Research Article

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Growth and yield performance of some exotic clones of *Hevea brasiliensis* in North Kerala region

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Abstract

The growth and yield performance of a set of exotic clones from Malaysia and Ivory Coast was evaluated in comparison with RRII 105, a popular high yielding indigenous clone, for their adaptability in the northern tract of Kerala. The region is characterised by absence of sufficient summer showers and relatively long dry spells. Analysis of growth up to 16 years after planting revealed significant clonal differences in growth pattern, only from the 10^{th} year of planting. Girth and girth increment was the highest in IRCA 130, followed by PB 330. The lowest girth was observed in RRIM 703. The clone IRCA 130 also exhibited significantly high annual and summer yield followed by PB 255. Peak rubber yield was recorded in the month of September irrespective of clones. IRCA 130 showed significantly superior branching height and bole volume followed by PB 255. Incidence of tapping panel dryness (TPD) and pink disease in IRCA 130 was comparable to clone RRII 105. The suitability of the newly introduced clones for the region is discussed.

Keywords: Bole volume, growth, *Hevea brasiliensis*, IRCA clones, PB clones, rubber yield

Introduction

Cultivation of *Hevea brasiliensis* is fast expanding in the northern tracts of Kerala often with replacement of established tree species such as cashew, arecanut and pepper. Even though located within the traditional rubber growing tract, the region is characterised by high intensity rains during the months of June to September with relatively few showers during the North East monsoon season which commences from October and lasts till November/December. Summer showers are scanty. Annual average rainfall ranges from 3000 to 4500 mm. However, distribution of rainfall is poor in this region. The dry humid summer months extends from December to May. Soil moisture is a critical limiting factor for growth of plants in the region. Hence, suitable clones adapted to withstand the biotic and abiotic constraints of the region have to be developed.

At present, the clone widely planted in this region is RRII 105, an indigenously developed high yielding clone. Clones such as GT 1 and RRIM 600 grown in the early years are no longer adopted, due to the low productivity of these clones compared to RRII 105. Apart from developing indigenous clones suited to the prevailing agro climatic conditions, rubber breeders continue to resort to introducing proven superior clones from other rubber growing countries in order to circumvent the long breeding and selection cycle. Conventionally, introduced clones are evaluated directly in the large scale trials, surpassing the preliminary evaluation stages. A total of 127 exotic clones have been introduced so far (Mydin *et al.*, 2009). Among these, a set of clones introduced from Prang Besar (PB) Estate, Malaysia, Rubber Research Institute of Malaysia (RRIM) and Ivory Coast (Institute de Recherches sur le Caoutchouc en Afrique - IRCA) are performing well in the advanced evaluation trials in Central and

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South Kerala (Soman *et al.,* 2004, 2010; Reghu *et al.,* 2008;Varghese *et al.,* 2009). The growth and yield performance of these clones is yet to be evaluated for their adaptability in northern Kerala region. The present study was taken up with the objective of assessing the growth and yield performance of certain exotic clones in comparison with the check clone RRII 105 so as to identify the most promising clones suited to the region.

Materials and methods

A large scale clone evaluation trial with 11 clones was laid out in 1996 at the farm of Regional Research Station of RRII, Padiyoor ($11^0$36' N latitude, 76^0 33'E Longitude and 60 m above msl). A randomised complete block design with 3 replications and a plot size of 36 (gross) and 16 (net) trees with a spacing of 4.9 m x 4.9 m was adopted. Soil of the experimental area is typically lateritic. Five clones each of Malaysian origin and Ivory Coast were planted along with RRII 105 as the control. Details of planting materials are given in Table 1. Two whorled poly bag plants were used for field planting. All cultural operations as per the recommended package of practices were followed.

Growth was monitored annually by measuring trunk girth at 150 cm height from the bud union, commencing from the 3^{rd} year after field planting. Growth data from 1999 to 2012 were used for analysis. Annual girth increment for the immature and mature phases were arrived at from the girth data. The percentage of tappable trees attaining a girth of 50 cm at a height of 1.25 m from the bud union was recorded during the 9^{th} and 10^{th} year of planting. Trees were opened for tapping in March 2006 under the S/2 d3 6d/7 tapping system. Tree wise yield was recorded monthly by cup coagulation method and dry weight of cup lumps was accounted. The yield reduction in summer was calculated by deducting the summer yield (Feb-May) from the annual yield and expressed in percentage. The yield for the months of September to December was pooled together to get the peak yield. Bole height was measured as the distance from the bud union to the first branching level. Clear bole volume was estimated from the data on bole height and girth of trees 16 years after planting following the method of Chaturvedi and Khanna (1982). Incidence of tapping panel dryness (fully dried trees) and pink disease was recorded for three consecutive years.

