Research Article

Journal of Plantation Crops, 2008, 36 (3): 175-179

Clones of rubber (*Hevea brasiliensis*) introduced from Cote d'Ivoire: Growth and yield performance in India

C.P. Reghu[1], Jayashree Madhavan, G.P. Rao, Saji T. Abraham and Y. Annamma Varghese

Rubber Research Institute of India, Kottayam - 686009, Kerala, India

Abstract

Five elite clones of *Hevea brasiliensis* introduced in 1991 from the Institut de Recherches sur le Caoutchouc (IRCA), Cote d'Ivoire, were evaluated in India for their early mature performance. A field trial was laid out in a randomized block design with five replications, using the most popular Indian clone RRII 105 as control. IRCA 130 had the highest yield over five years of tapping (65 g/t/t), followed by IRCA 111 (52 g/t/t), which was on par with RRII 105 (48.7 g/t/t). Average summer depression in yield over 5 years was maximum in IRCA 18 and IRCA 111 and least in IRCA 130. IRCA 111, followed by IRCA 130, had the highest girth, total stand and highest percentage of tappable trees at the time of opening the trees for tapping. Growth in summer was maximum in IRCA 130 and RRII 105, and minimum in IRCA 18 and IRCA 111. IRCA 230 and IRCA 130 had the maximum bark thickness (6.73 and 6.42 mm respectively). Clear bole volume at the age of 14 years was the highest in IRCA 130 (0.15 m^3), followed by IRCA 111 (0.12 m^3). In general, of the five IRCA clones evaluated, two clones IRCA 130 and IRCA 111 were found to be better than RRII 105, the currently popular clone, for dry rubber yield and timber quantity.

Keywords: bark anatomy, *Hevea brasiliensis*, IRCA clones, rubber yield, timber yield

Introduction

Introduction of high yielding clones developed in other countries and their evaluation under Indian conditions has been one of the methods of crop improvement adopted to increase productivity in rubber (Varghese and Mydin, 2000). Five promising clones were introduced into India during 1991 as part of the bilateral clone exchange programme between the Rubber Research Institute of India (RRII) and the Institute Researches sur le Caoutchouc (IRCA), Cote d'Ivoire. These elite clones were selected in the home country based on their performance in terms of yield over the control clone GT1 from the small scale/preliminary proof trials (IRCA, 1990). All the five clones are being evaluated in India with the objective of assessing their performance under Indian field conditions, along with RRII 105 as control.

Dry rubber yield is the most important parameter deciding the worth of a clone. In view of the increasing demand for rubber wood, the timber potential of a clone also has to be assessed (George and Joseph 2002). Girth and number of latex vessel rows are important structural components contributing to yield. In addition, high growth rate and low summer yield depression are desirable attributes in a clone. Reports on the performance of these clones even in Cote d'Ivoire are extremely scanty. The present paper is the first report on their performance in India and hence a detailed analysis of the early mature performance of the IRCA clones for various characters including yield has been presented.

Materials and methods

The field study was conducted at Central Experiment Station of Rubber Research Institute of India, Chethackal, Ranni, Kerala, India. The station is situated at 100 MSL with 9° 22' N and 76° 50' E in the typical traditional rubber growing tract. The soil type is laterite and the annual rainfall ranges from 2000 mm to 4500 mm. The following clones were used in this study.

Clone	Parentage
IRCA 18	PB 5/51 x RRIM 605
IRCA 109	PB 5/51 x RRIM 600
IRCA 111	PB 5/51 x RRIM 605
IRCA 130	PB 5/51 x IR 22
IRCA 230	GT 1 x PB 5/51
RRII 105	Tjir 1 x Gl 1

[1] Corresponding author Email: cpreghu@gmail.com

The clones were planted in a randomized block design at a spacing of 4.5 x 4.5 m in five replications and a plot size of eight, during 1992. RRII 105 was used as the control. Trees were opened for regular tapping in 2001 at the age of 9 years under half spiral, once in three days (½ S d/3) system and average dry rubber yield was recorded once a month by cup coagulation from January 2002 onwards. Yield for the month of January 2003 could not be collected. The following characters were recorded:

