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Exploitation Systems for Some *Hevea brasiliensis* Muell. Arg. Clones for Improved Economic Performance

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ABSTRACT. *The long immature period of rubber and shortage of skilled tappers are some issues affecting the profitability of both smallholdings and plantations. In this study, the possibility of tapping some clones at a relatively early growth stage was tested. Three tapping systems were tested in trees tapped at recommended girth, G_{20} and at relatively lower girth levels, G_{16} and G_{18}.*

RRIC 102, RRIC 121 and RRISL 211 clearings with 60% of the trees having reached a girth of 40 cm were selected for the study. Out of the G_{16} trees selected, one sample of trees (G_{16}) were tapped immedediately, whilst other two samples were tapped when they reached 45 cm (G_{18}) and 50 cm (G_{20}) growth stages.

Annual dry rubber yield per tree was comparable in low frequency tapping (LFT) with stimulation and in the 1/2S d/2 conventional system in the clone RRIC 121 amongst the three clones tested. Comparable yields with lesser number of tappings through LFT, leads to lower tapping cost and bark consumption rate. Studies, on yield determining parameters indicated that a high yield per tree per tapping with LFT, was mainly due to reduced plugging index. Yields have increased with increase in girth and this is more prominent in the highest yielding clone RRISL 211. Further, commencing of tapping at early growth stages has reduced post-tapping growth in all clones tested. Effects of early tapping of some clones using LFT with stimulation involves a trade off between the long-term income levels and early receipt of income.

INTRODUCTION

Rubber (*Hevea brasiliensis* Muell. Arg.) is economically important mainly because of its latex, found in the latex vessels of the plant. Latex, which contains around 30-40% rubber, is harvested from the main trunk of the plant by systematic tapping of its bark. Tapping is an important agronomic practice determining the productivity of rubber plantations and smallholdings (Wimalarathna, 1973). The actual rubber yield in each tapping depends on clone, age of the tree, the tapping system, stimulation and the depth,

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slope and length of tapping cut (Lee and Tan, 1979). The main yield determining parameters are initial flow rate, plugging index, length of tapping cut and dry rubber content (Sethuraj, 1981).

Latex yields can also be increased by the correct use of yield stimulants, such as, Ethrel (Boatman, 1966). Stimulation introduces flexibility into tapping and labour use in this activity may be reduced with the use of it. Tapping technique adopted should be capable of giving highest biologically possible yields for a longest possible period (Peries and Fernando, 1983).

Rubber trees can be regarded as tappable with continuous excision method, once they attain a girth of 50 cm, measured at height of 120 cm from the highest point of the union. Trunk girth is an important growth parameter in experiments with rubber due to its significant correlation with the yield of the tree (Narayan and Chai Yee, 1970). Even though, high yielding clones are recommended to the industry to realize the full potential of the high yielding clones, it is important that both clones and tapping systems are correctly adopted. In Sri Lanka, the widely recommended exploitation system for the currently recommended clones is half-spiral alternate daily tapping (1/2S d/2). Anyhow, this system results in a high tapper requirement. Rubber industry in Sri Lanka is currently experiencing a problem of shortage of tappers.

Hence the potential yield from 1/2S d/2 system is not harvested in the majority of plantations and smallholdings due to 20% of vacant blocks and about 28% of unskilled tappers (Nugawela, 1998). Use of unskilled tappers to overcome tapper shortage results in immediate and long-term crop losses.

There is no one tapping system that will give the best results on all cultivars and under all conditions. In times of low rubber prices and high wages, the yield per tapper is of greater importance than the yield per unit land area. Hence, tapping systems which give a high yield per unit of labour are of considerable economic importance (Nayagam *et al.*, 1993). Tapping cost is the largest single item in the cost of production (Westgarth and Narayan, 1964). Because of these economic considerations, it is important to obtain as high a yield as possible with as few as possible tappings.

