PROMISING ORTETS OF *HEVEA* FROM SMALL HOLDINGS OF KERALA: SMALL SCALE EVALUATION IN DAKSHIN KANNADA DISTRICT OF KARNATAKA

M.B. Mohamed Sathik, T.R. Chandrasekhar and M.A. Nazeer

Rubber Research Institute of India, Rubber Board, Kottayam-686 009, India

Received: 02 February 2017 Accepted: 22 March 2017

Sathik, M.B.M., Chandrasekhar, T.R. and Nazeer, M.A. (2017). Promising ortets of *Hevea* from small holdings of Kerala: Small scale evaluation in Dakshin Kannada District of Karnataka. *Rubber Science*,**30**(1): 42-55.

As the cultivation of *Hevea* in India is extended to non-traditional regions, it is necessary to identify high yielding clones for each agro-climatic zone. For this purpose, three sets of ortets found promising from holdings in Kerala were planted in South Karnataka region and their performance was evaluated. This report discusses about the performance of one set of 14 ortets in comparison with the performance of check clones RRII 105, GT1 and RRIM 600. In terms of girth, tappability, annual yield, yield stability and summer yield stability, the ortets Tly 55, Tly 56, CES 140, Kly 30, Pal 39A and Kly 26 were superior among the ortets studied they were on par with the control clone GT1 in terms of yield in the agro-climatic conditions of the DK district of Karnataka. Among the above promising ortets, Kly 30 has an additional advantage of being tolerant to abnormal leaf fall disease. These clones need to be further subjected to large scale participatory on - farm trials to validate and confirm their superiority in this agro-climatic region.

Key words: Dakshin Kannada, *Hevea brasiliensis*, Ortet selection, Small scale evaluation

INTRODUCTION

Large populations of seedling stands that existed in various plantations in India were subjected to systematic ortet selection programmes from 1954 which led to the development of valuable primary clones in the RRII 1-10 series (Marattukalam *et al*., 1980). In the early years, primary focus was on ortet selection followed by hybridization.

Ortet selection consists of identification of elite trees from a large base population of genetically variable seedling trees, through regular monitoring of their performance over a period (Mydin and Saraswathyamma, 2005). Ortet selection programmes initiated in Indonesia and Malaysia in the early 1900's resulted in significant yield improvement over the parent population of unselected seedlings (Khoo *et al*., 1982). Some of the important primary clones developed through ortet selection are RRII 5, GL 1, Tjir 1, PB 86, PB 28/59, PB 280, GT 1, PR 107, Mil 3/2 and Haiken 1. These primary clones were subsequently used in the subsequent hybridization programmes which led to the evolution of successful secondary hybrid clones like RRII 105, RRII 203, RRII 208, RRIC 100 and RRIM 600.

Correspondence: M.B.Mohamed Sathik (Email: sathik@rubberboard.org.in)

Ortet selection in India which started in 1954 involved screening of various estates in South India that resulted in identification of 46 primary clones among which RRII 5 was found outstanding in terms of yield, vigour and secondary attributes (Marattukalam *et al*., 1980; Saraswathyamma *et al*., 2000a,b). Clones in the series from RRII 1 to RRII 100 are ortet clones developed by RRII (Marattukalam *et al*., 1980). A systematic screening programme of seedling plantations initiated during the 1980s in large estates and in small holdings of Kerala resulted in the selection of 530 ortets which eventually led to the identification of 31 primary clones with superior yield and timber characteristics (Mydin *et al*., 2005; Mercykutty *et al*., 2013; John *et al*., 2013). In order to select location specifie clones, screening of these ortets was attempted in different agro-climatic zones. When a selected set of ortets from polyclonal seedlings established in Dapchari, Maharashtra, a drought prone region (Chandrasekhar *et al*., 2002), was evaluated in the traditional region (Central Experiment Station of Rubber Research Station of India), two promising ortet clones (D111 and D37) with superior traits were identified (Mydin *et al*., 2016). In another attempt, three set of ortets selected from small holdings across Kerala were planted in South Karnataka region (Dakshin Kannada or DK District) and their performance was evaluated. Promising ortets from one set of 15 clones was recently reported by Reju *et al*. (2016). This study identified ortets Ayr 2 and Pai 17as superior clones in terms of girth and yield while Alk 47 was a potential latex-timber clone. Results of another set of 16 ortets from the same area was reported by Gireesh *et al*. (2016) which identified Ayr 1 as the best performer in terms of girth (114 cm) and yield (78 g t^{-1} t^{-1}) followed by GT1 (92 cm and 71 g $t^{-1}t^{-1}$, respectively). The present report discusses the performance of another set of 14 ortets in the same South Karnataka region in comparison with the performance of the check clones RRII 105, GT1 and RRIM 600.

