INFLUENCE OF FYM AND CHEMICAL FERTILIZERS ON GROWTH OF YOUNG RUBBER (*HEVEA BRASILIENSIS*) AND SOIL PROPERTIES IN TRIPURA

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A field experiment was conducted at Pathalia, Sepahijala district of Tripura during 2007 to 2013 to study the effect of integrating organic manures with chemical fertilizers on soil properties, growth and uptake of nutrients by young rubber. Treatments were standard recommended dose of chemical fertilizers (RDF), farm yard manure (FYM) @ 20 kg plant^{-1} + 50 per cent of RDF and control (no fertilizer and no manures). The field experiment was conducted in farmer's field in blocks of 125 plants in each block. Significant increase in girth and height were observed in plants that received FYM @ 20 kg plant^{-1} + 50 per cent of RDF and its influence was more pronounced in the initial years. At the end of six years, mean girth and tappability of the plants receiving FYM @ 20 kg plant^{-1} with 50 per cent of RDF, were 48.3 cm and 68.3 per cent, respectively. The corresponding mean girth for plants receiving 100 per cent recommended dose of chemical fertilizers and control plot were 44.7 cm and 35.8 cm, respectively. Tappable plants under these two treatments were 57.6 and zero per cent, respectively. Integrating FYM with chemical fertilizers increased the available N significantly compared to application of chemical fertilizers alone or control. Significant increase in leaf nutrient content of plants was also observed due to combined application of FYM and chemical fertilizers (RDF) indicating higher uptake of applied nutrients. DTPA extractable Zn and Mn were also significantly increased due to combined application of FYM and chemical fertilizers. Results from the experiment revealed that application of FYM @ 20 kg plant^{-1} with 50 per cent RDF could reduce the gestation period of rubber plants by six months to one year, besides improving soil health, when grown in the denuded lands in Tripura.

Key words: Degraded soils, Nutrient management, Soil fertility, Tripura, Young rubber

INTRODUCTION

Rubber (*Hevea brasiliensis*) is a major cash crop in the state of Tripura. It is mostly cultivated in the rolling hills (tilla/upland) of the state. Majority of the rubber growing soils in the state were once subjected to shifting cultivation which was usually preceded by burning the organic debris. These soils are acidic in reaction and poor in nutrient content (Chaudhuri *et al.,* 2001). Relative abundance of degraded illite clay minerals was recorded from these soils. This results in high K-fixation and poor K availability to plants (Mandal *et al.*, 2005). Growth and yield of rubber plants grown in

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north-east India were reported to be low in comparison to traditional rubber growing tract (Reju *et al.*, 2001). Low fertilizer consumption or non-availability of the same at the right time coupled with loss of top soil through erosion also affect growth of plants. Nutrient imbalance in soil was observed due to application of N-alone or application of NPK in sub-optimal rate, which may reduce crop yield besides reducing nutrient use efficiency (Sanyal *et al.*, 2014). Studies on the integrated effect of organic and chemical fertilizers on growth and yield of annual crops are reported by many workers (Selvi *et al.*, 2005; Singh *et al.*, 2008; Singh *et al.*, 2009; Chesti *et al.*, 2013), but it is limited in a perennial crop like rubber. Integration of chemical and organic sources of nutrients and their effective management yielded promising result in rubber in traditional region (Philip *et al.*, 2012). It is expected that increased growth and higher productivity of rubber, particularly in degraded soils of Tripura, could be achieved by combined application of organic and chemical fertilizers. In a preliminary study from Tripura, a treatment combination of FYM @ 20 kg plant^{-1} with recommended doses of NPK led to significant increase in girth of rubber plants (Anon, 2004). In the present experiment, an investigation was conducted in a farmer's field for six consecutive years to study the effect of integrated application of organic and chemical sources of nutrients on growth of young rubber and soil properties.

