**Journal of Animal & Plant Sciences, 2009. Vol. 2, Issue 3: 109 - 117.**
*Publication date: 02 April 2009,* *http://www.biosciences.elewa.org/JAPS*; **ISSN 2071 - 7024**

# Low tapping frequency with hormonal stimulation on *Hevea brasiliensis* clone PB 217 reduces tapping manpower requirement

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**Key words**
*Hevea brasiliensis*, tapping, frequency, stimulation, profit margin, Côte d'Ivoire

## 1 SUMMARY
**In rubber tree growing, the tapping manpower is scarce and expensive. One way to remedy this problem is by reducing the tapping frequency, with production compensated for by hormonal stimulation of the plant. The aim of this work was to study the influence of low tapping frequency on rubber production parameters. Weekly tapping of clone PB 217 of *Hevea brasiliensis*, grown in the southeast of Côte d'Ivoire under different stimulation systems, was compared to the tapping done every four days (classical tapping). The weekly tapping, compensated by the stimulation, had rubber production levels and profit margins comparable to those of the classical tapping. Moreover, the weekly tapping has no negative effect on the vegetative, sanitary and physiological state of the trees. Our results show that with clone PB 217 it is possible to remedy tapping manpower scarcity and cost by reducing tapping frequency and compensating production by stimulation. With the low tapping frequency system, the number of tappers required can be reduced by up to 33 %.**

## 2 INTRODUCTION
The cost and shortage of tapping manpower considerably reduces the profitability of rubber farms in Côte d'Ivoire (Anonymous 1, 1998; Soumahin, 2003). One of the means to remedy this problem is through reduction of the tapping intensity, either by reducing the annual tapping sessions (tapping frequency) or by reducing the tapping cut length (Anonymous 1, 1998; Vijayakumar, 2001; Soumahin, 2003; Obouayeba *et al.*, 2006).

The reduction of tapping intensity is possible provided the yield is increased through a well planned hormonal stimulation, i.e. concentration of Ethephon (2-chloroethylphosphonic acid) and annual application frequency (Hashim, 1988). Ethephon prolongs the duration of the latex flow. This extension of the flow is due to the stabilization of the lutoides, which retards coagulation of the latex (Compagnon, 1986).

A study of the weekly tapping schedule combined with hormonal stimulation to compensate for any lost production was studied on rubber clone PB 217 at the Rubber Tree Program of the CNRA, in the southeast of Côte d'Ivoire. The results of thirteen years of experimentation with weekly tapping on the production parameters and the farm profitability are presented in this paper.

## 3 MATERIAL AND METHODS
**3.1 Plant material:** The plants used in this experiment were of the clone PB 217 of *Hevea brasiliensis,* which has a slow metabolism (Anonymous 2, 1993).

**3.2 Study site:** The experiment was carried out on the experimental land of the CNRA, Bimbresso research station, in Anguédédou, southeast of Côte d'Ivoire, in an area of 4.15 hectares. This region is characterized by a subequatorial climate with two rainy seasons and two dry seasons. The soils are ferralitic derived from tertiary sand (Keli *et al*., 1992). The trees were planted in 1981. The test was set up in March 1988. The tapping of trees was done at 1.20 m from the ground.

**3.3. Experiment design and layout:** The statistic device used is a single tree single plot randomized design (one tree plot design, each tree being a repetition) with 14 treatments and 33 trees per treatment. The trees chosen are those with a circumference varying between 47 and 54 cm (average of 52.60 cm) when measured at 1 m above the ground. The treatments included are as shown in table 1 (Lukman, 1983; Vijayakumar, 2008).

**Table 1**: Tapping frequency and hormonal stimulation treatments applied on rubber trees clone PB 217 in Côte d'Ivoire.

