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Original Research Article

1 Agronomic potential of some rubber tree clones (*Hevea brasiliensis*) of the fast metabolic activity class in the absence of hormonal
2 stimulation in southwestern of Côte d'Ivoire
3
4

Abstract

5 Fast-metabolism clones of rubber tree (*Hevea brasiliensis*) are appreciated for their good agronomic performance with little hormonal
6 stimulation, due to their high intrinsic metabolic activity. They are highly demanded and therefore exposed to a significant risk of
7 overexploitation. In order to solve this problem, a study was carried out in a ~~randomised~~ ^{randomised block} design with clones IRCA 111, IRCA 130 and PB
8 260 planted at a density of 510 plants/ha in southwestern of Côte d'Ivoire for nine years. A single tapping system, that is every four days (d4)
9 with different hormonal stimulation regimes (0/y; 2/y; 4/y; 6/y; 8/y; 13/y; 18/y; 26/y and 39/y), was applied to all treatments. The parameters
10 measured in rubber trees were rubber yield, radial vegetative growth, physiological profile and sensitivity to tapping panel dryness. The results
11 indicated that non-stimulated rubber trees of clones IRCA 111 and IRCA 130 showed the best rubber yields while two annual stimulations were
12 necessary to clone PB 260. Moreover, the lack of hormonal stimulation had no negative impact on the vegetative growth, physiological profile
13 and sensitivity to tapping panel dryness of those rubber trees. Clones IRCA 111 and IRCA 130 can therefore be tapped in S/2 d4 without
14 hormonal stimulation. ^{d/y}
15

16 **Keywords:** Fast-metabolism clones, *Hevea brasiliensis*, hormonal stimulation, rubber yield, vegetative growth, physiological profile, tapping
17 panel dryness, Côte d'Ivoire.
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1. Introduction

19 Rubber tree clones (*Hevea brasiliensis*) of the fast-metabolism class, including IRCA 18, IRCA 111, IRCA 130, PB 255, PB 280, PB 330 and
20 PB 260, are generally appreciated for their good agronomic performance and especially their rapid yield increase [1,2]. These clones are
21 characterized by a very easy flow, thus a high intrinsic yield and have a good activating capacity of latex-producing metabolism in the absence
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23 of hormonal stimulation. Therefore, fast-metabolism clones require very little or no hormonal stimulation for giving a good level of rubber yield.
24 This is plausible especially as the recent works of Diarrassouba and Traoré [3,4] showed that clones PB 235 and PB 260 of the fast metabolic
25 activity class having sufficient intrinsic energy ensures good rubber yield with a very low stimulation regime (respectively 1 and 2/y).
26 Moreover, Lacote *et al.* [5] showed that the intrinsic energy of fast-metabolism clones is such that some of them, including clone IRCA 130,
27 tapped in d4 do not need hormonal stimulation at all. Indeed, their rubber productivity without hormonal stimulation is significantly higher than
28 that of all stimulation regimes applied to them.

29 The conclusions of those works are interesting and likely especially as it is assumed that tapping, due to the stress it induces, activates the
30 metabolism of latex vessels along with hormonal stimulation, by producing ethylene. Indeed, ethylene, produced and released, during stress in
31 the tissues, activates the whole biosynthetic process of the cis-polyisoprene molecule or rubber [6,7]. It is as if tapping alone provides so
32 sufficient metabolic energy that hormonal stimulation even at very low regime would be harmful; since it can lead to an excess of energy which
33 would excessively meet the latex-producing metabolism enough to cause physiological fatigue [8] and therefore tapping panel dryness due to
34 overexploitation it would have caused [2,9,10,11,12].

35 The availability of metabolic energy activating the rubber biosynthetic process varies according to the metabolic activity class of the clone [13]
36 and within the same class [5,14]. Thus, in the perspective of rubber tapping ecological management, it would be wise and efficient to exploit, on
37 the one hand, the activation potential of latex-producing metabolism by tapping and, on the other hand, the capacity of active or fast-metabolism
38 clones to achieve a good level of rubber yield with little or no hormonal stimulation. Given the high cost of stimulants and their adverse effects,
39 in the more or less long term, on the yield, the applicator and the environment, it is therefore well-founded to know whether the proven fact that
40 clone IRCA 130 does not need hormonal stimulant may be extended to other clones of this metabolic activity class.

