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YIELD AND YIELD COMPONENTS IN RENEWED PANEL (BI-1) OF RRII 400 SERIES RUBBER CLONES

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Yield components like total volume and dry rubber content (DRC) of latex were analyzed in summer and peak yielding seasons in the renewed bark to assess the performance of RRII 400 series clones. Significant variations were observed among the clones under evaluation with regard to the parameters. RRII 414 and RRII 430 showed the highest total latex volume as well as dry rubber yield both in summer and peak yielding seasons when tapped in the renewed bark. Total latex volume was less irrespective of the clone during summer compared to peak season. Clones responded differently to summer stress. The drop in total latex volume during summer ranged from 39.5 to 64 per cent and 36.6 to 60.9 per cent in LST I and LST II, respectively. The highest drop in summer latex volume was recorded in clone RRII 430. When virgin and renewed panels were compared, the total volume of latex was less in renewed panel compared to virgin panel in both the LST's barring very few exceptions. Status of clones with regard to latex volume, DRC and dry rubber yield in virgin panel (BO-1) and renewed panel (BI-1) were comparable in majority of the clones. The present study proved the superiority of RRII 430, RRII 417 and RRII 414 in the long run as well.

Key words: *Hevea brasiliensis*, RRII 400 series, Renewed panel, Summer yield, Yield components

INTRODUCTION

Hybridization and clonal selection has been successfully employed in the development of several outstanding *Hevea brasiliensis* clones. Licy *et al*. (1992) reported the production of high yielding hybrid clones of the RRII 400 series from the cross RRII 105 x RRIC 100. The heterotic response for yield and related attributes of those clones was reported by Licy *et al*. (2003) and high yield and precocity over four years of tapping by Mydin and Mercykutty (2007). Mydin *et al*. (2011) reported the yield and related attributes in two virgin panels of those clones. Based on the results obtained from evaluation trials of RRII 400 series clones, Rubber Research Institute of India has released RRII 414, RRII 430, RRII 417 and RRII 422 for large scale planting.

Rubber being a long duration crop with half of its yielding period in the virgin panel and another half in the renewed panel, it is imperative to know its yield performance in the renewed panel as well. Certain clones exhibit variation in their performance in renewed panel as compared to virgin panel. Clones such as GT 1 and PB 217 show an increasing trend whereas PB 235 shows a decreasing trend in yield in the renewed panel (Sethuraj, 1992). Since RRII 400 series clones were recommended under category 1 of the planting recommendation and widely

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planted in traditional rubber growing regions in India, it is very important to understand its long term yield performance in the renewed panel as well. Rubber yield in *Hevea brasiliensis* is governed by complex multicomponent factors. Information on these components associated with yield will help to understand the yield performance in the renewed panel. The present study discusses the yield components of RRII 400 series clones with emphasis on renewed tapping panel (BI-1) with an aim to study the performance of those clones in the long run.

MATERIALS AND METHODS

Twenty clones were evaluated in comparison with clone RRII 105 in two large scale trials (LSTs') laid out in 1993 at the Central Experiment Station of the Rubber Research Institute of India at Chethackal in Central Kerala, India (Table 1). The clones evaluated under LST I included RRII 402, RRII 403, RRII 407, RRII 414, RRII 417, RRII 429, RRII 446, RRII 449, RRII 453, one tetraploid clone (RRII 55) and a clone derived from the progeny of the compact canopy type (RRII 54). Clones under evaluation in LST II included RRII 410, RRII 422, RRII 427, RRII 430, RRII 434, RRII 454, two clones derived from the progeny of the compact canopy type (RRII 52 & RRII 53) and one introduced clone PB 330 (Prang Besar - Malaysia). The experimental clones were planted in two adjacent field trials employing randomized block design with 16 trees per plot. In LST I, 12 clones were replicated six times, while in LST II, 10 clones were replicated thrice. The system of tapping followed was S/2 d3 6d/7. Tapping in the renewed bark commenced after completing 12 years of tapping in the virgin panels (BO-1 and BO-2) and data from the renewed tapping panel (BI-1) was recorded

