PERFORMANCE OF NEW GENERATION CLONES OF *HEVEA BRASILIENSIS* UNDER THE DRY SUB-HUMID CLIMATE OF NORTH KERALA

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A large-scale clone evaluation trial incorporating 12 popular clones including the new RRII 400 series clones was laid out in Padiyoor, in Kannur district of North Kerala. Overall performance in terms of growth during immature and mature phase, dry rubber yield over seven years of tapping, disease incidence and secondary traits was studied. The highest percentage of tappable trees was recorded in PB 217 (82%) followed by RRII 430 (76%). Growth performance of RRII 400 series clones was superior to RRII 105 in the immature phase and comparable to RRII 105 in the mature phase. RRII 430 was the highest yielder during the entire tapping period of seven years with a mean yield of 60.98 gt^{-1} t^{-1} and was significantly superior to that of RRII 105. The yield of RRII 414, RRII 417 and RRII 422 was comparable to that of RRII 105 which recorded 51.14 g t^{-1} t^{-1}. RRII 422 recorded the maximum summer yield (41.11 g t^{-1} t^{-1}). Seasonal yield behaviour of RRII 430 was very distinct from other clones. RRII 430 and RRII 417 recorded relatively high drc (39%). Observations on abnormal leaf fall disease under sprayed conditions, the RRII 400 series clones showed high leaf retention above 80 per cent of which the lowest retension was observed in RRII 422. Pink disease incidence was the lowest in RRII 430, while disease incidence in RRII 414, RRII 417 and RRII 422 was comparable to that of RRII 105. The suitability of RRII 400 series clones to the prevailing dry sub-humid climatic conditions of the region is discussed.

Keywords: Dry sub-humid climate, Growth, *Hevea brasiliensis*, RRII 400 series clones, Yield

INTRODUCTION

The release of clone RRII 105 three decades ago, apart from its high yield potential provided added advantage to the growers in terms of high adaptation to the traditional rubber growing tracts of Kerala and Kanyakumari district of Tamil Nadu. In the context of climate change and unpredictable weather conditions, identifying high yielding clones with consistency in yield performance and desirable secondary attributes remains a challenge for *Hevea* breeders in the 21st century. Rubber cultivation in the northern

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tract of Kerala, though falling within the traditional zone is faced with distinct agro climatic conditions (Lakshmanan *et al.*, 2014) by way of scanty summer showers, relatively long dry spells and high intensity rains. The trees come into tappable girth by 8-10 years depending on environmental factors and agromanagement practices. Hence, identifying high yielding clones specifically suited to this region assumes significance. The new generation RRII 400 series clones developed indigenously (Licy *et al.*, 2003) are performing superior to or on par with RRII 105 in South Kerala (Varghese *et al.*, 2009), Central Kerala (Mydin *et al.*, 2011) and in the non-traditional rubber growing areas of North East India (Deepthi *et al.*, 2010; Meenakumari *et al.*, 2011; Das *et al.*, 2012), notwithstanding location variations. These clones are also under evaluation in a large scale clone trial in Padiyoor village in Kannur district of North Kerala, as part of Multi Environment Trials (METs) initiated in five locations across the country. Commencement of tapping was delayed in this region, compared to other locations due to delayed attainment of stipulated girth. The growth and yield performance of these clones along with five other promising clones (including two from Malaysia and one from Sri Lanka) in comparison with RRII 105 is reported in this paper with the objective of identifying and selecting the best clones suited to the prevailing dry sub humid climate of the region.

MATERIALS AND METHODS

The trial was laid out in 1996 in the farm of Regional Research Station of Rubber Research Institute of India (RRII) located at Padiyoor (11^{0}58' N, 75^0 36' E and 60 m above MSL). A total of 12 clones including nine indigenous (five from RRII 400 series) and three exotic clones from Malaysia and Sri Lanka were incorporated in the study and the details are furnished in Table 1. A randomised complete block design was adopted with 3 replications, of 36 (gross) and 16 (net) trees planted in each plot with a spacing of 4.9m x 4.9m. Soil of the experimental site is typically lateritic. All cultural operations as per the recommended package of practices were adopted. The trees were opened for tapping during 2006. Tapping system followed was S/2 d3 6d/7. The following observations were recorded.