MATERIALS AND METHODS

Field experiment was conducted in a farmer's field at Pathalia (23^{0}34.37' N and 91^{0}22.46' E), Sipahijala district of Tripura state during 2007 to 2013. The region received an annual rainfall of 1849 mm, RH ranged from 63.7 to 89.6 per cent, average bright sunshine hours was 5.7 hours, mean maximum temperature ranged from 24.6 to 33.6 ^{0}C, minimum temperature ranged from 10.1 to 25.5 ^{0}C and evaporation rate was 2 mm day^{-1}. The agro-climate of this state represents a sub-tropical weather. Polybag plants of the clone RRIM 600, were planted during 2007. The experiment was carried out in three blocks with 125 plants per block per treatment. The treatments were 20 kg FYM plant^{-1} + 50 per cent of the recommended dose of chemical fertilizer (T1), 100 per cent of recommended dose of chemical fertilizer alone (T2), absolute control with no chemical fertilizer and no manure (T3). The standard NPK fertilizer recommendation is provided Table 1.

Table 1. **General recommended dose of chemical fertilizers**

Year of planting	Dose of NPK (kg ha^{-1} year^{-1})*
First year	14 : 14 : 7
Second year	50 : 50 : 25
Third year	65 : 65 : 35
Fourth year	50 : 50 : 25
Fifth to seventh year	35 : 35 : 35

*Applied in two equal splits during May and September

Nitrogen was supplied through urea, phosphorus through Rajphos and K through muriate of potash. The treatments were applied in two equal split doses during May and September. The nutrient content of dry FYM were 0.56 per cent N, 0.23 per cent P and 0.56 per cent K. Pre-treatment soil samples were analyzed for available nutrient status. Periodic recording of height and girth of the plants (at 25 cm from bud union) were done for the initial two years. Later, girth of the plants was recorded twice in a year at a height of 150 cm from the bud union.

Tappability (%) of plants was computed based on girth of plants attaining 50 cm. At the end of the sixth year, surface soil samples (0-30 cm) were collected and the physico-chemical properties were estimated following the standard analytical methods as outlined by Jackson (1973). Bulk density (BD) and particle density (PD) were determined from core samples following the procedure as depicted by Black (1965) and porosity of soil was calculated from the formula: Porosity = 100(1-BD/PD). Microbial biomass carbon of soils under each treatment was determined by chloroform fumigation method (Barua and Barthakur, 1997). After 5th year of plantation, six composite leaf samples were collected from each block under the three treatments and analyzed for N, P and K contents following standard analytical techniques (Piper, 1966). Paired 't' test was employed to analyze the growth data statistically. One way analysis of variance was computed for the comparison of soil properties and leaf nutrient concentration between the treatments.

RESULTS AND DISCUSSION

Effect of treatments on growth

At the early immature phase, significant difference in girth and height of plants was observed due to imposition of treatments (Table 2). Highest mean girth was observed in treatment T1 and the difference in girth between plants receiving treatments 'T_1 and T_2' and 'T_1 and T_3' were 3.5 cm and 4.3 cm, respectively. Similarly, mean height of plants was higher under treatment T_1 (488.6 cm) in comparison to treatment T_2 (454.2 cm) and treatment T_3 (410.2 cm). At the end of 2nd year of plantation, a girth increment of 13.8 cm was observed in treatment T_1 and corresponding girth increment values for treatment T_2 and T_3 were 10.1 cm. and 9.4 cm, respectively. Growth of plants during the late immature period (3-6 years) followed similar trend. At the end of 6th year of plantation, mean girth of the plants (Table 3) under treatment T_1 ranged from 42.8 to 57.2 cm with a mean value of 48.3 cm. Corresponding mean values under T_2 and T_3 were 44.7 and 35.8 cm, respectively. During this period, a girth increment of 27.1 cm was recorded from plants under treatment T_1. However, mean girth increment for plants under treatment T_2 and T_3 for this period were 25.6 cm and 20.5 cm, respectively. The beneficial effect of integrating FYM + chemical fertilizer on growth was, therefore, quite evident. The rubber growing soils in Tripura are highly degenerated, poor in nutrient content and rich in low active kaolinitic clay (Mandal *et al.*, 2013). Therefore, benefit of attaining higher growth of plants due to integrated use of FYM along with chemical fertilizers might be attributed to the increased availability of nutrients and the conducive physical environment of soil leading to better root activity and higher nutrient absorption.

