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EFFECT OF PANEL CHANGING ON LONG TERM YIELD RESPONSE OF *HEVEA BRASILIENSIS* (CLONE RRII 105) UNDER DIFFERENT FREQUENCIES OF TAPPING AND STIMULATION

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The effect of panel changing on long term yield response of *Hevea brasiliensis* (clone RRII 105) under different frequencies of tapping and stimulation was studied over a period of eleven years. There were eight treatments comprising of d2, d3 and d4 frequencies of tapping of half spiral cuts with and without panel change at different levels of stimulation. Considerable yield variation was observed among various treatments over the years. Effect of panel change on yield increase was more prominent in the initial five years. No significant beneficial impact of panel change on yield increase was observed under different systems of tapping. Higher yield could be obtained under d2 and d3 frequency of tapping with upper panel change (CUT). Comparable yield could be obtained under various frequencies of tapping. Cumulative yields observed within similar systems of tapping with or without panel change were also comparable. In general, similar trend was also noticed in kg per tree, g $t^{-1}t^{-1}$ and kg tap^{-1}. Significant increase in yield per tap and g $t^{-1}t^{-1}$ was noticed under d4 frequency of tapping. However, highest cumulative yield was observed under d2 frequency of tapping which was observed to be at par with d3 frequency of tapping with or without panel change. Panel change resulted in higher TPD under d2 frequency of tapping compared to lower frequency of tapping. Moreover, benefit of panel change was reflected only in the initial five years but panel management after first five years of tapping is difficult. Hence, continuous panel change cannot be considered for managing TPD or to get sustainable high yield over long period.

Keywords : Long term yied, Panel change, RRII 105, Rubber yield, Tapping panel dryness

INTRODUCTION

Natural rubber is collected from rubber trees by tapping, a process of controlled wounding, which may last for 20 to 50 years depending on the strategies and tapping systems adopted (Paardekooper, 1989; Gohet *et al.*, 1991). Panel changing is attempted in some plantations under the assumption that it helps to manage tapping panel dryness and yield increase. It is also considered to be useful for reducing the physiological stress generated in the panel particularly by high frequency tapping (Eschbach *et al.*, 1986). Bark consumption or panel consumption is an important component of any tapping system which determines land and labour productivity

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and economic life of rubber trees. Panel changing, management, tapping and their impact on growth and yield of rubber trees have been the subject of some studies (Sivakumaran *et al.*, 1983; Krishnakumar and Jacob, 2002; Lacote *et al.*, 2004; 2006). Though, initial few years information is available on the impact of panel changing on the yield response of few clones, details on long term effect of continuous panel changing on yield response of *Hevea brasiliensis* (clone RRII 105) under different frequencies of tapping and stimulation is scanty. In view of this, the present study was undertaken during the period from 1997 to 2008.

MATERIALS AND METHODS

The experiment was carried out in the Experimental Farm Unit (EFU) of Rubber Research Institute of India, located at Kottayam, Kerala (9° 32' N; 76° 36' E) with clone RRII 105 planted in 1989. Average stand of trees was 450 per ha. The trees were opened for tapping in 1996 and the experiment was initiated in 1997. There were eight treatments comprising of d2, d3 and d4 frequencies of tapping of half spiral cuts with and without panel change and different levels of stimulation. The experiment had randomized block design with six replications comprising of 15 trees per replication. Yield stimulation was carried out with 2.5 per cent ethephon (2-chloro-ethyl phosphonic acid; 17.5 mg active ingredient per tree) on the panel (Rajagopal *et al.*, 2000).

The treatment details are given below as per the new tapping notations (Vijayakumar *et al.*, 2009).

T1⁺ - S/2(RG) d2 6d/7

T2# - S/2(RG) d2 6d/7

T3⁺ - S/2(RG) d3 6d/7 ET 2.5 % Pa1(1.5) 4/y*

T4# - S/2(RG) d3 6d/7 ET 2.5 % Pa1(1.5) 4/y*

T5⁺ - S/2(RG) d4 6d/7 ET 2.5 % Pa1(1.5)7/y *

T6# - S/2(RG) d4 6d/7 ET 2.5 % Pa1(1.5) 7/y*

T7⁺ - S/2(RG) d4 6d/7 ET 2.5 % Pa1(1.5) 9/y*

T8# - S/2(RG) d4 6d/7 ET 2.5 % Pa1(1.5) 9/y*

(+ without panel change; # with panel change)

The trees were rainguarded and tapped throughout the year. Other cultural practices were followed as per the package of practices recommended by Rubber Board, 2012. Yield was recorded from all the tappings as latex and scrap separately. Dry rubber content (DRC) was determined gravimetrically. Dry rubber yield was calculated by converting latex weight proportionate to the DRC and scrap weight based on 60 per cent DRC. Tapping panel dryness (TPD) was recorded as complete drying of the tapping panel. The study was continued for eleven years. Data were processed statistically employing F-test using Analysis of variance (ANOVA) and Duncans' multiple range test (DMRT).

RESULTS AND DISCUSSION

Annual dry rubber yield (kg ha^{-1}) under different frequencies of tapping with and without panel change and stimulation is depicted in Table 1. Considerable yield variation was observed among various treatments during the years 1997-2008 (Tables 1 - 4, Figs. 1 - 3). Effect of panel change on yield increase was more prominent during the initial years (Table 1). With upper panel change tapping (*i.e.*, controlled upward tapping- CUT), during 2004-2005, significant beneficial effect of panel change on higher yield was observed under d2 and d3 frequency of tapping over other treatments (Table 1). Similar beneficial effect of CUT on yield increase was reported by Vijayakumar *et al.* (2002, 2005a) and Thomas *et al.* (2009). However, yield obtained under different systems of

Table 1. **Long-term effect of panel change on annual dry rubber yield (kg ha^{-1}) of *Hevea brasiliensis* (clone RRII 105) under different frequencies of tapping and stimulation**

