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RESEARCH ARTICLE

EVALUATION OF VERTICAL TAPPING IN NATURAL RUBBER

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Natural rubber is obtained commercially from *Hevea brasiliensis* by the process of controlled wounding called tapping. Optimising tapping systems with appropriate dose and frequency of ethephon application can be one of the approaches to address shortage of skilled tappers and can help in realising potential yield from rubber trees. In the present scenario, yield stimulation technology has been perfected and advocated to get promising yield under lower frequencies of tapping, from mini cuts or from punctures with gaseous / ethephon stimulation. An experiment with vertical tapping cuts of 22 and 10 cm cut lengths with different levels of yield stimulation with 2.5 per cent ethephon was conducted for four years to examine the scope and feasibility of vertical tapping as a latex harvest technology tool for crop extraction of mature rubber trees of clone RRII 105. Initial results from the study indicated promise of adoption of vertical tapping of 22 cm (with ET 2.5 % 12 or 24 rounds per year) or 10 cm (with ET 2.5 % 24 or 36 rounds per year) with yield level at par with standard recommended crop harvesting practice (S/2 d3 6d7 ET 2.5% 3 rounds per year) without deleterious effect. The system is also having the additional advantage of tapping one panel for two years unlike in half spiral downward tapping panel marked for one year which can be tapped only for a year.

Key words: *Hevea brasiliensis*, Latex harvest technology, Natural rubber, Vertical tapping, Yield stimulation

INTRODUCTION

After evaluation of different tapping systems, the present tapping system of half spiral cut was evolved. Before the evolution of present day tapping system (half spiral cut from high left to low right at 30 degree slope) various types of tapping cuts were attempted (Dijkman, 1951). The yield per unit length of tapping cut was less in most of the tapping systems tried and were abandoned in due course. An ideal tapping system is one which gives optimum yield from trees with minimum excision of bark, lowest interference with health of trees, their capacity for sustainable rubber production at lower tapping cost and less incidence of tapping panel dryness (TPD) formerly known as brown bast (Baptiste, 1962). However in the present scenario, yield stimulation technology has been perfected, advanced and advocated to get promising yield from lower frequencies of tapping (LFT), mini cuts, reduced spiral cuts or even from punctures with gaseous or ethephon stimulation (Gohet *et al.*, 1991; Thanh *et al.*, 1998; Rajagopal *et al.*, 2000; 2004; Thomas *et al.*, 2002; Vijayakumar *et al.*, 1997; 2001; 2003; 2005; Sivakumaran, 2002; 2005; Siva

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Karunaichamy *et al.*, 2013; Sreelatha *et al.*, 2019). Alternative approaches of crop harvesting with proper yield stimulation and reduced skill will also be rewarding for a perennial tree crop like rubber. Earlier reports had shown good yield response of clones to less labour input tapping systems with ethephon application (Abraham and Isamil Hashim, 1983; Sivakumaran and Chong, 1994; Thanh *et al.*, 1996; Eva and Kuswanhadi, 2015). Similarly, potential crop yield can be extracted by stimulation of mini (5 cm cut) or reduced spiral cuts (Lukman, 1995). Optimum dose and frequency of ethephon application with a combination of low frequency and short tapping cut is also feasible for sustainable production (Lee, 1989). Though ethephon is potential yield stimulant widely used in rubber plantation sector, unscrupulous use of ethephon (high concentration, dose *etc.*) can subject trees to more stress which cannot be alleviated later (Sulochanamma and Thomas, 2000). Influence of gaseous stimulation with reduced cut length of even 1/8S on rubber yield has been reported earlier (Rodrigo and Kudaligama, 2012). Research data on response of mature rubber trees to vertical tapping with stimulation either on virgin or on renewed panels is meager. It will be interesting and worthwhile to examine the scope and feasibility of vertical tapping as latex harvest technology tool for crop extraction of mature rubber trees. Hence, an experiment was carried out and attempts were made with the objective of evolving vertical tapping as a crop harvesting method of rubber.

