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EVALUATION OF CRUMB RUBBER FACTORY SLUDGE AS MANURE FOR RUBBER

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An incubation and a nursery trial were conducted to evaluate the sludge obtained from settling tanks of crumb rubber factories as a source of nitrogen in comparison with urea. Results of the incubation study indicated that the release of inorganic nitrogen from sludge was slow and steady for 75 days. Nursery trial conducted on the same bed for three years indicated that sludge can be effectively used either in combination with urea, or singly at higher concentration to improve growth of young rubber. The sludge acts as a slow but steady source of nutrients for young rubber.

Key words: Crumb factory waste, Growth, *Hevea brasiliensis,* Inorganic nitrogen, Rubber nursery, Sludge.

INTRODUCTION

A thick layer of froth is formed on the top of effluent water from crumb rubber factories producing technically specified block rubber in the settling tanks. This sludge, which consists of dirt, tree bark particles and rubber, is periodically removed from the tank. The disposal of the sludge around the factory premises causes environmental pollution. A simple solution for the problem would be to recycle this organic residue as manure.

An incubation study was conducted to observe the pattern of mineralisation of nitrogen (N) from the sludge in comparison with that from urea. A nursery trial was also conducted to evaluate sludge as a source of nutrients for young rubber plants.

MATERIALS AND METHODS

Sludge sample: collection and analysis

About 2 kg of the sludge samples was collected at two month intervals for one year from the Pilot Crumb Factory (PCRF) of the Rubber Research Institute of India (RRII) at Kottayam in Kerala, India and the Crumb Rubber Factory (CRF) of Travancore Rubber and Tea Estate at Mundakayam. The samples collected from both factories were air dried and analysed for nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) as per the standard procedures (AOAC,1970).

Incubation study

An incubation study was conducted to observe the release of nitrate and ammoniacal nitrogen from sludge in comparison with urea at different intervals of time at field capacity. The soil selected for the study was collected from the RRII Farm. The physico-chemical properties of the soil are given in Table 1.

The treatments consisted of either sludge or urea each at 30, 60 and 90 kg/ha and a no nitrogen control, laid out in a com-

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Table 1. **Physico-chemical properties of the soil**

Parameter	Content
Texture	Sandy clay loam
OC (%)	0.75
Available P (mg/100g)	1.69
Availabile K (mg/100g)	6.75
Available Ca (mg/100g)	14.03
Available Mg (mg/100g)	2.64
pH	4.80
Total N (ppm)	75.20
Ammoniacal-N(ppm)	39.00
Nitrate-N (ppm)	8.20

pletely randomized design with six replications. Treatment materials were added to 1 kg of soil taken in 2 litre capacity containers. Soils were maintained at field capacity for 75 days under ambient conditions. Soil samples were drawn at 15 day intervals and analyzed for NH_4-N, NO_3-N and pH (Jackson, 1958).

Nursery study

A field trial was conducted for a period of 3 years with rubber seedlings. The experiment was laid out at the Central Nursery of Rubber Board, India, Karikattoor, Kerala in a completely randomized design with nine treatments and four replications. The initial nutrient status of the soil is given in Table 2. The soil was sandy clay and acidic in reaction. It was medium in OC and available K and high in available P and Mg.

Table 2. **Initial nutrient status of the field**

Parameter	Content
OC (%)	1.61
Available P (mg/100g)	7.50
Available K (mg/100g)	5.20
Available Ca (mg/100g)	17.98
Available Mg (mg/100g)	3.48
pH	4.62
EC	0.054 d s/M

Table 3. **Treatment details**

Treatment No.	Quantity
T_1	500 kg N /ha/year as urea
T_2	500 kg N/ha/year as urea + 250 kg N /ha/year as sludge
T_3	500 kg N/ha/year as urea + 500 kg N/ha/year as sludge
T_4	250 kg N/ha/year as urea
T_5	250 kg N/ha/year as urea + 250 kg N/ha/year as sludge
T_6	250 kg N/ha/year as urea + 500 kg N/ha/year as sludge
T_7	500 kg N/ha/year as sludge
T_8	250 kg N/ha/year as sludge
T_9	Control (no N)