Treatments	Year											
	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	Mean
1. S/2 d2 6d/7												
(without panel change)	1722 c	2677 c	2671 a	2392	3976 a	3652 a	2923 bcde	2669 bcd	3839 a	2698 ab	1917 ab	2831 a
2 S/2 d2 6d/7												
(with panel change)	2291 a	3372 ab	2066 bcd	2416	2193 bc	3832 a	3177 ab	4000 a**	3695 a**	2235 bc	1697 b	2816 a
3. S/2 d3 6d/7 ET2.5% Pa.4/y*												
(without panel change)	1704 c	2874 abc	1873 d	2529	2834 b	3723 a	2958 abcd	1990 d	2255 b	1669 c	2321 a	2430 ab
4. S/2 d3 6/d7 ET2.5% Pa.4/y*												
(with panel change)	1734 c	2890 abc	1888 d	2581	2472 bc	2692 b	2536 cde	3335 ab**	3015 ab**	2448 ab	1893 ab	2498 ab
5. S/2 d4 6d/7 ET2.5% Pa.7/y*												
(without panel change)	1690 c	2671 c	2042 cd	2232	2083 c	2323 b	3125 abc	2074 d	2240 b	2389 abc	1817 ab	2244 b
6. S/2 d4 6d/7 ET2.5% Pa.7/y*												
(with panel change)	2036 b	3468 a	2388 abc	2162	2173 bc	2808 b	2487 de	2338 cd	2842 ab	2895 ab	1846 ab	2495 ab
7. S/2 d4 6d/7ET2.5% Pa.9/y*												
(without panel change)	1762 c	2948 abc	2150 bcd	2600	2494 bc	2595 b	3570 a	2829 bc	3026 ab	3062 a	2195 ab	2657 a
8. S/2 d4 6/d7 ET2.5% Pa.9/y*												
(with panel change)	1508 d	2780 bc	2453 ab	2813	2812 b	2811 b	2317 e	2308 cd	2594 b	2743 ab	1999 ab	2467 ab
LSD (P=0.05)	158.0	619.5	397.3	NS	720.5	591.3	625.0	728.6	1029.0	728.8	539.5	408.1

** with upper panel change (CUT)
within two columns, values followed by same letter/s are not statistically different form each other;
NS - Not significant

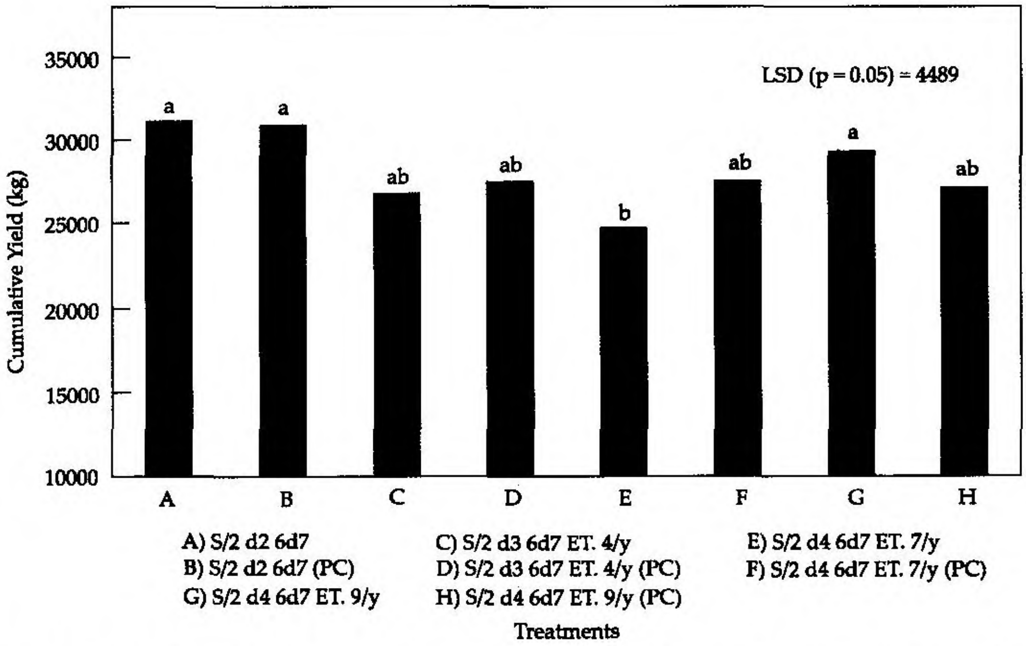

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Fig. 1. Long-term effect of panel change (PC) on cumulative dry rubber yield (kg) of *Hevea brasiliensis* (clone RRII 105) under different frequencies of tapping and stimulation (cumulative of eleven years)

tapping were comparable during 2005-2006 (Table 1).

Cumulative yield for eleven years under different frequencies of tapping with and without panel change and different levels of stimulation is presented in Figure 1. Highest cumulative yield was observed under d2 frequency of tapping which was observed to be at par with d3 frequency of tapping and d4 frequency of tapping with panel change and stimulation. Mean dry rubber yield and cumulative dry rubber yield indicated no significant difference due to panel change within different systems of tapping (Table 1, Fig. 1). Present observations are in agreement with the findings of earlier reports (Lacote *et al.*, 2004; 2006).

Yield per tree was also significantly affected by the treatments. No significant beneficial effect of panel change on yield per tree could also be observed particularly under d3 and d4 frequencies of tapping (Table 3). Tapping days ranged from 74 to 143 days depending on frequency of tapping and was highest under d2 frequency of tapping and lowest under d4 frequency of tapping (Table 4).

Mean monthly variation in yield per tap (kg tap^{-1} and g $t^{-1}t^{-1}$) is presented in Figures 2 and 3. Considerable seasonal variation in yield per tap was observed in the present study as is evident from Figures 2 & 3. In general, the yield pattern observed in the present study is bimodal. This is in conformity with earlier reports in clone RRII 105 (Karunaichamy *et al.*, 2001; Rajagopal *et al.*, 2004).