1. Annual girth (cm) at 150 cm from bud union from fourth year (1996) onwards
2. Girth in February and May 2001 (ninth year)
3. Mean dry rubber yield (g/t/t) once a month for five years, from 2002 onwards.
4. Bark thickness (mm)
5. Total number of laticifer rows (TLVR):
6. Density of laticifers (DLV) per row per mm distance
7. Branching (bole) height in 2006 (m)

The anatomical traits were recorded in the year of opening (2001). Bark samples were collected at a height of 150 cm height and bark thickness was recorded. Radial longitudinal (RLS) and tangential longitudinal (TLS) sections of the bark were taken at 40 – 80 µm thickness with Reichert Jung sledge microtome and stained with Oil red 'O' (Ommen and Reghu, 2003) for microscopy, to record the number of rows and density of laticifers respectively.

The following parameters were calculated from the data collected:

1. Mean annual yield per tree per tapping (g/t/t), computed from the monthly yield data.
2. Mean summer yield depression (SYD), calculated each year as the drop in the average monthly yield during the summer months when compared to the mean monthly yield for the remaining months in a given year and expressed as percentage.
3. Summer girth increment (SGI) in the ninth year (2001) was computed, expressed as a percentage of the total girth increment in 2001-2002.
4. Girth increment (GI) was calculated every year using the data on annual girth, and the trend before and after commencement of tapping.
5. The percentage of trees that attained tappability (50 cm girth at 125 cm height from the bud union) in each clone was determined from the 7^{th} year onwards.
6. Clear bole volume (m^3) in 2006, estimated from the data on bole height and girth using the quarter girth method (Chaturvedi and Khanna, 1982):

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

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

The data were subjected to analysis of variance.

Results and discussion

Tree girth is an indicator of vigour that contributes to both yield and bole volume. Girth has been identified as one of the most important traits contributing to latex yield in *Hevea* (Ho *et al.*, 1973; Premakumari *et al.*, 1997). Faster growing clones also have shorter immaturity periods. Analysis of girth in the 4^{th} year, 9^{th} year (year of opening) and 16^{th} year after planting revealed significant differences between the clones ($P<0.05$) (Table 1). IRCA 111 and IRCA 130 had the highest girth values every year. RRII 105 was initially significantly inferior to these clones, but due to a relatively higher growth rate, it was on par with IRCA 111 by the 16^{th} year. IRCA 111 followed by IRCA 130 was consistently superior to all other clones every year, while the ranking of the remaining clones varied. RRII 105 showed a relatively higher rate of growth once tapping commenced.

Table 1. Growth of clones over years

Clone	4^{th} year	9^{th} year	16^{th} year	SGI% (2002-01)	GI (cm/year) for 5 years Before opening	After opening
IRCA 130	23.5	55.3	70.6	29.3	6.4	2.3
IRCA 109	22.0	50.8	61.6	26.0	5.8	1.8
IRCA 111	24.7	55.5	70.3	12.0	6.2	2.3
IRCA 18	21.0	53.0	64.8	11.4	6.4	2.0
IRCA 230	21.7	51.5	62.8	22.3	6.0	1.9
RRII 105	18.9	49.3	64.7	28.4	6.1	2.6
SE	1.62	1.98	2.73	4.01	0.35	0.3
CD(P=0.05)	3.38	4.13	5.69	8.36	NS	NS

The mean GI over a period of five years just before and after opening the plants for tapping was 6.1 cm/year and 2.1 cm/year respectively (Table 1). Clonal differences were not significant.

Clonal differences were significant for growth during summer ($P<0.01$) (Table 1). IRCA 130 ha[illegible] highest summer growth rate (29.3%). RRII 105 wa[illegible] on par with IRCA 130, though the girth *per se* of RRII 105 was the lowest in that year. IRCA 109 and IRCA 230 were also on par with IRCA 130. IRCA 111, the most vigourous clone, showed the least growth during summer (12%) along with IRCA 18 (11.4%). Growth in summer is indicative of a clone's ability to continue its metabolic functions under stress. Hence, the extent of depression in growth and yield of a clone in summer could be an indication of its adaptability to drought stress.

