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Agronomic Performance of the Clone IRCA 111 of Hevea brasiliensis *under Different Frequencies of Tapping and Stimulation in South-West Côte d'Ivoire*

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Clone IRCA 111 was developed in Côte d'Ivoire in 1975 to contribute in increasing the rubber production. Nine years of study were conducted on a large scale to identify the optimal tapping system for its exploitation before being released to the producers. The experimental design was that of a Randomised Complete Bloc (RCB). Among the six tapping systems tested (½ S d/2 6d/7; ½ S d/3 6d/7. ET 2.5%. Pa 1 (1). 4/y; ½ S d/4 6d/7. ET 2.5%. Pa 1 (1). 4/y; ½ S d/4 6d/7. ET 2.5%. Pa 1 (1). 8/y; ½ S d/5 6d/7. ET 2.5%. Pa 1 (1). 8/y and ½ S d/6 6d/7. ET 2.5%. Pa 1 (1). 10/y) tapping twice per week with 4 annual stimulations (½ S d/3 6d/7. ET 2.5%. Pa 1 (1). 4/y) turned out to be the optimal exploitation system for IRCA 111. Nevertheless, with a limited number of tappers, weekly tapping with 10 annual stimulations (½ S d/6 6d/7. ET 2.5 %. Pa 1 (1). 10/y) was the most appropriate. The production of rubber per tree and per tapping (g/t/t) was in logarithmic relation with the intensity of tapping. The rate of tapping panel dryness (TPD) was related to the intensity of tapping by a quadratic polynomial function. The study also demonstrated that IRCA 111 had a high yield, a fast growth rate and an active metabolism as compared to the standard clone PB 235.

Keywords: *Hevea brasiliensis*; clone IRCA 111; agronomic performance; tapping system; optimal exploitation; high producer; active metabolism; Côte d'Ivoire

The clone IRCA 111 is one of the first clones bred in Côte d'Ivoire to improve the rubber production of the country. However, the optimal conditions related to its exploitation is under investigation for the last decade. The exploitation system varies from one clone to another. The main factors of an exploitation system include the tapping frequency and the hormonal stimulation. The tapping fluctuates from low (d/6 6d/7) to high frequency (d/3 6d/7) regardless of the latex metabolic activity[1], while the hormonal stimulation differs according to the latex metabolic activity. A high hormonal stimulation is needed for the low metabolic activity clones and the country[1] is in need of such a clone. Thus, the frequency of stimulation is more for the low (clones PB 217, PR 107), moderate for the intermediate

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(clone GT 1) and low for the active (clones PB 235, IRCA 18) metabolism clones. In order to improve the production[1–7], an exploitation system could be intensified by combining both factors, the tapping and hormonal stimulation. The intensification of the exploitation could also be done through a high frequency of tapping, particularly the d/2 6d/7. This type of system exploitation is rare or not practised in Africa, but currently used in the Southeast of Asia[8]. In fact, the intensification of the exploitation is increasingly proportional to the rubber production. However, it should be noted that an active metabolism clone couldn't stand a strong hormonal stimulation, without a strong negative effect on the physiological status of the clone[9].

The present study has been conducted for nine years and aims at assessing the exploitation systems of IRCA 111 for high rubber production, while preventing the appearance of tapping panel dryness, due partially to the hormonal stimulation[10–12].

MATERIAL AND METHODS

Planting Material

The material consists of IRCA 111, a fast growing clone that could be tapped between 4.5 years and 5 years after planting. It is bred in Côte d'Ivoire and is a progeny of PB 5/51 × RRIM 605. It grows vigourously during tapping[13]. However the trees used in this experiment are those with comparable girth of around 49.5 cm in average with a CV of 0.6%. Its yield potential is high indeed, but the low sucrose reserves within latex predispose it to high risks of physiological imbalance in the event of overstimulation[11]. The trees (20-month grafted stumps) of clone IRCA 111 were planted in June 1988. The trees were planted in straight lines, with a density of 510 trees per ha (7 m × 2.8 m). RCB (Randomised Complete Bloc) of 6 treatments and 4 repetitions were used as experimental design with around 100 trees per plot.