Mean yield per tap (kg tap^{-1}) under different treatments are presented in Table 2. Mean yield per tap under d2 system ranged

Table 2. **Long- term effect of panel change on dry rubber yield (kg tap^{-1} per 400 trees) of *Hevea brasiliensis* (clone RRII 105) under different frequencies of tapping and stimulation**

Treatments	Year											
	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	Mean
1. S/2 d2 6d/7												
(without panel change)	12.0e	20.7d	20.8d	15.7f	28.9d	28.7b	19.8d	19.3d	26.2ab	17.8c	16.1d	20.6d
2. S/2 d2 6d/7												
(with panel change)	14.1de	22.7d	27.0c	20.7ef	30.1d	26.0b	22.8cd	34.0ab**	29.1ab**	17.1c	14.8d	23.5cd
3. S/2 d3 6d/7 ET2.5% Pa.4/y*												
(without panel change)	17.0cd	30.4c	28.1c	22.1de	30.6d	36.9a	28.3bc	21.3cd	23.2b	20.6c	24.5bc	25.7bc
4. S/2 d3 6d/7 ET2.5% Pa.4/y*												
(with panel change)	17.8bc	30.6c	32.3b	27.2cd	33.6cd	27.3b	25.6cd	40.1a**	35.1ab**	25.3bc	20.0cd	28.6b
5. S/2 d4 6d/7 ET2.5% Pa.7/y*												
(without panel change)	21.4ab	37.1b	34.8b	26.0cd	39.6bc	35.1a	41.5a	28.4bc	29.5ab	39.0a	28.7ab	32.8a
6. S/2 d4 6d/7 ET2.5% Pa.7/y*												
(with panel change)	22.4a	38.6ab	38.6a	36.6a	49.5a	40.0a	33.7b	31.5b	37.3a	37.0a	27.9ab	35.7a
7. S/2 d4 6d/7 ET2.5% Pa.9/y*												
(without panel change)	21.1ab	40.2ab	33.8b	30.4bc	38.4bc	34.9a	47.8a	33.9ab	36.0a	39.6a	31.4a	35.2a
8. S/2 d4 6d/7 ET2.5% Pa.9/y*												
(with panel change)	22.0a	42.6a	38.2b	34.4ab	42.4b	34.9a	29.2bc	28.0bc	31.2ab	33.2ab	27.6ab	33.1a
LSD (P=0.05)	3.6	5.3	3.3	5.7	6.6	5.5	6.4	8.1	12.4	8.3	6.0	4.1

** with upper panel change (CUT)

within two columns, values followed by same letter/s are not statistically different form each other

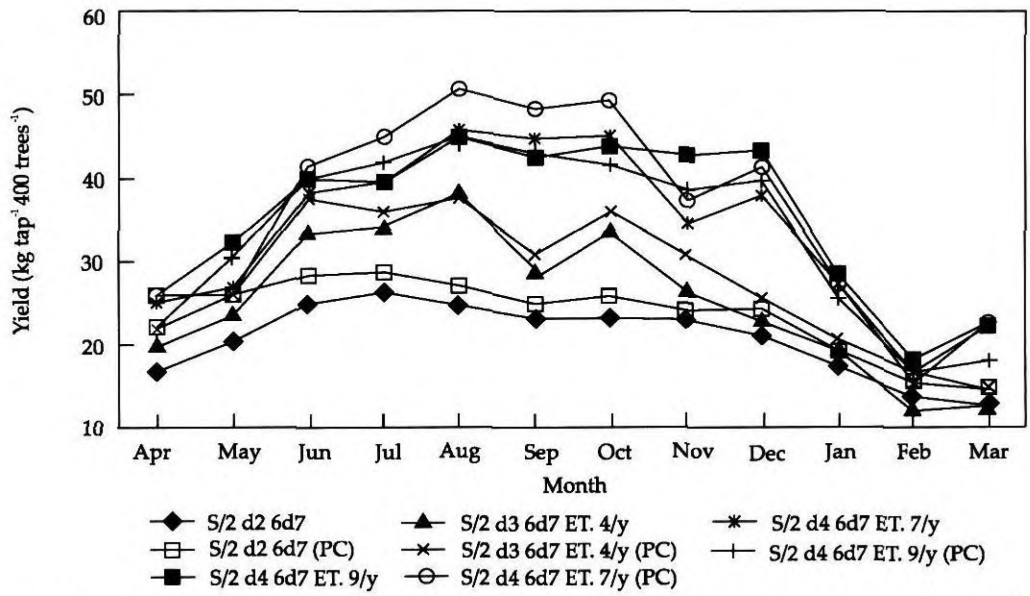

Fig. 2. Long-term effect of panel change (PC) on mean monthly variation in per tap yield (kg tap^{-1}400 $trees^{-1}$) of *H. brasiliensis* (clone RRII 105) under different frequencies of tapping and stimulation (mean of eleven years)

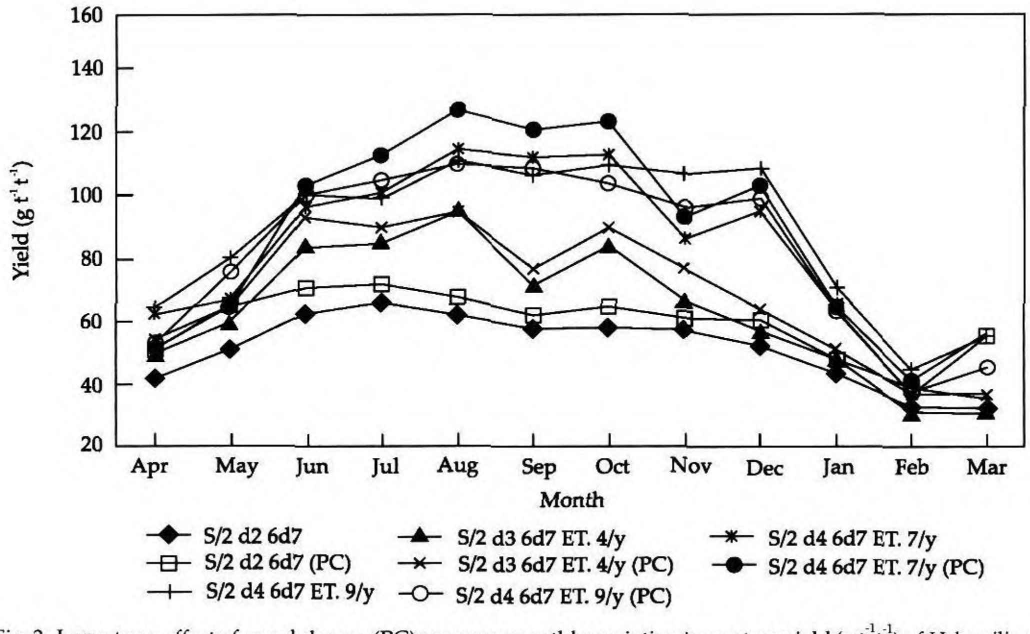

Fig. 3. Long-term effect of panel change (PC) on mean monthly variation in per tree yield (g $t^{-1}t^{-1}$) of *H. brasiliensis* (clone RRII 105) under different frequencies of tapping and stimulation (mean of eleven years)