| No. | Treatment code | Description |
|---|---|---|
| 1 | **Absolute control** | Without tapping |
| 2 | **½ S d/4 6d/7 ET 2.5 % Pa 1(1) 10/y** | Half spiral cut tapped downward at fourth daily frequency, six days in tapping followed by one day rest; stimulated with ethephon of 2.5 % active ingredient with 1 g of stimulant applied on panel on 1 cm band, 10 applications per year. |
| 3 | **½ S d/6 6d/7 *nil stimulation*** | Half spiral cut tapped downward at sixth daily frequency, six days in tapping followed by one day rest ; without stimulation |
| 4 | **½ S d/6 6d/7 ET 2.5 % Pa 1(1) 8/y** | Half spiral cut tapped downward at sixth daily frequency, six days in tapping followed by one day rest; stimulated with ethephon of 2.5 % active ingredient with 1 g of stimulant applied on panel on 1 cm band, 8 applications per year. |
| 5 | **½ S d/6 6d/7 ET 2.5 % Pa 1(1) 13/y** | Half spiral cut tapped downward at sixth daily frequency, six days in tapping followed by one day rest; stimulated with ethephon of 2.5 % active ingredient with 1 g of stimulant applied on panel on 1 cm band, 13 applications per year. |
| 6 | **½ S d/6 6d/7 ET 2.5 % Pa 1(1) 26/y** | Half spiral cut tapped downward at sixth daily frequency, six days in tapping followed by one day rest; stimulated with ethephon of 2.5 % active ingredient with 1 g of stimulant applied on panel on 1 cm band, 26 applications per year. |
| 7 | **½ S d/6 6d/7 ET 2.5 % Pa 1(1) 52/y** | Half spiral cut tapped downward at sixth daily frequency, six days in tapping followed by one day rest; stimulated with ethephon of 2.5 % active ingredient with 1 g of stimulant applied on panel on 1 cm band, 52 applications per year. |
| 8 | **½ S d/6 6d/7 ET 5 % Pa 1(1) 8/y** | Half spiral cut tapped downward at sixth daily frequency, six days in tapping followed by one day rest; stimulated with ethephon of 5 % active ingredient with 1 g of stimulant applied on panel on 1 cm band, 8 applications per year. |
| 9 | **½ S d/6 6d/7 ET 5 % Pa 1(1) 13/y** | Half spiral cut tapped downward at sixth daily frequency, six days in tapping followed by one day rest; stimulated with ethephon of 5 % active ingredient with 1 g of stimulant applied on panel on 1 cm band, 13 applications per year. |
| 10 | **½ S d/6 6d/7 ET 5 % Pa 1(1) 26/y** | Half spiral cut tapped downward at sixth daily frequency, six days in tapping followed by one day rest; stimulated with ethephon of 5 % active ingredient with 1 g of stimulant applied on panel on 1 cm band, 26 applications per year. |
| 11 | **½ S d/6 6d/7 ET 5 % Pa 1(1) 52/y** | Half spiral cut tapped downward at sixth daily frequency, six days in tapping followed by one day rest; stimulated with ethephon of 5 % active ingredient with 1 g of stimulant applied on panel on 1 cm band, 52 applications per year. |

### 3.4 Data recorded

**3.4.1 Rubber production:** A production check on each tree was made every 4 weeks. A sample of the rubber yielded was used to determine the coefficient of transformation of each treatment, which permits determination of the weight in dry rubber. The production was expressed in gram per tree (g/t) and in gram per tree per tapping (g/t/t).

**3.4.2 Radial vegetative growth:** Radial growth was measured at the beginning of the experiment in March 1988, and thereafter once per year (in January). Tree circumference was measured at 1.70 m above the ground.

**3.4.3 Latex analysis:** A latex microdiagnosis was carried out once per year between August and January taking into account the dry rubber rate and the sucrose, inorganic phosphorus and thiol contents. To determine the dry rate (%), a latex sample was weighed before and after drying in oven at 80°C for 24 h. The sucrose, the inorganic phosphorus and the reduced thiol groupings were measured on the clear serum called TCA-serum (trichloroacetic acid) that is obtained after latex acid coagulation, respectively, by the Ashwell anthrone method (1957), the Taussky and Shorr molybdate ammonium method (1953) and the Boyne and Ellman acid dinitro-dithio-dibenzoic (DTNB) method (1972). The results are stated in mmole per litre of latex (mM/l).

**3.4.4 Economic analysis:** For each tapping system, the profit margin (P.M) was calculated and stated in US $ as follow:

P.M = O.I – O.C.; with O.I. = Y x S.P.R. and O.C. = M.C + S.C.