Girth forms the best and most practicable criterion to determine tappability (Girst and Menz, 1995). If tapping of rubber trees can be commenced at a lower girth than practiced currently, it will enable the grower to earn an income earlier while reducing immature costs. Previous studies show that, commencing tapping at a lower girth results in relatively lesser yields. Nevertheless, in these trials trees of different girths were selected simultaneously from a clearing. Therefore, relatively lesser yields in lower girth trees may have been due to differences in growth and vigour. Generally, the dry rubber yield (gram per tree per tapping) increases with increase in girth class within a clone. Trees that reach a higher girth class later, yield less than that reached the same girth earlier (Anon, 1999). In the light of this situation, the present study was undertaken to investigate optimum tapping regimes to harvest maximum dry rubber yields from some clones while reducing the immature period, tapping cost, tapper requirement and physical injury to the plant.

MATERIALS AND METHODS

Experimental area and clones used

Hevea brasiliensis plants of genotypes RRIC 121 (recently developed), RRIC 102 and RRISL 211 (widely grown) planted in 1995 at Dartonfield group, Rubber Research Institute, Agalawatta was selected for the study. The climate of this region is characterized by a mean monthly temperature of 22-31°C, ample rainfall round the year with no marked dry periods, high ambient humidity (88%), moderate wind and bright sunshine. This region is located in the agroecological zone WL_1. The soil is silty clay loam in texture and strong brown to yellowish red in colour (Red Yellow Podzol).

Tapping treatments

Tapping in each of the clearing, of all three clones was commenced when 60% of trees reached a girth of 40 cm measured at height of 120 cm from the union. For the study 100 such trees were selected from each clone and each of the 100 trees were grouped into 4 with 3 groups having 30 trees each and the other with 10 trees. Tapping was commenced immediately in the first group having 30 trees in all three clones. Rest of the 30 tree groups of each clone were tapped when 60% of trees reached a girth of 45 and 50 cm at 120 cm from the union. The 10 tree group of each clone remained untapped.

Thirty trees selected from each clone for commencement of tapping at different girths were randomly separated into 3 sub groups with each sub group having 10 trees. For each sub-group the one of the following treatments were introduced randomly on a single tree plot design. Treatments were 1/2S d/2 (T1); 1/2S d/3 (T2) and 1/2S d/3 + E (T3).

Measurements

During the period of study, after each tapping the latex was collected into the cups. Once latex flow stopped, after each tapping, the latex volume was measured using a measuring cylinder, separately for each tree. Initial flow rate was determined by measuring the latex volume, during the first five minuets after tapping and dividing it by the time period, *i.e.*, 5 min. The dry rubber yield from a tree per tapping was determined by the volume of latex and the percentage of rubber it contains at each and every tapping. The mean annual dry rubber yield per tree per tapping was multiplied by the number of tappings per year to calculate yield per tree per annum (kg t^{-1} yr^{-1}). At monthly intervals, the yield determining parameters, such as, plugging index, dry rubber content and initial flow rate were monitored. Once in three months, measurements were taken on girth and incidence of tapping panel dryness. Annually, bark consumption (cm), bark thickness (cm) and length of the tapping (cm) cut were measured. At the end of each quarter, the trunk girth was measured at a height of 150 cm from the highest point of the union in each tree of each treatment.

The plugging index is a measure of the rate of plugging of latex vessels and is therefore a measure of the time over which latex will flow after commencement of tapping. The plugging index was determined by using the following formula, described by Milford *et al.* (1969).

$$Plugging\ index = \frac{Mean\ flow\ rate\ (ml\ \mathrm{min}^{-1})\ during\ the\ first\ five\ \mathrm{min}\ after\ tapping}{Tota\ latex\ volume\ (ml)}$$

Analysis of variance (ANOVA) of the measured data was carried out using the SAS statistical package.

RESULTS AND DISCUSSION

Data obtained during the first year after introducing the tapping treatments for different girth classes and clones selected for the study are presented in this paper. Analysis of variance revealed that the two-way and three-way interactions between the three treatment factors were not significant at $p>0.05$.

Dry rubber yield per tree per tapping

In all clones tested, yield per tree per tapping ($g\ t^{-1}\ t^{-1}$) increased with girth. Yield of G_{16} trees were the lowest in all three clones tested. Highest dry rubber yield was given by G_{20} trees in all clones tested. Among different tapping system low frequency tapping with stimulation performed better in trees opened at G_{16} in all three clones. At higher girth classes such differences were more prominent in clone RRIC 121 (Table 1).

