INTEGRATED NUTRIENT MANAGEMENT PRACTICES FOR YOUNG RUBBER IN TRIPURA, NORTH-EAST INDIA

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A field experiment was conducted during 2009-2015 at Taranagar, West district of Tripura to study the effect of integrated nutrient management practices on growth of young natural rubber plants (NR) and on soil chemical properties. Growth of NR (clone RRIM 600) was compared among the treatments comprising an absolute control, bio-inoculant alone, standard dose of chemical fertilizers and 25, 50, 75 and 100 per cent of the standard recommendation of N and P fertilizers in combination with bio-inoculants (BI). Though no significant improvement in girth was recorded during the initial two years of planting, increase in plant height was observed with the treatments 50 and 75 per cent of N and P in combination with bio-inoculants. Significant increase in girth was recorded from 3rd year onwards with the combined application of BI along with 50 or 75 per cent of N and P and the growth improvement was on par among the two levels. Application of BI alone was not sufficient to meet the nutrient demand of young rubber plants. A combination of 50 per cent of the standard recommendation of N and P together with the recommended dose of K and BI was effective in improving the growth of plants and improving the soil fertility with the added advantage of cost saving through the reduction of N and P fertilizer by 50 per cent of the recommended dose.

Key words: *Hevea brasiliensis*, Integrated nutrient management, Natural rubber, North-East India, Soil properties, Tripura

INTRODUCTION

The majority of natural rubber (*Hevea brasiliensis*) growing soils of North-East India in general, and Tripura in particular, are highly weathered, poor in fertility status and rich in low active kaolinite clay belonging to Alfisol or Ultisol order (Bhattacharya *et al.*, 2004). It is reported that growth and yield of natural rubber (NR) in North-East India is low in comparison to traditional NR growing regions of India (Reju *et al.*, 2001). Proper fertilization is one of the key inputs to ensure healthy growth of NR trees and maintain the nutrient balance in NR plantation (Krishnakumar and Potty, 1992). Nutrient management of NR plants from their early growth stage is very important to reduce immaturity period *vis-à-vis* ensure sustained productivity during the yielding phase of the plantation. In many places, nutrient deficiency in NR growing soils was observed which could be due to application

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of N, P and K in sub-optimal rate (Mandal *et al*., 2013). Again, there are growing environmental concerns over the leaching loss of added chemical fertilizers to the adjacent water bodies causing eutrophication. As a result, some of the states in North-East India do not permit to apply chemical fertilizers in the slope lands. In addition, continuous application of high analysis chemical fertilizers to soil may adversely affect the availability of secondary and micronutrients in the long run (Mandal *et al*., 2010). Therefore, it has become an important management strategy to increase the use efficiency of chemical fertilizers. Bio fertilizers including beneficial micro-organisms when applied along with chemical fertilizers could increase the nutrient availability in soil (Chesti *et al*., 2013). It has been reported that chemical fertilizers when amended with organic manures became more beneficial to NR (Philip *et al*., 2012; Abraham *et al*., 2015; Pradeep and Manjappa 2015a; Joseph *et al*., 2017; 2015b).

Therefore, it was felt that integration of chemical fertilizer along with bio-inoculants *viz*. N fixers, P solubilizers, plant growth promoting rhizobacteria (PGPR) and P mobilizers could be a viable option as a nutrient management strategy for NR in North-East India. This may improve the availability and uptake of nutrients to enhance the growth of NR. This practice may help to reduce the use of chemical fertilizers and check environmental pollution too. With this objective, the present field experiment was conducted to study the effect of integrated nutrient management practices for young NR plants in Tripura.

MATERIALS AND METHODS

A field experiment was conducted in the experimental research farm at Taranagar (23^{0}57.20'N and 91^{0}21.34'E) under the of Regional Research Station, Rubber Research Institute of India, Agartala, Tripura during 2009 to 2015. The region's weather conditions were: annual rainfall of 1800 to 2200 mm, relative humidity of 63.7 to 89.6 per cent, average bright sunshine hours 5.7 hrs. mean maximum temperature 24.5 to 33.8^{0}C, minimum temperature 10 to 25.3^{0}C and evaporation rate 2 mm day^{-1}. The agro-climate of this state represents a subtropical weather.