Treatments

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

Tapping system 1

½ S d/2 6d/7 not stimulated (control)
Half spiral cut tapped downward at alternate daily frequency, six days in tapping followed by one day rest ; not stimulated.
Relative intensity of tapping[14,15] 100 %

Tapping system 2

½ S d/3 6d/7. ET 2.5 %. Pa 1 (1). 4/y
Half spiral cut tapped downward at third daily frequency, six days in tapping followed by one day rest ; stimulated with Ethephon of 2.5 % active ingredient with 1 g of stimulant applied on panel on a 1 cm band, 4 applications per year.
Relative intensity of tapping[14,15] 67 %

Tapping system 3

½ S d/4 6d/7. ET 2.5 %. Pa 1 (1). 4/y
Half spiral cut tapped downward at fourth daily frequency, six days in tapping followed by one day rest ; stimulated with Ethephon of 2.5 % active ingredient with 1 g of stimulant applied on panel on a 1 cm band, 4 applications per year.
Relative intensity of tapping[14,15] 50 %

Tapping system 4

1⁄2 S d/4 6d/7. ET 2.5 %. Pa 1 (1). 8/y
Half spiral cut tapped downward at fourth daily frequency, six days in tapping

followed by one day rest ; stimulated with Ethephon of 2.5 % active ingredient with 1 g of stimulant applied on panel on a 1 cm band, 8 applications per year.

Relative intensity of tapping[14,15] 50 %

Tapping system 5

½ S d/5 6d/7. ET 2.5 %. Pa 1 (1). 8/y

Half spiral cut tapped downward at fifth daily frequency, six days in tapping followed by one day rest ; stimulated with Ethephon of 2.5 % active ingredient with 1 g of stimulant applied on panel on a 1 cm band, 8 applications per year.

Relative intensity of tapping[14,15] 40 %

Tapping system 6

½ S d/6 6d/7. ET 2.5 %. Pa 1 (1). 10/y

Half spiral cut tapped downward at sixth daily frequency, six days in tapping followed by one day rest ; stimulated with Ethephon of 2.5 % active ingredient with 1 g of stimulant applied on panel on a 1 cm band, 10 applications per year.

Relative intensity of tapping[14,15] 33 %

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:

- d/2 : 1.0 to 1.3 mm/tapping, 156 tapping per year (156 to 203 mm/y)
- d/3 : 1.3 to 1.5 mm/tapping, 104 tapping per year (135 to 156 mm/y)
- d/4 : 1.5 to 1.8 mm/tapping, 78 tapping per year (117 to 140 mm/y)
- d/5 : 1.7 to 2.0 mm/tapping, 65 tapping per year (110 to 130 mm/y)
- d/6 : 1.8 to 2.0 mm/tapping, 52 tapping per year (93 to 104 mm/y)

Stimulation

The trees were stimulated on panel and tapping cut with 1 g per tree of homogenised paste containing Ethephon at 2.5 % of active ingredient. The product used was ELS 50 Double Red diluted by an equal amount of water (1 weight of ELS 50 + 1 weight water).

Measurements

Yield was estimated by weighing the fresh coagulated rubber of each experimental unit every 4 weeks (28 days). For each treatment, samples of 2 kg fresh coagulated rubber were used to calculate the transformation coefficient, which was used to determine the weight of the dry rubber per tree (g/t), the yield per tree per tapping (g/t/t) and the yield expression in kg/ha. In addition to the yield other parameters were determined annually:

- Girth (at 1.70 m from the ground) in January
- Tapping panel dryness which was obtained by counting the percentage of dry trees (TPD) and visually estimating the percentage of dry-cut length (DCL) on each tree.

In addition, the sample of latex was used for analysis of biochemical parameters including dry rubber content (DRC), sucrose (Suc), inorganic phosphorus (Pi) and thiol (RSH) contents. These analysis were carried out by the “micro latex diagnosis[9]” (MDL) method.

The dry rubber content was determined from 1 mL of latex taken in each sample (treatment), which was weighed before and after drying in the oven for 24 h. The difference in weight expressed as a percentage indicates the dry rubber content (DRC). Pi, sucrose and thiol content (RSH) were measured from the trichloracetic acid (TCA) serum obtained by mixing 1 mL of latex and 9 mL of TCA 2.5 %. Using a rod, the coagulated rubber was taken and separated from TCA 2.5 %.

Statistical Analysis

An analysis of variance of the data including the rubber yield, vegetative radial growth, latex micro diagnosis and tapping panel dryness was done with the SAS statistical software[16] and the Student-Newman-Keuls test, at $P < 0.05$.

