Latex production of some recommended rubber clones on low tapping frequency

M Aji¹,², Supijatno³, and E Santosa³
¹Magister Student at Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University, Bogor, Indonesia
²Indonesian Rubber Research Institute, South Sumatera, Indonesia
³Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University, Bogor, Indonesia

Corresponding author email: martiniaji.ma@gmail.com

Abstract. In the current fluctuating global rubber price, cost production efficiency, such as reducing the tapping frequency in the rubber harvesting, is important to maintain the sustainability of rubber production. However, a decrease in tapping frequency can cause a decrease in latex production. This study aimed to determine the effect of low tapping frequency in several rubber clones on rubber production. The research was conducted at Indonesian Rubber Research Institute, South Sumatra, from July 2020 to January 2021. This study used a nested design with two factors, i.e., tapping and stimulant application frequency. The rubber tree used recommended clones of IRR 112, IRR 118, and BPM aged 24 years old after planting in 2010. The results showed that decreasing in tapping frequency from d3 to d5 decreased productivity by 30-40%, from d5 to d7 by 20-40%, and from d3 to d7 decreased by 60%. Stimulant applications increased the production of clones BPM 24, IRR 112, and IRR 118 by 83%, 66%, and 333%, respectively. Overall, tapping on IRR 118 with d5 frequency and the addition of stimulant showed better results. This study implies that reduction of tapping frequency in combination with stimulant application is prospective to be implemented.

Keywords: rubber tree; tapping; production; low tapping system; latex

1. Introduction
Rubber tree (Hevea brasiliensis) is one of the plantation crops that produce natural rubber which is important for the Indonesian economy, besides being a source of income for many farmers, it is also an export commodity that generates foreign exchange for the country in addition to oil and gas. The area of rubber plantations in Indonesia in 2018 was 3.6 million hectares with total production 3.6 million tons, which was dominated by smallholder plantations [1]. Despite having the largest rubber plantation area, the productivity of rubber plantations in Indonesia is still lower than in other Asian countries such as the Philippines, Vietnam, and Thailand [2]. The low productivity of rubber is primarily due to the application of technology and field management that has not been following the recommendations. In some large plantations, sustainable productivity is still difficult to be achieved on a commercial scale. Rubber plant productivity depends on the productivity of tapping trees per day, the number of tapped trees per hectare, and the effective number of tapping days per year. These factors must be maintained to produce high and sustainable rubber productivity [3].
Currently, the world rubber price is relatively fluctuating, where since 2012 the price of rubber has continued to decline, one of which is due to the weakening consumption of rubber as an industrial raw material [4]. These fluctuations have an impact on the rubber farmers' income, which results in the level of welfare. One adaptation model of farmers to such price fluctuation is to regulate the frequency of tapping.

Rubber tapping is a latex harvesting technique by cutting about 1-2 mm of the skin of the bark of the rubber tree to open the latex vessel [5]. In general, the success of tapping is determined by the type of clone, plant age, agro-ecosystem situation, as well as seasonal variations in planting locations that affect the speed of latex regeneration and the duration of latex flow.

Tapping frequency arrangement will benefit the health of rubber plants because the latex formation process takes approximately 48 hours [6]. In addition, setting the tapping frequency will affect production costs because tapping costs reach 40-60% of the total production costs [7]. One way to control the tapping frequency is to reduce the tapping frequency, by changing the tapping every 3 days (d3) to 4 (d4), 5 (d5), 6 (d6), or even 7 (d7) days [8]. Reducing the frequency of tapping in addition to reducing the cost of tapping can also solve the problem of scarcity of tappers in several rubber centres. On the other side, a reduction in the frequency of tapping can increase levels of sucrose and total solid content (TSC) as well as decreased levels of phosphate inorganic that affect the flow of latex and crop production. Application of tapping with low frequency is usually followed by the use of stimulants to optimize production. Thomas states that, in India, the frequency tapping of d7 followed by the application of stimulants is the best tapping system, which saves labour and productivity [9]. This study aimed to find out the production and physiological response of several recommended rubber clone on low tapping frequency. The implication of this latex research is to get the best frequency tapping and treatment stimulants combination, and further research can be done regarding this aspect.

