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HIGH LATEX YIELDING AND DISEASE RESISTANCE OF RUBBER CLONES IRR 200 SERIES

Penghasil Lateks Tinggi dan Ketahanan Penyakit Beberapa Klon Karet IRR Seri 200

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ABSTRACT

Rubber clones of Indonesian Rubber Research (IRR) 200 series have been produced from intensive breeding program started in 1985. Some clones showed superior characteristics such as high latex yielding, vigorous, and disease resistant. This study aimed to test their performances in a field trial conducted since 1999 at Sungei Putih Experimental Garden, North Sumatra. The experiment was designed in a randomized block, using twelve IRR clones as treatment and PB 260 clone as control, three replications. Planting distance was 5 m x 4 m and plot size was 10 rows x 50 trees. Observations were made on girth size of the 2, 3 and 4 year-old trees, dry rubber yield following the 1/2S d/2 and 1/2S d/3.ET2.5% tapping systems, bark thickness, rings number and diameter of latex vessels, as well as leaf fall diseases intensities of 3-5 year-old trees. The results showed four IRR 200 clones, i.e. IRR 207, IRR 208, IRR 211 and IRR 220 produced high latex. Using the 1/2S d/2 tapping system, three clones with highest dry rubber yield were obtained, namely IRR 208 (49.8 g tree^{-1} tapping^{-1} or g t^{-1} t^{-1}), IRR 211 (48.8 g t^{-1} t^{-1}) and IRR 220 (52.0 g t^{-1} t^{-1}), whereas that using the 1/2S d/3. ET2.5% tapping system, their yields were 63.2 g, 64.3 g, and 66.2 g t^{-1} t^{-1}, respectively. At four year-old, these clones had girth size of 41.4-51.0 cm, girth increment 9.7-11.6 cm year^{-1}, bark thickness 6.3-7.2 mm, latex vessel rings number 6.8-7.0, and diameter of latex vessels 23.75-26.57 µm. All of the clones were moderately resistant to *Colletotrichum, Oidium* and *Corynespora* leaf fall diseases. This study suggests that IRR 207, IRR 208, IRR 211 and IRR 220 rubber clones are suitable for commercial stake holders and the recommended tapping system is 1/2S d/3.ET2.5%.

[***Keywords***: *Hevea brasiliensis*, rubber, IRR 200 series, latex yield, disease resistance]

ABSTRAK

*Karet klon IRR (*Indonesian Rubber Research*) seri 200 dihasilkan melalui program pemuliaan yang intensif mulai tahun 1985. Beberapa klon menunjukkan karakteristik unggul sebagai penghasil lateks tinggi, jagur, dan tahan terhadap penyakit. Penelitian ini bertujuan untuk menguji kinerja klon pada percobaan lapangan yang dibangun tahun 1999 di Kebun Percobaan Sungei Putih, Sumatera Utara. Percobaan dirancang dalam acak kelompok dengan perlakuan dua belas klon IRR dan kontrol klon PB 260, tiga ulangan. Jarak tanam 5 m x 4 m dan luas plot 10 baris x 50 pohon. Pengamatan dilakukan terhadap ukuran lilit batang pada umur 2, 3 dan, 4 tahun, hasil karet kering dengan sistem sadap 1/2S d/2 dan 1/2S d/3.ET2,5%, tebal kulit, jumlah cincin, dan diameter pembuluh lateks. Intensitas serangan penyakit gugur daun diamati pada tanaman berumur 3 dan 5 tahun. Hasil penelitian menunjukkan empat klon karet IRR seri 200 yaitu IRR 207, IRR 208, IRR 211, dan IRR 220 menghasilkan lateks yang tinggi. Dengan sistem sadap 1/2S d/2, tiga klon memiliki hasil karet kering paling tinggi, yaitu IRR 208 (49,8 g pohon^{-1} sadap^{-1} atau g p^{-1} s^{-1}), IRR 211 (48,8 g p^{-1} s^{-1}), dan IRR 220 (52,0 g p^{-1} s^{-1}), sedangkan menggunakan sistem sadap 1/2S d/3. ET2,5%, hasil masing-masing klon adalah 63,2 g, 64,3 g, dan 66,2 g p^{-1} s^{-1}. Pada umur empat tahun, klon-klon ini memiliki ukuran lilit batang 41,4-51,0 cm, pertambahan lilit batang 9,7-11,6 cm tahun^{-1}, ketebalan kulit 6,3-7,2 mm, jumlah cincin pembuluh lateks 6,8-7,0, dan diameter pembuluh lateks 23,75-26,57 mm. Semua klon tahan terhadap penyakit gugur daun* Colletotrichum, Oidium, *dan* Corynespora. *Dengan demikian, klon karet IRR 207, IRR 208, IRR 211, dan IRR 220 cocok dikembangkan secara komersial dan sistem sadap yang dianjurkan adalah ½S d/3.ET2,5%.*