*Where*;

O.I. is Operating Income; O.C. is Operating Cost; Y is Yield in kg of ex-farm rubber/hectare; S.P.R is Ex-farm Selling Price per kg of rubber; M.C. is Manpower Cost; S.C. is Stimulation Cost. *NB: Ex-farm kg of rubber = kg of dry rubber / 60 %.*

The payment method of the tappers is on per working day basis. The tapping manpower cost per working day (M.C.D) is determined as follows: M.C.D. = M.C.d. x Tg.N x Tr.N.

*Where* M.C.d. is manpower cost per tapper and per working day; Tg.N. is tapping number; Tr.N. is the number of tappers.

The profit margins are calculated theoretically basis on a single tapping on an area of 1 hectare for each tapping system. The cost of the kilogram of ex-farm rubber is fixed at 0.4 US $. For calculation, the costs of the tapper per working day are set at 4, 5, 6, 7, 8 and 9 US $ per day per tapper.

**3.4.5 Statistical analysis:** The rubber production, plant growth and the latex analysis data were subjected to analysis of variance using statistics software SPSS. The level of significance of the differences between averages was estimated by the Newman-Keuls test at a limit of 5 %.

## 4 RESULTS

**4.1 Rubber production:** The weekly tapping schedule for most treatments gave statistically identical production to that of the control (tapping three times per fortnight) (table 2). The exceptions were tapping systems 3 and 11 (non stimulated and stimulated 52 times per year with 5% active ingredient, respectively), which produced significantly less than the control. The non-stimulated treatment (3) had the lowest production.

**Table 2:** Annual mean dry rubber yield expressed in gram per tree (g/t) and gram per tree and per tapping (g/t/t) of clone PB 217 of *Hevea brasiliensis* under weekly downward tapping with different intensities of stimulation using Ethephon during 13 years.

| Treatment No. | Treatment details | g/t | g/t/t |
|---|---|---|---|
| 1 | Absolute control (without tapping) | - | - |
| 2 | ½ S d/4 6d/7 Et 2,5% Pa 1(1) 10/y | 5423 a | 70 ab |
| 3 | ½ S d/6 6d/7 *nil stimulation* | 3036 c | 58 b |
| 4 | ½ S d/6 6d/7 Et 2,5% Pa 1(1) 8/y | 4008 abc | 77 ab |
| 5 | ½ S d/6 6d/7 Et 2,5% Pa 1(1) 13/y | 4378 abc | 84 ab |
| 6 | ½ S d/6 6d/7 Et 2,5% Pa 1(1) 26/y | 5218 ab | 100 ab |
| 7 | ½ S d/6 6d/7 Et 2,5% Pa 1(1) 52/y | 4085 abc | 79 ab |
| 8 | ½ S d/6 6d/7 Et 5% Pa 1(1) 8/y | 4495 abc | 86 ab |
| 9 | ½ S d/6 6d/7 Et 5% Pa 1(1) 13/y | 4361 abc | 84 ab |
| 10 | ½ S d/6 6d/7 Et 5% Pa 1(1) 26/y | 4502 abc | 87 ab |
| 11 | ½ S d/6 6d/7 Et 5% Pa 1(1) 52/y | 3528 bc | 68 ab |

Means followed by same letter in each column are not significantly different (test of Newman-Keuls at 5 %). Treatments are fully described in table 1.

In all systems where tapping was done on d/6, the production of rubber per tree was statistically identical regardless of the concentration of active ingredient used and the number of stimulations done. The increase in stimulation intensity has therefore no significant effect on rubber production by trees that were tapped consistently on d/6.

The change from 8 to 52 stimulations per year has no significant influence on the rubber production per tree regardless of the concentration of active ingredient (2.5 or 5%). At a concentration of 2.5 % Ethephon, a progressive increase (though not significant) in rubber production was noticed from 8 to 26 stimulations. Beyond 26 stimulations, the production decreased.

At the concentration of 5% of Ethephon, the production trend had a 'saw tooth' evolution between the 8th and the 52nd stimulation.
Comparing the same number of stimulations, the production per tree is higher when stimulated using 2.5% than at 5 %, except for 8 stimulations per year where the opposite effect is noticed. Broadly, the stimulation at 2.5 % is more productive than stimulation at 5 %. Regardless of the concentration of active molecule, 26 stimulations per year gave the highest production per tree, among the treatments having low tapping frequency.

