Journal of Applied Biosciences 121: 12098-12109

ISSN 1997-5902

Latex micro diagnosis, modern management tool of rubber plantations of clones with moderate metabolism GT 1, RRIC 100 and BPM 24

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Original submitted in on 27th September 2017. Published online at www.m.elewa.org on 31st January 2018
https://dx.doi.org/10.4314/jab.v121i1.1

ABSTRACT

Objective: The cultivated rubber clones are sensitive to latex harvesting regimes according to their laticiferous metabolism. This study was done to determine the best latex harvesting system (s) of clones with moderate metabolism (GT 1, RRIC 100 and BPM 24).

Methodology and Results: Six latex harvesting technologies were applied to these clones in a bulk statistical device from Fisher to four rehearsals. The rubber trees were tapped in downward half spiral stimulated or not, for nine years after the opening of the tapping panel. The agronomic parameters (latex production, vegetative growth), the tapping panel dryness and those of the latex micro diagnosis were evaluated. The results indicate that these clones independently of the latex harvesting system have good rubber productivity (2234 $kg.ha^{-1}.y^{-1}$) with good radial vegetative growth (2.4 $cm.y^{-1}$). Their trees showed a well-balanced physiological profile and an acceptable sensitivity to the tapping panel dryness (3.2 %). However, the physiological index, the bark consumption and the sensitivity to the tapping panel dryness lead to retain the latex harvesting technology "S/2 d4 6d/7 Pa1 (1) ET2.5% 4/y" for the best.

Conclusion and application of results: This index, favourably influencing the choice of technologies adapted to clones with active metabolism, contributes to the modern and efficient management of a rubber plantation.

Key words: latex-harvesting technology, rubber clones, moderate metabolism, tapping panel dryness, physiological parameters

INTRODUCTION

The production of rubber from a rubber plantation inevitably results from tapping (Serres *et al*., 1994; Obouayeba *et al*., 2000). It is obtained from an incision (cut) of the tissues of the trunk bark (Obouayeba *et al*., 2000). As a result of this incision, the laticiferous vessels, which are specialized tissues, with special rubber-producing cells (laticiferous), are severed leaving the latex from which the natural rubber is extracted (Obouayeba *et al*., 2000). However, the tapping of trees in a plantation makes it possible to produce rubber, but this production is limited (Traoré *et al*., 2014). It cannot be adapted to the needs of the users and, above all, tapping alone cannot make it possible to improve the production potential of the different rubber clones (Jacob *et al*., 1988). These potentialities are indeed dependent on the metabolic function of the laticiferous cell of these clones. To address these concerns, nowadays and in a systematic way, the hormonal stimulation of rubber production (Obouayeba, 1995 and 2009; Soumahin, 2010) is added to the tapping system. This consists in applying to the tree a stimulating paste with an active ingredient concentration (Ethephon) ranging from 2.5 to 5 % in order to improve its rubber productivity (Abraham *et al*., 1968). Latex harvesting systems improve the rubber productivity of plantations (Jacob *et al*., 1990). This productivity is also a function of the intensity of the applied latex harvesting system and the metabolic class of the cloned clone (Dian, 1997). The practice of tapping or a tapping system (Obouayeba, 1995 and 2009) and/or a strategy of hormonal stimulation of rubber production may constitute a more or less intensive latex harvesting system or technology for a clone of a given metabolism. However, it is known that the most efficient latex harvesting technologies in rubber production weaken the physiological state of the trees. Thus, in order to sustain and even raise the productivity of rubber tree, many important studies have been carried out in the field of plant physiology and latex (Jacob *et al*., 1988). This work has made it possible to group clones currently cultivated into three classes of metabolic activity and to establish a clonal typology of the metabolic functioning of the laticiferous system (Eschbach *et al*., 1984; Jacob *et al*., 1988; Serres *et al*., 1994; Jacob *et al*., 1995; Gohet *et al*., 1996). The latter is based on the response to the hormonal stimulation of rubber production of the groups of clones concerned. Given the heavy investment in rubber production and the late return on investment, the management of a plantation must be modern using the Latex Micro Diagnosis (LMD) in order to make the rubber production activities profitable over the long term. This requires the implementation of efficient latex harvesting technologies adapted to the clonal laticiferous metabolisms, that is to say they are durable without damage to the trees. For this purpose, the physiological profile of the rubber obtained from the four parameters of the Latex Micro Diagnosis (LMD) of moderate metabolism clones GT 1, RRIC 100 and BPM 24 subjected to six (6) of the latex harvesting technologies is analyzed to determine the best.