Table 1. **Details of clones**

Clone	Parentage	Developed by
RRII 414	RRII 105 x RRIC 100	India
RRII 417	RRII 105 x RRIC 100	India
RRII 422	RRII 105 x RRIC 100	India
RRII 429	RRII 105 x RRIC 100	India
RRII 430	RRII 105 x RRIC 100	India
RRII 203	PB 86 x Mil 3/2	India
RRII 51	Primary clone	India
RRII 176	Mil 3/2 x PB 5/60	India
PB 217	PB 5/51 x PB 6/9	Malaysia
RRIM 600	Tjir 1 x PB 86	Malaysia
RRIC 100	RRIC 52 x PB 83	Sri Lanka
RRII 105	Tjir 1 x Gl 1	India

Growth and tappability

Girth of the trees was recorded annually from the 3rd to 17th year of field planting. The percentage of tappable trees attaining a girth of 50 cm was recorded in the year of opening (2006). Girth increment rate during immature phase was recorded from the difference in growth up to the commencement of tapping and for the mature phase from the 1st to 7th year of yield recording.

Dry rubber yield

Yield recording was carried out fortnightly by cup coagulation method and expressed as gram per tree per tap ($gt^{-1}\ t^{-1}$). Apart from annual dry rubber yield, yield during the lean season (February – May) was also computed separately. Volume of latex (mL) and dry rubber content (drc) was determined for two consecutive years on a seasonal basis. Monthly variation in yield was plotted from yield data for seven years.

Anatomy

Bark samples were collected randomly using standard procedure and radial longitudinal sections cut at 100 µm were stained using Oil red O (Oomman and Reghu, 2003). Bark thickness (mm) and number of latex vessel rows were recorded using a bright field microscope.

Tapping Panel Dryness (TPD) and disease incidence

The number of fully dried trees was recorded in the 7th year after opening. Incidence of pink disease and abnormal leaf fall in the high yielding clones were recorded for three years. Extent of wind damage was assessed from uprooted as well as trunk snap affected trees.

Statistical analysis

The data were subjected to analysis of variance (ANOVA) followed by Duncan' Multiple Range Test (DMRT) to test for significant difference from the control.

RESULTS AND DISCUSSION

Weather data of the station during the study period (1996-2012) is given in Figure 1a. The region receives an average annual rainfall of 3000 to 4000 mm with optimum number of rainy days (125) as ideally required (Rao and Vijayakumar, 1992). However, rainfall distribution is highly skewed (Fig. 1b) with rains mostly concentrated during the months from June to August. North east monsoon showers are limited and summers are relatively dry. The uneven distribution of rainfall results in a longer dry spell of 4 to 5 months due to which the region experiences severe seasonal drought. Temperatures are also high with maximum temperature ranging from 35 to 38 °C during the summer months.

Growth and tappability

Early tree growth was observed to be slow in the region which resulted in delayed commencement of tapping. During the 10th year of planting, the highest percentage of tappable trees was recorded in PB 217 (82%) followed by RRII 430 (76%). The RRII 400 series clones except RRII 429 recorded higher tappability (63-76%) as compared to RRII 105 which recorded 51 per cent tappability (Table 2). Lakshmanan *et al.* (2014) reported 53 per cent tappability for RRII 105 trees of same age from this region. Tan (1987) and Simmonds (1989) established that early vigour is an important factor that determines the tappability and yielding ability of clones. The precocity of RRII 400 series clones (Mydin *et al.*, 2007) is one of the major advantages over RRII 105.

Girth at opening of most of the clones was significantly superior to RRII 105 (Table 2). RRII 430 showed the maximum girth at opening (54.93 cm). Lowest girth was recorded by RRIM 600 (43.87 cm). Goncalves *et al.*, (2004) considered girth as an important character for the selection of location specific clones in different environments. At the 17th year of planting highest girth was exhibited by RRII 176 (69.25 cm) and PB 217 (69.39 cm), followed by RRII 203 (65.90 cm) and these