The weekly tapping schedule gives rubber production per tree and per tapping that is identical to that of the schedule where tapping is done three times per fortnight. Except for treatment 11 (weekly tapping stimulated 52 times per year with 5% active ingredient), in which production per tree and per tapping is inferior to that of the control, the reduction of tapping frequency induces an increase in the production per tree and per tapping compared to the control. This increase in the production per tree and per tapping reaches its peak when the trees are stimulated 26 times per year regardless of the concentration in active ingredient (2.5 or 5 %). However, production is higher with the Ethephon concentration of 2.5 % (+43 %) than with 5 % (+24 %).

**4.2 Radial vegetative growth:** The absolute control with no tapping (treatment 1), had the highest annual average girth increment (cm/year) (table 3), which is statistically superior to that of all the other treatments. The relative control (treatment 2) had an annual average girth increment that is identical to those of the treatments with low tapping frequency, except for treatment 3 (non stimulated), whose girth increment is superior. The change from 8 to 26 stimulations per year reduced the annual girth increment rate as the frequency of stimulation increased. The treatments stimulated 52 times per year (treatments 7 and 11) gave the lowest (not significantly) annual average girth increments.

**Table 3:** Annual mean girth increment (cm/year) of clone PB 217 of *Hevea brasiliensis* under weekly downward tapping with different intensities of stimulation with Ethephon during 13 years.

| Treatment No. | Treatment details | Girth increment (cm/year) |
|---|---|---|
| 1 | 1. Absolute control (without tapping) | 4,5 a |
| 2 | 2. ½ S d/4 6d/7 Et 2,5 % Pa 1(1) 10/y | 2,5 cd |
| 3 | 6. ½ S d/6 6d/7 *nil stimulation* | 3,5 b |
| 4 | 7. ½ S d/6 6d/7 Et 2,5 % Pa 1(1) 8/y | 2,9 bc |
| 5 | 8. ½ S d/6 6d/7 Et 2,5 % Pa 1(1) 13/y | 2,5 cd |
| 6 | 9. ½ S d/6 6d/7 Et 2,5 % Pa 1(1) 26/y | 2,6 cd |
| 7 | 10. ½ S d/6 6d/7 Et 2,5 % Pa 1(1) 52/y | 1,7 d |
| 8 | 11. ½ S d/6 6d/7 Et 5 % Pa 1(1) 8/y | 2,9 bc |
| 9 | 12. ½ S d/6 6d/7 Et 5 % Pa 1(1) 13/y | 2,1 cd |
| 10 | 13. ½ S d/6 6d/7 Et 5 % Pa 1(1) 26/y | 2,1 cd |
| 11 | 14. ½ S d/6 6d/7 Et 5 % Pa 1(1) 52/y | 1,7 d |

Means followed by same letter are not significantly different (test of Newman-Keuls at 5 %). Treatments are fully described in table 1.

**4.3 Physiological profile**

*4.3.1 Dry rubber content (DRC)*: At the beginning of the experiment, the relative control (treatment 2) had one of the lowest rates while treatment 3 (not stimulated), showed one of the highest rates (table 4). At the end of the experiment, an increase in the dry rubber rate was noticed for all the treatments. The absolute control (treatment 1), which was not tapped at all, had a DRC rate identical to those of treatment 7, 8 and 9 (weekly tapping respectively stimulated 52 times per year with 2.5% active ingredient, 8 and 13 times per year with 5% active ingredient) and superior to those of the other treatments. The treatments that were not stimulated had DRC rates that were statistically identical to those of the stimulated treatments. The change from 8 to 52 stimulations per year, with a weekly tapping, had no significant effect on the rate of dry rubber, regardless of the concentration of active ingredient.

**Table 4:** Evolution of latex physiological parameters of clone PB 217 of *Hevea brasiliensis* under weekly downward tapping with different intensities of stimulation with Ethephon during 13 years of experimentation in Cote d'Ivoire.

