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LONG-TERM YIELD AND GROWTH PERFORMANCE OF IRCA RUBBER CLONES IN INDIA

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India introduced five hybrid clones of *Hevea brasiliensis* in 1991 from the Institut de Recherches sur le Caoutchouc (IRCA), Cote d'Ivoire. A field evaluation trial comprising of these clones and a popular Indian clone, RRII 105 was laid out during 1992 in a randomized block design with five replications and a plot size of eight plants. The trial was opened for regular tapping at the age of nine years and the growth performance and monthly dry rubber yield trend were evaluated. Significant clonal differences were observed for all the characters studied. At the time of opening, IRCA 111 and IRCA 130 were superior to all other clones in terms of vigour, while RRII 105 had the least girth. The remaining three IRCA clones were on par with RRII 105. IRCA 111 and IRCA 130 maintained their superiority over the next 10 years of tapping too. In the 10th year of tapping, IRCA 111 and IRCA 130 continued to show the highest girth, followed by IRCA 18 and RRII 105.

Clonal differences for yield were highly significant every year. In the first year of tapping, IRCA 130 had the highest yield (52.0 g $t^{-1}t^{-1}$). IRCA 111 (47.2 g $t^{-1}t^{-1}$) was on par with it, followed by IRCA 18 (39.7 g $t^{-1}t^{-1}$), while the check clone RRII 105 recorded 36.2 g $t^{-1}t^{-1}$. Yield in the 10th year continued to be the highest in the clone IRCA 130 (93.0 g $t^{-1}t^{-1}$) followed by RRII 105 (72.1 g $t^{-1}t^{-1}$) and IRCA 111 (64.8 g $t^{-1}t^{-1}$). IRCA 130 had the highest mean yield over ten years of tapping (76.0 g $t^{-1}t^{-1}$), followed by RRII 105 (56.8 g $t^{-1}t^{-1}$) and IRCA 111 (55.9 g $t^{-1}t^{-1}$) which were on par.

Yield components such as plugging index (PI) and dry rubber content were recorded in the 19th year of growth. Lowest PI was recorded in the clones IRCA 130 and IRCA 111. The clone IRCA 109 had the highest dry rubber content, while RRII 105 and IRCA 230 were on par with IRCA 130. IRCA 111 had the lowest dry rubber content. IRCA 130 remained in the top for timber volume followed by IRCA 111, IRCA 109 and IRCA 18. These four clones had significantly higher bole volume than RRII 105. Two clones (IRCA 130 and IRCA 111) with good dry rubber yield and timber yield can be considered as potential latex- timber clones.

Keywords: Dry rubber yield, Girth, Plugging index, Timber yield

INTRODUCTION

Five promising IRCA clones were introduced into India during 1991 from Cote d'Ivoire as part of the bilateral clone exchange programme between Institut de Recherches sur le Caoutchouc (IRCA) and Rubber Research Institute of India. These elite clones were selected in the home

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country based on their growth and yield performance compared to the control clone GT1 from the preliminary proof trials (IRCA, 1990). The field performance of these five clones was evaluated in India for a period of 19 years, along with RRII 105 as control. A detailed analysis on the performance of these clones in the early growth phase for various characters has been published earlier (Reghu *et al.*, 2008). The present paper deals with a detailed analysis on the long term growth and yield performance of the IRCA clones in India.

MATERIALS AND METHODS

The study was conducted at the Central Experiment Station of Rubber Research Institute of India. The station is situated in the traditional rubber growing tract at 9 °N and 76 °E and at a height of 100 m MSL. The soil type is laterite and the annual rainfall ranges from 2000 mm to 4500 mm. Table 1 gives the list of clones under evaluation along with their respective parentage.

The trial was planted during 1992 in a randomized block design at 4.5 x 4.5 m spacing in five replications with a plot size of eight plants. The popular Indian clone RRII 105 was used as control. The trees were opened for regular tapping in 2001 at the age of 9 years. The tapping system followed was S/2 d3 and the mean dry rubber yield was recorded by cup coagulation method once a month from 2002 onwards.

The characters recorded were (i) girth (cm) of the trees, (ii) annual girth increment (cm), (iii) dry rubber yield (g $t^{-1}t^{-1}$) for a continuous period of 10 years, (iv) plugging index (PI), (v) dry rubber content (drc %), (vi) clear bole height (m), (vii) clear bole volume (m^3) and (viii) incidence of tapping panel dryness.