41 In order to address this concern, several experiments testing different latex harvesting technologies including non-stimulated treatment on clones
42 IRCA 111, IRCA 130 and PB 260 of the fast metabolic activity class, were conducted for nine years in SCASO (former HEVEGO) in
43 southwestern of Côte d'Ivoire.
44

No clear statement of objective

2. Material and methods

2.1. Material

The plant material used consisted of three clones from the active or fast metabolic activity class of *Hevea brasiliensis* ~~Mueller Argoviensis~~ ^{Mueller Arg.} ~~Euphorbiaceae~~. These are clones IRCA 111, IRCA 130 and PB 260.

- Clone **IRCA 111** was created in Côte d'Ivoire in 1975 by crossing PB 5/51 and RRIM 605. It was planted for the first time in CCGE in 1983. This clone shows a very good vegetative vigor in immature period [2] and an average annual increase after opening higher than those of clones GT 1 and PB 235 with a tendency to bend at 10 years. It has low sucrose content but relatively higher than that of PB 235 and is part of active or fast-metabolism clones [15]. Its yield expressed in grams per tree per tapping is very high. It has a sensitivity to tapping panel dryness that increases with the latex harvest period [2].
- Clone **IRCA 130** was created in Côte d'Ivoire in 1975 by crossing PB 5/51 and IR 22. It was planted for the first time in CCGE in 1983. It has a rapid height growth and is part of fast-metabolism clones. It is a vigorous clone with a beautiful crown and a slightly bent trunk [15]. Its yield expressed in grams per tree by tapping is very high. It has a good physiological profile at latex harvesting commencement. It has a relative sensitivity to breakage due to wind.
- Clone **PB 260** (Prang Besar 260) is the result of PB 5/51 x PB 49 crossing. It is originally from Malaysia. Its vegetative growth before tapping commencement switches from average to good. After tapping commencement, it remains average. Its yield commencement is fast. It is a vigorous and high yielding clone. It is sensitive to tapping panel dryness and is moderately resistant to ^{wind damage} ~~gale force winds~~ [16]. It requires a moderate stimulation regime.

(16)

The ^{experimental} ~~experiment~~ design was the randomised ~~complete~~ block design consisting of 10 blocks at 33 trees per block. Each clone was represented in each block.

2.2. Methods

2.2.1. Experimental design and treatments

The experimental design used was the mono tree or "one tree plot design", that is to say, a tree makes up a repetition. In that respect, 330 trees were selected based on the homogeneity of their girth at 1m 70 above the ground, their ^{blank} ~~blank~~ yield (without stimulation) and their tapping panel dryness rate (0%). ^{On each plot the selected trees were divided into 10 separate treatments at the rate of 33 trees (repetitions) per treatment.} A single tapping system was applied to all the trees of all treatments, tapping every four days (4/4) with one day of rest per week and different hormonal stimulation regimes. A non-tapped absolute control was included so as to allow the monitoring of rubber trunk isodiametric growth, in order to better understand the effect of treatments on it (Table 1).

The trees of the experiment were planted at a density of 510 trees per hectare (7 m x 2.8 m). For nine years, the tapping technique followed the classic pattern of tapping panels conduct in use in Côte d'Ivoire [17].

2.2.2. Measurements

Rubber yield

Rubber yield was assessed per treatment. The coagulum, extracted at the following tapping, was collected, weighed monthly (fresh weight, F.W.) and stored. The transformation coefficient, dry rubber percentage of a given sample of fresh rubber, was used to calculate the dry rubber yield for each pattern. It has been calculated from a sample of coagulum per treatment. Each sample was weighed, crimped, dried at 80 °C in an oven for 24 hours and reweighed.

The dry rubber yield was expressed in grams per tree per tapping (g/t).

Trunk isodiametric growth

For each treatment, the trunk girth at 1.70 m was measured on each tree at the beginning of experiment and at the end of physiological cycle (January to February), before the start of annual defoliation. The average annual increase has been expressed (cm/year).

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89 Measurements of latex physiological parameters

90 ~~The most significant~~ ^{from} physiological parameters of the latex, ~~because of their involvement in rubber yield-related mechanisms~~, were analyzed once
91 a year, in November. They are the dry rubber content and the sucrose, inorganic phosphorus and thiol groups contents in the latex. Some latex
92 collected by pricking under the tapping panel (downward tapping), according to the "latex micro diagnosis" method [18] (LMD) was used to
93 determine the values of physiological parameters.

94 Measurement of the dry content

95 The dry matter content of the latex was determined by weighing 1 ml of fresh product in a 10-ml pillbox, before and after ~~stoving~~ ^{heating} at 80 °C for 24
96 h.