Three whorl polybag plants of RRIM 600wereplanted during 2009. The field was maintained with luxurious growth of cover crops (*Puerariaphaseoloides*). Prior to planting, soil samples (0-30 cm)were collected and fertility status was ascertained. The soils were sandy clay in texture with a pH of 4.2, organic carbon content of 0.91per cent, available Pof 1.8and available Kof 101.2 kg ha^{-1}of soil. Available N in these soils was low whereas available Ca and Mgwere found well above their respective critical levels.

The experiment was laid out in Randomized Block Design (RBD) with 25 plants per plot. The experiment had seven treatments and three replications. The treatments were: T1-absolute control without chemical fertilizers and bio-inoculants (BI), T2 - standard recommendation of chemical fertilizers (SR), T3-25 per cent N and P of SR with recommended dose of K + BI, T4- 50 per cent N and P of SR with recommended dose of K + BI, T5-75 per cent N and P of SR with recommended dose of K + BI, T6- 100 per cent N and P of SR with recommended dose of K + BI and T7 -BI alone. Microbial consortia of BI applied were one isolate of N fixing bacteria (*Azotobacter sp*.), two strains of P solubilizing bacteria (*Bacillus sp*.), and two strains of PGPR (*Pseudomonas sp*.) isolated from the rubber growing soils and AMF, received from TERI, New Delhi. Twenty gram each of lignite based preparation of *Azotobacter* *sp*., phosphobacteria and *Pseudomonus sp*. with ten gram of talc based preparation of AMF were mixed together and applied to the plant basin and incorporated in the soil by gentle forking 21 days after the application of chemical fertilizers. Treatments were applied twice in a year (May and September). Rate of application of N, P and K during immature phase was fixed as per the standard recommendation for the North East region (Karthikakuttyamma *et al*., 2000). The treatment combinations were continued up to four years (2009-12). After that, addition of BI was withdrawn but chemical fertilizers were applied as per the scheduled doses for three more years. Girth of plants at a height of 15 cm from bud union and height of plants were recorded for the first two years of planting (2009 and 2010). From 2011-15, girth of the plants was recorded at a height of 125 cm from bud union.

At the end of the 4th year, composite soil samples (0-30 cm) were collected under each treatment to determine the chemical properties following standard analytical methods as outlined by Jackson (1958). Microbial biomass carbon of soils under each treatment was determined by chloroform fumigation method (Barua and Barthakur, 1997). Composite leaf samples were collected from each treatment after 4th and 6th year of planting and analyzed for total N, P and K contents (Piper, 1966). The leaf analytical values were compared between the two regimes to understand the carry over effect of BI on nutrient uptake of plants. All the data were analyzed statistically (Snedecor and Cochran, 1967).

RESULTS AND DISCUSSION

Influence on growth

During the initial two years of planting, no significant increase in girth of plants was recorded due to the imposition of treatments. However, significant improvement in plant height was observed in treatments T4 and T5 over other treatments (Fig. 1). Significant increase in girth was recorded from 3rd year (2012) onwards. Treatments T4 and T5 showed a significant improvement in girth compared to treatments T1 and T7 and was on par with treatments T2, T3 and T6. At the end of 4th year of plantation (2013), highest girth was recorded under treatment T4 (27.9 cm) which was on par with treatment T2 (27.5 cm) whereas, lowest girth was observed under treatment T1 (21.9 cm). It was also observed that, girth increment of the plants was higher when inorganics were

Table 1. **Effect of integrated nutrient management on girth (cm) of young NR plants**

