Natural Rubber Research, **22** (1&2): 17-26, 2009

PERFORMANCE OF CERTAIN HYBRID CLONES OF *HEVEA BRASILIENSIS* UNDER SMALL-SCALE EVALUATION

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Sankariammal, L., Varghese, Y.A., Thomas, V. and Mydin, K.K. (2009). Performance of hybrid clones of *Hevea brasiliensis* under small-scale evaluation. *Natural Rubber Research*, **22**(1 & 2):17-26.

The performance of 34 hybrid clones of rubber, *Hevea brasiliensis* (Willd. ex A. Juss.) Muell. Arg., evolved from the 1989 hand pollination programme, was evaluated in a small-scale trial over a period of 12 years (seven years before tapping and five years under tapping). Yield over a period of five years, summer yield depression, girth increment before tapping and on tapping, mean girth at opening and in the fifth year of tapping, bark thickness and number of latex vessel rows at the time of opening the trees for tapping, incidence of major diseases, wind damage and tapping panel dryness were recorded. Five clones recorded significantly higher yield than the control RRII 105 in the first five years of tapping. The mean yield ranged from 10.22 to 62.00 g/t/t. The hybrid clone 89/95 recorded the highest yield (62.00 g/t/t) followed by the clone 89/7 (60.89 g/t/t). Girth at opening ranged from 37.25 cm (89/287) to 62.83 cm (89/27). Girth increment before opening was high in 89/27 and in the mature phase it was high in clone 89/88. Bark thickness was high in 89/27 and the number of latex vessel rows was high in 89/95. Incidence of major diseases and damage caused by wind were comparatively less. Thirteen clones *viz.* 89/7, 89/27, 89/63, 89/64, 89/79, 89/95, 89/102, 89/124, 89/243, 89/308, 89/309, 89/349 and 89/356 showing high yield and good secondary attributes were selected for the next phase of evaluation.

Keywords: Biotic and abiotic stresses, Dry rubber yield, Girth increment, *Hevea brasiliensis*, Latex vessel rows, Yield depression.

INTRODUCTION

The Rubber Research Institute of India (RRII) has been evolving new clones of rubber (*Hevea brasiliensis*) through breeding and selection since 1955. Selected clones have been used as parents in hybridization which have resulted in some very successful cultivars, of which RRII 105 is the most popular (Nair and Panikkar, 1966; Nair and George 1968; Nair *et al.*, 1975; Nazeer *et al.*, 1986; Mydin *et al.*, 1994). Subsequent hybridization programmes have led to the release of 200 series (Saraswathyamma *et al.*, 1980), 300 series (Premakumari *et al.*, 1984) and 400 series (Licy *et al.*, 1992; Mydin *et al.*, 2005) clones. Among the 400 series, RRII 414, RRII 417, RRII 422 and RRII 430 are now popular (Saraswathyamma *et al.*, 1990; Licy *et al.*, 1993; Mydin *et al.*, 2005; Varghese *et al.*, 2009). Conventionally, hybrids from the nursery selection are multiplied and evaluated in a phased manner in small-scale trials, large-scale trials and on-farm trials (Tan, 1987). The first report on the evaluation

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of a set of selected hybrid clones, resultant of a 1989 hand pollination programme, over a period of 12 years along with the control RRII 105 is presented in this paper.

MATERIALS AND METHODS

A total of 395 hybrid seedlings generated from the 1989 hand pollination (HP) was raised in a seedling nursery and subjected to selection based on test tap yield, growth and other secondary attributes. Thirty four selections were cloned through bud-grafting, and planting materials were appropriately raised following accepted *Hevea* breeding procedures. The clones were evaluated in a small-scale trial with RRII 105 as control at the Central Experiment Station of RRII at Chethackal, Ranni in Central Kerala. The parentage of the clones is given in Table 1. These 34 clones were derived from 12 cross-combinations involving three indigenous clones *viz.* RRII 105, RRII 49 and RRII 118 and seven exotic clones *viz.* PB 260, PB 242, PB 311, PB 235, GT 1, IAN 45-873 and RRIM 600.