97 ~~Determination~~ ^{of} ~~sucrose,~~ ^{sucrose,} ~~inorganic~~ ^{inorganic} ~~phosphorus~~ ^{phosphorus} ~~and~~ ^{and} ~~thiol~~ ^{thiol} ~~compounds~~
98 Sucrose contents, inorganic phosphorus and thiol groups were measured out from the TCA serum obtained after latex coagulation in
99 trichloroacetic acid (TCA). These contents, expressed in millimoles per liter of latex (mmol.l⁻¹), were measured out by the anthrone method
100 developed by Ashwell [19] the Taussky and Shorr method [20] and the Boyne and Ellman method [21], respectively for sucrose, inorganic
101 phosphorus and thiol groups.

102 The interpretation of physiological parameter values took into account the reference values set by Jacob *et al.* [22].

103 Visual estimate of tapping panel dryness

104 The quick survey method by visual assessment helps report the appearance and the progress of tapping panel dryness [23]. For each tree tapped,
105 a number ranging from 0 to 6 was assigned, proportional to the length of tapping cut affected by tapping panel dryness (Table 2).
106 For each plot, the exact count of the condition of trees was carried out and the rates of total diseased cut length (DCL %) and completely dry
107 trees were determined for each treatment.

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111 2.2.3. Statistical Analyses

112 Data ~~relating to~~ ^{on} rubber yield, trunk isodiametric growth, latex micro diagnosis and tapping panel dryness statement were processed using the
113 statistical software STATISTICA 7.5. An analysis of variance was performed and the level of significance of differences between averages was
114 estimated by the NEWMAN-KEULS test for a threshold of 5%. For the comparison of percentages, the average comparison test by means of the
115 least significant difference (Lsd) at the threshold of 5% was used.

116 3. Results

117 3.1. Rubber yield

118 The average annual rubber yields of clones IRCA 111, IRCA 130 and PB 260 were significantly influenced by the hormonal stimulation regime
119 after nine years of experiment. They ranged from 47 to 58 g/t/t, 37 to 49 g/t/t and 54 to 70 g /t/t respectively for clones IRCA 111, IRCA 130 and
120 PB 260. The trees of non-stimulated treatment (0/y) gave rubber yields that were the highest and statistically superior to those of trees stimulated
121 in clones IRCA 111 and IRCA 130. However in clones PB 260, the stimulation regimes 2/y, 4/y and 6/y resulted in yields that were ~~significantly~~
122 ~~identical to each other and~~ significantly superior to those of treatment ~~0/y, 2/y and 4/y, which were identical to each other.~~ ^{irrespective of the}
123 ~~Whatever~~ clone, the lowest rubber yields were obtained with the high annual stimulation frequency (18/y, 26/y and 39/y; Table 2).

124 3.2. Radial vegetative growth of rubber trees

125 The average annual increase was significantly influenced by the tapping commencement of trees in clones IRCA 111, IRCA 130 and PB 260.
126 Non-tapped trees had an average annual increase rate statistically superior to those trees tapped regardless of the clone. The different hormonal
127 stimulation frequencies applied to clones IRCA (111 and 130) did not significantly affect the average annual growth of trees. However, in clone
128 PB 260, the non-stimulated trees had an average annual increase statistically equivalent to that of stimulated trees 2/y and significantly superior
129 to those of the other stimulated trees (Table 3). ^{In addition the variation due to gelling rate}
130 ^{was clear with seven eight distinct classes (Table 3).}

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3.3. Physiological parameters of rubber trees

3.3.1. Clone IRCA 111

Dry Rubber Content (DRC): the dry rubber contents of the trees of clone IRCA 111 ~~switched statistically~~ ^{ranged} from 46.91 to 58.56% according to the different treatments after nine years of experiment (Table 4). These rates were very high regardless of the latex harvesting technology. The non-stimulated trees had the highest rate (58.56%), which was statistically superior to those of the other treatments. The lowest dry rubber contents were obtained with stimulated trees 2 and 4/y.

Sucrose Content (Suc): the average sucrose content of clone IRCA 111 trees ranged from 5.90 to 19.77 mmol.l⁻¹ based on the treatments after nine years of experiment (Table 4). The non-tapped trees (control) showed a high (19.77 mmol.l⁻¹) significantly higher than those of tapped trees. The stimulated and ~~non-stimulated~~ ^{non} trees (2/y, 6/y, 13/y, 18/y, 26/y and 39/y) ~~showed average contents which were statistically identical to each other and superior to those of stimulated trees 4 and 8/y.~~ ^{showed average contents which were statistically identical to}