Treatments	July -2009 (pretreatment)	December -2009	July -2010	December-2010
T1	3.1	5.2	7.8	10.3
T2	3.1	5.5	8.1	11.8
T3	3.2	5.7	7.9	11.7
T4	3.2	5.8	8.4	11.9
T5	3.1	5.8	8.3	11.6
T6	3.3	5.7	8.4	11.5
T7	3.2	5.4	7.8	10.4
Sem ±	0.25	0.27	0.42	0.58
CD (0.05)	NS	NS	NS	NS

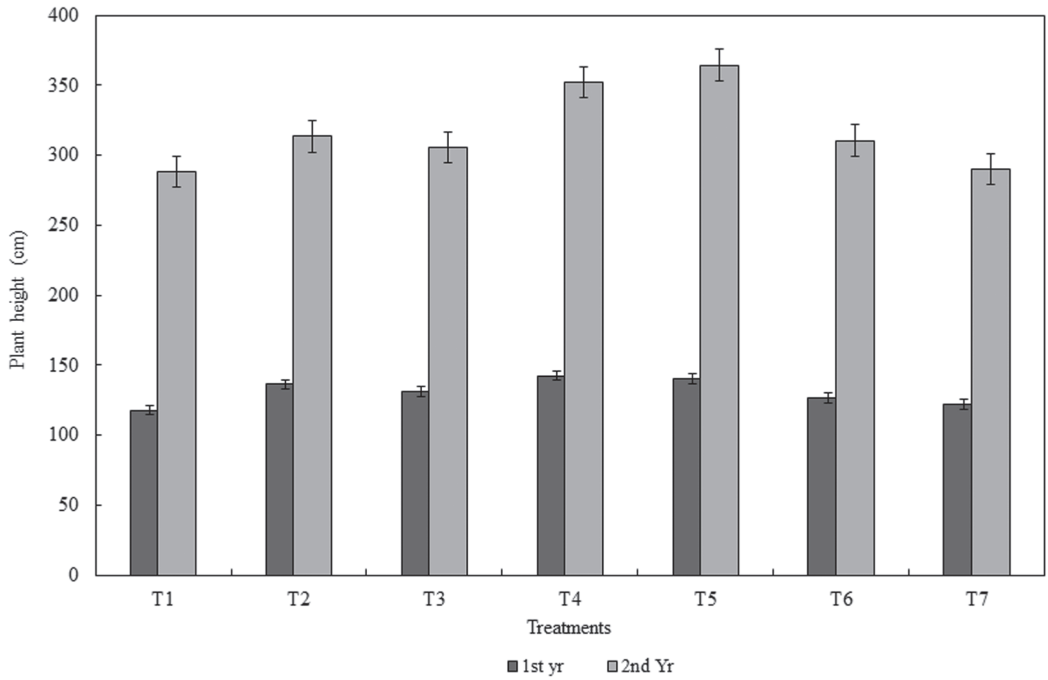

Fig. 1. Effect of integrated nutrient management on plant height

applied along with BI (Fig. 2). The result clearly showed that application of BI alone (T7) was not sufficient to meet the nutrient demand of young rubber plants. From 2013 onwards, application of BI was withdrawn from the treatment combination to see the carry over effects of BI on growth of plants. The data showed (Table 2) a gradual decline in girth of the plants receiving treatment BI along with reduced doses of chemical fertilizers as in treatment T3 to T5 in comparison to treatments T2 and T6. Similar

Table 2. **Effect of integrated nutrient management on girth (cm) of rubber from 3rd year onwards**

Treatments	Girth (cm)				
	Dec-2011	Dec-2012	Dec-2013	Dec-2014	Dec-2015
T1	10.8	15.3	21.9	28.5	35.1
T2	12.1	18.7	27.5	35.3	43.1
T3	11.7	18.1	26.4	34.0	41.3
T4	12.0	19.2	27.9	34.8	42.2
T5	12.1	18.8	27.4	35.1	42.0
T6	12.2	18.9	27.2	35.5	42.8
T7	11.1	16.3	22.4	29.2	36.4
Sem ±	0.6	0.7	0.8	0.8	0.7
CD (P=0.05)	NS	1.9	2.9	2.7	2.5

