

## **Original Research Article**

### **EFFECT OF EARLY UPWARD TAPPING ON RUBBER PRODUCTIVITY OF CLONE PB 260 OF THE FAST METABOLIC ACTIVITY CLASS**

#### **Abstract**

In order to evaluate the effect of early upward tapping on rubber productivity of rubber trees and to determine its proportion relative to downward tapping, a study was conducted at SAPH Divo on the PB 260 clone of the fast metabolic activity class. The experimental set-up was a Fisher block with seven treatments and three replications. Tapping was carried out in d3 with 6 stimulations. Three upward tapping times at 6, 7 and 8 years, each coupled with two concentrations of the stimulating paste 2.5 and 5% of Ethephon and a downwardly tapped control stimulated with 5% of Ethephon were tested. The data collected were for rubber production, isodiametric growth, tapping panel dryness susceptibility and tree physiological profile. The results showed that the different treatments tapped in upward at 6, 7 and 8 years of age significantly improved the productivity of the PB 260 clone relative to the control by descending for nine years. All treatments combined, rubber productivity ( $4723 \text{ kg.ha}^{-1}.\text{yr}^{-1}$ ) and radial vegetative growth ( $3.8 \text{ cm.yr}^{-1}$ ) were good. The gain in rubber productivity of the early upward tapping compared to the downward tapping was 42%. The tapping panel dryness rate was low at 2.6% and the physiological profile of the trees was well balanced. Our results suggest that PB 260, and therefore metabolically active clones, can be tapped in early upward tapping, especially at 6 years of age.

**Key words:** tapping, upward, early, productivity

**Comment [Dr. Nas1]:** keywords are written alphabetically

## 1. INTRODUCTION

*Hevea brasiliensis* Muell Arg. (Euphorbiaceae) is a tropical plant species cultivated for its latex, used in innumerable fields (tires, medicine, etc...). The exploitation of rubber trees can last more than thirty years [1, 2]. In Côte d'Ivoire, this thirty-year period of latex harvesting is carried out in two distinct phases. The first phase consists of alternately exploiting the two low panels (BO) in descending tapping for nine years [3]. This phase is immediately followed in the tenth year by the second phase, which consists of exploiting the high panel (HO) in quarter spiral for four years [4]. At the end of this first series of four years of upward tapping, which ends in the 13th year of tapping of the rubber tree, a second series of downward tapping (14th and 15th years) is carried out. This is followed by the second series of four years of upward tapping completing the tapping on virgin bark.

This current tapping panel management scheme [4] in the African rubber region is effective since these two phases are characterized by an increasing gradient of rubber productivity [4, 5]. Despite this increasing productivity, non-industrial rubber farmers expect more. This is especially true since this environment is characterized by, among other weaknesses, a very high consumption of bark [5], which further complicates the management of their bark capital, according to the tapping panel management scheme of Gohet *et al* [4]. Where possible, they want to have latex harvesting systems that provide a higher return on investment in a short period of time [3]. This aspiration can only be met by adjusting the downward tapping time. In particular, by shortening it and replacing the delay gap with upward tapping, which is much more productive and whose yield is at least 25% higher than that of downward tapping [5]. However, the proportion of this improvement in rubber productivity due to upward tapping is not known, especially in relation to latex harvesting technology and clone metabolism. For it is known that latex harvesting technologies giving high rubber production induce dry notching and exacerbate trees, reducing radial vegetative growth and creating physiological disorder.

Thus, our study aims to evaluate the productivity of rubber trees and to determine the proportion of productivity differential of early upward tapping versus down tapping of clone PB 260 during four years of latex harvesting. Specifically, to determine the effect of early upward tapping on:

- rubber productivity ;
- radial vegetative growth;

**Comment [Dr. Nas2]:** tapping is done at a height of 130 cm - 300 cm from the ground. Tapping on the top tapping plane is done using the upward tapping method. In general, the top tapping is done when the bottom tapping field has been exhausted, but not a few rubber plantations also perform these two tapping techniques simultaneously to optimize latex productivity.

**Comment [Dr. Nas3]:** bottom tapping technique where the height of the tapping field starts from the ground level to a height of 100 cm and the tapping direction is from the top left to the bottom right towards the base of the stem.

**Comment [Dr. Nas4]:** Add citations from recent journals to support your statement

**Comment [Dr. Nas5]:** add excerpts from the latest journals to achieve your goals

- the rate of trees affected by tapping panel dryness;
- physiological profile.

**Comment [Dr. Nas6]:** it is advisable to add citations from the most recent journals placed before the research objectives paragraph to support the research objectives

## 2. MATERIALS AND METHODS

### 2.1. Materials

#### 2.1.1. Study site

The experiment was conducted in the rubber plots of the Société Africaine de Plantation d'Hévéa (SAPH) in Divo, from October 2012 to December 2016. The plots of this company are located in Divo in east-central Côte d'Ivoire, between 5°49' north latitude and 5°22' west longitude. The department of Divo is subject to a tropical and rainy climate characterized by an average temperature at Divo of 25.3°C and annual rainfall of 1388 mm.

**Comment [Dr. Nas7]:** add the data source so that the data submitted can be justified scientifically

#### 2.1.2 Plant material

The plant material used consists of *Hevea brasiliensis* clone PB 260. This clone is of the fast metabolic activity class and is one of the most planted clones in Côte d'Ivoire, as it is considered a high producer. This clone originates from Malaysia and is a genetic cross of PB 5/51 × PB 49 [6]. Bahan tanaman yang digunakan terdiri dari klon *Hevea brasiliensis* PB 260.

