Possible Reasons for Growth Variation among Immature Plants of *Hevea brasiliensis* Clone RRIC 121

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ABSTRACT

In immature rubber clearings a growth variation among plants of similar age and clone is evident. This study was carried out to establish same and identify possible reasons for it. Three RRIC 121 clearings of different ages were identified and from each around 200 trees were randomly selected for the study. Growth variation among the plants selected for the study was established by measuring the girth of plants at a height of 120 cm from the union. Growth variations were apparent and were more prominent in the relatively older clearings. In each clearing the ten lowest (LPP) and highest (HPP) performing plants were selected to identify reasons for growth variation despite of similar age and clone. Soil physiographic and chemical properties were studied in the micro environment in both LPP and HPP. Data were analyzed using a T test. The results revealed that soil nutrients to be relatively less in the micro environment of LPP. Based on the results, strategies for minimizing the number of LPP in clearings are proposed.

KEYWORDS: Clones, Growth variation, *Hevea brasiliensis*, Soil chemical properties, Soil physiography

INTRODUCTION

Rubber (*Hevea brasiliensis)* is one of the major plantation crops grown in Sri Lanka. It is commercially cultivated in areas belonging to several agro ecological regions of the country. Apart from the major rubber growing area, i.e. Low country wet zone, rubber is also planted in the intermediate zones of low, mid and up country (Tillakaratne and Nugawela, 2001).

In Sri Lanka, the total rubber production and the cultivated extent were 157.9 Mn kg and 127,000 ha respectively during the year 2011 (Central Bank Annual Report, 2011). Further, each year around 2,850 and 1,500 ha are re and newly planted in the country. Among the different clones planted, RRIC 121 is given very high priority by the growers due to its relatively high growth vigor and yield. Hence, this particular clone was selected for this study.

Though the tolerance to *Oidium* and *Phytopthora* leaf diseases are below average, the girth increment before and after tapping is reported to be above average in clone RRIC 121. It is also reported that after the third year of tapping, clone RRIC 121 is capable of giving an average yield of over 3500 kg/ha/yr (Tillakaratne and Nugawela, 2001). Due to these positive features of this clone it is currently planted widely exceeding the recommended extents.

Immature stage of a rubber plantation is defined as the period from field planting upto the commencement of harvesting. Correct agro-management is very important to obtain rubber plantations with optimum stand per hectare, tree growth and also land productivity.

Growth is generally defined as an irreversible increase in size of whole or part of an organism. The rubber plant increases its height and girth during its growth. Though the plantation sector of the country has the potential to use high quality planting material and good agricultural practices, growth variation among the plants of similar age and clone can be seen. This leads to sub optimal stand/hectare, tree growth leading to extended uneconomical period and poor land productivity in rubber plantations. Since this is an issue to the growers as well as the country studies to find solutions are needed. The objective of this study was to determine the extent of this problem and to find possible causes for it.

Soil physiographic features such as slope, depth, rock out crop, and chemical properties, i.e. N, P, K, Mg, soil pH, organic carbon (OC) and cation exchange capacity (CEC) are some factors that could be responsible for growth variation in immature rubber plants. For optimum growth and productivity of rubber, both soil physical and chemical aspects need to be present (Samarappuli, 2000).

The outcome of this study will provide information on causes for growth variation in immature rubber plantations. Such knowledge will be helpful to identify strategies to optimize plant growth leading to enhanced land productivity and profitability.

MATERIALS AND METHODS

Location

The study was carried out at Muwankande estate Mawathagama, Kurunegala during the period January to March 2013.

Experimental Area

Three different immature rubber clearings of clone RRIC 121, established in years 2011 (age 20 months), 2010 (age 32 months) and 2008 (age 51 months) were selected for the study.

Collection of Data

From each of the three clearings identified for the study, an area of about 2 ha (consisting of about 1000 plants) was demarcated in the field to collect relevant data. Two hundred plants were selected randomly from each of the three demarcated areas and the girth of these plants was measured at a height of 120 cm from the bud union. In each of the three clearings, the number of plants falling into the girth classes 6 to 10 cm, 11 to 15 cm, 16 to 20 cm, 21 to 25 cm, 26 to 30 cm, 31 to 35 cm, 36 to 40 cm, 41 to 45 cm, 46 to 50 cm and 51 to 55 cm were counted. Thereafter in the individual clearings the percentage number of plants in each girth category was calculated.

Further, from each clearing the ten poorest (LPP) and the ten highest (HPP) performing plants were selected to study factors responsible for the growth variation. Each of these trees selected from the microenvironment the following, soil physiographic and chemical properties were studied.

