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Effect of tapping systems and height of tapping opening on clone PB 235 agronomic parameters and it's susceptibility to tapping panel dryness in south-east of Côte d'Ivoire

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ABSTRACT
Objectives: An experiment in southeast of Côte d'Ivoire on the combined effect of tapping systems and height of opening on clone PB 235 agronomic parameters and susceptibility to tapping panel dryness was led in order to determine the best exploitation system.
Methodology and results: The clone was planted at the density of 510 trees per hectare (7 m x 2.80 m) comparing two tapping systems S/2 d3 6d/7 ET2.5% Ba2(2) 2/y(m) (high tapping intensity) and S/2 d4 6d/7 ET2.5% Pa1(1) 8/y(m) (low tapping intensity) and two opening heights (1.20 m and 0.75 m above ground level) using a split-plot lay out. Measurements included yield, growth, and rate of tapping panel dryness (TPD), dry rubber and sucrose contents. Results shown that the opening of clone PB 235 at 0.75 m doesn't affect significantly growth but gives lower yields and higher rates of TPD mainly with high tapping intensity. Intensive tapping results in a decrease of sucrose content and significant increase in the rate of TPD.
Conclusions and potential application of findings: The opening height has significant effect on clone PB 235 yield but not on it's growth. Tapping intensity could be the main factor of the appearance of clone PB 235 TPD. Opening trees at 0.75 m above the ground cannot be practical in the exploitation system of this clone. The lower tapping frequency (S/2 d4 6d/7) combined with high intensity of stimulation (8/y(m)) allows a better carbohydrates supply and enhances the maintaining of a better sucrose availability. The low tapping intensity S/2 d4 6d/7 8/y(m) at 1.20 m above ground level is the best one that need to be applied on clone PB 235.
Keywords: clone PB 235, tapping systems, opening height, tapping panel dryness.

INTRODUCTION
Together with wind breakage, tapping panel dryness (TPD) is considered today as one of the main factors limiting land productivity in rubber estates (Commère *et al.*, 1989). The cause has not yet been identified, but numerous studies have shown that intense exploitation enhances occurrence of panel dryness (Eschbach *et al.*, 1989). Each clone of *Hevea brasiliensis* has its

own intrinsic characters. Thus, PB 235 is reputed to be a high-yielding clone with an active metabolism and is known particularly to be susceptible to tapping panel dryness (Sivakumaran *et al.*, 1988; Commère *et al.*, 1989; Eschbach *et al.*, 1989; Anonymous 1, 1991; Obouayeba et Boa, 1993; Obouayeba *et al.*, 2006). The purpose of this study is to describe the combined effect of tapping systems and height of opening on agronomic parameters and susceptibility of PB 235 to tapping panel dryness. So the work consisted particularly in investigating the effect of two tapping systems with two opening heights on cumulative yield, girth, dry rubber content, sucrose content and rate of tapping panel dryness on six years old experiment in south-eastern Côte d'Ivoire.

MATERIALS AND METHODS

The experiment whose results are described, was set up at the CNRA experimental station, in south-east of Côte d'Ivoire. At the beginning of the trial, clone PB 235 plot was planted as budded stumps in June 1977 at the density of 510 trees per hectare (7 m x 2.80 m) and opened for tapping in November 1981. Trees was chosen according to their homogenous girth, trunk regularity and unstimulated yield. In addition, the trees studied are chosen to have a circumference not less than 50 cm at 1 m above the ground level. The study included 4 replicates with 0.1 hectare per elementary plot that represent a total of 0.4 hectare for each combination (main and secondary treatments). A split-plot statistical method was used with the following characteristics:

Main treatments including two types of tapping systems and their description:

Type 1: S/2 d3 6d/7 ET2.5% Ba2 (2) 2/y (m) (High tapping frequency and low stimulation frequency)

Half spiral downward tapping at three days frequency, six days tapping followed by one rest day; stimulated with Ethrel at 2.5% of Ethephon (active ingredient) with 2 g of stimulant applied on scraped bark on 2 cm band, 2 applications per year at monthly interval.

Type 2: S/2 d4 6d/7 ET2.5% Pa1 (1) 8/y(m) (Low tapping frequency and high stimulation frequency)

Half spiral downward tapping at four days frequency, six days tapping followed by one rest day; stimulated with Ethrel at 2.5% of Ethephon with 1 g of stimulant applied on panel on 1 cm band, 8 applications per year at monthly interval.