Table 3. **Long-term effect of panel change on dry rubber yield (kg t^{-1} y^{-1}) of *Hevea brasiliensis* (clone RRII 105) under different frequencies of tapping and stimulation**

Treatments	Year											
	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	Mean
1. S/2 d2 6d/7												
(without panel change)	4.4 ab	7.6 ab	6.9 bc	5.8 bcd	10.6	10.6 a	7.1 ab	6.7 c	9.8 ab	6.1 ab	5.1	7.3 b
2. S/2 d2 6d/7												
(with panel change)	5.1 a	8.3 a	8.8 a	7.7 a	11.1	9.4 a	8.2 b	11.8 a**	10.2 a**	6.3 ab	4.7	8.3 a
3. S/2 d3 6d/7 ET2.5% Pa.4/y*												
(without panel change)	4.1 b	7.4 ab	6.2 cd	5.6 cd	7.7	9.2 a	7.0 ab	5.2 c	6.1 c	5.3 b	5.5	6.3 cd
4. S/2 d3 6d/7/ ET2.5% Pa.4/y*												
(with panel change)	4.3 ab	7.4 ab	7.2 b	6.9 ab	8.4	6.7 b	6.1 bc	9.4 b**	9.3 ab**	5.9 ab	4.4	6.9 bc
5. S/2 d4 6d/7 ET2.5% Pa.7/y*												
(without panel change)	3.9 b	6.8 b	6.0 d	5.0 d	7.5	6.7 b	7.5 ab	5.4 c	5.6 c	7.4 a	4.8	6.0 d
6. S/2 d4 6d/7 ET2.5% Pa.7/y*												
(with panel change)	4.1 b	7.1 b	6.5 bcd	7.0 ab	9.4	7.6 b	6.0 bc	6.0 c	7.5 abc	7.2 a	4.6	6.6 cd
7. S/2 d4 6d/7 ET2.5% Pa.9/y*												
(without panel change)	3.9 b	7.1 b	5.8 d	5.8 bcd	7.3	6.6 b	8.5 a	6.4 c	7.0 bc	7.5 a	5.2	6.5 cd
8. S/2 d4 6d/7 ET2.5% Pa.9/y*												
(with panel change)	4.0 b	7.7 ab	6.9 bc	6.6 abc	8.1	6.7 b	5.2 c	5.3 c	5.8 c	6.3 ab	4.6	6.1 d
LSD (P=0.05)	0.8	1.0	0.7	1.2	NS	1.4	1.516	2.225	2.976	1.712	NS	0.6987

** with upper panel change (CUT)
within two columns, values followed by same letter/s are not statistically different form each other;
NS - Not Significant

Table 4. Long-term effect of panel change on dry rubber yield (g $tree^{-1}$ tap^{-1}) of *Hevea brasiliensis* (clone RRII 105 under different frequencies of tapping and stimulation

	Treatments	Year												Tap
		1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	Mean	Days
1.	S/2 d2 6d/7 (without panel change)	30.1 d	51.9 d	52.1 d	39.3 f	72.2 d	71.8 b	49.6 e	49.1 d	66.2 bc	42.9 c	40.1 c	51.4 d	143
2.	S/2 d2 6d/7 (with panel change)	35.1 cd	56.8 d	67.5 c	51.9 ef	75.1 d	65.0 b	56.8 de	84.7 ab**	70.1 abc**	44.0 bc	37.0 c	58.6 cd	143
3.	S/2 d3 6d/7 ET2.5% Pa.4/y* (without panel change)	42.6 bc	75.8 c	70.3 c	55.2 de	76.9 d	92.1 a	70.5 bcd	53.4 cd	60.1 c	55.6 bc	61.6 ab	64.9 bc	97
4.	S/2 d3 6d/7 ET2.5% Pa.4/y* (with panel change)	44.6 b	76.5 c	80.7 b	68.1 cd	84.1 cd	68.1 b	64.1 cde	100.1 a**	93.0 ab**	62.2 b	50.0 bc	72.0 b	97
5.	S/2 d4 6d/7 ET2.5% Pa.7/y* (without panel change)	53.5 a	92.8 b	86.9 b	65.0 cde	98.9 bc	87.8 a	103.9 a	70.8 bc	72.8 abc	98.5 a	71.6 a	82.0 a	74
6.	S/2 d4 6d/7 ET2.5% Pa.7/y* (with panel change)	56.0 a	96.4 ab	96.4 a	91.5 a	123.9 a	100.2 a	84.2 b	78.8 b	96.7 a	95.1 a	69.6 a	89.9 a	74
7.	S/2 d4 6d/7 ET2.5% Pa.9/y* (without panel change)	52.7 a	100.5 ab	84.5 b	75.9 bc	96.1 bc	87.3 a	119.5 a	84.5 ab	91.5 ab	99.3 a	78.5 a	88.2 a	74
8.	S/2 d4 6d/7 ET2.5% Pa.9/y* (with panel change)	55.0 a	106.6 a	95.5 a	85.9 ab	106.0 b	87.4 a	73.0 bc	70.1 bc	76.2 abc	84.6 a	69.0 a	82.7 a	74
	LSD (P=0.05)	7.7	13.3	8.2	14.4	16.6	13.0	16.0	20.3	29.7	19.0	15.0	8.3	-

** with upper panel change (CUT)

within two columns, values followed by same letter/s are not statistically different form each other

