Rubber Science, **33**(2): 186-197, 2020 *RESEARCH ARTICLE*

OPTIMIZATION OF YIELD THROUGH JUDICIOUS STIMULATION IN NEW CLONES IN THE NORTH EASTERN REGION OF INDIA

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Effect of frequency of stimulation with ethephon (2-chloro ethyl phosphonic acid) on yield performance of five clones *viz.* RRII 417, RRII 422, RRII 429, RRII 430 and RRIM 600 were evaluated under S/2 d3 6d/7 tapping system with stimulation and S/2 d2 6d/7 tapping system without stimulation with two months tapping rest. A five year study showed increase in dry rubber yield due to application of three to four stimulations per year in d3 system of tapping in all the clones. Highest yield was observed in clone RRII 429 which also had the highest growth. Incidence of tapping panel dryness was non-significant. Four rounds of stimulation in a year gave a higher yield of 1866 kg 400 trees^{-1} year^{-1} in clone RRII 429 under d3 system which was comparable with yield under d2 system (without stimulation) in North Eastern region of India.

Key words: *Hevea*, Low frequency tapping, North East India, Stimulation, 400 series clones, Yield

INTRODUCTION

Present trends of increasing cost of production of natural rubber (*Hevea brasiliensis*) and diminishing labour availability have led to a continued search for methods to reduce cost of production in rubber plantations. Increasing productivity by proper latex harvesting method is one of the approaches for reducing the cost of production of natural rubber. Yield stimulation offers opportunities for reducing number of tapping days by adoption of lower frequency tapping systems and thus reduces the labour cost. Due to high incidence of tapping panel dryness, alternate daily tapping (S/2 d2 6d/7 system) has been discouraged and third daily tapping (S/2 d3 6d/7 system with stimulation) is being recommended for high yielding clones in the traditional region of India.

Increasing productivity by adopting low frequency tapping with yield stimulation (using ethephon) is an important approach to reduce the cost of production (Gohet *et al.*,1991). Earlier reports had also shown good yield response of rubber clones to ethephon application (Sivakumaran and Chong, 1994; Nugawela *et al.*, 1997; Thanh *et al.*, 1996). Optimum yield could be harvested by low frequency tapping with

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rainguard (Sdoodee and Lacote, 2017). The productivity of high yielding clones can be further enhanced without any adverse effect by judicious yield stimulation under d3 frequency of tapping (Gohet *et al.*, 1991). Apart from the exploitation of genetic potential, judicious yield stimulation can also be employed for high productivity of rubber (Vijayakumar *et al.*, 2001). However, sustainable yield increase from third daily tapping is possible by limited number of stimulations (Rajagopal *et al.*, 2004). The use of ethephon to increase yield remains the most widely used latex yield stimulant (Pardekooper, 1989; Karunichamy *et al.*, 2001). Sustainable yield and productivity can be maintained through stimulation under reduced tapping frequency and tapping cut length (Thomas *et al.*, 2003; Zarin *et al.*, 1991; Vijayakumar *et al.*, 2002).

Genetic potential is important for high yield. Generally low yielding clones responded to stimulation better than the high yielding ones. In the traditional region of India, sustainable yield increase was reported in popular clone RRII 105 under third daily tapping (d3) by judicious application of ethephon from the opening onwards without any harmful effect in the long run (Dey and Thomas, 2011). Panel application of stimulant was reported to be more promising (Rajagopal *et al.*, 2000).

Rubber cultivation has extended to non-traditional areas of North eastern region of India to meet the increasing demand. The North eastern states have great potential for natural rubber cultivation and production. The crop has gained popularity among the native peoples of the region. About 1,85,770 hectre area is under natural rubber cultivation in this region as of 2016-17 (Rubber Board, 2017), of which more than 80 per cent of area is in the small holding sector with an average holding size of one hectare. The productivity in this region is 1241 kg ha^{-1}, which is lower than the national average (Sharma *et al.*, 2018). Majority of the area has been planted with RRIM 600. Recently RRII 429 was released for planting in North eastern region of India. Each of the RRII 400 series clones belong to different yield classes. However, there is no data on the response of these clones to yield stimulant application in North East India.