**Comment [Dr. Nas8]:** add a data source stating this statement

### 2.2. Methods

#### 2.2.1. Experimental setup

Trees of clone PB 260 were planted in a straight line at a density of 510 trees per hectare (7m x 2.8m). The experimental design used is a Fisher block, composed of 7 treatments repeated three times with 25 trees per elementary plot. These different plots were bled when 50% of the selected trees had a circumference of 50 cm at 1 m above the ground. Pohon klon PB 260 ditanam secara berjajar dengan kerapatan 510 pohon per hektar (7m x 2,8m).

**Comment [Dr. Nas9]:** If this experiment is adopted and modified from the journal, please write

#### 2.2.2. Treatment

Trees in the elementary plots were opened in October 2012 in upward tapping at 1.25 m above the ground on panel A (HO-1), in the 6th, 7th, 8th year after five years of downward tapping on panels A (BO-1) and B (BO-2) (Table I).

**Comment [Dr. Nas10]:** Are there data sources that support this statement?

**Table I:** treatments applied to clone PB 260 in October 2012

N°	Treatments	abbreviations	Designation
1	S/4 U d3 6d/7 ET 5% Pa 1(1) 6/Y ( <b>6 years</b> ) :	(6 years, 5%ET)	Quarter-spiral tapping at 6 years of age every three days, six working days out of seven; stimulated with 5% concentrated ethephon at a rate of 1 g of stimulant on a 1 cm wide strip; 6 stimulations performed per year
2	S/4 U d3 6d/7 ET 2.5% Pa 1(1) 6/Y ( <b>6 years</b> ) :	(6 years, 2.5%ET)	Quarter-spiral tapping at 6 years of age every three days, six working days out of seven; stimulated with 2.5% ethephon concentrate at a rate of 1 g of stimulant on a 1 cm wide strip; 6 stimulations performed per year
3	S/4 U d3 6d/7 ET 5% Pa 1(1) 6/Y ( <b>7 years</b> ) :	(7 years, 5%ET)	Quarter-spiral tapping at 7 years of age every three days, six working days out of seven; stimulated with 5% concentrated ethephon at a rate of 1 g of stimulant on a 1 cm wide strip; 6 stimulations performed per year
4	S/4 U d3 6d/7 ET 2.5% Pa 1(1) 6/Y ( <b>7 years</b> ) :	(7 years, 2.5%ET)	Quarter-spiral tapping at 7 years of age every three days, six working days out of seven; stimulated with 2.5% ethephon concentrate at a rate of 1 g of stimulant on a 1 cm wide strip; 6 stimulations performed per year
5	S/4 U d3 6d/7 ET 5% Pa 1(1) 6/Y ( <b>8 years</b> ) :	(8 years, 5%ET)	Quarter-spiral tapping at 8 years of age every three days, six working days out of seven; stimulated with 5% ethephon concentrate at a rate of 1 g of stimulant on a 1 cm wide strip; 6 stimulations per year
6	S/4 U d3 6d/7 ET 2.5% Pa 1(1) 6/Y ( <b>8 years</b> ) :	(8 years, 2.5%ET)	Quarter-spiral tapping at 8 years of age every three days, six working days out of seven; stimulated with 2.5% ethephon concentrate at a rate of 1 g of stimulant on a 1 cm wide strip; 6 stimulations performed per year
7	S/2 d3 6d/7 ET 2.5% Pa 1(1) 6/Y ( <b>control</b> ):	(10 years, 5%ET)	Downward half-spiral tapping every three days, six working days out of seven; stimulated with ethephon concentrated at 5% at a rate of 1 g of stimulant on a 1 cm wide strip; 6 stimulations are practiced per year (upward tapping at 10 years with 5%ET)

### 2.2.3. Trial conduct and data collection

- **Production data**

Rubber production data were collected by tapping trees in the elemental plots in quarter spiral every 3 days (d3), with 6 annual stimulations (6/y). The stimulating paste is concentrated at 5 or 2.5% active ingredient which is chloro-2-ethyl phosphonic acid or Ethephon (ET5% Pa1(1) or (ET2, 5% Pa1(1)). The collection lasted four years, alternating annually between tapping panels A (HO-1), B (HO-2), C (HO-3) and D (HO-4). Rubber production from each treatment was weighed every 4 weeks using a scale. Samples of fresh rubber were collected for each treatment to determine the Coefficient of Transformation (CT), which is the percentage of dry matter in a given rubber sample, which was used to calculate the production of dry rubber expressed in grams per tree per tapping ( $\text{g t}^{-1} \text{t}^{-1}$ ) and in kilograms per hectare per year ( $\text{kg ha}^{-1} \text{y}^{-1}$ ).

- **Radial vegetative growth**

At the beginning of the experiment, and then once a year in December, the circumference of the trunk of the trees was measured at 1.70 m from the ground with a tape measure. The average annual increase in circumference was determined by the following relationship:

$$Gi (\text{cm year}^{-1}) = G_n - G_{n-1}. (1)$$

Where  $G_n$  is the mean girth of trees in the year  $n$  and  $G_{n-1}$ , the mean girth of trees in the year  $n-1$ .

