RESPONSE OF LOW FREQUENCY CONTROLLED UPWARD TAPPING WITH YIELD STIMULATION IN CLONE RRII 118

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The present study was taken up to compare yield response of continuous Low Frequency Controlled Upward Tapping (LFCUT) from old and senile rubber trees of clone RRII 118 at Central Experiment Station of Rubber Research Institute of India. The trial was conducted for six years in the virgin bark of high panel above the renewed panels. Mean dry rubber yield over six years period under S/4 d3 frequency was comparable to S/4 d4, S/3 d4 and S/3 d7 frequencies of tapping. An increase in yield of 23 and 52 per cent was observed in the first year of high panel tapping under S/3 d4 with once in six week stimulation and S/3 d7 with once in three weeks stimulation over S/4 d3 with once in six weeks stimulation. However, considering the overall mean for six years, yield increase of 26 per cent could be obtained under S/3 d7 with once in three weeks stimulation than S/4 d3 with once in six weeks stimulation. By adopting d4 and d7 frequencies of tapping, requirement of tapper can be reduced by 25 and 51 per cent, respectively, compared to third daily tapping (d3), with the additional benefits of long term sustainable yield and longer economic life at reduced cost. Practice of continuous controlled upward tapping (CUT) is ideal for assured sustainable rubber production even from trees having unsuitable renewed basal panel, due to high incidence of tapping panel dryness (TPD).

Key words: Controlled upward tapping, *Hevea brasiliensis*, Low frequency tapping, Natural rubber, Yield stimulation

INTRODUCTION

Hevea brasiliensis (Wild ex A. Juss.) Muell. Arg, (Para rubber) has been accounted as the most important source of natural rubber (NR). India stands sixth in production and second in consumption of NR among the major rubber producing and consuming countries of the world. NR plantation industry in India is facing constraints due to low rubber prices, spiraling cost of production and shortage of skilled tappers. In India, cost of production is also high due to undulating topography, agro climate and other cultural practices. Cost of tapping accounts for major part in the cost of production of NR and in some countries, tapping alone accounts for more than 70 per cent of the cost of production of NR. India's productivity level has declined from the global position of first (1876 kg ha^{-1}) to third (1450 kg ha^{-1}) in the recent past. The continuous fall in NR price resulted in sharp decline in NR production as growers' left

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large extent of mature area untapped. This decline in area coupled with the decline in productivity and the resultant decline in production has increased imports to India. Majority of the small growers are tapping once in two days leading to lower economic life. Increasing labour productivity by adopting low frequency tapping (LFT) with mild yield stimulation (ethephon) is one of the approaches to reduce the cost of production and to overcome tapper shortage (Gohet *et al.*, 1991; Vijayakumar *et al.*, 2001; Karunaichamy *et al.*, 2001). Earlier reports also had shown good yield response of rubber clones to less labour input tapping systems with ethephon application (Abraham and Ismail Hashim, 1983; Sivakumaran and Chong, 1994; Thanh *et al.*, 1996).

Use of ethephon under low frequency tapping is recommended in India during 2001 for high yielding clones like RRII 105. There is no adverse effect by judicious yield stimulation on high yielding clones tapped under low frequency tapping (Karunaichamy *et al.*, 2001; 2012; 2013 Vijayakumar *et al.*, 2002; 2012; Rajagopal *et al.*, 2004 and Sreelatha *et al.*, 2019). In India, significant and sustainable yield increase in the basal panel tapping was achieved in RRII 105 under low frequencies of tapping by judicious application of ethephon from opening onwards without any harmful effect in the long run (Vijayakumar *et al.*, 2001, Karunaichamy *et al.*, 2001; 2012; Rajagopal *et al.*, 2004).