MATERIALS AND METHODS

Plant material: The plant material is composed by clones of *Hevea brasiliensis,* GT 1, RRIC 100 and BPM 24, described as follows:

The clone GT 1 (Gondang Tapen) is from Java in Indonesia. It is a medium vegetative growth clone before tapping (Chapuset, 2001; Obouayeba, 2005). Its production at the tree is not very high but largely compensated by its good homogeneity. This clone is not very sensitive to the tapping panel dryness, it is resistant to breakage due to wind;

The clone RRIC 100 (Rubber Research Institute of Ceylon), is derived from the cross RRIC 52 x PB 86. Its immature vigour is large and equivalent to that of AVROS 2037 with a moderate height. It has large round leaves and very large seeds. It provides good ground coverage when young, but poor coverage in adulthood. Its physiological profile has a low thiol content and its productivity is greater than or equal to that of GT 1 (Chapuset, 2001);

The clone BPM 24 (Balai Penelitian Perkebunan Medan) is from Malaysia where it belongs to class 2. It comes from crossing GT 1 x AVROS1734. This clone has a round crown, abundant branches and light. It has thin bark, some exudations of latex on the trunk, persistent secondary branching and good ground cover. It produces abundant, round, clear seeds and then gives good opening rubber production (Chapuset, 2001).

Experimental design: The trees of these different clones were planted in straight lines at a density of 510 trees per hectare (7m x 2.8m). The "Fisher Blocks" of 6 treatments and 4 repetitions was used as an experimental device with 96 trees per elementary plot. The trial covers an average area of 4.7 ha. This trial was set up on the research station of HEVEGO (Hévéa du Gô), the current SCASO (Agricultural Civil Company of South-west located in the south-west of Côte d'Ivoire.

The experiments started as soon as the staggered opening of the trees as follows:

March 1995 and were completed in February 2004 for the clone RRIC 100;

October 1995 to September 2004 for the clone GT 1;

March 1997 to February 2006 for the clone BPM 24.

Treatments: The trees were opened at height of 1.20 m (panel BO-1). The tapping systems imposed and the intensity of tapping are shown below in **Table 1**:

Table 1: Treatments applied in tapping downward to clones Gt 1, RRIC 100 and BPM 24 during nine year of experimentation in southwestern Cote d'Ivoire

N°	Treatments	TI (%)	Description
1	**S/2 d2 6d/7, *nil stimulation***	100	Half spiral cut tapped at alternate daily frequency ,six day in tapping followed by one day rest, not stimulated
2	**S/2 d3 6d/7 ET2.5% Pa1(1) 4/y**	67	Half spiral cut tapped at third 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, 4 applications per year.
3	**S/2 d4 6d/7 ET2.5% Pa1(1) 4/y**	50	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, 4 applications per year.
4	**S/2 d4 6d/7 ET2.5% Pa1(1) 8/y**	50	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, 8 applications per year.
5	**S/2 d5 6d/7 ET2.5% Pa1(1) 8/y**	40	Half spiral cut tapped at fifth 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, 8 applications per year.
6	**S/2 d6 6d/7 ET2.5% Pa1(1) 10/y**	33	Half spiral cut tapped at sixth 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, 10 applications per year.

TI: Tapping Intensity

Tapping: Two tappers were employed with repetitions. A and B assigned to tapper A, and repetitions C and D to tapper B. Average consumption of bark (perpendicular to the tapping cut) were:

d2: 1.0 to 1.3 mm/tapping, 156 tapping per years (156 to 203 mm/y)

d3: 1.3 to 1.5 mm/tapping, 104 tapping per years (135 to 156 mm/y)

d4: 1.5 to 1.8 mm/tapping, 78 tapping per years (117 to 140 mm/y)

d5: 1.7 to 2.0 mm/tapping, 65 tapping per years (110 to 130 mm/y)

d6: 1.8 to 2.0 mm/tapping, 52 tapping per years (93 to 104 mm/y)

Hormonal Stimulation: All selected trees were stimulated on the tapping panel, on a 1 cm wide band, due to 1 g of stimulant per tree (Abraham *et al.*, 1968, Traore *et al.*, 2014). The stimulating product used is obtained by mixing Ethrel and palm oil. Ethrel contains 2.5 % of active ingredient, which is 2-chloroethylphosphonic acid or Ethéphon (CEPA).

Measured parameters: For each parameter, the annual average of the measurements made was chosen.

- **Rubber production:** Rubber production of 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 was used to calculate the production of dry rubber expressed in kilograms per hectare per year ($kg.ha^{-1}.y^{-1}$).

- **Radial vegetative growth:** The circumferences of trees were measured annually in March (opening trees in March 1995 for clone RRIC 100 and March 1997 for clone BPM 24) and in October (opening trees in October 1995) for clone GT 1. The measurements were made at the height of 1.70 m above the ground using a measuring tape.
- **Rates of tapping panel dryness:** The percentage of tapping panel dryness was determined visually. This rate was obtained by taking into account of percentage of dry trees.
- **Latex Micro Diagnosis:** From the latex sampled, it was possible to determine annually, by the Latex Micro Diagnosis (LMD) method, the levels of dry rubber content (ExS) and the contents of sucrose (Suc), inorganic phosphorus (Pi) and thiol groups (R-SH) of the latex. The dry rubber content was determined according to the method described by Eschbach *et al*. (1984), while the contents of sucrose, inorganic phosphorus and thiol groups were obtained respectively by Ashwel (1957), Taussky and Shorr (1953), Boyne, and Ellman (1972). The LMD data were analyzed based on the reference values established by Jacob *et al*. (1987) and interpreted according to the Roussel interpretation scheme (Jacob *et al*., 1987).