Secondary treatments including two opening heights:

Height 1: opening on virgin bark of the first low panel (BO-1) at 1.20 m above the ground level.

Height 2: opening on virgin bark of the first low panel (BO-1) at 0.75 m above the ground level

The tapping was performed in half-spiral for both main treatments at variable frequencies: every three days and four days intervals. Scraped bark was stimulated two times per year with 2 g of oil palm mixture containing Ethrel (at 2.5% of Ethephon: active matter) in the first main treatment. While 1 g of oil palm mixture containing Ethrel (at 2.5% of Ethephon: active matter) is applied onto the cutting in the second main treatment. Panel management of the four combinations (main treatments and secondary treatments) during the experimental period is shown in Figure 1. Latex was collected in polyethylene bags once monthly and measurements were analysed annually:

The yield assessment was made per tree by weighting the cumulate coagulate rubber every four weeks (28 days) as following:

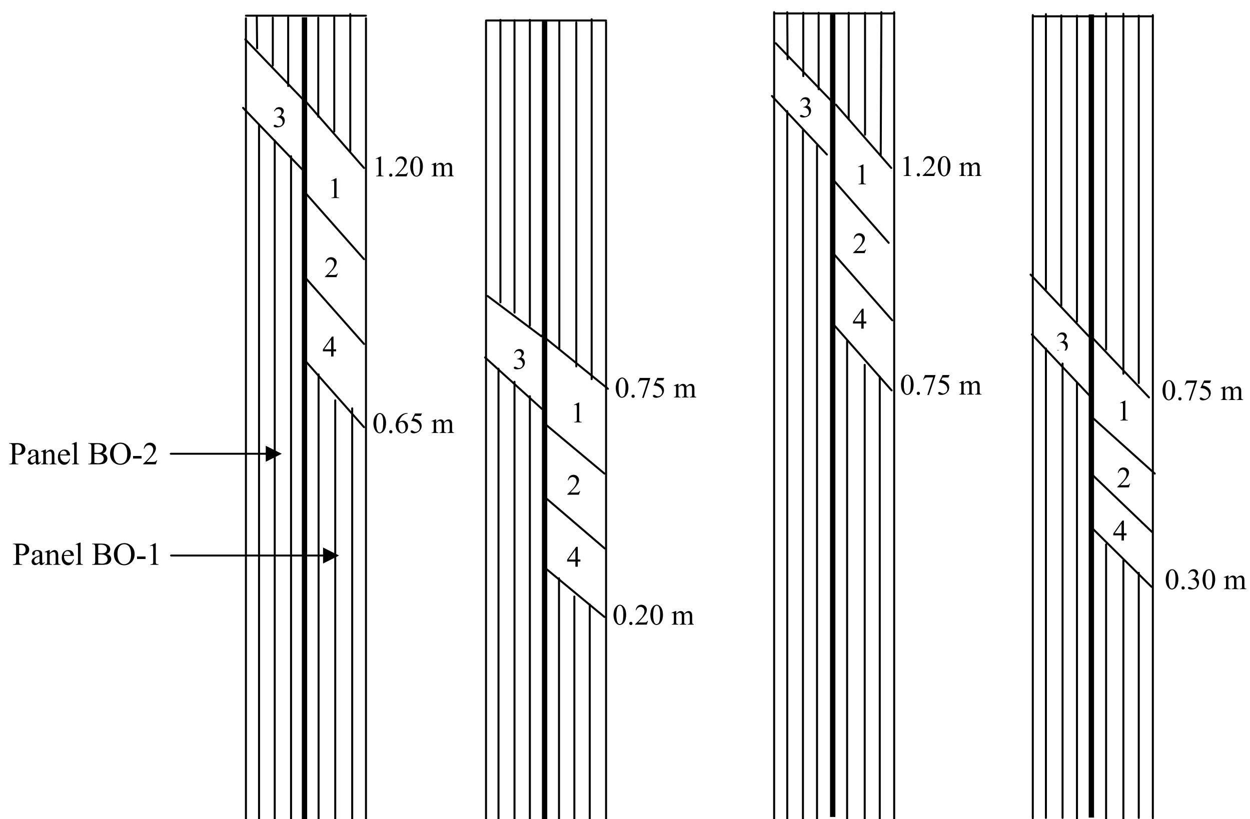
- Cumulated yield in gram of dry rubber content per tree (g/t) from opening in November 1981 to March 1986;
- Yield in gram of dry rubber content per tree (g/t) from the latest physiological season in April 1985 to March 1986;
- Girth measurement in centimetre (cm) at 1.70 m above the ground level;
- Rate (%) of Tapping Panel Dryness or (TPD) determined by visual estimation of dry tapping cuts (Anonymous 2).