The high panel harvesting was introduced in Malaysia in the mid-1970s (P'Ng *et al.*, 1976). During 1980s, introduction of upward tapping systems in industrial plantations led to significant increase in rubber production (Eschbach *et al.*, 1986). In India, 50 per cent yield increase under CUT comprising S/2, S/3 or S/4 spiral cuts in clone RRIM 600 compared to basal panels has been reported (Vijayakumar, 1991). Controlled Upward Tapping (CUT) of high panel has given good yield in most of the clones after completion of renewed panel (Hashim *et al.*, 1981; Zarin and Wan, 1987; Karunaichamy *et al.*, 2005; Karunaichamy and Rajagopal, 2018). Introduction of CUT with S/3 spiral cuts for eight months, followed by S/2 spiral in the basal panel for four months under d2 frequency of tapping after BO-2 panel completion showed better yield than continuous tapping on renewed panel (BI-1) in clones PR 107, RRIM 600 and GT 1 (Gan and Chew, 1986). Under continuous CUT, good yield was obtained in clone PB 5/51 under S/4 d3 with stimulation (Goh, 1986). To suit the agro climatic conditions of India, a modified practice of periodic panel change with tapping of S/2 spiral cuts in basal tapping using rain guarding during monsoon season and high panel CUT (S/4) during summer months for obtaining sustainable yield has been successfully developed (Vijayakumar *et al.*, 2002). Trees can be tapped either continuously or with periodic panel change which showed sustainable yield in clone RRII 105 (Karunaichamy and Rajagopal, 2018).

Estimates based on data published by Rubber Board revealed an increase in the share of area under the tapping age group 14 and above which was 59.1 per cent in 2011-12 and declined to 55 per cent during 2014-15 (Jacob and George, 2016). High incidence of tapping panel dryness and unsuitable renewed bark in the basal panel may lead to low yield which is uneconomic to the rubber growers. Under these circumstances, continuous high panel tapping with yield stimulation brings fresh hope for the rubber growers to obtain sustainable high yield. The Indian hybrid clone RRII 118 was a top yielder in terms of

rubber production, growth and timber yield (Meenakumari *et al.*, 2015). Data on long term yield performance of continuous Low Frequency Controlled Upward Tapping (LFCUT) in clone RRII 118 is very scanty. Therefore, an experiment was laid out in the Central Experiment Station (CES) of Rubber Research Institute of India at Chethackal, to compare yield response of Continuous Low Frequency Controlled Upward Tapping (LFCUT) with yield stimulation in clone RRII 118 for six years and the results are reported here.

MATERIALS AND METHODS

The experiment was laid out at the Central Experiment Station of Rubber Research Institute of India located at Chethackal, Kerala (9°22'N; 76°50'E) with clone RRII 118. Trees were tapped on the high panel using modified long handled gouge knife after completion of renewed panel of BI-1 panel. There were five treatments comprising d3, d4 and d7 frequencies of tapping combined with yield stimulation of high panel (virgin bark) of clone RRII 118. Schematic representation of year wise tapping panels under different panel change systems is shown in Figure 1. The experiment was laid out with completely randomized design (single tree, single plot) with five treatments and 50 trees per replication. Yield stimulation was carried out by applying five per cent ethephon on the tree lace for d3 and d4 frequencies of tapping, whereas groove application was