| Treatment | DRC (%) | | Sucrose (mM/l) | | Pi (mM/l) | | RSH (mM/l) | |
|---|---|---|---|---|---|---|---|---|
| | Begin | End | Begin | End | Begin | End | Begin | End |
| 1. Control (untapped trees) | - | 71,4 a | - | 41,7 a | - | 2,6 d | - | 0,58 a |
| 2. ½ S d/4 6d/7 Et 2,5 % Pa 1(1) 10/y | 36,5 e | 55,4 c | 16,0 a | 29,4 bcd | 11,0 bcd | 11,6 c | 0,61 cd | 0,46 ab |
| 3. ½ S d/6 6d/7 *nil stimulation* | 50,2 a | 56,8 bc | 11,0 c | 37,6 ab | 5,7 e | 11,9 bc | 0,71 a | 0,48 ab |
| 4. ½ S d/6 6d/7 Et 2,5 % Pa 1(1) 8/y | 48,9 ab | 60,4 bc | 4,6 e | 30,3 bc | 12,2 abc | 17,9 ab | 0,71 a | 0,47 ab |
| 5. ½ S d/6 6d/7 Et 2,5 % Pa 1(1) 13/y | 46,4 d | 55,8 c | 5,6 e | 29,5 bcd | 12,9 ab | 17,5 abc | 0,70 ab | 0,47 ab |
| 6. ½ S d/6 6d/7 Et 2,5 % Pa 1(1) 26/y | 49,0 ab | 57,7 bc | 4,8 e | 20,2 def | 10,1 cd | 15,2 abc | 0,62 bcd | 0,39 b |
| 7. ½ S d/6 6d/7 Et 2,5 % Pa 1(1) 52/y | 42,7 bc | 61,4 abc | 5,6 e | 20,2 def | 12,4 ab | 20,0 a | 0,55 de | 0,44 ab |
| 8. ½ S d/6 6d/7 Et 5 % Pa 1(1) 8/y | 49,1 ab | 64,8 abc | 5,4 e | 26,7 cde | 9,4 d | 16,9 abc | 0,62 bcd | 045 ab |
| 9. ½ S d/6 6d/7 Et 5 % Pa 1(1) 13/y | 47,7 abc | 66,9 ab | 10,4 cd | 22,7 cdef | 14,3 a | 19,3 a | 0,72 a | 0,47 ab |
| 10. ½ S d/6 6d/7 Et 5 % Pa 1(1) 26/y | 49,0 ab | 60,6 bc | 8,3 d | 14,4 ef | 10,0 d | 16,8 abc | 0,66 abc | 0,48 ab |
| 11. ½ S d/6 6d/7 Et 5 % Pa 1(1) 52/y | 44,8 cd | 58,0 bc | 13,4 b | 13,2 f | 9,7 d | 17,4 abc | 0,53 e | 0,45 ab |

Means followed by same letter in each column are not significantly different (test of Newman-Keuls at 5 %).

*4.3.2 Latex sucrose content:* At the beginning of the experiment, the relative control (treatment 2) had latex sucrose content that was superior to that of the other treatments. Treatments 4, 5, 6, 7 and 8 (weekly tapping respectively stimulated 8, 13, 26 and 52 times per year with 2.5% active ingredient) had the lowest sucrose contents. At the end of the experiment, an increase in the latex sucrose content was noticed in almost all the treatments. The absolute control's content was identical to that of treatment 3 (not stimulated), and was superior to content of all the other treatments. The relative control's content was statistically identical to that of the treatment with low tapping frequency, except for treatments 10 and 11, that were stimulated 26 and 52 times per year, respectively, using 5 % active ingredient. These treatments had the lowest sucrose contents. A progressive decrease in the sucrose content was noticed for trees with between 8 and 52 stimulations per year, regardless of the concentration in active ingredient.

*4.3.3 Inorganic phosphorus content (Pi) latex:* At the beginning of experimentation, the non-stimulated treatment (treatment 3) had the lowest inorganic phosphorus content, while treatment 9 (weekly tapping stimulated 13 times per year with 5 % active ingredient) had one of the highest contents. At the end of experimentation, an increase in latex inorganic phosphorus content was noticed for all the treatments. The absolute control (treatment 1) had the statistically lowest content. The relative control (treatment 2) had a content that was statistically identical to that of the farming systems, which have low tapping frequency, except for farming systems 4, 7 and 9, in which the contents are significantly superior. Where stimulation frequencies varied between 8 and 52 times per year, no significant effect on the inorganic phosphorus content was noted, regardless of the concentration in active ingredient. The non-stimulated treatments had similar *Pi* content to the stimulated treatments except for treatments 7 and 9 (weekly tapping respectively stimulated 52 times per year with 2.5% active ingredient and 13 times per year with 5% active ingredient).