The treatments consisted of different levels of N as urea, sludge or their combinations as given in Table 3. The plants received a uniform application of P_2O_5, K_2O and MgO at the rates 250, 100 and 37.5 kg/ha. Seedling diameter at collar region was recorded annually during January, March and May. At the end of the third year, one plant was uprooted from each of the 36 plots. The plant samples were separated into leaf, stem and root. Dry weights were recorded and N, P, K, Ca and Mg analyzed by standard methods (Karthikakuttyamma, 1989). The uptake of N, P, K, Ca and Mg by plants was also worked out. Soil samples were collected from the base of the uprooted plants and subjected to chemical analysis (Jackson, 1958).

Table 4. **Nutrient content of sludge from crumb factory**

Source	Nutrient content (%)				
	N	P_2O_5	K_2O	CaO	MgO
PCRF-RRII	3.06	0.25	0.22	1.57	0.27
CRF-TR&T	3.05	1.08	0.29	1.54	0.30

RESULTS AND DISCUSSION

Sludge samples

The average nutrient content of the sludge collected from both locations are given in Table 4. Higher P_2O_5 content was noted in sludge collected from CRF of TR &T which may be due to difference in quality of raw material used for processing.

Incubation studies

The effect of the two sources *viz.* sludge and urea, each applied at the three levels of nitrogen, on the nitrate nitrogen (NO_3-N), ammoniacal nitrogen (NH_4-N) and total inorganic nitrogen in the soil at different periods of incubation are given in Tables 5, 6 and 7 respectively.

For both the sources, NH_4-N content decreased with increasing period of incubation, while NO_3-N content showed the reverse trend. As expected, both NH_4-N and NO_3-N content were higher with increasing rates of application. At 15 days all the three levels of urea gave significantly higher NH_4-N than sludge, though on subsequent days the difference was not significant. No difference was noted for NO_3-N content for both sources as well as periods of incubation.

High inorganic N content at first sampling after 15 days was noted for both sources which corresponded to the N content of sources and their application rate (Fig. 1). The initial high inorganic N content is due

Table 5. **Mean NH_4-N content (ppm) of treated soil**

Treatment		Days of incubation					
Source	N (kg/ha)	15	30	45	60	75	Mean
	30	112.52	53.74	28.32	17.71	12.31	44.92
Urea	60	123.73	56.73	23.78	20.59	12.87	47.54
	90	126.37	67.28	23.61	25.24	20.86	52.67
	30	60.79	44.57	22.02	20.85	17.93	33.19
Sludge	60	61.95	53.83	24.25	20.29	15.60	35.18
	90	65.85	51.36	25.88	20.72	23.32	37.43
Control	0	53.91	16.86	20.02	7.01	12.54	22.07
SE		7.18	3.72	2.04	1.44	2.94	
CD (P≤0.05)		20.62	10.62	NS	NS	NS	

Table 6. **Mean NO_3-N content (ppm) of treated soil**

Treatment		Days of incubation					
Source	N (kg/ha)	15	30	45	60	75	Mean
	30	15.47	17.25	29.76	41.04	65.82	33.87
Urea	60	16.40	17.34	38.83	44.98	73.48	38.21
	90	22.76	39.86	97.99	52.51	126.45	67.91
	30	8.51	19.62	42.63	47.53	59.54	35.56
Sludge	60	18.88	20.37	49.05	51.83	99.17	47.86
	90	20.41	22.07	51.07	61.69	93.38	49.72
Control	0	9.51	15.22	19.66	24.38	28.74	19.50
SE		2.79	3.44	8.32	8.07	11.14	
CD (P≤0.05)		8.00	9.86	23.29	24.20	31.99	