The girth of the trees was analysed for a continuous period of 16 years starting from the 4th year to 19th year after planting, and the girth increment over the previous year was calculated every year, before the commencement of tapping as well as during the tapping period. The annual yield per tree per tapping was computed from the monthly yield data. The clear bole volume was estimated from the girth and bole height adopting the quarter girth method (Chaturvedi and Khanna, 1982) as follows:

$$V = (G/4)^2 \times L$$

where , V= bole volume (m^3); G= girth (m) and L= bole height (m).

The data were subjected to analysis of variance as per Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Growth

Figure 1 depicts the growth trend of IRCA clones and the control clone RRII 105 over a period of 19 years. Significant clonal variation was observed in the girth pattern. In the 4th year after planting, clonal differences were significant (at $P<0.05$), with IRCA 111 recording the maximum girth (24.7 cm) followed closely by IRCA 130 (23.5 cm),

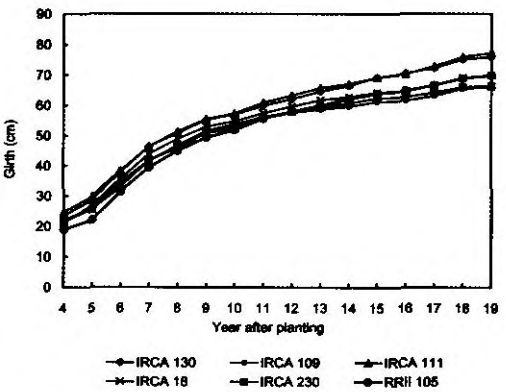

Fig. 1. Growth of IRCA clones over years

while RRII 105 recorded the least girth (18.9 cm). The same trend was maintained with minor variations up to the time of opening in the 9th year. IRCA 111 and IRCA 130 were superior to all clones in terms of vigour (55.5 and 55.3 cm respectively), while the remaining 3 clones were statistically on par with the least vigorous clone RRII 105 (49.3 cm), as reported earlier (Reghu *et al.*, 2008). Soman *et al.* (2012) also observed that IRCA 111 had the highest girth at opening, and RRII 105 the least among the IRCA clones being tested at Kanyakumari. Over the next 10 years of tapping too, IRCA 111 and IRCA 130 maintained their superiority, while RRII 105 showed an increased rate of growth compared to the remaining three clones. From the 4th year onwards, in general, all the clones evaluated showed a sharp increase in their girthing pattern till the commencement of tapping (9th year). This was followed by a gradual slowing down of the growth during the subsequent years under tapping in all clones except IRCA 111 and IRCA 130 which continued the same rate of growth. RRII 105 however, showed a relatively higher girthing rate after tapping, causing it to overtake the remaining three IRCA clones by the 7th year of tapping. In the 19th year after planting (10th year of tapping), clonal differences for girth became highly significant ($P<0.01$); IRCA 111 (77.3 cm) continued to show the highest girth, followed closely by IRCA 130 (75.9 cm). IRCA 18 (69.9 cm) was on par with RRII 105 (69.8 cm). Among the other clones IRCA 230 (66.4 cm) ranked 5th and IRCA 109 (65.8 cm) had the least girth (Table 2). Growth of IRCA 111 has been reported to be extremely high in other parts of India too (Soman *et al.*, 2012; Bal Krishan, 2013; Lakshmanan *et al.*, 2013).

The results indicated the better growth performance of IRCA 111 and IRCA 130 under Indian conditions, similar to that in Cote de' Ivoire (Obouayeba *et al* ., 2009).

Table 1. **Parentage of clones**

Sl. No.	Clone	Parentage
1	IRCA 18	PB 5/51 x RRIM 605
2	IRCA 109	PB 5/51 x RRIM 600
3	IRCA 111	PB 5/51 x RRIM 605
4	IRCA 130	PB 5/51 x IR 22
5	IRCA 230	GT1 x PB 5/51
6	RRII 105	Tjir 1 x Gl 1

Table 2. **Girth, yield and bole volume of IRCA clones in the 19th year of planting**

Clone	Girth** (cm)	Present tappable stand per plot** (G>50 cm)	Yield** (10th year of tapping) (g $t^{-1}t^{-1}$)	Mean yield over 10 years** (g $t^{-1}t^{-1}$)	PI**	DRC * (%)	Bole height* (m)	Bole volume** (m^3)
IRCA 130	75.9	7.2 (36)	93.0	76.0	1.59	33.62	6.88	0.24
IRCA 109	65.8	7.0 (35)	52.5	38.8	3.56	38.25	5.97	0.16
IRCA 111	77.3	7.8 (39)	64.8	55.9	2.05	33.85	5.93	0.20
IRCA 18	69.9	5.2 (26)	39.6	40.1	4.93	34.93	5.13	0.16
IRCA 230	66.4	7.0 (35)	54.5	40.9	3.86	35.59	4.69	0.13
RRII 105	69.8	6.0 (30)	72.1	56.8	3.36	36.66	3.80	0.11
CD (P= 0.05)	6.68	1.23	16.15	12.92	0.90	2.80	1.60	0.04

(Figures in parenthesis indicate total number of trees over all replications in each clone in the trial)

* and **: Clonal differences significant at $P<0.05$ and 0.01, respectively.

