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Integrating organic manure to reduce chemical fertilizer input and enhance growth in young rubber plantations

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Abstract

A field experiment was initiated at the Central Experiment Station, Chethackal of Rubber Research Institute of India during 2001 to study the effect of integrating organic manure with chemical fertilizers on growth of rubber and soil properties. The treatments comprises chemical fertilizer alone, farm yard manure (FYM) alone, different proportions of chemical fertilizer and FYM and control. The available zinc status was significantly increased by the application of FYM alone and 25 per cent recommended dose of chemical fertilizer (RDF) with 75 per cent FYM. Microbial population was also significantly increased by the incorporation of 25 per cent RDF with 75 per cent FYM. In the fifth year, FYM alone and 25 per cent RDF with 75 per cent FYM applied plots recorded significantly higher leaf N content than the chemical fertilizer alone applied plots. Leaf P content was significantly higher in plots receiving FYM alone and 50 per cent RDF with 50 per cent FYM than the recommended practice. Integrated use of chemical fertilizer with FYM in 25:75 ratio resulted in significantly higher girth than the use of chemical fertilizer alone in the 9th year of planting. This combination was found to be superior to all other treatments in the 10th year of planting.

Keywords: Fertilizer, immature rubber, organic manure, soil health

Introduction

Fertilizers are applied to soil to supplement the nutrients already present in the soil. But the continuous and increased use of chemical fertilizers in agricultural systems result in deterioration of soil health and increase in environmental pollution. Though the use of chemical fertilizers cannot be avoided in agriculture, its quantity can be reduced by the application of organic manures. Increasing chemical fertilizer cost and awareness of soil health and environmental pollution necessitated in integrating organic manures with chemical fertilizers. Complementary use of organic manure and chemical fertilizer had been proved as a sound soil fertility management strategy in many crops (Naeem *et al.*, 2006; Vijaya Sankar Babu *et al.*, 2007).

Regular manuring is practised in immature rubber plantations to enhance the growth of trees and to reduce the gestation period. For rubber, chemical fertilizer alone is recommended after planting. Early rubber plantations were raised in forest cleared lands which were high in organic carbon content. Recent studies indicated a decline in organic carbon status by continuous rubber cultivation (Abraham *et al.*, 2001; Karthikakutty Amma *et al.*, 2002). Also, now more and more marginal lands are being brought to rubber cultivation. Maintaining soil health is of primary importance in sustaining soil productivity. Considering the above factors, the present study was undertaken to find out the effect of integrating organic manure with chemical fertilizers on the growth of rubber, soil physico-chemical properties and microbial population.

Materials and Methods

A field experiment was initiated at the Central Experiment Station of Rubber Research Institute of India, Chethackal during July 2001 with polybag plants of clone RRII 105. The experiment was laid

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out in randomised block design with six treatments replicated four times. The gross and net plot size were 25 and 9 plants respectively. The treatments comprises control (no chemical fertilizer and no organic manure), recommended dose of chemical fertilizer (RDF) alone, organic manure alone, and different proportions of organic and inorganic fertilizers (75:25, 50:50, 25:75). The RDF for rubber in the initial four years is as follows: 10:10:4:1.5 NPKMg mixture @ 450, 900, 1100 and 900 g/plant/year. From 5th year onwards the RDF is 30:30:30 kg NPK per ha. Urea, rockphosphate, muriate of potash and magnesium sulphate were the fertilizers used. Farm yard manure (FYM - 0.54% N, 0.30% P_2O_5 and 0.17% K_2O) was used as the organic manure. The 100 per cent FYM corresponds to 4, 8, 10 and 8 tonnes/ha for the 1st, 2nd, 3rd and 4th year respectively. From 5th year onwards, FYM was applied at the rate of 6 tonnes/ha. The treatments were applied in two equal split doses during April-May and September-October of each year. Chemical fertilizer was applied two weeks after the application of FYM.

The experimental field was acidic with a pH of 4.52, organic carbon 1.88 per cent, available P 0.65 mg/100 g, available K 4.57 mg/100 g, available Ca 12.98 mg/100 g and available Mg 2.33 mg/100 g. Soil samples were collected from individual plots during 2009 and analysed for soil physico-chemical properties (Jackson, 1973) and microbial population (Timonin, 1940). Leaf samples were also collected during August 2005 & 2009 and analysed for nutrient content as described by Piper (1966). Girth of the plants at 150 cm height above bud union were recorded annually. The data were subjected to statistical analysis (SPSS 10.0).