[***Kata kunci***: Hevea brasiliensis, *karet, IRR seri 200, hasil lateks, ketahanan penyakit*]

INTRODUCTION

Superior clones of rubber trees having high productivity and resistant to pest and diseases are important for competitive and profitable rubber development in the era of globalization. This goal has been anticipated by conducting rubber breeding activities in Indonesia since 1985; one of them is IRR series clones studies (Woelan and Pasaribu 2007). The IRR series studies have produced four generations of rubber clones (IRR series). These clones have been evaluated for their latex yielding, girth growing,

resistance to diseases and other secondary characters (Aidi-Daslin *et al*. 2009).

In the rubber breeding programs, selection and testing of promising clones were carried out in systematic and continuous stages, starting from testing seedling progeny populations of crossing, promotion plot trials, preliminary and further trials, as well as adaptability trials (Tan 1987; Simmond 1989). According to Aziz (1988), dry rubber yield potency can be increased at average of 7-8 t ha^{-1} $year^{-1}$ from 2.0 t ha^{-1} $year^{-1}$ of recommended clones at present. Evaluation of the preliminary trials of IRR 200 series rubber clones produced some new promising clones with high latex yield (Woelan *et al*. 2009; Aidi-Daslin 2011).

Selection of clonal resistance to *Colletotrichum gloeosporioides*, *Oidium heveae* and *Corynespora cassiicola* leaf fall diseases is very important, because although the clones include high yielding group, they may be susceptible to leaf fall diseases, so the latex yield become low due to low density of canopy and disturbed photosynthesis (Pawirosoemardjo and Suryaningtyas 2008). Basuki *et al*. (1990) reported that reduced latex yield can reach 40% caused by leaf fall diseases continuously. Pathogens of *Colletotrichum* and *Oidium* infect young leaves, so the plant had thin canopy, late growing and delayed girth tapping (Pawirosoemardjo *et al*. 1998). While the pathogen of *Corynespora* causes extensive damage on mature rubber trees and may become a potential limiting factor of rubber yield in Asia since 1980 (Situmorang *et al*. 1996; Breton *et al*. 2000). The susceptible clones could delay tapping mature period and decrease latex yield (Situmorang *et al*. 2007). The result of research showed that there were resistance differences of rubber germplasm in the clonal collection garden at Sungei Putih Research Center (Aidi Daslin *et al*. 2011). Hence, the use of resistant clones is strategic for controlling leaf fall diseases. This study aimed to test the growth, yield and disease resistance of some promising rubber clones of IRR 200 series in field condition.

MATERIALS AND METHODS

The study was conducted in 1999 at Sungei Putih Experimental Garden, Indonesian Rubber Research Institute, North Sumatra. The site has flat topography, elevation of 25 m above sea level, Ultisols soil type, sandy clay loam soil texture, and rain fall of 2200 mm $year^{-1}$, 120-150 rain days $year^{-1}$ and 2-3 dry month $year^{-1}$.

The experiment was designed in a randomized block clonal with three replications. The eleven clones of IRR 200 series tested were IRR 205, IRR 206, IRR 207, IRR 208, IRR 209, IRR 211, IRR 215, IRR 216, IRR 217, IRR 219 and IRR 220 and compared with the control clone PB 260 (Table 1).

Planting materials were prepared in two whorl leaves growth in polybag, planting distance of 5 m x 4 m, hole size 60 cm x 60 cm x 40 cm, and plot size 10 rows x 50 trees. Planting was conducted in June 1999 using the standard practice management.