MATERIALS AND METHODS

The 14 ortets selected from various holdings in Kerala were planted in *Hevea* Breeding Sub Station in Nettana, Dakshin Kannada District, Karnataka which is part of the coastal Karnataka region. The farm lies in the latitude of 12° 43′ N and longitude of 75° 32′ E and at an altitude of 120 m above the MSL. This region receives heavy rainfall during the south-west monsoon and has a weak north-east monsoon. The annual rainfall ranged from 3000 mm to 5000 mm. Available weather parameters recorded in this region from 1989 to 2009 are given in Table 1. Maximum rain fall occurs between June and December. The area also experiences dry period from December to April. Maximum temperature in this area was observed in March and minimum temperature during January. Total annual rainfall recorded for twenty one years was 4696 mm and the average daily bright sunshine hours recorded was six. The average relative humidity (RH) during the study period ranged between 83.1 per cent (Dec) and 92.8 per cent (Jul) in the morning and between 39.4 per cent (March) and 84.2 per cent (July) in the evening. Soil is lateritic with sandy clay loam texture.

Fourteen ortet clones along with three check clones were planted in 1988 in a Small Scale Trial (SST). The ortet clones were selections from seedling plantations of small holdings in Kerala (Table 2). The clones were planted in Randomized Block Design (RBD) with three replications and five plants per plot, and the spacing adopted was 5m x 5m in a square planting system. The ortet clones were Pal 39A, Tly 55, Kly 26, Tly 56, Rni 64, Pai 11, Alk 49, Kly 30, Chi 51, CES 152, CES 140, CES 32, CES 6 and CES 10/9 and the check clones were RRII 105, GT 1 and RRIM 600.

Girth was recorded (at 125 cm height from the bud-union) quarterly from the third year of planting during the immaturity period and annually since the opening of the trees during the maturity period. Tappability of the clones was also recorded before opening. Girth increment during the immature and mature phases and drop in girth increment due to crop harvesting were computed.

Shukla's stability variance analysis was carried out to assess the growth stability of clones during both immature and mature phases (Prabhakaran and Jain, 1994). The trees were opened for tapping during September 2002 under S/2 d3 6d/7 tapping system when all the clones attained tappable girth. The rubber yield was recorded as dried rubber from the cup coagulum collected after each tapping as gram per tree per tap (g t^{-1} t^{-1}). Duncan's Multiple Range Test (DMRT) was used to test the significance of clonal difference at P=0.05 level (Gomez and Gomez, 1989). The dry rubber yield from BO 1 panel (2002 to 2006), BO 2 panel (2007 to 2013), average yield of the first four years of tapping, annual yield for the period between 2002 and 2013, and yield during summer months (February to May), monsoon period (June to September) and post-monsoon period (October to January) were analysed to assess the yield potential of the ortet clones. Stability variance of clones was computed for yield in both BO 1 and BO 2 panels and over the long term period spanning eleven years of tapping. Tapping in the BO 2 panel was prolonged due to the non-tapping of the trees in 2010 on account of inevitable circumstances as a result of labour unrest.