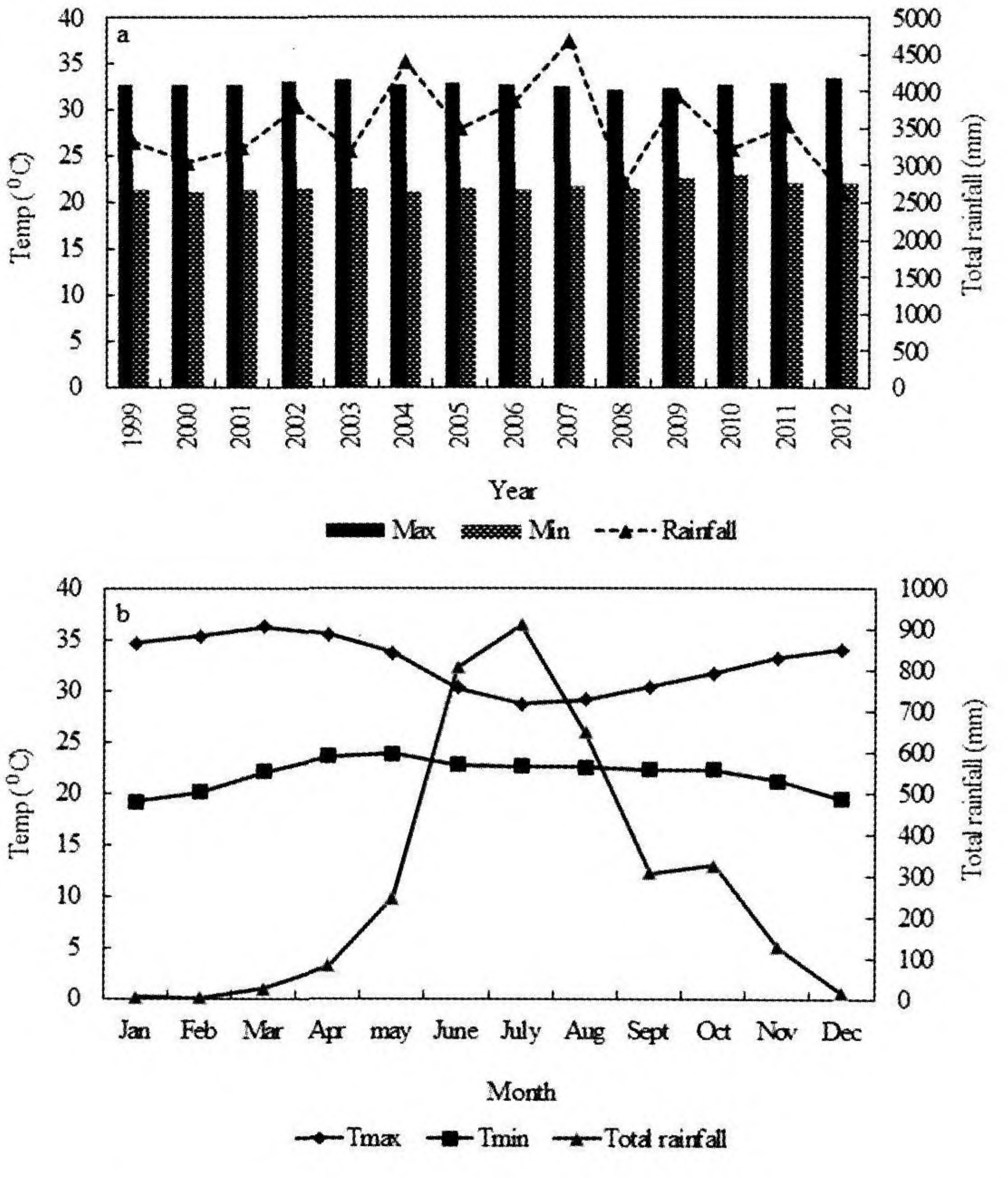


Fig. 1a. Weather during the study period (1996-2012), b. Monthly variation in temperature and rainfall distribution (1996-2012)

Table 2. **Girth at opening and girth increment rate of clones**

Clone	Tappability (%) (10th yr)	Girth at opening (cm)	Girth during 17th year of planting (cm)	Girth increment rate (cm)	
				At immaturity	On tapping
RRII 414	74.20	54.05 abc	60.36 bcd	5.95 ab	0.92 d
RRII 417	63.49	50.80 abcd	61.58 bcd	5.74 abc	1.29 bcd
RRII 422	62.92	50.19 abcd	60.03 bcd	5.53 abc	1.26 bcd
RRII 429	53.33	47.22 de	59.14 bcd	5.18 bcd	1.50 bc
RRII 430	76.07	54.93 a	62.18 bcd	5.97 ab	1.12 cd
RRII 203	70.58	51.37 abcd	65.90 ab	5.81 ab	1.75 ab
RRII 51	52.42	48.11 cde	60.32 bcd	5.25 bcd	1.71 ab
RRII 176	75.00	54.30 ab	69.25 a	6.25 a	1.70 ab
PB 217	82.00	50.82 abcd	69.39 a	6.08 a	2.12 a
RRIM 600	30.00	43.87 e	58.84 cd	4.62 d	2.09 a
RRIC 100	67.08	53.71 abc	65.05 abc	6.20 a	1.39 bcd
RRII 105	50.93	48.47 bcde	57.56 d	4.98 cd	1.53 bc