Physiological index: Physiological studies have shown the strong involvement of certain physiological parameters in the production of rubber (Jacob *et al*., 1985) and, consequently, allowed the prediction of rubber production (Koffi *et al*., 2004). The influence of these physiological parameters on the production of rubber may or may not vary from one technology of harvesting the latex to another. Thus, the physiological index that we define as the product of the average concentrations of sucrose, inorganic phosphorus and thiol compounds at a given moment makes it possible to distinguish significantly the latex harvesting systems applied to rubber trees. The recovery of this physiological index reflects a good metabolic activation of the laticiferous tissues.

Determination of better latex harvesting systems: In order to determine the best latex harvesting systems, the physiological parameters taken into account in the realization of the latex micro diagnosis (dry rubber content, sucrose, inorganic phosphorus and thiol groups) and those of production, isodiametric growth and tapping panel dryness sensitivity have been put to use. The mean values of these parameters were subjected to an analysis of variance. This made it possible to classify the different latex harvesting technologies according to their effect on the parameters studied. The best technologies for latex harvesting have been those that have produced both:
A high level of rubber production; Low impact on isodiametric growth; Low sensitivity to the tapping panel dryness, expressed by low percentages of LEM; A good physiological profile with a dry rubber content, sucrose, inorganic phosphorus and thiol compounds ranging from medium to high.

Statistical analysis: An analysis of variance of the data including the rubber yield, vegetative radial growth, latex micro diagnostic and tapping panel dryness was done with the SAS statistical software and the Student-Newman-Keuls test, at $P < 0.05$.

RESULTS

Rubber production of clones with moderate metabolism GT 1, RRIC 100 and BPM 24

Clone GT 1: Average annual production per hectare (downward tapping), with all latex harvesting technologies, reached 1955 kg (Table 2). This production did not appear to be related to latex harvesting technologies applied to trees. The increase in stimulation frequency did not have a significant effect on production when tapping was performed every 4 days (treatments 3 and 4). Similarly, the passage of tapping frequencies every 4 days to every 5 days (treatments 4 and 5) for the same stimulation frequency (8/y) did not have a significant impact on production.

Clone RRIC 100: Rubber production expressed in $kg.ha^{-1}.y^{-1}$ did not distinguish latex harvesting technologies (Table 2). Treatment 5 (d5-8/y), at 40 % tapping intensity, was the highest (2648 $kg.ha^{-1}.y^{-1}$) and statistically identical to that of the other treatments. The average annual production of dry rubber per hectare (tapping downward), with all latex harvesting technologies, reached 2565 $kg.ha^{-1}.y^{-1}$. This production has not been influenced by latex harvesting technologies applied to trees.

Clone BPM 24: The production of rubber expressed in $kg.ha^{-1}.y^{-1}$ reached 2183 (Table 2). This production did not significantly vary regardless of the latex harvesting technology. The increase in stimulation frequency did not have a significant effect on production when tapping was performed every 4 days (treatments 3 and 4). Similarly, the passage of tapping frequencies every 4 days to every 5 days (treatments 4 and 5) for the same stimulation frequency (8/y) did not have a significant impact on production.

Tableau 2: Average annual dry rubber production expressed in $kg.ha^{-1}.y^{-1}$ in tapping downward of clones GT 1, RRIC 100 and BPM 24 for nine years in the south-west of Côte d'Ivoire

Treatments	**Dry rubber production ($kg.ha^{-1}.y^{-1}$)**			
	GT 1	**RRIC 100**	**BPM 24**	**Mean**
S/2 d2 6d/7 *nil stimulation*	2038 a	2488 a	2271 a	**2266 A**
S/2 d3 6d/7 ET2.5% Pa1(1) 4/y	2097 a	2633 a	2315 a	**2348 A**
S/2 d4 6d/7 ET2.5% Pa1(1) 4/y	1998 a	2602 a	2171 a	**2257 A**
S/2 d4 6d/7 ET2.5% Pa1(1) 8/y	1961 a	2587 a	2293 a	**2280 A**
S/2 d5 6d/7 ET2.5% Pa1(1) 8/y	1919 a	2648 a	2133 a	**2234 A**
S/2 d6 6d/7 ET2.5% Pa1(1) 10/y	1716 a	2432 a	1915 a	**2021 A**
Mean	**1955 C**	**2565 A**	**2183 B**	**2234 ± 1184**

In each column, the values assigned to the same letter are not significantly different (Student Newman-Keuls test at 5%

Synthesis of Rubber Productivity Results of Clones with moderate Metabolism GT 1, RRIC 100 and BPM24: The average annual yield of dry rubber, all latex harvest technologies and all clones combined, reached 2234 $kg.ha^{-1}.y^{-1}$. This yield did not distinguish latex harvesting technologies (Table 2). Regardless of the applied latex harvesting system, clone RRIC 100 was the most productive, followed by clone BPM 24. Clone GT 1 displayed the lowest production.