RESULTS AND DISCUSSION

The regions situated below 10^{o}N latitude are considered traditional areas of rubber cultivation and region above this latitude as

Table 1. **Weather parameters at the experimental site**

Month	Air temperature (°C) (1989 – 2009)		Sunshine hours	Rainfall (mm)	Relative humidity (%) (1995 – 2009)	
	Maximum	Minimum	(1989 – 2009)	(1989 – 2009)	Morning	Evening
Jan	34.1	15.6	8.8	3.7	85.6	40.6
Feb	35.0	16.7	8.8	9.4	87.8	41.2
Mar	36.2	20.0	8.6	15.1	87.7	39.4
Apr	35.6	22.2	8.0	111.3	88.4	49.1
May	33.7	22.7	6.6	216.3	90.0	61.8
Jun	29.5	21.6	2.7	874.5	92.1	79.6
Jul	27.6	21.5	1.3	1370.0	92.8	84.2
Aug	27.9	21.8	2.0	1070.9	92.0	80.6
Sep	29.8	21.7	4.5	470.9	91.5	73.6
Oct	31.4	21.6	5.6	412.2	90.9	68.3
Nov	32.8	19.8	7.1	112.0	86.8	57.2
Dec	33.2	16.8	8.2	30.1	83.1	46.8
Mean/ Total	32.2	20.2	6.0	4696.4	89.1	60.2

non-traditional regions. Dakshin Kannada District of Karnataka falls under non-traditional rubber growing area. Though there is high rainfall, the region experiences severe moisture deficit stress for four to six months during December to May (Sanjeeva Rao and Vijayakumar, 1992). The weather parameters are provided in Table 1.

The girth of the plants during 25th year (13th year of tapping) indicated ortet Tly 55 as superior clone with 133.9 cm followed by Pai 11, Kly 26 and CES 140 which were on par with Tly 55 with 108.7, 102.7 and 102 cm, respectively (Table 3). All these clones were superior to GT1 which attained 97.7 cm. Girth of other check clones, namely, RRII 105 and RRIM 600 were on par with GT1 (78.3 and 74.3 cm respectively). Girth during the opening of these trees was superior in clones. Kly 26 (82.3 cm), Tly 55 (81.6 cm), Tly 56 (79.3 cm), CES 140 (78.9 cm) and GT1 (77.9 cm) whereas clones. Kly 30 (71.5 cm), RRII 105 (70.7 cm), Pal 39A (69.9 cm), CES 32 (69.9 cm), CES 10/9 (69.3cm), Pai 11 (65.5 cm), RRIM 600 (64.3 cm), Chi 51 (62.8 cm), Alk 49 (62.8 cm) and Rni 64 (61.8 cm) had girth on par with the superior clones. Clones CES 6 (52.8 cm) and CES 152 (51.5 cm) had the least girth during opening.

Trees of two clones CES 140 (52.6) and Tly 55 (51.1) showed more than 50 per cent tappability (Table 4) during the 7th year while GT1 had 48.5 per cent only. During the subsequent (8th) year, nine clones including GT1 and RRIM 600 had tappability of 50 per cent and above. The clone, CES 140 and Tly 55 maintained their higher tappability at the rate of 57.7 and 56.8 per cent, respectively. The other clones that were found to have about 50 per cent tappability are Tly 56 (55.2), Kly 26 (53.3), Pal 39A (51.5), Kly 30 (50.0) and CES 10/9 (49.9) while GT1 and RRIM 600 attained 54 and 50.8 per cent respectively. During 9th year, most of the clones attained above 50 per cent tappability except four clones Alk 49 (49.8 %), CES 6 (44.9 %), Pai 11 and CES 152 (both 44.1 %). Among them, CES 140, Kly 26, Tly 55 and Tly 56 were the clones that had higher tappability (of about 62.6, 62.3, 62.0 and 61.9 per cent respectively) while control clones GT1 and RRIM 600 had 60.2 and 56.2 per cent tappability, respectively.