The rates were estimated by the rapid visual assessment method. During tapping execution, the technician follows the tapper and estimates the length of dry tapping cuts. Determination of DTP consists in attributing to tapped trees a notation between "0" and "6", according to the severity of the panel dryness. The note "0" means that the whole length of tapping cut is healthy; while note "6" means that the tree tapped doesn't produce any latex and the tapping has to be stopped consequently. Trees that are fallen down, broken or affected by leaves disease were not taken in account. Finally, total length cut dryness (TLCD) was determined as follow:

TLCD = (0.1 n_1 + 0.3 n_2 + 0.5 n_3 + 0.7 n_4 + 0.9 n_5 + n_6) / N;

For each considered category coefficient is defined as an average of tapping panel dryness (TPD) percentage; n_i is the number of trees per category of dry tapping cut. But n_6 particularly is the number of trees whose tapping cut is totally dried and trees whose tapping was stopped due to total panel dryness; N is the total number of the whole trees categories.
In physiological parameters of latex, only sucrose content was determined. Latex was exudated through a puncture wound just below the tapping cut in order to determine sucrose and dry rubber contents within latex from different treatments. The rate of dry rubber content was measured using 1 ml latex sample of each treatment. This latex was weighed and dried in an oven at 80 °C during 24 h. Dry rubber content, expressed as a percentage, is defined as follow: Dry rubber content = 100 (dry weight/fresh weight). Sucrose content was measured with tricloroacetic acid (TCA) serum. This serum is obtained from a mixture containing 1 ml of latex and 9 ml of TCA 2.5%. The coagulated rubber was squeeze out and separated from TCA 2.5%. Sucrose content is measured in mmole per litre of latex (mM) by using the method of Ashwell (1957) based on anthrone. In fact, when sucrose is mixed with concentrate acid, it dehydrated itself and turns to a compound which reacts with anthrone giving a green and blue staining. The intensity of this staining is appreciated by a spectrophotometer at 625 nm wavelength (Ashwell, 1957).
Data analysis: All data (cumulative yield, girth, dry rubber content, sucrose content and percentage of cut length affected) were submitted to a variance analysis according to Newman & Keuls test at 5% threshold. Data reported and analysed are from the period between November 1981 and March 1986 when panel management of the two secondary treatments (types and height of opening) were comparable; the only difference for each main treatment method was the height of the tapping cut above the ground level.
Figure 1: Tapping panel management according to the four treatments studied.
1.1. S/2 d3 6d/7 ET2.5% Ba2 (2) 2/y (m) opened at 1.20 m. (High tapping frequency and high opening cut)
1.2. S/2 d3 6d/7 ET2.5% Ba2 (2) 2/y (m) opened at 0.75 m. (High tapping frequency and low opening cut)
2.1. S/2 d4 6d/7 ET2.5% Pa1 (1) 8/y (m) opened at 1.20 m. (Low tapping frequency and high opening cut)
2.2. S/2 d4 6d/7 ET2.5% Pa1 (1) 8/y (m) opened at 0.75 m. (Low tapping frequency and low opening cut)

Panel management



S/2 d3 6d/7 ET2.5% Ba2(2) 2/y(m) S/2 d4 6d/7 ET2.5% Pa1(1) 8/y(m)

Untapped panel Tapped panel

1: Tapping from November 1981 to March 1983 on panel BO-1
2: Tapping from April 1983 to March 1984 on panel BO-1
3: Tapping from April 1984 to March 1985 on panel BO-2
4: Tapping from April 1985 to March 1986 on panel BO-1