Inorganic Phosphorus (Pi) content: the average inorganic phosphorus contents of clone IRCA 111 trees ~~switched~~ ^{ranged} from very high to high after nine years of experiment. They ~~ranged~~ ^{switched} from 17.27 to 31.87 mmol.l⁻¹ (Table 4). The non-stimulated trees ~~showed contents (30.93 mmol.l⁻¹) statistically identical to those of non-tapped trees (29.79 mmol.l⁻¹) and stimulated 2/y (31.87 mmol.l⁻¹).~~ ^{showed contents (30.93 mmol.l⁻¹) statistically identical to those of non-tapped trees (29.79 mmol.l⁻¹) and stimulated 2/y (31.87 mmol.l⁻¹).} The lower contents were obtained with the stimulated trees 26 and 39/y. ^{(29.89) (17.27)}

Thiol groups (RSH) contents: the average thiol group contents of the latex of clone IRCA 111 trees were significantly influenced by the latex harvesting technology and have, generally, increased according to the intensification of hormonal stimulation after nine years of experiment. They ranged from 0.36 (non-tapped treatment) to 0.56 mmol.l⁻¹ (stimulated treatment 18/y) according to the treatment. These values ~~switched~~ ^{switched} from low to very low (Table 4). ^{are rated}

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3.3.2. Clone IRCA 130

Dry Rubber Content (DRC): the dry rubber contents of the latex of clone IRCA 130 trees were significantly influenced by the different latex harvesting technologies. ~~These very high rates ranged from 53.67 to 64.83 % depending on the treatment after nine years of experiment (Table 5).~~ ^{the variation of} The dry rubber content from non-tapped trees was statistically superior to those of the other treatments that were equivalent to each other.

Sucrose content (Suc): the average sucrose content of the latex of clone IRCA 130 trees, in accordance with those of fast metabolism clones ranged from high to very high ~~(9.10 to 23.60 mmol.l⁻¹) depending on the treatment after nine years of experiment (Table 5).~~ ^{(9.10 to 23.60 mmol.l⁻¹) depending on the treatment after nine years of experiment (Table 5).} The non-tapped trees (control) showed a very high latex sucrose content significantly superior to those of the latex of tapped trees which were statistically identical to each other. However, the stimulated trees, with the exception of treatments 9 and 10, showed contents lower than of non-stimulated trees.

Inorganic Phosphorus Content (Pi): the average contents of inorganic phosphorus of the latex of clone IRCA 130 trees were significantly influenced by the different latex harvesting technologies after nine years of experiment. They ~~switched~~ ^{ranged} from high (23.33 mmol.l⁻¹) to very high (28.40 mmol.l⁻¹) respectively for treatments 13 and 0/y (Table 5). ^{respectively}

Thiol group contents (RSH): the average thiol group contents of the latex of clone IRCA 130 trees ~~switched~~ ^{ranged} from medium to good ~~and~~ ^{at} statistically equivalent to each other regardless of the latex harvesting technology after nine years of experiment. They ranged from 0.65 to 0.77 mmol.l⁻¹ (Table 5).

3.3.3. Clone PB 260

Dry Rubber Content (DRC): the dry rubber content of the latex of clone PB 260 trees were significantly influenced by the various latex harvesting technologies. ~~These rates, very high, ranged from 46.96 to 59.57% depending on the treatment after nine years of experiment (Table 6).~~ ^{the variation of} The tapped trees, stimulated or not showed dry rubber contents of latex statistically inferior to those of non-tapped trees. ^{of low values compared to the}