Dry rubber yield per tree per annum

Dry rubber yield per tree per annum increases with increasing girth in all clones. 1/2S d/2 and low frequency tapping (LFT) with stimulation have given similar dry rubber yields per tree per annum at lower girth classes, *i.e.*, G_{16} and G_{18}. Nevertheless, at G_{20} this trend is found only in RRIC 121 (Table 2).

Cost of tapping

It is apparent that the yield levels achieved from 1/2S d/2 conventional tapping system, can be harvested with a lower tapping cost by adopting low frequency tapping with stimulation, *i.e.*, 1/2S d/3 + E. Amongst the three clones tested RRISL 211 shows the lowest tapping cost. Further, commencing tapping at higher girth has also resulted in a lower tapping cost (Table 3).

Table 1. Effect of different tapping systems at different girths on yield per tree per tapping (g t^{-1} t^{-1}) in clones RRIC 102, RRIC 121 and RRISL 211.

Clone	Tapping treatments	Yield (g t^{-1} t^{-1})		
		G_{16}	G_{18}	G_{20}
RRIC 102	T_1	6.875[b]	12.192[b]	17.554[b]
	T_2	8.884[a]	13.855[b]	23.155[a]
	T_3	10.394[a]	17.914[a]	22.606[a]
RRIC 121	T_1	6.240[b]	14.305[b]	22.727[b]
	T_2	6.933[b]	13.231[b]	23.440[b]
	T_3	10.253[a]	19.435[a]	37.534[a]
RRISL 211	T_1	13.782[b]	25.308[a]	33.103[a]
	T_2	16.248[ab]	29.377[a]	32.158[a]
	T_3	19.852[a]	27.088[a]	32.577[a]

Means of each category with the same letter are not significantly different at P>0.05.

Table 2. Effect of different tapping systems at different girths on total dry rubber yield per tree per annum of clones RRIC 102, RRIC 121 and RRISL 211.

Clone	Tapping treatments	Yield (kg t^{-1} $annum^{-1}$)		
		G_{16}	G_{18}	G_{20}
RRIC 102	T_1	1.189	2.109	3.036
	T_2	1.003	1.565	2.616
	T_3	1.174	2.024	2.554
RRIC 121	T_1	1.079	2.474	3.931
	T_2	0.783	1.495	2.648
	T_3	1.158	2.196	4.241
RRISL 211	T_1	2.384	4.378	5.726
	T_2	1.836	3.319	3.633
	T_3	2.243	3.060	3.681

Yield is calculated from measured parameters.

Table 3. Tapping cost for different systems of tapping in clones RRIC 102, RRIC 121 and RRISL 211.

Clone	Tapping treatments	Tapping cost (Rs kg^{-1})*		
		G_{16}	G_{18}	G_{20}
RRIC 102	T_1	36.37	20.50	14.24
	T_2	18.77	12.03	7.19
	T_3	16.04	9.30	7.37
RRIC 121	T_1	40.08	17.48	11.00
	T_2	24.05	12.59	7.11
	T_3	16.26	8.576	4.44
RRISL 211	T_1	18.14	9.87	7.55
	T_2	10.25	5.67	5.18
	T_3	8.39	6.15	5.11

* Task size = 300 trees day^{-1}; Wage of tapper day^{-1} = Rs. 150.00; Tapping cost is calculated from measured parameters.

Both the annual mean and the total yield per tree per annum are less in trees opened at G_{16} and G_{18} when compared with G_{20} in all clones tested (Table 1 and 2). Therefore, the tapper productivity, *i.e.*, dry rubber yield per tapping task (ca. 300 trees) per tapping will be less if tapping is commenced at girths lower than G_{20} resulting in a high tapping cost. Tapping cost is a significant component in the cost of production of rubber (Sivakumaran, 1991) and hence such agronomic practices may not be economically beneficial. Nevertheless, when trees are opened at an early growth stage the growers are benefited with an early return for their investment, particularly in the smallholders sector.