Table 7. **Mean inorganic N content (ppm) of treated soil**

Treatment		Days of incubation					Mean
Source	N (kg/ha)	15	30	45	60	75	
	30	127.96	70.98	58.08	53.35	83.53	78.78
Urea	60	142.77	75.75	62.61	57.85	94.07	86.61
	90	146.49	107.14	121.61	73.37	151.69	120.06
	30	72.13	64.20	64.30	65.46	80.27	69.27
Sludge	60	79.48	74.20	73.30	67.43	119.46	82.81
	90	86.26	73.43	76.96	85.08	120.02	88.35
Control	0	34.30	32.08	39.68	36.92	45.75	37.75
SE		7.97	6.26	9.11	8.83	11.56	
CD ($P \leq 0.05$)		22.89	17.96	26.16	25.35	33.20	

to already mineralized N present in both sources. After 30 days of incubation, inorganic N content showed a slight decrease and then began to increase by 75 days. Inorganic N content was significantly lower for sludge than for urea at all the three levels and did not increase significantly with rate of application for each source. It could be due to less N content in sludge. Inorganic N content in soil incubated without additional nitrogen remained almost constant throughout the incubation period.

The effect of pooling levels and periods of incubation on NO_3-N, NH_4-N and total inorganic N content is given in Table 8. An increase in all forms of N was observed with increase in the dosage. This effect was marginally more in urea than in sludge. (Fig. 1)

The pH of the samples as determined at periodic intervals of 15, 30, 45, 60 and 75 days are given in Table 9. There was an initial increase in pH for all the levels of urea and sludge when compared to the control. However, this declined after 30 days and remained stable thereafter, on par with the control. Temporary increase during the initial periods may be due to the bicarbonate and ammoniacal concentration in the soil by rapid hydrolysis of urea (Mohanty and Mandal, 1989). Since nitrification is an acidifying process (Alexander, 1977), that effect was more pronounced in urea than in sludge.

Nursery studies

The data on the diameter of seedlings recorded during 2000-01, 2001-02 and 2002-03 are given in Table 10. The data on diameter of seedlings recorded during the three seasons indicated that the treatment sludge alone at the rate of 250 kg N/ha was inferior to all other treatments which received fertilizer though it was on par with the control. Application of N at the rate of 500, 750 and 1000kg/ha are at par while N at the rate of 250 kg/ha as sludge alone was found to be inferior to same level of N as urea.

Among the treatments tried, T_6 (250 kg N as urea + 500 kg N as sludge) was the best followed by T_2, T_5 and T_3 (various combinations of urea and sludge). Though T_1 and T_7 (urea and sludge alone respectively, each at 500kg/ha) were also statistically on par with T_6. The slightly better performance of the combinations of urea and sludge might be due to the effect of the biomass turnover of N from the large organic pool, aided by the fertilizer N addition and