*4.3.4 Latex thiol contents (RSH):* At the beginning of the experiment, treatments 3, 4, 5, 9 and 10 (weekly tapping respectively non stimulated and stimulated 8 and 13 times per year with 2.5% active ingredient, 13 and 26 times per year with 5% active ingredient) had the highest latex thiol contents while treatments 7 and 11 (weekly tapping stimulated 52 times per year respectively with 2.5% and 5% active ingredient) had the lowest contents. At the end of the experiment, a decrease in the latex thiol contents was noticed for all the treatments. The absolute control (in which tapping was not done) had the highest content, though statistically identical to those of the other treatments except treatment 6. The relative control (treatment 2) had content that was statistically identical to that of all the treatments with low tapping frequency.

**4.4 Profitability:** The profit margins of the tapping systems are proportional to the yield and increase with the selling price per kilogram of ex-farm rubber, but decrease with increase in the cost of manpower (figure 1). Treatment 6 showed profit margins superior to that of the control when the tapping manpower cost per working day is more than or equal to 6 US $. The other tapping systems with low tapping frequency show profit margins that are inferior to that of the control regardless of the cost of manpower.

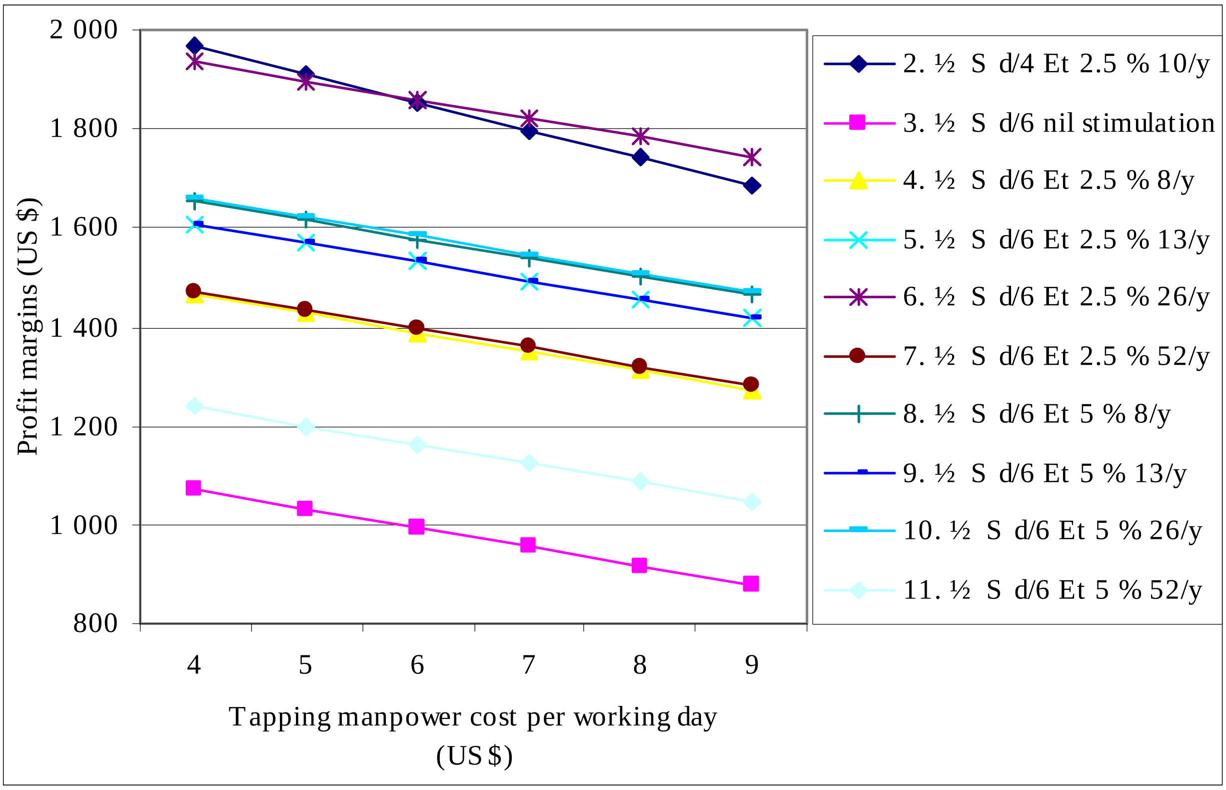


**Figure 1:** Evolution of profit margins according to the tapping manpower cost per working day of clone PB 217 of *Hevea brasilensis* under weekly downward tapping with different intensities of stimulation when the selling price of the kilogram of ex-farm rubber is 0,4 US $. Treatments are more completely described in table 1.