Table 1. **Pedigree of clones under evaluation**

LST I		LST II	
Clone	Pedigree	Clone	Pedigree
RRII 402	RRII 105 x RRIC 100	RRII 410	GT 1 x RRIC 100
RRII 403	,,	RRII 422	RRII 105 x RRIC 100
RRII 407	,,	RRII 427	,,
RRII 414	,,	RRII 430	,,
RRII 417	,,	RRII 434	RRII 105 x PR 107
RRII 429	,,	RRII 454	GT 1 x RRIC 100
RRII 446	GT 1 x RRIC 100	RRII 52	Normal morphotype progeny from compact canopy type
RRII 449	,,	RRII 53	,,
RRII 453	,,	PB 330	PB 5/51 x PB 32/36
RRII 54	Normal morphotype progeny from compact canopy type	RRII 105 (check clone)	Tjir 1 x Gl 1
RRII 55	Tetraploid (2n = 72)		
RRII 105 (check clone)	Tjir 1 x Gl 1		

consecutively for three years from the 2nd year onwards.

Yield components under study included total volume of latex (mL t^{-1} t^{-1}) and dry rubber content (DRC). Both parameters were recorded in summer and peak seasons during March-April and November-December respectively. In each block, data was recorded consecutively for three years from randomly selected three trees per plot in LST I and four trees per plot in LST II. DRC was recorded using standard laboratory methods. The dry rubber yield was expressed in gram per tree per tap (g t^{-1} t^{-1})

The per cent drop in total latex volume during summer in comparison to peak yielding season was worked out and the response of clones to summer stress was analyzed. The per cent increase in DRC during summer was also analyzed. The total volume of latex and DRC recorded during 4th year of tapping in virgin panel (BO-1) was compared with that of the renewed panel (BI-1) in the 4th year of tapping to identify clones with consistent performance in terms of yield components. Analysis of variance and the Duncan's Multiple Range Test (DMRT) was used to identify the significance of clonal difference at P=0.05 level (Gomez and Gomez, 1989).

RESULTS AND DISCUSSION

Total latex volume, DRC and dry rubber yield in the renewed panel

Significant variation was observed among the clones under evaluation in both the trials with regard to the parameters under evaluation. In LST I, RRII 414 showed the highest total latex volume during summer (122 mL t^{-1} t^{-1}) as well as during the peak season (283 mL t^{-1} t^{-1}). This was comparable

Table 2. **Total latex volume, DRC and dry rubber yield in the renewed bark (BI-1) of clones in LST I during peak yield and summer season (Mean of 3 years)**

Clone	Total latex volume (mL)		DRC (%)			Dry rubber yield (g t^{-1} t^{-1})	
	Peak	Summer	Peak	Summer	% increase	Peak	Summer
RRII 446	89.3 d	43.8 e	37.6 cd	43.6 ab	16.0	33.4 e	20.1 e
RRII 55	168.1 bc	92.5 bc	42.6 b	42.7 bc	0.4	68.9 bc	39.6 ab
RRII 54	107.4 d	65.0 cd	40.8 bc	41.7 bc	2.1	45.4 de	28.4 cd
RRII 417	238.1 ab	113.0 ab	40.5 bc	40.9 c	1.2	95.4 ab	45.2 ab
RRII 407	164.0 bc	68.4 cd	34.5 e	42.2 bc	22.2	55.7 cd	26.3 de
RRII 403	223.0 ab	80.2 c	46.7 a	48.9 a	4.7	101.6 a	38.3 bc
RRII 449	116.0 d	66.1 cd	40.2 bc	44.6 ab	10.8	46.6 de	29.6 cd
RRII 429	210.6 ab	75.8 cd	39.4 bc	43.0 ab	9.1	81.2 ab	33.4 bc
RRII 402	154.5 cd	68.3 cd	40.9 bc	47.6 ab	16.5	61.2 cd	30.8 cd
RRII 453	103.9 d	48.8 de	36.8 de	41.7 bc	13.1	39.1 de	19.8 e
RRII 414	283.1 a	122.3 a	42.9 b	44.2 ab	3.6	112.6 a	52.5 a
RRII 105	237.0 ab	90.8 bc	41.7 b	44.7 ab	7.3	98.4 ab	41.2 ab
GM	174.6	77.9	40.4	43.8	8.9	70.0	33.8
CV%	34.5	27.1	7.2	10.2		36.3	31.2

Means followed by the same letter do not differ significantly at 5 per cent level.

with RRII 105 that recorded a total volume of 90 and 237 mL t^{-1} t^{-1} during summer and peak seasons, respectively. RRII 414 showed highest rubber yield also during summer (52 g t^{-1} t^{-1}) as well as peak yielding period (112 g t^{-1} t^{-1}) which were comparable with RRII 105 with summer and peak season yields of 41 and 98 g t^{-1} t^{-1}, respectively. DRC in RRII 414 was 44.5 and 43.0 per cent during summer and peak seasons, respectively which was also comparable with RRII 105 which recorded 44.7 per cent and 41.7 per cent DRC respectively. RRII 417 and RRII 429 also showed comparable summer as well as peak season yield with that of RRII 105 (Table 2).