Results and discussion

Growth and tappability

The trunk girth and girth increment of clones in the immature and mature phases and percentage of tappability are given in Table 2. Girth at four years after planting did not show any significant clonal variation. Girth in the year of opening showed clonal variation. IRCA 130 recorded the highest girth at opening (55 cm). Of the PB clones, the highest girth at opening was recorded by PB 314 (54 cm) followed by PB 330 (52.6 cm). RRIM 703 recorded the lowest girth (44.5 cm). RRII 105 recorded a mean girth of 50.6 cm. Girth of the trees has long been identified as one of the most important

Table 1. Details of clones included in the study

Clone	Parentage	Country of origin	Year of introduction
PB 255	PB 5/51 x PB 32/36	Malaysia	1985
PB 314	RRIM 600 x PB 235	Malaysia	1985
PB 330	PB 5/51 x PB 32/36	Malaysia	1985
PB 28/59	Primary clone	Malaysia	1963
RRIM 703	RRIM 600 x RRIM 500	Malaysia	1966
IRCA 18	PB 5/51 x RRIM 605	Ivory Coast	1991
IRCA 109	PB 5/51 x RRIM 600	Ivory Coast	1991
IRCA 111	PB 5/51 x RRIM 600	Ivory Coast	1991
IRCA 130	PB 5/51 x IR 22	Ivory Coast	1991
IRCA 230	GT1 x PB 5/51	Ivory Coast	1991
RRII 105	Tjir1 x Gl1	India	-

Table 2. Girth (cm), girth increment (cm) and tappability (%) of *Hevea* clones

Clone	Girth 4th year after planting	Girth at opening	Girth 6th year after opening	Girth increment Immature phase 2000-06	Girth increment Mature phase 2007-12	Percentage tappability 9th year	Percentage tappability 10th year
PB 255	16.6	49.5	63.5	5.73	2.18	45.83	62.50
PB 314	20.9	54.3	63.9	5.88	1.65	51.81	68.19
PB 330	15.0	52.6	69.8	6.60	2.84	44.12	70.12
PB 28/59	15.9	50.7	63.3	5.98	1.96	18.45	57.94
RRIM 703	14.1	44.5	56.9	5.34	1.98	12.50	34.49
IRCA 18	17.7	54.4	68.1	6.49	2.26	49.62	74.81
IRCA 109	18.2	50.8	60.9	5.81	1.59	34.19	54.02
IRCA 111	18.3	50.5	61.5	5.69	1.79	31.75	52.22
IRCA 130	16.3	55.0	69.3	6.96	2.41	52.06	77.01
IRCA 230	19.0	53.8	64.3	6.15	1.75	53.90	68.83
RRII 105	14.0	50.6	63.3	6.49	2.08	40.49	53.60
CD	NS	5.5	4.7	0.47	0.62	NS	NS

trait contributing to latex yield (Narayanan and Ho *et al*., 1973) and girth at opening is a significant clonal character (Nazeer *et al.,* 1986). Vigorous growth of the plants enable early opening of the trees for tapping and thereby have a strong influence on initial yield. Six years after opening, girth of the clones ranged from 56.9 cm (RRIM 703) to 69.8 cm (PB 330). Girth of PB 330 and IRCA 130 was found to be significantly superior to RRII 105. Goncalves *et al.,* (2004) considered tree girth as a stable character for location specific selection of *Hevea* clones in different environments.

Girth increment rate is yet another important clonal character indicating the efficiency of clones on assimilate partitioning, once brought under tapping. With respect to girth increment during the immature phase, clones PB 330, IRCA 18, IRCA 130 and IRCA 230 were on par with the control and the highest girth increment was noticed in IRCA 130 (6.96 cm year^{-1}). Tapping retards the girth increment rate, the extent of which varies widely between clones (Paardekooper, 1989). The breeder's task is to maximize latex yield in a tree which is still growing vigorously enough to sustain a rising yield trend for many years (Templeton, 1969; Wycherley, 1976). Narayanan and Ho, 1970 and 1973 established relationship of girth of immature as well as mature trees with high latex yield. Girth increment on tapping in the present study ranged from 1.59 cm yr^{-1} (IRCA 109) to 2.84 cm yr^{-1} (PB 330) and clonal differences were significant. IRCA 130 and PB 330 exhibited high growth vigour before and after tapping and were superior to RRII 105 in terms of this trait. The superiority of IRCA 130 in terms of growth has been reported by Reghu *et al*. (2008). The low girth increment rate observed for PB 314 is in conformity with earlier reports (John *et al.,* 2004) whereas that of PB 255 is in contrary to that reported by John *et al.,* 2004.