A plantation is usually opened for regular tapping when 70 per cent of the trees attain a girth of 50 cm, at a height of 125 cm (Vijaykumar *et al.*, 2000). However, in some estates, the girth criterion is lowered to 45 cm

(IRRDB, 1984). All trees with girth more than 50 cm were opened for tapping in the ninth year of growth, irrespective of clone. However, there were clonal differences for vigour, due to which some of the clones had attained tappability earlier than others. The percentage of trees in each clone that had attained girth of 45 and 50 cm respectively from the 4[th] year onwards, along with the total stand is shown in Table 2. IRCA 111, IRCA 130 and IRCA 230 had the highest percentage tappable trees. When the girth criterion of 50 cm was applied, only IRCA 111 and IRCA 130 attained tappability in the ninth year, while only 44 – 64 % of the trees in the remaining clones had attained tappable girth. IRCA 18 had the least number of tappable trees. However, if 45 cm was taken as the criterion for opening for tapping, clones IRCA 111 and IRCA 130 were the first to attain tappable girth in the eight year of growth, while the remaining IRCA clones attained tappability in the ninth year and RRII 105 only in the 10[th] year.

Table 2. Year wise percentage of trees that attained tappability

Clone	Tree Stand (16[th] yr)	7th year 45cm	7th year 50cm	8th year 45cm	8th year 50cm	9th year 45cm	9th year 50cm	10th year 45cm	10th year 50cm
IRCA 130	38	64.1	41.0	78.9	63.2	84.2	76.3	89.5	81.6
IRCA 109	38	39.5	5.3	52.6	28.9	84.2	52.6	92.1	60.5
IRCA 111	39	67.5	42.5	80.0	65.0	87.5	77.5	87.2	82.1
IRCA 18	33	39.4	15.2	60.6	42.4	71.0	61.3	69.7	60.6
IRCA 230	39	20.5	10.3	61.5	20.5	74.4	64.1	84.6	64.1
RRII 105	37	10.5	5.3	50.0	13.2	68.4	44.7	81.1	54.1

Mean yield (g/t/t) in the first five years of tapping is presented in Table 3. Highly significant clonal differences were observed for yield in the fifth year of tapping, mean yield over all the tapping years and extent of summer yield depression. In the fifth year of tapping, IRCA 130 had the highest yield (76.0 g/t/t), followed by IRCA 111 and RRII 105, which were on par (58.5 and 56.5 g/t/t respectively). The remaining clones had yield levels between 38.9 and 41.3 g/t/t. The mean yield per tree per tapping over the first five years also followed a similar pattern for the six clones. IRCA 130 was superior to all the others with an average yield of 65 g/t/t over five years, followed by IRCA 111 (52 g/t/t), which was on par with RRII 105 (48.7 g/t/t).

The monthly yielding behaviour of the clones, analysed separately for each year, are shown in Figs. 1a-e. In general, clones tended to follow the same pattern in