Table 2. **The ortets used in this study and their place of origin**

Sl. No.	Ortet	Place of origin
1	Pal 39A	Pala
2	Tly 55	Talasserry
3	Kly 26	Kanjirappally
4	Tly 56	Talasserry
5	Rni 64	Ranni
6	Pai 11	Paika
7	Alk 49	Alakkode
8	Kly 30	Kanjirappally
9	Chi 51	Chemberi
10	CES 152	CES, Chethackal
11	CES 140	CES, Chethackal
12	CES 32	CES, Chethackal
13	CES 6	CES, Chethackal
14	CES 10/9	CES, Chethackal

The Shukla's stability variance data (Table 5) with regard to stability of growth indicated that clones Pal 39A, Tly 55, CES 140, Rni 64, CES 32, Kly 30, CES 10/9, Chi 51and check clones GT1, RRII 105 and RRIM 600 were having better stability before opening while Tly 55 and CES 140 had girth superior to GT1. Shukla's stability variance analysis for girth after opening indicated better growth stability in CES 140, Kly 26, Tly 56, Pai 11, Pal 39A, Kly 30, CES 10/9, Chi 51 and check clones RRII 105 and RRIM 600 while GT1 had least growth stability. The clone Tly 55 which had the highest mean girth after opening was the least stable clone

Table 3. **Girth of clones at the time of opening and 25 years after planting**

Clone	Girth at opening (cm)	Girth at 25th year (cm)
Pal 39A	69.9 [ab]	92.6 [bcd]
RRII 105	70.7 [ab]	78.3 [bcd]
CES 152	51.5 [b]	69.4 [cd]
Tly 55	81.6 [a]	133.8 [a]
CES 140	78.8 [a]	102.0 [abc]
Kly 26	82.3 [a]	102.7 [abc]
GT1	77.9 [a]	97.7 [bcd]
Tly 56	79.3 [a]	88.8 [bcd]
Rni 64	61.8 [ab]	81.3 [bcd]
Pai 11	65.4 [ab]	108.6 [ab]
CES 32	69.9 [ab]	84.6 [bcd]
Alk 49	62.8 [ab]	84.1 [bcd]
Kly 30	71.5 [ab]	90.0 [bcd]
CES 6	52.8 [b]	62.8 [d]
CES 10/9	69.3 [ab]	94.4 [bcd]
RRIM600	64.2 [ab]	74.3 [bcd]
Chi 51	62.8 [ab]	80.8 [bcd]

Means followed by the same letters do not differ significantly

in terms of growth. The clones CES 140 and Kly 26 maintained superior girth while displaying better stability in terms of growth after opening.

When girth increment of the clones during immature and matures phases was analysed (Table 6), the clones did not exhibit any significant difference in girth increment during the immature phase though significant difference could be observed during mature phase. The girth increment during immature phase was in the range of 5.3 to 8.15 cm and between 1.09 and 4.53 cm during mature phase. The clone Tly 55 had a superior annual girth increment of 4.53 cm followed by Kly 26 (3.19 cm), Chi 51 (2.97 cm) and Kly 30 (2.95 cm) during mature phase while the check clones GT1, RRII 105 and RRIM 600 had an annual girth increment of 1.92, 1.85 and 1.27 cm, respectively. The general mean annual girth increment during immature phase was 6.71 cm while it was only 2.3 cm during mature phase. The reduction in mean girth increment rate between immature and mature phases is attributed to the loss of biomass through crop harvest. The clonal variation in girth increment during mature phase was more (36.2%) than during immature phase (16.1%). When the drop in girth increment due to crop harvest was computed, the clone Tly 55 displayed the least drop among the clones (40.43%). This was followed by Chi 51 (52%), Kly 30 (54.6%), Rni 64 (55.1%) and Pal 39A (57.0%) while maximum drop was found in clones CES 152 (82.6%) and check clone RRIM 600 (80.5%), respectively.