Sustainable latex productivity of the rubber tree has always been an objective for planters. Information on sustainable productivity of the high yielding clones by judicious yield stimulation under third daily tapping was not available in non-traditional areas of North eastern region India. The present paper reports the yield performance of different high yielding RRII 400 series clones under two tapping systems with different frequencies of stimulation in North eastern region.

MATERIALS AND METHODS

The experiment was conducted at the experimental farm of the Regional Research Station of the Rubber Research Institute of India at Taranagar (23° 53' N and 91° 15' E, 30m MSL). This trial was planted in a randomized block design with five clones and four treatments with five replications and plot size of eight trees (160 trees per clone as initial stand) at a spacing of 4.9 m x 4.9 m during 2007. The treatments were, S/2 d2 6d/ with 2 months rest in February & March (T1); S/2 d/3 6d/7 - ET 2.5%. Pa 0.02(2). 2/Y(T2); S/2 d/3 6d/7 - ET 2.5%. Pa 0.02(2). 3/Y(T3) and S/2 d/3 6d/7 - ET 2.5%. Pa 0.02(2). 4/Y(T4). The clones tested were RRII 417, RRII 422, RRII 429, RRII 430 and RRIM 600. All five clones are recommended for

cultivation in the North eastern region in different categories (Rubber Board, 2017). Clone RRII 429 was recommended in category I for commercial cultivation during 2020.

The trees were under S/2 d2 6d/7 and S/2 d3 6d/7 frequency of tapping from opening onwards. Each treatment was replicated five times. Stand per hectare was 420. Trees were rain guarded and tapped throughout the

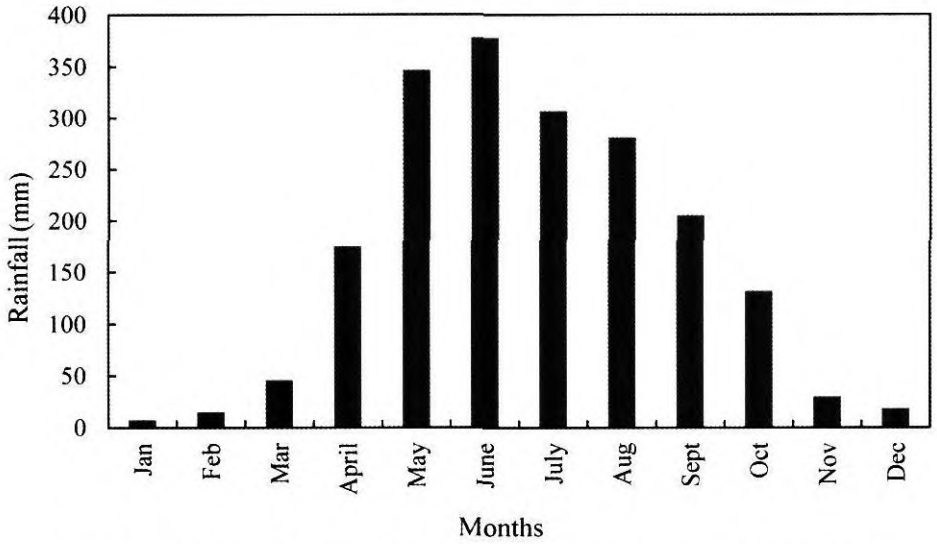

Fig. 1. Monthly rainfall (mean of five years) during tapping period of experiment