RESULTS AND DISCUSSION

Yield: The yield showed a significant effect of opening height on yield independently of the tapping system (the interaction between opening height and tapping system was not significant). The opening at 1.20 m above the ground level gave approximately 7% more rubber than the opening at 0.75 m above the ground level. The results observed confirm a study led on GT1 (Anonymous 3, 1983) when assessing the influence of height of tapping cut. This study revealed that carbohydrate supply was speed up and metabolism activated with opening height by allowing good drainage of latex and consequently by increasing the yield. So, when the tapping height decreases the physiological characteristics particularly sucrose, lutoïds and thiols are altered as the yield (Anonymous 3, 1983) (Table 1). Moreover, the renewed bark below the tapping cut requires large amounts of photosynthesis supply for its tissues regeneration (Anonymous 3, 1983). So the importance of this area limits the photosynthesis supply of the latex producing area (Anonymous 3, 1983). The phenomenon commonly referred to as "panel blockage" (in which yield decreases as the tapping cut approaches the ground) was particularly marked in the physiological tapping season period between 1985 and 1986 for trees opened at 0.75 m (Table 2). At the end of this period, the tapping cut was at 20 cm from the ground level in d3 tapping (55 cm of consumed bark in BO-1 from opening height) and 30 cm from the ground level in d4 (45 cm of consumed bark in BO-1 from opening height) as shown in Figure 1. Tapping cuts were at 65 cm from the ground level in tapping system d3 and at 75 cm from the ground level in tapping system d4 for openings at 1.20 m (Figure 1). During this physiological period yields of trees opened at 0.75 m were 25 to 30% lower than those opened at 1.20 m from the ground level (Table 2) and in which the bark consumption was 45 cm. This could be probably the joint effect of the low metabolite supply to the drained or producing area due to the low down tapping cut position from the ground level and the vicinity of the rootstock/scion union, with varying compatibility between stock and scion tissues.

Table 1: Yield of clone PB 235 in gram of dry rubber per tree (g/t) according to tapping systems and opening heights from November 1981 to March 1986.

	Opening Heights		
Tapping systems	1.20 m (High)	0.75 m (Low)	Average for each tapping system
S/2 d3 6d/7 ET2.5% Ba2(2) 2/y(m) (High)	20 177 **	18 802*	19 490a
S/2 d4 6d/7 ET2.5% Pa1(1) 8/y(m) (Low)	20 104**	18 696*	19 400a
Yield average for each opening height	20 141A	18 749B	19 445

Numbers followed by the same letter or symbol are not significantly different (Newman & Keuls at 5% threshold).

Results obtained are in contradiction with finding of Gener and Duplessix (1971) on clone PB 235 that showed that low opening (0.70 m above the ground level) gave yields in g/t significantly higher than those at 1.20 m. In the same way, Langlois (1969), in a study dealing with height influence on the production of clone PR 107, revealed that latex dry rubber content (DRC) and tapping output were very increased with low opening. According to these authors, low openings, by their low plugging index, were better as increasing yield in comparison to high openings. This finding seems to be in agreement with conclusion of a study led by Wei *et al.* (2008) including different opening heights (from 0 to 7 m above the ground level) on clones PR 107, PB 86, GTI, RRIM 600 and Haiken1. In fact, trunk girth, bark thickness and amounts of laticifers decrease with importance of trunk height (Obouayeba (2005) and Obouayeba *et al.* (2005)).

Under the conditions of the trial, yield from high tapping frequency (S/2 d3 6d/7 ET2.5% Ba2 (2) 2/y(m)) was statistically similar to this one from low tapping frequency (S/2 d4 6d/7 ET2.5% Pa1(1) 8/y(m)) as reported in table 1. The equal yield obtained with the both systems whatever the tapping frequency could be related to the hormonal stimulation. So in comparison to high exploitation system (S/2 d3 6d/7 ET2.5% Ba2(2) 2/y(m)), increasing stimulation frequency in low exploitation system (S/2 d4 6d/7 ET2.5% Pa1(1) 8/y(m)) played a great role in compensating the low tapping frequency. Increasing the frequency of hormonal stimulation led to an increase of latex flow time that allows harvesting important amounts of latex (Jacob *et al.*, 1988).

Table 2: Yield of clone PB 235 in gram of dry rubber per tree (g/t) according to tapping systems and opening heights during April 1985 to March 1986.

	Opening heights		
Tapping systems	1.20m (High)	0.75m (Low)	Average for each tapping system
S/2 d3 6d/7 ET2.5% Ba2(2) 2/y(m) (High tapping and low stimulation frequencies)	5 904***	4 050*	4 977a
S/2 d4 6d/7 ET2.5% Pa1(1) 8/y(m) (Low tapping and high stimulation frequencies)	5 337**	3 904*	4 621b
Yield average for each opening height	5 621A	3 977B	4 799

Numbers followed by the same letter or symbol are not significantly different (Newman & Keuls, 5% threshold).