RESULTS

Production of Rubber

The yield of rubber expressed in grams per tree per tapping (g/t/t) is inversely proportional to the tapping intensity (*Table 1*). The intermediate values were observed with medium tapping frequencies (½ S d/4 6d/7 4/y or 8/y ; treatments 3 and 4). However, in the d/4 medium tapping frequency under 4 stimulations gave better g/t/t than under 8 times. Thus, even, though the hormonal stimulation improved the production significantly (g/t/t), for the same frequency of tapping the increase in the frequency of stimulation beyond 4 times per year seemed to have an unfavourable effect on the rubber yield. The results for the yield per tree per tapping (g/t/t) also showed that the combination of a low frequency of tapping to a high frequency of stimulation was more appropriate for the clone IRCA 111.

The yield per tree (g/t) of tapping systems varied from 4069 to 5000 g/t with a cumulated average value of 4735 g. The highest yield (5000 g/t) was observed with treatment 1 (d/2 6d/7 not stimulated or control) and the lowest with treatment 6 (d/6 6d/7 10/y ; 4069 g/t). Treatments 2 & 3 (d/3 6d/7 4/y and d/4 6d/7 4/y) had similar yield values (4799 g/t) and were significantly higher than that of treatment 5 (d/5 6d/7 8/y ; 4352 g/t) and treatments 6 (d/6 6d/7 10/y ; 4069 g/t), which were comparable.

The yield in kg/ha for all the treatments was statistically comparable except treatment 6 (d/6 6d/7 10/y), which had a low value (1727 kg/ha). However, treatment 2 (d/3 6d/7 4/y) was above other treatments though the difference was not significant.

TABLE 1. PRODUCTION OF RUBBER ACCORDING TO THE TAPPING SYSTEM APPLIED TO THE CLONE IRCA 111 DURING THE FIRST NINE DOWNWARD TAPPING YEARS

		Mean Grams/tree/tapping (g/t/t)	Mean Grams/tree (g/t)	Mean kg/ha
½ S d/2	6 d/7 nil	33.6 e	5000 a	1960 ab
½ S d/3	6 d/7 4/y	48.3 d	4799 ab	2039 a
½ S d/4	6 d/7 4/y	64.2 bc	4799 ab	1932 ab
½ S d/4	6 d/7 8/y	59.5 c	4444 bc	1880 ab
½ S d/5	6 d/7 8/y	70.3 b	4352 bc	1877 ab
½ S d/6	6 d/7 10/y	82.3 a	4069 c	1727 b

Mean affected by the same letter are not significantly different, test of Newman Keuls at 5 %.

Radial Vegetative Growth

The girth was not influenced by the stimulation. Indeed, the control (treatment 1; ½ S d/2 6d/7 not stimulated) had the highest values over the 9 years of exploitation, both for the girth (81.9 cm) and girth increment (3.6 cm/year) (*Table 2*). The same observation was noticed with the percentage of tapping panel dryness for which the control was doubled.

Treatments 2, 4 and 5 (½ S d/3 6d/7 4/y; ½ S d/4 6d/7 4/y and ½ S d/5 6d/7 8/y) had comparable values for the two parameters, girth (77.6 cm; 76.6 cm; 77.5 cm) and girth increment (3.1 cm; 3.05 cm; 3.08 cm) but lower than those of treatments 3 and 6 (½ S d/4 6d/7 4/y and ½ S d/6 6d/7 10/y).

Tapping Panel Dryness

The percentage of the tapping panel dryness was almost doubled for control (½ S d/2 not stimulated; 22.4) as compared to the other treatments where it varied from 8.3 to 11.1 (*Table 2*). The annual average of girth increment, for the 9 tapping years, independent of the treatment, was 3.22 cm/year.

Physiological Profile

Dry rubber content (DRC). There was a little influence of the tapping system on the dry rubber content. Indeed, the low frequency of tapping (½ S d/6 6d/7 10/y; treatment 6) gave the highest rate of dry rubber content, statistically close to treatments 1 (½ S d/2 6d/7 not stimulated) and 3 (½ S d/4 6d/7 8/y) (*Table 3*). The lowest DRC values were observed in treatments 2 and 5 (½ S d/3 6d/7 4/y and ½ S d/5 6d/7 8/y). The average dry rubber content of all the treatments was 42.62 % with 3.4 % of coefficient of variation (CV).