- **Tapping panel dryness**

The quick measurement method of tapping panel dryness was done by visual assessment. The trees were scored on a 0- 6 scale based on the progress of tapping panel dryness (TPD). The percentage of trees completely dry (TPD) was determined by the following relation:

$$TPD (\%) = (n6 + DT) \times N^{-1}$$

With:  $N$ : Total number of trees;  $DT$ : Number of trees which tapping has been already stopped because of total tapping panel dryness (Dry Trees).  $n6$  : For each treatment, the percentage of trees completely dry

- **Physiological parameters**

Latex was collected for the realization of the latex micro diagnosis (LMD) in view of the physiological state of the trees studied through the dry extract rate (Ex.S) of the latex and the contents of sucrose (Sac), inorganic phosphorus (Pi) and thiol group of the latex. The dry extract content was determined according to the method described by Eschbach *et al.* [6], while the methods of Ashwel [7], Taussky and Shorr [8], Boyne, and Ellman [9] were used to determine

**Comment [Dr. Nas11]:** Is this equation adopted from a journal or book, if yes please write it down

**Comment [Dr. Nas12]:** Is this equation adopted from a journal or book, if yes please write it down

the sucrose, inorganic phosphorus, and thiol group contents of latex, respectively. The MDL data were analysed based on the reference values established by Jacob et al. [10]. The results were expressed in millimoles per litre of latex ( $\text{mmol l}^{-1}$ ) from the coefficients of the calibration ranges.

- **-Statistical Analysis**

The collected data were processed using XL-STAT statistical software. An analysis of variance was performed to determine the level of significance. The difference between the means was estimated by the NEWMAN-KEULS test at a threshold of 5%.

### 3. RESULTS

#### 3.1. Rubber production

The average annual production at the tree and at the tapping stage was  $111.0 \text{ g t}^{-1} \text{ t}^{-1}$ , all treatments combined (Table II). It varied significantly according to the treatment (84 to  $130 \text{ g t}^{-1} \text{ t}^{-1}$ ). The production of treatments 1 (6 years, ET5%;  $126 \text{ g t}^{-1} \text{ t}^{-1}$ ), 2 (6 years, ET2.5%;  $126 \text{ g t}^{-1} \text{ t}^{-1}$ ) and 3 (7 years, ET5%;  $130 \text{ g t}^{-1} \text{ t}^{-1}$ ) are statistically identical to each other and were significantly higher than those of the downwardly tapping control (10 years, ET5%;  $84 \text{ g t}^{-1} \text{ t}^{-1}$ ) and treatments 5 (8 years, ET5%;  $90 \text{ g t}^{-1} \text{ t}^{-1}$ ) and 6 (8 years, ET2.5%;  $86 \text{ g t}^{-1} \text{ t}^{-1}$ ).

Similarly, the average annual rubber yield expressed in  $\text{kg.ha}^{-1}.\text{yr}^{-1}$  for all treatments combined, under early upward tapping, was  $4612 \text{ kg.ha}^{-1}.\text{yr}^{-1}$ . It was influenced by the treatment and ranged from 3566 to  $5239 \text{ kg.ha}^{-1}.\text{yr}^{-1}$ . Treatments 1 (6 years, ET5%;  $5488 \text{ kg.ha}^{-1}.\text{yr}^{-1}$ ), 2 (6 years, ET2.5%;  $5373 \text{ kg.ha}^{-1}.\text{yr}^{-1}$ ) and 3 (7 years, ET5%;  $5354 \text{ kg.ha}^{-1}.\text{yr}^{-1}$ ) had statistically identical and higher yields than the other treatments. However, those of treatments 5 (8 years, ET5%;  $3916 \text{ kg.ha}^{-1}.\text{yr}^{-1}$ ), 6 (8 years; ET2.5%;  $3665 \text{ kg.ha}^{-1}.\text{yr}^{-1}$ ) and the control (10 years, ET5%;  $3335 \text{ kg.ha}^{-1}.\text{yr}^{-1}$ ) were significantly lower by the same amount.

The concentration of the stimulating paste did not significantly influence rubber production.

The overall average productivity gains for all tapped treatments, in early upward, was 42% higher than that of the control.

In general, the production was of a good level and the rubber trees were more productive in the 6- and 7-year-old tapped designs with gains of more than 50%.

**Comment [Dr. Nas13]:** This is discussed in the discussion which states significantly lower by the same amount ... what parameters affect it.

**Comment [Dr. Nas14]:** what is the reason, convey in the discussion

**Comment [Dr. Nas15]:** what is the reason, convey in the discussion  
Does it have anything to do with the effect of the treatment?

**Comment [Dr. Nas16]:** Is this statement a research objective and is it based on economic calculations?

**Table II:** Average dry rubber production of clone PB260, subjected to early upward tapping.

N° Treatments	Average rubber production			
	g.t <sup>-1</sup> .t <sup>-1</sup>	Gain (%)	kg.ha <sup>-1</sup> .yr <sup>-1</sup>	Gain (%)
1 S/4U d3 6d/7 ET5% Pa1(1) 6/y (6 years)	126 ± 15,5 a	50	5488 ± 64,3 a	65
2 S/4U d3 6d/7 ET2.5% Pa1(1) 6/y (6 years )	126 ± 27,4 a	50	5373 ± 11,4 a	61
3 S/4U d3 6d/7 ET5% Pa1(1) 6/y (7 years )	130 ± 14,7 a	55	5354 ± 58,9 a	61
4 S/4U d3 6d/7 ET2.5% Pa1(1) 6/y (7 years )	108 ± 19,6 ab	29	4540± 82,3 ab	36
5 S/4U d3 6d/7 ET5% Pa1(1) 6/y (8 years )	90 ± 7,3 b	7	3916 ± 28,6 b	17
6 S/4U d3 6d/7 ET2.5% Pa1(1) 6/y (8 years )	86 ± 7,0 b	2	3665 ± 30,0 b	10
7 S/2 d3 6d/7 ET5% Pa1(1) 6/y (Control)	84 ± 6,8 b	0	3335 ± 27,9 b	0
<b>Overall average (early upward tapping times)</b>	<b>111 ± 17,6</b>	<b>33</b>	<b>4723 ± 73,3</b>	<b>42</b>