Low frequency tapping with stimulation has given a significantly high yield per tree per tapping at G_{16} in all clones tested (Table 1). Further, the annual total yields are similar to that of 1/2S d/2 system (Table 1 and 2). At G_{20} a similar trend is apparent in clone RRIC 121 only. In this study, the tapping cost per kg of rubber is lowest for 1/2S d/3 tapping with stimulation using 2.5% Ethrel (Table 3). Further, low frequency tapping (LFT) systems reduce the tapper requirement and number of tappings per tree per annum. A lower tapping cost with LFT could result in lower cost of production and hence a higher profitability. An in-depth economic analysis is needed to find out the economic benefits, if any, of early tapping together with the use of low frequency tapping and stimulation.

Latex volume (ml)

Latex volume per tree per tapping increases with increasing girth in all clones. In clone RRIC 102 and 121 low frequency tapping with stimulation gives the highest latex volume per tree per tapping in all girth classes tested. Such differences are not apparent in clone RRISL 211 (Table 4).

Table 4. **Effect of different tapping systems at different girths on mean latex volume (ml) per tapping of clones RRIC 102, RRIC 121 and RRISL 211.**

Clone	Tapping treatments	Mean latex volume (ml)		
		G_{16}	G_{18}	G_{20}
RRIC 102	T_1	20.320[b]	49.249[b]	57.757[b]
	T_2	24.700[b]	43.955[b]	69.024[ab]
	T_3	31.090[a]	63.586[a]	71.637[a]
RRIC 121	T_1	14.830[b]	39.581[b]	56.498[b]
	T_2	15.570[b]	33.123[b]	54.108[b]
	T_3	24.530[a]	52.502[a]	93.995[a]
RRISL 211	T_1	43.060[b]	109.530[a]	137.340[a]
	T_2	50.860[b]	126.620[a]	132.090[a]
	T_3	65.200[a]	128.990[a]	130.900[a]

Means of each category with the same letter are not significantly different at $P>0.05$.

Plugging index

In all clones tested plugging index (PI) is high in trees opened at G_{16} than in trees opened at G_{18} and G_{20}. Further, it is lowest in stimulated trees than in unstimulated trees in all girth classes and clones (Table 5).

Table 5. **Effect of different tapping systems at different girths on plugging index of clones RRIC 102, RRIC 121 and RRISL 211.**

Clone	Tapping treatments	Mean PI		
		G_{16}	G_{18}	G_{20}
RRIC 102	T_1	5.173[a]	3.521[a]	3.965[a]
	T_2	4.978[a]	3.799[a]	4.219[a]
	T_3	3.531[b]	2.818[b]	2.580[b]
RRIC 121	T_1	8.249[a]	5.777[b]	5.464[a]
	T_2	8.386[a]	6.253[a]	5.922[a]
	T_3	6.825[b]	3.650[c]	4.258[a]
RRISL 211	T_1	5.792[a]	3.500[a]	3.604[a]
	T_2	6.002[a]	2.964[a]	3.259[b]
	T_3	4.023[b]	2.347[b]	2.290[c]

Means of each category with the same letter are not significantly different at $P>0.05$.

Initial flow rate

Initial flow rate is low in trees opened at G_{16} than in trees opened at G_{18} and G_{20} in all clones. Initial flow rates were significantly high in low frequency tapping with stimulation in clone RRIC 121. Such a trend is not evident in the other two clones (Table 6).

Table 6. Effect of different tapping systems at different girths on initial flow rate (ml min^{-1}) in clones RRIC 102, 121 and RRISL 211.

