Effect of fertilization on latex yield potential and physiological parameters of clone PB 217 in Cambodia

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Abstract

Fertilization is one of the most important factors that affect growth and yield of rubber tree. It takes a high rate of capital investment for plantation. Regulation on fertilizer quantity or/and ratio among fertilizer nutrients results in remarkable economical and technical impacts on the rubber plantation during the immature period. During the mature period, data are still controversial. This experimental study aimed to evaluate the effects of fertilizer on the latex yield and physiological parameters. After four years of experimentation, results showed that fertilization had a positive effect on the cumulative yield (kg.ha^{-1}) by 4% whereas the rubber yield per tree (g.tree^{-1}) increased by 10%. Physiological parameters of latex cells, sucrose, thiols and inorganic phosphorus contents, were slightly increased by the use of fertilization. This positive physiological change in latex sugar loading and in latex metabolism might be related to yield increase after fertilization.

Keywords: rubber, latex, fertilizer, production, physiological parameters

1. Introduction

Rubber tree (*Hevea brasiliensis* Müll. Arg.) is among the major tropical economic tree crops of the world. Originating from the Amazonian tropical rainforests, rubber is intrinsically suitable for climates that are warm and moist throughout the year (Priyadarshan, 2003; Priyadarshan *et al*., 2005). The Association of Natural Rubber Producing Countries (ANRPC) (2010) estimated that from 2003 to 2010 more than 1,500,000 ha of land were converted to rubber in southern China, Thailand, Vietnam, and Cambodia. Increasingly, the loss of community-based resources such as non-timber forest products and agricultural land must be weighed against the economic benefits, as rubber cultivation provides for the livelihoods of smallholders and their workers, together numbering in the millions (Simien and Penot, 2011).
Moreover, some studies reported that fertilizer is one of the most important factors that affect obviously growth and yield of rubber tree, and at the same time, it takes a high rate of capital investment for plantation. Therefore, any regulation and optimization of fertilizer quantity and/or ratio among fertilizer nutrients will result in remarkable economical and technical impacts on the rubber plantation during the immature and mature periods (Ngo Thi Hong Van *et al.*, 2001). Response of rubber tree to fertilizer application depends on its nutrient status. For rubber trees that are nutrient deficient, the effect of fertilizer application could be seen in short time that is one year or less (Ismail, 1981). Manuring recommendation is generally

based mainly on the requirement of macro nutrients N, P, K, and Mg (Adiwiganda *et al*., 1994), while the requirement of micro nutrients is considered small and can usually be satisfied by the soil. The role of micro nutrient gets less attention on rubber trees (Yogaratnam and Perera, 1985). Our research is motivated by the fact that fertilizer application can sometimes improve latex yields up to 15-30% (Adiwiganda *et al.,* 1994). The effects of combined intensification and fertilization are often observed below +10% when compared to the production of the unfertilized control and therefore hardly statistically significant at a 5% risk (Gohet *et al*. 2013). To improve the understanding of the potential impacts of fertilizer on rubber yield, the objectives of this study were to determine effect of fertilizer on latex yield and physiological parameters.