Parameters observed on this study covered girth growth, latex yield, bark thickness, rings number and diameter of latex vessels, as well as resistance to leaf fall diseases. Girth growth was observed at 150 cm above soil surface of the 2, 3 and 4 year-old trees. The trees were tapped using the 1/2S d/2 tapping system, i.e. cut in a half spiral long, once in two days, and the 1/2S d/3. ET2.5% tapping system, i.e. cut in a half spiral long, once in three days, and the plant was treated with ethepon at concentration of 2.5% a.i. to stimulate latex production (Sumarmadji 2000). Bark thickness, rings number and diameter of latex vessels were measured at the age of 5 years (Sethuraj *et al*. 1974). Observation on leaf fall diseases were conducted on the 3 and 5 year-old trees. Disease intensity was calculated based on the formula developed by Pawirosoemardjo *et al*. (2000).

RESULTS AND DISCUSSION

Girth Growth

Average girth growth of the 2-4 year-old rubber plant of IRR 200 series clones differed significantly. Two of them, i.e. IRR 211 and IRR 215, were much better than the standard clone PB 260. They had good average

Table 1. Parentage of tested IRR 200 series rubber clones used in this study.

Clone	Parentage
IRR 205	PB 260 X BPM 101
IRR 206	PB 260 X BPM 101
IRR 207	BPM 24 X IAN 873
IRR 208	BPM 24 X IAN 873
IRR 209	PB 260 X F 4542
IRR 211	PB 260 X IAN 873
IRR 215	PB 260 X IAN 873
IRR 216	PB 260 X F 4542
IRR 217	PB 260 X F 4542
IRR 219	PB 260 X IAN 873
IRR 220	PB 260 X IAN 873

girth ranged from 26.3 to 27.9 cm at 2 year-old and increased significantly as the plant getting older (Table 2). The average girth increment was 11.6 cm year^{-1}, higher than the control clone PB 260 (10.6 cm year^{-1}). IRR 211 and IRR 215 clones had the fastest growth in immature rubber period. According to Aidi-Daslin *et al.* (2010), clones with fast growth during immature stage (>11 cm year^{-1}) were more resistant to wind damage.

Table 2. Average girth growth of eleven rubber clones of IRR 200 series at different ages.

Clone	Girth (cm)			Girth increment (cm year^{-1})
	2 years	3 years	4 years	
IRR 205	22.2 (90)*	41.7 (109)*	46.7 (102)	12.3 (116)*
IRR 206	21.2 (86)*	36.7 (96)*	42.6 (93)*	10.7 (101)
IRR 207	22.6 (92)*	37.0 (97)*	45.7 (100)	11.6 (109)*
IRR 208	22.1 (90)*	34.4 (90)*	41.4 (90)*	9.7 (92)*
IRR 209	24.2 (98)	37.1 (97)*	47.5 (104)	11.7 (110)*
IRR 211	27.9 (113)*	39.5 (103)	51.0 (111)*	11.6 (109)*
IRR 215	26.3 (107)*	40.8 (107)*	49.5 (108)*	11.6 (109)*
IRR 216	25.8 (105)	41.6 (106)*	48.0 (105)	11.1 (105)
IRR 217	26.0 (106)	38.5 (101)	47.5 (104)	10.8 (102)
IRR 219	28.5 (116)*	39.2 (102)	46.1 (101)	8.8 (83)*
IRR 220	26.7 (109)*	40.4 (105)*	47.0 (103)	10.8 (102)
PB260	24.6 (100)	38.3 (100)	45.8 (100)	10.6 (100)

Numbers in brackets are percentage to PB 260.
* = significantly different at P ≤ 0.05 compared to PB 260.

Dry Rubber Yield

Dry rubber yield of the IRR 200 series rubber clones varied (Table 3). The highest dry rubber yields following the 1/2S d/2 tapping system were obtained on IRR 208 (49.8 g t^{-1} t^{-1}), IRR 211 (48.8 g t^{-1} t^{-1}), and IRR 220 (52. 0 g t^{-1} t^{-1}), significantly higher (9-16%) than the control clone PB 260 (44.9 g t^{-1} t^{-1}). When using the 1/2S d/3.ET2.5% tapping system, four clones were superior, i.e. IRR 207 (60.1 g t^{-1} t^{-1}), IRR 208 (63.2 g t^{-1} t^{-1}), IRR 211 (64.3 g t^{-1} t^{-1}) and IRR 220 (66.2 g t^{-1} t^{-1}), 8-19%, higher than the control clone PB 260 (55.9 g t^{-1} t^{-1}). Potential dry rubber yield of these clones were 2594-2860 kg ha^{-1} year^{-1}.

The relationship between rubber yields and tapping years of high yielding rubber clones of IRR 200

Table 3. Dry rubber yield of eleven rubber clones of IRR 200 series with 1/2S d/2 and 1/2S d/3. ET 2.5% tapping systems.