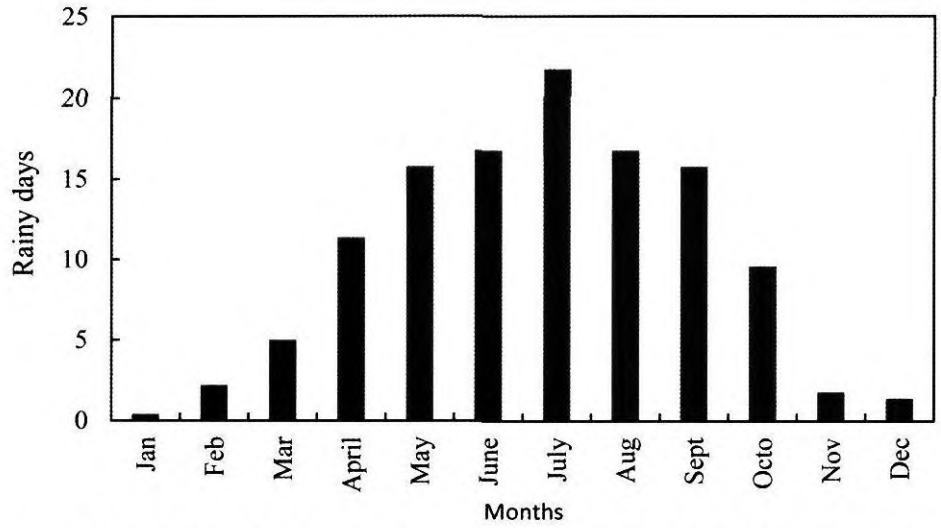

Fig. 2. Monthly rainy days (mean of five years) during tapping period of the experiment

year without any rest period in d3 system of tapping and two month rest during February and March in d2 system of tapping. Other cultural practices were as per the package of practices recommendations of the Board. Dry rubber content (DRC) of latex was determined on weight by weight basis once in a month before the next stimulation. Average number of tapping days in a year was 90 for d3 system of tapping and 110 for d2 system of tapping. Tapping was on panel BO-1 up to the fifth year of the experiment. The yield of individual trees was recorded following cup coagulation method. Girth of the trees was recorded at a height of 150 cm from bud union. Tapping panel dryness (%) was recorded as complete drying of tapping cut.Yield stimulation was carried out by applying 2.5 per cent ethephon (2-CEPA, 20 mg a.i. $tree^{-1}$ $application^{-1}$) on the panel. The stimulant was applied using a brush on the panel so that each tree received one ml of the product. Stimulation was carried out at the middle of the month (April/May, June, August, October). All stimulations were completed before the winter season. The stimulant (2.5% of ethephon) was prepared from the 10 per cent stock. The data were analyzed in factorial randomized block design as per Panse and Sukhatme (1961).

RESULTS AND DISCUSSION

During the study period, rainfall started from the middle of May and ended in September. Total rainfall was 1941 mm (Fig. 1) and total raining days were 119 days (Fig. 2) during the study period (2014-2018). Highest rainy days were observed in the month of July (22) followed by June and August (17). Of the total rainfall, 78 per cent was recorded during the rainy months. It peaked in June (378 mm) and followed by May (347 mm). Average highest maximum temperature was 31.1°C and average minimum temperature was 20 °C.

Girth of clones significantly varied from 46.2 to 58.1 cm in the seventh year after planting (Table 1). The growth curve of clones during experimental period is presented in Figure 3. The vigorous clone RRII 429 (57.3 cm) maintained high girth in all the years followed by RRII 430 (52 cm)

Table 1. **Effect of different frequency of ethephon application on girth, girth increment and tapping panel dryness (%)**

Clone	Treatment	Girth (cm)	GI * (cm)	TPD (%)
RRII 417	T1	51.2	3.0	2.5
	T2	51.1	3.1	5
	T3	49.6	2.9	1.3
	T4	51.5	3.1	2.5
RRII 422	T1	46.2	3.1	5
	T2	47.0	3.2	2.5
	T3	47.6	2.2	1.7
	T4	48.2	2.1	1.3
RRII 429	T1	56.8	3.1	7.5
	T2	57.3	3.5	5
	T3	56.9	3.6	5
	T4	58.1	3.1	7.5
RRII 430	T1	52.8	1.8	5
	T2	52.3	2.9	7.5
	T3	51.6	2.9	2.5
	T4	51.4	1.5	2.5
RRIM 600	T1	50.1	3.1	1.3
	T2	51.7	3.0	1.2
	T3	51.3	2.9	2.7
	T4	51.2	2.4	2.7
CD (P=0.05)				
Clone (C)		1.57	0.45	NS
Treatment (T)		NS	0.08	NS
C X T		NS	NS	NS