Means followed by the same letters are not significantly different

three clones were significantly superior to RRII 105 (57.56 cm). In order to obtain sustainable yield for a long period, it is necessary to maintain a satisfactory rate of growth of trees. RRII 203, RRII 176 and PB 217 showed high girth increment rate in both immature and mature phases. The RRII 400 series clones in general, exhibited superior girth increment rate in the immature phase, whereas in the mature phase the growth rate was comparable to that of RRII 105. Significantly high girth at opening and girth increment rate at immaturity followed by variable response in growth rate under tapping was reported earlier among 15 clones of RRII 400 series (Mydin *et al.*, 2011). Growth trend in the non traditional areas (Deepthy *et al.*, 2010) also corroborates with these findings.

Dry rubber yield

Annual mean yield of RRII 430 was significantly superior to all other clones tested in the BO-1 panel (60.25 g t^{-1} t^{-1}). The trend in yield (Table 3) was observed to be the same for the first year of tapping in the BO- 2 panel and for the entire tapping duration of seven years (60.98 g t^{-1} t^{-1}). RRII 105 recorded a mean yield of 49.88 g t^{-1} t^{-1} in the BO- 1 panel, 58.71 g t^{-1} t^{-1} in the first year of tapping in BO-2 panel and 51.14 g t^{-1} t^{-1} for the seven year tapping period. The yield of RRII 414, RRII 417 and RRII 422 was comparable to that of RRII 105. Yield performance of all other clones except RRIC 100 was inferior. Yield of the clones during lean period (Feb-May) also showed significant clonal variation. RRII 422 recorded the maximum summer yield (41.11 g t^{-1} t^{-1}) which was significantly superior to that of RRII 105 (34.19 g t^{-1} t^{-1}) followed by RRII 414 (35.51 g t^{-1} t^{-1}) and RRII 430 (34.52 g t^{-1} t^{-1}). Low summer yield was observed in RRII 203 and RRIM 600. Summer yield showed significant positive correlation (0.648*) with annual yield in the present study. High annual yield coupled with high summer

Table 3. **Mean annual yield and summer yield of clones**

Clone	Annual yield (g t^{-1} t^{-1})			Summer yield
	BO -1 panel	BO -2 Panel (1^{st} yr.)	Mean over 7 years	(g t^{-1} t^{-1})
RRII 414	49.59 ^{bcd}	49.28 ^{abcde}	49.55 ^{bcd}	35.51 ^{ab}
RRII 417	53.83 ^{b}	53.62 ^{abcd}	53.80 ^{b}	29.03 ^{cdef}
RRII 422	51.68 ^{b}	58.00 ^{abc}	52.58 ^{bc}	41.11 ^{a}
RRII 429	45.14 ^{cde}	50.03 ^{abcde}	45.84 ^{cde}	32.45 ^{bcde}
RRII 430	60.25 ^{a}	65.33 ^{a}	60.98 ^{a}	34.52 ^{bcd}
RRII 203	37.31 ^{g}	40.34 ^{cde}	37.74 ^{fg}	26.88 ^{ef}
RRII 51	36.05 ^{g}	39.72 ^{de}	36.57 ^{g}	28.16 ^{def}
RRII 176	38.02 ^{fg}	53.17 ^{abcd}	40.19 ^{efg}	33.02 ^{cdef}
PB 217	43.62 ^{def}	46.22 ^{bcde}	43.99 ^{def}	31.84 ^{bcde}
RRIM 600	39.31 ^{efg}	35.37 ^{e}	38.75 ^{fg}	25.27 ^{f}
RRIC 100	44.93 ^{cde}	60.59 ^{ab}	47.17 ^{bcd}	35.28 ^{abc}
RRII 105	49.88 ^{bc}	58.71 ^{ab}	51.14 ^{bc}	34.19 ^{bcd}

Means followed by the same letters are not significantly different

yield will ensure better return to the grower round the year.