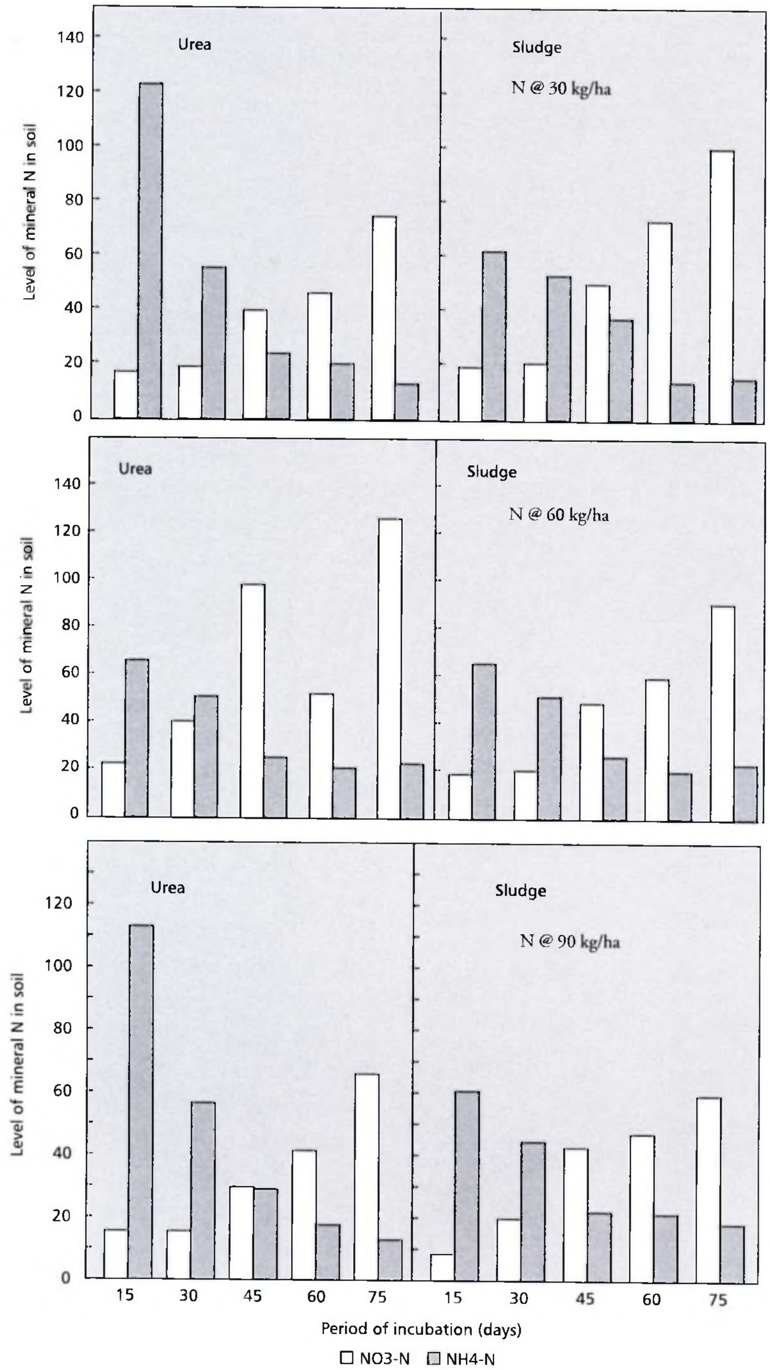

Fig. 1. Effect of different levels of N as urea and sludge on mineral N in soil

Table 8. **Mean value (ppm) of different forms of N as influenced by level of N application**

Levels of N (kg/ha)	Mean value of NO_3-N		Mean value of NH_4-N		Mean value of inorganic N	
	Urea	Sludge	Urea	Sludge	Urea	Sludge
30	33.87	35.56	44.92	33.19	78.78	69.27
60	38.21	47.86	47.54	35.18	86.61	82.81
90	67.91	49.72	52.67	37.43	120.06	88.35
Mean	46.66	44.38	48.38	35.27	95.15	80.14

Table 9. **Mean pH as influenced by N sources and levels of application**

Days of incubation	Source	Levels of N (kg/ha) 30	60	90	Mean	Control (no nitrogen)
15	Urea	5.2	5.3	5.3	5.3	4.5
	Sludge	5.0	5.0	4.7	4.9	
30	Urea	4.2	4.1	4.1	4.1	4.4
	Sludge	4.4	4.4	4.3	4.4	
45	Urea	4.0	4.0	3.9	4.0	4.2
	Sludge	4.2	4.2	4.2	4.2	
60	Urea	3.8	3.8	3.7	3.8	4.0
	Sludge	4.1	4.1	4.1	4.1	
75	Urea	4.1	4.2	4.1	4.1	4.4
	Sludge	4.2	4.2	4.4	4.3	

Table 10. **Effect of different combinations of urea and sludge on the growth of seedlings**

Treatment		Diameter of seedlings (mm)		
Urea	Sludge	2000-01	2001-02	2002-03
500	0	14.47	13.74	14.69
500	250	15.05	13.90	15.15
500	500	15.31	14.94	15.05
250	0	13.65	12.81	13.87
250	250	15.20	13.45	15.13
250	500	14.39	14.04	15.61
0	500	14.40	13.16	14.63
0	250	12.58	11.48	12.18
0	0	10.62	11.07	11.30
Mean		13.97	13.17	14.18
SE		0.54	0.41	0.56
CD ($P \leq 0.05$)		1.57	1.19	1.62

also due to the encapsulation of urea, by sludge, thus preventing the loss of N from urea through volatilization (Jenkinson *et al.*, 1985). Treatment T_4 (urea at 250kg/ha) was better than T_8 (pure sludge at 250kg/ha), which may be due to the delayed decomposition and mineralisation of N from the sludge which is in tune with the results reported by Joseph (1986).