The trial was laid out in 1995 in randomized block design with three replications and four trees per plot. The trees were opened for tapping during the eighth year after planting. Tapping system followed was S/2 d3 6d/7. Yield was recorded at fortnightly intervals by cup coagulation method and the data over five years of tapping are presented. Mean annual dry rubber yield, dry rubber yield during the stress period (February – May) and peak

Table 1. **Parentage of clones evaluated**

Clone	Parentage			Clone	Parentage		
89/7	PB 260	x	RRIM 600	89/115	RRII 105	x	RRII 118
89/21	PB 260	x	RRIM 600	89/123	RRII 105	x	RRII 118
89/27	PB 260	x	RRIM 600	89/124	RRII 105	x	RRII 118
89/30	PB 260	x	RRIM 600	89/128	RRII 105	x	RRII 118
89/240	PB 260	x	RRIM 600	89/145	RRII 105	x	RRII 118
89/243	PB 260	x	RRIM 600	89/181	IAN 45-873	x	RRII 105
89/40	RRIM 600	x	PB 242	89/262	PB 235	x	RRII 105
89/48	RRIM 600	x	PB 242	89/274	PB 235	x	RRII 105
89/49	RRIM 600	x	PB 242	89/331	GT 1	x	PB 311
89/63	PB 311	x	RRII 105	89/349	GT 1	x	RRIM 600
89/95	PB 311	x	RRII 105	89/344	GT 1	x	RRIM 600
89/102	PB 311	x	RRII 105	89/287	GT 1	x	RRII 105
89/64	PB 311	x	RRII 105	89/356	GT 1	x	RRII 105
89/79	PB 311	x	RRII 105	89/395	GT 1	x	RRII 49
89/88	PB 311	x	RRII 105	89/318	IAN 45-873	x	RRII 118
89/103	PB 311	x	RRII 105	89/230	IAN 45-873	x	RRIM 600
89/308	PB 311	x	RRII 105	RRII 105	Tjir 1	x	Gl 1
89/309	PB 311	x	RRII 105				

yielding period (October – January) were computed separately. Yield depression under stress was computed as percentage over the annual mean value. The girth of the trees was recorded annually from the third year of planting and was used to determine the tappability of clones and girth increment rate during the pre-tapping and tapping phases. Bark samples were collected at the time of opening at a height of 150 cm and the number of latex vessel rows (LVR) was counted by microscopic observations of thin sections. Incidence of diseases such as abnormal leaf fall, powdery mildew, pink disease, tapping panel dryness and damage caused by wind were assessed. The data on yield, yield depression, girth, bark thickness and latex vessel rows were statistically analysed.

RESULTS AND DISCUSSION

Yield of clones

The performance of 34 hybrid clones and control in respect of yield is presented in Table 2. Mean yield over five years revealed that five clones were significantly superior to the control. Clone 89/95 was the highest yielder (62.00 g/t/t) followed by clone 89/7 (60.89 g/t/t). The control clone recorded 41.23 g/t/t. Other clones which showed significantly higher yield than the control were 89/64 (58.25 g/t/t), 89/79 (54.60 g/t/t) and 89/308 (54.54 g/t/t). Clone 89/287 was the lowest yielder recording 10.22 g/t/t. The comparative yield performance of the better yielding clones during the first five years of tapping is depicted in Figure 1.

Drop in yield in *Hevea* in summer (February to May) is a very complex phenomenon caused by soil moisture stress and a synchrony of various other physiological complexities due to

Table 2. **Yield performance of clones**

Clone	Mean yield over 5 years (g/t/t)	Yield (peak period) (g/t/t)	Yield (stress period) (g/t/t)	Summer yield depression (%)
89/7	60.89	91.60	35.73	52.19
89/21	40.91	38.29	28.80	26.64
89/27	48.88	82.00	36.32	45.16
89/30	37.08	52.07	23.07	44.25
89/40	30.97	49.47	26.47	39.12
89/48	28.23	42.64	17.99	46.19
89/49	32.04	45.03	17.78	54.18
89/63	42.00	67.26	31.38	32.27
89/64	58.25	73.73	45.82	30.54
89/79	54.60	64.42	30.78	52.90
89/88	31.86	64.73	27.75	36.85
89/95	62.00	80.90	48.54	29.48
89/102	47.68	63.53	32.03	44.09
89/103	27.49	33.74	20.25	27.70
89/115	22.04	37.87	15.63	47.66
89/123	27.43	31.55	8.96	65.45
89/124	48.58	63.64	24.66	54.45
89/128	30.61	51.04	16.93	51.45
89/145	38.19	54.27	21.26	50.15
89/181	15.34	23.55	14.76	17.95
89/230	36.19	56.71	30.50	35.22
89/240	25.51	37.83	17.56	40.82
89/243	42.80	57.20	21.31	56.40
89/262	32.91	43.82	15.03	48.86
89/274	18.52	30.45	14.50	34.12
89/287	10.22	17.19	7.86	33.28
89/308	54.54	73.00	42.71	37.43
89/309	54.21	94.00	44.86	33.97
89/318	35.65	54.88	31.95	62.45
89/331	32.87	42.25	13.47	47.20
89/344	24.22	31.46	12.62	32.70
89/349	43.65	73.21	35.80	57.82
89/356	49.78	65.79	24.07	37.90
89/395	11.34	17.11	7.53	42.30
RRII 105	41.23	40.23	14.02	64.94
CD (P = 0.05)	13.05	12.42	10.25	9.68