Year wise yield of the clones in comparison with RRII 105 is depicted in Figure 2. RRII 430 showed consistently superior yield from the first year onwards. The stability of performance of RRII 430 within a location as well as across diverse

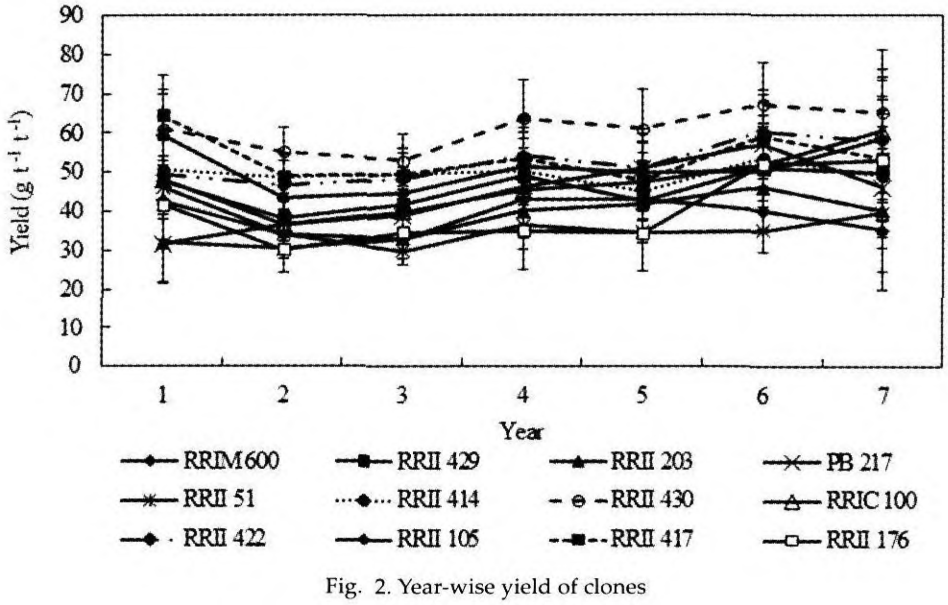


Fig. 2. Year-wise yield of clones

locations has already been reported (Meenakumari *et al.*, 2010; 2011).

Monthly variation in yield

Clonal differences in yield performance were more conspicuous during wet months than in the dry months. Monthly variation in yield of the high yielding clones is given in Figure 3. Minimum performance was noticed during the drought prevailing months (Feb-May) for all the clones. A progressive increase in yield was seen from June onwards, depending on inherant variation of the clones. A striking feature was the shift in seasonality of yield in North Kerala compared to rest of the traditional belt. Peak yield observed in the present study was during the months of Aug-Sep. Lakshman *et al.* (2014) also reported similar pattern from the region in a study with exotic clones. In South and Central Kerala which experience both monsoons, a dual peak could be observed during July and November (Rajagopal *et al.*, 2003; Mydin *et al.*, 2007). In the present study, even though a second peak was observed in November, yield was relatively lower, presumably due to moisture stress consequent to weak north east monsoon rains.

RRII 430 showed a very distinct behaviour from the other clones. A sizeable share of the annual yield of RRII 430 was realised in the monsoon and post monsoon phase. Summer yield contribution to the total yield was very low. The present results are in close proximity with the reports from Central Kerala, that rain guarding is very essential to take advantage of this high yielding clone (Mydin *et al.*, 2007). The peak yielding season in northern Kerala