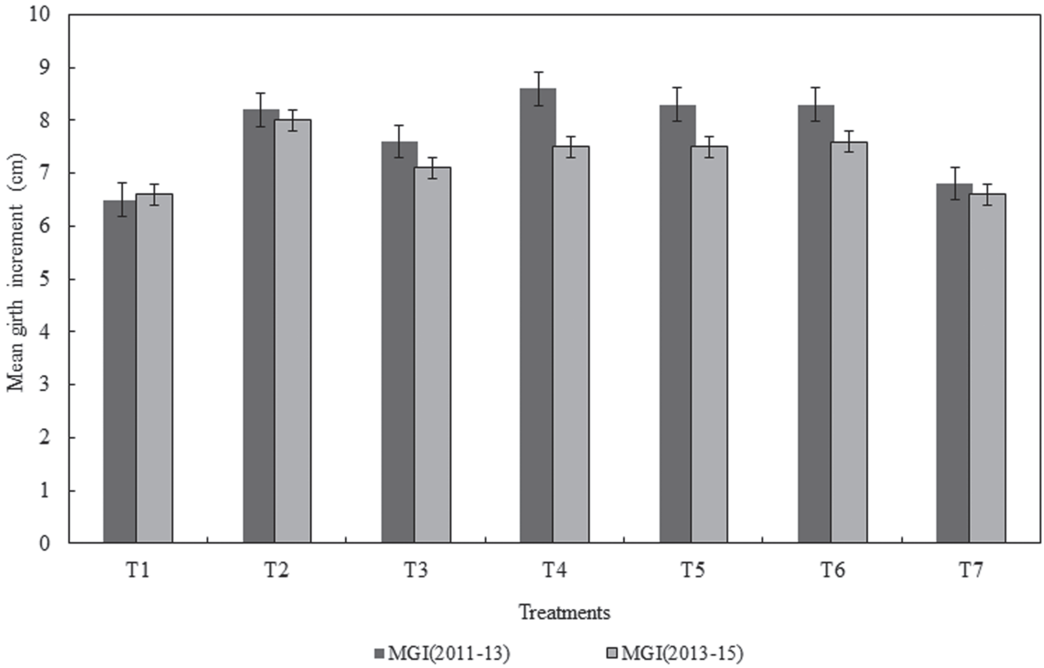

Fig. 2. Effect of integrated nutrient management on mean girth increment (MGI)

trend was observed for girth increment also (Fig. 2). The results suggested that fertilizer use efficiency could be enhanced when it was applied along with BI. Similar observations on improvement of growth were reported by many workers in the traditional rubber growing regions of India also (Syamala *et al*., 2015; Pradeep and Manjappa, 2015a). However, once BI was withdrawn from the treatment combination (T3 to T5), their carry

Table 3. **Effect of integrated nutrient management on nutrient availability in the surface (0-30 cm) soil**

Treatments	pH	OC (%)	Available nutrients (kg ha^{-1})		
			P	K	N
T1	4.24	0.89	0.82	95.8	184.0
T2	4.02	0.92	4.10	142.5	228.6
T3	4.08	0.95	3.67	127.9	222.4
T4	4.11	1.03	3.42	137.7	237.3
T5	4.15	1.02	3.60	119.2	240.6
T6	4.04	0.96	3.96	140.7	231.2
T7	4.22	0.94	1.42	85.3	191.3
SE	0.09	0.12	0.69	9.41	10.1
CD (P= 0.05)	NS	NS	1.72	21.8	27.2

Table 4. **Effect of integrated nutrient management on the availability of secondary and micronutrients in the soil (four year after planting)**