Radial vegetative growth of clones with moderate metabolism GT 1, RRIC 100 and BPM 24: The average annual tree circumference increments of clones GT 1, RRIC 100 and BPM 24 (downward tapping), all latex harvesting technologies, were respectively 2.3; 2.6 and 2.3 cm (Table 3). They did not significantly vary from latex harvesting technology to another, although tapping every two days without stimulation of rubber production recorded the highest values. All technologies of latex harvesting and all clones combined, the average annual increase in circumference of the trees reached 2.4 cm. The mean annual increments expressed by clones GT 1, RRIC 100 and BPM 24 are statistically similar.

Tableau 3 : Mean values of tree trunk circumference ($cm.y^{-1}$) in clones GT 1, RRIC 10 and BPM 24, in tapping from treatment for nine years in the southwest Côte d'Ivoire

Treatments	**Tree trunk circumference growth ($cm.y^{-1}$)**			
	GT 1	**RRIC 100**	**BPM 24**	**Mean**
S/2 d2 6d/7 *nil stimulation*	2,4 a	3,1 a	2,4 a	**2,6 ± 0,4 A**
S/2 d3 6d/7 ET2.5% Pa1(1) 4/y	2,2 a	2, 6 a	2,2 a	**2,3 ± 0,2 A**
S/2 d4 6d/7 ET2.5% Pa1(1) 4/y	2,3 a	2,7 a	2,3 a	**2,4 ± 0,2 A**
S/2 d4 6d/7 ET2.5% Pa1(1) 8/y	2,2 a	2,5 a	2,2 a	**2,3 ± 0,2 A**
S/2 d5 6d/7 ET2.5% Pa1(1) 8/y	2,3 a	2,3 a	2,2 a	**2,3 ± 0,04 A**
S/2 d6 6d/7 ET2.5% Pa1(1) 10/y	2,4 a	2,7 a	2,3 a	**2,5 ± 0,2 A**
Mean	**2,3 ± 0,1 A**	**2,6 ± 0,3 A**	**2,3 ± 0,1 A**	**2,4**

In each column, the values assigned to the same letter are not significantly different (Student Newman-Keuls test at 5%

Sensitivity to the tapping panel dryness of moderate metabolic clones GT 1, RRIC 100 and BPM 24

Clone GT 1: The average tapping panel dryness rate, all technologies combined, reached 2.46 % (Table 4). This rate is very low and shows an effect of the latex harvesting intensity (tapping-stimulation). Indeed, treatment "tapping every two days, without hormonal stimulation", has the highest rate of tapping panel dryness (3.9 %) while those of other treatments are statistically equivalent to each other. However, the tapping panel dryness rates expressed by the very low-to-low GT 1 clone are not detrimental to the subsequent harvest of the latex.

Clone RRIC 100: The average rate of tapping panel dryness for all technologies combined reached 4.1 % (Table 4). This rate of tapping panel dryness is moderate and shows overall a technology effect of latex harvesting. Trees in the absence of hormonal stimulation pattern, most frequently tapped, showed the highest tapping panel dryness rate (6.9 %). This is statistically equivalent to those of the 2 (d3-4/y), 3 (d4-4/y) and 4 (d4-8/y) motifs, and statistically higher than those of the 5 (d5-8/y) and 6 (d6-10/y) that displayed the smallest tapping panel dryness rates statistically identical.

Clone BPM 24: The average tapping panel dryness rate, for all latex harvesting technologies combined, was 2.9 % (Table 4). This rate is very low and shows a latex technology harvesting effect. In fact, treatment 1 (d2-nil stim), with 100 % tapping intensity, recorded the highest tapping panel dryness rate (5.3 %). This rate is statistically equivalent to those of units 2 (d3-4/y) and 4 (d4-8/y) with respectively 67 and 50 % tapping intensity, and statistically higher than those of units 3 (d4-4/y), 5 (d5-8/y) and 6 (d6-10/y), tapping intensity respectively 50, 40 and 33 %, which displayed the smallest and identical tapping panel dryness rates. The increase in the number of stimulations in d4 (from 4 to 8/y) resulted in an increase in the tapping panel dryness rate (d4-4/y: 1.9 % and d4-8/y: 3.3 %). On the other hand, for the same level of stimulation (treatment 2: d3-**4**/y and treatment 3: d4-**4**/y then treatment 4: d4-**8**/y and treatment 5: d5-**8**/y), the rate of tapping panel dryness is higher in rubber trees tapped at high frequency (d3-**4**/y: 3.4 % and d4-**4**/y: 1.9 %, d4-**8**/y: 3.3 % and d5-**8**/y: 1.8 %).