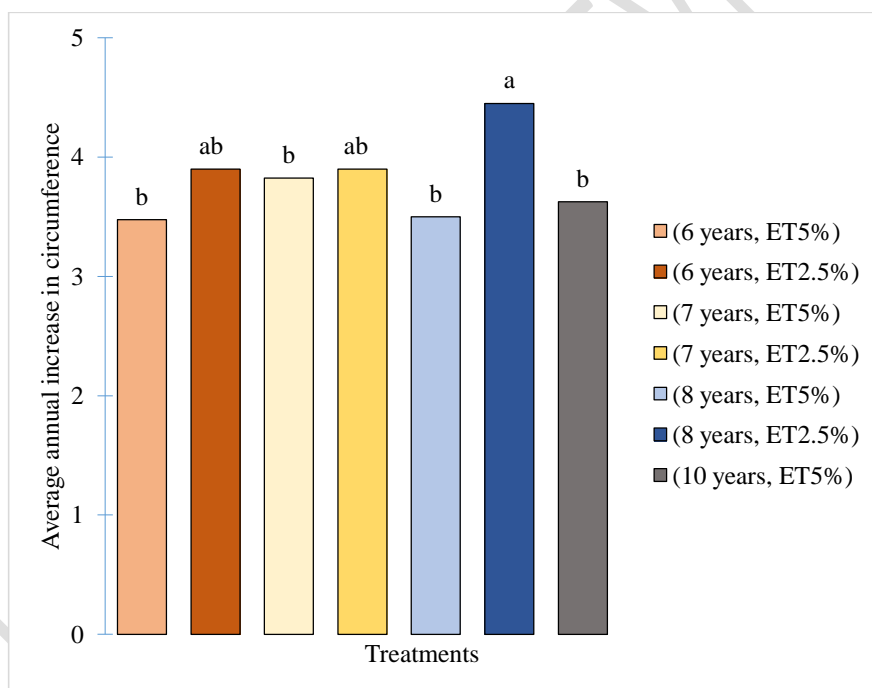
Within a column, the means assigned the same letters are not significantly different (Newman keuls 5%).

**Comment [Dr. Nas17]:** Does this statement have anything to do with the effect of treatment, if yes, please convey it in the discussion accompanied by citations from the latest relevant journals

**Comment [Dr. Nas18]:** add reference of this statement

### 3.2. Radial vegetative growth

The average annual increase in circumference presented in Figure 1 shows that the delay in upward tapping had a significant effect on the radial vegetative growth of the trees with an overall average of  $3.8 \text{ cm} \cdot \text{year}^{-1}$ . The average annual increments are globally of a good level with a variation ranging from 3.5 to  $4.4 \text{ cm} \cdot \text{year}^{-1}$ . The highest average annual increase in girth was obtained with treatment 5 (8 years, 2.5% ET;  $4.4 \text{ cm} \cdot \text{year}^{-1}$ ) tapped in reverse at 8 years with a concentration of 2.5% Ethephon. In addition, for the same year of upward tapping, the average annual increase in girth of trees that received a stimulating paste with a concentration of 2.5% Ethephon was greater than those that received a stimulating paste with a concentration of 5% Ethephon.



**Figure 1:** Average annual girth increase during four years of upward tapping of clone PB 260

**Comment [Dr. Nas19]:** Please share this statement in the discussion, and add quotes from recent journals to support your statement

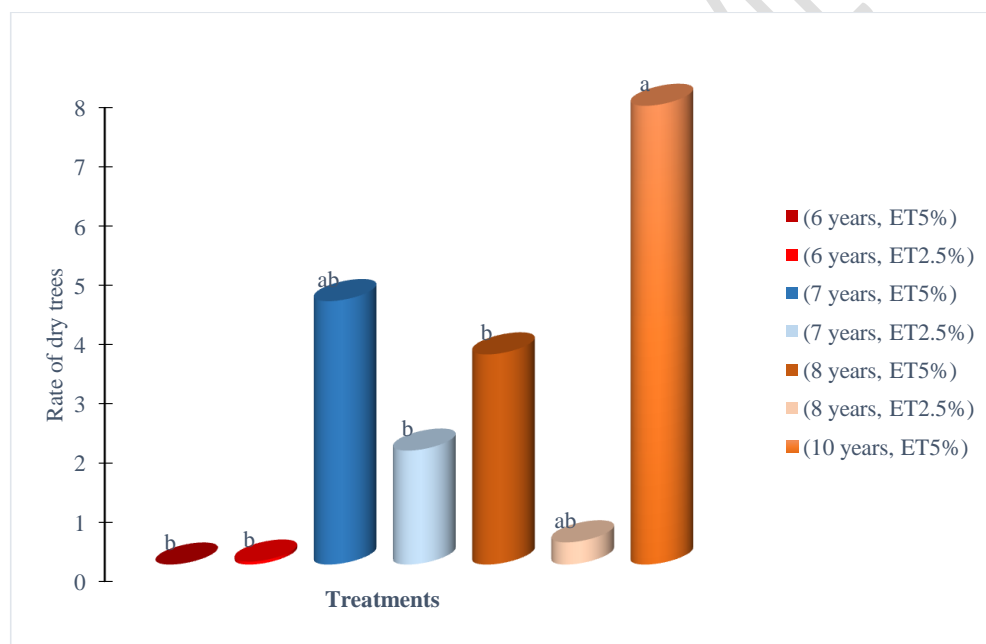
**Comment [Dr. Nas20]:** what is the cause of the difference in results and relate it to the effect of treatment?



