable nitrogen (available N) were estimated as the availability indices. The rubber growing soils are rich in the total N, different fractions of N and organic carbon status. The major portion of nitrogen (96%) is in the organic form. The available N status was in the medium range. Continuous application of high levels of nitrogen did not influence significantly the nitrogen transformation in the soil. Significant positive correlations were observed between total N and different fractions of N, total N and available N, NH_4-N and available N, NO_3-N and available N and available N with organic carbon. Available N estimation through alkaline permanganate oxidation method gave a better indication of the nitrogen supplying power of the soil compared to organic carbon.

INTRODUCTION

Rubber growing soils are characterized by the high content of organic carbon contributed by the decay of leguminous cover crop in the immature phase as well as the addition through the annual leaf fall. Theoretically the major portion of nitrogen for plant uptake is contributed from the native source. In soil the major portion of nitrogen is in the organic pool and is converted to the inorganic NH_4 + and NO_3 - forms through mineralisation. In the fertiliser experiments conducted in South India, the responses to added N were highly variable for the seedling nursery, immature and mature rubber (Punnoose *et al.*, 1975). The potentially mineralisable N estimation by alkaline permanganate method proposed by Subbiah and Asija (1956) gives good indication of the N availability. Organic carbon is also an index of N availability. The present research work was undertaken to study the status of total as well as the different fractions of N in the rubber growing soils. Also the two methods viz., alkaline permanganate N and organic carbon were compared to assess the suitability of these methods.

METERIALS AND METHODS

Soil samples from two depths, 0-30 (surface) and 30 - 60 cm (sub-surface) were collected from the selected treatments from the N P K trial on mature fifteen year old rubber. The treatments selected were control, 40 and 80 kg N and K_20 ha^{-1}, 30 and 60 kg P_2O_5 ha^{-1} and combination of 40:30:40 and 80:60:80 kg ha^{-1} of N, P_2O_5 and K_2O. Also samples were collected from the fields of different ages of rubber viz., first, fifth, tenth, twentieth and thirtieth year of planting which received the general fertilizer recommendation. The samples were collected from two replications and statistical analysis were undertaken by considering it in a completely randomised design (Snedecor and Cochran, 1968). Total N and different fractions of N viz., ammonical (NH_4-N), nitrate (NO_3-N) organic N (org. N) and total hydrolisable N (tot. hydro.N) were estimated according to the procedure given by Keeney and Bremner (1964). Organic carbon (Walkley and Black, 1934) and available N (Subbiah and Asija, 1956) were also estimated as the indices for nitrogen supplying capacity of the soil.

RESULTS AND DISCUSSION

The total N, org. N and total hydro. N for the surface soil are given in Table I. and the same data for the sub-surface soil are given in Table II. The total N content for the surface soil ranged from 2397 kg ha^{-1} (0.12%) to 4489 kg ha^{-1} (0.22%). The highest value was recorded in the first year of plantation. The same trend was observed in the case of organic N also. The total hydro. N ranged from 1748 kg ha^{-1} to 2869 kg ha^{-1}. The highest total hydro. N was also recorded by the first year field. In the subsurface layer the highest total N (2994 kg ha^{-1}) was recorded in the thirtieth year field followed by twentieth year field indicating the accumulation of large quantities of organic matter through annual leaf fall and crop residues in the rubber plantation in the long run (Table II). For org. N the highest value was recorded by the first year field as in the case of surface layer. The field was a new planting area with high organic carbon status.

In general, the total N values were very high with the values ranging from 1748 kg ha^{-1} (0.09%) to 4489 kg ha^{-1} (0.22%) compared to the average values recorded by the laterite and red soils of India. The average values for laterite soils in India is only 0.04 per cent (Kanwar, 1976). The rubber plantation in general are situated in the forest cleared areas. Also this might be due to the addition of large quantities of oraganic matter and biologically fixed N through leguminous cover crop in the immature phase and the addition through annual leaf fall in the mature phase. Through legume cover crop biologically fixed N is added to the soil system and much of the legume N remains in soil organic N pools and is only slowly made available (Ladd and Amato, 1986).

Of the total N, 97.7 per cent is in the organic form and 66.3 per cent is in the tot-^{1} hydro. N form. The total hydro. N is the p- tentially mineralisable source of N in the soil. The high organic N content in the soil indicates the high N supplying power of the soil.