A girth of 45 to 50 cm at 150 cm above the bud union for budded plants is used in different rubber growing countries as a criterion for selecting trees for tappability (Paardekooper, 1989; Obouayeba *et al.,* 2000; Vijayakumar *et al.,* 2000). Compared to the general practice of commencement of tapping by the 7th year, tapping was delayed by 1-2 years in this region due to slow growth of trees. By the 9th year of planting nearly 50 per cent of trees in clones PB 314, IRCA 130, IRCA 230 and IRCA 18 had attained a tappable girth of 50 cm and above (Table 2) while only 40 per cent of trees of RRII 105 attained tappable girth. By the 10th year, over 70 per cent trees of clones IRCA 130, IRCA 18 and PB 330 had attained tappability. Highest percentage of tappability for IRCA 130 and IRCA 230 has been reported from Central Kerala whereas it was poor in IRCA 18 (Reghu *et al.,* 2008). Only 54 per cent of trees in the check clone RRII 105 and 35 per cent of RRIM 703 attained tappable girth by the

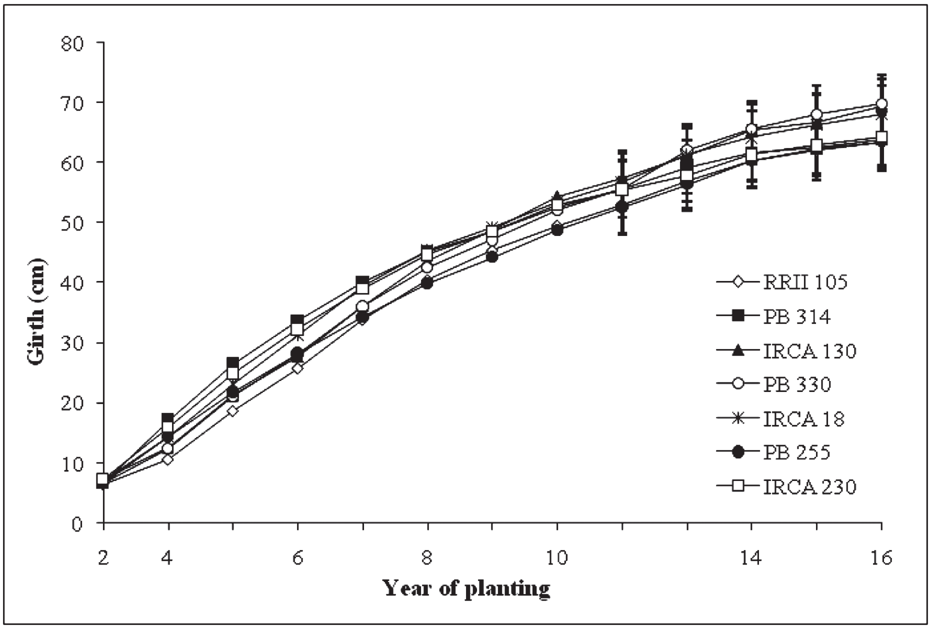

Fig. 1. Growth over 16 years of promising rubber clones

same period. A growth curve plotted for the entire study period showed that there was no significant difference in girth up to the ninth year after planting (Fig. 1) beyond which the clonal differences were prominent. Significant clonal variability for girth increment at maturity due to differential yield response of clones to tapping has been reported earlier (Mydin *et al.,* 2011).