2. Materials and Methods

The experimental site is located in the Cambodian Rubber Research Institute (CRRI). The experimental rubber plantation is on a level plain set in red basaltic latosols. The soil texture is clay with about 8.37% fine sand, 10.12% coarse silt, 19.5% fine silt, 7.35% coarse sand and 55.1% clay. The climate is governed by the Asian monsoon, which produces two distinct seasons: a wet season (approximately May–October) and a dry season (approximately November–April). Annual precipitation in 2010 to 2015 was 1247, 1511, 1745, 1467, 1726 and 1225 mm, respectively. Rainy seasons extended from late-May to late-November in 2010, and late-April to mid-November in 2011. The mean annual temperature was significantly higher in 2013 (28.2◦C) follow by 2010 (28.1◦C), 2015 (28.0◦C), 2012 (27.9◦C), 2014 (27.6◦C) than in 2011(27.2◦C). Rubber trees, clone PB 217 were planted in 2004 using a regular spacing of 6 m in north-south direction and 3 m in east–west direction, resulting in a potential tree density of 555 trees ha^{-1}. Latex tapping was initiated in November, 2010. The experiment was arranged in randomized block design with 4 treatments and 4 replications with 80 trees per plot. The experiment was conducted from the first year of tapping until fourth year. During the immature period fertilizers were applied two times per year, in May and October during 4 years. The formula was NPK 15-15-15 with 200 g per tree the two first years, with 300 g per tree in year 3 and with 400 g per tree in year 4. During the mature period the same NPK fertilizer formula was applied with different doses according to the treatment given in Table 1. The soil carbon (C) was analyzed by Black method, soil nitrogen (N) was analyzed by Kjeldalh method, soil P available was analyzed by Olsen method and soil exchangeable base K was analyzed by flame spectrophotometer and atomic absorption spectrophotometer (Black, C.A.,1965). Tapping system was S/2 d3 7d/7 ET 2.5% Pa 1(1) 10/y (half spiral cut, tapped downward every 3 days with ethephon stimulation (2.5% active ingredient, application 1 g/tree, ten times per year at monthly interval (Vijayakumar *et al*., 2009). Daily fresh latex of each replication per treatment was weighed. Cup-lumps were collected then weighed the day after. The yield was calculated every month in total of kilogram of each replication. Dry rubber content of latex from each block was determined every week. Dry rubber content of cup lumps was measured in a bulk in each treatment in order to convert yields in grams of dry rubber per tree. The girth of the trees was measured at 1.70 m above ground level every year in wintering season. The main latex biochemical parameters, i.e. sucrose (Suc) and inorganic phosphorus (Pi) contents, were measured tree by tree (10 trees per treatment) each year between September and November using methods developed by CIRAD and CNRA (Jacob *et al*., 1995).

Table 1. Treatments of fertilizer application during mature period (in $g.tree^{-1}.year^{-1}$)

No	Treatments
T0 (Control)	0
T1	330
T2	600
T3	1200

3. Results

Soil nutrient contents before the implementation of treatment are shown in Table 2.

Table 2. The soil nutrient content before tapping

Parameter	pH (H_2O)	C	N	P available	K	C/N ratio
		%	%	ppm	meq/100 g	
Value	4.7	2.06	0.175	175.5	0.51	12

Girth measurements

The rubber girths of all treatments were comparable at opening of tapping (Table 3). The rubber girth increments in T2 treatment (6.3 cm) was slightly higher after 4 years of planting than T0 (5.9 cm), T1 (5.3 cm) and T3 (5.2 cm) treatments.

Table 3. Annual girth and girth increments in mature period (cm) from year 1 (G1) to year 4 (G4).

Treatments	Girth					Increment
	Opening	G1	G2	G3	G4	
T0	49.7	50.2	52.7	53.4	55.7	5.9
T1	49.6	50.1	52.5	53.3	54.9	5.3
T2	49.2	50.1	52.7	53.8	55.5	6.3
T3	50.0	50.7	52.9	53.2	55.2	5.2

Yield measurement

After 4 years of tapping, highest yield in gram per tree ($g.tree^{-1}$) was obtained by +10% compared to the control with treatment T3, the highest rate of fertilizers (Table 4). The yield ($g.tree^{-1}$) in the first year was not significantly different among treatments. In second and third years of tapping, the yield was significantly different with a positive effect on yield of treatment T3. In third year, the yield of T3 treatment was significantly higher than that treatment T0, but it was not significantly different with treatments T1 and T2. In fourth year, the yield of all treatments was not significantly different among treatments.