Sucrose. Sucrose content was low for clones with active metabolism (*Table 3*). However the system of high frequency tapping/low stimulation [5.2 mM; treatment 2 (d/3 6d/7 4/y)] and low frequency tapping/high stimulation [7.6 mM; treatment 6 (d/6 6d/7 10/y)] had the highest sucrose content as compared to the other treatments, which had similar values

TABLE 2. GIRTH (CM), ANNUAL MEAN GIRTH INCREMENT (CM) AND PERCENTAGE OF TPD ACCORDING TO THE TAPPING SYSTEM APPLIED TO THE CLONE IRCA 111 DURING THE FIRST NINE DOWNWARD TAPPING YEARS

	Annual mean of girth increment during 9 tapping years	Girth during 9 tapping years	Percentage of tapping panel dryness during 9 tapping years
½ S d/2 6 d/7 nil	3.60 a	81.9 a	22.4 a
½ S d/3 6 d/7 4/y	3.10 b	77.6 b	11.1 b
½ S d/4 6 d/7 4/y	3.25 ab	78.0 ab	8.3 c
½ S d/4 6 d/7 8/y	3.05 b	76.6 b	10.6 bc
½ S d/5 6 d/7 8/y	3.08 b	77.5 b	8.6 c
½ S d/6 6 d/7 10/y	3.32 ab	79.0 ab	10.0 bc

Mean affected by the same letter are not significantly different, test of Newman Keuls at 5 %.

TABLE 3. PHYSIOLOGICAL PROFILE OF LATEX ACCORDING TO THE TAPPING SYSTEM APPLIED TO THE CLONE IRCA 111 DURING THE FIRST NINE DOWNWARD TAPPING YEARS

	DRC (%)	Suc (mM)	Pi (mM)	RSH (mM)
½ S 6 d/7 nil	48.4 ab	3.2 c	34.5 bc	0.28 d
½ S d/3 6 d/7 4/y	45.9 d	5.6 b	27.6 d	0.35 c
½ S d/4 6 d/7 4/y	48.2 abc	4.2 bc	40.2 ab	0.53 a
½ S d/4 6 d/7 8/y	47.0 bcd	4.0 bc	35.9 b	0.42 b
½ S d/5 6 d/7 8/y	46.1 cd	4.3 bc	42.8 a	0.44 b
½ S d/6 6 d/7 10/y	50.1 a	7.6 a	29.6 ad	0.40 bc

Mean affected by the same letter are not significantly different, test of Newman Keuls at 5 %.

except the control in which the lowest was observed.

Pi. Unlike the sucrose content, treatment 2 (d/3 6d/7 4/y) and 6 (d/6 6d/7 10/y) resulted in low phosphorus (Pi) quantity, 27.6 and 29.6 mM respectively (*Table 3*). The phosphorus contents of the other treatments were above the control (34.5 mM) and varied between 35.9 and 42.8 mM. The highest quantity of phosphorus was observed in treatments 3 and 5.

RSH. The treatments had considerable effects on the thiol content (*Table 3*). For example, the thiol concentration was almost doubled with treatment 3 (d/4 6d/7 4/y; 0.53 mM) as compared to the control (d/2 6d/7 not stimulated; 0.28 mM). The same observation was made with treatments 4, 5 and 6 (d/4 6d/7 8/y, d/5 6d/7 8/y and d/6 6d/7 10/y). This indicated that, in spite of the absence of hormonal stimulation, the protection system which secured colloidal stability was weakened (RSH content was too low, 0.25 mM). When considering the biochemical parameters altogether, the results in *Table 3* revealed that treatment 2, third daily tapping with 4 annual stimulations, showed the best balanced physiological profile. This trend was followed by treatments 6 (d/6 6d/7 10/y) and 3 (d/4 6d/7 4/y) then treatments 4 (d/4 6d/7 8/y) and 5 (d/5 6d/7 8/y). It appeared that the control (d/2 6d/7 not stimulated) had the least physiological stability of latex.

Relationship between the g/t/t and the Intensity of Tapping

The yield of rubber expressed in g/t/t is dependent on the tapping intensity (TI) in a relation of logarithmic type of general expression: $P\ (g/t/t) = a/(1+TI^{b})$ where a and b are parameters. This relation becomes (*Figure 1*): $g/t/t = 1469/(1 + TI^{0.81})$.