The data on total dry matter production of plants and uptake of nutrients as influenced by different combinations of urea and sludge are presented in Table 11. Neither dry matter production nor nutrient uptake was significantly influenced by the treatments.

The chemical properties of soil samples at the close of the experiment are given in Table 12. The data indicated that the different treatments did not affect total N. available P, K, Mg and pH of the soil, but influenced the organic carbon and available calcium in the soil. Treatment T_7 (sludge at 500 kg/ha) had the highest organic car-

Table 11. **Effect of urea and sludge on dry matter production and uptake of nutrients**

Treatment	Dry matter (g/plant)	Uptake of nutrient (g/plant)				
		N	P	K	Ca	Mg
T_1	69.57	1.02	0.10	0.30	0.78	0.16
T_2	85.37	1.18	0.12	0.41	0.79	0.24
T_3	77.70	1.03	0.12	0.48	0.94	0.18
T_4	55.23	0.78	0.08	0.29	0.52	0.13
T_5	69.55	0.83	0.08	0.31	0.57	0.14
T_6	84.45	1.19	0.14	0.43	0.86	0.22
T_7	77.00	1.10	0.13	0.46	0.80	0.21
T_8	58.58	0.75	0.09	0.27	0.64	0.15
T_9	45.87	0.64	0.05	0.23	0.42	0.12
Mean	69.25	0.94	0.10	0.35	0.70	0.17
SE	16.14	0.21	0.023	0.094	0.18	0.04
CD ($P \leq 0.05$)	NS	NS	NS	NS	NS	NS

Table 12. **Soil chemical properties at the end of the nursery experiment**

Treatment	Urea	Sludge	pH	C (%)	N (%)	Soil nutrient status(mg/100g soil)			
						Av.P	Av.K	Av.Ca	Av.Mg
T_1	500	0	4.38	1.38	0.15	27.50	3.50	12.05	0.15
T_2	500	250	4.23	1.54	0.17	31.25	3.94	14.20	0.17
T_3	500	500	4.38	1.67	0.18	29.00	4.13	32.24	0.18
T_4	250	0	4.27	1.42	0.15	31.38	3.50	11.83	0.15
T_5	250	250	4.36	1.57	0.16	35.63	3.13	20.61	0.16
T_6	250	500	4.47	1.68	0.17	20.75	2.63	28.07	0.17
T_7	0	500	4.52	1.70	0.17	28.38	3.06	35.93	0.17
T_8	0	250	4.44	1.38	0.15	30.13	4.13	26.80	0.15
T_9	0	0	4.49	1.32	0.17	30.38	5.81	22.08	0.17
Mean			4.39	1.51	0.16	29.38	3.76	22.64	0.16
SE			1.40	0.07	0.03	7.04	1.21	5.46	0.03
CD ($P \leq 0.05$)			NS	0.21	NS	NS	NS	15.85	NS

bon and available Ca content .All combinations of urea and sludge (T_2, T_3, T_5 and T_6) also showed high organic carbon while high available Ca content was observed in treatment combinations with 500kg/ha sludge. The high organic carbon and calcium status of the specific treatments might be due to the residual effect of continued application of organic source, rich in calcium, which may have enriched the soil (Hattab *et al.*, 2000).

Sludge, a heterogeneous waste of crumb rubber factories can be effectively used to improve growth of young rubber, either in combination with urea, or singly at higher concentration of 500kg/ha. The sludge acts as a slow but steady source of nutrients to young rubber. Apart from its economic advantage, this is also a novel method of reducing pollution.

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