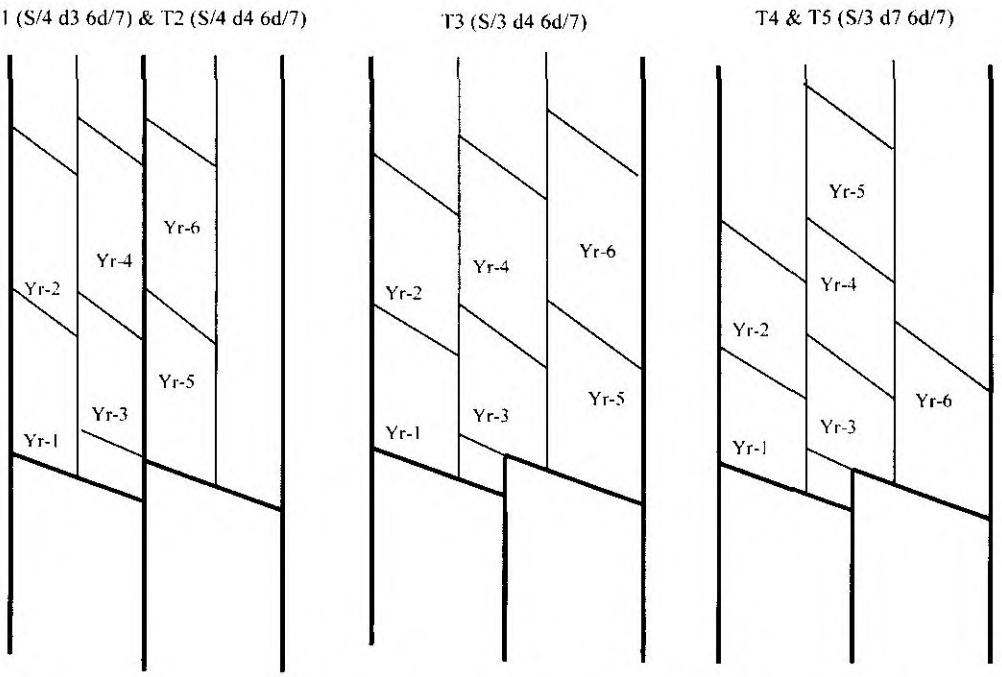

Fig. 1. Schematic representation of tapping panels under Low Frequency Controlled Upward Tapping (LFCUT) system

carried out under d7 frequency of tapping. The treatments as per the new tapping notations (Vijayakumar *et al.*, 2009) were, T1-S/4(RG)U d3 6d/7 ET 5.0% La 8/12(6w) (During sixth year, stimulation schedule changed to once in three weeks), T2-S/4(RG)U d4 6d/7 ET5.0% La 17/12(3w), T3- S/3(RG)U d4 6d/7 ET5.0% La 8/12y(6w), T4- S/3(RG)U d7 6d/7 ET5.0% Ga 17/y(3w), T5-S/3(RG)U d7 6d/7 ET5.0% Ga 12/y(m).

All the experimental trees were rain guarded during rainy season and tapped throughout the year without giving any rest. Trees were rain guarded in the high panel Southwest and Northeast monsoon season using wider (36" width) polythene. Other cultural practices were followed as per the package of practices and recommendations (Rubber Board, 2016). Yield from each replicate was recorded as cup lump for each tapping. Dry rubber of cup lump weight was arrived at based on 50 per cent dry rubber content. Bark consumption was measured every year and tapping panel dryness (TPD) was assessed and expressed as the percentage of trees with complete drying of tapping cut. The study was continued for six years and all the data collected were analysed statistically.

RESULTS AND DISCUSSION

Annual dry rubber yield (kg ha^{-1}) for six years under continuous LFCUT with yield stimulation are presented in Table 1. During first year of tapping, yield under S/3 d7 with once in three weeks stimulation showed significantly higher yield than S/4 d3 with once in six weeks stimulation, S/4 d4 with once in three weeks, S/3 d4 with once in six weeks and S/3 d7 frequency of tapping with monthly stimulation. Yield increase of 23 and 52 per cent was observed in the first year of high panel (HO-1) tapping under S/3 d4 (once in 3 weeks stimulation) and S/3 d7 (once in 3 weeks stimulation). Yield increase of 38 per cent was reported in the first year under d3 and d4 frequencies of high panel tapping over the basal panel tapping of clone RRII 105 (Karunaichamy and Rajagopal, 2018). During second year of high panel tapping of HO-1(2), yield under S/4 d3 was comparable with S/4 d4, S/3 d4 and S/3 d7 frequencies of tapping. During third year of HO-2(1) panel tapping, yield could be significantly increased under S/4 d4 and S/3 d7 frequencies of tapping with once in three weeks stimulation than S/4 d3 frequency of tapping (Table 1). Earlier studies reported increased yield during first year of upward and downward tapping with stimulation as high as 3000 kg ha^{-1} (Hashim *et al.*, 1981). During fourth year also, S/4 d3 frequency recorded significantly less yield than S/4 d4, S/3 d4 and S/3 d7 with once in three week stimulation. Yield under S/3 d7 with monthly stimulation was comparable with