Inorganic N status in the surface soil (Table III) revealed that the NH_4 -N content ranged from 26 to 54 kg ha^{-1}. The lowest value was recorded from the 30 kg P_2O_5 ha^{-1} applied field and the highest value by the thirtieth year field followed by first year field (53 kg ha^{-1}). Similarly NO_3 -N content ranged from 8.2 to 67.6 kg ha^{-1}. The highest values of NO_3-N was recorded by the first year field. The total inorg. N content ranged from 37.7 to 120.6 kg ha^{-1}. In the subsurface soil the values ranged from 31 to

Table I. Total N, Organic N and total hydro N status in the surface soil (kg ha^{-1})

Treatments (kg ha^{-1})	Total N		Organic N		Total hydro N	
Control	3275	(0.164)*	3225	(98.5)**	1870	(57.1)**
40 N	3093	(0.155)	3037	(98.1)	1718	(55.5)
80 N	2953	(0.148)	2892	(97.9)	1746	(59.1)
30 P_2O_5	3080	(0.154)	3043	(98.8)	2072	(67.3)
60 P_2O_5	3476	(0.174)	3409	(98.1)	2651	(76.3)
40 K_2O	2710	(0.136)	2637	(97.3)	1965	(72.5)
80 K_2O	2397	(0.120)	2344	(97.8)	2041	(85.1)
40:30:40 N P_2O_5 K_2O	3221	(0.161)	3164	(98.2)	2150	(66.7)
80:60:80 N P_2O_5 K_2O	3306	(0.165)	3239	(98.0)	2345	(70.9)
Ist year GFR	4489	(0.224)	4369	(97.3)	2869	(63.9)
5th year GFR	3179	(0.159)	3107	(97.7)	1758	(55.3)
10th year GFR	2728	(0.136)	2667	(97.8)	2107	(77.2)
20th year GFR	3060	(0.153)	3026	(98.9)	1687	(55.1)
30th year GFR	2604	(0.130)	2539	(97.5)	2069	(79.5)
SED	317		353		170	
CD	690		769		370	

GFR - General Fertilizer Recommendation, * Total N expressed in percentage, ** Percentage values to the total N

Table II. Total N, organic N and total hydro N status in the subsurface soil (kg ha^{-1})

Treatments (kg ha^{-1})	Total N		Organic N		Total hydro N	
Control	3354	(0.168)*	3301	(98.4)	1676	(50.0)**
40 N	2438	(0.122)	2385	(97.8)	1343	(55.1)
80 N	2758	(0.148)	2691	(97.6)	1866	(67.7)
30 P_2O_5	2054	(0.103)	1985	(96.6)	1748	(85.1)
60 P_2O_5	2935	(0.147)	2869	(97.8)	1605	(54.7)
40 K_2O	2637	(0.132)	2589	(98.2)	1888	(71.6)
80 K_2O	2258	(0.113)	2206	(97.7)	1781	(78.9)
40:30:40 N:P_2O_5:K_2O	2165	(0.108)	2108	(97.4)	1754	(81.0)
80:60:80 N:P_2O_5:K_2O	2058	(0.103)	1996	(97.2)	1297	(63.2)
Ist year GFR	2878	(0.144)	2823	(98.1)	1824	(63.4)
5th year GFR	2229	(0.111)	2086	(94.0)	1441	(64.6)
10th year GFR	1748	(0.09)	1689	(96.6)	1086	(62.1)
20th year GFR	2936	(0.147)	2889	(98.4)	1637	(55.8)
30th year GFR	2994	(0.150)	2932	(98.0)	1831	(61.2)
SED	390		385.0		312	
CD	849		838.0		680	

GFR - General Fertiliizer Recommendation
*Total N expressed in percentage values
** Percentage values to the total N

Table III. Inorganic nitrogen status in the surface soil (kg ha^{-1})

Treatments (kg ha^{-1})	NH_4 - N	NO_3 - N	Total inorganic - N	
Control	41	12.1	53.1	(1.6)*
40 N	41	14.7	55.7	(1.8)
80 N	44	17.2	61.2	(2.0)
30 P_2O_5	26	11.5	37.7	(1.2)
60 P_2O_5	47	20.2	67.2	(1.9)
40 K_2O	46	27.0	73.0	(2.7)
80 K_2O	38	15.4	53.4	(2.2)
40:30:40 N:P_2O_5:K_2O	35	22.7	57.7	(1.8)
80:60:80 N:P_2O_5:K_2O	46	22.2	67.7	(2.0)
Ist year GFR	53	67.6	120.6	(2.7)
5th year GFR	43	28.8	71.8	(2.30)
10th year GFR	45	16.0	61.0	(2.2)
20th year GFR	41	8.2	49.2	(1.6)
30th year GFR	54	11.7	65.7	
SED	4.6	4.4	6.8	
CD	10.0	9.7	14.9	