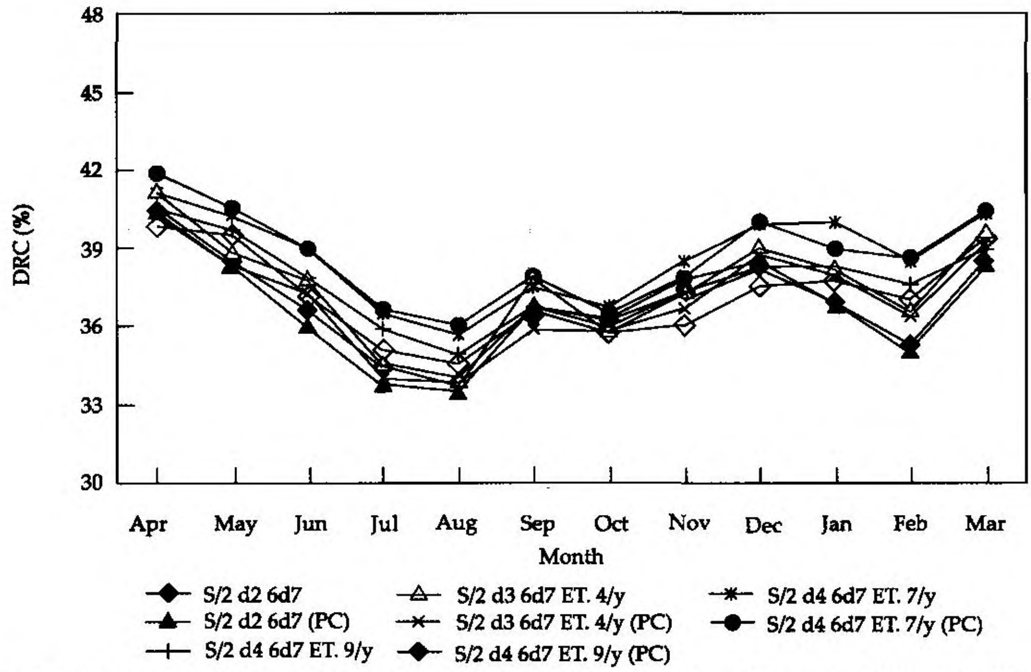

Fig. 4. Long-term effect of panel change (PC) on monthly variation in dry rubber content (DRC) % of *Hevea brasiliensis* (clone RRII 105) under different frequencies of tapping and stimulation

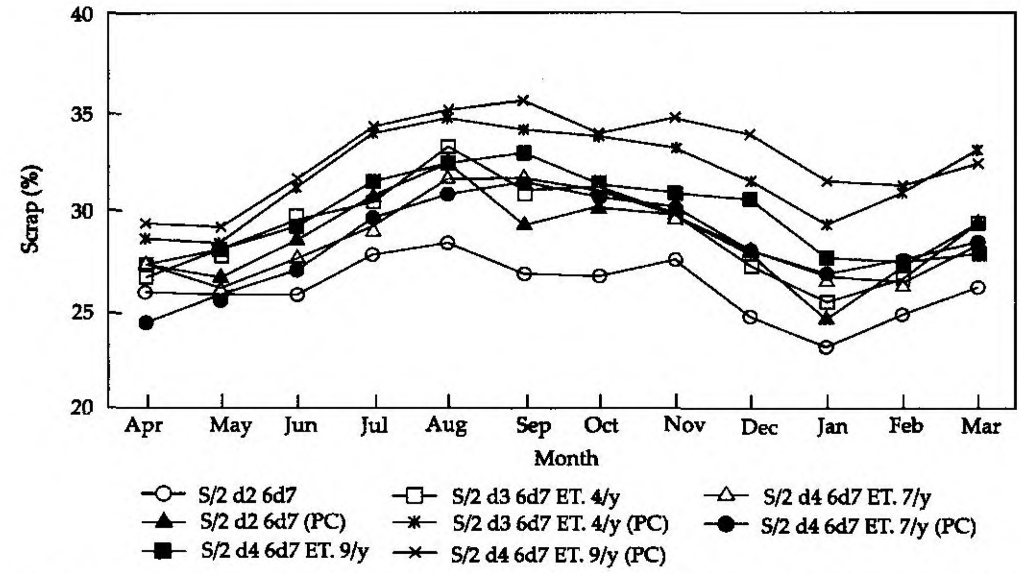

Fig. 5. Long-term effect of panel change (PC) on monthly variation in scrap (%) of *Hevea brasiliensis* (clone RRII 105) under different frequencies of tapping and stimulation

Table 5. Long-term effect of panel change on dry rubber content (%) of *Hevea brasiliensis* (clone RRII 105) under different frequencies of tapping and stimulation

Treatments	Year											
	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	Mean
1. S/2 d2 6d/7 (without panel change)	32.2e	36.2a	36.2bc	37.8cde	35.1e	36.7bc	38.2d	39.8a	39.5abcd	38.1bc	39.4abc	37.2bc
2. S/2 d2 6d/7 (with panel change)	34.7a	33.4d	34.7c	36.8e	37.0d	39.1a	38.4cd	39.0a**	39.1cd**	36.8d	38.9abc	37.1bc
3. S/2 d3 6d/7 ET2.5% Pa.4/y* (without panel change)	32.8cde	33.7d	36.3bc	38.9bcd	38.7abc	37.5bc	39.2abcd	39.1ab	39.1cd	37.8cd	39.0abc	37.5bc
4. S/2 d3 6d/7 ET2.5% Pa.4/y* (with panel change)	33.4bcd	33.9cd	36.0bc	37.5de	37.6cd	36.2c	39.7ab	38.2b**	38.5d**	38.2bc	38.1c	37.0c
5. S/2 d4 6d/7 ET2.5% Pa.7/y* (without panel change)	33.9ab	35.2ab	37.3ab	40.4a	39.5a	40.2a	39.4abc	39.8a	40.4ab	39.1ab	40.2a	38.7a
6. S/2 d4 6d/7 ET2.5% Pa.7/y* (with panel change)	33.7abc	34.9bc	38.5a	39.4ab	39.4ab	39.1a	40.2a	39.9a	40.6a	39.9a	39.9ab	38.7a
7. S/2 d4 6d/7 ET2.5% Pa.9/y* (without panel change)	32.9bcde	33.9cd	36.7b	39.2abc	37.9bcd	39.2a	38.6cd	39.4ab	39.9abc	37.8cd	38.6bc	37.7b
8. S/2 d4 6d/7 ET2.5% Pa.9/y* (with panel change)	32.6de	33.9cd	36.6b	37.6de	36.7d	37.7b	39.1bcd	39.0ab	39.3bcd	38.2bc	38.3c	37.2bc
LSD (P=0.05)	1.0	1.0	1.6	1.4	1.5	1.3	1.0	1.2	1.1	1.1	1.5	0.69