2. Materials and methods
The experiment was conducted from July 2020 to January 2021 in the Experimental Field of Indonesian Rubber Research Institute, Banyuasin District, South Sumatera, Indonesia. The Field is located at an altitude of ±10 m above sea level and the topography of the land is relatively flat (0-3%). The type of land is dominated by red-yellow podzolic soil, the texture is loamy loam to sandy loam, the consistency is rather sticky, and the drainage is rather good.

The study used three rubber recommendation clones, namely BPM 24, IRR 112, and IRR 118 in the 2010 planting year with a spacing of 6 m x 3 m. The trees have been tapped for 5 years with a tapping frequency of d3. Determination of tree samples was carried out by measuring the girth of the tree at a height of 100 cm above the soil surface or above the grafting linkage. Trees are selected with homogeneous trunk girth conditions.

The study used a nested design with two factors of treatments. The first factor was tapping frequency and the second factor was the frequency of stimulants application, where second factor nested in first factor. The first factor consisted of three levels of tapping frequency, i.e. tapping every 3 days (d3), every 5 days (d5), and every 7 days (d7). The second factor consisted of three levels of frequency of stimulant administration, i.e., stimulant application 12 times in 1 year (12/y), stimulant application 18 times in 1 year (18/y), and stimulant application 21 times in 1 year (21/y). Each treatment combination was tested on BPM 24, IRR 112, and IRR 118. The experiment was repeated 3 times so that there were 81 experimental units. Each experimental unit used 10 plants so that the total plants used are 810 trees.

Observation included yield (gram/tree/tapping) measured as the total rubber production in the form of latex and lump every tapping. The production calculated based on one year's average production assuming the number of plants per ha is 500 trees and tapping days per year 110 days (d3), 66 days (d5), and 52 days (d7). Observation of bark consumption was carried out every 3 months by measuring the width of the incision from the beginning of the study. Latex diagnostic tests were carried out monthly, the parameters measured included the content of sucrose, thiol, and inorganic phosphate according to the procedure from IRRDB [10].
The latex diagnostic test used a sample in the form of serum trichloroacetic acid (TCA). TCA serum was prepared by mixing 1 ml of fresh latex with 9 ml of 2.5% TCA. The solids and liquids were separated, then the liquid was used as a serum for further testing. Sucrose levels were measured by the Anthrone method. Dehydration of sucrose in concentrated acid (H$_2$SO$_4$ 70%) and heating gave furfural derivatives that reacted with anthrone and were measured at an absorbance of 620 nm. Thiol content was measured based on its reaction with dithiobisnitribenzoic acid (DTNB) to form yellow TNB and measured at an absorbance of 412 nm. Inorganic phosphate levels were measured based on the principle of binding by ammonium molybdate, then reduced by FeSO$_4$ in an acid reaction so that it turned blue, and then the absorbance was measured at 740 nm.

Total solid content (TSC) was calculated using the Chee Method approach with the following formula:

$$\text{TSC} = \frac{\text{DW}}{\text{WW}} \times 100\% \text{; where DW = dry weight; WW = wet weight.}$$

The dry cut length (DCL) was carried out visually by calculating the percentage of the tapping groove that did not emit latex. The data obtained were tabulated to facilitate data analysis. The data was analyzed using variance, if the data shows a significant effect, further testing was carried out with Duncan's test with a level of 5%.

3. Results and discussion

F test summary showed that administration of multiple frequencies stimulants did not have any significant effect on the treatment of each parameter. No interaction between factors of tapping frequency and the frequency of stimulants was detected.