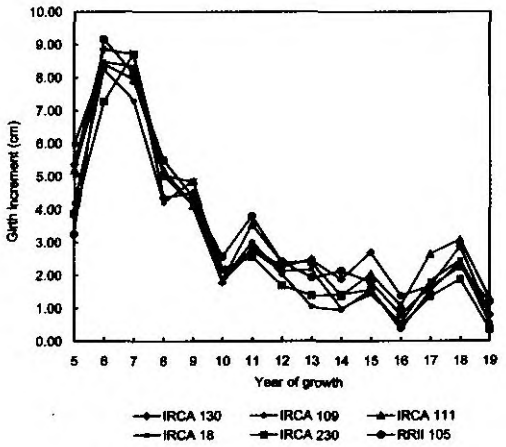

Fig. 2. Annual girth increment

Girth increment

The mean girth increment per year for the six clones before tapping, was much higher (6.13 cm per year, over a period of five years) than that after commencement of tapping (2.12 cm per year in the five years after commencement of tapping, and 1.48 cm per year over ten years of tapping) (Table 3). Clonal differences for average girth increment every year were not statistically significant over the five year period prior to commencement of tapping, as well as over the first five years of tapping. However differences between clones for girth increment increased and became significantly different (P< 5%) in the next five tapping years, with highly significant differences (P<1%) between clones being recorded in individual years. Over 10 years of tapping, IRCA 111 and IRCA 130 showed an average growth of 2.17 and 2.07 cm per year respectively followed by RRII 105 with 1.88 cm per year. Figure 2 shows that the girth increment was highest during the 6th year of growth (5th year after planting) for all clones except IRCA 230 (which peaked the next year), after which the increment continued, but at a rapidly decreasing rate. After the 10th year, girth increment every year was only nominal. These two stages probably coincided with canopy closure and commencement of tapping, respectively. Soman *et al.* (2000) also found that girth increment percentage declined sharply after the 9th year.

Table 3. **Average girth increment before and after tapping (cm/year)**

Clone	Average GI over 5 years before tapping	Average GI over first 5 years after tapping	Average GI over next 5 years after tapping*	Average GI over 10 years tapping
IRCA 130	6.35	2.25	1.88	2.07
IRCA 109	5.80	1.79	1.23	1.51
IRCA 111	6.17	2.32	2.03	2.17
IRCA 18	6.39	1.97	1.41	1.69
IRCA 230	5.97	1.85	1.12	1.48
RRII 105	6.07	2.55	1.21	1.88
CD (5%)	ns	ns	0.64	ns
Average of all clones	6.13	2.12	1.48	1.80
CV (%)	8.88	21.85	3.15	24.37

* Clonal differences significant at P<0.05

Dry rubber yield

Clonal differences for yield were highly significant every year (Fig. 3). In the first year after opening the trees for tapping, clone IRCA 130 had the highest yield (52.0 g $t^{-1}t^{-1}$) followed by IRCA 111 and IRCA 18 (47.2 and 39.7 g $t^{-1}t^{-1}$), while the check clone RRII 105 recorded 36.2 g $t^{-1}t^{-1}$. Mean yield in the 10th year after opening was the highest in the clone IRCA 130 (93.0 g $t^{-1}t^{-1}$) followed by RRII 105 (72.12 g $t^{-1}t^{-1}$) and IRCA 111 (64.80 g $t^{-1}t^{-1}$) which were on par. The mean dry rubber yield of IRCA 109 (52.47 g $t^{-1}t^{-1}$), IRCA 230 (54.45 g $t^{-1}t^{-1}$) and IRCA 18 (39.61 g $t^{-1}t^{-1}$) were significantly lower than that of the control clone RRII 105. The mean yield over ten years of tapping was highest in IRCA 130 (76.0 g $t^{-1}t^{-1}$), followed by RRII 105 (56.8 g $t^{-1}t^{-1}$) and IRCA 111 (55.9 g $t^{-1}t^{-1}$). The superior performance of IRCA 130 for yield corroborates the findings of Lakshmanan *et al.* (2013).