### 3.3. Tapping Panel Dryness

The rate of tapping panel dryness for all treatments is presented in Figure 2. The annual average tapping panel dryness rate for all treatments was 2.6%. This rate was low and significantly influenced by treatment. Treatments 1 (6 years, ET5%; 0%), 2 (6 years, ET2.5%; 0%) and 6 (8 years, ET2.5%; 0.3%) yielded nearly zero annual mean rates. The rate of dry trees in the control treatment (10 years, ET5%; 7.75%) was significantly greater than in the other treatments. For the same year of upward tapping, at 6, 7, or 8 years, the designs that received the 5% Ethephon yielded more trees with dry notches.

**Comment [Dr. Nas21]:** What caused the difference, please write in the discussion? also convey the cause of the treatment effect



**Figure 2:** Average annual rate of trees with tapping panel dryness during four years of upward tapping

### 3.4. Physiological profile

The analysis of the dry extract rate shows that both at the beginning and at the end of the experiment, all the trees had very high latex dry extract rates (> 43, reference value; Table III). The average annual rate for all treatments combined was 46.6% at the beginning and 59.1% at the

end of the experiment. At the beginning of the experiment, the dry rubber content varied statistically according to the treatment and fluctuated from 43 to 54.2%. The dry rubber content of treatments 3 (7 years, ET5%; 54%) and 4 (7 years, ET2.5%; 50%) was significantly higher than that of treatments 2 (6 years, ET5%; 45%), 5 (8 years, ET5%; 44%), 6 (8 years, ET2.5%; 43%) and 7 (control, 10 years ET5%; 43%). At the end of the trial, the rates all increased to an overall average of 59% and the different treatments had no significant effect on the dry extract rate.

**Comment [Dr. Nas22]:** The reason for the difference, please convey the discussion and complete it with quotes from the latest journals

At the beginning of the experiment, the average annual sucrose content of the latex, all treatments combined, was very low ( $2.4 \text{ mmol.l}^{-1}$ ) and did not vary relative to the treatment. At the end of the trial, there was an increase in content reaching  $7.7 \text{ mmol.l}^{-1}$ , which is an average content and consistent with that of an active metabolism clone. At the beginning of the trial, the averages per treatment were all the same, while at the end of the experiment the sucrose contents of the latex were influenced by the time of upward tapping. They increased, whatever the treatment. The highest contents were obtained from treatments 2 (6 years, ET2.5%;  $9.8 \text{ mmol.l}^{-1}$ ) and 5 (8 years, ET5%;  $10.4 \text{ mmol.l}^{-1}$ ) and the lowest from treatments 7 (10 years, ET5%;  $5.2 \text{ mmol.l}^{-1}$ ) and 1 (6 years, ET5%;  $5.1 \text{ mmol.l}^{-1}$ ).

**Comment [Dr. Nas23]:** The reason for the difference, please convey the discussion and complete it with quotes from the latest journals

The mean annual inorganic phosphorus content of the latex was average at the beginning and high at the end of the trial, with means for all treatments combined of  $15.5 \text{ mmol.l}^{-1}$  and  $24.3 \text{ mmol.l}^{-1}$  respectively. The Pi content of the latex of the different treatments was statistically different according to the treatment at the beginning and at the end of the trial. At the beginning of the trial, the Pi content of the latex of the control, tapped in reverse at 10 years ( $18 \text{ mmol.l}^{-1}$ ) and of treatments 5 (8 years, ET5%;  $19 \text{ mmol.l}^{-1}$ ) and 6 (8 years, ET2.5%;  $23.6 \text{ mmol.l}^{-1}$ ) were significantly equivalent and higher than those of the other treatments while that of treatment 2 (6 years, ET5%;  $6.3 \text{ mmol.l}^{-1}$ ) was significantly lower. At the end of the trial, the contents were mostly high with contents ranging from  $18.8$  to  $31.5 \text{ mmol.l}^{-1}$ , giving significantly higher and identical values between them, obtained in treatments 1, 2, 3, 4 and 7.

**Comment [Dr. Nas24]:** the extent of the effect of treatment on the differences that occur

The content of thiol compounds in the latex of all treatments is very low at the beginning of the trial ( $0.5 \text{ mmol.l}^{-1}$ ) and then becomes high at the end ( $0.8 \text{ mmol.l}^{-1}$ ) of the trial. All treatments, regardless of the period, gave statistically different levels. However, the trees opened at six years of age had the highest levels of SH-R at the beginning and at the end of the trial.