Clone	Tapping treatments	Mean initial flow rate (ml min^{-1})		
		G_{16}	G_{18}	G_{20}
RRIC 102	T_1	1.036^{a}	1.397^{a}	1.432^{a}
	T_2	1.046^{a}	1.487^{a}	1.555^{a}
	T_3	0.904^{a}	1.327^{a}	$1:402^{a}$
RRIC 121	T_1	1.144^{b}	2.151^{b}	2.117^{b}
	T_2	1.226^{b}	2.313^{ab}	2.335^{ab}
	T_3	1.454^{a}	2.532^{a}	2.590^{a}
RRISL 211	T_1	1.800^{b}	2.473^{ab}	2.523^{b}
	T_2	2.314^{a}	2.845^{a}	3.084^{a}
	T_3	2.106^{ab}	2.229^{b}	2.386^{b}

Means of each category with the same letter are not significantly different at $P>0.05$.

Trunk girth

The percentage girth increment after tapping increases with increasing girth in all three clones (Table 7).

Table 7. Effect of different tapping systems at early growth stages on girthing in clones RRIC 102, 121 and RRISL 211.

Clone	Girth at opening	Girth increment (%)
RRIC 102	G_{16}	31.441^{b}
	G_{18}	33.336^{b}
	G_{20}	40.989^{a}
RRIC 121	G_{16}	42.892^{a}
	G_{18}	45.395^{a}
	G_{20}	46.055^{a}
RRISL 211	G_{16}	18.941^{c}
	G_{18}	26.328^{b}
	G_{20}	30.783^{a}

Means of each category with the same letter are not significantly different at $P>0.05$.

Variations in yield, either due to different girths at opening or different tapping systems could be due to the same of yield determining parameters. High yield per tree per tapping level apparent with low frequency tapping at G_{16} in all clones is associated with a lowering plugging index (Table 8).

Table 8. Yield per tree per tapping, PI and initial flow rates of G_{16} trees of clones RRIC 102, 121 and RRISL 211 tapped at different tapping systems.

Clone	Treatment	$g\ t^{-1}\ t^{-1}$	PI	Initial flow rate (ml min^{-1})
RRIC 102	T_1	6.875^b	5.173^a	1.036^a
	T_2	8.884^a	4.978^a	1.046^a
	T_3	10.394^a	3.531^b	0.904^a
RRIC 121	T_1	6.240^b	8.249^a	1.144^b
	T_2	6.933^b	8.386^a	1.226^b
	T_3	10.253^a	6.825^b	1.454^a
RRISL 211	T_1	13.782^b	5.792^a	1.800^b
	T_2	16.248^{ab}	6.002^a	2.314^a
	T_3	19.852^a	4.023^b	2.106^{ab}

Means of each category with the same letter are not significantly different at P>0.05.

Among clones tested PI is relatively high in clone RRIC 121. At all girth classes tested the yield per tree per tapping of clone RRIC 121 has responded positively to yield stimulation, and it too is associated with a lowering of the plugging index (Table 1 and 5).

In clones RRIC 102 and RRISL 211 lowering of PI has not resulted in an increased yield per tree per tapping. The initial flow rate is also associated with yield differences observed with different tapping systems at G_{16} but to a lesser extent to that of plugging index (Table 8). It is reported that the relative importance of initial flow rate as a factor determining the yield is less than that of plugging index (Sethuraj *et al.*, 1974). Further the high yield per tree per tapping of clone RRIC 121 with low frequency tapping with simulation is also linked to an increased initial flow rate (Table 1 and 6). It is apparent that relatively high yields possible with stimulation is more due to lowering of plugging index than enhanced initial flow rates.

Girthing of trees after tapping is important to achieve high yields from a tree during its tapping cycle. Nevertheless, girthing after tapping is relatively less in trees opened at lower girths in all clones tested (Table 7). Therefore, the total yield that could be harvested from a tree could be significantly reduced if trees are opened at an early growth stage.

CONCLUSIONS

In three genotypes tested commencing of tapping at relatively lower girths resulted in lower yields and reduced girthing after tapping. These attributes could eliminate the economic benefits from early returns to the grower by tapping at lower girths. Clone RRIC 121, characterised by a higher plugging index has responded positively to low frequency tapping with stimulation by giving yields comparable to 1/2S d/2 system. Therefore, adoption of such tapping systems in clone RRIC 121 will lower tapping costs whilst reducing tapper requirement. Increasing yield per tree per taping with stimulation is more due to lowering of plugging index than enhancing of the initial flow rates.

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