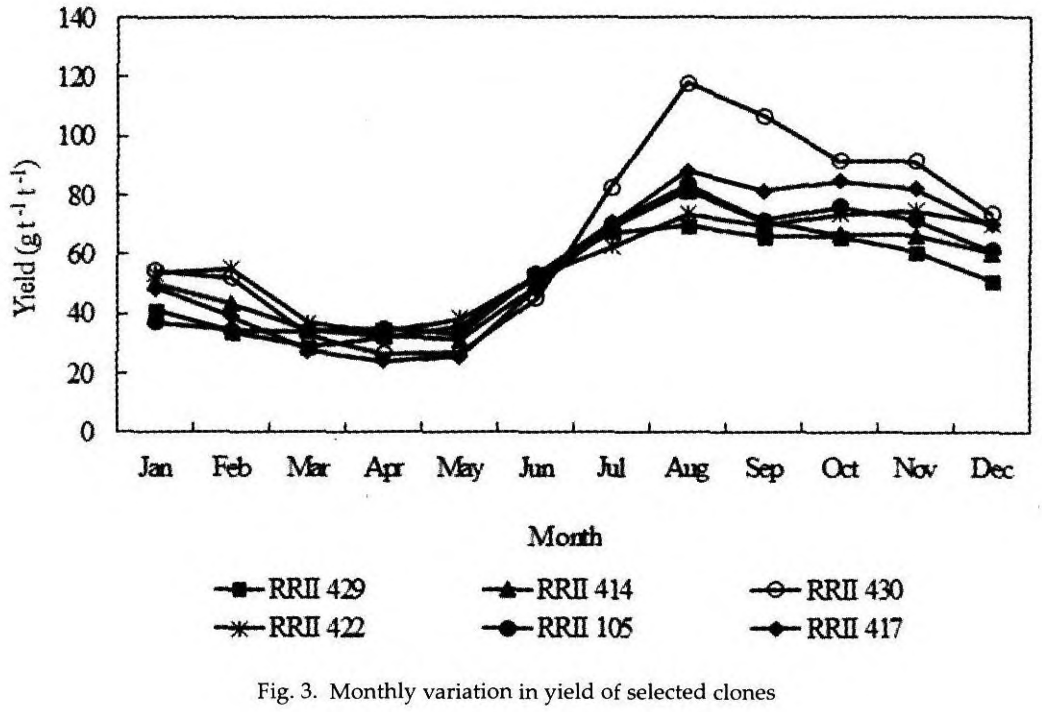


Fig. 3. Monthly variation in yield of selected clones

coinciding with south west monsoon can result in considerable loss of tapping days (Vijayakumar *et al.*, 2000) and hence rainguarding is all the more warranted for this region. Moreover, wintering and refoliation in RRII 430 is reported to be late *i.e.* by Feb-Mar (Licy *et al.*, 2003) compared to the other RRII 400 series clones. The low summer yield of RRII 430 could be apparently due to late wintering and refoliation which impose competition for photosynthates coupled with other prevailing stress factors. A reduction in yield during or soon after wintering has been reported (Wimalaratna and Pathiratna, 1974; Sethuraj, 1977). The clones RRII 417, RRII 422 and RRII 414 maintained yield levels comparable to RRII 105 during the entire period.

Yield components and secondary traits

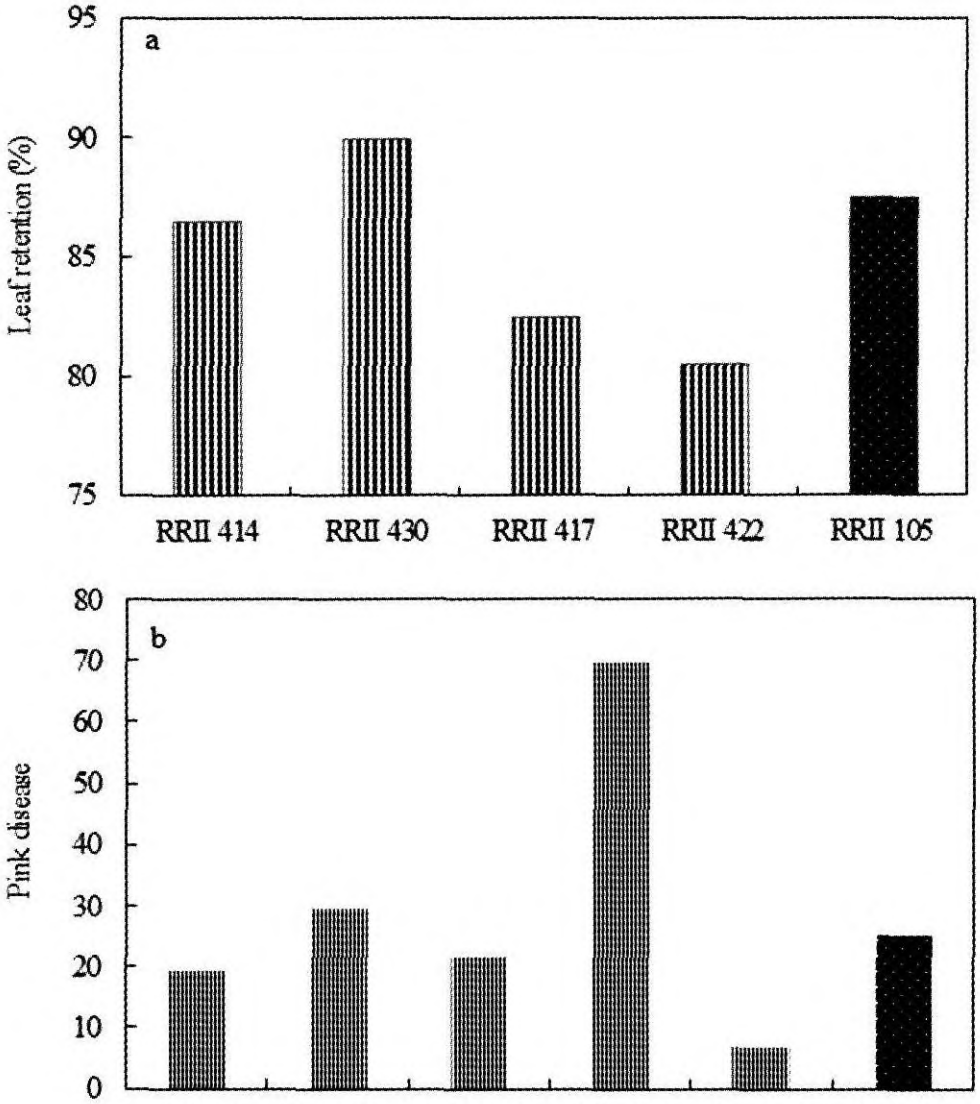
Volume of latex ranged from 97 mL t^{-1} t^{-1} (RRII 51) to 135 mL t^{-1} t^{-1} (RRII 422 and PB 217). RRII 105 recorded 108 mL t^{-1} t^{-1}. Three clones *viz.*, RRII 430, RRII 417 and RRIC 100 recorded high drc (39 per cent) whereas RRIM 600 (33%) and RRII 414 (34%) recorded relatively lower drc. Highly significant clonal variation for dry rubber yield, volume of latex, rate of latex flow, dry rubber content, and number of latex vessel rows in both virgin and renewed bark has been reported by Licy *et al.* (2003) in the preliminary evaluation of these clones. However, the nature and magnitude of different yield components controlling rubber yield of *Hevea* clones differ in different environments (Jayasekera *et al.*, 1977).

