Aplication Of PGR IAA And Kinetin On Rubber Clones To Accelarate Mature Tapping

Try Koryati

Abstract: This study aims to determine the most appropriate concentration of IAA hormones + Kinetin on rubber clones to accelerate the mature tapping. Experiments have been carried out in Karang Inong Plantation, PTP N I Langsa, East Aceh. This study is arranged in two factors of Nested Design. Clones factor is consisted of 5 level and IAA hormon + Kinetin factor has 7 levels. The results showed that the concentration of IAA hormones + Kinetin is different to each clone to accelerate mature tapping. Application of IAA hormone + Kinetin significantly affect the parameters of girth, bark thickness, number of latex vessels, latex vessel diameter, leaf area and the amount of chlorophyll. Application of IAA 600ppm + Kinetin 60 ppm (H6) show the largest increase on the girth. Clone treatment is also has significant effect on all parameters, but the largest girth found in clones PB 330 and IRR 5. Combination of Clones with IAA hormone + Kinetin significantly affects the bark thickness, the number of latex vessels and latex vessel diameter. Application of IAA 400 ppm + Kinetin 60 ppm has no significant effect on girth, but able to accelerate the mature tapping particularly for clones PB 330 and IRR5 (K2H4 and K5H4) as indicated by girth size namely 48.15 cm and 48.20 cm respectively at planting age 46 months.

Keywords: rubber clones, immature plant periods, IAA hormones, Kinetin

1 Introduction

Length of plant immature periods (TBM) is very closely related to the size of girth. Girth has significant relationship with the initial volume of latex flow, total latex volume, and clogging index (CI). This is an indication of the importance of the girth criteria in rubber tapping (Hamzah and Gomez, 1982). For rubber, the standard of tapping requirement (exploitation) is 70% of planting area has reached mature tapping or productive with criteria if the girth measured at a height of 100 cm from the grafting linkage has reached 45 cm in bark thickness at least 7 mm (Paardekooper, 1989; Anwar, 2006; Junaidi and Kuswanhadi, 2006; Sundiandi, et al., 2009). Economic analysis has shown losses during plant immature periods, including the costs and time, can be closed more quickly by shortening plant immature periods (Anwar, 2006). Various attempts have been made to shorten TBM or accelerate mature tapping and optimize plant productivity, among others by application of proper cultivation techniques. Technology component applied to support the shortening of NPA is the use of high yield clones, good and selected planting material, land preparation that meet with mechanic and chemical requirement, planting legume cover crop (LCC), intensive fertilizer, canopy manipulation through branches induction and toppings to prevent wind attacks, and routines maintenance such as weeding, JAP control (Adiwiganda et al.1995; Sundiandi, et al., 2009). Siagian (2010, 2014) shows that chance to shorten TBM with the use of root stoct planting materials has not giving yet a significant results. Of the efforts to shorten the TBM period, presently there are clones with productive age (mature tapping) at 4 years. However, such efforts need to be supported by basic research that includes the use of plant growth regulator (PGR) to achieve productive age under 4 years old. The use of PGR in agricultural crops has been widely applied and has been successful in increasing production and improves growth quality.

In rubber tree, the use of growth substance can affect the cambium, because rubber tree is dicotyledonous plant that has open xylem and phloem vessels (Barlow, 1978). Wilson (1970) states that the activities of the cambium are depend on intern factors such as growth substances. Gouwentak (1941) as cited by Fahn (1991) states that stimulation of cambium activity require combination of particular growth substance. There are two groups of growth substances namely auxin and cytokinin which has proved affect the cambium activities. Auxin is one of the main hormones that regulate the formation of wood. Auxin is produced in young leaves and moves down towards the cambium, causing the formation of wood. Cytokines produced in the root tip and moves upward to activate cambium sensitivity to auxin signal and stimulate cell division in cambium (Aloni, 2007). Wilson (1970) confirms that directly auxin application on the stem can increase size of trunk diameter of woody plants. The increase is to the maximum limit in line with increasing doses of auxin. Enlargement of the stem is formed by the wood and skin tissue. Aloni (1987, 2007) and Wattimena (1988) states that IAA has important roles in secondary growth, including cells division in cambium and formation of xylem and phloem tissue. In terms to accelerate the return on equity and increase the productivity of rubber tree, improvement of culture techniques continue to be pursued. If the NPA period can be shortened and the initial production can be improved, the return on equity will be faster and gains will be even greater, the costs incurred up to the NPA fell by 18-19% (Anwar, 2006; Sundiandi, et al., 2009). Even, the efficiency will higher if based on the present value. Such improvement is absolutely necessary in order to maintain investor interest on rubber commodity and to enhance the market competitiveness of natural rubber producing countries. Exogenous application of PGR is an alternative to accelerate the increase of girth, in turn rubber more quickly tapped. The use of growth regulators to increase latex production can be addressed by research on the effect of growth regulators application on *Havea brasiliensis* (Nurhamida, et al., 2005). Plant growth regulators are useful to enhance the growth and development of *Havea brasiliensis*. Furthermore, the potential of rubber production is also dependent on the growing environment (agro-climatic), management and clones (genetically).