## 5 DISCUSSION

The production results (per tree, per tree and per tapping) show that when there is no stimulation, tapping every six days induces losses in the production to the order of 44 % when compared to tapping every 4 days. This loss in production is due to the fact that on one hand the rubber tree reacts to tapping, with the lacticigenous function being intensified by tapping (Compagnon, 1986). The reduced gram per tree and per tapping obtained by tapping every 6 days compared to 4 days tapping illustrates the importance and effect of frequent tapping, since the more the rubber tree is tapped, the higher it produces. Thus, the production metabolism is intensified with the tapping frequency (Obouayeba & Boa, 1993).

The increase in stimulation intensity (from 8/y to 52/y and from 2.5 to 5% concentration) raised production level with tapping every six days (d/6) to make it equivalent to that of tapping every 4 days (d/4) (Wei *et al.*, 2003). The losses in production caused by the reduction in tapping frequency are therefore compensated for by the intensified yield made possible by hormonal stimulation.

The production increases along with the stimulation frequency, regardless of the concentration in active ingredient, but only up to 26 stimulations per year. The stimulation acts on the physicochemical processes of the production in order to increase it (Compagnon, 1986). It appears that the more the stimulation, the stronger is the extent of the physicochemical processes and the higher is the production (Wei *et al.*, 2003).

The production is higher when trees are stimulated using 2.5% than with 5 % Ethephon. Previous surveys have shown that 2.5 % is more effective and more adapted to the downward tapping than 5% (Obouayeba, 1993). Our experiment was conducted using the downward tapping procedure, hence the greater effectiveness of the 2.5% Ethephon concentration. When using the downward tapping method, an increase in the concentration of active ingredient most likely becomes toxic to the trees, possibly due to an overdose effect. Furthermore, with this method, the compensation for low tapping frequency by increasing the stimulation frequency is a better choice than increasing the concentration of active ingredient, which would be more costly (Vajayakumar *et al.*, 2003, Hashim, 1988).

With the same tapping frequency, the rate of girth increment decreased as the stimulation intensity increased. Increased stimulation intensity therefore has a depressive effect on tree growth, without significantly increasing production.

According to our observations, with the same number of stimulations, reducing the tapping frequency (therefore tapping intensity) would induce an increase in tree circumference, which shows increased growth. Since the growth potential is negatively correlated with rubber production (Tjasadihardja, 1988; Gohet, 1996), the depressive impact of production on growth would be even higher as the growth potential increases, and vice versa (Obouayeba *et al.*, 2002). The exploitation of the rubber tree, influences its vegetative growth negatively (Templeton, 1969; Wicherley, 1976; Paardekooper, 1989; Obouayeba & Boa 1993; Obouayeba *et al.*, 1996; Obouayeba *et al.*, 2002) since high competition for assimilates and the energy necessary for metabolism commences between vegetative growth and the production of rubber. Concerning the trees on which tapping was not done, there is no competition and thus normal tree growth occurs. All assimilates and energy are directed to vegetative growth, resulting in to the highest girth increments recorded.

The dry rubber contents (DRC) were observed to be good at the beginning and at the end of the experimentation period. These contents increased at the end of the experimentation for all the tapping systems, which indicates strong activity of the regeneration metabolism. This activity was higher in the tapping systems that have low tapping frequency than in the control. The reconstitution of the latex stock that is extracted during tapping needs a certain period of time (Compagnon, 1986; Lacrote, 1991). The longer this period of time is, the higher is the reconstruction and the more the dry rubber content realised. The period of time between two consecutive tappings was longer in d/6 than in d/4, and this explains the fact that the dry rubber content of the d/6 treatment is higher than that of d/4 treatment (Rajagopal *et al.*, 2003; Wei *et al.*, 2003). For the same reason, high dry rubber content was noted on the trees on which tapping was not done.