Treatments	Available nutreints (mg kg^{-1})					
	Ca	Mg	Fe	Mn	Cu	Zn
T1	89.2	39.3	108.6	1.16	1.02	0.38
T2	168.3	42.4	96.7	1.29	1.58	0.41
T3	113.6	43.6	93.6	1.05	1.50	0.62
T4	129.3	42.1	100.3	1.21	1.52	0.58
T5	159.6	41.3	77.5	1.23	1.42	0.54
T6	175.3	42.3	88.3	1.33	1.57	0.60
T7	94.6	39.6	101.6	0.97	0.93	0.46
SE	7.15	2.6	10.2	0. 18	0.13	0.12
CD (P= 0.05)	18.6	NS	NS	NS	0.37	NS

over effect on girth began to decline. The data further suggested that, a combination of 50 per cent of standard recommendation of N and P together with recommended dose of K and BI could be a viable alternative to reduce the dose of N and P fertilizers for young NR in this location. In rubber seedlings in nursery, Joseph *et al*. (2015) also reported the same trend.

Influence on soil fertility

Composite soil samples (0-30 cm) were collected under each treatment after four years of plantation and the fertility status is

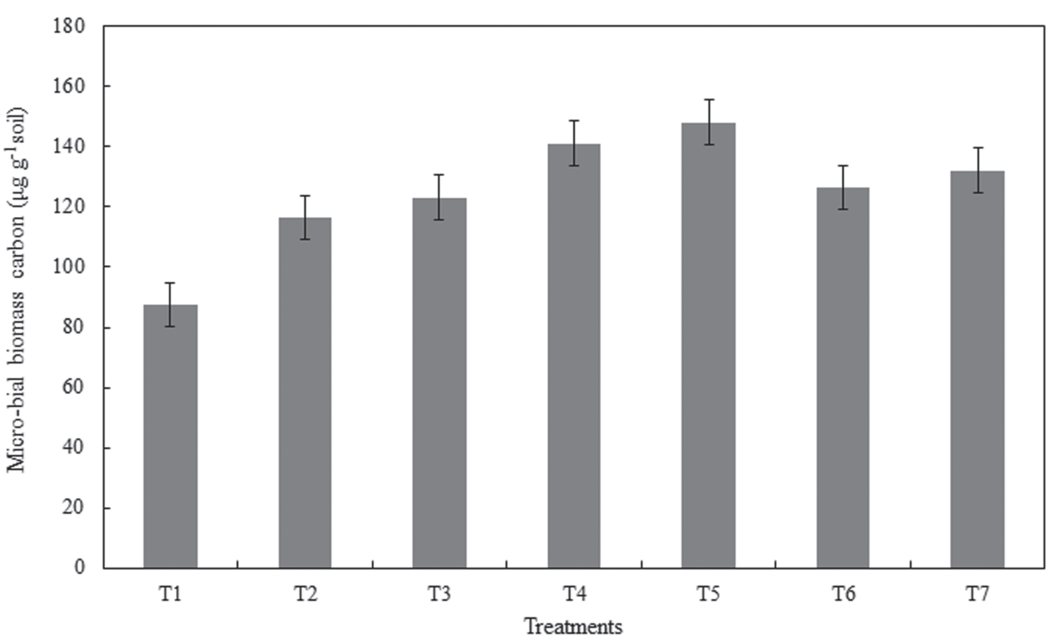

Fig. 3. Effect of integrated nutrient management on microbial biomass carbon

Table 5. **Effect of integrated nutrient management on leaf nutrient concentration (%)**

Treatment	2013			2015		
	N	P	K	N	P	K
T1	2.82	0.16	0.89	2.78	0.17	0.88
T2	3.13	0.22	1.16	3.06	0.21	1.15
T3	2.96	0.18	0.98	2.94	0.19	0.95
T4	3.11	0.21	1.10	3.07	0.20	1.03
T5	3.14	0.22	1.17	3.12	0.21	1.08
T6	3.14	0.21	1.16	3.11	0.21	1.15
T7	2.90	0.18	0.91	2.82	0.18	0.91
SE	0.04	0.009	0.06	0.05	0.015	0.04
CD (P=0.05)	0.11	0.03	0.14	0.12	0.04	0.11