Table 2. **Effect of treatments on the growth of the plants at the early immature phase**

Treatment	1st year		2nd year	
	Girth (cm)	Height (cm)	Girth (cm)	Height (cm)
T_1	7.1	201.2*	15.9*	488.6*
T_2	7.0	184.6	12.4	454.2
T_3	6.3	168.7	11.6	410.2

*Significant at t (5%)

Tappability

In north-east India, about eight years were required to reach 70 per cent tappability for commercial exploitation of rubber plants (Reju *et al.*, 2001). In the present case, at the end of 6th year of plantation, 68.3 per cent plants under treatment T_1 attained tappable

Table 3. **Effect of treatments on girth (cm) and tappability (%) of rubber plants**

Treatment	Year of planting					Tappability (%)
	3rd year	4th year	5th year	6th year	AMGI	
T_1	21.2	32.2*	43.6*	48.3*	9.1	68.3
T_2	19.1	28.7	40.6	44.7	8.8	57.6
T_3	15.3	23.2	33.7	35.8	6.8	0.0

AMGI= annual mean girth increment; * significant at t (5%)

girth which was close to bench mark values of 70 per cent tappability. The corresponding values under treatment T_2 and T_3 were 57.6 and nil, respectively. The result showed a significant improvement in tappable plants due to imposition of treatment T_1. Therefore integrating organic manure along with chemical fertilizers could effectively reduce the gestation period of rubber plants in Tripura.

Soil properties

Some important physical and chemical properties of the surface soils are presented in Fig.1 and Table 4. The soil is very strongly acidic, low in organic carbon, available N, P and K as per the ratings followed in rubber (Karthikakuttyamma *et al*., 2000). The result revealed that application of chemical fertilizers with or without FYM over a period of six years resulted in non-significant changes in CEC, pH and clay content of soil, a positive improvement in soil pH, CEC and clay content was observed due to application of FYM on soil. Higher contents of clay in surface soil under treatment T_1 could be attributed to improved clay-humus binding capacity. This may resist the possible erosion of top soil due to high rainfall prevailing in this region. Application of FYM also positively influenced the cation exchange capacity of the soil by increasing the exchange sites of clay matrix of soil. Porosity of soils (63.5%) also increased due to combined application of chemical fertilizers and FYM (Fig. 1) in comparison to treatments T_2 (57.4%) and T_3 (53.3%). This could be attributed to increased micropores, higher microbial activity as indicated by higher microbial