In LST II, RRII 430 showed highest total latex volume during summer (101 mL t^{-1} t^{-1}) as well as peak season (260 mL t^{-1} t^{-1}) which were comparable with RRII 105 having summer and peak latex volumes of 92 and 198 ml $t^{-1}t^{-1}$, respectively (Table 3). RRII 430 showed highest rubber yield during summer (50 g t^{-1} t^{-1}) as well as peak (122 g t^{-1} t^{-1}) which were comparable with RRII 105 having summer and peak rubber yield of 42 and 85 g t^{-1} t^{-1}, respectively. DRC in RRII 430 was 50 and 47 per cent during summer and peak season, respectively which was comparable with RRII 105 having 46 and 42 per cent, respectively. RRII 422 also showed comparable summer as well as peak season yield with that of RRII 105 (Table 3).

Clones RRII 414, 417, 422, 429 and 430 were reported to yield significantly better than RRII 105 in the small scale trial (Licy *et al*., 2003) as well as in the initial four years in the large scale evaluation trials (Mydin and Mercykutty, 2007). Superiority of these clones in the two virgin panels was further reported by Mydin *et al*. (2011). The present study proved the superiority of these clones in the long run (renewed panel) as well.

Seasonal variations in total latex volume and DRC

Total volume of latex of clones in LST I ranged from 89.4 to 283.2 mL and 43.8 to 122.3 mL

Table 3. **Total latex volume, DRC and dry rubber yield in the renewed bark (BI-1) of clones in LST II during peak yield and summer season (Mean of 3 years)**

Clone	Total latex volume (mL)		DRC (%)			Dry rubber yield (g t^{-1} t^{-1})	
	Peak	Summer	Peak	Summer	% increase	Peak	Summer
RRII 454	102.9 d	65.2 cd	32.6 e	37.8 cd	16.0	33.2 d	23.3 cd
RRII 430	260.6 ab	101.8 ab	47.6 a	50.3 a	5.6	122.4 a	50.1 a
RRII 434	92.6 d	55.6 d	36.7 d	38.7 bc	5.4	33.5 d	18.9 d
RRII 427	118.8 cd	70.4 bc	43.3 b	37.8 cd	-12.7	49.7 cd	26.9 bc
RRII 53	100.1 d	51.4 d	39.4 cd	45.7 ab	16.7	38.3 cd	22.7 cd
RRII 422	195.5 b	90.2 ab	44.1 ab	44.5 ab	0.9	85.9 b	40.1 ab
PB 330	275.4 a	110.0 a	48.2 a	48.9 a	1.7	131.5 a	52.9 a
RRII 410	203.6 ab	91.0 ab	44.4 ab	51.8 a	16.6	86.7 b	43.8 ab
RRII 52	181.5 bc	103.6 ab	38.2 d	35.9 d	-6.1	66.3 bc	41.9 ab
RRII 105	198.3 ab	92.2 ab	42.8 bc	46.5 ab	8.6	85.1 b	41.9 ab
GM	172.9	83.1	41.7	43.7	5.2	73.3	36.3
CV%	24.4	22.2	5.3	10.0		22.4	27.2

Means followed by the same letter do not differ significantly at 5 per cent level.

