Evaluation of Low Frequency Tapping Systems with Stimulation of *Hevea* in Traditional Rubber Growing Area of Cambodia

Phen Phearun[1], Mak Sopheaveasna[1], Chhek Chan[1],
Eric Gohet[3] and Régis Lacote[2,3]

1 - Cambodian Rubber Research Institute (CRRI) #59E, St Betong, Sangkat Prek Leap, Khan Chroy Changva, P.O. Box: 1337, Phnom Penh, Cambodia
2 - CIRAD - HRPP, Kasetsart University – 10900 Bangkok
3 - CIRAD, UPR Systèmes de Pérennes. F-34398 Montpellier, France
* Corresponding author: phearun_phen@yahoo.com

Abstract

In Cambodia, the common tapping system which is widely adopted by smallholders and agro-industry plantations is S/2 d3 for downward tapping and S/4 d3 for upward tapping. However, under the decline of rubber price and increasing labor shortage, the application of low frequency tapping systems (LFT) may be a choice to solve these problems. Hence, different low frequency tapping systems were tested in traditional rubber growing area of Cambodia. An experiment was established using seven-year old rubber trees of RRIM 600 clone at the Cambodian Rubber Research Station located in Tbong Khmum province. The experimental design was Randomized Complete Block Design with four treatments i.e.T0: S/2 d3 7d/7 ET 2.5% 4/y, T1: S/2 d4 7d/7 ET 2.5% 5/y, T2: S/2 d5 7d/7 ET 3.3% 6/y and T3: S/2 d6 7d/7 ET 3.3% 10/y comprising three replications (12 elementary plots). After 3 years of tapping, LFT system S/2 d6 with Ethephon application (T3) provided the highest dry rubber yield per tree per tapping (g/t/t) but the lowest yield in gram per tree (g/t) and kilogram per hectare (kg/ha). As compared to d3, LFT systems (d4, d5 and d6) caused a loss in dry rubber yield in kg/ha by 3, 9 and 11%, respectively but resulted in increased labour productivity (g/t/t) by 11, 28 and 48%, respectively. Therefore, the increase in labour productivity (g/t/t) was higher than the loss in land productivity (kg/ha). Girth increment was not significantly different between treatments. Sucrose and reduced thiol contents of all treatments were not significantly different but inorganic phosphorus content was significantly different depending on the tapping system. Tapping panel dryness was comparable in all treatments after three years of tapping.

Keywords: *Hevea*, clone, low frequency tapping, ethephon

1. Introduction

Up to the end of 2018, the total area of rubber plantations in Cambodia was 436,682 hectares in which 201,949 hectares were under tapping. Some areas are now untapped due to labour shortage. High cost of skilled tappers and tapper shortage are new issues for Cambodia as well as for other natural rubber growing countries. Low frequency tapping (LFT) system might be the solution to solve these problems (Gohet *et al.*, 1991, Soumahin *et al.*, 2009; Kudaligama *et al.*, 2010; Prasanna *et al.*, 2010; Soumahin *et al.*, 2010). LFT system combined with proper ethephon stimulation can maintain the yield as similar as the normal frequency. Ethephon releases ethylene, increasing the duration of latex flow after tapping, by delaying latex coagulation (improvement of lutoid membranes stability) and by activating latex cell metabolism (Jacob *et al.,* 1989; d'Auzac *et al.,* 1997). Therefore, yield can be significantly improved at each tapping. This leads to a higher labour productivity (kg per tapper and per day) that can compensate the reduction of tapping frequency when using ethylene stimulation (Gohet *et al*., 1991., Lacote *et al.*, 2010; Njukeng *et al.*, 2011; Traore *et al.*, 2011).The common tapping system for almost all plantations in Cambodia is S/2 d3 7d/7for downward tapping and S/4 d3 7d/7 for upward tapping. In order to recommend LFT system to growers, Cambodian Rubber Research Institute (CRRI) has developed research on LFT Systems with stimulation; (i) to evaluate the efficiency of LFT systems with ethephon stimulation on yield and labour productivity and their effect on some physiological parameters, (ii) to identify the tapping systems with best efficiency.

2. Materials and Methods

The experiment was carried out at the CRRI research station located in Tbong Khmum province on a level plain set in red basaltic latosols. The climate is governed by the Asian monsoon, which produces two distinct seasons: a rainy season (approximately May to October) and a dry season (approximately November to April).