*GI- Girth increment during tapping

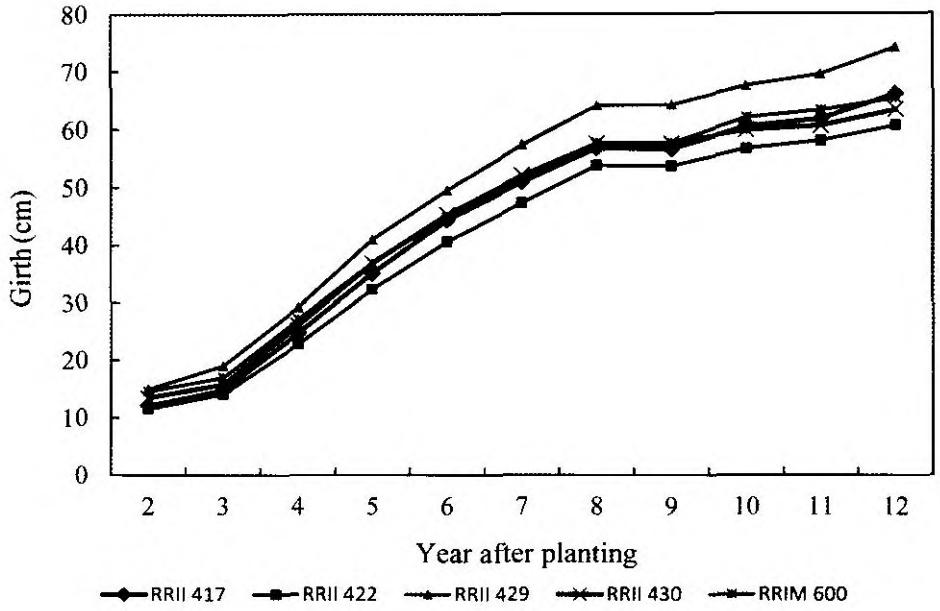

Fig. 3. Growth of the plants for 12 years after planting

during the immature phase. The girth increment after initiation of tapping ranged from 1.5 cm to 3.6 cm per year. Clone RRII 429 has also maintained high growth after tapping in subsequent years (Fig. 3). Significant variation in annual girth increment among the clones and treatments were observed during tapping period (Table 1).

Significant difference were observed in mean annual yield (kg400 trees^{-1}) among the clones in all the years 2014-15, 2015-16, 2016-17, 2017-18 and 2019-20 (Table 2). Significant differences in treatments were observed in the first three years *viz.* 2014-15, 2015-16 and 2016-17 and subsequent two years were not significant. However, increase of yield was observed in all the years due to application of four round of stimulation. Five year mean annual yield (kg 400 trees^{-1}) was significant. With two, three and four round of stimulations in d3 system of tapping, the mean yield of five years was 1397, 1448 and 1521 kg 400 trees^{-1} year^{-1} respectively and 1464 kg in the d2 system of tapping without stimulation. Clone RRII 429 showed highest mean yield among clones (Fig.4). Highest cumulative yield for five years was observed in treatment T4 (Fig. 5).