Synthesis of results of tapping panel dryness rates of clones with moderate metabolism GT 1, RRIC 100 and BPM 24: Overall, the mean tapping panel dryness rate of the clones GT 1, RRIC 100 and BPM 24 (downward tapping) of all latex harvesting technologies was 3.1 % (**Table 4**). This low rate is generally related to the latex harvesting technology, notably the tapping intensity and increased with this parameter of tapping panel dryness. Treatment without hormonal stimulation, with 100 % tapping intensity, had the highest tapping panel dryness rate (5.4 %), followed by treatment with 2 (d3-4/y: 3.6 %), 3 (d4-4/y: 2.4 %) and 4 (d4-8/y: 3.3 %) which are statistically similar to each other and higher than those of the treatments 5 (d5-8/y: 2.2 %) and 6 (d6-10/y: 1.9 %) which are statistically identical to each other. These last two treatments recorded the most statistically low rates. The change from 4 to 8 annual stimulations for the same tapping frequency (d4) resulted in an increase in tapping panel dryness rate (treatments 3: 2.4 % and treatment 4: 3.3 %). On the other hand, for the same level of stimulation (treatment 2: d3-**4**/y and treatment 3: d4-**4**/y then treatment 4: d4-**8**/y and treatment 5: d5-**8**/y), the rate of dry score is higher in rubber trees bled at high frequency (d3-**4**/y: 3.6 % and d4-**4**/y: 2.4 %, d4-**8**/y: 3.3 % and d5-**8**/y: 2.2 %). Compared to the clones, it appears that clones RRIC 100, had the highest tapping panel dryness rate (4.1 %), and followed by that of clone BPM 24 (2.9 %) and that of clone GT 1 (2.5 %).

Tableau 4 : Average tapping panel dryness rates of trees in clones GT 1, RRIC 100 and BPM 24, in tapping downward, according to treatments for nine years in south-west Côte d'Ivoire

Treatments	Tapping panel dryness rates (%)			
	GT 1	RRIC 100	BPM 24	Mean
S/2 d2 6d/7 *nil stimulation*	3,9 a	6,9 a	5,3 a	**5,4 ± 1,5 A**
S/2 d3 6d/7 ET2.5% Pa1(1) 4/y	2,6 b	5,0 ab	3,4 ab	**3,6 ± 1,2 B**
S/2 d4 6d/7 ET2.5% Pa1(1) 4/y	2,1 b	3,3 ab	1,9 b	**2,4 ± 0,8 C**
S/2 d4 6d/7 ET2.5% Pa1(1) 8/y	2,3 b	4,5 ab	3,3 ab	**3,3 ± 1,1 BC**
S/2 d5 6d/7 ET2.5% Pa1(1) 8/y	1,8 b	2,9 b	1,8 b	**2,2 ± 0,6 C**
S/2 d6 6d/7 ET2.5% Pa1(1) 10/y	2,1 b	1,8 b	1,9 b	**1,9 ± 0,2 C**
Mean	**2,46 ± 0,8 B**	**4,1 ± 1,8 A**	**2,9 ± 1,4 B**	**3,15**

In each column, the values assigned to the same letter are not significantly different (Student Newman-Keuls test at 5%

Physiological profile of clones with moderate metabolism GT 1, RRIC 100 and BPM 24

Clone GT 1: The solids content of the latex of all latex harvesting technologies was 49.7 % (Table 5). Pattern 6 (d6-10/y), with 33 % tapping intensity, recorded the highest rate (52.1 %). This rate is statistically higher than those of treatments 1 (d2-nil stim), 2 (d3-4/y), 3 (d4-8/y) and 4 (d4-8/y).The average sucrose content of the latex (10.8 $mmol.l^{-1}$), all latex harvesting technologies combined, is high. It remained statistically invariable regardless of the latex harvesting technology.The average inorganic phosphorus content, all latex harvesting technologies combined, was 20.73 $mmol.l^{-1}$. It is also high and has not statistically undergone the latex harvest technology effect. The average content of thiol groups of the latex, all latex collection technologies combined, is of an average level (0.69 $mmol.l^{-1}$). All levels of thiol groups of stimulated treatments are statistically equivalent to each other regardless of the latex harvesting technology and inferior with the treatment unstimulated.

Clone RRIC 100: The average solids content of the latex of all latex harvesting technologies was 50.1 % (Table 5). This rate is very high. Pattern 3 (d4-4/y) with 50 % tapping intensity recorded the highest rate (50.8 %), which is statistically identical to pattern 4 (d4-8/y), 5 (d5-8/y) and 6 (d6-10/y), and statistically higher than that of pattern 2 (d3-4/y) which is also statistically higher than that of motif 1 (d2-nil stim), which has the lowest rate (47.9 %). For all latex harvesting technologies, the average values of sucrose (10.4 $mmol.l^{-1}$), inorganic phosphorus (19.7 $mmol.l^{-1}$) and thiol groups (0.56 $mmol.l^{-1}$) are strong, medium and low respectively. These levels remained statistically unchanged regardless of the latex harvesting technology.