Table 4. **Tappability of clones**

Clone	Tappability (%)		
	7th year (1995)	8th year (1996)	9th year (1997)
Pal 39A	44.4	51.5	57.3
RRII 105	43.5	48.1	55.3
CES 152	35.7	39.8	44.1
Tly 55	51.1	56.8	62.0
CES 140	52.6	57.7	62.6
Kly 26	47.3	53.3	62.3
GT1	48.5	54.0	60.2
Tly 56	47.7	55.2	61.9
Rni 64	42.0	46.1	51.2
Pai 11	39.3	42.1	44.1
CES 32	43.5	49.1	55.0
Alk 49	41.6	44.6	49.8
Kly 30	46.4	50.0	52.9
CES 6	38.4	41.2	44.9
CES 10/9	45.2	49.9	54.2
RRIM600	45.0	50.8	56.2
Chi 51	45.4	48.4	52.0

The clone Tly 55 displayed more advantageous features such as highest girth increment during mature phase, lowest drop in girth increment and high yield potential (in BO-1 panel). As the clones with high growth rate during mature phase can be treated as clones with high timber yield potential (John *et al*., 2013), the clones Tly 55 with the above superior features can be selected as high timber clone. The scatter diagram (Fig. 1) of girth increment during immature and mature phases indicates clones such as Tly 55, Kly 26, Tly 56 and CES 140 as superior clones. The Shukla's stability variance calculated for girth increment shows that most of the clones are stable during immature phase while many of the clones with higher girth increment did not display better stability (Table 7). For *e.g*. the clones Tly 55 and Kly 26 which had superior girth increment were found highly variable. Among the clones with stable girth increment, the clone Rni 64 was found highly stable.

With regard to yield (Table 8) in the BO-1 panel (first four years of tapping), the check clone GT1 was the highest yielder (78.91 g t^{-1} t^{-1}) while ten clones *viz*. Tly 56, Kly 30, Kly 26, RRII 105, Pal 39A, Tly 55, Rni 64, Pai 11, Alk 49 were on par with the same. The poor yielders among the clones tested were CES 10/9 (33.8 g t^{-1} t^{-1}), CES 152 (33.7 g t^{-1} t^{-1}) and CES 6 (35.8 g t^{-1} t^{-1}). In the case of BO-2 panel also, GT1 was superior

Table 5. **Stability of girth before and after opening**

Clone	Girth – immature phase (1990-2000)			Girth – mature phase (2001-2013)		
	Shukla's stability variance	F value	Mean girth	Shukla's stability variance	F value	Mean girth
Pal 39A	1.36	0.11 ns	43.3	0.16	0.002 ns	81.4
RRII 105	-0.28	-0.02 ns	41.6	31.10	0.46 ns	74.7
CES 152	27.22	2.18 **	33.9	30.67	0.45 ns	57.5
Tly 55	15.76	1.26 ns	48.1	1252.11	18.43 **	104.9
CES 140	8.20	0.66 ns	48.4	-6.74	-0.10 ns	91.2
Kly 26	28.01	2.24 **	46.7	7.88	0.11 ns	92.9
GT1	9.60	0.77 ns	45.8	986.66	14.53 **	88.9
Tly 56	24.83	1.98 *	46.7	7.50	0.11 ns	88.5
Rni 64	0.92	0.07 ns	40.3	525.16	7.73 **	72.8
Pai 11	25.87	2.07 **	35.0	88.18	1.30 ns	81.4
CES 32	0.23	0.02 ns	41.6	2.34	0.03 ns	77.0
Alk 49	4.86	0.39 ns	38.4	20.31	0.30 ns	75.1
Kly 30	0.80	0.06 ns	43.0	-6.77	-0.10 ns	82.3
CES 6	32.81	2.62 **	35.5	20.34	0.30 ns	56.9
CES 10/9	-0.42	-0.03 ns	42.3	-5.05	-0.07 ns	83.0
RRIM600	3.29	0.26 ns	42.1	10.88	0.16 ns	70.7
Chi 51	5.72	0.46 ns	40.5	-3.63	-0.05 ns	74.1
	GM	42.0		GM	79.6	

ns: non-significant, * significantly unstable (P=0.05)