Data on dry rubber yield per tree per tap (g t^{-1} t^{-1}) for five years are shown in Table 3. Mean yield per tap ranged from 34.8 to 51.8g in the stimulated trees under d3 system of tapping. However, lowerdry rubber yield was observed in d2 system of tapping. Mean yield was 34.5 g t^{-1}t^{-1} in the d2 system of tapping and it increased to 42.2 g t^{-1}t^{-1} by stimulation under d3 system of tapping (Table 3). All the clones under the study recorded better yield performance and the yield improvement ranged from 16 per cent (RRII 422) to 29 per cent (RRII 417) with four

Table 2. **Effect of different frequency of ethephon application on dry rubber yield (kg 400 tees^{-1}year^{-1})**

Clone	Treatments	Yield (kg 400 trees^{-1} ha^{-1} year^{-1})					
		2014-15	2015-16	2016-17	2017-18	2018-19	Mean
RRII 417	T1	794	956	1516	2072	1425	1353
	T2	1120	1042	1334	1761	1329	1317
	T3	1125	1023	1288	2011	1358	1361
	T4	1235	1193	1522	2067	1497	1503
RRII 422	T1	654	964	1768	2048	1600	1407
	T2	826	997	1530	1999	1413	1703
	T3	766	1004	1670	1980	1436	1371
	T4	774	964	1671	1953	1694	1411
RRII 429	T1	1130	1234	2215	2429	1975	1797
	T2	1233	1253	1943	2177	1911	1703
	T3	1290	1251	2039	2163	1982	1745
	T4	1364	1404	2167	2563	1834	1866
RRII 430	T1	1012	1046	1597	1993	1478	1425
	T2	1013	1056	1442	1952	1341	1361
	T3	1038	1081	1497	1878	1539	1407
	T4	1058	1133	1539	1963	1448	1428
RRIM 600	T1	880	1017	1477	1777	1616	1339
	T2	852	991	1301	1594	1524	1253
	T3	986	1022	1380	1793	1609	1358
	T4	990	1106	1449	1797	1640	1397
CD (P=0.05)							
Clone (C)		71.7	87.2	176.6	214	201	94.4
Treatment (T)		64.1	78.0	158.0	NS	NS	84.4
C X T		NS	NS	NS	NS	NS	NS

stimulations per year under d3 system of tapping compared to the d2 system of tapping practiced in the region. RRII 429 recorded 24 per cent yield improvement with stimulation under d3 system (Table 3). The increase in yield with reduced tapping frequency can be due to the fact that such trees had long intervals between successive tapping days which allows better latex regeneration (Sivakumaran *et al.*, 1982). There was considerable seasonal variation in yield (Fig. 6). Yield pattern observed in the present study is with one peak in the post monsoon season during month of November and it was comparatively lower in the rainy season. Promotive effect of ethephon application on yield, under reduced intensity of tapping was reported

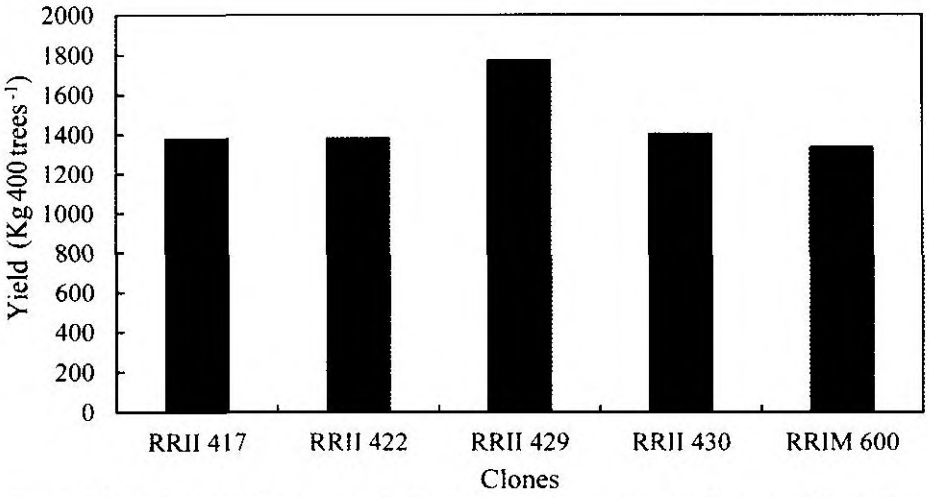

Fig. 4. Effect of varying frequency of ethephon application on annual average dry rubber yield (kg 400 trees^{-1} year^{-1})