Relationship between the Tapping Panel Dryness (TPD) and the Intensity of Tapping

The percentage of tapping panel dryness (TPD) depends on the tapping intensity (TI) in a polynomial relation of general expression: $TPD = a\ TI^2 + b\ TI + c$; where a, b and c are parameters. This relation becomes (*Figure 2*): $TPD\ (\%) = 10^{-3}\ TI^2 - 21.10^{-3}\ TI + 5.40$

DISCUSSION

The yield of rubber per tree per tapping (g/t/t) during downward tapping (the first 9 years) is

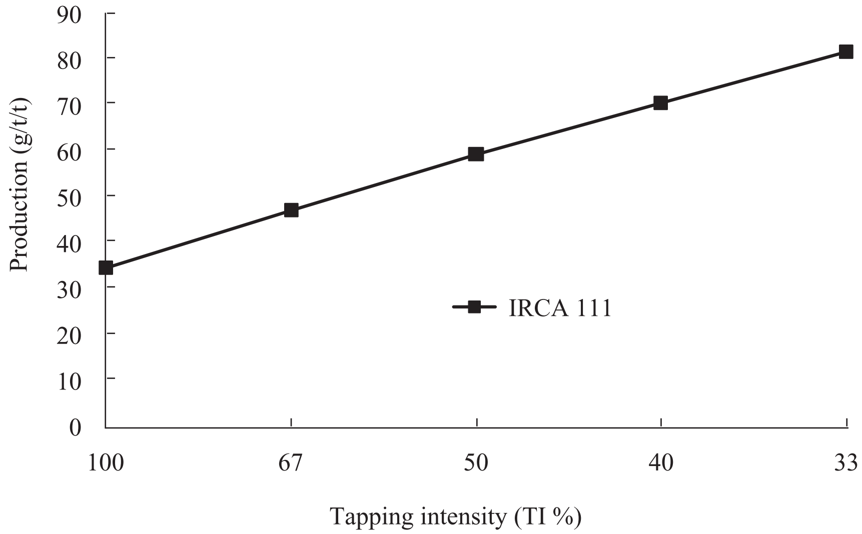

Figure 1. Logarithmic relationship between tapping intensity and rubber production g/t/t of Hevea brasiliensis.

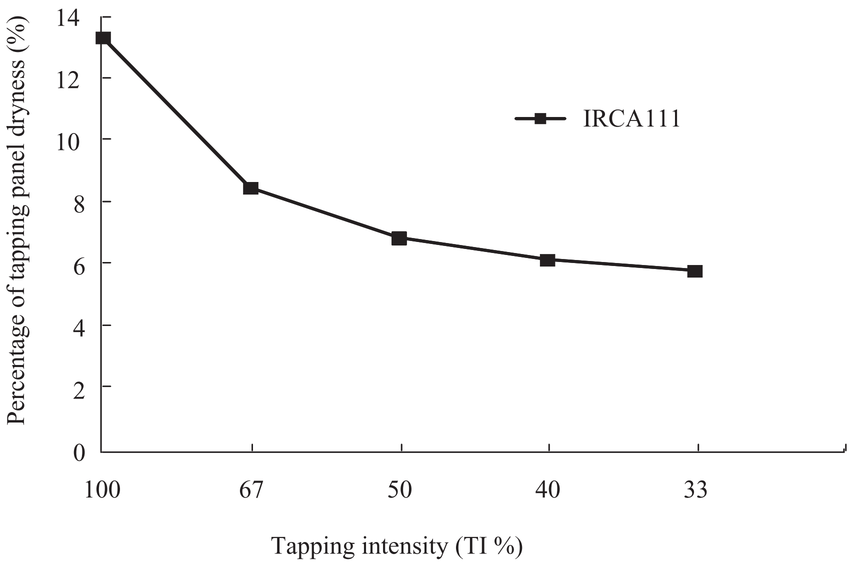

Figure 2. Quadratic relationship between tapping intensity and tapping panel dryness rate of Hevea brasiliensis.