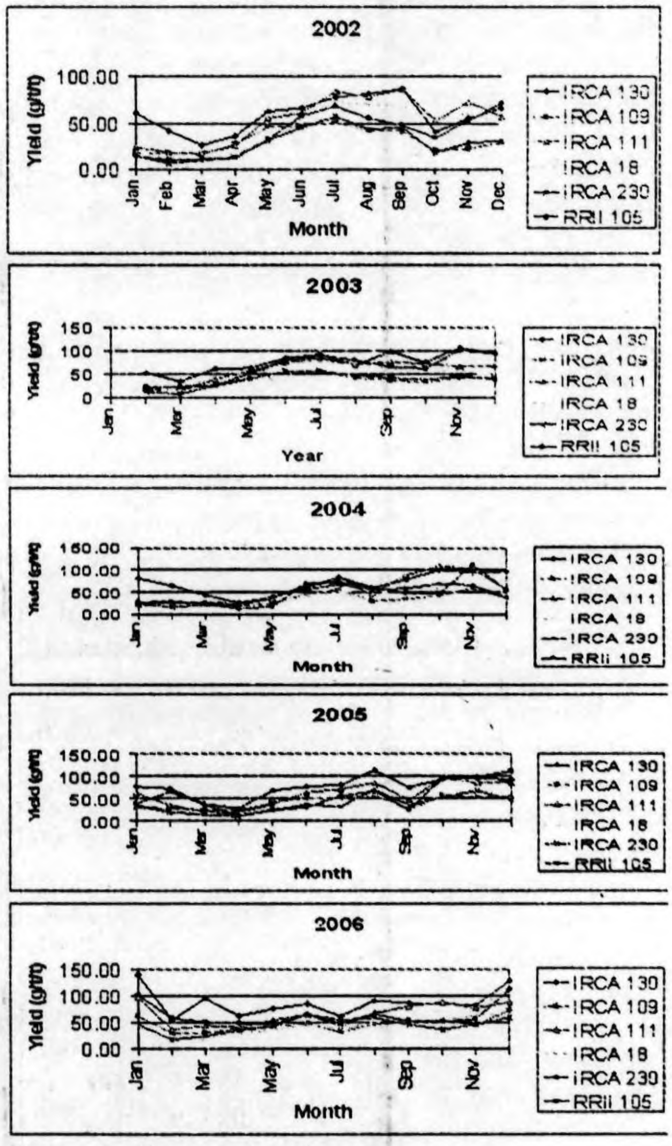

Fig. 1a-e. Monthly variation in yield for different years

Table 3. Performance of IRCA clones for yield over five years

Clone	Mean yield (g/t/t) 1st year	2nd year	3rd year	4th year	5th year	Over 5 years	Mean SYD% over 5 years
IRCA 130	52.0	68.3	62.9	67.8	76.0	65.0	41.3
IRCA 109	29.2	34.1	31.4	37.3	41.3	34.6	45.6
IRCA 111	47.2	52.8	50.8	53.0	58.5	52.0	61.0
IRCA 18	39.7	47.8	37.1	34.1	38.9	38.8	61.8
IRCA 230	27.2	34.3	39.4	32.4	39.9	34.5	61.2
RRII 105	36.2	57.9	43.2	49.6	56.5	48.7	53.3
SE	4.21	6.44	6.25	5.94	7.94	5.53	2.9
CD(P=0.05)	8.78	13.44	13.05	12.39	16.56	11.53	6.17

a given year, though the patterns varied slightly from year to year. However, the performance of IRCA 130, especially in summer, was remarkably different and consistently superior to the remaining clones every year. A significant depression in yield was observed in all the clones in October 2002, September 2005 and July 2006. Yield peaked in most cases in July-September in 2002 and in August 2005, while two peaks were observed in 2005 in July and November. In 2006, yield showed less variation throughout the year, with all clones showing the highest yield in January and December. The minimum yielding period, which coincides with refoliation and summer, in general extended from January to April in 2002, February to March in 2003, January to May in 2004, February to April in 2005, and February to May in 2006. The extent of fall in yield during this period, relative to the yield in the rest of the year (summer yield depression), is known to differ between clones (Mydin *et al.*, 2005). Clonal differences were highly significant every year ($P<0.01$), with IRCA 130 being significantly superior to the remaining clones most of the years. The mean SYD% over five years is given in Table 3. IRCA 130 and IRCA 109 had the least depression in yield, followed by RRII 105. With the exception of RRII 105, all the clones showed a more or less constant trend for SYD% over the years. These clones also exhibited high summer girth increment indicating its stress tolerance.