- *Try Koryati, Faculty of Agriculture University Amir Hamzah, Medan Indonesia. E-mail: atikmarno@yahoo.co.id*

2. MATERIALS AND METHODS

This research was conducted at Karang Inong Plantation, PTP Nusantara I in Nanggroe Aceh Darussalam. The site is located in Alue Genteng village , District of Ranto Peurelak, regency of East Aceh, with a distance of ± 70 km from the Central Office Langsa. The altitude is 51 m above sea level. Topography is Flat to undulating. Rubber clones is ± 34 month old in the field. This research is two factors of Nested Design, namely clones factors and hormone factors. Clones Factor (K) consists of 5 levels ie; K1 = Clone PB 260, K2 = clones IRR 107 and K 3 = clone PB 340, K4 = clones PB 330 and K5 = clones IRR 105. Factors of IAA Hormone and Kinetin (H) is consists of 7 levels ie; H0 = Control (without IAA and Kinetin), H1 = IAA (400 ppm) + Kinetin (50 ppm), H2 = IAA (400 ppm) + Kinetin (60 ppm), H3 = IAA (500 ppm) + Kinetin (50 ppm), H4 = IAA (500 ppm) + Kinetin (60 ppm), H5 = IAA (600 ppm) + Kinetin (50 ppm) and H6 = IAA (600 ppm) + Kinetin (60 ppm. Treatment is repeated 2 times, but nested within clones' factors treatment, so the number of experimental unit is 7 x 5 x 2 = 70 unit. Each unit consists of 4 rubber trees, therefore in total is 280 trees. Analysis of variance was performed to test each treatment. If the test results show significant or very significant different, then followed by DMRT test. Research Implementation. Prepare experimental plot in rubber planting area that selected relatively close to each other among the clones used. Preliminary observations were conducted on each sample from each treatment in accordance with observation of response variable. IAA and Kinetin applied in accordance with the treatment that is blended with lanolin (pasta) and smeared on a circle of bark that has been rubbed with sand paper for 2.5 cm around the stem in two positions for each tree. The first position is located at a height of 70 cm above the ground and second position above the first position. Application interval is once a month for 4 applications. Observations variables is agronomic characters, include: girth (cm), bark thickness (mm), leaf area (cm^2), the amount of chlorophyll ($fruit/mm^2$) and the character of anatomy include: the number of latex vessels (fruit) and the latex vessel diameter (π).

3. RESULTS AND DISCUSSION

a. Effect of Single Factor

Mean different test of girth (cm), bark thickness (mm), the number of latex vessels (JPL) (bh), latex vessel diameter latex (DPL) (μ), leaf area (cm^2) and the amount of chlorophyll ($unit/mm^2$) for clones and IAA hormone + Kinetin treatment is presented in Table 1. Table 1 show that clone and IAA hormone + Kinetin had significant effect on the observed parameters. Response of each clone is different for the observed parameters. The largest girth found in clones PB 330, namely ± 46.28 cm, which is significantly different from the other clones, except clone IRR5 of ± 46.15 cm that show not significant different. The largest bark thickness found in clones PB 340 but not significant different with clones PB 260 and PB 330. The highest JPL and DPL found in IRR 107, while the widest leaf area found in clones PB 330 and the highest amount of chlorophyll is IRR 5. Hormone treatment (Table 1) has significant effect on all observed parameters. The largest girth found at IAA hormone 500 ppm + 60 ppm Kinetin (H4) (size ± 46.36 cm)) which is only significantly different from H_0 (girth size is 40.36 cm). The largest bark thickness and highest amount of latex vessels found in IAA hormone 500 ppm + Kinetin 50 ppm (H3), whereas the widest leaf area found at IAA hormone 600 ppm + Kinetin 50 ppm (H5) and the highest amount of chlorophyll is at H6 (IAA 600 ppm + Kinetin 60 ppm).