**Comment [Dr. Nas25]:** what is the cause please discuss

**Table III:** Physiological parameters of latex from trees tapped in upward during four years

N°	Treatments	DRC ( % )		Suc ( mmol.l <sup>-1</sup> )		Pi ( mmol.l <sup>-1</sup> )		R-SH ( mmol.l <sup>-1</sup> )	
		Begin	End	Begin	End	Begin	End	Begin	End
1	S/4 U d3 6d/7 ET5% Pa 1(1) 6/y (6 years)	47 ±3,0 ab	58 ±2,6 a	2,4 ± 1,2 a	5,1 ± 1,1 b	6,3 ± 2,3 c	31,5 ± 6,2 a	0,76 ±0,6a	1,35 ± 0,2 a
2	S/4 U d3 6d/7 ET2.5% Pa 1(1) 6/y (6 years)	45 ±3,3b	59 ± 2,8 a	2,8 ± 1,9 a	9,8 ± 3,2 a	14,1 ± 3,8 b	28 ± 6,01 a	0,56 ± 0,2 ab	0,95 ± 0,2 a
3	S/4 U d3 6d/7 ET5% Pa 1(1) 6/y (7 years)	54±4,2 a	56 ± 2,7a	2,8 ± 1,8 a	7,3 ±2,6 ab	15,3 ± 4,1 b	21,8 ± 3,2 ab	0,52 ± 0,6 ab	0,64 ± 0,2 ab
4	S/4 U d3 6d/7 ET2.5% Pa 1(1) 6/y (7 years)	50 ±3,7 a	60 ± 2,6a	3,6 ± 2,1 a	8,3 ± 2,8 ab	13 ± 3,2 b	22,9 ± 3,4 ab	0,63 ± 0,8 ab	0,64 ± 0,2 ab
5	S/4 U d3 6d/7 ET5% Pa 1(1) 6/y (8 years)	44 ±3,5b	62 ± 2,7a	1,6 ± 1,2 a	10,4 ± 3,7a	19 ± 4,2 ab	19,8 ± 4,3 b	0,54 ± 0,3ab	0,66 ± 0,2 ab
6	S/4 U d3 6d/7 ET2.5% Pa 1(1) 6/y (8 years)	43 ±3,05b	59 ± 2,5a	1,9 ± 1,4 a	8 ±2,6 ab	23,6 ± 3,7 a	18,8 ± 4,1 b	0,59 ± 0,2 ab	0,59 ± 0,2 b
7	S/2 d3 6d/7 ET5% Pa 1(1) 6/y (Control, 10 years)	43 ±3,01 b	60 ±2,3 a	1,5 ± 0,7 a	5,2± 1,1 b	18 ± 4,1 a	27 ± 5,9 a	0,31 ± 0,2 b	0,66 ± 0,2 ab
<b>General averages</b>		<b>47 ±3,3 a</b>	<b>59 ±2,2 a</b>	<b>2,5±1,2b</b>	<b>8,1±3,1a</b>	<b>15,2±3,8 b</b>	<b>26,9±3,4 a</b>	<b>0,6±0 ,1 a</b>	<b>0,8±0,32 a</b>

**Comment [Dr. Nas26]:** This data needs to be discussed comprehensively accompanied by citations that support statements from the latest journals  
The discussion presented is related to the interaction between treatments

In the same column, the means assigned the same letters are not significantly different (Newman keuls 5%)

**Comment [Dr. Nas27]:** what is the cause of the difference in results and relate it to the effect of treatment?

#### 4. DISCUSSION

The study of the effect of early upward tapping on the agrophysiological parameters of clone PB 260, during four years of upward tapping, shows that the average tree and tapping productivity ( $107.00 \text{ g.t}^{-1}.\text{t}^{-1}$ ) and kilogram per hectare ( $4450 \text{ kg.ha}^{-1}.\text{yr}^{-1}$ ) of the different treatments are good. This productivity at the tree and at the tapping is largely superior to the average productivity (between 65 and  $80 \text{ g.t}^{-1}.\text{t}^{-1}$ ) in downward and upward tapping obtained from the works of [10-14]. Moreover, the yield obtained is higher than the national average annual yield of  $1700 \text{ kg.ha}^{-1}.\text{yr}^{-1}$ , which is among the best in the world. These results show that early upward tapping positively affects tree production, and despite the reduction in notch length from half spiral in downward tapping to quarter spiral in upward tapping, upward tapping is significantly more productive. This result is contrary to the findings of [10] analysing the effect of reducing the length of the tapping notch on the productivity of the rubber tree. According to this work, short notches are less metabolically active than long notches. However, this result further confirms the fact that a properly exploited short notch, good tapping frequency and good concentration of stimulating pulp Etherephon, is at least as productive as a long notch [14]. Furthermore, they confirm the findings of the work of many authors who have shown that upward tapping produces 25% more than downward tapping [5, 15].

Despite the good production level of the PB 260 clone, the average annual increase in trunk circumference of the trees is also of a good level. This result reflects the fact that the photosynthates necessary for latex production (secondary metabolism) within the laticifers [16], and for primary biomass production are consequently available to feed these two metabolisms equally within the tree. It also indicates a low impact of rubber production on tree trunk thickness growth [17]. In this respect, the highest intra-lactose availability could be the one for which the antagonism between growth and production is the lowest [18]. This confirms once again an increased and especially non-limiting intracellular sucrose availability at the PB 260 clone level, regardless of the early upward tapping delay [20,21] Furthermore, early upward tapping trees (6 years, 7 years, 8 years) expressed relatively less sensitivity to tapping panel dryness than the downward tapping control. This result shows that early upward tapping is a practice that elicits less physiological disorder leading to the onset and exacerbation of dry notch. This statement is similar to and corroborates numerous studies [21, 14, 20, 15] conducted under upward tapping.

**Comment [Dr. Nas28]:** In the discussion, add a discussion of interactions between treatments and also add citations from recent journals from relevant journals to support your assertion.