The laticiferous system in the bark is both the storage region from which latex is released on tapping and the site of the final stages in rubber synthesis in *Hevea brasiliensis* (Gomez, 1966). Variability for its structural components viz., girth, number of latex vessel rows, density and diameter of latex vessels will be reflected in the quantum of laticiferous tissue and hence productivity. Clonal differences have been reported earlier for these traits (Markose, 1984; Licy and Premakumari, 1988; Premkumari, 1992). Bark thickness has also been reported to influence yield (Rao and Reghu, 2000; Licy *et al*, 2003; Rao *et al.*, 2006), probably through its correlation with latex vessel rows (Gomez *et al*, 1972; Narayanan *et al*, 1973, 1974) and girth (Narayanan *et al*, 1974; Hamazah and Gomez, 1982). Clonal differences were significant ($P<0.05$) for bark thickness in this study too (Table 4). However, clonal differences for total number of laticifer rows and density of laticifers were not statistically significant, and hence are not likely to be the cause of the large differences observed for yield in this group of clones.

Branching height is to some extent a managed trait in rubber, as all branches below a height of 2 m are removed. However, many clones are found to branch at higher levels, this being a clonal characteristic (MRB, 2003). This is borne out by the highly significant clonal differences ($P<0.01$) observed for branching height (clear bole height) at the age of 14 years in this set of clones, ranging from 3.2 m in RRII 105, to 5.5 m in IRCA 130 (Table 5). This trait contributes to clear bole volume. Highly significant clonal differences were noted for this trait too. IRCA 130 was significantly superior to all other clones for bole volume ($0.15 m^3$), followed by IRCA 111 ; IRCA 230. RRII 105 had the least bole volume (0.08 m^3). RRII 105 is known to have low vigour, in spite of its high yield.

Table 4. Bark structural characteristics

Clone	Bark thickness	TLVR	DLV
IRCA 130	6.42	14.80	30.70
IRCA 109	6.10	16.80	29.80
IRCA 111	5.31	13.50	32.05
IRCA 18	5.61	15.70	32.55
IRCA 230	6.73	14.00	31.80
RRII 105	6.11	15.80	32.15
SE	0.385	1.142	1.253
CD (P=0.05)	0.803	NS	NS

Table 5. Branching height and timber (bole) yield

Clone	14th year	
	Branching height (m)	Bolevol (m^3)
IRCA 130	5.49	0.154
IRCA 109	4.35	0.098
IRCA 111	4.19	0.117
IRCA 18	3.84	0.096
IRCA 230	4.34	0.100
RRII 105	3.23	0.078
SE	0.397	0.011
CD (P=0.05)	0.828	0.0232

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, rubber yield and timber, indicating the potential of these clones as latex-timber clones. IRCA 130 also had the maximum summer growth and least summer yield depression, and is therefore likely to perform well in drought areas also.

Acknowledgements

The authors are grateful to Dr. N.M. Mathew, former Director, Rubber Research Institute of India for providing necessary facilities and encouragement during the course of this work. Thanks are also due to Mr. Sabu P. Idicula, Deputy Director, Central Experiment Station, Chethackal, Ranny, for providing facilities for the maintenance of the trial.

References

Chaturvedi, A.N. and Khanna, L.S. 1982. *Forest Mensuration*, Interntional Book Distrubutors, Dehradun, pp. 310.

George, K.T. and Joseph, T. 2002. Rubber wood production and utilization in India. pp. 1-9. In: *Rubber wood processing and utilization in India* (Eds.) R. Gnanaharan, K. Tharian George, K. Damodaran), Ganesh Publications Pvt. Ltd., Bangalore, India.

Gomez, J.B. 1966. Electron Microscopic Studies on the Development of Latex Vesels in *Hevea brasiliensis* Muell. Arg. *Ph.D. Thesis*, University of Leeds.

Gomez, J.B., Narayanan, R. and Chen K.T. 1972. Some structural factors affecting the productivity of *Hevea brasiliensis*. I. Quantitative determination of the laticiferous tissues. *Journal of the Rubber Research Institute of Malaya* **23**:193.

Hamzah, S.B. and Gomez, J.B. 1982. Some structural factors affecting productivity of *Hevea brasiliensis*. III. Correlation studies between structural factors and plugging. *Journal of the Rubber Research Institute of Malaysia* **30**: 148-160.

Ho, C.Y., Narayanan, R. and Chen, K.T. 1973. Clonal nursery studies in *Hevea*. I. Nursery yields and associated structural characters and their variation. *Journal of the Rubber Research Institute of Malaysia* 23: 305-316

IRCA, 1990: Annual report, 1989-90. p. 75-76.