b. Interaction Effect between Clones and Hormones

Observations show that combination of clones with IAA hormone + Kinetin only has significant effect on the number of latex vessels and latex vessel diameter, but not significant different on others parameter (Table 2) Table 2. shows that the highest number of latex vessels are combination of clones PB 330 with application of IAA hormone 400 ppm + Kinetin 60 ppm (K_2H_2), PB 340 with IAA hormone 600 ppm + Kinetin 50 ppm (K_3H_5) and K_3H_6 and clones IRR 5 with IAA hormone 500 ppm + Kinetin 50 ppm respectively, each 7.00 fruit observation that significantly different from the combination of other treatments. The largest latex vessel diameter found at IRR 5 with IAA hormone 500 ppm + Kinetin 50 ppm (K_5H_3), namely 27.19 μ and followed by K_1H_2 26.75 μ. Although the treatment combination had no significant effect on girth, but the largest size of girth found in IRR 5 and PB 330 with IAA hormone 500 ppm + Kinetin 60 ppm (K_5H_4 and K_2H_4), each around 48.20 cm and 48.15 cm at age plant of 46 months in the field, followed by K_2H_6 (around 47.50 cm girth).

Table 1. *Mean different test of girth, bark Thickness, Number of Latex Vessel (JPL) and Diameter of Latex Vessel (DPL), Leaf area and Number of Chlorophyll at 46 months by Clones and Hormone Treatment*

Treatment	Girth (cm)	Bark Thickness (mm)	JPL (fruit)	DPL (µ)	Leaf Area (cm^2)	Number of Chlorophylls (fruit/mm^2)
Clone (K)						
K_1 = PB 260	45.20 b	5.01	3.50 c	14.01a	50.60 bc	47.93c
K_2 = PB 330	46.28 a	5.06	4.00 b	13.52ab	58.94 a	47.43c
K_3 = PB 340	45.48 b	4.76	4.00 b	13.24b	46.39 c	52.26ab
K_4 = IRR 107	45.21 b	5.03	4.00 b	13.96a	46.57 c	49.87bc
K_5 = IRR 5	46.15 a	4.94	5.00 a	13.43ab	53.83 ab	53.66a
Hormone IAA+Kinetin (H)						
H_0= control	40.36 b	4.20 c	24.19 b	12.69c	49.20 bc	52.08ab
H_1=400 ppm+50 ppm	45.75 a	5.06 ab	25.08 a	13.27bc	55.23 ab	50.00abc
H_2= 400ppm+60 ppm	45.80 a	5.12 ab	25.33 a	13.54ab	51.02 abc	50.65abc
H_3=500 ppm+50 ppm	45.63 a	5.18 a	25.42 a	13.98a	49.12 bc	50.95abc
H_4=500 ppm+ 60 ppm	46.36 a	4.91 ab	24.37 b	13.73ab	50.23 abc	48.21bc
H_5 =600ppm+ 50ppm	45.38 a	5.05 ab	25.29 a	13.98a	55.81 a	47.19c
H_6= 600ppm+60 ppm	45.87 a	4.89 b	15.34 a	14.23a	48.25 c	52.55a

Note: *Figures followed by the same letter in the same column is not significant different at 5% level by Duncan Multiple Range Test*

Table 2. *Mean different test of girth, bark Thickness, Number of Latex Vessel (JPL) and Diameter of Latex Vessel (DPL) 46 months by Clones and Hormone Treatment*