Clone BPM 24: The average solids content of the latex of all latex harvesting technologies reached a very high level (47.9 %) (Table 5). Pattern 6 (d6-10/y), with 33 % tapping intensity, recorded the highest rate (51.3 %). This rate is statistically identical to that of the other reasons, except that of treatment 1 (d2-nil stim) which is the most statistically weak (44.5 %). For all latex harvesting technologies, the average values of sucrose (5.4 $mmol.l^{-1}$), inorganic phosphorus (13.9 $mmol.l^{-1}$) and thiol components (0.53 $mmol.l^{-1}$), were all physiologically weak. Sucrose and inorganic phosphorus levels remained statistically invariant regardless of latex harvesting technology, while that of thiol groups showed a significant variation between treatment 1 (d2-nil stim), which had the highest content (0.83 $mmol.l^{-1}$) and the other treatments which expressed statistically identical contents.

Tableau 5 : Annual mean values of the physiological parameters of clones GT 1, RRIC 100 and BPM 24, tapping for nine years in south-west Côte d'Ivoire

Treatments	Latex physiological parameters of clone trees according to latex harvesting technology											
	GT 1				**RRIC 100**				**BPM 24**			
	ExS	Suc	Pi	R-SH	ExS	Suc	Pi	R-SH	ExS	Suc	Pi	R-SH
d2-*nil stim*	47,9 b	11,6 a	18,9 a	0,82 a	47,9 c	11,2 a	16,2 a	0,69 a	44,5 b	4,8 a	13,1 a	0,83 a
d3-4/y	49,1 b	10,7 a	23,3 a	0,70 b	49,5 bc	10,8 a	17,7 a	0,56 a	46,8 ab	6,0 a	17,7 a	0,50 b
d4-4/y	48,9 b	11,1 a	20,7 a	0,70 b	50,8 a	9,5 a	21,7 a	0,54 a	48,2 ab	4,9 a	12,0 a	0,47 b
d4-8/y	50,2 ab	10,0 a	21,8 a	0,61 b	50,8 ab	11,1 a	21,9 a	0,5 a	48,2 ab	4,9 a	14,2 a	0,57 b
d5-8/y	50,3 ab	10,0 a	20,1 a	0,66 b	50,1 ab	9,3 a	22,2 a	0,55 a	48,4 ab	6,4 a	13,0 a	0,37 b
d6-10/y	52,1 a	11,7 a	19,5 a	0,63 b	51,5 ab	10,3 a	18,5 a	0,51 a	51,3 a	5,3 a	13,2 a	0,47 b
Means	**49,7 ±1**	**10,8 ±1**	**20,7 ±21**	**0,69 ±0,1**	**50,1 ±1**	**10,4 ±1**	**19,7 ±2**	**0,56 ±0,1**	**47,9 ±2**	**5,4 ±1**	**13,9 ±14**	**0,53 ±0,2**

In each column, the values assigned to the same letter are not significantly different (Student Newman-Keuls test at 5%
ExS : Dry rubber content ; **Suc** : Sucrose ; **Pi** : Inorganic phosphorus ; **R-SH** : Thiol groups

Synthesis of Physiological Profile and Physiological Index of Clones with moderate metabolism GT 1, RRIC 100 and BPM 24

Synthesis of Physiological Profile: On the physiological level, two groups of physiological parameters are noted; sucrose and inorganic phosphorus, which did not significantly differentiate modern latex harvesting technologies and other physiological parameters, particularly the solids content and thiol groups, the grades of which vary according to the treatment (Table 6). Overall, the solids content (49.3 %) and the sucrose content (8.9 mmol.l^{-1}) are very high-to-high while the inorganic phosphorus contents (18.1 mmol.l^{-1}) and thiol groups (0.6 mmol.l^{-1}) are moderate.

Physiological index: The analysis in Table 6 shows that two groups of physiological index, with respect to latex harvesting systems, are noted; the d2-nil stim and d4-4/y systems, which statistically present the highest and equivalent values, and then the other systems whose values, are statistically identical.