A reduction in the frequency of tapping caused a decrease in the cumulative production per year (Table 1). Reduction tapping from d3 to d5 caused a decrease in the production of 30-47% in the three clones. Latex reduction on d5 to d7 ranged from 20-40%, whereas from d3 to d7 decreased in latex production up to 60%. The decrease in total latex production was due to a reduction in the number of tapping days in a year.

| Tapping Frequency | Number of Tapping (days) | Production (kg ha$^{-1}$ year$^{-1}$) |
|-------------------|--------------------------|---------------------------------------|
|                   |                          | BPM 24 | IRR 112 | IRR 118 |
| d3                | 110                      | 2118$^a$ | 1703$^a$ | 1887$^a$ |
| d5                | 66                       | 1118$^b$ | 959$^b$ | 1302$^b$ |
| d7                | 52                       | 859$^c$  | 779$^c$ | 798$^c$  |

Note: *) Numbers followed by the same letter in the same column are not significantly different according to the DMRT Test at 5%.

**) Assuming the number of plants per ha is 500 trees.

Research on the effect of tapping frequency on production and other parameters has also been carried out by [12], [13], and [14]. Here, the decrease in tapping frequency from d3 to d4 or d5 increased latex production per tree per tapping (gt$^{-1}$ t$^{-1}$), however, the total latex showed a decrease in the cumulative production of a tree. Tapping frequency followed by stimulant applications twice per month increased the production, it was equivalent to tapping system stimulant d3 with one application per month. From the experiment, the decrease in tapping frequency without stimulant application did not increase production per tap significantly but reduced the production. After stimulation application, clones IRR 112 and IRR 118 showed an increase in yield (Table 2). In general, stimulant applications on tree increase latex production of BPM 24, IRR 112, and IRR 118 by 83%, 66%, and 333%, respectively. Stimulants application is a common practice in natural rubber plantation. The active ingredient commonly used is ethephon (2-chloroethylphosphonic acid)[15]. Some studies also mention that stimulant application can increase latex production by prolonging latex flow [16, 17, 18]. [19] mentions that stimulants can increase production but decrease dry rubber content. The provision of stimulant
The application depends on the physiological status of the plant [20], seasonal variations [21], and clones [15].

The primary limiting factors in production are latex in situ regeneration and latex flow. Several biochemical parameters connected with the processes involved in the flow and regeneration phenomenon [22]. Latex diagnosis is performed to determine the levels of the biochemical parameters that affect the metabolism of the rubber plant. The compounds analysed included the levels of thiol, inorganic phosphate, and sucrose (Figure 1).

**Table 2.** Yield of rubber clones BPM 24, IRR 112, and IRR 118 on several tapping systems.

| Tapping Frequency | Yield (gt·t⁻¹) Before stimulation | Yield (gt·t⁻¹) After stimulation |
|-------------------|-----------------------------------|----------------------------------|
|                   | BPM 24   | IRR 112 | IRR 118 | BPM 24   | IRR 112 | IRR 118 |
| d3                | 27.69 ᵃ  | 23.32 ᵃ  | 13.12 ᵃ | 46.63 ᵃ  | 36.70 ᵇ  | 50.22 ᵇ |
| d5                | 21.36 ᵇ  | 23.35 ᵃ  | 12.01 ᵇ | 43.29 ᵃ  | 33.35 ᵇ  | 60.02 ᵃ |
| d7                | 22.95 ᵇ  | 19.23 ᵃ  | 11.01 ᵇ | 40.57 ᵇ  | 37.98 ᵇ  | 45.49 ᵇ |

Note: *Numbers followed by the same letter in the same column are not significantly different according to the DMRT Test at 5%*.

**Figure 1.** Physiological parameters: (a) thiol, (b) sucrose, (c) phosphate inorganic, and (d) total solid content of clones BPM 24, IRR 112, and IRR 118 in several tapping systems.
The observation of the thiol levels indicated a difference among clones and tapping frequency. There was no significant difference between tapping frequencies in clone BPM 24. For clone IRR 112, the tapping frequency d3 had a smaller thiol content than tapping d5 and d7, while clone IRR 118 had less thiol content at tapping frequency d7 than d3 and d5. According to [23] thiol levels are an important indication related to the physiological susceptibility of latex, especially in the incidence of tapping panel dryness (TPD). Thiols bind to toxic oxygen thereby increasing colloid stability and latex flow.