Results and Discussion

Nine years after initiation of the study, treatment effect was not significant with respect to soil organic carbon, available major nutrients and pH (Fig. 1). However, FYM applied (either alone or in combination with chemical fertilizer) plots recorded comparatively higher organic carbon, available phosphorus and magnesium than chemical fertilizer alone applied plots. A lower pH was observed in chemical fertilizer alone applied plots compared to other treatments.

Incorporation of FYM increased the availability of Zn in the soil (Table 1). Application of FYM alone and integration of 75 per cent FYM with 25 per cent chemical fertilizer resulted in significantly higher Zn status (0.76 ppm and 0.71 ppm respectively) than that in the recommended practice (0.32 ppm). Cu was significantly higher in the FYM alone applied plots compared to all other treatments. In the case of Fe and Mn, no significant difference between treatments was noticed. Increase in soil micronutrient status with the addition of FYM might be attributed to the supply of micronutrients by FYM and prevention of fixation of these cations by the chelation action of organic compounds released during decomposition of manures. These results are in agreement with that of Devaraja *et al.* (1980).

Table 1. Effect of integrating organic manure with inorganic fertilizers on soil (0-30 cm) micronutrient status nine years after the initiation of the study

Treatments	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)
T_1 - control	44.71	2.14	8.15	0.26
T_2 - FYM alone	62.25	2.83	17.15	0.76
T_3 - RDF alone	49.91	2.49	9.09	0.32
T_4 - 75% FYM + 25% RDF	55.79	2.97	11.26	0.71
T_5 - 50% FYM + 50% RDF	46.54	2.39	8.47	0.54
T_6 - 25% FYM+ 75% RDF	45.79	2.24	9.13	0.46
SE	5.15	0.49	1.43	0.12
CD (P=0.05)	NS	NS	4.31	0.35

FYM - Farm yard manure RDF - Recommended dose of fertilizer
NS - Not significant

It was noticed that application of FYM at different levels did not influence bulk density and porosity significantly (Table 2). However, lower bulk density and higher porosity were observed in

Table 2. Effect of integrating organic manure with inorganic fertilizers on soil (0-15 cm) physical properties

Treatments	Bulk density (g/cc)	Porosity (%)
T_1 - control	0.94	55.75
T_2 - FYM alone	0.90	58.75
T_3 - RDF alone	1.03	53.50
T_4 - 75% FYM + 25% RDF	0.89	59.00
T_5 - 50% FYM + 50% RDF	0.92	56.75
T_6 - 25% FYM + 75% RDF	1.00	53.75
SE	0.07	2.80
CD (P=0.05)	NS	NS