MATERIALS AND METHODS

The study was carried out at the Experimental Farm Unit (EFU) of Rubber Research Institute of India, located at Pampady, Kottayam, Kerala (9° 32' N; 36' E) with clone RRII 105. The experiment in randomized block design had five treatments and five replications comprising of eight trees per replication (40 trees treatment^{-1}). Average stand of trees was 450 per ha. The trees were under tapping in the 2nd year of the renewed basal panel (BI-1). Tapping system adopted was once in three days with Sunday rest (d3 6d/7). Actual tapping days realised year^{-1} varied from 90-101 during the study period. The treatments comprised of half spiral downward cut and vertical tapping cuts of 22 cm and 10 cm with different levels of stimulation. The tapping panel of the downward half spiral cuts were marked with 30° standard template and vertical tapping cuts were marked using specially devised vertical tapping template (Fig. 1) with a supporting cut for guiding latex in to the collection cups (Fig. 2). Yield stimulation was carried out with 2.5 per cent ethephon (2-chloro-ethyl phosphonic acid; 17.5 mg active ingredient/tree) on the panel (Rajagopal *et al.*, 2000). The treatments were S/2 (RG) d3 6d/7 ET. 2.5% Pa 3/y (T1-Control), Vert. 22 cm (RG) d3 6d/7 ET. 2.5 % Pa 12/y (T2), Vert. 22 cm (RG) d3 6d/7 ET. 2.5 %

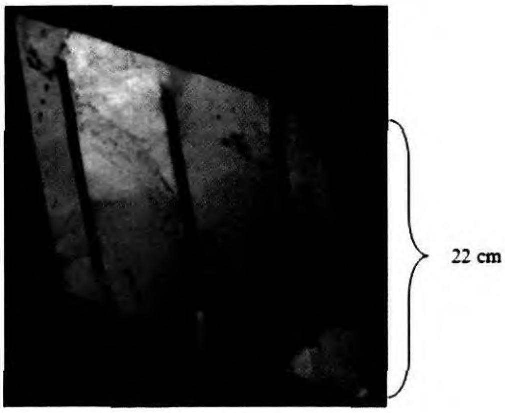

Fig. 1. Template for vertical tapping

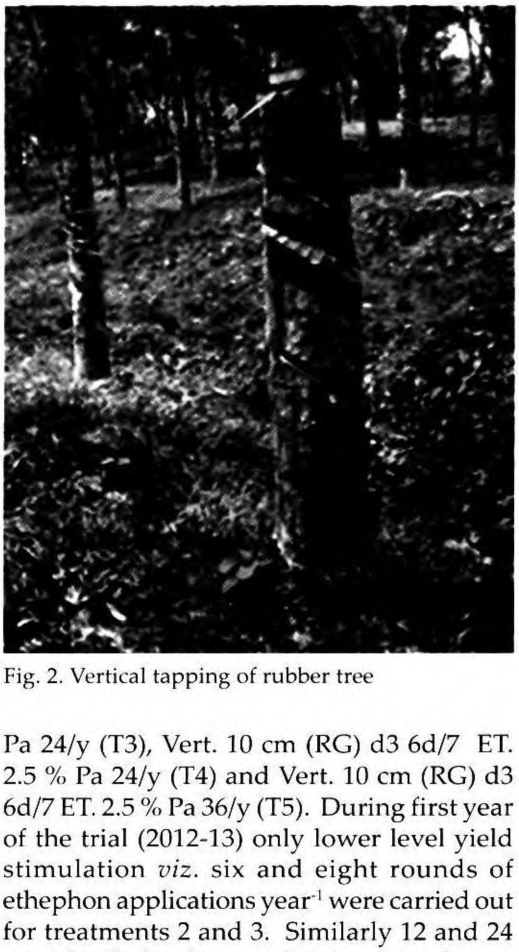

Fig. 2. Vertical tapping of rubber tree

Pa 24/y (T3), Vert. 10 cm (RG) d3 6d/7 ET. 2.5 % Pa 24/y (T4) and Vert. 10 cm (RG) d3 6d/7 ET. 2.5 % Pa 36/y (T5). During first year of the trial (2012-13) only lower level yield stimulation *viz.* six and eight rounds of ethephon applications year^{-1} were carried out for treatments 2 and 3. Similarly 12 and 24 rounds of ethephon applications year^{-1} were carried out for treatments 4 and 5, which were revised to higher levels in the subsequent years as per the treatment details shown below.

The trees were rain guarded and tapped throughout the year. Other cultural practices were followed as per the package of practices recommendations (Rubber Board, 2016). Yield from each replicate was recorded as cup lump for each tapping day. Dry rubber yield (g t^{-1} t^{-1}) from cup lump weight was arrived at based on 50 per cent dry rubber content. Tapping panel dryness (TPD) was recorded as complete drying of the tapping cut. The study was continued for four years. Data were processed and analysed statistically employing F-test using Analysis of Variance (ANOVA) and Duncan's multiple range test (DMRT). Means are presented with least significant difference (LSD).