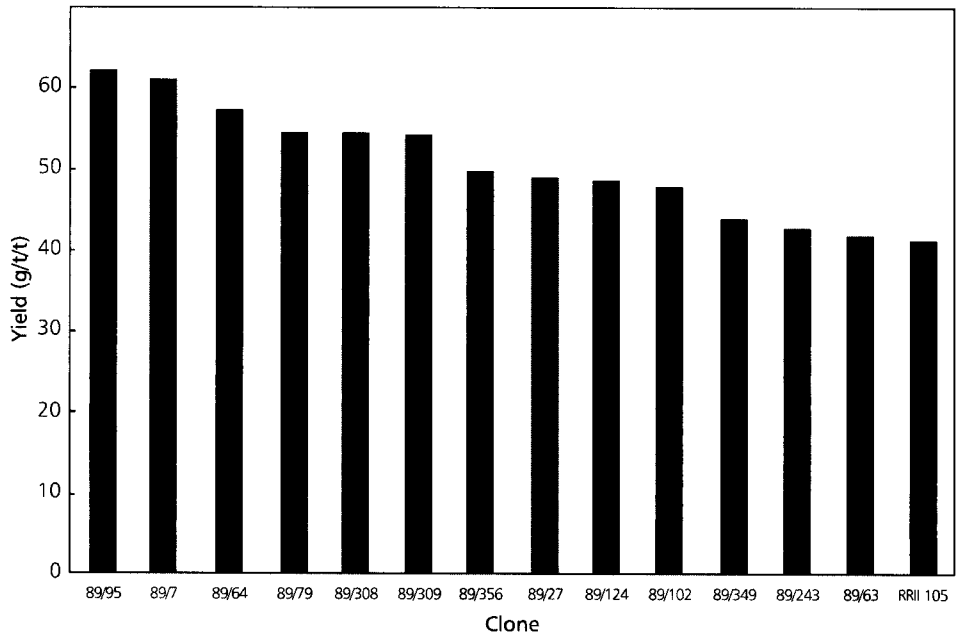

Fig.1. Mean yield of the promising clones over five years

defoliation, flowering and refoliation (Chua, 1970). The top yielding clone 89/95 showed high yield during the summer period (48.54 g/t/t) followed by clone 89/309 (44.86 g/t/t). The clone 89/309 also showed the highest yield in the peak yielding period (94 g/t/t) followed by clone 89/7 (91.60 g/t/t). The other superior yielders in summer *viz.* 89/64, 89/27 and 89/308 recorded 45.82, 36.32, and 42.71 g/t/t, respectively. Summer yield depression of clones ranged from 17.95 in 89/181 to 65.45 per cent in 89/123.

Improvement in rubber yield is the major objective of *Hevea* breeding programme. Clones 89/95, 89/7, 89/27, 89/63, 89/64, 89/79, 89/308, 89/349 and 89/309 showed high annual mean yield as well as summer yield. These clones showed less fluctuation in yield over seasons and so these can be considered as relatively stable clones.