FYM - Farm yard manure RDF - Recommended dose of fertilizer
NS - Not significant

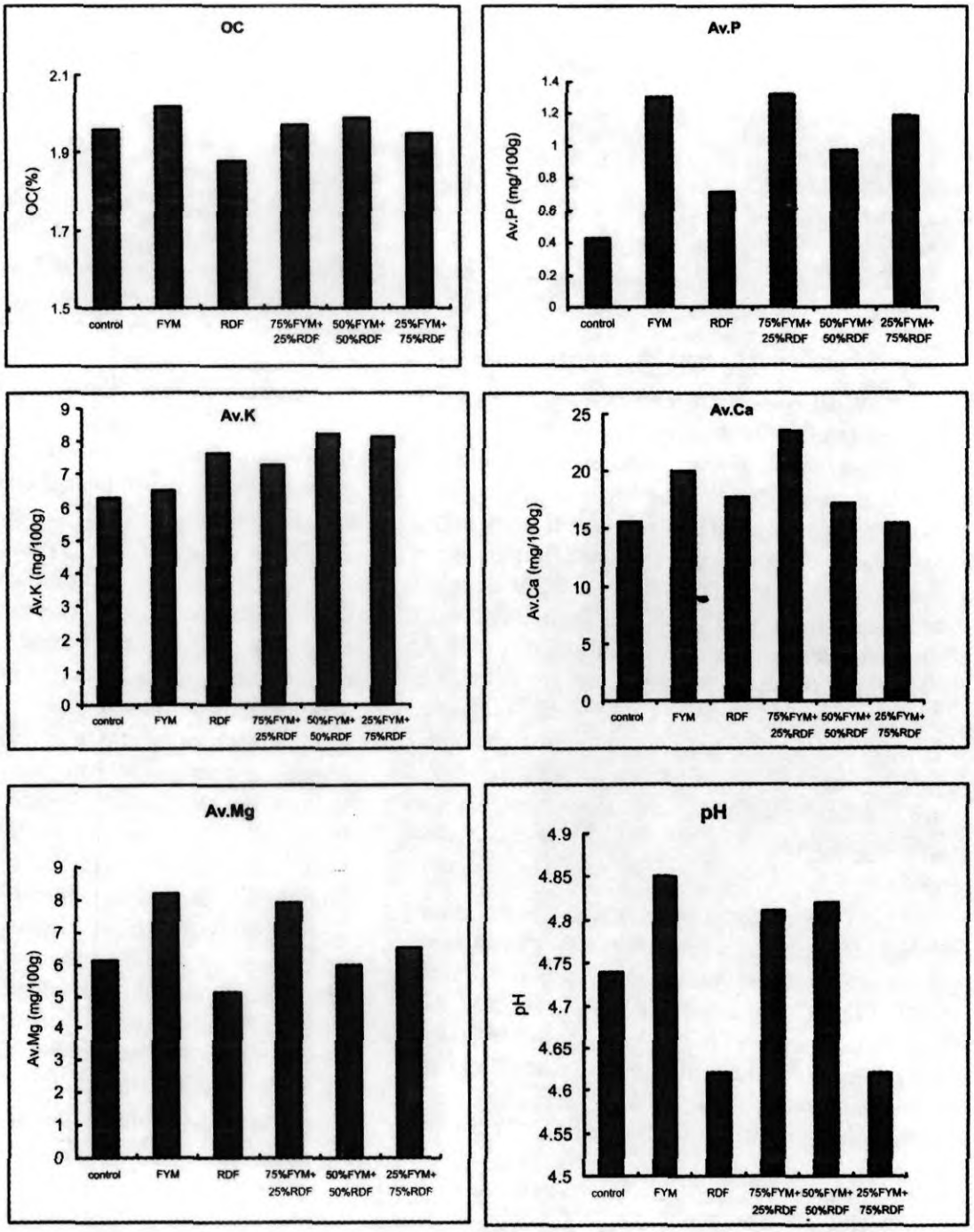

Fig. 1. Effect of integrating organic manure with inorganic fertilizers on soil (0-30cm) chemical properties nine years after initiation of the study

FYM applied plots compared to chemical fertilizer alone applied plots.

Use of FYM alone or in combination with chemical fertilizer led to higher number of microbes than the use of chemical fertilizer alone (Table 3). The microbial population was significantly higher in the plots supplied with 75 per cent FYM + 25 per cent RDF compared to all other treatments. It was followed by the treatment 50 per cent FYM + 50 per cent RDF. The lowest microbial population was recorded in chemical fertilizer alone applied plots. Jessy *et al.* (1996) and Kibunja *et al.* (2010) also reported higher microbial population in organic manure applied plots compared to chemical fertilizer applied plots.

Table 3. Effect of integrating organic manure with inorganic fertilizers on microbial population (cfu/g soil)

Treatments	Total bacteria x10^5	Phosphate solubilising bacteria x10^5	Fungi x 10^4	Actinomycetes x 10^5
T_1 - control	43.00	17.25	19.50	5.25
T_2 - FYM alone	50.75	24.00	66.50	6.50
T_3 - RDF alone	39.75	12.75	19.00	6.00
T_4 - 75% FYM + 25% RDF	92.25	32.50	72.75	8.25
T_5 - 50% FYM + 50% RDF	62.75	25.50	57.00	5.75
T_6 - 25% FYM + 75% RDF	44.25	22.00	44.00	6.50
SE	0.90	0.63	0.97	0.50
CD (P=0.05)	2.71	1.91	2.92	1.51

FYM - Farm yard manure RDF - Recommended dose of fertilizer

With regard to leaf nutrient status the treatment effect was significant in the 5th year of planting (Table 4). Nitrogen content in the treatments FYM alone and 75 per cent FYM + 25 per cent RDF were comparable and this was significantly higher than that of recommended practice. In the case of phosphorus content, the treatments FYM alone and 50 per cent FYM + 50 per cent RDF were comparable and was significantly higher than the chemical fertilizer alone treatment. Potassium content was significantly higher in the treatments of chemical fertilizer alone and 75 per cent FYM + 25 per cent RDF than control and 50 per cent FYM + 50 per cent RDF treatments. However, nine years after planting, no significant difference between treatments was noticed in leaf nutrient content.