** with upper panel change (CUT)

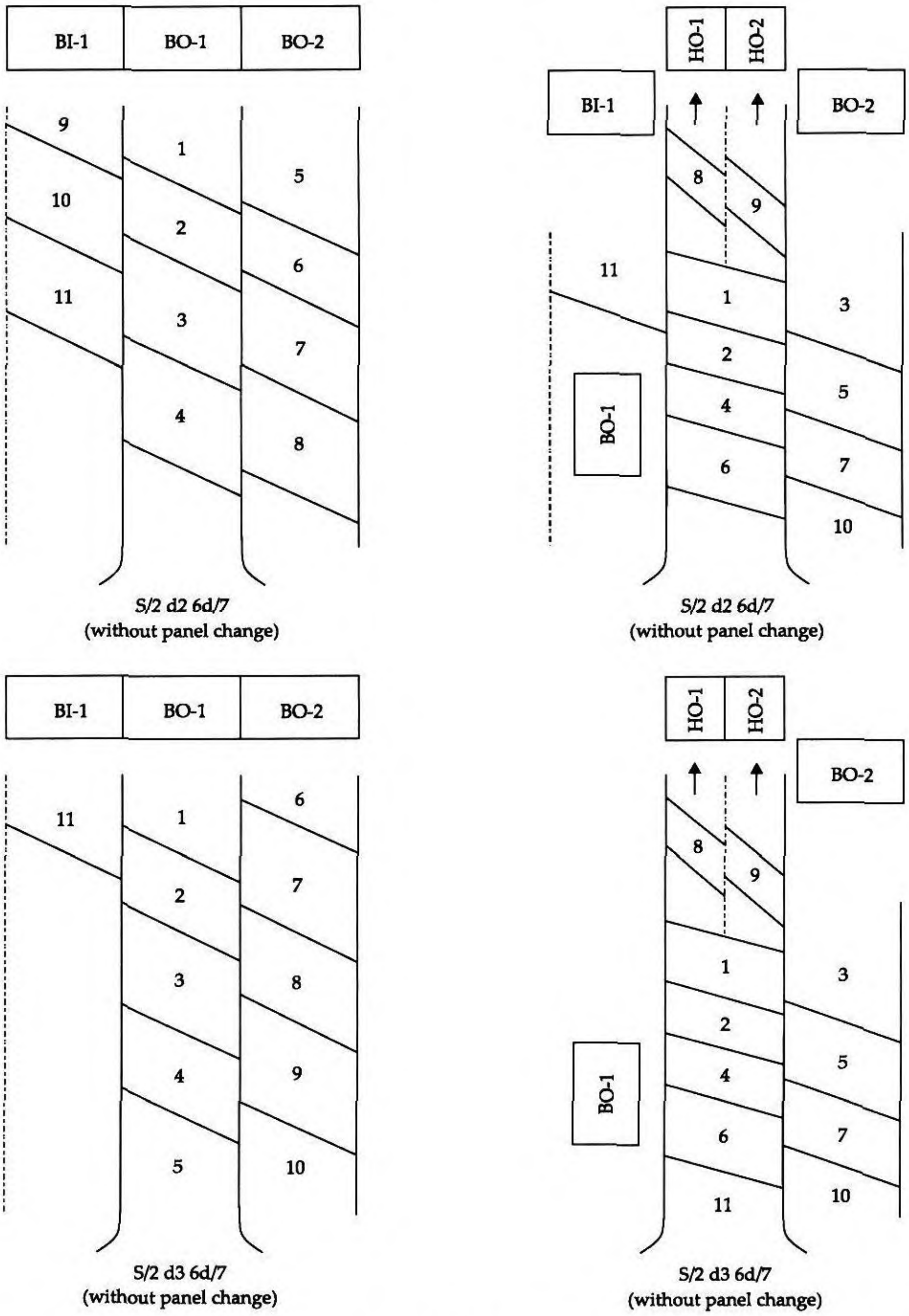

Fig. 6. Schematic representation of panels under d2 and d3 frequencies of tapping with and without panel change (Year wise)

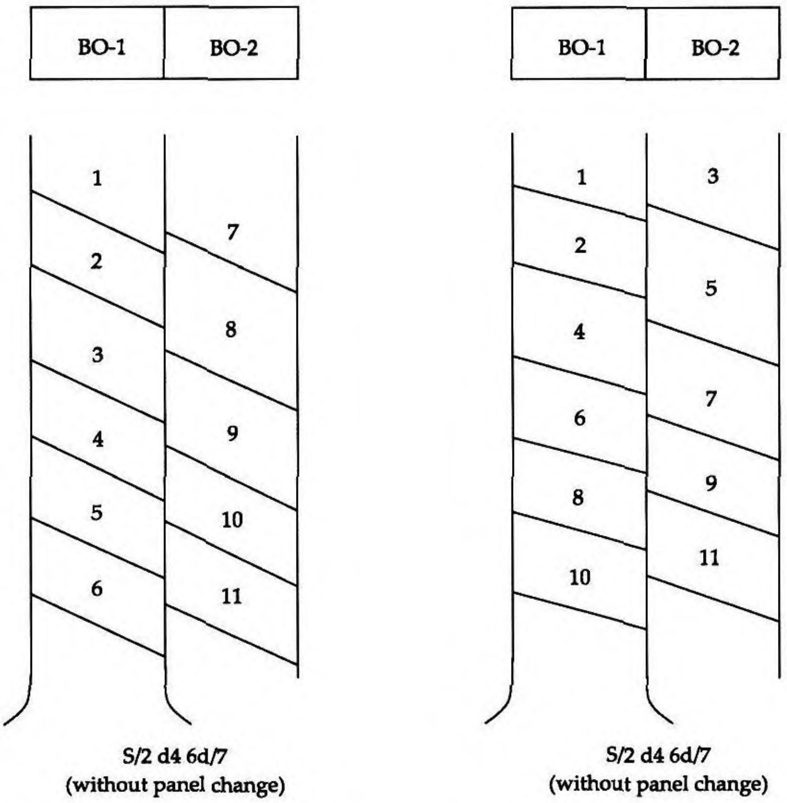

Fig. 7. Schematic representation of panels under d4 frequency of tapping with and without panel change (Year wise)

from 12 to 34 kg and d3 system ranged from 17.6 to 40 kg. Highest yield per tap could be observed under lowest frequency tapping (d4) with or without panel change and ranged from 21.1 to 49.5 kg. Mean yield for eleven years also showed similar trend (Table 2). Alternate daily tapped trees showed the lowest yield per tap throughout the study period irrespective of panel change. In general, all the stimulated treatments showed higher yield per tap. Similar trend was also noticed for yield per tree per tap (Table 4). As observed in mean annual dry rubber yield and cumulative dry rubber yield, no significant yield difference due to panel change within different systems of tapping, could be observed for these parameters also (Table 1; Fig. 1). Lower tapping frequency of d3 and d4 gave higher yield per tap (g $t^{-1}t^{-1}$ and kg tap^{-1}) and lower annual and cumulative land productivity (kg ha^{-1}), with or without panel change, though comparable to higher tapping frequency of d2 system of tapping (Tables 1, 2 & 4; Fig. 1). Similar results of higher yield per tap and lower land productivity under lower frequencies of tapping was reported by Do Kim Thanh *et al.* (1996b). Such, higher yield per tap with lower frequencies of tapping with ethephon