Table 6. **Annual girth increment (GI) of clones and reduction in GI after tapping**

Clone	Girth increment (cm year^{-1}) immature phase	mature phase	Drop in girth increment due to crop harvest (%)
Pal 39A	6.5	2.5 [bcd]	57.0
RRII 105	7.0	1.8 [bcd]	73.7
CES 152	5.3	1.1 [d]	82.6
Tly 55	7.6	4.5 [a]	40.4
CES 140	7.5	2.4 [bcd]	68.3
Kly 26	8.1	3.2 [ab]	60.8
GT1	7.5	1.9 [bcd]	73.7
Tly 56	8.1	2.3 [bcd]	71.1
Rni 64	6.4	2.9 [bc]	55.1
Pai 11	6.5	1.7 [bcd]	71.8
CES 32	6.6	1.7 [bcd]	74.9
Alk 49	6.6	2.0 [bcd]	69.9
Kly 30	6.5	3.0 [b]	54.6
CES 6	4.9	1.3 [cd]	74.5
CES 10/9	6.3	2.4 [bcd]	61.4
RRIM600	6.5	1.3 [cd]	80.5
Chi 51	6.2	3.0 [b]	52.0

Means followed by the same letters do not differ significantly.

with and yield of 64.2 g $t^{-1}t^{-1}$ while the clone Tly 55 was superior among the ortets. However, the clones CES 140, Alk 49, Tly 56, RRII 105, Rni 64, Kly 26, Pai 11, Kly 30 and Pal 39A were found to yield on par with the top yielders (GT1 and Tly 55). In contrast, clones such as CES 6 and CES 32 were low yielders with 15.5 and 17.8 g $t^{-1}t^{-1}$, respectively. In the case of overall mean yield over 11 years of tapping, control clone GT1 was still the top yielder with 70.9 g $t^{-1}t^{-1}$ while the clones Tly 55 (63.1 g t^{-1} t^{-1}), CES 140 (61 g t^{-1} t^{-1}), Tly 56 (58.6 g t^{-1} t^{-1}), Kly 30 (52.4 g t^{-1} t^{-1}), Kly 26 (51.6 g t^{-1} t^{-1}), Alk 49 (51.2 g t^{-1} t^{-1}), Pal 39A (49.8 g t^{-1} t^{-1}), Rni 64 (48.6 g t^{-1} t^{-1}) and RRII 105 (52.7 g t^{-1} t^{-1}) were on par with GT1. The ortet CES 6 was found the lowest yielder with 24.8 g $t^{-1}t^{-1}$. Clones can be selected based on rubber yield itself (Mydin *et al.*, 2016) which is a highly heritable trait (Tan, 1981).

When seasonal yield of promising clones was examined (Table 9), clones Tly 56, Alk 49, Kly 26 and CES 140 were found to perform well under summer season when compared