**Comment [Dr. Nas29]:** In this discussion, it is necessary to build an interaction effect between treatments to make it more comprehensive

The occurrence and evolution of tapping panel dryness is not a limiting factor in improving the productivity of a rubber plantation under upward tapping, especially early tapping [21, 3]. The higher rate obtained by down-tapping trees indicates that the applied half-spiral causes an overexploited state in the trees well before upward tapping. These assertions are supported by the findings of studies by Krishnakumar and Jacob [22] on the effect of changing the panel of a tree with tapping panel dryness in rubber trees. This work indicated that once a tree is affected by this disorder, it will likely develop on other panels as well. From this statement, we can deduce that trees bled at 6, 7, 8 years in reverse tapped are less likely to be affected by this disorder.

**Comment [Dr. Nas30]:** It is recommended that the conclusion statement be presented in the conclusion, not in the discussion

In terms of physiological parameters, the very high latex dry extract rate reflects a high activity of the latex and therefore rubber regeneration metabolism, and the rubber factory, which is the laticifier cell, has been running or functioning with a good yield [23]. This high activity is the same regardless of the time of upward tapping. This justifies a good regeneration of the latex exported in upward tapping, because the dry extracts, the dry matter of the latex, reflect the efficiency of isoprenic syntheses within the laticifere cells as highlighted by Jacob et al. [24].

**Comment [Dr. Nas31]:** high statement whether it can be presented in quantitative form, scientifically there is certainty

The sucrose content was very low at the beginning and average at the end of the experiment. In view of the high Pi content of the latex, this low sucrose content, which is characteristic of metabolically active clones, is probably due to a high utilization of sucrose in the rubber production mechanism. These results corroborate those obtained from the work of many authors [20, 18]. The increase in content at the end of the trial shows that the trees still have a good supply of photosynthates [24].

**Comment [Dr. Nas32]:** What is the stated very low value? Are there any literature references?

Inorganic phosphorus in the latex can be considered as an indicator of the energy intensity of the metabolism of the laticifier cells [25]. Its average and high level expressed by the different treatments is due to the fact that the PB 260 clone of the fast metabolic activity class, like all other clones of this metabolic class, is known to have high inorganic phosphorus contents in the latex [16, 18]. This is one of the characteristics of clones of this metabolic activity class, and is also a good indication that the availability of metabolic energy in the laticifers is not a limiting factor in production. This explains the good rubber productivity of this clone in this study regardless of the latex harvesting technology.

**Comment [Dr. Nas33]:** add quotes from recent journals to strengthen your statement

Thiol groups are a major parameter of latex diagnosis [26], as they determine the physiological state of the laticifers of the bled trees. In our trial, they were low at the beginning, and at a good

level after four years of experimentation. This low level at the beginning is not the result of a weak protection, but rather of the low sugar content, another limiting factor. Indeed, the regeneration of the thiol group also requires energy in the form of ATP and therefore also depends on a part of the sugar available in situ, since it is the origin of the molecular carbon [25, 18].

## 5. Conclusion

At the end of this study, which aimed to evaluate the effect of early upward tapping on the agrophysiological and sanitary parameters of clone PB 260, we can conclude that early upward tapping does not negatively affect the productivity of the trees of this clone, quite the contrary. Productivity was very good overall, but that of the trees tapped in reverse at less than 10 years of age was higher than that of the downward bled trees, with a rate of 42%. In addition, the radial vegetative growth was satisfactory, the tapping panel dryness rate negligible and the physiological profile balanced. From these results, we can conclude that upward tapping can be started as early as the sixth year without risk of negatively affecting the physiological condition of trees of clone PB 260.

**Comment [Dr. Nas34]:** Is there any effect of sugar content on the thiol group. If there is please add a quote to strengthen your statement

**Comment [Dr. Nas35]:** This sentence is recommended to be written at the end of the introduction

**Comment [Dr. Nas36]:** It is recommended that there is no conclusion sentence in the conclusion section

**Comment [Dr. Nas37]:** It is recommended that there is no conclusion sentence in the conclusion section

**Comment [Dr. Nas38]:** It is recommended before the reference to add "Acknowledgments" especially for those who have helped in this research activity

## Références

1. Ahoba A., 2011. Evaluation of some dendrometric characteristics of three *Hevea brasiliensis* Muell clones. Arg. (PR 107, PB 86, GT 1). *Agronomie Africaine*, 23 (3): 227-236.
2. Dusotoit-Coucaud A., 2009. Physiological and molecular characterization of sugar and polyol transporters of laticifers cells in *Hevea brasiliensis*, in relation with latex production. PhD thesis from the University of Auvergne, France, 160 p.
3. Obouayeba S., Soumahin E. F., Lacote R., Essehi J. L., Gohet E. & Obouayeba A. P., 2021. Improvement of the GT 1 moderate metabolism clone of *Hevea brasiliensis* Müll A rg by early upward tapping in Côte d'Ivoire. *American Journal of Bioscience*, 9(1): 25-33.
4. Gohet E., Lacrotte R., Obouayeba S. & Commere J. 1991. Tapping systems recommended in West Africa. Proceeding Rubber Research Institute. Malaya Rubber Growers' Conference 1991, 235–254.
5. Obouayeba S., Soumahin E. F., Boko A. M. C., Dea G. B., Dian K. & Gnagne Y. M., 2008. Improvement of Productivity of Rubber Trees in Smallholding by the Introduction of Upward Tapping in the South-East of Côte d'Ivoire. *Journal Rubber Research*, 11(3): 163-170.
6. Eschbach JM, Roussel D, Van De Sype H, Jacob JL, D'auzac J. 1984. Relationships between Yield and Clonal Physiological Characteristics of Latex from *Hevea brasiliensis*. *Physiologie Végétale*. 1984;22:295-304.
7. Ashwell G. 1957. Colorimetric analysis of sugar. *Methods in Enzymology*. 1957;3:73105.
8. Taussky HH, Shorr E. 1953. A Micro Colorimetric Method for the Determination of Inorganic Phosphorus. *Journal of Biology and Chemistry*. 1953;20:675 - 685.
9. Boyne AF, Ellman GI. 1972. A methodology for analysis of tissue sulphydryl components. *Analytical Biochemistry*. 1972;46:639-653.
10. CIRAD, 1993. Compendium of rubber tree clone files. Perennial crops, Ed Montpellier, France 20 p 53.
11. Obouayeba S., 2009. Low-intensity tapping applied to the *Hevea brasiliensis* clone PB 217 to compensate for a shortage and/or high cost of tapping manpower. Technical sheet, CNRA, Ivory Coast, 6 p.

