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ENHANCING SOIL FERTILITY AND PLANT GROWTH OF IMMATURE RUBBER (*Hevea brasiliensis*) BY THE APPLICATION OF BIOFILM BIOFERTILIZER

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ABSTRACT

Use of biofertilizers in agriculture is considered to be an eco-friendly procedure which is more cost-effective than chemical fertilizers. They are highly advantageous in the enrichment of soil fertility and fulfilling the plant nutrient availability. The aim of this study was to assess the effect of biofertilizer on plant growth, soil and plant nutrient levels of immature rubber. Microorganisms isolated from rubber root rhizosphere were formulated as biofilm biofertilizer (BFBF) under in-vitro conditions. It was applied to immature rubber plants growing in Boralu series soil at a rate of 50%, 75% and 100% of the Rubber Research Institute of Sri Lanka (RRISL) recommended levels of inorganic fertilizers and 100% RRISL recommended fertilizers alone as a control treatment. The growth of rubber plants was monitored by measuring plant diameter throughout the experimental period of 14 months. Major nutrient contents in the leaves and soil samples were determined to assess the nutritional status of the plant and soil. Further soil pH, bulk density (BD), cation exchange capacity (CEC) and organic carbon (OC) was also measured at the end of 14 months period. At 14 months after planting, treatments having 50% recommended fertilizer with BFBF (50% F + BFBF) and 75% recommended fertilizer with BFBF (75% F + BFBF) gave significantly higher plant diameter values compared to recommended fertilizer alone control treatment (100%F). Moreover, significantly higher plant diameter increment in between 3rd and 14th months was observed with the same treatments compared to control treatment (100%F). There were no significant differences could be observed between treatments for major leaf nutrients nitrogen (N), Phosphorus (P), potassium (K) and magnesium (Mg). Soil fertility parameters were measured as soil pH, BD, CEC, and OC also showed the same pattern that could be observed related to leaf nutrients. These conditions could be created that BFBF with reduced amount of fertilizers and control treatment (100%F) gave comparable assessments of plant nutrients and some soil fertility parameters. Furthermore, BFBF applied treatments 50% F + BFBF and 75% F + BFBF showed significantly higher values of available P and BFBF applied treatments 75% F + BFBF and 100% F + BFBF showed significantly higher values of exchangeable K compared to those in control treatment (100%F).

On the above-ground, there is a possibility of using BFBF and reduced amount of inorganic fertilizer as an integrated manner as a substitute for conventional recommended fertilizer application for immature rubber.

Keywords: Biofilm fertilizer, Hevea brasiliensis, Macro nutrients, Plant growth

INTRODUCTION

Application of N, P, K and Mg in a correct proportion is essential to obtain optimum growth during the immature phase of rubber (Yogaratnam *et al.*, 1984) and to attain high yields throughout the mature phase of rubber plants (Samarappuli and Yogaratnam, 1997). Loss of nutrients through erosion, leaching, volatilization, and fixation reduces fertilizer use efficiency and enhances environmental pollution. Therefore, development of a suitable alternative to optimize the use of fertilizers is an essential approach to enhance nutrient availability in soil, increase fertilizer use efficiency and mitigate environmental problems (Li *et al.*, 2015). There are varieties of strategies available to increase fertilizer use efficiency. Biofertilizers are an alternative to mineral fertilizers for increasing soil fertility and plant growth in a sustainable manner (Vessely, 2003; Anderson *et al.*, 1993; Whiting *et al.*, 2001). Therefore, the present study aimed to evaluate the effectiveness of BFBF on the growth of immature rubber plants and soil nutrient availability at field conditions.

MATERIALS AND METHODS

An experiment was laid down at Millawa estate, Horana to study the effectiveness of BFBF on soil fertility, and their influence on the mineral composition of rubber leaves and growth of RRISL 203 *Hevea* genotype. Young budding plants were established in the field and were manured according to the experimental design shown in Table 1. N, P, K and Mg containing fertilizer mixture R/U 12:14:14 and kieserite were applied as 100%, 75% and 50% of the Rubber Research Institute of Sri Lanka (RRISL) recommended inorganic fertilizers for immature rubber with BFBF (T2, T3 & T4) and 100% of recommended inorganic fertilizers for immature rubber was applied as a control treatment (T1). These resulted in 4 treatment combinations (Table 1). Treatments were arranged in a randomized complete block design with five replicates and 25 plants per each replicate. BFBF and inorganic fertilizers were applied at three months intervals as four split applications during the first year. Stem diameter was taken at 15 cm above the ground level of the plant throughout the experimental period. Fourteen months after planting, soil and leaf samples were collected for nutrient analysis and to assess other soil fertility parameters; soil pH, BD, CEC, and OC.

Table 1: Treatment Combinations of the Experiment

Treatment	Design
T1	100%F
T2	100%F+BF
T3	75%F+BF
T4	50%F+BF

100%F = Recommended fertilizer
75%F = 75% of the recommended fertilizer
50%F = 50% of the recommended fertilizer
BFBF = Biofilm fertilizer

Statistical Analysis

Statistical analysis of the experimental data was done by analysis of variance followed by a mean separation procedure, Duncan's Multiple Range test (DMRT), at a probability level of 0.05.