Phosphate inorganic (PI) is an indicator of plant metabolic activity, which describes the ability of plants to convert raw materials (sucrose) into rubber particles [23]. Three clones showed that d3 has the highest levels of phosphate inorganic (Figure 1). It could be said that the decrease in tapping frequency can reduce plant metabolic activity. In contrast, lower tapping frequencies had higher sucrose levels. This could be seen in BPM 24 and IRR 112, while IRR 118 did not show a significant difference. Testing the sucrose content in latex is necessary because sucrose is the main precursor for the formation of rubber particles [24].

Total solid content is a way of estimating dry rubber content, which can be used to estimate rubber production. TSC tends to decrease with the prolonged of the latex flow [25]. Levels of TSC on BPM 24 clone is lower than IRR 112 and IRR 118. In general, tapping d3 had TSC levels significantly lower compared with tapping frequency d5 and d7 in the third test clones.

In tapping norms, the recommended tapping thickness is between 1.5-2 mm in each tapping [5], this is done to remove blockages skin in the latex vessel. In the observations, the bark consumption of the three test clones at the tapping frequency d7 was higher than that of d3 and d5 (Table 3). These results are in line with [26] which states that tapping with low frequency tends to have higher daily bark consumption but lower annual bark consumption. This is due to the lower number of tapping days per year. In India, [9] stat that for optimum results under d7, bark shaving of each tapping should have 2.5 mm thickness, because thinner shaving will lead to partial opening of latex vessels so that reduced yield.

### Table 3. Bark consumption of BPM 24, IRR 112, and IRR 118 on several tapping systems.

| Tapping Frequency | Bark consumption (mm) | Bark usage cm/year** |  |
|------------------|-----------------------|----------------------|---|
|                  | BPM 24 | IRR 112 | IRR 118 | BPM 24 | IRR 112 | IRR 118 |  |
| d3               | 1.66 c | 1.74 c | 1.60 c | 18.2 | 19.1 | 17.6 |  |
| d5               | 1.81 b | 1.76 b | 1.85 b | 12.0 | 11.6 | 12.2 |  |
| d7               | 2.70 a | 2.79 a | 2.70 a | 14.0 | 14.5 | 14.0 |  |

Note: *) Numbers followed by the same letter in the same column are not significantly different according to the DMRT Test at 5%.

**) Assuming the number of plants per ha is 500 trees; tapping days per year 110 (d3), 66 (d5), and 52 (d7).

Observation of the percentage of dry cut length (DCL) partially on the three test clones on average was below 25% (Table 4). IRR 118 tapped at d3 showed a high level of dry tapping compared to other treatments. In general, the three clones showed that the lower tapping frequency indicated a decrease in the percentage of TPD. Overall, tapping on IRR 118 with d5 frequency and the addition of stimulant showed better results than BPM 24 and IRR 112. However, more in-depth observations were needed on the three clones to determine the response in a longer period of time.
Table 4. Percentage of dry cut length of BPM 24, IRR 112, and IRR 118 on several tapping systems.

| Tapping Frequency | Dry cut length (%) |  |  |  |  |  |
|-------------------|--------------------|---|---|---|---|---|
|                   | Jul-20             | Sep-20 | Oct-20 | Nov-20 | Dec-20 | Jan-20 |
| BPM 24            |                    |        |        |        |        |        |
| d3                | 6.45               | 5.14   | 1.56   | 4.56   | 3.89   | 6.19   |
| d5                | 12.85              | 7.28   | 2.56   | 3.83   | 6.00   | 7.00   |
| d7                | 15.17              | 6.24   | 0.95   | 2.72   | 2.33   | 4.80   |
| IRR 112           |                    |        |        |        |        |        |
| d3                | 2.89               | 2.67   | 1.39   | 1.72   | 1.39   | 2.33   |
| d5                | 7.22               | 2.83   | 2.72   | 2.11   | 2.17   | 2.67   |
| d7                | 3.72               | 4.00   | 2.44   | 3.61   | 1.83   | 3.17   |
| IRR 118           |                    |        |        |        |        |        |
| d3                | 9.22               | 7.50   | 5.89   | 8.11   | 8.61   | 8.89   |
| d5                | 2.17               | 1.73   | 1.72   | 2.33   | 2.44   | 2.83   |
| d7                | 5.06               | 3.83   | 2.78   | 4.61   | 4.28   | 6.33   |