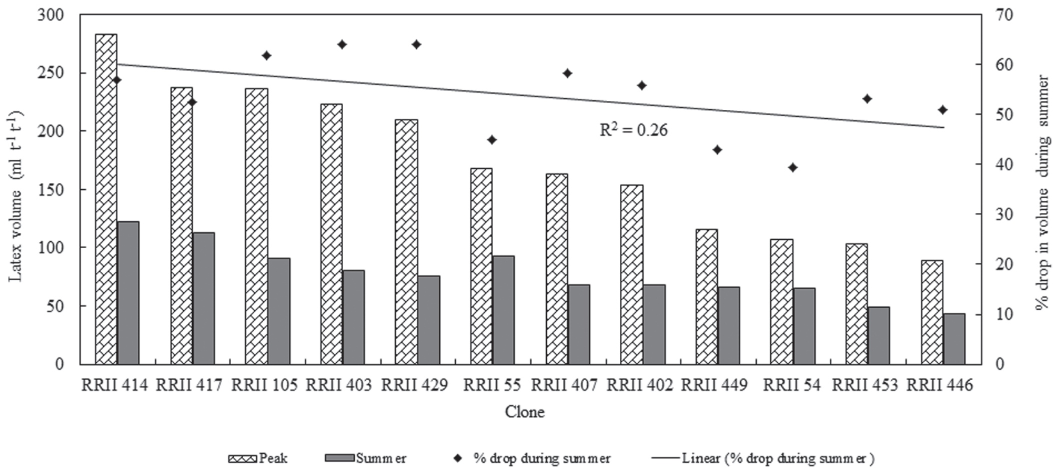

Fig. 1. Peak and summer latex volume and per cent drop during summer under LST I

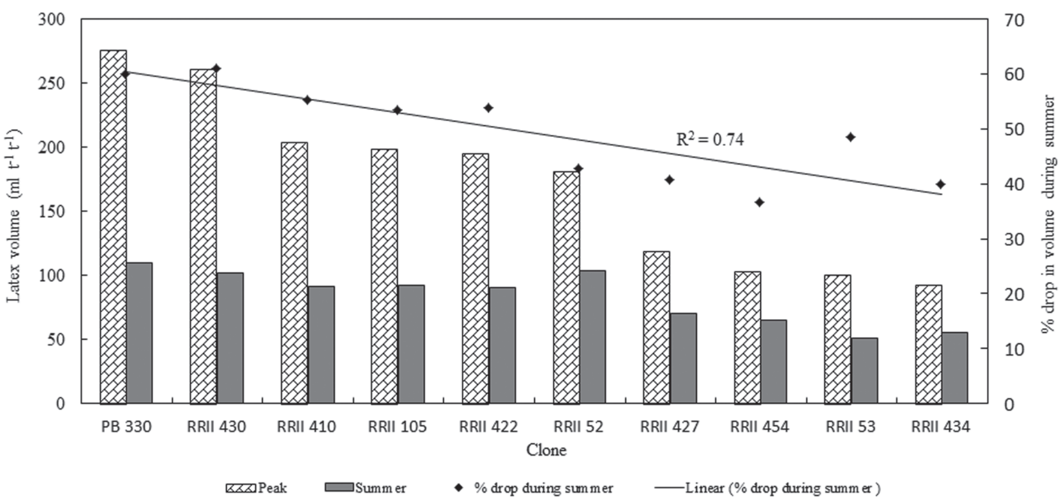

Fig. 2. Peak and summer latex volume and per cent drop during summer under LST II

during peak season and summer season, respectively (Table 2). In LST II, it ranged from 92.7 to 275.5 mL and 55.6 to 110 mL, respectively (Table 3). Total latex volume was less irrespective of the clone during summer compared to peak season. The per cent drop in latex volume during summer ranged from 39.5 to 64 per cent and 36.6 to 60.9 per cent in LST I and LST II, respectively (Fig. 1 & 2). The drop in total latex volume in summer observed in the present study was found to be in agreement with an earlier report showing a yield drop ranging from 28.0 to 68.6 per cent (Mydin and Mercykutty, 2007). The clones responded differently to summer stress. The per cent drop in latex volume generally showed a decreasing trend from high yielders to low yielders.