Girth: All treatments are strictly identical with respect to opening heights allowing to conclude that high opening (1.20 m) enables better management of the antagonism between growth and yield of clone PB 235 (identical girth and significantly greater yield in trees with high tapping cuts). But Gener and Duplessix (1971) showed that the growth of clone PB 235 was better with low opening (0.70 m) than this one at 1.20 m above the ground level (Table 3).

Our results confirmed those obtained by Wei *et al.* (2008) who showed that the trunk girth decreasing with height wasn't very marked as compared to the lowest part of the trunk. The antagonism phenomenon between growth and yield in partition of photosynthesis supplying has been brought up by Wycherley (1976) and studied by Gohet *et al.* (1996). In fact, according to Vollema (1941); Templeton (1969); Obouayeba & Boa (1993); Gohet *et al.* (1996); Obouayeba *et al.* (1996, 2002); Obouayeba (2005), the Hevea growth decreases when yield increases.

Table 3: Girth (cm) of clone PB 235 according to tapping systems and opening heights in January 1986.

	Opening heights		
Tapping systems	1.20 m (High)	0.75 m (Low)	Average for each tapping system
S/2 d3 6d/7 ET2.5% Ba2(2) 2/y(m) (High tapping and low stimulation frequencies)	60.3*	60.8*	60.5a
S/2 d4 6d/7 ET2.5% Pa1(1) 8/y(m) (Low tapping and high stimulation frequencies)	61.0*	60.1*	60.5a
Girth average for each opening height	60.6A	60.4A	60.5

Numbers followed by the same letter or symbol are not significantly different (Newman & Keuls, 5% threshold).

Dry rubber content: Results showed that the opening height influences significantly the dry rubber content. Thus, low opening (0.75 m above the ground level) gave values superior than those with high opening (1.20 m from ground) in both tapping systems. The difference is significant in S/2 d3 6d/7 ET2.5% Ba2(2) 2/y(m) but not in S/2 d4 6d/7 ET2.5% Pa1(1) 8/y(m) where the both opening are statistically comparable (Table 4).

Table 4: Dry rubber content (%) of clone PB 235 according to tapping systems and opening heights, assessed in November 1986.

	Opening heights		
Tapping systems	1.20 m (High)	0.75 m (Low)	Average for each tapping system
S/2 d3 6d/7 ET2.5% Ba2(2) 2/y(m) (High tapping and low stimulation frequencies)	46.43*	54.48**	50.45b
S/2 d4 6d/7 ET2.5% Pa1(1) 8/y(m) (Low tapping and high stimulation frequencies)	48.90*	52.70*	50.80a
Dry rubber content average for each opening height	47.66B	53.59A	50.62

Numbers followed by the same letter or symbol are not significantly different (Newman & Keuls at 5% threshold).

Sucrose content in the drained area: Sucrose content in exploitation system S/2 d4 6d/7 ET2.5% Pa1(1) 8/y(m), whatever the height of opening cuts (1.20 m and 0.75 m), is higher than this one in S/2 d3 6d/7 ET2.5% Ba2(2) 2/y(m). Moreover, sucrose content in S/2 d4 6d/7 ET2.5% Pa1 (1) 8/y (m) at 1.20 m is significantly higher than this one in low opening (0.75 m). Sucrose content with opening cut at 1.20 m is higher than opening at 0.75 m, whatever the tapping system (table 5). Opening at 1.20 m above ground level seems to result in a good supply of carbohydrates to laticiferous tissues in the drained area. This could be probably the explanation of the positive effect previously observed on yield especially in the physiological period 1985-1986 (Table 2). These results were confirmed by Wei *et al.* (2008) on the upward tapping in China. They showed that the sucrose content of latex in low parts of trunk was lower than in higher position due to the impact of tapping. That leads to conclude that the bark of high parts of trunk has high potential of latex production ability. At a same opening height (1.20 m or 0.75 m) sucrose content is significantly lower with S/2 d3 6d/7 ET2.5% Ba2(2) 2/y(m) than with S/2 d4 6d/7 ET2.5% Pa1(1) 8/y(m) (Table 5). This is probably linked to an increase of difficulties in sucrose supply to the drained area in d/3 tapping (Tupy, 1985). In addition, there is a low sink effect because of reduced stimulation intensity, an important area of regenerating bark above the cut (55 cm in S/2 d3 and 45 cm in S/2 d4) and an incomplete substitution of carbohydrates between two tappings. The phenomenon can be justified by the level of yield expressed in g/t in d3. Those results confirmed findings of many authors (Van De Sype, 1984; Tupy, 1985) who showed that generally the high frequency of tapping leads to the decrease of sucrose content in the latex due to the metabolism activation which therefore increases the yield.