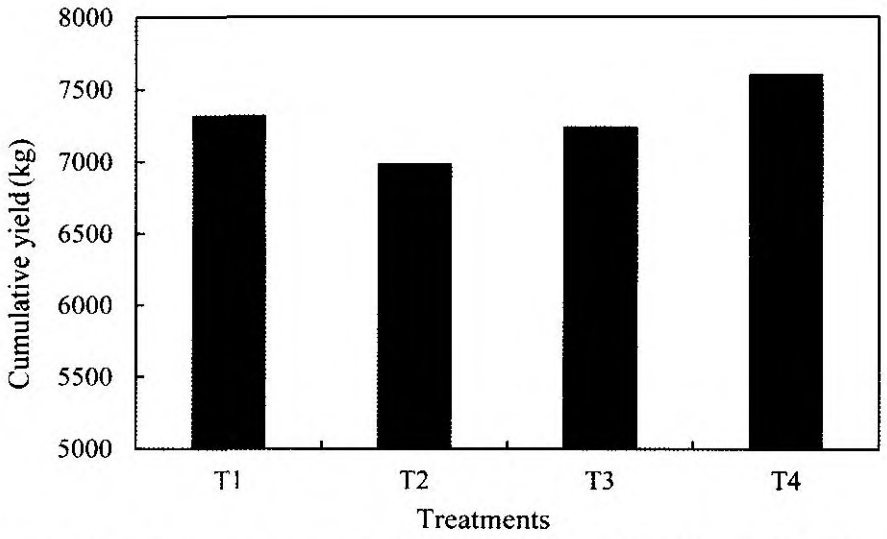

Fig. 5. Effect of varying frequency of ethephon application on dry rubber yield (kg 400 trees^{-1} year^{-1}) (cumulative of five years)

by earlier workers also (Nugawela *et al.*, 1997; Zarina *et al.*, 1991; Gohet *et al.*, 1991; Sivakumaran *et al.*, 1982; Rajagopal *et al.*, 2004, Dey *et al.*,2005; Karunaichamy *et al.*, 2012). Stimulation with ethephon resulted in higher yield due to inhibition of plug formation leading to increased latex flow (Kush *et al.*, 1990). Mode of action of ethylene is through increased chitinase activity leading to reduced plug formation that leads

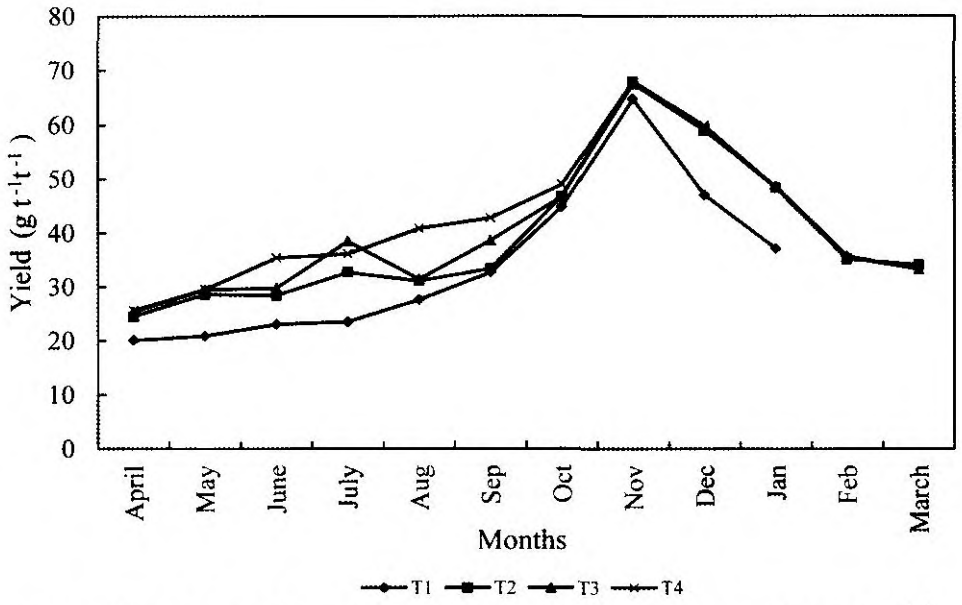

Fig. 6. Effect of varying frequency of ethephon application on mean monthly yield (g $t^{-1}t^{-1}$) (mean of five years)