4. Conclusion

The reduction in tapping frequency reduced crop productivity per year due to a reduction in the number of tapping days. The level of reduction depended on the frequency of tapping. The changes in tapping frequency from d3 to d5 decreased latex productivity by 30-40%, from d5 to d7 by 20-40%, and from d3 to d7 by 60%. At lower tapping frequency, stimulants application increased latex production. The addition of stimulants in general increased the production of clones BPM 24, IRR 112, and IRR 118 by 83%, 66%, and 333%, respectively. Overall, tapping on IRR 118 with d5 frequency and the addition of stimulant showed better results than BPM 24 and IRR 112. This study implies that reduction of tapping frequency in combination with stimulant application is prospective to be implemented with minimum effect on latex production. However, this research needs further observation on to the effect of stimulants to obtain the optimum tapping system in the different farmer fields.

Acknowledgments

The authors sincerely thank to LPDP, Ministry of Finance, Republic of Indonesia for funding this research through Indonesian Education Scholarship program, and also Indonesian Rubber Research Institute where the research was conducted.

References

[1] BPS 2020 Statistik Karet Indonesia 2019 (Jakarta, Indonesia: Badan Pusat Statistik)
[2] FAOStat 2021 Crop data
[3] Siagian N 2013 Kunci aspek teknis dalam peraihan produktivitas tinggi dan berkelanjutan di perkebunan karet Workshop Exploitasi Tanaman Karet Menuju Produktivitas Tinggi dan Umur Ekonomis Optimal Workshop Exploitasi Tanaman Karet Menuju Produktivitas Tinggi dan Umur Ekonomis Optimal (Medan) p 19
[4] Syarifa, LF and Tistama, R 2020 Analisis Kinerja dan Prospek Komoditas Karet (Ringkasan) Anal. Dan Opini Perkeb. 1 2–7
[5] Kuswanhadi and Herlinawati E 2018 Penyadapan Tanaman Karet Saptabina Usahatani Karet Rakyat (Balai Penelitian Sembawa-Pusat Penelitian Karet) pp 105–15
[6] Siregar T H, Tistama R and Atminingsih 2013 Penyadapan tanaman karet dan stimulansia Workshop Exploitasi Tanaman Karet Menuju Produktivitas Tinggi dan Umur Ekonomis Optimal Workshop Exploitasi Tanaman Karet Menuju Produktivitas Tinggi dan Umur Ekonomis Optimal (Medan) p 26
[7] Sivakumar 2013 Short-Medium and Long-Term Solutions for Problem of Tapper Shortage and Rising Cost of Production *International Workshop on Latex Harvesting Technology* (Vietnam)

[8] Vijayakumar K R, Gohet E, Thomas K U, Xiaodi W, Sumarmadji, Lakshman R, Thanh D K, Pichit Sopchoke, Karunaichamy K.S.T.K. and Mohd Akbar S 2009 *Revised international notation for latex harvest technology* (IRRDB)

[9] Thomas K 2017 Low frequency weekly tapping: benefits aplenty *Rubber Asia*

[10] IRRDB 1995 *Manual Biochemistri & Physiology Test for Hevea brasiliensis*

[11] Vachlepi A, Purbaya M, Hanifarianty S and Suwardin D 2018 Teknologi Pengolahan Bokar *Saptabina Usahatani Karet Rakyat* (Balai Penelitian Sembawa-Pusat Penelitian Karet) pp 119–30