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176 Sucrose content (Suc): the different latex harvesting technologies have had a significant impact on the average sucrose content of the latex of
 177 clone PB 260 trees. These contents, very high for non-tapped trees (23.54 mmol.l⁻¹), were statistically superior to those of the other treatments
 178 which were identical to each other. However, the sucrose content of the latex of stimulated trees have, generally, decreased compared to non-
 179 stimulated trees (Table 6).
 180 Inorganic Phosphorus content (Pi): the average inorganic phosphorus contents of the latex of clone PB 260 trees were significantly influenced
 181 by the different treatments after nine years of experiment. They ranged from 20.01 to 35.66 mmol.l⁻¹ (Table 6). These contents, very high for
 182 little stimulated or not stimulated treatments, had a tendency to decrease with strong hormonal stimulation frequencies (26 and 39/y).
 183 Thiol group contents (RSH): the average thiol group contents of the latex of clone PB 260 trees were significantly influenced by the different
 184 treatments. They were low for all treatments (Table 6). However, the tapped trees, stimulated or not showed contents superior to that of the latex
 185 of non-tapped trees.
 186 3.4. Sensitivity to rubber tree tapping panel dryness
 187 The different latex harvesting technologies have had a significant impact on the rates of diseased cut length and completely dry trees of clones
 188 IRCA 111 and PB 260 except for clone IRCA 130 (Table 7). The average rates of diseased cut length ranged from 2.73 to 16.06% for clone
 189 IRCA 111, from 24.24 to 45.45% for clone IRCA 130 and 6.64 to 20.30% for clone PB 260. The non-stimulated treatments (0/y), have induced
 190 the lowest rates of diseased cut length regardless of the clone. The stimulated treatments induced high rates of diseased cut length.
 191 The rate of completely dry trees have evolved in the same order as those diseased cut lengths.
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196 4. Discussion
 197 4.1. Impact of different latex harvesting technologies on dry rubber yield and radial vegetative growth of fast metabolism clones of *Hevea*
 198 *brasiliensis*
 199
 200 The analysis of the average annual yield of rubber trees revealed that only clones IRCA 111 and IRCA 130 enable to have the best rubber yield
 201 in the absence of hormonal stimulation after nine years of experiment. In clone PB 260, the non-stimulated treatment showed a rubber yield
 202 statistically inferior to those of stimulated treatments 2, 4 and 6/y which were equivalent to each other. However, the rubber yield of non-
 203 stimulated trees was significantly superior to those of trees treated with high frequency stimulation. These results confirm that these clones
 204 belong to the fast activity class basing on their yield with little hormonal stimulation according to the works of Eschbach *et al.* [24]; Serres *et al.*
 205 [25]; Jacob *et al.* [13] and Gohet *et al.* [8]. Indeed, the metabolic activity being governed by the intrinsic energy [5,26], it was sufficient
 206 enough to enable clones IRCA 111 and IRCA 130 to reach a maximum rubber yield. However, the low rubber yield shown by the non-
 207 stimulated treatment in clone PB 260 compared to stimulated treatments (2, 4 and 6/y) highlights the inadequacy of this intrinsic energy
 208 necessary to a high yield. Thus, to compensate for the energy difference, some authors [27,28,29] have justified and proposed an exogenous
 209 energy provided by hormonal stimulation (ethylene). And yet, for all the clones studied, hormonal stimulation has also resulted in average rubber
 210 yield declines after nine years of experiment. These results reflect the depressive effect of high levels of stimulation on rubber yield. Because, as
 211 stated by Gohet *et al.* [8], this effect results in a malfunction of the latex-vessel system characterized by the impossibility of raising the activation
 212 level of latex-producing metabolism by hormonal stimulation [4]. This causes either a physiological fatigue of overused latex-producing tissues,
 213 or a phytotoxic effect due to Ethephon by the excessively frequent use of Ethrel leading to rubber yield decrease.
 214 Moreover, some studies have highlighted the stimulating power of tapping which produces ethylene in the tissues of rubber trees through the
 215 stress it causes [6,7]. It could, therefore, constitute a power source to compensate for metabolic energy differential through a slight increase in
 216 the tapping frequency, particularly in d3, so as to improve the yield of clone PB 260 in the absence of hormonal stimulation.
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218 Concerning the radial vegetative growth of trees of the clones studied, the average annual increase in girth of non-tapped trees was superior to
219 that of tapped trees ~~whatever the clones~~. This due to the fact that rubber tree tapping commencement results in the diversion of a fraction of
220 photosynthetic assimilates, strictly allocated to the general metabolism of the tree and the primary biomass. Indeed, a strong competition for
221 photosynthetic assimilates occurs between vegetative growth and rubber yield [8,30,31]. This is more likely especially as tapping
222 commencement is inevitably accompanied by a reduction in the annual rate of vegetative growth [1,32,33].

223
224 The increase in stimulation frequency causes a reduction in girth increase regardless of the clone. This could be due to the phytotoxicity problem
225 relating to the use of hormonal stimulation. Moreover, the growth potential being negatively correlated with rubber yield [34], the depressive
226 impact of yield on growth will be important especially as the growth potential is high and *vice versa* [31]. This explains well the reduction in the
227 girth of stimulated trees compared to non-stimulated trees.

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230 4.2. Impact of different latex harvesting technologies on the physiological profile and sensitivity to tapping panel dryness of fast- 231 metabolism clones of *Hevea brasiliensis*

232 Concerning the physiological profile, the very high level of dry rubber content observed in all the clones studied shows an increased biosynthesis
233 of rubber within latex-vessels ~~whatever the level of hormonal stimulation~~. However, the dry rubber content was higher in non-tapped trees. This
234 is due, ~~on the one hand, by the fact that there is no rubber export by harvest and, on the other hand, by the active nature of the latex-producing~~ *and higher intrinsic energy level*
235 ~~metabolism of these clones due to the important and available intrinsic energy.~~ The dry rubber content of the stimulated or non-stimulated trees
236 has relatively decreased compared to that of non-tapped trees. This decrease in dry rubber content is explained by the fact that hormonal
237 stimulation induces an increase of water transfers within latex-vessel tissues [6,35]. This process leads to latex dilution in time which is the
238 source of lower dry rubber contents.