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**Comment [Dr. Nas46]:** This journal was published 29 years ago, it is recommended to replace the latest relevant journal Journals and other books and sources cited are recommended for publication within the

12. Traoré M. S. 2014. Effects of different annual frequencies of ethylenic stimulation on the agrophysiological parameters of *Hevea brasiliensis* Müll clones. Arg. (Euphorbiaceae), PB 235, PB 260, GT 1 and PB 217 grown in the south-east of Côte d'Ivoire. Doctoral thesis, Félix Houphouët-Boigny University, Abidjan, Ivory Coast, 150 p.
13. Obouayeba S., Boko AMC, Soumahin EF, Elabo AEA, Dea GB, N'guessan BEA, Kouamé C., Zéhi B., & Kéli ZJ, 2016. *Hevea brasiliensis*, component of stable rural production systems: summary of forty years of work, IRRDB Regional Workshop, Yamoussoukro (Côte d'Ivoire), 27 p.
14. Coulibaly L. F., 2012. Latex harvesting techniques adapted to clones of *Hevea brasiliensis* Muell. Arg (Euphorbiaceae): Case of PB 235 in the south-east of Côte d'Ivoire. Doctoral thesis from the University of Cocody, Abidjan (Ivory Coast), 159 p.
15. Jacob J. L., Prévôt J. C., Lacrotte R., Clément A., Serres E. & Gohet E., 1995. Clonal typology of the functioning of laticifers in *Hevea brasiliensis*. *Plantation Research Development*, 2(5): 43-49.
16. Obouayeba S., 2005. Contribution to the determination of the physiological maturity of the bark for tapping *Hevea brasiliensis*. Mull. Arg: Open standards. Doctoral thesis. University of cocody-Abidjan, Ivory Coast, 225 p.
17. Gohet E., 1996. Latex production by *Hevea brasiliensis*. relationship with growth. Influence of different factors: clonal origin, hormonal stimulation, hydrocarbon reserves. University Doctorate Thesis, Montpellier II University. Sciences and techniques of Languedoc, France, 343 p.
18. Diarrassouba M., 2013. Contribution to the definition of latex harvesting technology adapted to clones of *Hevea brasiliensis* Muell. Arg (Euphorbiaceae) active, moderate and slow metabolic activity classes. Doctoral thesis from the University of Cocody-Abidjan (Côte d'Ivoire), 207p.
19. Soumahin E. F., 2010. Optimization of rubber farming systems by reducing tapping intensities. Doctoral thesis, Cocody University, Abidjan (Ivory Coast), 149 p.

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20. Vijayakumar K. R., Thomas K. U., Rajagopal R. & Karunaichamy K. 2003. Response of Hevea clone to low frequency tapping. Proceed International Work Exploitation Technology, India, pp 17-42.
21. Jacob JL, Prévôt JC, Lacote R., Gohet E., Clément A., Gallois R., Joet T., PujadeRenaud V. & d'Auzac J. [1998]. The biological mechanisms of rubber production by Hevea brasiliensis . Plantation Research Development, 5-13.
22. Krishnakumar, R., Jacob, J., 2003. Over production of endogenous ethylene inhibits rubber biosynthesis in Hevea brasiliensis. In: Bioprospecting of commercially important plants. Proceedings of the national symposium on "Biochemical approaches for utilization and exploitation of commercially important plants", Jorhat, India, 12-14 Nov. Indian Society of Agricultural Biochemists, 2004. p. 198-201.
23. Obouayeba S. & Boa D., 1993. Frequency and annual rest of bleeding of Hevea brasiliensis, clone PB 235, in the south-east of Côte d'Ivoire. Agriculture Notebook, 2 (6): 387 – 393.
24. Jacob JL, Serres E, Prevot JC, Lacrotte R, Clement-Vidal A, Eschbach JM. [1988]. Development of latex diagnostics. Grtrop. 12(2):97-118.
25. Lacrotte R., 1991. Study of the relationship between the sugar content of latex and production: approach to the mechanisms of sucrose loading in laticifers of Hevea brasiliensis Muell. Arg. University Doctorate Thesis, University of Sciences and Techniques of Languedoc, Montpellier II (France), 266 p
26. Jacob J. L., Serres E., Prévôt J. C., Lacrotte R., Clement-Vidal A., Eschbach J. M. & D'Auzac J., [1988]. Development of latex diagnostics. Agritrop, 12: 97-118.

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