Table 5: Sucrose content (mM) of clone PB 235, assessed in January 1986.

	Opening heights		
Tapping systems	1.20 m (High)	0.75 m (Low)	Average for each tapping system
S/2 d3 6d/7 ET2.5% Ba2(2) 2/y(m) (High tapping and low stimulation frequencies)	6.57*	5.23*	5.90b
S/2 d4 6d/7 ET2.5% Pa1(1) 8/y(m) (Low tapping and high stimulation frequencies)	11.96***	8.5**	10.23a

Average for each opening height	9.26A	6.86B	8.06

The figures followed by the same letter or symbol are not significantly different (Newman & Keuls, 5% threshold).

Rate of TPD: Results showed that the rate of TPD is significantly higher in S/2 d3 6d/7 ET2.5% Ba2 (2) 2/y(m) than in S/2 d4 6d/7 ET2.5% Pa1(1) 8/y(m) whatever the opening height (Table 6). These results confirmed the conclusion of Obouayeba *et al.* (2006) study showing that the susceptibility to tapping panel dryness and to intensity of tapping were both linked in several clones. So, occurrence and severity of tapping panel dryness depend strongly on tapping systems intensity. Compensation of low tapping frequency (changing the tapping frequency from d3 6d/7 to d4 6d/7) with a planned stimulation intensification could allow a diminution of tapping panel dryness appearance. Interaction between tapping frequency and opening height was very highly significant with respect to tapping panel dryness. It was significantly higher with low opened treatments (0.75 m) than with high opening (1.20 m) in S/2 d3 6d/7 ET2.5% Ba2(2) 2/y(m). But no difference was observed in S/2 d4 6d/7 ET2.5% Pa1 (1) 8/y(m) where the rate of tapping panel dryness from both opening heights was statistically identical.

Table 6: Rate of TPD of clone PB 235, according to tapping systems and opening heights, assessed in November 1985.

	Opening heights		
Tapping systems	1.20 m (High)	0.75 m (Low)	Average for each tapping system
S/2 d3 6d/7 ET2.5% Ba2(2) 2/y(m) (High tapping and low stimulation frequencies)	11.8**	19.8***	15.8a
S/2 d4 6d/7 ET2.5% Pa1(1) 8/y(m) (Low tapping and high stimulation frequencies)	5.5*	4.6*	5.1b
Average for each opening height	8.7B	12.2A	10.5

The figures followed by the same letter or symbol are not significantly different (Newman & Keuls, 5% threshold).

CONCLUSION

The opening height has significant effect on yielding but not on growth of clone PB 235. Tapping intensity of clone PB 235 can be considered as the main causal factor in the occurrence of tapping panel dryness. Opening at 0.75 m above the ground level gives lower yields and higher percentages of tapping panel dryness than opening at 1.20 m, mainly with high tapping intensity (e.g. S/2 d3 6d/7). High tapping intensity leads simultaneously to a fall of sucrose content in the drained area and a very significant increase in the rate of tapping panel dryness whatever the opening height. The tapping panel dryness appears to be strongly correlated with sucrose availability decrease in the drained area, resulting for example from a relatively intensive tapping (S/2 d3 6d/7) added to stimulation (2/y(m)). Use of a low tapping frequency (S/2 d4 6d/7) combined with a high intensity of stimulation (8/y(m)) enabling at least partial compensation of tapping intensity (yield equivalent to that of S/2 d3 6d/7) allows a good carbohydrates supply (sucrose content greater than that of S/2 d3 6d/7) and enhances the maintaining of better sugar availability in the drained area.

REFERENCES

Anonymous 1, 1991. Fiche de clone n° A 4, PB 235. Département des plantes à latex, p. 6.

Anonymous 2. Fiche technique IRCA : Le relevé rapide d'encoche sèche avec estimation visuelle. Pp. 2.

Anonymous 3, 1983. IRCA, Rapport annuel, p. 81.

Ashwell G, 1957. Colorimetric analysis of sugar, Method Enzymol., 3, 73-105.