RESULTS AND DISCUSSION

Results of the present investigation are presented in Tables 1-6. During first year of the trial (2012-13), significant yield variation among the treatments could be observed. Dry rubber yield of 34 g t^{-1} t^{-1} could be obtained with vertical tapping cut of 10 cm with 24 rounds of yield stimulation with ethephon. Similarly with a vertical tapping cut of 22 cm and six rounds of stimulation dry rubber yield of only 28 g t^{-1} t^{-1} could be obtained which was observed to be at par with eight rounds of stimulation. Dry rubber yield and allied yield variables from vertically tapped trees during initial year of the experiment was observed to be significantly different and lower compared to dry rubber yield of normal down ward half spiral tapped trees under d3 frequency of tapping (Table 1).

From the year 2013-14 (second year) onwards, higher levels of stimulation were imposed in treatments with vertical tapping cuts. With the increased level of stimulation significant yield improvement could be noticed under vertical tapping cuts. Similar enhancing effect of increased levels of stimulation under mini and reduced spiral tapping cuts was reported earlier in clone RRII 105 by Thomas *et al.* (2002). Successful results from one third spiral cut (1/3S) was also reported (Rubber Research Institute of India, 1993). Highest yield was observed in trees tapped under half spiral downward tapping cut with application of three rounds

Table 1. **Yield performance under S/2 and vertical tapping systems*during 2012-13 (first year of tapping)**

Treatments	$g\ t^{-1}\ t^{-1}$	kg $tree^{-1}$	kg 400 $trees^{-1}$	kg tap^{-1} 400 $trees^{-1}$
T1-S/2 (RG) d3 6d/7 ET 2.5 % Pa (3/y) control	77.2 a	6.9 a	2760 a	30.9 a
T2-Vertical 22 cm (RG) d3 6d/7 ET 2.5 % Pa (6/y)	27.8 b	2.5 b	1000 b	11.1 b
T3-Vertical 22 cm (RG) d3 6d/7 ET 2.5 % Pa (8/y)	26.0 b	2.4 b	960 b	10.4 b
T4-Vertical 10 cm (RG) d3 6d/7 ET 2.5 % Pa (12/y)	26.1 b	2.4 b	960 b	10.4 b
T5-Vertical 10 cm (RG) d3 6d/7 ET 2.5 % Pa (24/y)	33.8 b	3.1 b	1240 b	13.5 b
CD (P=0.05)	15.6	1.35	543.9	6.03

Values followed by same letter/s are not significantly different
*Tapping days-90

of ethephon $year^{-1}$ which is the standard recommended practice. However, yield obtained under this system was noted to be comparable and statistically at par with vertical tapping cuts with higher levels of stimulation except Treatment 2 (vertical tapping cut of 22 cm with 12 rounds of ethephon application per year) (Table 2).

During third year of the experiment (2014-15) no significant difference in yield and allied variables such as kg $tree^{-1}$ $year^{-1}$, kg tap^{-1} $year^{-1}$ and kg 400 $trees^{-1}$ $year^{-1}$ could be obtained (Table 3). However, during the fourth year, significant yield difference among the treatments could be observed. Among the treatments, highest yield of 62.6 g t^{-1} t^{-1} was observed in treatment with vertical tapping cut of 22 cm and ethephon application of 24 rounds $year^{-1}$ which was significantly different and higher than the control (standard practice) but at par with all other treatments. Same trend was noticed for the per hectare or per block level of computation of yield also. (Table 4). Pooled mean analysis of the data (2013-2016) indicated no significant difference among various treatments (Table 5).

Present findings from data on vertical tapping indicated that, it is feasible to get comparable yield with that of normal half spiral downward tapping (Tables 2-5) with appropriate stimulation. The system is also having the additional advantage of tapping one panel for two years unlike in half spiral tapping panel which can be tapped only for an year. The economic life of rubber trees mainly depend on tapping systems adopted

Table 2. **Yield performance under S/2 and vertical tapping systems*during 2013-14 (second year of tapping)**

Treatments	$g\ t^{-1}\ t^{-1}$	kg $tree^{-1}$	kg 400 $trees^{-1}$	kg tap^{-1} 400 $trees^{-1}$
T1-S/2 (RG) d3 6d/7 ET 2.5 % Pa (3/y) control	55.9 a	5.7 a	2280 a	22.4 a
T2-Vertical 22 cm (RG) d3 6d/7 ET 2.5 % Pa (12/y)	35.3 b	3.6 b	1440 b	14.1 b
T3-Vertical 22 cm (RG) d3 6d/7 ET 2.5 % Pa (24/y)	47.8 ab	4.8 ab	1920 ab	19.1 ab
T4-Vertical 10 cm (RG) d3 6d/7 ET 2.5 % Pa (24/y)	44.8 ab	4.6 ab	1840 ab	17.9 ab
T5-Vertical 10 cm (RG) d3 6d/7 ET 2.5 % Pa (36/y)	48.0 ab	4.9 ab	1960 ab	19.2 ab
CD (P=0.05)	17.3	1.75	702.2	6.88