Bark structural parameters and secondary traits of clones are given in Table 4. Bark thickness ranged from 5.4 mm (RRII 429) to 7.69 mm (PB 217). RRII 203 and PB 217 are the vigorous clones which recorded significantly superior bark thickness than the control. Nugawela *et al.* (2002) observed increased bark thickness with increasing girth in certain Sri Lankan clones. The clones RRII 51 (17) RRII 414 (15) and RRII 430 (15) showed high number of latex vessel rows (15) better than the check

Table 4. **Structural features and secondary traits of clones**

Clone	Bark thickness (mm)	No. of latex vessel rows	TPD (%)	Wind damage (%)
RRII 414	7.13 ^{ab}	15.41 ^{ab}	7.69	7.69
RRII 417	6.63 ^{bcd}	14.00 ^{bc}	2.63	10.53
RRII 422	6.00 ^{cdef}	12.16 ^{cd}	13.95	4.65
RRII 429	5.41 ^{f}	13.90 ^{bc}	7.32	4.88
RRII 430	6.48 ^{bcde}	15.11 ^{ab}	0.00	0.00
RRII 203	7.63 ^{a}	13.97 ^{bc}	6.82	0.00
RRII 51	7.13 ^{ab}	17.06 ^{a}	5.00	15.00
RRII 176	5.77 ^{ef}	13.30 ^{bc}	4.35	4.35
PB 217	7.69 ^{a}	13.07 ^{bcd}	3.23	3.23
RRIM 600	5.93 ^{def}	10.50 ^{b}	9.00	3.23
RRIC 100	6.34 ^{bcde}	11.43 ^{cd}	2.38	0.00
RRII 105	6.80 ^{bc}	12.84 ^{bcd}	13.79	27.59

Means followed by the same letters are not significantly different clone (12). Number of latex vessel rows was the lowest in RRIM 600 (10.50). Bark characters assume significance in relation to latex yield. As in the case of girth, bark thickness is a clonal character showing association with number of latex vessel rows (Gomez, 1982) and influencing the latex yield of different clones (Narayanan *et al.*, 1973). Incidence of TPD (per cent fully dried trees) was the highest in RRII 422 and RRII



Figs. 4. Incidence of (a) ALF and (b) Pink disease (%)