In LST II, the highest drop in summer latex volume was recorded in clone RRII 430 with 60.9 per cent drop from peak yielding season (Fig. 2). The earlier reports also demonstrated similar kind of behavior in RRII 430. Although annual mean yield in RRII 430 is significantly superior to all other clones, summer yield contribution to the total yield was very low and suggested that rain guarding is highly essential to take advantage in clone RRII 430 (Mydin and Mercykutty, 2007; Mydin *et al.*, 2011; Meenakumari *et al.*, 2015). Although RRII 430 is reported to be a drought tolerant clone (Annamalainathan *et al.*, 2010; Ravichandran *et al.*, 2011; Sumesh *et al.*, 2011; Thomas *et al.*, 2014; Meenakumari *et al.*, 2015; Krishan, 2017) the yield drop during summer is very high. Meenakumari *et al.* (2015) attributed the summer yield drop in RRII 430 to late wintering and refoliation which impose competition for photosynthates coupled with other prevailing stress factors. RRIM 600, a proven drought tolerant clone was also reported to show low summer yield (Meenakumari *et al.*, 2015). But, it has been reported that RRIM 600 is an early to intermediate wintering clone (Vinod *et al.*, 1996; Suryakumar *et al.*, 2002). Hence, it is clear that late wintering and refoliation alone is not the reason for drop in summer yield. Moreover, clones such as GT 1 although a late wintering clone is considered to be a high summer yielder. These observations also suggest that lesser summer yield loss cannot be considered as an indicator of drought tolerance. It can be hypothesized that drought tolerant clones might be effectively managing and diverting part of the photoassimilates and other resources to activate drought tolerance mechanism rather than latex biosynthesis when exposed to summer stress.

Among the high yielders, the drop in summer yield of RRII 422 was comparatively less (53.9%) (Fig. 2). The lower drop in summer yield could be the reason behind the earlier reports that RRII 422 recorded maximum summer yield per se (Mydin and Mercykutty, 2007; Mydin *et al.*, 2011; Meenakumari *et al.*, 2015). Although RRII 422 is not considered as a highly drought tolerant clone, the summer yield drop is less. Hence, it is hypothesized that RRII 422 is not as efficient as RRII 430 in effectively managing and diverting the photoassimilates used in latex biosynthesis into drought tolerance which is in contrast with that observed in drought tolerant clones RRII 430 and RRIM 600.

Dry rubber content in LST I ranged from 34.5 to 46.7 per cent and 40.9 to 48.9 per cent during peak season and summer season, respectively (Table 2). In LST II, DRC ranged from 32.6 to 48.2 per cent and 35.9 to 51.8 per cent during peak season and summer season, respectively (Table 3). Dry rubber content was high during summer in majority of the clones barring very few exceptions (RRII 427 & RRII 52) compared to peak season. The per cent increase in DRC was not found to be correlated with yield status in both the trials and hence it can be considered as a clonal character independent of the yield potential. Sreelatha *et al*. (2011) reported a significant reduction in dry rubber yield in all the five RRII 400 series clones under the study during the stress period compared to peak yielding season when the variation in yield and associated biochemical changes was studied in comparison with clone RRII 105.

Yield comparison of virgin and renewed panels

In order to understand the ability of clones to produce higher yield throughout its commercial yielding period, a comparison of virgin and renewed panel was undertaken with regard to the total volume of latex and DRC in the fourth year of tapping in the respective panels. In general, total volume of latex was less in renewed panel compared to virgin panel in both the trials (Table 4 & 5). The average volume of latex was 166.4 and 129.9 mL in virgin and renewed panel, respectively in LST I and 152 and 120.4 mL in LST II. The respective dry rubber yield was 61.0 and 53.8 g t^{-1} t^{-1} in LST I and 62.9 and 55.3 g t^{-1} t^{-1} in LST II.

In LST I, very high yielding clones in the virgin panel such as RRII 417, RRII 403, RRII 414 and RRII 105 maintained its high yield in the renewed panel as well (Table 4). But some of the best performing clones in virgin panel such as RRII 55, RRII 429 and RRII 402 failed to sustain its performance in the renewed panel. Hence, these clones cannot be recommended for commercial cultivation although high yielders in the initial years.

In LST II, RRII 427, the highest latex yielding clone in virgin bark failed to show the same performance in the renewed bark with yield of less than half of that in virgin bark indicating that it cannot be recommended for commercial cultivation (Table 5). Performance of RRII 422 was also not superior in renewed bark. The annual yield should be evaluated before deciding the inferiority of RRII 422 as it was showing significantly high yield in summer which might be the case with rest of the months also which may make the clone superior. Clone PB 330 which was not among the top performers in virgin panel, emerged as the top performer in the renewed panel showing that the clone is a late yielder.