Clone	Dry rubber yield (g t^{-1} t^{-1}) at different years								Mean
	1	2	3	4	5	6	7	8	
IRR 205	24.2	31.3	26.8	31.4	29.4	44.6	58.7	55.5	37.7 (84)
	30.2	**42.6**	**31.7**	**37.7**	**45.6**	**59.1**	**60.0**	**56.1**	**45.4 (81)***
IRR 206	21.4	32.9	24.9	31.8	36.3	45.0	41.0	39.9	34.2 (76)*
	29.8	**37.0**	**28.8**	**34.9**	**51.2**	**55.5**	**50.2**	**59.7**	**43.4 (78)***
IRR 207	20.2	30.4	29.3	51.2	53.8	44.5	42.2	59.7	41.4 (92)
	36.9	**38.3**	**40.8**	**68.6**	**50.8**	**81.5**	**78.9**	**84.8**	**60.1(108)***
IRR 208	32.6	44.9	29.4	38.2	43.8	50.9	77.8	80.5	49.8 (111)*
	40.1	**49.0**	**51.8**	**58.8**	**78.8**	**55.6**	**87.9**	**83.8**	**63.2 (113)***
IRR 209	19.8	23.4	18.5	28.8	26.6	36.3	39.9	41.1	29.3 (65)*
	20.0	**29.8**	**20.6**	**30.6**	**51.2**	**59.9**	**49.8**	**56.5**	**39.8 (71)***
IRR 211	34.1	40.1	50.9	46.8	43.3	54.8	50.3	70.0	48.8 (109)*
	42.8	**52.8**	**38.4**	**60.2**	**83.7**	**90.2**	**61.9**	**84.2**	**64.3 (115)***
IRR 215	20.2	29.0	23.8	31.0	39.5	48.3	45.4	58.4	37.0 (82)
	30.6	**38.3**	**25.6**	**34.9**	**39.0**	**51.5**	**65.6**	**78.6**	**45.5 (81)***
IRR 216	21.9	34.4	24.2	31.5	41.0	48.9	47.8	64.3	39.3 (88)
	31.6	**36.5**	**45.9**	**30.5**	**56.6**	**53.2**	**59.7**	**64.5**	**47.3 (85)**
IRR 217	23.8	33.3	26.9	31.8	36.8	49.8	50.7	47.4	37.6 (84)
	29.2	**47.0**	**32.3**	**48.9**	**34.1**	**52.3**	**60.8**	**73.1**	**47.2 (84)**
IRR 219	18.9	30.0	23.9	32.1	42.3	47.7	42.8	53.1	36.4 (81)*
	31.2	**40.7**	**27.5**	**33.9**	**58.8**	**51.5**	**67.2**	**48.7**	**44.9 (80)***
IRR 220	30.8	43.0	36.6	43.0	51.2	60.6	64.4	86.3	52.0 (116)*
	37.9	**48.4**	**35.7**	**62.4**	**81.2**	**72.3**	**87.2**	**104.1**	**66.2 (118)***
PB 260	30.0	37.7	32.2	36.9	42.2	68.3	57.5	54.0	44.9 (100)
	35.6	**42.4**	**39.9**	**50.4**	**79.9**	**71.4**	**57.8**	**70.1**	**55.9 (100)**

Data in bold tapped by 1/2S d/3.ET2.5%
Numbers in brackets are percentage to PB 260 at tapping system respectively.
* = significantly different at P ≤ 0.05 compared to PB 260 at tapping system respectively.

series and PB 260 with 1/2S d/2 and 1/2S d/3.ET2.5% tapping systems is presented in Figures 1 and 2. The IRR 207 was the most responsive rubber clone to the tapping system of 1/2S d/3.ET2.5% than to the tapping method of 1/2S d/2 as it significantly increased 45% latex yield than the other clones, i.e. IRR 211 (32%), IRR 220 (27%) and IRR 208 (26%). Njukeng *et al.* (2011) reported that the clonal variation of latex yield at different tapping systems can be due to the differences in latex metabolic activities. This means the 1/2S d/3.ET2.5% tapping system is recommended for commercial rubber plantations. Besides, this tapping method also requires less labor and production cost (Lukman 1996; Lacote *et al*. 2006; Rodrigo 2007).