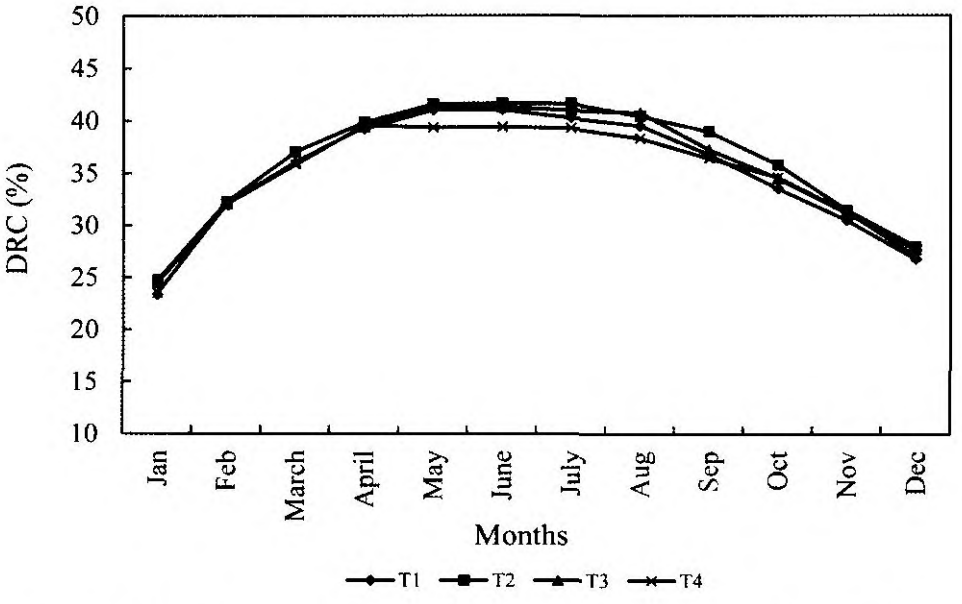

Fig. 7. Effect of varying frequency of ethephon application on mean DRC (%) in different months

Table 3. **Effect of different frequency of ethephon application on dry rubber yield (g t^{-1} t^{-1}) of experimental clones**

Clone	Treatments	Yield (g t^{-1} t^{-1})					
		2014-15	2015-16	2016-17	2017-18	2018-19	Mean
RRII 417	T1	19.1	23.4	32.9	46.7	35.3	32.5
	T2	32.5	27.7	34.4	50.3	38.6	36.6
	T3	32.7	27.2	33.2	57.1	39.5	37.9
	T4	35.9	31.7	39.2	58.7	43.5	41.8
RRII 422	T1	15.7	23.6	38.4	46.1	39.6	33.8
	T2	24.0	26.5	39.5	56.8	41.1	37.5
	T3	22.3	26.7	43.0	56.2	41.7	38.0
	T4	22.5	25.6	43.7	55.5	49.2	39.2
RRII 429	T1	27.1	30.3	48.1	54.7	48.9	41.8
	T2	35.8	33.3	50.1	61.8	55.6	47.3
	T3	37.5	33.3	52.5	61.4	57.6	48.5
	T4	39.7	37.3	55.8	72.8	53.3	51.8
RRII 430	T1	24.3	25.6	34.7	44.9	36.6	33.2
	T2	29.5	28.1	37.2	55.5	38.9	37.8
	T3	30.7	28.7	38.5	53.3	44.7	39.1
	T4	30.7	30.1	39.6	55.7	42.1	39.7
RRIM 600	T1	21.1	24.9	30.6	40.1	40.0	31.3
	T2	24.8	26.3	33.5	45.3	44.3	34.8
	T3	28.7	27.2	35.6	50.9	46.8	37.8
	T4	28.8	29.4	37.3	51.0	47.7	38.8
CD (P=0.05)							
Clone (C)		2.0	2.29	4.48	4.90	5.66	2.52
Treatment (T)		1.8	2.0	4.0	5.28	5.06	2.26
C X T		NS	NS	NS	NS	NS	NS