Growth parameters

Though yield of rubber is the major consideration in the breeding of improved clones, there are other characteristics that are equally important in ensuring stability in rubber yield and thereby enhancing the value of the rubber tree. The important growth parameters of the clones studied are presented in Table 3. There was clonal variation with respect to growth characters such as girth at opening and girth increment in the immature phase and in the mature phase. Mean girth at opening ranged from 37.25 in clone 89/287 to 62.83 cm in 89/27. Moreover, all the trees attained tappable girth in clone 89/27 at the time of opening in the eighth year. Girth increment in the immature phase ranged from 3.70 in 89/331 to 7.85 cm per year in 89/27. Girth increment in the mature phase ranged from 1.37 in 89/123 to 3.88 cm per year in 89/88. Among the

Table 3. **Important growth parameters**

Clone	Mean girth at opening (cm)	Percentage tappability	Girth in 5th year of tapping (cm)	Girth increment in immature phase (cm/year)	Girth increment in mature phase (cm/year)
89/7	56.75	91.67	70.96	7.09	3.55
89/21	50.08	50.00	58.83	6.26	2.19
89/27	62.83	100.00	76.94	7.85	3.53
89/30	48.67	50.00	57.32	6.08	2.16
89/40	51.42	41.67	62.25	6.42	2.71
89/48	46.08	41.67	54.33	5.76	2.06
89/49	50.11	33.33	56.32	6.26	1.55
89/63	53.54	83.33	68.29	6.69	3.69
89/64	59.17	83.33	72.88	7.39	3.43
89/79	51.14	50.00	64.86	6.39	3.43
89/88	48.61	41.67	64.13	6.07	3.88
89/95	55.36	83.33	68.28	6.92	3.23
89/102	54.69	66.66	65.04	6.83	2.59
89/103	50.64	75.00	63.97	6.33	3.33
89/115	49.10	41.67	60.50	6.13	2.85
89/123	37.41	00.00	42.89	4.67	1.37
89/124	53.17	66.66	65.58	6.64	3.10
89/128	55.25	75.00	66.33	6.90	2.77
89/145	46.83	25.00	56.38	5.85	2.39
89/181	52.81	58.33	65.28	6.60	3.12
89/230	48.79	25.00	62.33	6.09	3.39
89/240	45.29	25.00	56.00	5.66	2.68
89/243	48.92	41.67	58.46	6.11	2.38
89/262	48.83	50.00	59.88	6.10	2.76
89/274	52.00	66.66	62.58	6.25	3.15
89/287	37.25	8.33	46.50	4.65	2.31
89/308	55.17	75.00	63.88	6.89	2.18
89/309	53.17	66.66	65.29	6.64	3.03
89/318	55.22	75.00	68.33	6.90	3.28
89/331	50.97	41.67	59.75	3.70	2.20
89/344	46.50	16.66	57.25	5.81	2.69
89/349	52.21	50.00	67.13	6.52	3.73
89/356	59.67	83.33	70.33	7.45	2.67
89/395	40.67	8.33	47.17	5.08	1.63
RRII 105	45.46	41.67	53.46	5.68	2.00
CD (P = 0.05)	8.25	-	10.57	1.02	0.84

34 hybrid clones, 21 exhibited mean girth above 50 cm at opening. Most of the high yielders such as 89/7, 89/27, 89/63, 89/64, 89/95 and 89/309 showed a girth increment of more than 3 cm per year in the tapping phase.

According to Simmonds (1989), yield and vigour in this crop are hardly separable. Growth vigour is genetically controlled and there is marked clonal variation with regard to girth increment under tapping and its effect on yield (Ferwerda, 1969). The vigorous growth habit of clone 89/27 was evident as it attained 100 per cent tappability at the time of opening. The same clone continued to be the most vigorous in the fifth year of tapping (76.94 cm). Of the other vigorous clones, 89/7 attained 91.67 per cent tappability, while clones 89/63, 89/64, 89/95 and 89/356 attained 83.33 per cent tappability at opening. Girth increment before opening was the highest in 89/27 (7.85 cm) followed by 89/64 (7.39 cm) and 89/7 (7.09 cm/year). After opening, girth increment was the highest in clone 89/88 (3.88 cm) followed by 89/349 (3.73 cm) and 89/63 (3.69 cm/year). As expected, girth increment in the tapping phase was low.

An ideal rubber clone would be one which maintains both high rubber yield and vigorous growth so as to sustain a high yield trend for many years (Mydin *et al.*, 2005). Yield and growth attributes would be of great value in the selection of superior clones. In the present study, the high yielding clones *viz.* 89/7, 89/64, 89/79, 89/95 and 89/308 showed yield above 50 g/t/t and also exhibited good girth. Growth of these high yielding clones up to twelfth year of planting is given in Figure 2. Girth at opening as well as in the fifth year of tapping was the highest in clone 89/27 recording 62.83 and 76.94 cm, respectively. Other clones such as 89/356 and