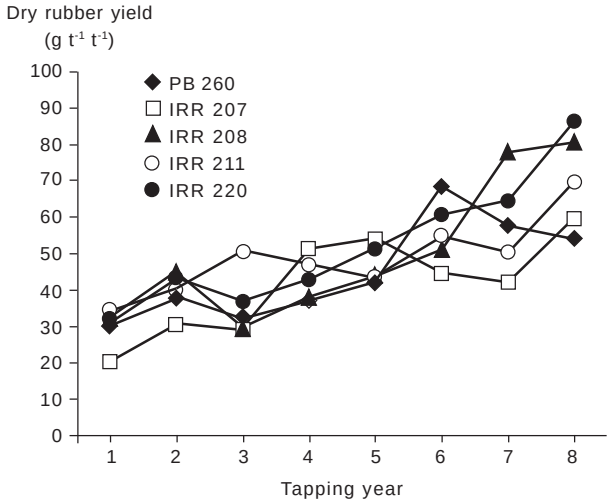

Fig 1. The relationship between dry rubber yield and tapping year of high yielding rubber clones of IRR 200 series and PB 260 (control) with 1/2 S d/2 tapping system.

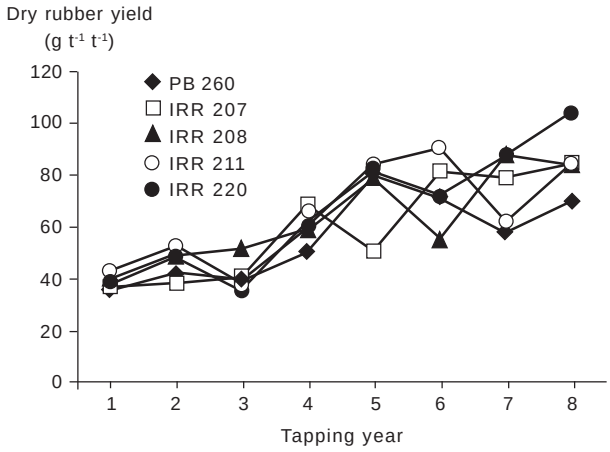

Fig 2. The relationship between dry rubber yield and tapping year of high yielding rubber clones of IRR 200 series and PB 260 (control) with 1/2 S d/3. ET 2.5% tapping system.

Bark Thickness and Latex Vessels

The study showed that the average of bark thickness of IRR 200 series clones ranged from 5.5 to 7.2 mm (Table 4). Clones having the highest bark thickness were IRR 211 (7.2 mm) and IRR 220 (6.3 mm); 136% and 119% respectively higher than the control clone PB 260 (5.3 mm). The average of latex vessel rings number ranged from 4.3 to 7.0; the highest were IRR 215 (7.0) and IRR 217 (6.8), i.e. 105-108% compared to PB 260 (6.5), while the lowest was IRR 205 (4.3). The variability of latex vessel diameters was small, ranged from 23.75 to 26.57 µm, but some clones, viz. IRR 208 and IRR 211, had the highest diameter of latex vessels ranged from 26.28 to 26.57 µm. These bark thickness, rings number and diameter of latex vessel are important parameters for clone selection because they are directly or indirectly correlated with the latex yield potential (Aidi-Daslin *et al*. 2008).

Leaf Fall Disease Resistance

The study showed that the tested IRR 200 series clones had moderately resistant to the *Colletotrichum* leaf fall disease, with disease intensity ranged from 20.67% to 26.56% (Table 5). All clones were classified to be resistant to the *Oidium* leaf fall disease; the disease intensity ranged from 16.24% to 20.66%,

Table 4. Bark thickness and latex vessel of eleven rubber clones of IRR 200 series.

Clone	Bark thickness (mm)	Latex vessel	
		Rings number	Diameter (µm)
IRR 205	5.7 (108)	4.3 (66)*	23.75 (90)*
IRR 206	5.6 (106)	6.3 (97)	25.32 (96)*
IRR 207	5.5 (104)	6.3 (97)	25.39 (97)*
IRR 208	5.9 (111)*	6.3 (97)	26.28 (100)
IRR 209	5.6 (106)	6.3 (97)	25.32 (96)*
IRR 211	7.2 (136)*	6.0 (92)*	26.57 (101)
IRR 215	6.1 (115)*	7.0 (108)*	25.94 (99)
IRR 216	6.0 (113)*	6.0 (92)*	24.07 (92)*
IRR 217	5.6 (106)	6.8 (105)	25.00 (95)*
IRR 219	5.6 (106)	5.0 (77)*	25.01 (95)*
IRR 220	6.3 (119)*	5.5 (85)*	25.63 (98)
PB260	5.3 (100)	6.5 (100)	26.26 (100)

Numbers in brackets are percentage to PB 260.
* = significantly different at $P \leq 0.05$ compared to PB 260.