Clone RRIM 600 was used in the experiment. Rubber trees were planted in 2005with the spacing of 6m x 3m (555 trees/ha). They were opened for tapping at the standard girth of 50 cm and opened at 1.30 m height from the ground. The tapping systems were S/2 d3 7d/7, S/2 d4 7d/7, S/2 d5 7d/7 and S/2 d6 7d/7.

The experimental design was Randomized Complete Block Design (RCBD) with 4 treatments comprising 3 replications (12 elementary plots). There were 120 trees per treatment in each elementary plot (Table 1).

The yield had been recorded in each tapping day and expressed as g/t/t, g/t and kg/ha. The girth of the trees was measured annually at 1.70 m above ground level. Latex diagnosis was performed on a pooled sample of 10 trees in each replication (Jacob *et al.,* 1989). Latex biochemical parameters including total solid content (TSC %), sucrose content (Suc, mMl^{-1}), inorganic phosphorus content (Pi, mMl^{-1}) and reduced thiol content (R-SH, mMl^{-1}) were evaluated according to the method developed by CIRAD adapted in 1995 by IRRDB (Jacob *et al.,* 1988; IRRDB 1995). Incidence of tapping panel dryness was evaluated by counting once a year the trees showing total bark dryness in each replication of the treatments. It was expressed as percentage in each treatment (Van de Sype, 1984). Statistical analysis of all data was performed by using SPSS software.

Table 1. Details of the experimental design

Treatments	Length of cut	Frequency of tapping	Stimulation (year 1-3)
T0	S/2	d3 7d/7	ET 2.5% Pa1(1) 4/y
T1	S/2	d4 7d/7	ET 2.5% Pa1(1) 5/y
T2	S/2	d5 7d/7	ET 3.3% Pa1(1) 6/y
T3	S/2	d6 7d/7	ET 3.3% Pa1(1) 10/y

3. Results

Dry rubber yield

The average yields after 3 years of tapping were significantly different among the four treatments (Table 2). The highest dry rubber yield per tree per tapping (g/t/t) was found with T3 (S/2 d6 7d/7 ET 3.3% Pa1(1) 10/y) reaching 48% more than T0 (S/2 d3 7d/7 ET 2.5% Pa1(1) 4/y) which showed the lowest g/t/t among the 4 treatments. As compared to d3, LFT systems (d4 and d5) increased g/t/t by 11 and 28%, respectively.

The highest dry rubber yield in gram per tree per year (g/t) was obtained by T0 followed by T1, T2 and T3. This can be related to the higher number of tapping per year. The lowest yield in g/t was found in LFT system d6 (T3).

Dry rubber yield, kilogram per hectare per year (kg/ha/y) also showed significant differences between treatments. T0 (d3) gave the highest yield in kg/ha (1716 kg/ha/y), higher than LFT system (d4, d5 and d6) by 3, 9 and 11%, respectively. However, there was no significant difference between T0 (S/2 d3) and T1 (S/2 d4) treatments.

Table 2: Average dry rubber yield (g/t, g/t/t and kg/ha) of different tapping systems after 3 year of tapping.

Treatments	**g/t**	**%**	**g/t/t**	**%**	**kg/ha**	**%**
T0: S/2 d3 7d/7 ET 2.5% Pa1(1) 4/y	3794[a]	100	43.71[d]	100	1716[a]	100
T1: S/2 d4 7d/7 ET 2.5% Pa1(1) 5/y	3581[b]	94	48.57[c]	111	1662[a]	97
T2: S/2 d5 7d/7 ET 3.3% Pa1(1) 6/y	3443[bc]	91	56.01[b]	128	1560[b]	91
T3: S/2 d67d/7 ET 3.3% Pa1(1) 10/y	3368[c]	89	64.68[a]	148	1520[b]	89
P value	0.001		0.000		0.000	

Note: Values with different letters in the same column are significantly different ($p<0.05$).

Latex biochemistry

Table 3 presents the averages of sucrose (Suc), inorganic phosphorus (Pi) and reduced thiols (R-SH) contents after three years of tapping. Sucrose and reduced thiol contents of all treatments were not significantly different. However inorganic phosphorus content was significantly different depending on the tapping system. With lower Pi levels, T2 (S/2 d5) and T3 (S/2 d6) showed less active latex metabolism than T0 (S/2 d3) and T1 (S/2 d4), in conformity with the recorded productions expressed in g/t/y.