GFR - General Fertiliizer Recommendation
* Percentage values to the total N

Table IV. Inorganic nitrogen status in the subsurface soil (kg ha^{-1})

Treatments (kg ha^{-1})	NH_4 - N	NO_3 - N	Total inorganic - N	
Control	36	17.5	53.5	(1.6)*
40 N	31	22.1	53.1	(2.2)
80 N	43	24.1	67.1	(2.4)
30 P_2O_5	33	16.4	49.4	(2.4)
60 P_2O_5	47	19.2	66.2	(2.3)
40 K_2O	31	16.9	47.9	(1.8)
80 K_2O	36	15.8	51.8	(2.3)
40:30:40 N:P_2O_5:K_2O	40	17.0	57.0	(2.6)
80:60:80 N:P_2O_5:K_2O	43	14.7	57.7	(2.8)
Ist year GFR	38	16.8	54.8	(1.9)
5th year GFR	100	42.8	142.8	(6.4)
10th year GFR	48	11.0	59.0	(3.4)
20th year GFR	34	13.4	47.4	(1.6)
30th year GFR	48	13.6	61.6	(2.1)
SED	12.4	4.4	13.8	
CD	27.0	9.7	30.0	

GFR - General Fertilizer Recommendation
* Percentage values to the total N

100 kg ha^{-1} for NH_4-N, from 11.0 to 42.8 kg ha^{-1} for NO_4-N and from 47.4 to 142.8 kg ha^{-1} for total hydro. N. In general, high values of NH_3-N were recorded by the surface soil, and NO_3-N values were high in the subsurface layer indicating the possibilities of downward leaching due to the heavy rainfall and slopy land situation prevailing in the rubber plantations. The application of graded levels of N, P_2O_5 or K_2O did not reveal significant difference in the NH_4-N or NO_3-N content. The NH_4-N values were high compared to NO_3-N indicating the slow release of NH_4-N from the organic pool and slow rate of nitrification. The nitrifying bacteria are reported to be temperature sensitive and so the possibilities of higher amount of NH_4-N in tropical soils are reported by Beck (1983). In addition, the nitrifying bacteria prefers more neutral to slightly acid pH condition. The low values of NO_3-N may also be due to the increased crop demands and uptake by the crop. The average inorg. N or mineral N was 2.2 per cent of the total N.

Organic carbon and available N in the surface soil are given in Table V. The values of OC ranged from 0.98 to 2.38 per cent in the surface soil and from 0.67 to 1.50 per cent in the sub-surface soil (Table VI). The highest values were recorded from the first year of planting. In general, OC values were very high compared to the all India standards (Kanwar, 1976). The available N values in the surface soil ranged from 213 to 335 kg ha^{-1} and in the subsurface soil values ranged from 217 to 296 kg ha^{-1}. The available N status were in the medium range. The values were low in the sub-surface soil compared to the surface layer. The application of N at 80 kg ha^{-1} increased the available N values of the soil. The available N fraction was 9.4 per cent of the total N. Application of fertiliser N has been reported to stimulate the mineralisation of soil N. But according to Scott Smith *et al.* (1989) inorganic N availability may have short term effects on metabolism of carbon in organic N but long lasting effects were minimal. Inconsistent effects of inorganic N on carbon mineralisation was reported by Johnson *et al.* (1980). Inhibitory effects of inorganic nitrogen was reported by Kowalaenko *et al.* (1978).

Correlation studies between interlinked parameters revealed positive and significant correlation between total N and available N (0.34*), Org. N (0.99**), total hydro. N (0.68**) and

Table V. Organic carbon and available nitrogen status in the surface soil

Treatments (kg ha^{-1})	O. C. (%)	Available N (kg ha^{-1})	
Control	1.41	253	(7.7)*
40 N	1.04	220	(7.1)
80 N	1.21	278	(9.4)
30 P_2O_5	1.28	213	(6.9)
60 P_2O_5	1.41	253	(7.2)
40 K_2O	1.31	275	(10.0)
80 K_2O	1.13	297	(12.3)
40:30:40 N:P_2O_5:K_2O	1.19	266	(8.3)
80:60:80 N:P_2O_5:K_2O	0.97	295	(8.9)
year GFR	2.38	335	(7.5)
year GFR	1.39	332	(10.4)
10th year GFR	0.93	253	(9.3)
20th year GFR	1.28	279	(9.1)
30th year GFR	1.31	265	(10.2)
SED	0.26	16.7	
CD	0.57	36.3	