Tableau 6 : Synthesis of physiological profiles and average values of physiological index of clones GT 1, RRIC 100 and BPM 24, in tapping downward during nine years of experimentation with respect to the six latex harvesting systems

Treatments	Physiological parameters				Physiological profile	Physiological index
	ExS (%)	Suc. (mmol.l^{-1})	Pi. (mmol.l^{-1})	R-SH. (mmol.l^{-1})		
d2 *nil stim*	46,8 C	9,2 A	16,1 A	0,78 A	Very balanced	115,5 A
d3-4/y	48,5 BC	8,7 A	19,3 A	0,56 B	Balanced	94,0 B
d4-4/y	49,7 AB	9,2 A	19,6 A	0,59 B	Balanced	106,4 A
d4-8/y	49,8 AB	8,5 A	18,1 A	0,57 B	Balanced	87,7 B
d5-8/y	49,6 AB	8,6 A	18,4 A	0,53 B	Balanced	83,8 B
d6-10/y	51,6 A	9,1 A	17,1 A	0,54 B	Balanced	84,0 B
Mean	**49,3**	**8,9**	**18,1**	**0,6**	Balanced	**96,7**

In each column, the values assigned to the same letter are not significantly different (Student Newman-Keuls test at 5%

DISCUSSION

Influence of latex harvesting technologies on the agronomic parameters of clones GT 1, RRIC 100 and BPM 24

Annual average dry rubber production: The rubber productions expressed in kg.ha^{-1}.y^{-1} are statistically identical regardless of the latex harvesting technology and the clones. This result seems to express a positive effect of tapping on the production of rubber. This is because tapping produces an activating effect of the rubber production metabolism as Obouayeba *et al.* (1996) and Atsin *et al*. (2016). Indeed, the tapping, by the stress that it induces, activates the metabolism of the laticiferous in the same way as the hormonal stimulation, by ethylene production (Chrestin, 1985 and Atsin *et al*., 2016). Overall, the results show that, whatever the treatment, the productions are very good and well above the national Ivorian average (≥1800 kg.ha^{-1}.y^{-1}) which is one of the best in the world. These productions even reach 2234 kg.ha^{-1}.y^{-1}. Although the three clones submitted for our investigation belong to the same metabolic class, the RRIC 100 is distinguished from the other two by its productivity in rubber. This significant difference in rubber productivity is probably due to its intrinsic energy, a priori superior to that of the other two clones of our study; its production of rubber without hormonal stimulation reinforces this assertion. This is all the more remarkable since Koffi (1995) and Gohet (1996) had already mentioned that within the same metabolic class, the activability of the rubber production metabolism could make it possible to distinguish certain clones from the others. These provisions appear to be the intrinsic energy availability (Lacote *et al*., 2010) conferring on these clones the ability to activate their metabolism in the absence of hormonal stimulation. The metabolism of the RRIC 100 clone can be considered to be more easily activated than that of the other two clones (GT 1 and BPM 24) as reported by Serres *et al*. (1986).

Radial vegetative growth: The average annual tree circumference increase, all latex harvesting technologies and all clones combined is 2.4 cm. This average annual increase in circumference is good and consistent with that of moderate vegetative growth clones, such as Obouayeba and Boa (1993) and Obouayeba *et al*. (2009) have indicated. This is particularly true since the yield of all clones and latex harvesting technologies combined reaches 2234 kg.ha^{-1}y^{-1}, as against 1903 kg.ha^{-1}y^{-1} obtained from the IRCA 111 clone (Obouayeba *et al*., 2009). This level of increase is explained by the fact that the activation of the function of rubber production by hormonal stimulation causes an increase in the energy requirements, as well as assimilates (minerals, enzymes and organic elements) necessary for the synthesis of latex constituents, and therefore of rubber production (Gohet, 1996, Lacote *et al*., 2010). In the face of these increased needs, the rubber plant, the laticiferous cell (Jacob *et al*., 1994) is obliged to use its reserves in case of shortage of assimilates (Jacob *et al*., 1988). The immediate consequence of this action is the reduction of vegetative growth (Obouayeba, 2005, Gohet, 1996, Wycherley, 1976, Templeton, 1969, Bouychou, 1962). For this purpose, the clones possessing the strongest laticiferous wells, that is to say having, for a level of production or an activation of the analogous metabolism, the highest intralaticiferous sucrose contents, could be those for which the antagonism between vegetative growth and rubber production is weakest and vice versa (Gohet, 1996). This last hypothesis is less corroborated by our results of rubber production, of intralaticiferous sucrose content and especially of radial vegetative growth, if not an opposition to the fact that the more the tree produces rubber, the less it develops as Diarrassouba *et al*. (2012); Obouayeba (2005) and Obouayeba *et al*. (2002) noted this. However, the depressive effect of hormonal stimulation on vegetative growth is attenuated by the reduction of the tapping intensity as the latter induces a stress on the tree, capable of playing a role of stimulation additional to that of hormonal stimulation (Chrestin, 1985). This is why the treatment trees d6 6/7 ET2.5% Pa1(1) 10/y have a radial vegetative growth statistically equal to that of the unstimulated trees, whereas they are strongly stimulated (10 times per year) with a low tapping frequency.