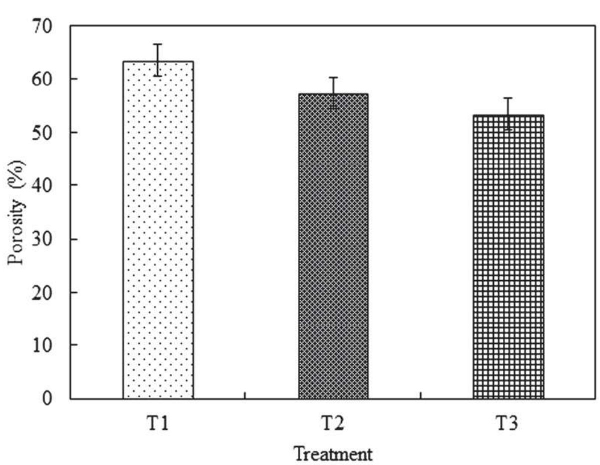

Fig. 1. Porosity of soils under different treatments

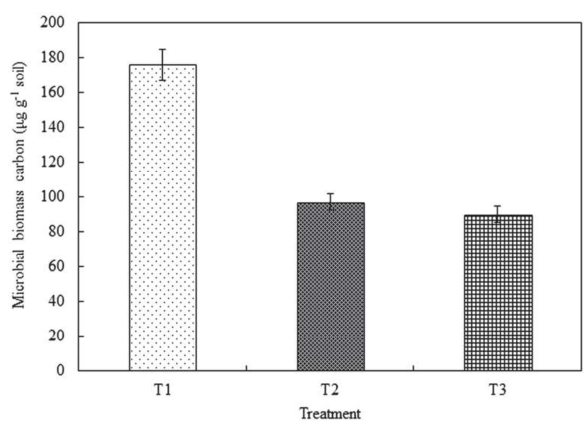

Fig. 2. Microbial biomass carbon of soils under different treatments

Table 4. **Effect of treatments on soil properties and availability of nutrients**

Treatments	pH	Clay (%)	OC (%)	Available nutrients (kg ha^{-1}) N	P	K	CEC (cmol (p+)kg^{-1})
T_1	4.80	22.6	0.96	226.3	4.63	124.2	9.97
	(4.62)	(19.4)	(0.7)	(172.6)	(2.02)	(117.5)	(7.62)
T_2	4.45	18.6	0.81	201.3	6.51	159.1	7.37
	(4.61)	(20.1)	(0.68)	(168.7)	(1.86)	(116.5)	(7.28)
T_3	4.58	18.8	0.74	188.1	1.80	104.5	7.68
	(4.62)	(19.6)	(0.72)	(175.7)	(1.72)	(120.9)	(7.54)
CD (P=0.05))	NS	NS	NS	18.8	0.54	12.8	NS

Values in parenthesis are pre-treatment values

biomass carbon (Fig. 2) and less compaction of surface soils under the above treatment, suggesting better physical soil condition under treatment T_1.

The organic carbon (OC) content of surface soil (0-30 cm) increased significantly from 0.70 to 0.96 per cent due to treatment T_1. Application of chemical fertilizers alone in treatment T_2 also showed a positive effect on OC content. The increase in organic carbon content in treatment T_1 could be attributed to direct addition of organic manure in the soil which stimulated the growth and activity of microorganisms. This was further evident from the higher microbial biomass carbon content (Fig 2) under treatment T_1 (153 to 198 µg g^{-1} soil) compared to treatment T_2 (92 to 101 µg g^{-1} soil) and T_3 (53 to 72 µg g^{-1} soil). Further, the addition of FYM might have created an environment conducive for formation of humic acid, increasing the organic carbon content of soil. These results are in agreement with the findings of previous workers (Bajpai *et al.*, 2006; Singh *et al.*, 2008).

The available N status of the soil before incorporation of treatments was low and ranged from 168.7 to 175.7 kg ha^{-1}. At the end of six years significant improvement in plant available N (226.3 kg ha^{-1}) was observed under treatment T_1. The corresponding values due to application of chemical fertilizers alone (T_2) and control plot (T_3) were 201.3 kg ha^{-1} and 188.1 kg ha^{-1}, respectively. The increase in available N could be attributed to the enhanced multiplication of microbes due to incorporation of FYM along with chemical fertilizers which helped in the conversion of organically bound N to inorganic form. The favourable soil condition under treatment T_1 might have accelerated the rate of mineralization of soil nitrogen leading to build up higher available N (Singh *et al.*, 2009; Vipan and Singh, 2010).

The status of available P before impossing of treatment in the experimental field ranged from 1.72 to 2.02 kg ha^{-1}. The values were well below the critical level for available P (22.4 kg ha^{-1}). At the end of 6th year available P of the soils ranged from 1.80 to 6.51 kg ha^{-1} and highest values were obtained under treatment T_2 due to application of 100 per cent of chemical fertilizer. Integrating FYM along with inorganics showed a moderate improvement in plant available P. The rubber growing soils in Tripura are predominantly acidic in reaction and rich in sesquioxide. Higher P fixation in these soils is, therefore, expected. Addition of organic manures in these soils will be beneficial in the long term for getting higher plant available P due to increased activity of soil micro-organisms.