presented in Tables 3 and 4. The soils of all the plots were highly acidic in nature and the pH ranged from 4.0 to 4.2. A decline in soil pH was observed under treatments T2 to T6 and this was more pronounced when full dose of chemical fertilizers were applied either alone (T2) or in combination with BI (T6). However, the decline in soil pH was relatively less when reduced doses of chemical fertilizers (T3, T4 and T5) were added along with BI. Similar result was observed by Orimoloye *et al*. (2010) and Abraham *et al*. (2015). No significant difference in soil organic carbon control (OC) was observed among the treatments, but building up of OC was recorded under treatments T4 and T5 over treatments T6 and T2 where full doses of chemical fertilizers were applied with or without BI. This could be attributed to the accumulation of higher amount of microbial bio-mass under treatments T4 and T5 (Fig. 3). Optimum supply of nutrients and better environment under these two treatments might have lead to proliferation of microbes resulting in increased microbial biomass carbon (MBC) which might have contributed to higher content of OC *vis-a-vis* higher growth of plants. On an average, build-up of OC content to the tune of 6.9 per cent was recorded in these soils under treatments T2 to T6 in comparison to their pretreatment values. Similar trend was reported by Mandal *et al.* (2017).

Though a significant increase in available P was recorded under treatment T2 to T6 in comparison to treatment T1 (control) and T7 (only BI) these values were still well below their critical values. Higher values of P could be due to inclusion of rock phosphate in these treatments. Similarly, significant increase in available K and N was recorded due to imposition of treatments (T2-T6). Build-up of K and N in the treated plots (T2-T6) was to the tune of 32.5 and 20.6 per cent, respectively over control plot. However, availability of K and N was more pronounced under treatment T4 where 50 per cent recommended dose of chemical fertilizers were applied along with BI achieving higher nutrient use efficiency by adopting integrated nutrient management practices. Significant increase in available Ca under treatments T2 to T6 compared to treatments T1 and T7 could be attributed to application of P as rock phosphate. Influence of treatments on soil available Mg was not pronounced. Similarly, effect of treatments on available micro nutrients *viz*. Fe, Mn and Zn was not observed. However, a significant increase in Cu content of soil was observed under these treatments, may be due to the application of rock phosphate (T2-T6) through which Cu is added to the soil. The soil analysis data clearly indicated a positive effect of integrating reduced doses of chemical fertilizers along with microbial consortia in maintaining the soil fertility in this location.

Influence on leaf nutrient concentration

Leaf nutrient status of plants under each treatment was analyzed after 4th year of plantation (2013). Application of BI was withdrawn after 2013 but the carry over effect on leaf nutrient content was tested after two years (2015) when composite leaf samples were collected and analyzed again (Table 5). Data revealed a significant increase in N, P and K contents were in both the regime due to imposition of treatments T2 to T6 in comparison to treatments T1 and T7. Higher leaf N, P and K content was recorded under treatments T4 and T5 though a gradual decline in leaf N, P and K content was observed under the treatments T3 to T5 when BI was withdrawn from the treatment. The leaf nutrient content under T4 and T5 was significantly higher than treatments T1 and T7 and on par with treatments T2 and T6. Therefore, beneficial effect of BI was found continuing even after two years of its withdrawal from the treatment. But, it is pertinent to note that addition of BI alone was not sufficient for enhanced uptake of nutrients.

CONCLUSION

The NR growing soils of North Eastern states of India are poor in fertility status. Therefore, it is expected that NR plants grown in this region should show good response towards fertilizer application. The present study indicated that application of bio-inoculants along with reduced doses of chemical fertilizers as a viable option for better management of young NR plantations grown in this location. This will help to reduce the use of chemical fertilizers besides maintaining the soil fertility at a desired level. However, the result needs to be reconfirmed by conducting more trials in farmer's fields having wide variation in soil fertility status and management practices.

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