Figure 3 depicts the mean dry rubber yield trend over 10 years of tapping. Among the IRCA clones, IRCA 130 was consistently superior to all other clones throughout the tapping period, followed by IRCA 111. These results are in conformity with the earlier report that IRCA 130 and IRCA 111 gave better yield increase during the mature period of exploitation (Clement-Demange, 1988).

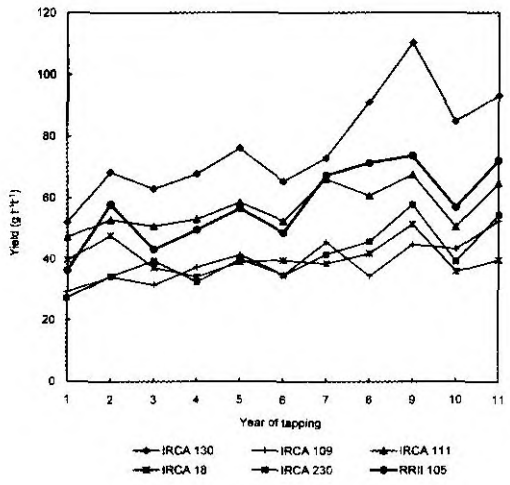

Fig. 3. Yield of IRCA clones

Tappable stand

The number of trees under tapping at any given time plays a significant role in the overall per hectare yield of a clone. The effect of high yield per individual tree in a clone will be offset if the stand per hectare is low. Clonal differences were significant (P<5%) for the number of trees under tapping (tappable stand) at the end of the 19th year of growth, with IRCA 111 and IRCA 130 having the highest stand (39 and 36 respectively, out of the 40 originally planted). IRCA 18 had the lowest number (26) of tappable trees.

Yield components

Yield components such as plugging index (PI) and dry rubber content (DRC %) were recorded in the 19th year of growth. Plugging index is the measure of the extent of latex vessel plugging during tapping (Pakianathan *et al.*, 1973). It is indicative of the duration of flow, though it has to be seen in the context of the initial volume in the first five minutes of flow, i.e. for the same initial volume, a lower PI will indicate a longer duration of flow. Highly significant clonal differences were recorded for PI. The lowest PI was recorded in the highest yielding clone IRCA 130 (1.53) followed by IRCA 111 (2.05) and the highest in IRCA 18 (4.93), which had the lowest yield. The PI of RRII 105 was 3.86. Sethuraj *et al.* (1992) have

also reported a negative correlation between yield and PI.

Clonal differences for drc percentage were statistically significant (P<5%). The maximum value was observed in IRCA 109 (38.25 %) followed by RRII 105 (36.66%), while the least was in IRCA 130 and IRCA 111 (33.62 and 33.85, respectively). (Table 2). Clones with high PI and drc are likely to respond more to yield stimulants like ethephon.

Bole height and bole volume

Significant clonal variation was observed in the bole height and clear bole volume (Table 2). The bole height was the highest in IRCA 130 (6.88 m) followed by IRCA 109 (5.97 m) , IRCA 111 (5.93 m) and these clones were statistically superior to RRII 105 (3.80 m). With regard to bole volume, IRCA 130 (0.24 m^3) remained in the top followed by IRCA 111 (0.20 m^3), IRCA 109 (0.16 m^3) and IRCA 18 (0.16 m^3). Two clones *viz.* IRCA 130 and IRCA 111 had significantly higher bole volume than that of RRII 105. Obouayeba *et al.* (2009) also reported the higher yield and faster growth rate in the clone IRCA 111 with active metabolism compared to the control clone PB 235 in South-West Cote d' Ivoire.

Tapping panel dryness

The trial was also screened for the susceptibility to tapping panel dryness (TPD). The TPD ranged from 5 to 11 per cent in the case of IRCA clones. The maximum TPD percentage was noticed in the high yielding clone IRCA 130 (11%) followed by IRCA 18 (8%) , IRCA 230 (8%), RRII 105 (8%), IRCA 109 (6%) and the least incidence for IRCA 111 (5%). High susceptibility to TPD in IRCA 130 has already been reported recently in Cote d' Ivoire (Elabo *et al.*, 2012). At another location too, IRCA 130 had the highest TPD (39.3%) among the IRCA clones (Soman *et al.*, 2012), while it ranged from 7-20 per cent among the remaining clones.

In general, of the five IRCA clones evaluated, two clones *viz.* IRCA 130 and IRCA 111 were found to be very vigorous, with better performance for girth, dry rubber yield and timber, indicating the potential of these clones as latex-timber clones.

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