IRRDB, 1984. Standards for recording observations in multilocational clone exchange trial. Dated 17th Jan 1984, pp. 18.

Licy J., and Premakumari, D. 1988. Association of characters in hand pollinated progenies of *Hevea brasiliensis* (Willd. ex. Adr. de Juss.) Muell.Arg. *Indian Journal of Natural Rubber Research* **1**(1): 18-21.

Licy, J., Saraswathyamma, C.K., Premakumari, D., Meenakumari, T., Meenattor, J.R. and Nazeer, M.A. 2003. Genetic parameters and heterosis in Rubber (*Hevea brasiliensis*) Muell. Arg.: V. Hybrid vigor for yield and yield components among the RRII 400 series clones in small-scale evaluations. *Indian Journal of Natural Rubber Research* **16**(1&2): 75-80.

rkose, V.C. 1984. Biometric Analysis Of Yield And Certain Yield Attributes In The Para Rubber Tree, *Hevea brasiliensis* Muell.Arg. *Ph.D. Thesis*, Kerala Agricultural University.

MRB, 2003. LGM Planting Recommendations 2003, *Malaysian Rubber Board Monograph* No.7. 24p.

Mydin, K.K., Mercykutty, V.C. and Saraswathyamma, C.K. 2005. Clonal selection for high yield and precocity in rubber (*Hevea brasiliensis*)- Early results of large scale evaluation of the RRII 400 series. pp. 27-36. In: International Natural Rubber Conference India, 6-8 November 2005, Preprints of papers. Rubber Research Institute of India.

Narayanan, R., Gomez, J.B. and Chen K.T. 1973. Some structural factors affecting productivity of *Hevea brasiliensis*. II. Correlation studies between structural factors and yield. *Journal of the Rubber Research Institute of Malaya* **23**(4): 285.

Narayanan, R., Ho, C.Y. and Chen K.T. 1974. Clonal nursery studies in *Hevea*. III. Correlations between yield, structural characters, latex constituents and plugging index. *Journal of the Rubber Research Institute of Malaya* **24**(1): 1-14

Omman, P. and Reghu, C.P. 2003. Staining procedure for laticiferous system of *Hevea brasiliensis* using Oil Red O. *Indian J. Natural Rubber Research* **16**(1&2): 41-44.

Premakumari, D. 1992. Variability, Correlations and Path Coefficient Analysis for Yield in Relation to Anatomical Characters in *Hevea brasiliensis*. *Ph. D Thesis*, University of Kerala, 260p.

Premakumari, D., Sasikumar, B., Panikker, A.O.N. and Marattukalam, J.G. 1987. Variability and association of certain bark anatomical traits in *Hevea brasiliensis* Muell.Arg. pp. 49-54. In: *Proceedings of the Sixth Symposium on Plantation Crops*, Kottayam.

Rao, G.P. and Reghu, C.P. 2000. Variability and character association in wild *Hevea* germplasm. pp. 10-11. In: *Proceedings of International Conference on Managing Natural Resources for Sustainable Agricultural Production in the 21st Century*, 14-18 Feb. 1999, New Delhi, India.

Rao, G.P., Balakrishan, Nazeer, M.A. and Annamma, Y.A. 2006. Early growth and yield performance of *Hevea* germplasm in the drought prone region of central-eastern India. *J. Plantn. Crops*. **34** (3) : 192-197.

Varghese, Y.A. and Mydin, K.K. 2000. Genetic improvement: pp. 36-46. In: *Natural Rubber- Agromanagement and crop processing*. (Eds.) P.J. George and C. Kurvilla Jacob), Rubber Research Institute of India, Kottayam, India.

Vijaykumar, K.R., Thomas, K.U. and Rajagopal, R. 2000. Tapping. pp. 215-238. In: *Natural Rubber: Agro management and Crop Processing* (Eds.) P.J. George and C.K. Jacob. Rubber Research Institute of India, Kottayam, India.