Physiographic Properties

Slope of Land

Two 1 m height poles were placed 1 m from the base of the plant along the slope. A 1 cm diameter transparent polythene pipe filled with water was held to the poles and the water columns were leveled (Figure 1). The distances x and AB were measured and the slope of land was calculated using the following formula.

$\tan \varnothing = (100-x)/AB$

Depth of Soil

A 2.5 cm diameter hole was made 1m away from the base of the plant using a crow bar. A steel rod with 1m marked on it was inserted into the hole to check whether the depth is less than 1m.

Rock Out Crop

Rock out crop in the vicinity of the tree was visually observed and ranked as low, moderate and high subjectively.

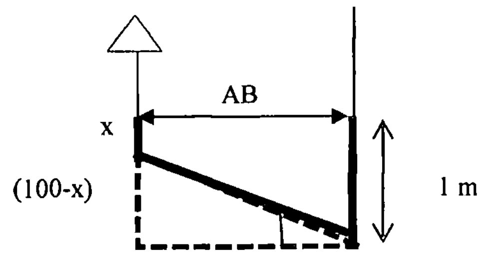

Figure 1. Slope measurement layout

Chemical Properties

From each plant a soil sample of about 500 g was collected from a depth of 0-15 cm, 1 m away from the plant base (Orimoloye *et al.*, 2010). Large soil lumps if any were broken into fine particles. Each of the ten LPP and the ten HPP were grouped randomly into three with each group having a minimum of three plants. Soil samples collected from plants representing each group were bulked and mixed thoroughly. From the bulk a 500 g composite soil sample was collected to a polythene bag and sealed. The resulting six soil samples for each clearing, i.e. Three from LPP and three from HPP were analyzed for soil chemical properties such as, i.e. N, P, K, Mg, Ca, soil pH, organic carbon and cation exchange capacity at the soil and plant nutrition department of the Coconut Research Institute of Sri Lanka.

Soil samples were labeled 2008 SL_1, 2008 SL_2, 2008 SL_3, 2008 SH_1, 2008 SH_2 ,2008 SH_3, 2010 SL_1, 2010 SL_2, 2010 SL_3, 2010 SH_1, 2010 SH_2, 2010 SH_3, 2011 SL_1, 2011 SL_2, 2011 SL_3, 2011 SH_1, 2011 SH_2 and 2011 SH_3. The sample number represented the planting year of clearing, whether it's low (L) or high (H) growing and the sample number.

Statistical Analysis

The soil chemical data were statistically analyzed by performing a two Sample T test.

RESULTS AND DISCUSSION

Based on their girth the randomly selected plants of each of the 3 clearings selected for the study was categorized into girth classes as follows (Table 1).

Table 1. Girth classes and percentage of trees in each girth class in the 3 clearings selected for study

Girth class (cm)	Clearings and the percentage of total plants		
	2011	2010	2008
6-10	1.5	-	-
11-15	28.5	1.0	-
16-20	65.0	9.5	-
21-25	5.0	43.8	2.5
26-30	-	40.3	3.4
31-35	-	5.5	15.3
36-40	-	-	27.2
41-45	-	-	34.6
46-50	-	-	13.8
51-55	-	-	3.0

The girth data shows that the variation in girth is highest in the 2008 clearing whilst it is lowest in the 2011. Hence, it is evident that the variation in girth in a clearing increases with its age. Since the clone is the same this behavior could be due to the relatively higher impact of the environment with the increasing age of the clearing.

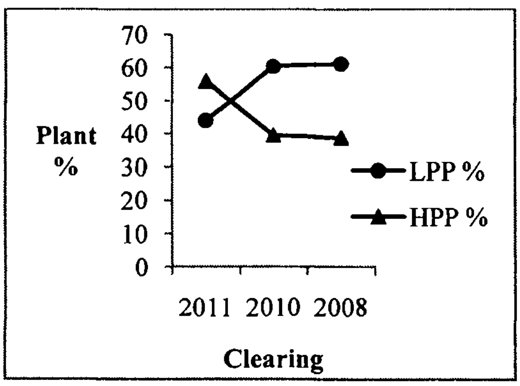

Figure 2. Relationship between percentage LPP, HPP and the age of clearing

A rubber tree is tapped when it reaches a girth of 50 cm at a height of 120 cm from the bud union. The clone RRIC 121 has the genetic potential to reach this girth in 5 years. Hence the average growth rate per year and a month should be 10 and 0.83 cm respectively. Accordingly, in the clearings selected for the study the potential girth of a tree is given in Table 2.