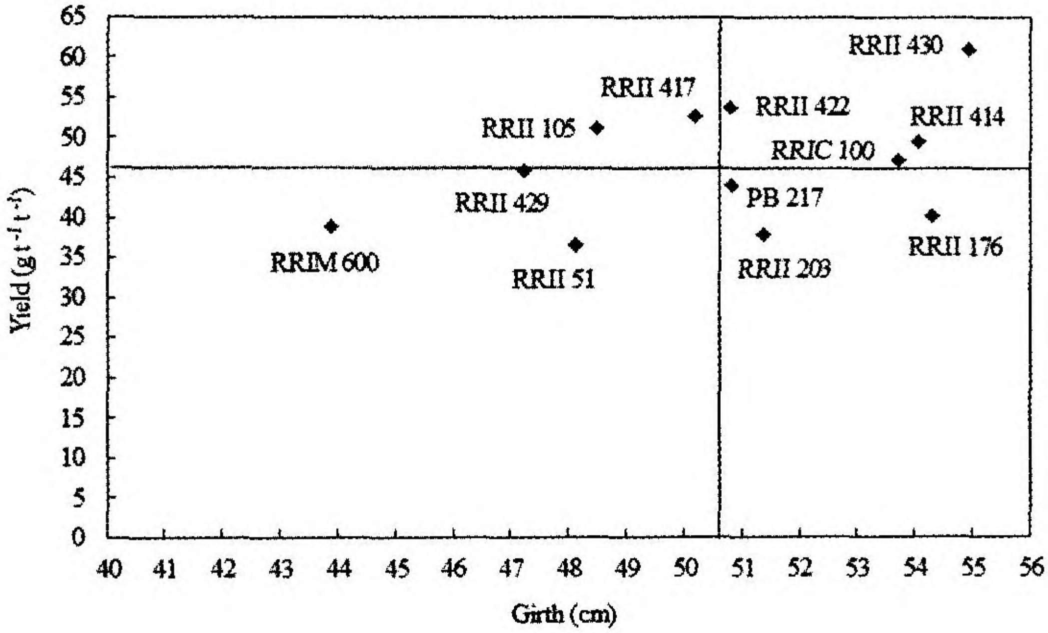


Fig. 5. Selection of clones for high yield and vigorous growth

105 (14%). Wind damage was the highest in RRII 105 (27%) followed by RRII 51 and RRII 417. Mydin *et al.* (2011) observed high TPD in clone RRII 429 and high wind damage for RRII 105. TPD incidence (fully dried) and wind damage of trees was not observed in RRII 430.

Disease incidence

Incidence of abnormal leaf fall (ALF) and pink disease in the high yielding clones are depicted in Figure 4. Under sprayed conditions, the RRII 400 series clones showed leaf retention above 80 per cent. RRII 430 showed very high retention (90%) and the lowest retention was observed in RRII 422. Pink disease incidence was the lowest in RRII 430, while disease incidence in RRII 414, RRII 417 and RRII 422 was comparable to that of RRII 105. RRII 429 recorded severe infestation of pink (69%) as also reported earlier by Mydin *et al.* 2011.

A scatter plot to identify promising clones for the North Kerala region based on growth vigour and high latex yield is given in Figure 5. The clones RRII 430, RRII 414, RRII 417 and RRIC 100 fell in the first quadrant corresponding to high girth and high yield. Clone RRII 430 which showed the highest values for both traits was identified as the most suited clone for the region. Clones RRII 414, RRII 417 and RRII 422 were placed in the high yielding quadrant along with RRII 105 of which the growth vigour of RRII 414 and RRII 417 was superior to RRII 422. Clone RRIC 100 showed high vigour with moderate yield. Majority of the farmers in North Malabar, especially small growers are extensively cultivating RRII 105. The susceptibility of

RRII 105 to *Corynespora* leaf spot disease in the adjoining areas of South Karnataka raises serious concerns on the area expansion of monoclonal plantations of RRII 105 in this region. In this context, the clones RRII 430, RRII 414, RRII 422 and RRII 417 assume significance.

CONCLUSION

Highly significant clonal variation for dry rubber yield, volume of latex, girth at opening, girth increment rate, bark anatomy, disease incidence and other secondary triats was observed among the 12 clones in the study. The RRII 400 series clones except RRII 429, showed superiority for all the aforementioned traits. The results confirm the suitability of all the four RRII 400 series clones for the dry sub-humid northern part of Kerala of which RRII 430 was consistently the best performer showing more than 20 per cent yield improvement over the check RRII 105 over seven years of tapping.

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