Table 4. **Total latex volume, DRC and yield in the 4th year of tapping in virgin (BO-1) and renewed bark (BI-1) (mean of summer & peak seasons) – LST I**

Clone	Total latex volume (mL)		DRC (%)		Dry rubber yield (g t^{-1} t^{-1})	
	Virgin panel	Renewed panel	Virgin panel	Renewed panel	Virgin panel	Renewed panel
RRII 446	93.6 b	67.8 e	41.3	40.6 ab	38.2 b	26.9 e
RRII 55	206.0 a	123.2 bc	42.0	40.3 ab	71.0 a	55.5 bc
RRII 54	75.0 b	81.1 de	41.7	37.7 b	23.8 b	35.8 de
RRII 417	219.0 a	179.3 ab	43.3	38.9 b	74.6 a	72.0 ab
RRII 407	178.3 a	125.7 bc	38.3	36.4 b	43.0 b	44.7 cd
RRII 403	194.6 a	168.3 ab	43.3	44.9 a	79.6 a	72.0 ab
RRII 449	73.6 b	97.1 cd	41.3	39.5 ab	29.5 b	38.6 cd
RRII 429	201.0 a	149.9 ab	39.0	38.1 b	81.8 a	60.0 bc
RRII 402	207.3 a	112.0 bc	42.7	44.5 a	76.3 a	48.7 cd
RRII 453	105.6 b	72.3 e	39.0	36.7 b	38.4 b	29.9 e
RRII 414	219.3 a	209.6 a	43.3	41.2 ab	89.9 a	89.2 a
RRII 105	222.6 a	172.9 ab	43.7	40.7 ab	85.7 a	71.2 ab
GM	166.4	129.9	41.7	40.1	61.0	53.7
CV%	25.7	44.6	12.7	10.3	30.3	32.1

Means followed by the same letter do not differ significantly at 5 per cent level

Table 5. **Total latex volume, DRC and yield in the 4th year of tapping in virgin (BO-1) and renewed bark (BI-1) (mean of summer & peak seasons) – LST II**

Clone	Total latex volume (mL)		DRC (%)		Dry rubber yield (g t^{-1} t^{-1})	
	Virgin panel	Renewed panel	Virgin panel	Renewed panel	Virgin panel	Renewed panel
RRII 454	130.2 d	80.0 cd	36.2	34.5 d	28.6 c	28.7 e
RRII 430	181.0 bc	182.5 ab	40.4	48.4 a	78.0 a	87.7 ab
RRII 434	71.0 e	66.4 d	38.9	36.6 cd	37.0 bc	27.1 e
RRII 427	249.0 a	87.0 cd	38.2	39.4 bc	88.5 a	38.2 de
RRII 53	69.3 e	61.6 d	40.2	40.2 bc	39.8 bc	31.0 de
RRII 422	210.6 ab	120.2 bc	42.3	44.7 ab	76.6 a	62.7 c
PB 330	130.2 d	186.6 a	40.4	46.7 a	78.2 a	91.8 a
RRII 410	118.4 d	134.5 ab	39.4	46.9 a	77.3 a	68.3 bc
RRII 52	142.9 cd	117.1 cd	37.9	36.3 cd	58.1 ab	53.1 cd
RRII 105	217.0 ab	168.1 ab	40.9	43.7 ab	66.3 ab	64.0 c
GM	152	120.4	39.5	41.8	62.8	55.3
CV%	16.5	30.4	8.2	6.6	26.2	22.7

Means followed by the same letter do not differ significantly at 5 per cent level

Mydin *et al*. (2011) had reported that when yield in PB 330 was not superior in the first virgin panel (BO-1) it turned to a significantly superior yielder in BO-2 panel. In both the trails, RRII 105 was a steady performer in virgin (BO-1) as well as in renewed panel (BI-1) tapping.

Licy *et al.* (1998) observed significant inter-character correlation between yield and yield components when performance of hybrid clones was evaluated for the first three years of tapping in comparison to early performance in the immature phase of four and a half years after field planting. They observed highly significant early versus mature association in the case of yield, total volume of latex per tap, rate of latex flow and plugging index indicating that most of the traits in the early phase have strong favorable association with yield in the mature phase. In the present study, the status of clones with regard to latex volume and DRC of both virgin panel and renewed panel were comparable in majority of the clones. Hence, the yield performance during virgin panel tapping can be treated as an indicator for yield in the renewed panel.

CONCLUSION

The status of clones with regard to latex volume and DRC of both virgin panel (BO-1) and renewed panel (BI-1) tapping were comparable in majority of the clones. Analysis of yield components in the renewed panel of RRII 400 series clones revealed that clones RRII 430, RRII 417 and RRII 414 maintained superiority in rubber yield over the high yielding check, RRII 105, justifying their release for wide scale planting in the traditional rubber growing regions of India.

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