Clone (K)	Hormone IAA+Kinetin (H)	Age plant of 46 months			
		Girth (cm)	Bark Thickness (mm)	JPL (fruit)	DPL (µ)
K1 =PB 260	H_O= Kontrol	40.75	4.10	3.50 d	24.38 c
	H_1= 400 ppm+50 ppm	44.90	5.27	4.50 c	26.75 a
	H_2= 400 ppm+60 ppm	45.75	5.22	5.00 c	24.69 cd
	H_3= 500 ppm+50 ppm	44.55	5.30	5.50 c	25.82 bc
	H_4= 500 ppm+60 ppm	44.50	4.70	6.00 b	25.26 c
	H_5= 600 ppm+50 ppm	44.55	5.10	6.00 b	24.69 cd
	H_6= 600 ppm+60 ppm	45.15	4.79	6.00 b	26.51 b
K2 = PB 330	H_O= Kontrol	40.40	4.31	4.00 d	23.44 d
	H_1= 400 ppm+50 ppm	45.80	5.30	5.00 c	26.13 b
	H_2= 400 ppm+60 ppm	46.30	5.41	7.00 a	25.94 b
	H_3= 500 ppm+50 ppm	47.30	5.27	6.00 b	25.26 c
	H_4= 500 ppm+60 ppm	48.15	4.46	4.50 c	23.13 d
	H_5= 600 ppm+50 ppm	45.10	5.13	5.00 c	27.19 a
	H_6= 600 ppm+60 ppm	47.50	4.64	6.50 ab	25.94 b
K3 = PB 340	H_O= Kontrol	40.15	4.18	4.00 d	24.69 cd
	H_1= 400 ppm+50 ppm	44.90	5.20	5.00 c	23.76 d
	H_2= 400 ppm+60 ppm	46.15	5.02	6.00 b	25.00 c
	H_3= 500 ppm+50 ppm	45.55	5.19	6.00 b	25.00 c
	H_4= 500 ppm+60 ppm	46.20	5.55	4.00 d	23.44 d
	H_5= 600 ppm+50 ppm	45.00	4.85	7.00 a	25.32 c
	H_6= 600 ppm+60 ppm	45.00	4.98	7.00 a	24.69 cd
K4 = IRR 107	H_O= Kontrol	40.20	4.17	4.00 d	24.07 d
	H_1= 400 ppm+50 ppm	46.55	4.71	6.00 b	25.32 c
	H_2= 400 ppm+60 ppm	45.65	4.93	4.00 d	24.85 cd
	H_3= 500 ppm+50 ppm	44.85	4.94	5.00 c	24.85 cd
	H_4= 500 ppm+60 ppm	44.75	4.94	5.00 c	24.69 cd
	H_5= 600 ppm+50 ppm	45.60	5.08	4.50 c	23.91 d
	H_6= 600 ppm+60 ppm	45.60	4.76	6.00 b	25.16 c
K5 = IRR 5	H_O= Kontrol	40.30	4.26	5.00 c	24.38 cd
	H_1= 400 ppm+50 ppm	46.60	4.83	6.00 b	23.44 d
	H_2= 400 ppm+60 ppm	45.15	5.03	6.00 b	26.19 b
	H_3= 500 ppm+50 ppm	45.90	5.22	7.00 a	27.19 a
	H_4= 500 ppm+60 ppm	48.20	4.93	6.50 ab	25.32 c
	H_5= 600 ppm+50 ppm	46.65	5.11	5.50 bc	25.32 c
	H_6= 600 ppm+60 ppm	46.10	5.31	6.00 b	24.38 cd

Note: *Figures followed by the same letter in the same column is not significant different at 5% level by Duncan Multiple Range Test*