GFR - General Fertiliizer Recommendation
* Percentage values to the total N

Table VI. Organic carbon and available N status in the subsurface soil

Treatments (kg ha^{-1})	O. C. (%)	Available N (kg ha^{-1})	
Control	1.31	223	(6.6)*
40 N	0.82	217	(8.9)
80 N	1.12	230	(8.3)
30 P_2O_5	0.76	223	(10.9)
60 P_2O_5	1.16	266	(9.1)
40 K_2O	1.16	238	(9.0)
80 K_2O	1.24	226	(10.0)
40:30:40 N:P_2O_5:K_2O	0.91	236	(10.9)
80:60:80 N:P_2O_5:K_2O	0.77	227	(11.0)
Ist year GFR	1.50	280	(9.7)
5th year GFR	1.07	275	(12.3)
10th year GFR	0.67	224	(12.8)
20th year GFR	1.14	257	(8.8)
30th year GFR	1.43	297	(9.9)
SED	0.24	19.0	
CD	0.52	41.6	

GFR - General Fertiliizer Recommendation
* Percentage values to the total N

Table VII. Correlation between Interlinked parameters

Sl. No.	Variables X	Variables y	Correlation coefficient (r)
1.	Total nitrogen	available nitrogen	0.34*
2.	Total nitrogen	organic carbon	0.16
3.	Total nitrogen	organic nitrogen	0.99**
4.	Total nitrogen	total hydro N	0.68**
5.	Total nitrogen	nitrite nitrogen	0.43**
6.	Total nitrogen	ammoniacal nitrogen	-0.16
7.	Organic nitrogen	totalhydro N	0.66**
8.	Organic nitrogen	available nitrogen	0.21
9.	Organic carbon	organic N	0.74**
10.	Organic carbon	available nitrogen	0.48**
11.	Total inorganic N	available nitrogen	0.41**
12.	Total inorganicN	organic carbon	0.28*
13.	Nitrate nitrogen	available nitrogen	0.43**
14.	Ammoniacal N	available nitrogen	0.26*

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

NO_3-N (0.43**). Organic carbon and available N were positively correlated (0.48**). Compared to organic carbon, available N positively correlated with NO_3-N (0.43**) and NH_4-N (0.26*) indicating the superiority of available N estimation. However, the total inorg. N was positively correlated with both available N (0.48**) and organic carbon (0.28*) justifying organic carbon as an estimate of N availability.

The rubber growing soils are rich in total N, different fractions of N and organic carbon status. The available N status is in the medium range. The application of inorganic N for years

did not contribute substanitially to the N build up of the soil. Organic carbon, total inorganic N and available N were increased during the thirtieth year of planting indicating the accumulation of organic matter and build up of nitrogen in the closed ecosystem of rubber plantations. Establishment of leguminous cover crops and biological fixation of N and recycling of organic residues through annual leaf fall have contributed to this build up of organic carbon and nitrogen.

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DISCUSSION

T.S. GOVINDARAJAN : What is the recommendation of fertilizer application for rubber? What are the criteria in choosing treatments N alone, P alone and K alone?

MERCYKUTTY : Fertilizer recommendation for mature rubber is 30:30:30 N, P_2O_5 and K_2O/ha. From the 3 NPK factorial trial these treatments were selected to study the effect of these treatments alone.

P.R.V. SUBRAMANIA IYER : When do you do sampling after application of fertilizer treatments? You said that nitrification is inhibited in tropical soils due to high temperature. In rubber, the temperature cannot be more than 40°C in soil.

MERCY KUTTY : The sampling is done during August, before the application of post monsoon fertilizer. The high value of NH_4-N compared to NO_3-N might be due to the slow nitrification rate which can be due to the temperature and pH sensitiveness of nitrifying bacteria. The low NO_3-N values can be due to the uptake of nitrogen by the plants in the NO_3 form. It can also be due to the increased suceptibility of NO_3-N to leaching losses through heavy rainfall prevailing in rubber growing tract.

C.S. SRINIVASAN : In your correlation study, you have shown even as low a value of r as .28 as highly significant. Is it correct? If so, what is the total number of r samples used for calculating?

MERCYKUTTY : The total number of samples is 58. The value of 0.28 as significant at 1% level is not correct. It is a typing mistake.