RESULTS

The soil classified as Boralu series (Silva, 1964) is shallow, gravelly loam, brown to reddish yellow in colour and overlying cabook. Pre-treatment soil analysis of the experimental site indicated the following mean values for the: pH 4.8; CEC 2.5 (cmol+/kg); organic carbon 1.5%; available phosphorus 8-10ppm and potassium 125ppm. The assessment of plant diameter gave significantly higher values for 50%F+BFBF and 75%F+BFBF treatments compared to control treatment (100%F) at fourteen months after planting. Similar pattern could be observed with diameter increment (Table 2). Leaf nutrient contents of N, P, K and Mg were tested of the immature *Hevea* plants at fourteen months after commencement of the experiment showed no significant differences in between treatments. Moreover, concentrations of major nutrients were generally within the acceptable level reported by Shorrocks 1965 (Table 3).

Table 2: Effect of Different Fertilizer Applications on Growth of Immature Rubber Plants

Treatments	Diameter (mm)				Diameter increment
	3rd month	6th month	9th month	14th month	
100%F	14.7^{a}	21.1^{a}	31.1^{a}	39.7^{b}	25.0^{b}
100%F+BFBF	15.0^{a}	21.5^{a}	30.6^{a}	40.8^{ab}	25.8^{ab}
75%F+BFBF	14.4^{a}	21.1^{a}	30.4^{a}	42.0^{a}	27.6^{a}
50%F+BFBF	14.8^{a}	21.7^{a}	31.5^{a}	41.6^{a}	26.8^{a}

Values in the same column followed by the same letter are not significantly different at p=0.05.

Table 3: Effect of Different Combination of Fertilizer Applications on Leaf Nutrient Contents of Immature Rubber Plants.

Treatments`	Leaf nutrients contents (%)			
	N	P	K	Mg`
100%F	2.428a	0.218a	0.540a	0.241a
100%F+BFBF	2.438a	0.224a	0.568a	0.251a
75%F+BFBF	2.425a	0.240a	0.578a	0.207a
50%F+BFBF	2.270a	0.224a	0.574a	0.177a

Values in the same column followed by the same letter are not significantly different at p=0.05

Soil fertility parameters were measured as soil pH, BD, CEC and OC also showed same pattern that could be observed related to leaf nutrients. However, BFBF applied soils gave slightly lower BD values, slightly higher OC and CEC values compared to control treatment (100%F). Furthermore, BF applied treatment 75% F + BF showed significantly higher values of available P and exchangeable K compared to those in control treatment (100%F) (Table 4).

Table 4: Effect of Different Fertilizer Application Treatments on pH, BD, OC, CEC, Available P and Exchangeable K Contents of the Top 0-15cm Soil Layer at the End of Fourteen Months after Planting.

Treatments	pH	Bulk density (g/cm3)	Organic Carbon%	Cation Exchange Capacity (cmol+/Kg)	Available P ppm	Exchangeable K ppm
100%F	4.77a	1.404a	0.72a	2.05a	57.53b	17.93b
100%F+BFBF	4.87a	1.41a	0.83a	2.40a	108.5ab	30.33a
75%F+BFBF	4.9a	1.35a	0.95a	2.3a	120a	26.12a
50%F+BFBF	5.04a	1.33a	0.92a	1.89a	135a	24.06ab

Values in the same column followed by the same letter are not significantly different at p=0.05

Quantitative response of inorganic fertilizers to immature field plants with BFBF showed that all the BFBF combinations were found to enhance soil pH, OC, available P and exchangeable K status compared to their non BFBF application control treatment (100%F).

DISCUSSION

Results from the experiment confirmed that the application of BFBF with a reduced amount of recommended fertilizer could produce plants significantly higher in diameter compared to recommended fertilizer application control treatment (100F %) at the end of fourteen months after planting. Improved growth parameters in some of the BFBF treatments could not be observed with N, P, K, Mg status in the leaves of immature rubber plants. However, high growth conditions could be attributed to the improvement of nutrients; available P and exchangeable K levels and other fertility parameters; pH, BD, CEC, and OC in the soil environment. Rubber generally grows well in acidic soils in Sri Lanka. However, extreme pH conditions are not favorable for good performance of rubber trees and stunted growth has been recorded. The effect of soil pH on plant growth is partly through its effects on root function and on soil properties (Samarappuli, 2001). Therefore, increasing soil pH from extremely acidic levels up to some extents is important for sustaining soil fertility in rubber growing soils of Sri Lanka. Also, BFBF applied soils gave slightly lower bulk density values compared with none BFBF control treatment (Table 4). According to the observations of Samarappuli *et al.*, (1992a &1992b) and Samarappuli and Yogaratnum, (1995) the management of ground cover in rubber growing soils help to improve organic carbon content and finally these conditions improved soil physical properties such as bulk density, soil porosity, and moisture retention. Accordingly, the high organic carbon content in BFBF treatments may help in decreasing bulk density compared to non BFBF control treatment (100%F). Several studies conducted so far with the BFBF biofertilizer under laboratory, nursery and field conditions for soybean, mung bean, wheat, rice, anthurium, and tea in Sri Lanka have shown positive results in relation to soil fertility and crop growth (Seneviratne and Jayasinghearachchi, 2005; Seneviratne *et al.*, 2009 and Seneviratne *et al.*, 2011; Seneviratne and Kulasooriya, 2013).

CONCLUSIONS

The study revealed that combined use of BFBF with modified fertilizer levels could enhance plant growth up to their optimum levels with improving some soil nutrient availabilities and enhancing soil fertility. In addition to the restoration of degraded rubber lands contributing to mitigate environmental pollution by reduced amount of inorganic fertilizer application would be a viable solution for achieving the sustainability of rubber plantations in Sri Lanka.

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