Table 6. **Long-term effect of panel change on tapping panel dryness of *Hevea brasiliensis* (clone RRII 105) under different frequencies of tapping and stimulation**

Treatments	Panel status (2007-08)	TPD trees	
		2006-07	2007-08
1. S/2 d2 6d/7 (without panel change)	BI-1 (3)	2	2
2. S/2 d2 6d/7 (with panel change)	BI-1 (1)	6	3
3. S/2 d3 6d/7 ET2.5% Pa.4/y* (without panel change)	BI-1 (1)	6	1
4. S/2 d3 6d/7 ET2.5% Pa.4/y* (with panel change)	BO-1 (5)	2	1
5. S/2 d4 6d/7 ET2.5% Pa.7/y* (without panel change)	BO-2 (5)	4	4
6. S/2 d4 6d/7 ET2.5% Pa.7/y* (with panel change)	BO-2 (5)	3	1
7. S/2 d4 6d/7 ET2.5% Pa.9/y* (without panel change)	BO-2 (5)	1	1
8. S/2 d4 6d/7 ET2.5% Pa.9/y* (with panel change)	BO-2 (5)	1	1

stimulation in other clones and in clone RRII 105 were reported by Sivakumaran and Chong Kewi, (1994); Do Kim Thanh *et al.*, (1996a, b); Karunaichamy *et al.*,(2001; 2012); Vijayakumar *et al.*, (2001; 2005b); Rajagopal *et al.* (2004; 2005). Stimulation with ethephon inhibits plug formation leading to increased latex flow resulting higher yield. Prolonged latex flow in the stimulated trees is due to the extension of drainage area on the panel (Kush *et al.*, 1990; Pakinathan *et al.* 1976). Increased alkalinisation and increased chitinase activity also lead to increased rate and duration of latex flow (Koshy, 1997; Thanh *et al.*, 1998) resulting in higher yield with ethephon stimulation.

In the present study, in all the treatments without annual panel change, subsequent panels were opened (under normal practice), in the 5th and 9th year under d2, 6th and 11th year under d3 and 7th year under d4 frequencies (Figs. 6 & 7) with high yield compared to previous year tapping (Tables 1- 4). Similar observations of higher yield after normal conventional panel change were reported earlier in other clones and in clone RRII 105 (Thanh *et al.*, 1998; Rajagopal *et al.*, 2004; 2005; Karunaichamy *et al.*, 2008; 2012). Higher yield observed during panel change is largely due to extension of drainage area on the panel and yield decline near the bud union can be ascribed to limitations in the availability of drainage area on the panel (Pakinathan *et al.*, 1976).

Significant variation in dry rubber content (%) was observed between treatments. However, the variation in DRC percentage was observed to be unaffected by panel change in any of the treatments (Table 5). There was considerable seasonal variation in DRC and was low in the rainy season (Fig. 4). The reduction in mean DRC percentage with higher levels of stimulation was not significant statistically (Table 5). Seasonal variation in scrap percentage was also observed in all the treatments and was more in the rainy season (Fig. 5). Similar trend in seasonal variation of DRC (%) and Scrap (%) were reported earlier by Rajagopal *et al.* (2004) in clone RRII 105.

Beneficial effect of panel change on occurrence of tapping panel dryness (TPD) was not observed under higher frequency of tapping in the present study. Year to year variation in TPD is due to alteration of panels (Table 6). It has already been shown that panel changing do not prevent occurrence of TPD (Eschbach *et al.*, 1986; Krishnakumar and Jacob, 2002; Lacote *et al.*, 2004).

As suggested by Lacote *et al.* (2006), no panel change would be more simple and cost effective. A continuous downward tapping is recommended without alternating the panels unless a sharp drop in yield and /or a damaged physiological status is/are observed (Lacote *et al.*, 2006). Results from the present study also support these findings. Hence, continuous panel changing is not a good practice which is not advisable and not recommended for high yielding clones like RRII 105.

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REFERENCES

Eschbach, J.M., Tupy, J. and Lacrote, R. (1986). Photosynthate allocation and productivity of latex vessels in *Hevea brasiliensis, Biologia Plantarum,* **28**: 321.

Gohet, E., Lacote, R., Obouayeba, S. and Commere, J. (1991). Tapping systems recommended in West Africa. In: *Proceedings of the Rubber Research Institute of Malaysia Rubber Growers Conference for Towards Greater Viability of the Natural Rubber Industry.* (Ed. Abdul Aziz Bin A. Kadir), Rubber Research Institute of Malaysia, Kuala Lumpur, Malaysia. pp. 235-254.

Karunaichamy, K., Vijayakumar, K.R., Thomas, K.U., Rajagopal, R. and Anilkumar, D. (2001). Response of rubber trees (*Hevea brasiliensis* Muell.Arg., clone RRII 105) to low frequency tapping systems (LFT). *Indian Journal of Natural Rubber Research,* **14**(2): 79-87.

Krunaichamy, K., Vijayakumar, K.R., Thomas, K.U., and Rajagopal, R. (2008). Approaches towards low cost crop harvesting technologies in rubber (*Hevea brasiliensis).* In: *Forest Biodiversity.* Volume.I (Eds. Muthuchelian, S. Kanian and A. Gopalan). Associated Publishing Company, New Delhi. pp. 64-74.

Karunaichamy, K., Vijayakumar, K.R., Thomas, K.U., and Rajagopal, R. (2012). Yield performance of clone RRII 105 under low frequency tapping in BO-2 and BI-1 panels. *Natural Rubber Research,* **25**(1): 52-59.