[12] Silva J Q, Gonçalves P de S, Scarpere Filho J A and Costa R B da 2010 Agronomical performance and profitability of exploitation systems in four rubber tree clones in São Paulo state *Bragantia* 69 843–54

[13] Hai T V, Toah N A, Trung L H, Nhat N V D, Tai N V and Nang N 2015 Influence of low frequency upward tapping systems combined with stimulation on clone PB 260 *IRRDB Workshop Harvesting Technology. 19-21 November 2013. IRRDB Workshop Harvesting Technology. 19-21 November 2013. (Vietnam)* pp 329–40

[14] Atsin G J O, Soumahin E F, Kouakou H T, Coulibaly L F, Traore S M, Alle J Y, N’Guessan A E B, Kouame C and Obouayeba S 2014 Impact of Reduced Tapping Frequency on Agronomic, Physiological and Biochemical Aspects of Clone PB 260 of Hevea brasiliensis in the Centre West of Cote D’Ivoire *J. Rubber Res.* 17 12

[15] Lacote R, Gabla O, Obouayeba S, Eschbach J M, Rivano F, Dian K and Gohet E 2010 Long-term effect of ethylene stimulation on the yield of rubber trees is linked to latex cell biochemistry *Field Crops Res.* 115 94–8

[16] Jetro N N and Simon G M 2007 Effects of 2-chloroethylphosphonic acid formulations as yield stimulants on Hevea brasiliensis *Afr. J. Biotechnol.* 6 523–8

[17] Krishnakumar R, Helen R L, Ambily P K and Jacob J 2011 A modified stimulation method in *Hevea brasiliensis* for reducing oxidative stress *IRRDB International Rubber Conference* (Chiang Mai, Thailand) p 10

[18] Zhu J and Zhang Z 2009 Ethylene stimulation of latex production in *Hevea brasiliensis* *Plant Signal. Behav.* 4 1072–4

[19] Atminingsih, Tistama R, Junaidi and saban I 2019 The effect of high stimulant concentration on the yield and dry rubber content of high metabolic clone RRIM 911 in low-tapping frequency practice *Agrium* 22 11–7

[20] Purwaningrum Y, Asbur Y and Junaidi J 2019 Latex quality and yield parameters of Hevea brasiliensis (Willd. ex A. Juss.) Müll. Arg. clone PB 260 for different tapping and stimulant application frequencies *Chil. J. Agric. Res.* 79 347–55

[21] Sainoi T, Sdoodee S, Lacote R, Gohet E and Chantuma P 2017 Stimulation affecting latex physiology and yield under low frequency tapping of rubber (Hevea brasiliensis) clone RRIM 600 in southern Thailand *Aust. J. Crop Sci.* 11 220–7

[22] Jacob J-L, Prévôt J, Roussel D, Lacrotte R, Serres E, d’Auzac J, Eschbach J M and Omont H 1989 Yield limiting factors, latex physiological parameters, latex diagnosis, and clonal topology *Physiology of Rubber Tree Latex: The Laticiferous Cell and Latex—A Model of Cytoplasm* ed J d’Auzac, J-L Jacob and H Chrestin (CRC Press)

[23] Sumarmadji and Tistama R 2004 *Deskripsi Klon Karet Berdasarkan Karakter Fisiologi Lateks Untuk Menetapkan Sistem Eksploitasi Yang sesuai* J. Penelit. Karet 22 27–40

[24] Jacob J-L, Prévôt J, Lacrotte R, Clément A, Serres E and Gohet E 1995 Clonal topology of laticifer functioning in Hevea brasiliensis *Plant. Rech. Dev.* 2 43–9
[25] Junaidi, Wijaya A, Rachmawan A and Andriyanto M 2019 Total Solid Content and Compound Properties from Different Collection Time of *Hevea brasiliensis* Latex *Acta Technol. Agric.* 22 104–8

[26] Junaidi J, Atminingsih A and Darojat M R 2019 Direction, Panel Height, and Tapping Frequency Affect The Daily Bark Consumption in Hevea Rubber Tapping *Planta Trop. J. Agro Sci.* 7