Table 1. **Yield (kg ha^{-1}) performance of continuous Low Frequency Controlled Upward Tapping (LFCUT)**

Treatments	1st year	2nd year**	3rd year	4th year	5th year**	6th year
T1- S/4(RG)U d3 6d/7 ET 5.0% La /12(6w)*	4484 b	5195	4258 b	2279 b	2264	2056 b
T2- S/4(RG)U d4 6d/7 ET 5.0% La 7/12(3w)	5127 b	5301	6021 a	3622 a	2969	2139 b
T3- S/3(RG)U d4 6d/7 ET 5.0% La8/12y(6w)	5499 b	6186	6174 a	3579 a	2962	2169 b
T4-S/3(RG)U d7 6d/7 ET 5.0% Ga 17/y(3w)	6811 a	5459	6464 a	3330 a	2531	3328 a
T5-S/3(RG)U d7 6d/7 ET 5.0% Ga 12/y(m)	4983 b	4526	5345 ab	2898 ab	2230	3140 a

Within the column, values followed by same letter/s are not significantly different from each other
* Stimulation schedule changed to once in three weeks during sixth year, ** Not significant

that of S/4 d3 frequency of tapping. There is no significant difference in yield among the treatments during fifth year of tapping. Significantly higher yield was obtained during sixth year of tapping under S/4 d7 frequency compared to S/4 d3, S/4 d4 and S/3 d4 frequencies of tapping. Earlier report indicated, marked increase in yield (54%) during first year and the rate of yield increase continuously dropped to 13 per cent in the fifth year in RRIM 600 clone under d3 frequency of tapping (Au Yong *et al.*, 1991). A minimum period of four to five years of downward tapping is necessary to make upward tapping more efficient. Obouayeba *et al.* (2016) also reported that the alteration between downward half-spiral cut and upward half-spiral cut after four year is essential for the production of maximum rubber yield in clone GT 1.

Mean dry rubber yield (kg ha^{-1}) for six years under different frequencies of high panel tapping were statistically analysed and presented in Table 2. Yield under S/4 d3 frequency was comparable to that of S/4 d4, S/3 d4 and S/3 d7 frequencies of tapping. Considering the overall mean of six years, yield increase of 20 and 26 per cent was noticed under S/4 d4 and S/3 d7 (once in 3 weeks stimulation) compared to S/4 d3 frequency of tapping. Overall mean yield of eight years showed an increase of 11 per cent under LFCUT over the basal panel tapping in clone RRII 105 (Karunaichamy and Rajagopal, 2018). The cumulative yield of three years under d3, d4 and d7 frequencies of tapping under LFCUT with two methods of stimulation (lace and groove) was as high as 8000 kg 400 $trees^{-1}$ in clone RRIM 600 at Central Experimental Station (CES), Kerala (Karunaichamy *et al.*, 2005). Yield performance with RRIMFLOW on high panels in clone RRIM 600 over a period of three to four years showed productivity ranging from 2019 to 2888 kg $ha^{-1}year^{-1}$ (Sivakumaran, 2002). Introduction of CUT after completion of BO-2 panel tapping in RRIM 600 showed higher yield than continuous tapping on renewed panel (Ahmad Zarin Mat Tasi *et al.*, 1991; Vijayakumar, 1991). Present study showed that the yield obtained over six years of continuous LFCUT was 9.5 kg $tree^{-1}$ (S/4 d3) and 11.7 kg $tree^{-1}$ (S/3 d7 with once in 3 weeks stimulation) in clone RRII 118. Use of ethephon under LFCUT is mainly to compensate the potential loss of yield due to less number of tapping days under low frequency tapping by increasing the production of latex. Higher yield obtained from high panel tapping on virgin bark is due to an extremely separate drainage area