Monthly yield pattern

The variation in mean monthly yield for the different clones is given in Figure 2. Clonal variations were prominent during the wet months than dry months. The yield of IRCA 130 was significantly higher than all other clones throughout the year, especially during the period December to April coinciding with leaf fall and

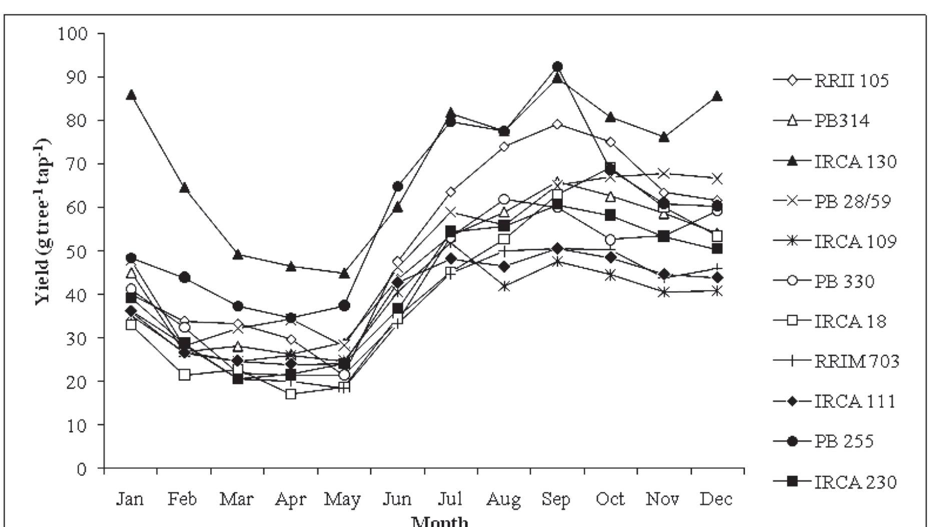

Fig. 2. Monthly variation in yield of rubber clones over four years of tapping

Table 3. Mean dry rubber yield over four years of tapping

Clones	Yield ($g\ t^{-1}t^{-1}$)				
	1st yr	2nd yr	3rd yr	4th yr	Pooled average
PB 255	47.0	51.9	72.5	63.5	58.7
PB 314	38.8	44.6	53.4	45.1	45.5
PB 330	17.7	41.3	52.9	49.7	40.4
PB 28/59	34.2	47.7	61.6	50.2	48.4
RRIM 703	23.8	37.8	42.4	37.7	35.4
IRCA 18	28.9	39.7	47.6	42.9	39.8
IRCA 109	34.1	32.8	41.4	36.4	36.2
IRCA 111	31.5	35.2	41.1	36.8	36.1
IRCA 130	49.1	65.6	81.8	74.3	67.7
IRCA 230	32.3	39.4	48.6	42.9	40.8
RRII 105	33.6	48.4	55.1	56.4	48.4
CD	13.4	14.7	14.7	12.3	12.4

refoliation. The yielding pattern of PB 255, the second best in terms of annual yield, was better than RRII 105, up to September and showed a marginal decline during October-December period. In general, the yield levels showed an increase from June in all clones with peak yield in September-October.

Annual, summer and peak yield

The average annual yield data (Table 3) for the first four years of tapping and summer yield (Table 4) for the period showed significant clonal differences. Among the 11 clones tested, annual dry rubber yield ranged from 67.7 $g\ t^{-1}t^{-1}$ (IRCA 130) to 35.4 $g\ t^{-1}t^{-1}$ (RRIM 703) over four years of tapping. IRCA 130 showed a rising yield trend, with consistent and superior yield to that of RRII 105 (40% increase), from the 1st year of tapping onwards. PB 255 also exhibited a rising trend in yield and performed better than RRII 105 with the second highest mean yield of 58.7 $g\ t^{-1}t^{-1}$ (22% increase). PB 314, PB 330, PB 28/59, IRCA 18 and IRCA 230 yielded on par with RRII 105. IRCA 130 and PB 255 have exhibited superior yield performance in large scale /block trials (Khoo *et al.,* 1991; John *et al.,* 2004; Reghu *et al.,* 2008; Soman *et al.,* 2010) elsewhere in Malaysia and India. The reported block yield of PB 255 from Malaysia is 2319 kg over 13 years of tapping (Saraswathyamma *et al.,* 2000) and 1878 kg over five years of tapping in India (Sankariammal *et al.,* 2008). IRCA 109, IRCA 111 and RRIM 703 were relatively low yielders in this region.