Commère J, Eschbach JM, Serres E, 1989. Tapping panel dryness in Côte d'Ivoire. Proc. Workshop on tree dryness, 26-27 June 1989, Penang, Malaysia, 83-98.

Eschbach JM, Lacrotte R, Serres E, 1989. Conditions which favor the onset of brown bast. Physiology of rubber tree latex, J. d'Auzac, J.L. Jacob, H. Chrestin, ed., CRC Press, Boca Raton, 443-458.

Gener P. and Duplessix CJ, 1971. Variation de l'indice de plugging en fonction de certaines conditions de saignée. Inst. Rech. Caout. Afrique, Rapp. Rech. S/A 1/71.
Gohet E, 1996. La production de latex par *Hevea brasiliensis*. Relation avec la croissance. Influence de différents facteurs : origine clonale, stimulation hormonale, réserves hydrocarbonées. Thèse de Doctorat d'Université, Université Montpellier II. Sciences et Techniques du Languedoc., France, 343 pp.
Jacob JL, Prevot JC, Lacrotte R, Serre E, Eschach JM, Vidal A, 1988. Latex flow, cellular regeneration and yield of Hevea brasiliensis. Influence of hormonal stimulation. International Congress Plant Physiology, New Delhi.
Langlois S, 1969. Influence of length and position of tapping cut and direction and frequency of tapping on yield of clone PR 107. J. Rubber. Res. Inst. Malaya, 21, 330-340.
Obouayeba S. and Boa D, 1993. Fréquence et repos annuel de saignée d'*Hevea brasiliensis*, clone PB 235, dans le sud-est de la Côte d'Ivoire. Cahiers Agricultures, 2 (6) 387-393.
Obouayeba S, Boa D, Keli ZJ, 1996. Adéquation entre quantité de pâte stimulante et production de caoutchouc d'*Hevea brasiliensis* dans le sud-est de la Côte d'Ivoire. Tropicultura, 14 (2) 54-58.
Obouayeba S, Boa D, Aké S, Lacote R, 2002. Influence of age and girth at opening on growth and productivity of Hevea. Indian Journal of Natural Rubber Research, 15(1) 66-71.
Obouayeba S, 2005. Contribution à la détermination de la maturité physiologique de l'écorce pour la mise en saignée d'*Hevea brasiliensis* Muell. Arg. (Euphorbiaceae) : Normes d'ouverture. Thèse de Doctorat, 43-48.
Obouayeba S, Dian K, Boko AMC, Gnagne YM and Aké S, 2005. Effect of planting density on growth and yield productivity of *Hevea brasiliensis* Muell. Arg. Clone PB 235, pp. 257-270.
Obouayeba S, Gabla O, Soumahin EF, Boko AMC, Doumbia A, Koto B, Gnagne YM, 2006. Relation entre l'intensité d'exploitation et la sensibilité à l'encoche sèche de clones d'*Hevea brasiliensis*. In Tapping Panel Dryness of Rubber Trees. Rubber Research Institute of India, pp. 45-54
Sivakumaran S, Haridas G, Abraham PD, 1988. Problem of tree Dryness with high yielding precocious clones and methods to exploit such clones. Proc. Coll. Hevea 88, IRRDB, Paris 1988, 253-267.
Templeton JK, 1969 Partition of assimilates. *J. Rubb. Res. Inst. Malaya* **21**, 259-273.

Tupy J, 1985. Some aspects of sucrose transport and utilization in latex producing bark of *Hevea brasiliensis* Müll. Arg. Biol. Plant, 27, 51-64.
Van De Sype H, 1984. The dry cut syndrome in *Hevea brasiliensis*, evolution, agronomical and physiological aspects. In C.R. Coll. IRRDB Physiologie Exploitation Amélioration Hevea. IRCA-CIRAD, ed., Montpellier, 227-249.
Vollema JS, 1941. Over den invloed van het tappen op den diktegroei van *Hevea brasiliensis*. Arch. Rubbercult., 25, 417 - 422.
Wei X, Xiao X, Luo S, Liu S. and Wu M, 2008. Upward tapping in china. Latex harvesting technologies. Rubber research Institute, Chinese academy of Tropical Science. Academy Hevea Malaysia, Malaysian Rubber Board, Sungai Buloh, Selangor. 10 pp.
Wycherley PR, 1976. Tapping and partition. J. Rubber Res. Inst. Malays. 24:169-194.