Table 2. **Mean yield (kg ha^{-1}) and related parameters of continuous Low Frequency Controlled Upward Tapping (LFCUT)**

Treatments	Yield** (kg ha^{-1})	No. of taps $year^{-1}$	kg tap^{-1} ha^{-1}	kg $tree^{-1}$	TPD*** (%)
T1-S/4(RG)U d3 6d/7 ET 5.0% La 8/12(6w)*	3714	102	36.4 d	9.5 b	18
T2-S/4(RG)U d4 6d/7 ET 5.0% La 17/12(3w)	4417	77	57.3 c	11.1 ab	18
T3-S/3(RG)U d4 6d/7 ET 5.0% La 8/12y(6w)	4470	77	58.0 c	10.4 ab	16
T4-S/3(RG)U d7 6d/7 ET 5.0% Ga 17/y(3w)	4674	51	91.6 a	11.7 a	14
T5-S/3(RG)U d7 6d/7 ET 5.0% Ga 12/y(m)	3934	51	77.1 b	9.3 b	6

Within the column, values followed by same letter/s are not significantly different from each other
* Stimulation schedule changed to once in three weeks during sixth year of tapping ** Not significant
*** 6^{th} year

and the absence of interruption between the drainage area and the canopy (P'Ng, 1981). The adverse impact on rubber synthesizing capacity of the panel by the higher frequencies of stimulation was less than that of trees tapped under higher intensity of tapping (Sivakumaran *et al.*, 1984). Ethephon application inhibits plug formation on latex vessels whereby prolong latex flow and resulted higher yield (Kush *et al.*, 1990). Increased alkalinisation and increased chitinase activity also leads to increased rate and duration of latex flow (Koshy, 1997; Thanh *et al.*, 1997). The effectiveness of ethephon is better with short cuts than long cuts where the plugging is feeble (Southorn and Gomez, 1970). Results of the present study showed that continuous LFCUT can be successfully carried out when the renewed basal panel yield was poor or when there is high incidence of TPD in the basal panel. This can be ascribed to regular tapping with application of yield stimulants and fixing of 36" polythene rain guarding on the high panel tapping during rainy months.

Highest per tap yield of 91.6 kg ha^{-1} was obtained under S/4U d7 frequency tapping with once in three weeks stimulation followed by S/4 d7 with monthly stimulation (77.1 kg); S/3 d4 (58.0 kg ha^{-1}) and S/4 d3 (36.4 kg ha^{-1}) as depicted in Table 2. Results indicated that ethephon application could increase per tap yield when continuous LFCUT systems are adopted in clone RRII 118. Thus, tapper's income is also increased through increased over poundage. Mean annual tapping days during the experiment period for d3, d4 and d7 frequencies of LFCUT were 102, 77 and 51 days, respectively. By adopting d4 and d7 frequencies of tapping, requirement of tapper can be reduced by 25 and 51 per cent respectively, compared to third daily tapping (d3). The rate of bark consumption was higher under d3 frequency than d4 and d7 frequencies of tapping. During second year of CUT, bark consumption was more due to higher tapping panel position. Bark consumption was higher under CUT and also rate of bark consumption varied from tapper to tapper as reported earlier (Goh, Beng, 1986). Weekly tapping showed less incidence of TPD compared to d4 and d3 frequencies of tapping. Tapping panel dryness is very low in high panel tapping than basal panel tapping. In the present study, even trees affected by TPD in basal panel gave high yield on high panel tapping.