Values followed by same letter/s are not significantly different
*Tapping days- 101

Table 3. **Yield performance under S/2 and vertical tapping systems*during 2014-15 (third year of tapping)**

Treatments	$g\ t^{-1}\ t^{-1}$	kg $tree^{-1}$	kg 400 $trees^{-1}$	kg tap^{-1} 400 $trees^{-1}$
T1-S/2 (RG) d3 6d/7 ET 2.5 % Pa (3/y) control	39.7	4.0	1600	15.9
T2-Vertical 22 cm (RG) d3 6d/7 ET 2.5 % Pa (12/y)	36.2	3.6	1440	14.5
T3-Vertical 22 cm (RG) d3 6d/7 ET 2.5 % Pa (24/y)	44.1	4.5	1800	17.6
T4-Vertical 10 cm (RG) d3 6d/7 ET 2.5 % Pa (24/y)	36.8	3.7	1480	14.7
T5-Vertical 10 cm (RG) d3 6d/7 ET 2.5 % Pa (36/y)	42.0	4.2	1680	16.8
CD (P=0.05)	NS	NS	NS	NS

*Tapping days- 100

Table 4. **Yield performance under S/2 and vertical tapping systems*during 2015-16 (fourth year of tapping)**

Treatments	$g\ t^{-1}\ t^{-1}$	kg $tree^{-1}$	kg 400 $trees^{-1}$	kg tap^{-1} 400 $trees^{-1}$
T1-S/2 (RG) d3 6d/7 ET 2.5 % Pa (3/y) control	41.4 b	3.7 b	1480 b	16.6 b
T2-Vertical 22 cm (RG) d3 6d/7 ET 2.5 % Pa (12/y)	48.6 ab	4.4 ab	1760 ab	19.4 ab
T3-Vertical 22 cm (RG) d3 6d/7 ET 2.5 % Pa (24/y)	62.6 a	5.7 a	2280 a	25.1 a
T4-Vertical 10 cm (RG) d3 6d/7 ET 2.5 % Pa (24/y)	50.0 ab	4.5 ab	1800 ab	20.0 ab
T5-Vertical 10 cm (RG) d3 6d/7 ET 2.5 % Pa (36/y)	54.2 ab	4.9 ab	1960 ab	21.7 ab
CD (P=0.05)	16.19	1.63	583.8	6.47

Values followed by same letter/s are not significantly different
*Tapping days- 90

and practiced. It can be further extended by adopting and scientifically practicing appropriate crop harvesting technologies such as low intensity tapping coupled with reduced length of tapping cut and yield stimulation. In the present experiment comparable or even better yield could be realized from vertical tapping cut of even 10 cm. Similar findings with mini and reduced spiral tapping cuts with higher levels of stimulation were reported earlier (Thomas *et al.*, 2002). Kuswanhadi and Junaidi (1986) made similar reports from 1/4S, 1/3S and 1/6S tapping cuts with

Table 5. **Yield performance under S/2 and vertical tapping systems*during 2013-16 (pooled mean of three years)**

Treatments	$g\ t^{-1}\ t^{-1}$	kg $tree^{-1}$	kg 400 $trees^{-1}$	kg tap^{-1} 400 $trees^{-1}$
T1-S/2 (RG) d3 6d/7 ET 2.5 % Pa (3/y) control	45.7	4.5	1800	18.3
T2-Vertical 22 cm (RG) d3 6d/7 ET 2.5 % Pa (12/y)	40.0	3.9	1560	16.0
T3-Vertical 22 cm (RG) d3 6d/7 ET 2.5 % Pa (24/y)	51.5	5.0	2000	20.6
T4-Vertical 10 cm (RG) d3 6d/7 ET 2.5 % Pa (24/y)	44.5	4.3	1720	17.5
T5-Vertical 10 cm (RG) d3 6d/7 ET 2.5 % Pa (36/y)	48.7	4.7	1840	19.5
CD (P=0.05)	NS	NS	NS	NS