Summer months are lean in terms of crop production and yield decrease in plantations during or soon after wintering had been reported (Dijkman, 1951). Summer yield and summer yield depression in the present study showed a similar trend as that of annual yield. Summer yield (Table 4) was the highest for IRCA 130 followed by PB 255 during the study period. The pooled average summer yield of IRCA 130 (49.8 $g\ t^{-1}t^{-1}$) was significantly superior to that of RRII 105 (29.2 $g\ t^{-1}t^{-1}$). PB 255 also recorded very high summer yield (38.67 $g\ t^{-1}t^{-1}$). Stable and better summer yield and good summer girth increment for IRCA 130 was reported from Central Kerala also (Reghu *et al.,* 2008). The summer yield of all the other test clones was on par with the control. Concurrently, the mean summer yield reduction over that of the annual yield was the least in IRCA 130 followed by IRCA 109 and PB 255, which was significantly less as compared to that of the control. Ang and Shepherd (1979) had reported high annual yield and low summer yield depression for PB 255 from Malaysia. Summer drop in yield in *Hevea* is a complex phenomenon caused by soil moisture deficit and a synchrony of various other physiological complexities due to defoliation, refoliation, flowering (Chau, 1970) and the incidence of powdery mildew disease on the new flushes. A reduction in the initial rate of flow of

Table 4. Summer yield, summer yield depression and peak yield of rubber clones

Clones	Summer yield ($g\ t^{-1}t^{-1}$) (Feb-May)	Summer yield depression (%)	Peak yield ($g\ t^{-1}t^{-1}$) (Sept-Dec)
PB 255	38.67	40.4	69.3
PB 314	27.25	45.3	60.8
PB 330	22.66	48.3	57.1
PB 28/59	30.17	41.8	67.6
RRIM 703	20.25	45.5	48.7
IRCA 18	19.08	59.9	62.7
IRCA 109	24.85	37.4	43.8
IRCA 111	23.71	41.5	47.4
IRCA 130	49.80	31.9	83.2
IRCA 230	22.87	47.7	55.9
RRII 105	29.21	48.6	68.1
CD	10.17	6.7	15.3

Table 5. Branching height and bole volume of rubber clones

Clone	Branching height (m)	Bole volume (m^3)
PB 255	2.91	0.077
PB 314	2.91	0.077
PB 330	3.06	0.089
PB 28/59	2.53	0.064
RRIM 703	2.70	0.056
IRCA 18	3.34	0.095
IRCA 109	3.08	0.073
IRCA 111	2.91	0.071
IRCA 130	3.93	0.118
IRCA 230	3.37	0.084
RRII 105	2.74	0.069
CD	0.54	0.021

latex and a rise in the rate of latex vessel plugging during drought period are also reported to cause considerable drop in yield during summer months (Premakumari, 1992).

Peak yield was observed in the month of September irrespective of clones. The period from September to December was conducive for maintaining high yield levels as the period coincided with near optimum levels of soil moisture and favourable weather conditions. The mean yield of IRCA 130 over four years was the highest during this season at 83.2 g $t^{-1}t^{-1}$ followed by that of PB 255 (69.3 g $t^{-1}t^{-1}$) and was on par with RRII 105 (68.1 g $t^{-1}t^{-1}$).

Branching height and bole volume

Branching height is a determinant factor with respect to timber potential of a tree. A higher bole height is desirable as it directly increases the timber volume of a tree. Clonal differences in branching height and bole volume were evident as given in Table 5. Most of the test clones were high branching compared to RRII 105. IRCA 130 registered a significantly superior branching height of 3.93 m and a clear bole volume of 0.12 m^3 compared to RRII 105. IRCA 18 and PB 330 were the other clones with significantly superior bole volume than the control. RRII 105 had a bole volume of 0.069 m^3 while RRIM 703 recorded the lowest bole volume of 0.056 m^3. All the PB clones were also better than RRII 105 for these traits, except for PB 28/59. PB 255 was noted for combining high yield, girth and timber volume in an earlier study (John *et al.,* 2004). Among the ancillary products from rubber plantations rubber wood is the major by-product in enhancing the net farm income. (Viswanathan *et al.*, 2002). Estimation of timber volume of test clones evaluated for yield could identify potential latex timber (LT) clones. Vigorous and fast growth rate of trees leads to early tappability and also enhances the wood volume. It has been estimated that, in general, the timber yield from India is relatively lower as compared to Malaysia (Joseph and George, 1996; Arshad *et al.,* 1995).