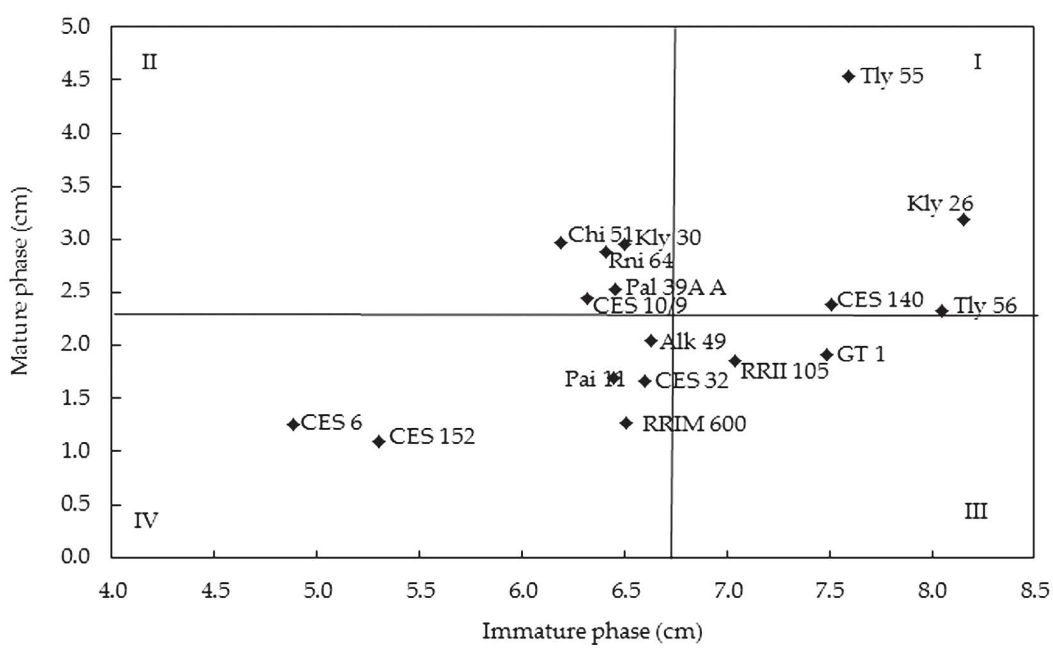

Fig 1. Girth increment of clones during mature and immature phases

Table 7. **Stability for annual girth increment of clones**

Clone	Girth increment - immature phase ($cm\ year^{-1}$) Shukla's stability variance	F value		GI	Clone	Girth increment - mature phase ($cm\ year^{-1}$) Shukla's stability variance	F value		GI
Pal 39A	4.51	2.51	**	6.5	Pal 39A	3.12	2.58	**	2.8
RRII 105	1.98	1.10	ns	7.0	RRII 105	1.20	0.99	ns	1.9
CES 152	0.60	0.34	ns	5.3	CES 152	1.95	1.61	ns	0.9
Tly 55	1.87	1.04	ns	7.6	Tly 55	7.91	6.53	**	4.5
CES 140	1.09	0.60	ns	7.5	CES 140	0.31	0.26	ns	2.4
Kly 26	1.41	0.78	ns	8.2	Kly 26	3.60	2.98	**	3.2
GT1	0.82	0.46	ns	7.5	GT1	1.41	1.16	ns	2.0
Tly 56	1.13	0.63	ns	8.0	Tly 56	2.64	2.18	**	2.3
Rni 64	1.45	0.81	ns	6.4	Rni 64	1.48	1.22	ns	2.9
Pai 11	0.57	0.31	ns	6.5	Pai 11	0.47	0.39	ns	1.8
CES 32	0.32	0.18	ns	6.6	CES 32	0.40	0.33	ns	1.7
Alk 49	2.20	1.22	ns	6.6	Alk 49	0.19	0.15	ns	2.0
Kly 30	2.26	1.25	ns	6.5	Kly 30	2.12	1.75	*	2.9
CES 6	1.08	0.60	ns	4.9	CES 6	2.14	1.77	*	1.3
CES 10/9	0.89	0.49	ns	6.3	CES 10/9	0.16	0.13	ns	2.4
RRIM600	3.35	1.86	*	6.5	RRIM600	1.61	1.33	ns	1.3
Chi 51	0.90	0.50	ns	6.2	Chi 51	5.47	4.52	**	3.0
General Mean				6.7	General Mean				2.3
CV				16.06	CV				36.2

ns: non-significant, * significantly unstable (P=0.05)