Table 5. Disease intensities of *Colletotrichum, Oidium* and *Corynespora* on eleven rubber clones of IRR 200 series.

Clone	*Colletotrichum*		*Oidium*		*Corynespora*	
	Intensity (%)	Resistance	Intensity (%)	Resistance	Intensity (%)	Resistance
IRR 205	24.27*	MR	18.06*	R	0.00	R
IRR 206	20.67	MR	17.85*	R	0.00	R
IRR 207	24.93*	MR	17.18*	R	0.00	R
IRR 208	23.31*	MR	16.39*	R	2.30*	R
IRR 209	23.69*	MR	18.46*	R	0.00	R
IRR 211	23.20*	MR	20.66*	MR	0.00	R
IRR 215	22.49	MR	19.93*	R	0.25	R
IRR 216	22.50	MR	17.88*	R	0.00	R
IRR 217	26.56*	MR	17.95*	R	0.17	R
IRR 219	25.78*	MR	16.24*	R	0.00	R
IRR 220	20.74	MR	18.50*	R	2.35*	R
PB260	18.96	R	14.41	R	0.00	R

MR = moderately resistant (disease intensity 21-40%)
R = resistant (disease intensity 0-20%)
* = significantly different at $P \leq 0.05$ compared to PB 260

except IRR 211 which was categorized moderately resistant. Similarly, all the tested clones were resistant to the *Corynespora* leaf fall disease (disease intensity less than 2.5%). The results indicated that the tested rubber clones are potential for reducing leaf fall diseases, which the susceptible clones can reduce productivity up to 25-40% (Basuki *et al*. 1990; Thomanee *et al*. 1992).

CONCLUSION

The rubber clones of IRR 200 series showed highest yielding are IRR 207, IRR 208, IRR 211 and IRR 220. Tapping system recommended is the 1/2S d/3.ET2.5% because it produced an average dry rubber yield during the first eight year periods ranged from 60.1 to 66.2 g t^{-1} t^{-1} (equivalent to 2594-2860 kg ha^{-1} $year^{-1}$). Besides, these clones showed superior performances for their girth size and increment, bark thickness and latex vessel. These clones were classified as moderately to highly resistant to *Colletotrichum*, *Oidium* and *Corynespora* leaf fall diseases. Therefore, these clones are recommended for commercial plantations in strengthening the competitiveness of Indonesia's natural rubber in the global market.

REFERENCES

Aidi-Daslin, Sayurandi, and S. Woelan. 2008. Genetic variability, heritability and correlation of several characters with rubber yield. Indones. J. Nat. Rubb. Res. 26(1): 1-9.

Aidi-Daslin, S. Woelan, M. Lasminingsih, dan H. Hadi. 2009. Kemajuan pemuliaan dan seleksi tanaman karet di Indonesia. Prosiding Lokakarya Nasional Pemuliaan Tanaman Karet 2005. hlm. 50-59.

Aidi-Daslin, Sayurandi, and S.A. Pasaribu. 2010. Potency of promising rubber clones IRR 200 series from ortet selection. Indones. J. Nat. Rubb. Res. 28(1): 1-10.

Aidi-Daslin. 2011. Further trial evaluation of IRR 200 series rubber clones in immature period. Indones. J. Nat. Rubb. Res. 29(2): 93-101.

Aidi-Daslin, Z. Fairuzah, and C.I. Dalimunthe. 2011. Resistance test of selected genotype of IRRDB germplasm on *Corynespora* leaf fall disease with leaf disc method. Indones. J. Nat. Rubb. Res. 29(1): 16-24.

Aziz, A SAK. 1988. Introducing research result into practice. The experience with natural rubber. *In* A. Aziz SAK and G.E. Schiwelzen. Research Management. RRIM, Kuala Lumpur.

Basuki, S. Pawirosoemardjo, U. Nasution, Sutardi, W. Sinulingga, dan A. Situmorang. 1990. Penyakit gugur daun *Colletotrichum* pada tanaman karet di Indonesia. Potensi, penyebaran dan penanggulangannya. Prosiding Lokakarya Nasional Pemuliaan Tanaman Karet 1990. hlm. 268-295.