good for any frequency of tapping. Except for the control (1⁄2 S d/2 6d/7 without stimulation) whose production represents only 73% of the average in Côte d'Ivoire[13], yields of all other treatments are higher than this reference value. The number of the days between two consecutive tappings is inversely proportional to the yield g/t/t, which implies that the low frequency tapping (of 2 consecutive tappings) is sufficient to allow a good regeneration of extracted cellular contents. However, the frequency of tapping d/3 6d/7 appears to be suitable in the improvement of the yield per tree and per hectare of clone IRCA 111. The average yield expressed in gram per tree (g/t) reached 4735. This value is acceptable compared to the standard yield which varies from 3000 to 6000. It is positively correlated to the frequency of tapping. Relations between the frequency of tapping (in particular intensity of tapping) and the production expressed in g/t/t, g/t and kg/ha have also been reported by Obouayeba and Boa (1993)[3] and Obouayeba *et al*., (1996 a, b)[4,5]. Results showed that except for the weekly tapping, with 10 times of stimulation per year (treatment 6) all other treatments gave a similar level of rubber yields. Thus, treatment 6 appears to be less adapted to the clone IRCA 111, whose fast metabolic activity requires an exploitation with a high intensity tapping system. The results for the rubber yield, vegetative growth during tapping, physiological profile and sensitivity to tapping panel dryness show that the clone IRCA 111 has a better performance with a high intensity tapping system. Similar results were observed with PB 235 by Obouayeba and Boa (1993)[3] and consequently confirm that IRCA 111 belongs to the active or rapid metabolic activity class such as clones PB 235, PB 260, PB 255[1,9,13].

The control, alternate daily tapping without stimulation, cannot be considered as the best tapping system because of the relatively high consumption of bark, 15 to 20 cm/year against 9 to 10.5 cm for the treatment d/6 6d/7. It used more bark with faster panel change, starting from the 7th year of tapping. Moreover, this treatment led to a high sensitivity to the tapping panel dryness, which undermines its usage. The yield of rubber per tree (g/t) and per hectare (kg/ha) indicates that the tapping systems with high tapping frequencies appear to be more effective on this clone than those with low frequencies. In the expression of the IRCA 111 yield potential, in particular to appreciate the productivity of the exploitation, the number of tappings per year appears to be more significant than the time between two consecutive tappings as shown by Obouayeba and Boa (1993)[3] on the clone PB 235. In contrary, considering the tapper productivity and that of the tree[18], it is rather the number of days between two consecutive tappings which is the essential parameter. Thus, the results can be used in two directions:

- first for an optimal exploitation of the potentialities of the clone IRCA 111, the tapping system 2, third daily tapping with 4 stimulations per year, is the best.
- secondly to deal with lack and/or costliness of tappers, the last treatment (tapping system 6 tapped weekly and stimulated 10 times per year), is the most suitable exploitation system.

In addition, two types of relations according to the tapping intensity (TI), are also seen. The rubber yield per tree per tapping (g/t/t) is in a logarithmic relation curve with intensity of tapping, the g/t/t, all the more lower since the intensity of tapping is high and vice versa. The tapping panel dryness (TPD %) rate and the tapping intensity follows a quadratic relation.

This relation draws the importance of regeneration in the rubber production process, namely in the production per tree and per tapping (g/t/t). Indeed, it is known[3,19] that the longer the regeneration period is, the more important the rubber production is. The regeneration period is defined as the period between two consecutive tappings, which is long for low intensities of tapping (½ S d/6 6d/7 et ½ S d/5 6d/7) and short for high intensities (½ S d/2 6d/7 et ½ S d/3 6d/7). This accounts for the yield obtained with high and low frequencies of tapping.

The tapping panel dryness (TPD %) rate is linked to the tapping intensity by a quadratic relationship. This polynomial relation reveals the fact that the higher the tapping intensity is, the more the rubber trees undergoing this tapping intensity are likely to have tapping panel dryness[3,9,19,20].

CONCLUSION

The exploitation system which consists of instead of in tapping every two days without stimulation (½ S d/2 6d/7 0/y), is not adequate to the context of rubber tree exploitation in Côte d'Ivoire. The clone IRCA 111 has a strong vegetative growth, its growth during tapping is also good but it decreases over exploitation time. It is a high productive clone which has a good and precocious increase in production. It has an active (or rapid) laticigenous metabolism and a low sugar reserve. The clone IRCA 111 is sensitive to tapping panel dryness rate which increases along with exploitation time. The exploitation system which consists of tapping twice per week and stimulating four times per year is the best as it improves the production capacities of the clone, with a good physiological profile, while limiting the risk of tapping panel dryness that may occur. The weekly tapping with ten annual stimulations is the exploitation system which can help in solving the problem of tappers scarcity. The intensity of tapping affects the production of rubber g/t/t and the rate of tapping panel dryness. These good agronomic results allow us to recommend the Clone IRCA 111 in Côte d'Ivoire.

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