The status of available K in these soils before imposing of treatment was in the medium category (116.5 to 120.9 kg ha^{-1}). At the end of 6th year a significant improvement in available K was recorded and the effect was more pronounced under treatment T2 where 100 per cent recommended dose of inorganic fertilizers were applied. Available K was significantly depleted in soils receiving no potassic fertilizer (T3). Continuous omission of K in crop nutritional trial may cause mining from its native pools and addition of organic manure (FYM) along with 50 per cent recommended dose of chemical fertilizer showed beneficial effect in keeping K-status of soil at the desired level. Dwivedi *et al*. (2007) also reported similar observation.

At the end of 6th year incorporation of FYM along with chemical fertilizers (T_1) increased the availability of Zn and Mn significantly in comparison to the other two treatments (Table 5). Increase in the micronutrient status of the soil could be attributed to the addition of FYM and possible prevention of fixation of these cations by the chelating action of organic compounds released during its subsequent decomposition. Zinc deficiency of soils was reported from many parts of the rubber growing locations of Tripura (Mandal *et al.*, 2010). Application of FYM along with chemical fertilizers will be beneficial to alleviate Zn deficiency. Similar observations were reported by Philip *et al.* (2012) from the traditional rubber growing belt of Kerala.

Table 5. **Effect of treatments on available micronutrient status**

Treatment	Available micronutrients (mg kg^{-1})			
	Mn	Fe	Cu	Zn
T1	20.5	100.8	0.62	0.95
T_2	15.9	94.7	0.51	0.47
T_3	10.3	97.8	0.45	0.41
CD (P=0.05)	5.58	ns	ns	0.33

Table 6. **Effect of treatments on the leaf nutrient concentration**

Treatment	Leaf nutrient concentration (%)		
	N	P	K
T_1	3.40	0.24	1.32
T_2	3.21	0.23	1.20
T_3	2.88	0.18	0.97
CD (P=0.05)	0.32	NS	0.21

Leaf nutrient status

Composite leaf samples from each treatment were collected during the 5th year and analyzed for their N, P and K concentrations (Table 6). Significant increase in leaf N in treatment T_1 and T_2 in comparison to treatment T_3 was recorded. Though N content of leaf under treatment T_1 and T_2 was on par, uptake of N by plants was high due to application of FYM in treatmant T_1 than application of chemical fertilizers alone (T_2). This could be due to favorable soil condition and proliferation of micro-organism under treatment T_1 which might have helped the plants for higher N-uptake during the active growth phase of plants resulting higher vegetative growth of plants. Similarly, a statistically significant improvement in leaf K status was recorded in treatment T_1 (1.32%) and treatment T_2 (1.20%) in comparison to treatment T_3 (0.97%). The treatments T_1 and T_2 were on par indicating that even with half dose of chemical fertilizer application combined with FYM the leaf K maintained at a high level. Significant difference in leaf P concentration was not observed among the treatments. Data on leaf analysis clearly showed that uptake of nutrients was enhanced due to combined application of organic manures and chemical fertilizers under treatment T_1 which might have effected higher girthing and increased tappability of plants.

CONCLUSION

The present study conclusively proved that integrating chemical fertilizers with FYM will be highly beneficial for young rubber plants being grown in the degraded lands of Tripura. A combination of 20 kg FYM plant^{-1} along with 50 per cent NPK at the recommended dose could reduce the gestation period of rubber by six months to one year besides improving the soil properties. It was also felt that other sources of organic fertilizers *viz*. compost or vermicompost along with reduced doses of inorganics may be used, in place of FYM, in uplands of Tripura for effective nutrient management programme for rubber.

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