4. DISCUSSION

Given that clones is very important as production aspects, that is level of productivity per unit area, length of TBM to be passed, production stability during productive age, maintenance costs to be incurred, and the quality of rubber produced, then carefully selection of clones is very important consideration for any plantation (Azwar and Ginting, 1990; Anwar, 2006). The results of the study on five tested clones for 12 months is that the faster clones for girth growth is clone PB 330 (K2 = 46.28 cm), followed IRR 5 (K5 = 46.15 cm), PB 340 (K3 = 45.48cm), IRR 107 (K4 = 45.21 cm) and PB 260 (K1 = 45.20 cm) at age 46 months in the field. So that circle girth for the tested clones has meets the criteria of mature tapping. It is because the clones is recommended commercial clones that grouped into two : clones PB 330, PB 260 and PB 340 clones as latex producer, and clone IRR 5 and IRR 107 as latex and wood producer (Daslin, Woelan and Suhendry 2009 and Anwar, 2006). Based on the criteria of mature tapping, the tested clones has meets the criteria, but 60% of the population stands not yet reach 45 cm of girth at the plantation. Although the combination of hormone with clones has no significant effect on girth, but at age of 46 months, the largest girth found in clones PB 330 and IRR 5 with hormone IAA 500 ppm + 60 ppm Kinetin (K2H4 and K5H4), namely 48.15 cm and 48.20 cm, followed by hormone IAA 600 ppm + Kinetin 60 ppm for clones PB 330 (K2H6) (± 47.50 cm), while the lowest found in each clones without hormones (H0) and the lowest is IRR 107 without hormones (K4H0), namely 40.20 cm. It is suspected that clones PB 330 is slow starter (SS), that is clones with low to medium metabolism, characterized by responsive to stimulants application, relatively more resistant to exploitation pressure and bark renewable is generally thick (Kuswanhadi et al. 2009). Thus, clones PB 330 is more responsive to hormone application as indicated by faster girth increase than other clones. Thus, the application of IAA hormone + Kinetin able to accelerate mature tapping for each clone, because the girth has been meet with the criteria of mature tapping (≥ 45 cm). This is confirmed by Wilson (1970) that directly auxin application on the stem can increase the size of the trunk diameter of woody plants. The increase is to the maximum in line with increasing auxin doses. In addition, clones PB 330 is recommended clone, grouped into latex producer clones and slow starter (Daslin, Woelan and Suhendry 2009; Kuswanhadi et al., 2009), while the IRR 5 is also recommended clone grouped into latex producer clones and slow starter and characterized with faster girth growth (Daslin, Woelan and Suhendry, 2009) Stem enlargement is the result of secondary growth caused by cambium division that forms xylem and phloem. Cambium activity is influenced by IAA (Hess, 1975; Aloni, 1987; 2007 and Wattimena, 1988). It is also may occur because of the applied IAA is directly absorbed by the stem, and directly affect the vascular tissue. Wilkins (1989) states that if PGR directly applied on the plant intact and capable to penetrate the surface, then they usually reach the vascular tissues and rapidly distributed with a speed of 50 mm/hour or more. This movement is non polar, both upwards and downwards, and the hormones are usually accumulated in an area that has rapid growth and expansion. Auxin transportation in the stem is polar in nature, that is base petal direction and slow movement, around 1 cm/hour, while cytokines transport is through xylem, then support cell division in the cambium (Uggla, et al. , 1998). Cell division in the cambium is known influenced by auxin and cytokinin, because the main function of cytokines is stimulate cell division (cytokinesis). Cytokinesis does not promote the growth of the organ itself, because cytokinesis only a division process (Salisbury and Ross, 1992). Physiologically, auxin can stimulate cell enlargement and stem growth, stimulates cells enlargement in cambium and stimulate differentiation of xylem and phloem. Wareing and Patrick (1975) states that IAA hormone has more directly function in the process of transport. Such condition will affect the increase of girth and bark thickness. Thus, there is synergism between IAA and kinetin to stimulate girth accretion. Koryati (1998) stated that application of IAA hormone and kinetin can simultaneously increase the girth and bark thickness of clones PB 260. The parameters of the number of latex vessels and latex vessel diameter at age 46 months showed that each clone and hormone treatment has significantly affect on the number of latex vessels. it is presumed that at the level, such combination is appropriate. In addition, the concentration of auxin can influence the vessel diameter and vessels density. Aloni (1987, 2007) states that if auxin concentration is high then there is more vessels density and vice versa. This is consistent with observations, it appears that at K5H3, lower auxin concentrations increase diameter of latex vessels in IRR 5, while for the number of latex vessels in K5H4, higher auxin concentration increase the number of latex vessels. This may occur because auxin can cause rapid cell differentiation to develop the vessels. It was alleged that exogenous auxin application will react with proteins from the plasma membrane, thereby changing the protein shape and in turn change the properties of membrane permeability. Water, organic ions and organic molecules (soluble) will exit or enter the cell and changing the osmotic pressure of the cell. The changes in cell osmotic pressure affect biochemical processes of cells and a series of reactions to produce visible growth response, such as formation of plant organs, vessels developments, changes in chemical composition and others (Wattimena, 1988).