Table 2. Age and potential girth of a tree in the clearings selected for the study

Clearing	Age (months)	Potential girth (cm)
2011	20	16.7
2010	32	26.6
2008	51	42.5

But from the girth data gathered, it is evident that only around 39, 40 and 56% of trees in 2008, 2010 and 2011 clearings have reached the potential girth, i.e. high performing plants (Figure 2). It is also apparent that, there is a trend of high performing trees declining with the age of the clearing. This will result in a longer immature period leading to a high capital cost. For the 2008 clearing to be tappable the present 36 cm girth trees should also reach a girth of 50 cm. At the current average growth rate of these plants for the 36 cm girth trees to reach girth of 50 cm, it will take a further 20 months. Accordingly, the total immature period of the 2008 clearing will be around 71 months. This is about 11 months longer than the expected 60 months of immature period. This study also attempts to identify the possible reasons for the underperformance of some plants in rubber clearings.

It is evident that the soil physiographic features such as slope, rockiness, soil depth have no influence on the growth of the plants (Table 3). However, the slope varied only between 0 to 19 degrees in the area selected for study. It is also reported that slopes up to 26% are favorable for the growth of rubber (Mathew and Sethuraj, 1992). In the selected fields for the study, the other soil physiographic features, i.e. soil depth and rockiness were in the favorable range and therefore may not have shown a negative influence on the growth of rubber plants.

Table 3. Relationship between girth and Soil physiographic features

Clearing	Performance	Girth (cm)	Slope (degrees)	ROC	depth (cm)
2008	Low	26.91	7	L	100
	High	49.62	12	L	100
2010	Low	17.63	10	M	100
	High	32.15	9	M	100
2011	Low	12.1	12	M	100
	High	21.35	19	M	100

ROC-Rock Out Crop L: Low M: Medium

The chemical analysis done on the soil sampled from the micro environment of high and low performing plants revealed that all macro nutrients, i.e. N, P, K, Mg and Ca were at a relatively high level among the high performing trees (Table 4). Therefore it may be that the relatively low levels of macro nutrients in the micro environment would have resulted in a relatively low growth rate in these plants. Either the inherent soil chemical properties or poor management practices such as not fertilizing, incorrect method of fertilizer application, not adding the recommended quantities of fertilizer for some plants may have resulted in low macro nutrient levels. In rubber plantations it is generally observed that trees located in areas convenient for supervising are generally healthy. Therefore, the management practices need to be high standard throughout a plantation to achieve high and uniform growth of the plants.

From the soil analysis it is also evident that the soil organic carbon (OC) and the cation exchange capacity (CEC) are relatively more favorable in the micro environment of high performing trees (Table 5). Such properties help in retaining nutrients in the soil for a prolonged period making them more available to the plant. Soil pH varied from 4.87 to 5.22. It is reported that rubber plants grow satisfactorily in the soil pH range of 4.5 to 7.

Table 5. The impact of soil OC, CEC and pH on plant growth

clearing	Performance	pH 1:5w/w	OC (%)	CEC Meq/100 g
2011	L	5.02	1.096	16.16
	H	4.99	1.363	21.98
2010	L	4.91	0.903	15.1
	H	5.06	1.146	16.42
2008	L	5.22	0.95	14.2
	H	4.87	1.056	15.3

L:Low H:High

However the statistical analysis carried on the above data indicate that the differences in macro nutrient levels between the LPP and HPP are statistically not significant (Table 6). This may be due to low number of soil samples tested and the high level of variation evident in the nutrient levels. The limited time period and resources compelled to restrict the number of soil samples tested in this study. Therefore the study needs to be repeated using adequate number of soil samples to arrive firm conclusions.

Table 6. Statistical Analysis of soil data

Two sample T test	T value	P value
N	1.52	0.151
P	- 1.13	0.284
K	1.01	0.326
Mg	0.84	0.414
Ca	- 0.39	0.707
OC	1.18	0.255
CEC	1.16	0.265
pH	- 0.89	0.389

Table 4. The impact of N, P, K, Mg and Ca on the growth of rubber plants

Clearing	Performance	N (mg/kg)	P (mg/kg)	K (meq/100 g)	Mg (meq/100 g)	Ca (meq/100 g)
2011	L	761.3	4.275	0.346	0.415	0.863
	H	1011.33	4.35	0.394	0.685	1.584
2010	L	565.33	6.075	0.226	0.441	0.737
	H	1256	8.11	0.266	0.481	0.779
2008	L	601.3	10.48	0.258	0.726	1.16
	H	683	11.72	0.303	0.737	1.513

CONCLUSIONS

A significant growth variation was found among the plants in the rubber clearings studied. The percentage of poor performing plants also increased with the age of the clearing. There was a tendency for soil macro nutrients to be relatively less in the micro environment of poor performing plants. This may be due to lapses in management practices and it needs to be confirmed using further studies. A high level of agro management is needed to raise rubber clearings to achieve potential benefits.

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