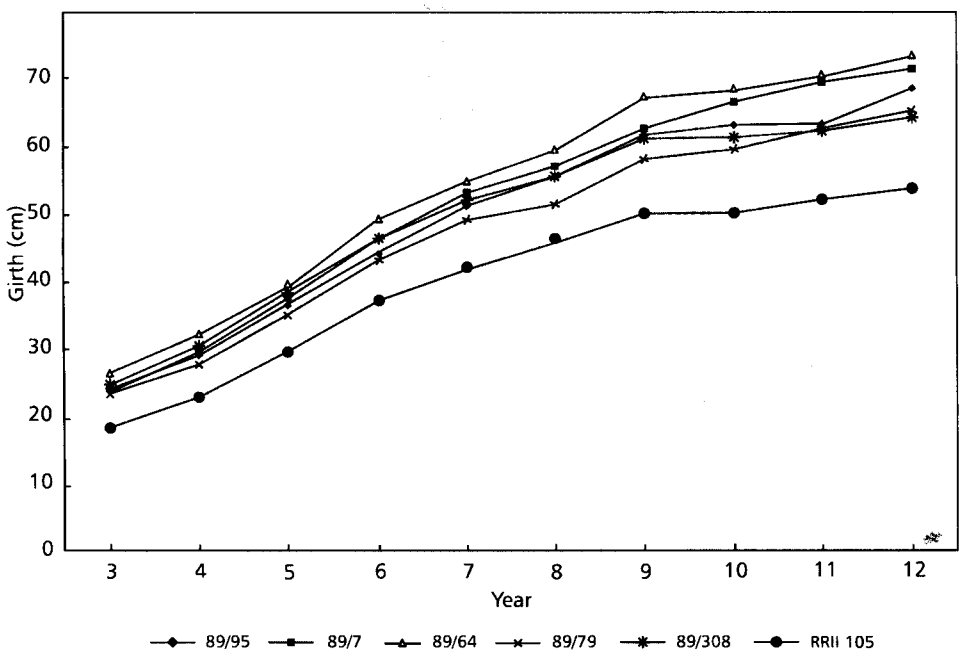

Fig. 2. Mean girth of superior clones up to 12th year of planting

89/64 ranked the second and third for girth at opening (59.67 and 59.17cm), while in the fifth year of tapping clone 89/64 was the second highest (72.88 cm) followed by clone 89/7 (70.96 cm). The majority of the high yielding clones showed high girth increment of more than 3 cm per year in the mature phase. The rising yield trend in these clones could be attributed to their vigorous growth even after commencement of tapping.

Anatomical observations

Total bark thickness (TBT) and number of latex vessel rows (LVR) in the clones are given in Table 4. Significant clonal variation was observed for bark thickness and number of latex vessel rows present in the bark. Total bark thickness ranged from 5.23 to 8.30 mm and LVR from 7.11 to 21.89. General mean for total bark thickness was 6.41 mm and that for LVR was 14.88. Seventeen clones recorded higher values for bark thickness and 16 clones for latex vessel rows than the general mean. Clone 89/27 recorded the highest bark thickness (8.3 mm) followed by clone 89/356 (7.94 mm). The highest number of LVR was observed in clone 89/95 (21.89) followed by clone 89/63 (20.62). According to Premakumari *et al.* (1998), yield performance of *Hevea* clones is governed by laticifer area index and orientation of laticifers. In the present study, clone 89/95 had the highest number of LVR and the highest yield. Other clones such as 89/63, 89/7 and 89/27 with high number of LVR also showed relatively better yield. Clone 89/123 having the least number of LVR (7.11) had a relatively low yield of 27.43 g/t/t. Clone 89/287 with the least bark thickness (5.23 mm) and low LVR (10.34) recorded the lowest yield of 10.22 g/t/t. In general, clones having high bark thickness recorded high number of LVR and showed better yield.