The girth data (Table 5) indicated that during the initial years, treatment effect was not significant. In the 8th year (2008), the treatments FYM alone, RDF alone, 75 per cent FYM + 25 per cent RDF and 50 per cent FYM + 50 per cent RDF showed significantly higher girth than the control. In 2009, the treatment 75 per cent FYM + 25 per cent RDF recorded significantly higher girth (50.78 cm) than the recommended practice (47.70 cm). In 2010, trees supplied with 75 per cent FYM + 25 per cent RDF showed superiority over all other treatments. Before commencing the experiment, the soil organic carbon status was 1.88 per cent. The data clearly showed that even when the soil organic carbon is high (>1.5%), integrated use of FYM and chemical fertilizer is advantageous. This may be attributed to improved soil physical conditions, increased microbial population and nutrient availability by the application of FYM and chemical fertilizer. Better growth of crops by the judicious combination of organic and inorganic fertilizers are reported by Bayu *et al*, (2006) and Ayoola *et al*, (2007). The treatments 50 per cent RDF + 50 per cent FYM, FYM alone and RDF alone were on par. The cumulative girth increment (2003-2010) also showed the same trend. Table 6 shows the per centage of tappable trees (trees with girth of 50 cm at a height of 125 cm from bud union) in 2010. The treatments FYM alone, RDF alone, 75 per cent FYM + 25 per cent RDF and 50 per cent FYM + 50 per cent RDF were comparable and these treatments were significantly higher than absolute control and

Table 4. Effect of integrating organic manure with inorganic fertilizers on leaf nutrient content (%)

Treatments	N		P		K	
	2005	2009	2005	2009	2005	2009
T_1 - control	3.14	3.37	0.17	0.28	0.58	0.85
T_2 - FYM alone	3.40	3.46	0.21	0.33	0.64	0.86
T_3 - RDF alone	3.16	3.33	0.18	0.31	0.78	0.94
T_4 - 75% FYM + 25% RDF	3.29	3.57	0.18	0.32	0.78	0.87
T_5 - 50% FYM + 50% RDF	3.23	3.31	0.20	0.32	0.62	0.87
T_6 - 25% FYM + 75% RDF	3.20	3.36	0.19	0.29	0.70	0.87
SE	0.04	0.11	0.005	0.017	0.045	0.027
CD (P=0.05)	0.12	NS	0.014	NS	0.14	NS

FYM - Farm yard manure RDF - Recommended dose of fertilizer

Table 5. Effect of integrating organic manure with inorganic fertilizers on the girth (cm) and girth increment (cm) of rubber plants

Treatments	2003	2004	2005	2006	2007	2008	2009	2010	Cumulative girth increment 2003-2010
T_1 - control	5.13	9.13	15.60	23.22	31.31	38.52	44.40	49.54	44.41
T_2 - FYM alone	5.93	10.10	17.93	26.70	35.30	42.90	48.10	52.95	47.03
T_3 - RDF alone	5.48	10.37	17.30	26.18	34.61	42.28	47.70	52.32	46.85
T_4 - 75% FYM + 25% RDF	5.60	10.75	18.60	27.18	36.02	44.42	50.78	56.21	50.49
T_5 - 50% FYM + 50% RDF	5.55	9.27	17.18	25.95	34.79	42.67	48.93	53.54	47.99
T_6 - 25% FYM + 75% RDF	5.38	8.35	16.58	24.89	33.90	41.35	46.96	51.33	45.96
SE	0.34	0.71	1.40	1.14	1.03	1.05	0.94	0.80	0.76
CD	NS	NS	NS	NS	NS	3.29	2.82	2.35	2.30

Table 6. Effect of integrating organic manure with inorganic fertilizers on the tappability (%) of plants

Treatments	Percentage of tappable trees (2010)
T_1 - control	62.5 (52.43)
T_2 - FYM alone	79.3 (62.97)
T_3 - RDF alone	71.8 (57.93)
T_4 - 75% FYM + 25% RDF	81.3 (64.71)
T_5 - 50% FYM + 50% RDF	71.0 (57.48)
T_6 - 25% FYM + 75% RDF	66.5 (54.82)
SE	2.59
CD	7.82

Figures in parenthesis are angularly transformed values

25 per cent FYM + 75 per cent RDF. The highest per centage tappability was recorded in the integrated use of chemical fertilizer with farm yard manure in 25:75 ratio.

The study clearly showed that integrating chemical fertilizer with FYM enhanced the growth of rubber plants and improved the soil properties. A combination of 25 per cent RDF and 75 per cent FYM was superior to all other treatments. By the integrated approach considerable reduction in the use of chemical fertilizer can also be achieved.

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