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240 The sucrose content of the latex of the studied clones ~~went from~~ *was* medium to high. They were very high for non-tapped trees regardless of the
241 clone. The stimulated trees have, on the whole, shown contents inferior to those of non-stimulated trees. These results are similar to those
242 obtained by Lacrotte [6] and Traoré [4] who showed that all stimulated trees have a sucrose content of latex inferior to that of non-stimulated
243 trees due to the use of sucrose for rubber biosynthesis. This result could be explained by the fact that ethylene stimulation strongly activates the
244 metabolism leading to a strong conversion of the sucrose present in latex-vessels [5], into latex-producing rubber since sucrose is the raw
245 material of the isoprene biosynthesis [36]. Now, in the conditions of our experiment, the non-stimulated trees of clones IRCA 111 and IRCA 130
246 showed better yields compared to stimulated trees. This suggests a good supply and efficient use of sucrose for rubber yield in the absence of
247 stimulation. This situation is probably the result of the fact that the intrinsic metabolic energy of these clones is sufficient for good biosynthesis
248 of the latex-producing rubber. Indeed, these clones, due to their very active metabolism, transform very quickly the sucrose into rubber and
249 respond only poorly to hormonal stimulation [8,13].

250

251 The inorganic phosphorus contents of the latex of trees, which are closely related to energy metabolism and rubber biosynthesis, reflect the
252 intensity of regeneration within the latex-producing tissue [8]. For each of the clones studied, the inorganic phosphorus contents were high in
253 non-stimulated trees as well as in stimulated trees. This result highlights the activating effect of metabolism by tapping, as shown by Obouayeba
254 *et al.* [7] and Dick *et al.* [28]. Tapping, due to the stress it induces [37], might activate latex-vessels metabolism along with hormonal
255 stimulation, by ethylene production. Indeed, as shown by Lacrotte [6], ethylene is a hormone that is produced and released during stress (tapping
256 or stimulation) in the tissue to act by activating the entire biosynthetic process of the *cis*-polyisoprene molecule or rubber. This explains the very
257 good level of rubber yield noticed in clones IRCA 111, IRCA 130 and, to a lesser extent, clone PB 260 in the absence of hormonal stimulation.
258 Given the results, tapping, particularly in the d4 frequency alone could not generate the activation energy necessary to enable clone PB 260 to
259 better express its yield potential.

260 The thiol group contents of the latex of trees were, generally, weak and in the same order of magnitude for all treatments regardless of the clone.
261 The level of these contents reflects, indeed, a decline of the biological protection of lutoids [6].

12

As regards the sensitivity to tapping panel dryness, the results revealed low rates of ~~DCL~~ ^{partially dry} and completely dry trees for the non-stimulated treatment and inferior to those of stimulated treatments in all the clones studied. These rates increased with the intensification of hormonal stimulation ~~whatever the clone~~. This negative impact of hormonal stimulation on the occurrence of the tapping panel dryness supports the works of De Fay [38], Chrestin [37] and Omokhal [39], who showed that tapping panel dryness increases with the frequency of hormonal stimulation. Indeed, the tapping panel dryness is generally caused by overexploitation of the trees. The sensitivity of clones to tapping panel dryness according to the metabolic activity class, is due to the fact that they have low levels of thiol compounds as indicated by Chrestin [40]. ~~According to the same author, these compounds favors the stability of laticifers and their low content causes decompartmentalization of those which are destroyed in situ.~~ Lysis of laticifers leads to the coagulation of latex within the latex-vessels, resulting thereafter, in the stoppage of latex flow and, subsequently, tapping panel dryness. ~~Furthermore, the rates of DCL and completely dry trees, more or less important, observed in non-stimulated trees highlights the specificity of the clones in this activity class as for their high sensitivity to tapping panel dryness [8,13].~~