5. CONCLUSION

1. Each clone has meet mature tapping criteria at age of 46 months; clones PB 330 and IRR 5 is faster than the other clones, characterized by girth size ± 46.28 cm and ± 46.15 cm, respectively.
2. CClones with application of IAA hormone + Kinetin can accelerate the mature tapping. The application of IAA hormone 500 ppm + Kinetin 60 ppm is faster, especially in clone IRR 5 and PB 330 (K5H4 and K2H4) as indicated by the girth size ± 48.20 cm and ± 48.15 cm, respectively and followed by IAA hormones 600 ppm + Kinetin 60 ppm in clones PB 330 (K2H6 with girth size ± 47.50 cm)

REFERENCES

[1]. Adiwiganda,Y.T.;A.E. Siahaan; J.P. Perangin-angin dan S.Darminta. 1995. Tinjauan Pemendekan Masa Remaja Tanaman Karet di PT. Good Year Sumatera Plantion dan PT. Perkebunan IVGunung Pamela. Warta Pusat Penelitian Karet, 14 (2) : 76-88

[2]. Aidi-Daslin; A. Baihaki; M.T. Danakusuma dan Murdaningsih, H. 1987. Interaksi Genotipe x Lingkungan pada Karet dan Peranannya dalam Seleksi Klon. Buletin Perkaretan BPP Sungai

Putih, 4(1) : 23-27

[3]. Aloni.R. 1987. The Induction of Vascular Tissue by Auxin In Peter J. Davies (ed). Plant Hormones and Their Role in Plant Growth and Development. Martinus Nijhoff Publishers, Netherlands. Pp : 363-373

[4]. Aloni.R. 2007. Phytohormonal Mechanisms that Control Wood Quality Formation in Young and Mature Trees. In: The Compromised Wood Workshop 2007. K. Entwistle,P. Harris, J. Walker (eds). The Wood Technology Research Centre, University of Centerbury, Christchurch, New Zealand, pp 1-22.

[5]. Anwar Chairil. 2006. Manajemen dan Teknologi Budidaya Karet. Pelatihan Tekno Ekonomi Agribisnis Karet di Jakarta,l 18 Mei 2006. 24 hal.

[6]. http://www.ipard.com/art_perkebun/MANAJEMEN%20DAN%20TEKNOLOGI%20BUDIDAYA%20KARET.pdf (Diakses Tanggal 26 Januari 2010)

[7]. Azwar, R dan S. Ginting. 1990. Rekomendasi Bahan Tanaman Karet 1991-1993. Warta Perkebunan, 9 (2) : 14-17.

[8]. Barlow, C. 1978. The Natural Rubber Industry Its Devolopment Techonology and Economy in Malaysia, Kuala Lumpur . OxfordUniversity Press, New York. Melbourne. Pp. ; 112-117

[9]. Daslin, A., S. Woelan, S dan I. Suhendry . 2009. Bahan Tanaman Klon Karet Unggul.. Balai Pusat Penelitian Sungei Putih Pusat Penelitian Karet, Medan. 40 hal.

[10]. Davies, P.J. 1987. The Plant Hormones. Their Nature, Occurance and Function. In Peter J. Davies (ed). Plant Homones and Their Role in Plant Growth and Develpoment. Martinus Nijhoff Publisher, Netherlands. pp : 4-7

[11]. Davies, P.J. 1987. The Plant Hormones. Their Nature, Occurance and Function. In Peter J. Davies (ed). Plant Homones and Their Role in Plant Growth and Develpoment. Martinus Nijhoff Publisher, Netherlands. pp : 4-7

[12]. Fahn, A. 1991. Anatomi Tumbuhan. Terjemahan Ahmad Soedarto Trenggono Koesumaningrat, Machmud Nata Saputra dan Hilda Akmal. Edisi Ketiga. GajahMadaUniversity Press, Yogyakarta. Hal. 226-245.