Table 4. **Anatomical parameters**

Clone	TBT (mm)	LVR (no.)
89/7	6.49	17.61
89/21	5.88	16.50
89/27	8.30	19.72
89/30	5.61	14.33
89/40	7.77	18.45
89/48	5.79	12.78
89/49	7.52	18.17
89/63	6.15	20.62
89/64	6.65	14.78
89/79	6.17	13.66
89/88	6.55	13.61
89/95	6.63	21.89
89/102	6.56	16.73
89/103	5.66	19.56
89/115	6.59	10.78
89/123	5.30	7.11
89/124	7.54	17.45
89/128	5.28	12.95
89/145	6.85	15.10
89/181	6.71	14.89
89/230	6.34	12.94
89/240	5.34	10.75
89/243	5.99	14.25
89/262	6.54	10.84
89/274	5.81	8.45
89/287	5.23	10.34
89/308	7.20	18.42
89/309	6.09	14.22
89/318	6.33	13.50
89/331	5.91	10.06
89/344	5.70	15.45
89/349	7.25	20.17
89/356	7.94	16.17
89/395	5.87	13.56
RRII 105	6.74	15.00
GM	6.41	14.88
CV	13.16	21.91

Incidence of biotic and abiotic stresses

Tolerance to various biotic and abiotic stresses is of great significance in assessing the performance of different clones. The present study gives only an indication of incidence since the plot size is too small to draw any valid conclusion. Incidence of TPD was maximum in RRII 105, three trees out of 12 were affected. In 89/243 and 89/79 two trees per clone, and in 10 other clones (89/21, 89/27, 89/48, 89/63, 89/115, 89/128, 89/181, 89/274, 89/308 and 89/318) one tree per clone, were affected by TPD. Symptoms of TPD were not observed in the other 22 clones. The intensity of abnormal leaf fall and powdery mildew was relatively less. Pink disease was found in most of the clones except 89/40, 89/103, 89/115, 89/318 and 89/331 in the third and fourth year of planting, while in the fifth year of tapping it was observed only in very few clones such as 89/21, 89/274, 89/79, 89/128, 89/123, 89/102 and 89/7. It was severe in 89/128, high in 89/102 and moderate in other clones. Wind damage was observed in five clones *viz.* 89/21, 89/79, 89/88, 89/128 and RRII 105, where one tree per clone was affected.

Introduction of divergent genotypes from other rubber growing countries provides opportunities for evolving promising clones through hybridization and clonal selection. Among the top yielders *viz.* 89/7, 89/64, 89/79, 89/95, 89/308 and 89/309, except in the case of 89/7, the female parent was PB 311 and male parent was RRII 105. PB 311, with parentage of RRIM 600 x PB 235 was introduced from Malaysia and was reported to have good yield and vigorous growth (John *et al.*, 2004; Varghese *et al.*, 2006). Though RRII 105 is not a vigorous clone, it is a high yielder. According to earlier reports (Simmonds, 1989; Mydin *et al.*, 1992; Licy *et al.*, 1993); rubber yield is highly heritable. The better performance of the above-mentioned hybrid progenies may be due to the combination of complementary characters contributed by the parental clones. In the case of the second highest yielder, clone 89/7, the parents were PB 260 and RRIM 600, both of which were introduced from Malaysia. RRII has already produced superior hybrid clones such as RRII 105 (Nair and Panikkar, 1966), RRII 414, RRII 417, RRII 422 and RRII 430 (Licy *et al.*, 1992, 1993; Mydin *et al.*, 2005) by crossing indigenous and exotic clones. These clones are now included in Category I of the planting recommendation in the traditional rubber growing regions in India.

Rubber yield in *H. brasiliensis* is a manifestation of various morphological, anatomical, physiological and biochemical characters of the tree (Pollinere, 1966). Among the 34 hybrid clones evaluated, yield of five *viz.* 89/7, 89/64, 89/79, 89/95, and 89/308 were significantly superior to the control clone RRII 105, the popular high yielding clone in India. These clones also exhibited good secondary characters such as good vigour, high bark thickness with greater number of latex vessel rows and tolerance to various diseases. Other clones showing relatively better performance than the control are 89/27, 89/63, 89/102, 89/124, 89/243, 89/309, 89/349 and 89/356. These 13 hybrid clones may perform better than RRII 105 and can be selected for the next phase of evaluation. According to Swaminathan (1975) the available genetic base could be broadened by frequent exchange of superior clones among rubber growing countries. Such exchange of genetic material has been useful in breeding for resistance to biotic and abiotic stresses.

ACKNOWLEDGEMENT

The authors are grateful to Director of Research, Rubber Research Institute of India for providing facilities and encouragement to carry out this study. The authors are also thankful to Smt. Liza Joseph and Sri. Aneesh P., Statistics and Computer Section of RRII, for analysis of data. The assistance for bark anatomical observations rendered by Mrs. Sobhana Sankar, Assistant Technical Officer and the supporting staff of Botany Division is gratefully acknowledged.

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