The latex sucrose contents, which are low on the whole at the beginning of the experiment, were high at the end. The increase in sucrose contents of all the tapping systems shows a good supply of the laticiferous (cells which produce latex) during successive tappings. The trees that were not tapped, and those tapped every six days (d/6) but not stimulated, had the highest sucrose contents. Increased tapping and stimulation thus would appear to induce a decrease in the sucrose content, which is the principal substrate for isoprenic synthesis. Except for the tapping systems d/6 and stimulated 26 and 52 times per year at the concentration of 5 % Ethephon, the tapping systems with low tapping frequency on the whole show sucrose contents in the same order as the one of the control (treatment 2). Reducing the tapping frequency from d/4 to d/6, in addition to an increase in the stimulation intensity has therefore no significant effect on the sucrose content.

Nevertheless a decrease in the sucrose content was observed along with an increase in stimulation intensity, possibly due to the fact that when the tapping number increases, the activation of laticigenous metabolism for rubber production increases and will consume more sucrose and thus produce more rubber (Compagnon, 1986). This phenomenon is amplified by the hormonal stimulation (Compagnon, 1986). Until the limit of 26 stimulations per year, this is explained by an important metabolisation of the imported sucrose (Lacrote, 1991) along with the increase in the stimulation intensity. Beyond 26 stimulations per year, the sucrose contents always decrease along with the increase in the stimulation intensity. This decrease of the sucrose contents is nevertheless not attributable to an important metabolisation of the sugars in the sense that the noted productions are the lowest. The latex sucrose content differential in this case can make reserves (starch) (Prevot *et al.*, 1986).

The inorganic phosphorus contents of the latex increase with time, possibly due to activation of the energetic laticigenous metabolism during tapping and the successive stimulations (Jacob *et al.*, 1988). The good levels of rubber production noted corroborate this. The tapping systems with reduced tapping frequency show latex inorganic phosphorus content superior to the one of the control (treatment 2). The availability of energy that is necessary for rubber synthesis is therefore higher with the systems with reduced tapping frequency than with the control (treatment 2). The untapped trees, the tapped trees (treatment d/6, not stimulated) and the control trees had the lowest inorganic phosphorus content owing to absence or only little tapping, and the absence of hormonal stimulation. The low Pi content is due to a weak activation of the energetic metabolism of the laticiferous (Jacob *et al.*, 1988).

The contents in thiol decreased relatively during the tapping to remain below the normal level. The systems with low tapping frequency had the same thiol content as the absolute and relative controls. Therefore, reduction in tapping frequency from d/4 to d/6, compensated for by increased stimulation intensity has no negative effect on thiol content.

On the overall it is observed that the systems with low tapping frequency induce high dry rubber contents which is a sign of good biosynthesis of rubber; good sucrose content which illustrates a good supply of the laticiferous in sugar; good inorganic phosphorus contents, which ensures availability of the energy necessary for rubber synthesis; and normal thiol content compared to those of the controls, which indicates enzyme availability assuring colloidal stability during the isoprenic synthesis process. The systems with reduced tapping frequency have no negative effect on the physiological profiles of the trees (Hashim, 1988; Wei *et al*, 2003).

In all cases the profit margins were positive. The profit margin in treatment 6 (weekly tapping stimulated 26 times per year with 2.5% active ingredient) are superior to the control when the tapping manpower cost per working day is higher than or equal to 6 US $. The important saving of manpower (33 %) compensates, in terms of profit margins, the losses in rubber production caused by the tapping frequency reduction (Hashim, 1988; Vijayakumar *et al.*, 2003; Wei *et al.*, 2003).

This study demonstrates that with clone PB 217, it is possible to remedy an insufficiency and high cost of rubber tapping manpower by applying systems with low tapping frequency with production compensated for by hormonal stimulation. A reduction of 33 % in tapping frequency corresponding to 33 % less requirement for tapping manpower was achieved by changing from tapping every four days to tapping every six days. This change can be effected without any negative effect on the vegetative state of the trees as well as on their physiological profile. Furthermore, these changes extend the economic life span of the trees by up to 25 %. We recommend the adoption of these better and sustainable management systems for rubber tree farms, which significantly reduce needs and cost for tapping labour, and hence increase income and the profitability of rubber tree farmers.

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