A combined analysis of yield and clear bole volume of the clones gave early indications of selection of clones based on these two traits (Fig. 3). IRCA 130 and PB 255 were included in the high yielding quadrant for both latex yield and bole volume. PB 314 recorded above average yield and timber volume and the clones IRCA 230, PB 330

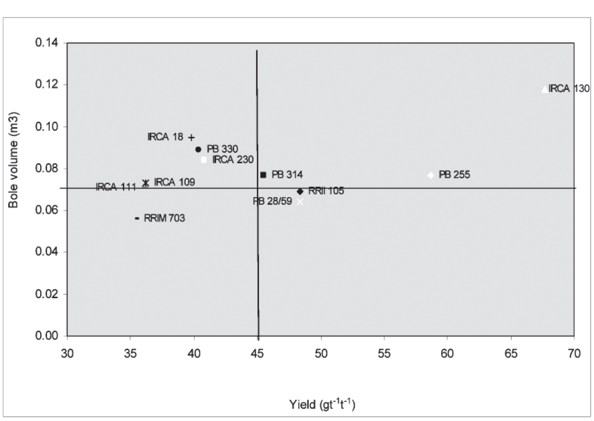

Fig. 3. Yield *vs.* clear bole volume of rubber clones

Table 6. Secondary characters of rubber clones

Clone	Percentage incidence	
	TPD	Pink disease
PB 255	8.33	30.40
PB 330	2.56	6.67
PB 314	7.14	40.80
PB 28/59	10.32	28.13
RRIM 703	4.44	53.77
IRCA 18	0	15.40
IRCA 109	8.84	49.57
IRCA 111	7.14	20.50
IRCA 130	8.93	27.50
IRCA 230	6.67	59.40
RRII 105	7.90	33.43

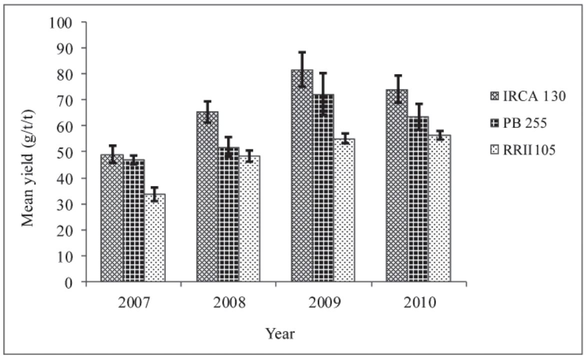

Fig. 4. Year wise yield of the top ranking rubber clones

and IRCA 18 produced high volume of timber, but were poor latex yielders. High bole volume recorded in PB 330 is in corroboration with earlier report of Mydin *et al.* (2011).

Secondary characters of clones

Taping panel dryness (TPD) and pink disease incidence

Clonal variability was observed in the percentage incidence of TPD and pink disease (Table 6). PB 28/59 recorded the highest TPD incidence of 10 per cent. No TPD incidence was observed in IRCA 18. Majority of clones including IRCA 130 and PB 255 showed 7-8 per cent TPD incidence. Only moderate levels of TPD for IRCA 130 have been reported from Ivory Coast also (Okama *et al.,* 2011). Pink disease incidence was the least observed in PB 330 (6.67%) and IRCA 18 (15%). However, more than 50 per cent incidence was observed in the clones RRIM 703 and IRCA 230. The high yielding clones IRCA 130 and PB 255 showed 27 and 30 per cent disease incidence respectively, which was similar to that of RRII 105 (33%).

According to Simmonds (1989) success in *Hevea* breeding depends on several factors, of which incorporation of more and more hybrid/ortet clones of diverse origin into the breeding pool assumes significance. Aziz (2002) emphasized that while yield of rubber is a major consideration of improved clones, characters such as girth and other desirable secondary attributes are equally important in ensuring stability of yield and thereby enhancing the value of the rubber tree. The results from the present study revealed high genetic variability in the population for all the traits examined in terms of yield, growth and secondary attributes, indicating scope for selection. A few high yielding and vigorous clones with desirable secondary traits suited for the local agro climatic conditions could be identified. The distinctly superior and sustainable yield of IRCA 130 (Fig. 4) and the promising performance of PB 255 across years and seasons are noteworthy. Further data on long term performance of these clones as well as their performance in on farm trials (OFTs) in diverse locations could confirm the present findings. PB 255 has already proven its merit in OFTs (Varghese *et al.,* 2009) and is currently included in the category II of the planting recommendations of Rubber Board for limited scale planting. On farm evaluation of IRCA clones are in progress in various locations. According to Priyadarsan *et al.* (2003) the clones evaluated in Ivory Coast are different from India and China since many of its new experimental areas experience moisture deficit in addition to severe wind. The high yield and growth of IRCA 130 coupled with low summer yield depression observed in the North Kerala region which experiences similar climatic constraints, except for strong wind, indicates the drought tolerance potential of this clone. Moreover, these exotic clones could be potential candidates for choice of parents in *Hevea* breeding programmes envisaged for this region.

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