Consolidated results on continuous LFCUT under d3, d4 and d7 frequencies of tapping were analysed and are shown in Table 3. Techno-economic analysis revealed

Table 3. **Techno-economic analysis of continuous Low Frequency Controlled Upward Tapping (LFCUT)**

Treatments	Yield** (kg 400 trees^{-1})	No. of taps year^{-1}	Productivity (kg 400 trees^{-1} tap^{-1})	Bark consumption (cm year^{-1})	Tapper demand ha^{-1} (%)
T1-S/4(RG)U d3 6d/7 ET 5.0% La 8/12(6w)*	3826 b (100)	102	37.5 d (100)	29	100
T2-S/4(RG)U d4 6d/7 ET 5.0% La 17/12(3w)	4434 ab (116)	77	62.4 bc (66)	26	75
T3-S/3(RG)U d4 6d/7 ET 5.0% La 8/12y(6w)	4194 ab (110)	77	59.0 c (57)	27	75
T4-S/3(RG)U d7 6d/7 ET 5.0% Ga 17/y(3w)	4683 a (122)	51	91.8 a (245)	21	49
T5-S/3(RG)U d7 6d/7 ET 5.0% Ga 12/y(m)	3733 b (98)	51	73.2 b (195)	21	49

Values in parentheses are percentage increase in yield compared to T1

* Stimulation schedule changed to once in three weeks during sixth year of tapping ** Not significant

that, the yield levels of treatments T2 (S/4 d4) and T4 (S/3 d7) were 4434 kg 400 trees^{-1} and 4683 kg 400 trees^{-1} which were 116 and 122 per cent respectively, compared to that of T1 (S/4U d3). Continuous LFCUT of weekly tapping showed higher labour productivity, lower bark consumption and lower tapper demand than d3 frequency with periodic panel change. Over a period of nine years of basal panel tapping under S/2 d3 frequency in clone RRII 118 (BO-1 and BO-2), gave mean yield of 5.7 kg tree^{-1} (John *et al.*, 2009). Four year mean yield in the renewed panel (BI-1) was 7.5 kg tree^{-1} under S/2 d3 frequency of tapping in clone RRII 118 (Meenakumari *et al.*, 2015). Results of present study showed that mean yield under S/4U d3 frequency of tapping was 10.1 kg tree^{-1}, which is about 35 per cent higher in the high panel tapping.

Fixing of rain guard on high panel tapping with wider polythene (36") was slightly costlier than fixing of rain guard on the basal panel tapping during rainy season. High panel rain guarding needs additional labour for carrying the ladder for fixing the wider polythene. Under continuous LFCUT, for weekly tapping, groove method of ethephon application was practiced during the study period. Removal of lace under weekly tapping on high panel during third year on the same panel is slightly difficult for ethephon application, but yield was higher than d3 and d4 frequencies of tapping. High bark consumption and spillage are controlled with improvement of technique by the tapper using modified long handled gouge knife. Fixing of small cup hanger on the right side of the tapping cut helps to place the wider polythene safely during tapping operations. Besides it also helps to prevent polythene sheet from touching the tapping panel during wind and heavy rains. Furthermore, it helps to allow free air circulation for drying the tapping panel during rainy season.

CONCLUSION

Present study clearly showed that, under conditions of high incidence of TPD and unsuitable (damaged) renewed bark in basal panel, continuous LFCUT with appropriate stimulation can give comparable yield to that of d3 frequency of tapping. Among the low frequency tapping systems, S/3 d7 with once in three weeks stimulation and S/3 d4 are giving sustainable higher yield (kg tree^{-1}). Share of old and senile trees accounts for more than 50 per cent of the total tapping area. By adopting LFCUT productivity and production can be enhanced considerably. There are several other benefits like extended period of tapping on the same panel and benefits to tappers by incentive/over poundage *etc.* By practicing continuous LFCUT, grower can also benefit from reduction in cost of production, increasing economic life of rubber trees and complete replacement of ladder tapping by practising long handled modified gouge knife. In India, large scale implementation of CUT can lead to considerable enhancement of production and productivity in the rubber plantation sector.

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