Influence of latex harvesting technologies on the tapping panel dryness sensitivity of clones GT 1, RRIC 100 and BPM 24: The average tapping panel dryness rate of clones GT 1, RRIC 100 and BPM 24, all latex harvesting technology combined, was 3.1 %. This low level is relatively good because clones of this metabolic class are generally considered moderately sensitive to tapping panel dryness (Eschbach *et al*., 1984, Prévôt *et al*., 1986, Serres *et al*., 1988, Jacob *et al*. 1995b, Gohet *et al*., 1996). This is a sign of a very good level of resistance to tapping panel dryness syndrome (Jacob *et al*., 1987) of these clones GT 1, RRIC 100 and BPM 24. It also expresses the very low impact of Latex harvest on tapping panel dryness sensitivity. Whatever the latex harvesting technology and the clone, the dry notch rate decreases with the reduction of tapping frequency. This result shows that the reduction of the tapping frequency leads to that of the tapping panel dryness sensitivity. On the other hand, the change from 4 to 8 annual stimulations in d4 leads to an increase in the tapping panel dryness rate. This highlights the detrimental effect of increasing the number of annual stimulations on rubber production (Traoré, 2014). These results illustrate the fact that the more productive a latex harvesting system, the more it is responsible for the increase in the tapping panel dryness ratio (Jacob *et al*., 1987). Indeed, the high rate of tapping panel dryness displayed by high-intensity systems is probably due to an exacerbation of metabolic activation (overheated and/or overstimulation) resulting in a large run-down of the productive process, resulting in a significant production of rubber and leading to an onset of physiological fatigue leading to the dry notch (Gohet, 1996; Soumahin, 2010).

Choosing the best latex harvesting systems for moderately metabolic clones: The objective of this study on moderate metabolism clones (GT 1, RRIC 100 and BPM 24) is to determine the best latex harvesting system applied to them. This is based on the parameters, physiological and sanitary, especially the sensitivity to tapping panel dryness. With respect to agronomic parameters, especially rubber production, all latex harvesting technologies are equivalent. On the other hand, in terms of bark consumption, latex harvesting technology; tapping every two days without hormonal stimulation of production, consumes more bark (15.6 < consumption (cm) < 20.3) than all other latex harvesting technologies, including weekly bleeding (9.4 < consumption (cm) < 10.4) according to the work of Obouayeba *et al*. (2009) which, therefore, does not recommend it for implementation. Relative to tapping panel dryness sensitivity, the trees of latex harvesting technology without hormonal stimulation are distinguished by their high sensitivity to the tapping panel dryness. It therefore appears that latex-harvesting technology without hormonal stimulation of production cannot be selected among the best. Regarding the physiological parameters, it appears from the synthesis of the physiological profiles that globally two main groups of treatments are noted; the first group is formed by latex harvesting technology without hormonal stimulation of production, with a very well balanced physiological profile. The second group consists of five (5) other latex harvesting technologies with a well-balanced physiological profile. The physiological index, produces contents of sucrose, inorganic phosphorus and thiol groups, distinguishes two groups of treatments; the first group consists of unstimulated latex harvesting technology and tapping every four (4) days stimulated four (4) times per year. The second group is the four other latex harvesting technologies. Our results show that rubber-harvesting technology without the hormonal stimulation of rubber production is certainly the most interesting in terms of its rubber productivity and especially its physiological profile, expressed by the tapped trees, which is significantly the best of all. However, this latex harvesting technology has a crippling parameter to its promotion. In fact, the bark consumption of this latex harvesting technology, which is one-third to almost double that of other latex harvesting technologies, poses a major substantive problem in the management of rubber production, on the long term. This parameter is ultimately an important constraint to the sustainable management of a plantation's rubber production. In fact, the consumption of bark, which is the capital of the rubber tree, negatively influences the management time of a plantation's rubber production by reducing it by one-third to one-half compared to other latex harvesting technologies. The physiological index and bark consumption results indicate that for best latex harvesting technology to be applied to moderately active (moderate) metabolism clones, tapping every four (4) days, stimulated four times in the year.

CONCLUSION

In downward tapping, during the first nine years after opening of the tapping panel moderate metabolism clones (GT 1, RRIC 100 and BPM 24), the results indicate that these clones have good rubber productivity (2234 $kg.ha^{-1}.year^{-1}$) with good radial vegetative growth (2.4 $cm.year^{-1}$), a well-balanced physiological profile and low sensitivity to the dry notch (3.2 %). The analysis of the influence of latex harvesting technologies on the agronomic, physiological and health parameters makes it possible to conclude that they are almost all adapted to moderate metabolism clones. However, the physiological index, the bark consumption and the tapping panel dryness sensitivity discriminate them sufficiently to retain only the latex harvesting technology "S/2 d4 6d/7 Pa1 (1) ET2.5 4/y "for the best. The latex micro diagnosis, through the physiological index, played a preponderant role in the choice of latex harvesting technologies adapted to moderate metabolism clones: GT 1, RRIC 100 and BPM 24, in our study conditions. It thus contributes to the modern and efficient management of rubber plantations.

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