Table 4. Annual latex production from year 1 (Y1) to year 4 (Y4) and cumulative of 4 years ($g.tree^{-1}$)

Fertilizer treatments	Y1	Y2	Y3	Y4	Cumulated	% Control
T0	4501	4562 b	5083 b	4480	18626	100%
T1	4571	4802 b	5371 ab	4678	19422	104%
T2	4463	4821 b	5376 ab	4667	19327	104%
T3	4663	5274 a	5907 a	4722	20566	110%
F obs	0.549	6.237	3.277	0.331		
Prob	0.661	0.014	0.073	0.803		

Letters indicate significant difference at $p < 0.05$

Rubber annual and cumulated yields in $kg.ha^{-1}$ are presented in Table 5. The annual yield in the first year of all treatments was not significantly different among treatments. In second year, the yield was significantly different: higher the fertilization rate, higher the yield, especially for the treatment T3. The yield of T0 treatment (without fertilizer application) was lower than that of treatment T3 treatment but it was not significantly different with T1 and T2. In third year, the yield of T3 treatment was the highest compared with other treatments. In fourth year, there was no significant difference in the yield among treatments. The cumulated yield after 4 years of tapping was only 4% more only with treatment T3. This difference between the effect of fertilizers on $g.tree^{-1}$ and $kg.ha^{-1}$ comes from the difference in the number of tapped per hectare: T0 (466 $trees.ha^{-1}$), T1 (445 $trees.ha^{-1}$), T2 (447 $trees.ha^{-1}$) and T3 (440 $trees.ha^{-1}$).

Table 5. Annual latex production from year 1(Y1) to year 4 (Y4) and cumulative of 4 years ($kg.ha^{-1}$)

Treatments	Y1	Y2	Y3	Y4	Cumulated	% Control
T0	2079	2138 b	2336 c	2076	8629	100%
T1	2035	2180 ab	2371 bc	2086	8672	100%
T2	2025	2195 ab	2425 b	2093	8738	101%
T3	1994	2286 a	2599 a	2078	8957	104%
F obs	0.732	2.858	22.531	0.054		
Prob	0.558	0.097	0.000	0.982		

Letters indicate significant difference at $p < 0.05$

Latex physiological parameters measurements

In average, after 4 years of experiment, latex physiological profile was slightly improved by fertilization when compared to the control treatment ((Table 6). Although a slightly higher production, latex Sucrose (Suc) content was slightly increased, as well as Pi and R-SH contents. It seems that fertilization application tends to have a significant positive effect on physiological characteristics of the latex cells driven by latex diagnosis analysis, although this difference is not significant.

Table 6. Latex physiological parameters

Fertilizer treatments	Parameters			
	Suc	R-SH	Pi	ExS
T0	3.6	0.20	25.53	49.81
T1	4.0	0.26	25.60	46.80
T2	4.1	0.24	23.22	49.14
T3	4.0	0.24	26.98	50.26

4. Discussion and conclusiouon

After four years of fertilizer application, the treatment with fertilizer did not show significant difference in rubber yield (gram.tree^{-1}), but could be increased by 10%. These results confirm previous results shown by Lalami (2000): rubber yields could be increased by 15-20% and Gohet *et al*. (2013). In our study we have seen a difference between the productions, either expressed in g/tree^{-1} or in kg.ha^{-1}. The rubber yield (kg.ha^{-1}) was not significantly different with all fertilizer treatments and was increased only by 4% with the use of fertilizers. This might be due to the direct effect of the number of tapped tree in the treatments. The treatment T3 showed less number tapped trees compared to T0 treatment. According to some authors (Lalani, 2000) the increase in yield due to fertilizer application could be a direct effect or mediated through the effect on other factors such as girthing, growth of bark, bark renewal, canopy maintenance etc. but in our condition, four years after fertilization, the average girth of rubber trees was similar (Noulsri *et al*., 1991). Any significant effect of fertilizers was seen on physiological parameters. Gohet *et al*. (2013) showed that latex sucrose latex Pi and latex R-SH contents were increased significantly after fertilizer application compared to the control treatment (normal stimulation without fertilization) and suggested that this improvement of latex physiological condition after fertilization could be the main driver of the effect of fertilizer on latex production.

In our local conditions of experimentations, based on 4 years experimental research, it can be concluded that fertilizer application will increase the yield (kg.ha^{-1}) by 4% and the yield per tree (g.tree^{-1}) by 10%. Nevertheless, an improvement of plot yield potentials by 5 to 10% may be highly economically interesting for planters, depending on rubber prices and fertilization associated costs, and may be the ultimate way to maximize plot productivity (Gohet *et al*., 2013).

5. Reference

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