Breton, F., C. Sanier, and J. Auzac. 2000. Role of cassiicolin, a host-selective toxin, in pathogenicity of *Corynespora cassiicola*, causal agent of a leaf fall disease of *Hevea*. J. Rubb. Res. 3(2): 115-128.

Lacote, R., O. Gabla, S. Obouayeba, E. Gohet, A. Doumbia, M. Gnagne, and J.M. Escbach. 2006. Some considerations concerning the panel management in rubber tapping (*Hevea brasiliensis*). International Natural Rubber Conference, Ho Chi Minh, Vietnam, 13-14 November 2006. pp. 3-15.

Lukman. 1996. Optimizing yield of mature rubber trees with high intensity exploitation system. Indones. J. Nat. Rubb. Res. 14(2): 125-136.

Njukeng, J.N., P.M. Muenyi, B.K. Ngane, and E.E. Ehabe. 2011. Ethephon stimulation and yield response of some *Hevea* clones in the humid forests of South West Cameroon. Int. J. Agron. 2011: 1-5.

Pawirosoemardjo, S., Syafiuddin, dan Sujatno. 1998. Resistensi klon harapan terhadap penyakit utama tanaman karet. Prosiding Lokakarya Pemuliaan 1998 dan Diskusi Prospek Karet Alam Abad 21. hlm. 223-235.

Pawirosoemardjo, S., Sujatno, and Suwarto. 2000. Study on development of race pathogen and recommended clones resistance of the fourth generation in order controlling for *Corynespora* and *Colletotrichum* leaf fall diseases. PAATP Research Report. 31 pp.

Pawirosoemardjo, S. dan H. Suryaningtyas. 2008. Strategi pengendalian penyakit gugur daun dan pencegahan penyakit hawar daun Amerika Selatan pada tanaman karet di Indonesia. Prosiding Lokakarya Nasional Agribisnis Karet, Yogyakarta 20-21 Agustus 2008. hlm. 194-212.

Rodrigo, V.H.L. 2007. Adoption of different tapping systems in the rubber industry of Sri Lanka with special reference to low frequency tapping. J. Rubb. Res. Inst. Sri Lanka 88: 1-21.

Sethuraj, M.R., S. Sulochanamma, and P.J. George. 1974. Influence of initial rate of latex flow, rows of latex vessels and plugging index on the yield of the progenies of *Hevea brasiliensis* derived from crosses involving Tjir 1 as the female parent. Indian J. Agric. Sci. 44(6): 354-356.

Simmond, N.W. 1989. Rubber breeding. pp. 85-124. *In* C.C. Webster and W.J. Baulkwill (Eds.). Rubber. Longman, London.

Situmorang, A., A. Budiman, S. Pawirosoemardjo, and M. Lasminingsih. 1996. Epidemic of *Corynespora* leaf fall disease and its preventive methods in rubber plantation. Proc. CLF Disease of Hevea Rubber, Medan. 260 pp.

Situmorang, A., M.S. Sinaga, R. Suseno, S.H. Hidayat, Siswanto, and A. Darussamin. 2007. Distribution of *Corynespora* leaf fall disease to rubber plantation in Indonesia. Indones. J. Nat. Rubb. Res. 25(1): 76-82.

Sumarmadji. 2000. Sistem eksploitasi tanaman karet yang spesifik-diskriminatif. Warta Pusat Penelitian Karet 19(1-3): 31-39.

Tan, H. 1987. Strategics in rubber tree breeding. pp. 27-29. *In* A.J. Abbot and R.K. Attein (Eds.). Improvement of Vegetatively Propagated Crop. Academic Press, London, UK.

Thomanee, A., S. Chimsathit, and Sookmark. 1992. Progress report on 1974 multilateral exchange clone trials. ANRPC Report of the First Meeting of Plant Breeders.

Woelan, S. and S.A. Pasaribu. 2007. Genotype selection of crossing result 1998/1999 based on agronomic characters. Indones. J. Nat. Rubb. Res. 25(2): 10-24.

Woelan, S., Aidi-Daslin, M. Lasminingsih, dan I. Suhendry. 2009. Evaluasi keragaan klon IRR seri 200 dan 300 pada tahap pengujian. Prosiding Lokakarya Nasional Pemuliaan Tanaman Karet 2009, Batam. hlm. 84-106.