Koshy, G. (1997). Studies on factors affecting regeneration and flow of latex in *Hevea brasiliensis.* Ph. D. Thesis, Mahathma Gandhi University, Kottayam, Kerala, India. 286 p.

Krishnakumar, R. and Jacob, J. (2002). Effect of panel changing on tapping panel dryness in *Hevea brasiliensis. Journal of Natural Rubber Research,* **15**(1): 96-99.

Kush, A., Goyvaerts, E.N., Chye, M.I. and Chya, N.H . (1990). Laticifer specific gene expression in *Hevea brasiliensis* (Rubber Tree). *Proceedings of the National Academy of Sciences,* USA, **87**: 1787-1790.

Lacote, R., Obouayeba, S., Demange, C.A., Dian, K., Gnane, M. and Gohet, E. (2004). Panel management in rubber (*Hevea brasiliensis*) tapping and impact on yield, growth and latex diagnosis. *Journal of Rubber Research,* 7(3): 199-217.

Lacote, R., Gabla, O., Obouayeba, S, Gohet, E., Doumbia, A., Gangne, M. and Eschbach, J.M. (2006). Some considerations concerning panel management in rubber (*Hevea brasilienis*). *Preprints of the International Natural Rubber Conference,* Rubber Research Institute of Vietnam, Vietnam. pp.3-15.

Paardekooper, E.C. (1989). Exploitation of the Rubber Tree. In: *Rubber* (Eds. C.C. Webster and W.J. Baukwil). Longman Scientific and Technical, England. pp. 349-414.

Pakinathan, S.W., Wain, R.I. and Ng, E.K. (1976). *Studies on displacement area on tapping in mature Hevea* trees. *Proceedings of the International Rubber Conference, Kula Lumpur.* **2**: 225-246.

Rajagopal, R., Vijayakumar, K.R. and Thomas, K.U. (2000). Comparative effectiveness of different stimulation methods on yield performance of *Hevea brasiliensis.* In: *Plantation Crops Research and Developments in the New Millennium.* (Eds. R.

Rethinam, H.H. Khan, V.M. Reddy, P.K. Mandal and K. Suresh), Coconut Development Board, Kochi. pp. 420-423.

Rajagopal, R., Vijayakumar, K.R., Thaomas, K.U and Karunaichamy, K. (2004). Effect of judicious ethephon application on yield response of *Hevea brasiliensis* (clone RRI 105) under 1/2S d/3 6d/7 tapping system. *Journal of Rubber Research* , 7(2) :138-147.

Rajagopal, R., Vijayakumar, K.R., Thomas, K.U. and Karunaichamy, K. (2005). Yield response of clone PB 217 to low frequency tapping. In: *Proceedings of the International Workshop on Exploitation Technology*. (Eds. K.R. Vijayakumar, K.U. Thomas, and R.Rajagopal), Rubber Research Institute of India, Kottayam. pp. 127-139.

Rubber Board. (2012). Rubber Growers' Companion. Rubber Board, Kottayam. pp. 32-41.

Sivakumaran, S., Pakinathan, S.W. and Gomez, J.B. (1983). Long-term ethephon stimulation. III. Effect of continuous ethephon stimulation with short cut panel changing system. *Journal of the Rubber Research Institute of Malaysia*, **31**(3): 151-174.

Sivakumaran, S. and Kewi, C. (1994). Yield stimulation in rubber: Current status and improvements for enhanced productivity. In: *Proceedings of the International Planters' Conference on Management for Enhanced Profitability in Plantations*. (Ed. Chee Kheng Hoy). The Incorporated Society of Planters, Kuala Lumpur, Malaysia. pp. 369-408.

Thanh, D.K., Sivakumaran, S. and Choo, W.K. (1996a). Long-term effect of tapping and stimulation frequency on yield performance of rubber clone GT. *Journal of Natural Rubber Research*, **11**(2): 96-97.

Thanh, D.K., Sivakumaran, S. and Choo, W.K. (1996b). Effect of tapping and intensive stimulation on yield, dryness incidence and some physiological latex parameters of clone RRIM 600. *Journal of Natural Rubber Research*, **11**(3): 200-214.

Thanh, D.K., Sivakumaran, S. and Wong, K.C. (1998). Influence of judicious methods of stimulation on the long term yield response of rubber clone RRIM 600. *Proceedings of IRRDB Symposium on Physiology and Exploitation and Crop protection and Planting Method*. Rubber Research Institute of Vietnam, Vietnam. pp. 66-70.

Thomas, K.U., Rajagopal, R., Vijayakumar, K.R. and Karunaichamy, K. (2009). Strategies for enhancing productivity and economic life of small holdings. In: *Towards Inclusive Rubber Development*. (Ed. C. Kuruvilla Jacob). Rubber Board, Kottayam. pp. 200-208.

Vijayakumar, K.R., Thomas, K.U., Rajagopal, R. and Karunaichamy, K. (2001). Low frequency tapping systems for reduction in cost of production of natural rubber. *Planters' Chronicle*, **7**(11): 451-454.

Vijayakumar, K.R., Thomas, K.U., Rajagopal, R. and Karunaichamy, K. (2002). Advances in exploitation research of *Hevea* in India. In: *Global Competitiveness of Indian Rubber Plantation Industry*. (Ed. C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam. pp. 155-162.

Vijayakumar, K.R., Thomas, K.U., Rajagopal, R. and Karunaichamy, K. (2005a). Extension of low frequency tapping and controlled upward tapping by researchers. In: *Proceedings of the International Workshop on Exploitation Technology*. (Eds. K.R. Vijayakumar, K.U. Thomas and R. Rajagopal). Rubber Research Institute of India, Kottayam. pp. 267-279.

Vijayakumar, K.R., Thomas, K.U., Rajagopal, R. and Karunaichamy, K. (2005b). Response of *Hevea* clones to low frequency tapping. In: *Proceedings of the International Workshop on Exploitation Technology*. (Eds. K.R. Vijayakumar, K.U. Thomas, and R. Rajagopal). Rubber Research Institute of India, Kottayam. pp. 17-42.

Vijayakumar, K.R., Gohet, E., Thomas, K.U., Xiaodi, W., Sumarmadji, Rodrigo, L., Thanh, D.K., Sobchoke, P., Karunaichamy, K. and Mohd Akbar md. Said. (2009). Revised International Notation for Latex Harvest Technology. *Journal of Rubber Research* ,**12**(2): 103-115.