Table 3. Average sucrose, inorganic phosphorus and reduced thiol content in the third year of tapping

Treatments	**Suc (mM.l^{-1})**	**Pi (mM.l^{-1})**	**R-SH (mM.l^{-1})**
T0: S/2 d3 7d/7 ET 2.5% 4/y	5.50 ^{a}	18.74^{a}	0.21 ^{a}
T1: S/2 d4 7d/7 ET 2.5% 5/y	6.83 ^{a}	17.75^{a}	0.20 ^{a}
T2: S/2 d5 7d/7 ET 3.3% 6/y	5.51^{a}	13.66^{b}	0.23 ^{a}
T3: S/2 d67d/7 ET 3.3% 10/y	5.19 ^{a}	15.27^{ab}	0.22 ^{a}
P- value	0.217	0.031	0.520

Note: Values with different letters in the same column are significantly different ($p<0.05$).

Girth and girth increment

Average girth increment after three years of tapping is shown in Figure 1. There is no significant difference between the treatments.

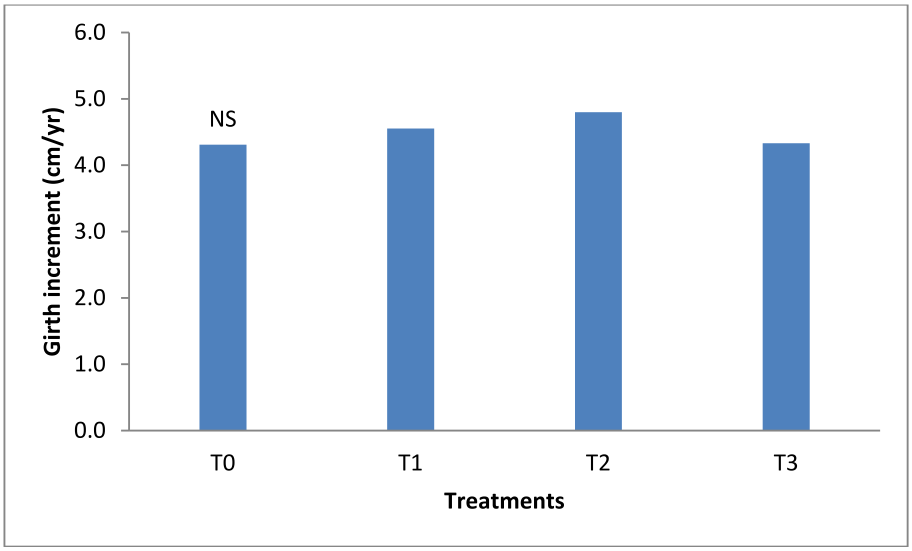

Figure 1: Average girth increment (cm/yr) after three years of tapping

Tapping panel dryness (TPD)

The incidence of tapping panel dryness was quite similar in all treatments and varied from 3 to 5% (Fig. 2).