5. Conclusion

This study was conducted in order to develop a latex harvesting system without hormonal stimulation and reach a good rubber yield for the clones of fast metabolic activity class. The results indicate that only clones IRCA 111 and IRCA 130 showed better rubber yield in the absence of hormonal stimulation after nine years of experiment in S/2 d4. The metabolic activity governed by the intrinsic energy was sufficient to enable these clones to better express their potentials unlike clone PB 260 which needed two annual stimulations for result. Furthermore, the absence of hormonal stimulation favored the radial vegetative growth of trees while the increase in stimulation frequency had a depressive effect on the average annual growth of trees of the clones studied. ~~It had no negative impact on the physiological parameters and the sensitivity to tapping panel dryness of trees.~~ ^{In addition, non-stimulation} Finally, this study has helped highlight the possibility of reaching a maximum rubber yield in the absence of hormonal stimulation ~~thanks to the stimulating power of tapping in clones IRCA 111 and IRCA 130. This stimulation potential offered by tapping may improve the yield of clone~~

PB 260 in the absence of hormonal stimulation through a slight increase in tapping frequency. Clones IRCA 111 and IRCA 130 can be tapped in S/2 d4 without hormonal stimulation.

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Tables

Table 1 : Treatments applied on clones IRCA 111, IRCA 130 and PB 260 during 9 years of experimentation in southwestern Côte d'Ivoire.

N°	Latex harvesting technologies	Description
	1/2 S, d/4 6d/7 12 m/12.ET2.5% Pa1(1)	Half spiral cut tapped at fourth daily frequency, six day in tapping followed by one day; stimulated with Ethephon of 2.5 % active ingredient with 1 g of stimulant* applied on panel on a 1 cm band
1	Control	Untapped trees
2	Not stimulated	Whithout stimulation
3	2/y	Two applications per year
4	4/y	Four applications per year
5	6/y	Six applications per year
6	8/y	Eight applications per year
7	13/y	13 applications per year
8	18/y	18 applications per year
9	26/y	26 applications per year
10	39/y	39 applications per year

*The stimulant used is ELS 50 Double Red diluted by 2 (1 weight of ELS 50 + 1 weight of water.

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Table 2 : Annual mean dry rubber yield of clones IRCA 111, IRCA 130 and PB 260 of *Hevea brasiliensis* expressed in g.t⁻¹.t⁻¹ during nine years in southwestern Côte d'Ivoire

N°	Latex harvesting technologies	IRCA 111	IRCA 130	PB 260
1/2 S, d/4 6d/7 12 m/12.ET2.5% Pal(1)				
1	Control (without tapping)	-	-	-
2	0/y	58 a	49 a	62 b
3	2/y	56 b	41 d	69 a
4	4/y	53 cd	41 d	70 a
5	6/y	54 c	37 f	69 a
6	8/y	52 d	46 b	63 b
7	13/y	56 b	39 e	62 b
8	18/y	51 e	38 ef	59 c
9	26/y	48 f	43 c	56 d
10	39/y	47 f	41 d	54 e

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

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Table 3 : Annual average girth increment (cm/year) according to the latex harvesting technologies applied to the clones IRCA 111, IRCA 130 and PB 260 during to the first nine downward tapping years in southwestern Côte d'Ivoire

N°	Latex harvesting technologies	IRCA 111	IRCA 130	PB 260
1/2 S, d/4 6d/7 12 m/12.ET2.5% Pal(1)				
1	Control (without tapping)	5.11 a	7.28 a	5.40 a
2	0/y	2.27 b	2.38 b	3.17 b
3	2/Y	1.82 b	2.18 b	3.01 bc
4	4/Y	2.01 b	2.25 b	2.80 c
5	6/Y	1.23 b	2.20 b	2.69 cd
6	8/Y	1.97 b	2.25 b	2.42 de
7	13/Y	2.52 b	2.08 b	2.40 de
8	18/Y	1.79 b	2.13 b	2.34 ef
9	26/Y	1.68 b	2.10 b	2.13 ef
10	39/Y	1.75 b	2.14 b	2.03 f

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

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Table 4 : Physiological profile of latex according to the latex harvesting technologies applied to the clone IRCA 111 during to the first nine tapping years in southwestern Côte d'Ivoire

N°	Latex harvesting technologies	DRC (%)	Suc (mmol.l-1)	Pi (mmol.l-1)	RSH (mmol.l-1)
1/2 S. d/4 6d/7 12 m/12.ET2.5% Pa1(1)					
1	Control (without tapping)	58,56 a	19,77 a	29,79 b	0,36 g
2	0/y	49,25 c	7,39 bc	30,93 ab	0,46 e
3	2/Y	46,91 d	7,10 bc	31,87 a	0,50 c
4	4/Y	47,10 d	6,35 c	27,95 c	0,46 de
5	6/Y	49,04 c	6,99 bc	27,96 c	0,47 d
6	8/Y	50,17 bc	5,90 c	29,73 b	0,46 e
7	13/Y	51,03 b	7,11 bc	29,65 b	0,52 b
8	18/Y	50,24 bc	7,99 b	30,92 ab	0,56 a
9	26/Y	48,64 c	7,52 bc	22,89 d	0,47 de
10	39/Y	48,47 c	7,18 bc	17,27 e	0,38 f