to increased rate and duration of latex flow (Thanh *et al.*, 1998).

There was reduction of dry rubber content (DRC) on higher round of stimulant application (Table 4). Considerable seasonal variation in DRC was observed (Fig. 7). Higher DRC was observed in summer months and lower during winter months. Clonal variation in DRC was not significant. The DRC values of trees tapped under d3 tapping system with two stimulations was higher than the d2 system of tapping in all clones.

Tapping panel dryness was not significant among clones and treatments during first five years of tapping (Table 1).

Table 4. **Effect of different frequency of ethephon application on dry rubber content (%)**

Clone	Treatments	DRC (%)					
		2014-15	2015-16	2016-17	2017-18	2018-19	Mean
RRII 417	T1	34.4	34.7	35.3	35.6	36.6	35.1
	T2	35.4	35.9	36.1	36.2	36.3	36.0
	T3	35.2	36.6	36.1	36.2	36.1	35.8
	T4	34.2	34.4	34.7	34.9	34.6	34.6
RRII 422	T1	34.6	35.3	35.3	35.4	35.5	35.2
	T2	35.2	36.5	36.3	36.4	36.4	36.1
	T3	35.3	35.5	35.9	35.7	36.1	35.7
	T4	34.3	34.4	34.5	34.6	35.0	34.5
RRII 429	T1	34.7	35.7	35.3	35.3	35.0	35.2
	T2	35.5	36.0	36.1	36.5	36.5	36.1
	T3	35.4	35.8	35.5	35.6	35.7	35.6
	T4	34.7	34.6	35.1	35.6	35.5	35.1
RRII 430	T1	34.9	35.0	35.0	35.4	35.5	35.2
	T2	35.5	35.6	36.3	36.3	36.4	36.0
	T3	34.9	35.0	35.1	35.6	35.6	35.3
	T4	34.0	34.6	34.1	34.6	35.3	34.5
RRIM 600	T1	34.7	35.1	35.2	35.2	35.3	35.1
	T2	35.8	36.3	36.0	36.1	36.3	36.1
	T3	35.1	35.5	35.7	35.6	35.7	35.5
	T4	34.6	34.6	35.0	34.6	34.8	34.7
CD (P=0.05)							
Clone (C)		NS	NS	NS	NS	NS	NS
Treatment (T)		0.72	0.68	0.60	0.56	0.61	0.30
C X T		NS	NS	NS	NS	NS	NS

This is evident from comparable incidence of tapping panel dryness (TPD) in different stimulated trees and maintained reasonable DRC in the stimulated trees throughout the period of study. Though TPD did not significantly vary among the clones, higher TPD incidence was observed in Clone RRII 429 in BO1 panel. Lower percentage of TPD in BO 1 panel was reported in North eastern region (Dey, 2006; Gogoi *et al.*, 2011).

CONCLUSION

Higher yield was observed in d3 system of tapping with application of three to four stimulations which was comparable with yield under d2 system of tapping. Increase of yield was obtained by judicious

application of stimulation in all the clones. Use of ethephon under low frequency tapping is mainly to compensate the potential loss of yield due to low frequency tapping. Yield can be increased by three to four stimulation under d3 tapping without any adverse effect. By adopting d3 system of tapping, grower can also benefit from reduction of tapping cost and increased economic life of rubber trees.

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