[13]. Hamzah, S.B.T.E. and J.B. Gomez. 1982. Some Structural factors Affecting the Productivity of Hevea brassiliensis III. Corellation Studies Between. Structural factors and Plugging. J. Rubb. Res. Int. Malaysia, 30 (3) : 148-160.

[14]. Hess, D. 1975. Plant Physiology. Springer-Verlag Berlin Heidelberg, New York. Pp. 190, 205-209.

[15]. Junaidi, U. dan Kuswanhadi, 2006. Penyadapan Tanaman Karet. Stabina Usaha Tani Karet Rakyat Edisi ke-4, Pusat Penelitian Karet, Balai Penelitian Sumbawa, Palembang.

[16]. Koryati, T. 1998. Pengaruh Aplikasi IAA, Kinetin dan Paklobutrazol pada Tanaman Karet Belum Menghasilkan Klon PB 260. Tesis Program Pasca Sarjana Universitas Sumatera Utara, Medan (Tidak dipublikasikan).

[17]. Kuswanhadi; Sumarmadji; Karyudi dan T.H.S. Siregar. 2009. Optimasi Produksi Klon Karet Melalui Sistem Eksploitasi Berdasarkan Metabolisme Lateks. Prosiding Lokakarya Nasional Pemuliaan Tanaman Karet

[18]. Kuswanhadi; Sumarmadji; Karyudi dan T.H.S. Siregar. 2009. Optimasi Produksi Klon Karet Melalui Sistem Eksploitasi Berdasarkan Metabolisme Lateks. Prosiding Lokakarya Nasional Pemuliaan Tanaman Karet

[19]. Nurhamida, L; Widya Mudiyantini; Marsusi. 2005. Perkecambahan, Pertumbuhan , dan Differensiasi Berkas Pengangkut Tanaman Karet (Hevea brassiliensis Muell.Arg) dengan Perlakuan Kombinasi Asam Indol-3-Asetat dan Asam giberellat. Biosmart Vol 7, Nomor 2 : 95-99

[20]. Paardekooper, E.C. 1989. Exploitation of the Rubber Tree. In C.C. Webster and W.J. Baukwill (eds.). Rubber. Longman Singapore Publisher (Pte) Ltd, Singapore. Pp. 349-352.

[21]. Salisbury, F.B. dan C.W. Ross. 1992. Plan Physiology. Fourth Edition. Diterjemahkan Oleh Diah R. Lukman dan Sumaryono. Fisiologi Tumbuhan Jilid 1 dan 3. ITB Bandung. Hal 105-110, 40-50, 71-77.

[22]. Siagian, N. 2010. Peluang Mempersingkat Masa Belum Menghasilkan pada Tanaman Karet Melalui Penggunaan Bahan Tanam Berbatang Bawah Banyak. Jurnal Penelitian Karet No.1 , Vol 28:

[23]. Siagian, N dan T.H.S Siregar. 2014. Pertumbuhan dan Produktivitas Awal Tanaman Karet Berbatang Bawah Banyak. Jurnal Penelitian Karet No.1, Vol. 32: 10-20

[24]. Subronto dan A.Harris. 1997. Indeks Aliran Lateks sebagai Parameter Fisiologi Penduga Produksi Lateks. Buletin, BPP Medan 8 (1) : 22-41

[25]. Sudiandi; J.H.Sihombing;N.Siagian dan Karyudi. 2009. Upaya Mempercepat Masa Tanaman Belum Menghasilkan Tanaman Karet di PTP Nusantara III. Prosiding Lokakarya Nasional

Pemuliaan Tanaman Karet.

[26]. Uggla, C., E.J. Mellerowicz, and B. Sundberg. 1998. Indole-3-Acetic Acid Controls Cambial Growth in Scots Pine by Positional Signaling. Plant Physiology 117: 113-121.

[27]. Wattimena, GA. 1988. Zat Pengatur Tumbuh Tanaman. Institut Pertanian Bogor, Bogor. Hal. 7-12, 16-18.

[28]. Wilkins, M.B. 1989. Fisiologi Tanaman. Terjemahan Mulyani Sutedjo dan A.G. Kartasapoetro. Bina Aksara, Jakarta. Hal. 30-52, 114-130, 199-202.

[29]. Wilson, B.F. 1970. The Growing Tree. University of Massachusetts Press, The United States of America. Pp. 95-100.