*Tapping days-97

stimulation. Short tapping cut such as 1/4S and 1/3S with stimulation is a recommended practice for marginal farmers in Sumatra (Kuswanhadi, 1989). The present positive results on reduced tapping cuts also get support from similar findings on 1/3S tapping cut with higher level of stimulation of upper panel as reported by Kurnaichamy and Rajagopal (2018). The action of yield stimulant is mediated through ethylene production through hydrolytic degradation. Short tapping cuts are not sustainable without appropriate yield stimulation (Lee, 1989). The adverse impact of rubber synthesizing capacity of the panel by the higher frequencies of stimulation was less than that of tress tapped under higher intensity of tapping as reported by Sivakumaran *et al.* (1984). This might be the plausible reason for the observed favourable impact of stimulation on yield in the present study even with short tapping cuts. Stimulation reduces the rate of plug formation and increases the duration of latex flow with subsequent increase in drainage area (Pakinathan and Millford, 1973; Kush *et al.*, 1990). Increased alkalinisation and increase chitinase activity of the latex also lead to increased rate and duration of latex flow (Koshy, 1997; Thanh *et al.*, 1998) resulting in better yield as observed in the present study. Southorn and Gomez, 1970 reported better effectiveness with short cuts than long cuts where the plugging is feeble. Reduction in panel width also increases the rate of plugging of latex vessels (Gomez, 1983).

Tapping panel dryness of the experimental trees was assessed by observing complete dryness of the tapping cut and is depicted in Table 6. Maximum number of only five TPD affected trees were noted in Treatment 3 *i.e.* vertical tapping of 22 cm with 24 rounds of ethephon applications year^{-1} which also recorded higher mean yield. Rest of the treatments also showed lower incidence of TPD (Table 6). Judicious use of ethephon under low intensity tapping by reduction of cut length will help in harvesting optimum crop depending on physiological efficiency of a clone, in tune with latex regeneration potential of rubber trees without causing additional stress to the trees, as is evident from the results of the present study (Tables 5, 6).

Table 6. **Comparison of tapping panel dryness under S/2 and vertical tapping systems**

Treatments	Number of TPD trees
T1-S/2 (RG) d3 6d/7 ET 2.5 % Pa (3/y)	2
T2-Vertical 22 cm (RG) d3 6d/7 ET 2.5 % Pa (12/y)	3
T3-Vertical 22 cm (RG) d3 6d/7 ET 2.5 % Pa (24/y)	5
T4-Vertical I 10 cm (RG) d3 6d/7 ET 2.5 % Pa (24/y)	1
T5-Vertical 10 cm (RG) d3 6d/7 ET 2.5 % Pa (36/y)	2

Table 7. **Cost of ethephon application under S/2 and vertical tapping systems**

Treatments	Cost of ethephon application (Rs. tree^{-1} year^{-1})
T1-S/2 (RG) d3 6d/7 ET 2.5 % Pa (3/y)	3.9
T2-Vertical 22 cm (RG) d3 6d/7 ET 2.5 % Pa (12/y)	10.8
T3-Vertical 22 cm (RG) d3 6d/7 ET 2.5 % Pa (24/y)	21.6
T4-Vertical 10 cm (RG) d3 6d/7 ET 2.5 % Pa (24/y)	12.3
T5-Vertical 10 cm (RG) d3 6d/7 ET 2.5 % Pa (36/y)	18.5

Since tapping cut length can be reduced by adoption of vertical tapping, the size of tapping task can be increased up to 500 trees or more from the present average task of 300 trees leading to significant reduction in cost of production of natural rubber as well as increased economic life of rubber trees. Tappers can also benefit through increased over poundage. Tapping is made easier with shorter tapping cuts and semi-skilled workers can also be engaged for tapping. Thus vertical tapping can also be considered as a viable crop harvesting method of rubber with additional benefits and can make rubber cultivation more cost effective and attractive in the present scenario.

CONCLUSION

Present study envisages feasibility of vertical tapping of reduced cut lengths with appropriate stimulation as a crop harvesting method of rubber. Results from four years of study indicated that, vertical tapping cut of 10 cm with 24 rounds of 2.5 per cent ethephon applications year^{-1} can be adopted for achieving comparable yield with that of normal half spiral down tapped trees (with 3 rounds of ethephon application year^{-1}) under d3 6d/7 frequency of tapping. The adoption of this system is also expected to results in additional benefits like increased task size (to tappers) and increased economic life (of tree). Besides, semi-skilled workers can also be engaged for easier tapping of shorter tapping cuts Thus vertical tapping can also be considered as a viable crop harvesting method of rubber with additional benefits and can make rubber cultivation more cost effective and attractive in the present scenario.

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