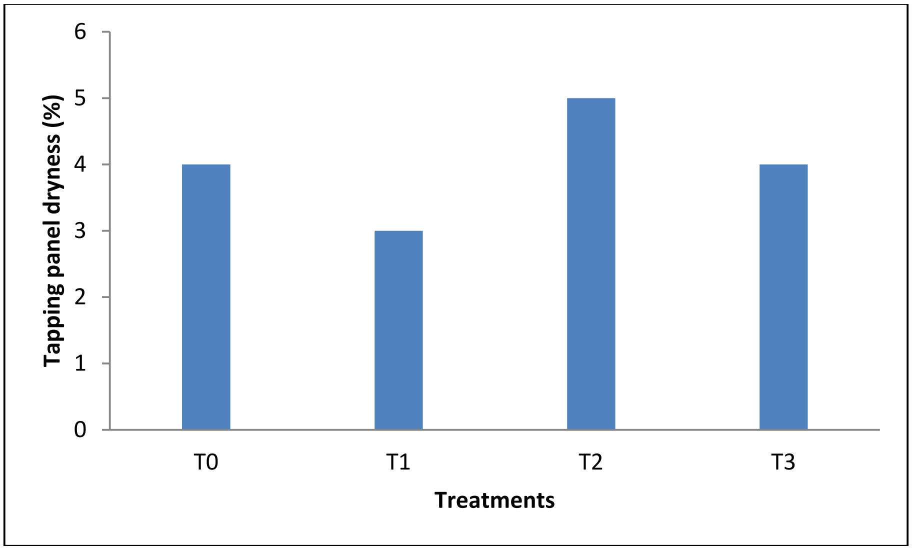

Figure 2: Tapping panel dryness (%) after three years of tapping

4. Discussion

Due to global changes induced by volatility of rubber prices, regular increase of agricultural salaries and probable increasing shortage of skilled tappers, the need to implement reduced tapping frequencies may be more and more important in the future. Reduction of tapping frequency will require compensation by hormonal ethylene stimulation (ethephon, ethylene) (Gohet *et al*., 1991, 1996, 2003, Lacote *et al*., 2010), whose response itself dependent on an increased latex sugar loading for latex regeneration (Gohet *et al*., 1996, 2003, Lacote *et al*., 2010). Dry rubber yield per tree per tapping (g/t/t) of LFT systems with ethephon stimulation was significantly higher than that of S/2 d3 tapping system (T0) which is widely used in Cambodia. LFT system combining reduction of tapping frequency with ethephon stimulation increase the duration of latex flow after tapping, with the reduction of latex coagulation and the activation of the latex cell metabolism (Jacob *et al.*, 1989; d'Auzac *et al.*, 1997). Therefore, more latex is collected at each tapping. Moreover, it was confirmed possible to compensate the reduction of tapping frequency when using ethephon stimulation. LFT systems (S/2 d4, S/2 d5 and S/2 d6) caused dry rubber yield loss in gram per tree per year and kilogram per hectare per year as compared to d3 tapping system, but this loss was not significant for S/2 d4. This was clearly related to the number of tapping per year. In our local condition, the reduction of tapping frequency with suitable stimulation could compensate the cumulative yield per tree with higher yield per tapping. These results confirmed previous works (Gohet *et al.*, 1991, Rodrigo *et al.*, 2011, Njukeng and Gobina, 2007), mentioning that low frequency tapping systems must be combined with proper stimulant to increase potential yield (g/t/t) at each tapping.

The latex biochemistry consists of inorganic phosphorus content (Pi), reduced thiol content (R-SH) and sucrose content (Suc). Sucrose and reduced thiol contents of all treatments were not significantly different but inorganic phosphorus content was significantly different depending on the tapping system. The effect of stimulation is well known by the use of R-SH as scavengers to protect the stability of the membranes of the vacuo-lysosomal system in the latex cells (Jacob *et al.,* 1989; d'Auzac *et al.,* 1997). The differences in sucrose and R-SH contents were not different among treatments. Pi levels were lower in S/2 d5 and S/2 d6, confirming a lower metabolic activity and a lower production expressed in g/t. Although not significantly different, lower levels of Suc. observed in those 2 systems S/2 d5 and S/2 d6 could be related to this lower metabolic activity, probably limiting the active importation of Suc into the latex. It could be related as well to the increase in g/t/t. As a matter of fact, an increase in g/t/t increases the need for Suc importation after each tapping (Jacob *et al*., 1989, Gohet *et al*., 1996, Lacote *et al*., 2010) to sustain latex regeneration. Girth increment measurement did not show any difference between treatments. Nugawela *et al.* (2000) found that low frequency tapping system with stimulation did not show negative effect on the growth of rubber trees. In our experiment, combining low frequency tapping with higher ethephon stimulation increased significantly the yield at each tapping while not significantly reducing the growth of the trees. The rate of tapping panel dryness (TPD) was found similar for all treatments, while Obouayeba *et al.* (2009) reported that the rate of TPD was related to the intensity of tapping.

5. Conclusion

After the first three 3 years of tapping, LFT system S/2 d6 with ethephon application (T3) provided the highest dry rubber yield per tree per tapping (g/t/t) but the lowest yield in gram per tree (g/t) and kilogram per hectare (kg/ha). As compared to d3, LFT systems (S/2 d4, S/2 d5 and S/2 d6) caused dry rubber yield loss in kg/ha by 3, 9 and 11%, respectively but resulted in increased labour productivity (g/t/t) by respectively 11, 28 and 48%. Therefore, the increase in labour productivity (g/t/t) was much higher than the loss in land productivity (kg/ha). Girth increment was not significantly different between treatments. Sucrose and reduced thiol contents of all treatments were not significantly different but inorganic phosphorus content was significantly different depending on the tapping system. Tapping panel dryness was similar in all treatments after three years of tapping. The results highlight that, in the traditional rubber growing zone of Cambodia, it is possible to use ethephon stimulation to increase the potential yield of the trees at each tapping (g/t/t). Therefore, LFT systems can be applied with proper stimulation to sustain the yield when reducing the tapping frequency.

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