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

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Table 5 : Physiological profile of latex according to the latex harvesting technologies applied to the clone IRCA 130 during to the first nine tapping years in southwestern Côte d'Ivoire

N°	Latex harvesting technologies	DRC (%)	Suc (mmol.l-1)	Pi (mmol.l-1)	RSH (mmol.l-1)
1/2 S. d/4 6d/7 12 m/12.ET2.5% Pa1(1)					
1	Control (without tapping)	64,83 a	23,60 a	25,57 abc	0,65 a
2	0/y	54,53 b	10,73 b	28,40 a	0,74 a
3	2/Y	53,90 b	9,74 b	26,23 ab	0,74 a
4	4/Y	57,13 b	9,25 b	25,40 abc	0,73 a
5	6/Y	55,93 b	9,10 b	25,93 ab	0,69 a
6	8/Y	55,63 b	10,00 b	25,43 abc	0,70 a
7	13/Y	54,53 b	10,01 b	22,33 c	0,71 a
8	18/Y	55,54 b	9,88 b	25,33 abc	0,71 a
9	26/Y	55,47 b	11,27 b	22,83 bc	0,77 a
10	39/Y	53,67 b	10,93 b	26,00 ab	0,67 a

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

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422 **Table 6 :** Physiological profile of latex according to the latex harvesting technologies applied to the clone PB 260 during to the first nine
423 **downward** tapping years in southwestern Côte d'Ivoire

N°	Latex harvesting technologies	DRC (%)	Suc (mmol.l-1)	Pi (mmol.l-1)	RSH (mmol.l-1)
1/2 S. d/4 6d/7 12 m/12.ET2.5% Pa1(1)					
1	Control (without tapping)	59,57 a	23,54 a	35,66 a	0,37 d
2	0/y	50,05 bcd	10,39 b	31,14 ab	0,45 bcd
3	2/Y	46,96 d	9,51 b	31,16 ab	0,47 abc
4	4/Y	48,04 cd	9,60 b	30,34 ab	0,51 abc
5	6/Y	49,99 bcd	9,36 b	27,50 abc	0,51 abc
6	8/Y	50,83 bc	8,53 b	30,16 ab	0,48 abc
7	13/Y	51,77 b	10,13 b	29,45 ab	0,53 ab
8	18/Y	50,74 bc	10,90 b	29,76 ab	0,57 a
9	26/Y	49,47 bcd	9,82 b	24,42 bc	0,48 abc
10	39/Y	49,32 bcd	9,46 b	20,01 c	0,41 cd

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

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433 **Table 7 :** Dry cut (%) and dry trees (%) of the clones IRCA 111, IRCA 130 and PB 260 of
434 *Hevea brasiliensis* after nine years in southwestern Côte d'Ivoire

Nº	Latex harvesting technologies	IRCA 111		IRCA 130		PB 260	
		Dry cut (%)	Dry trees (%)	Dry cut (%)	Dry trees (%)	Dry cut (%)	Dry trees (%)
1/2 S. d/4 6d/7 12 m/12.ET2.5% Pa1(1)							
1	Control (without tapping)	-	-	-	-	-	-
2	0/y	3.03 ab	3.03 ab	27.27 a	27.27 a	5.45 b	3.03 b
3	2/Y	9.09 ab	9.09 ab	33.33 a	33.33 a	3.64 b	3.03 b
4	4/Y	6.36 ab	6.06 ab	26.36 a	24.24 a	4.24 -b	3.03 b
5	6/Y	16.06 a	15.15 a	42.42 a	42.42 a	13.03 ab	12.12 ab
6	8/Y	9.09 ab	6.06 ab	24.24 a	24.24 a	16.36 ab	6.06 ab
7	13/Y	2.73 b	0.00 b	36.36 a	36.36 a	13.03 ab	9.09 ab
8	18/Y	10.91 ab	9.09 ab	45.45 a	45.45 a	8.79 ab	6.06 ab
9	26/Y	12.42 ab	9.09 ab	30.30 a	30.30 a	20.30 a	18.18 a
10	39/Y	11.21 ab	9.09 ab	36.36 a	36.36 a	20.30 a	18.18 a

435 Means followed by same letters in each column are not significantly different according the least significant difference (lsd) at the threshold of 5%.

24