to control clones RRII 105 and GT1. During monsoon season also, clones Tly 55, Tly 56, CES 140 and Pal 39A performed well when compared to RRII 105 and GT1. The clone Tly 55 with 90.8 g $t^{-1}t^{-1}$ was found superior under post-monsoon season when check clone GT1 yielded 94.4 g $t^{-1}t^{-1}$. The drop in summer yield was minimal in clones like Alk 49 (15.7%), Tly 56 (20.0%) and Kly 26 (21.1%) while RRII 105 and GT1 had 20.1 and 44.3 per cent, respectively. These three clones also maintained yield at par with GT1. The remarkable finding is that while clones GT1 and Tly 55 maintained higher yield during post-monsoon season, clone Tly 56, Alk 49, Kly 26 and CES 140 maintained better yield during summer. Clones Alk 49, Kly 26 and Tly 56 had least summer drop while maintaining higher yield indicating that these clones are superior for this region.

When mean monthly yield was analysed for a set of selected ortets (Fig. 2), a major peak in yield was found during November followed by another peak during June. The mean annual yield of high yielding ortet clones (Fig. 3) indicated that maximum yield was obtained between 2006 and 2008 revealing the increase in productivity towards the end of BO-1 panel and at the beginning of the BO-2 panel.

Shukla's stability variance was worked out for the average yield of BO-1 and BO-2

Table 8. **Yield performance of clones**

Clone	Average yield of clones (g t^{-1} t^{-1})		
	BO-1 panel (2002-06) mean yield	BO-2 Panel (2007-13) mean yield	Mean yield (2002-13)
Pal 39A	68.1^{abc}	33.5^{abcde}	49.8^{abcd}
RRII 105	68.8^{ab}	39.3^{abcde}	52.7^{abc}
CES 152	33.7^{d}	28.5^{bcde}	30.7^{cde}
Tly 55	63.9^{abcd}	61.8^{a}	63.1^{ab}
CES 140	70.7^{ab}	52.8^{ab}	61.0^{ab}
Kly 26	69.3^{ab}	36.8^{abcde}	51.6^{abc}
GT 1	78.9^{a}	64.2^{a}	70.9^{a}
Tly 56	72.9^{ab}	46.7^{abcd}	58.6^{ab}
Rni 64	60.6^{abcd}	38.6^{abcde}	48.6^{abcde}
Pai 11	56.3^{abcd}	36.2^{abcde}	45.3^{bcde}
CES 32	43.3^{bcd}	17.8^{de}	29.4^{cde}
Alk 49	51.2^{abcd}	51.0^{abc}	51.2^{abc}
Kly 30	70.0^{ab}	36.2^{abcde}	52.4^{abc}
CES 6	35.8^{d}	15.2^{e}	24.8^{e}
CES 10/9	33.8^{d}	21.0^{cde}	26.8^{de}
RRIM 600	46.5^{bcd}	20.6^{cde}	32.4^{cde}
Chi 51	37.9^{cd}	26.4^{bcde}	31.6^{cde}

Means followed by the same letters do not differ significantly.

panels and for the total period (11 years) tapping (Table 10). The clones CES 140 and Tly 56 displayed superior yield stability over the period of 11 years (stability variance 17.9 and 74, respectively) while maintaining superior yield on par with GT1 which had relatively higher stability variance. The other clones that had yield on par with GT1 and maintained higher stability over a period of 11 years were Kly 26, Pal 39A, Pai 11 and Rni 64. Among the check clones, both RRII 105 and RRIM 600 maintained higher stability while yield of RRII 105 was on par with GT1. The clones Kly 26, Pal 39A and Tly 55 which maintained higher stability in BO-1 panel by maintaining yield on par with the GT1, upon reaching BO-2 panel displayed higher instability. The scatter diagram (Fig. 4) of girth over 21 years and mean yield over 11 years revealed clones GT1, Tly 55, CES 140, Kly 30, Kly 26, Pal 39A and Pai 11 to fall in the first quarter and are superior to other clones. The clone Kly 30 was reported to be tolerant to abnormal leaf fall disease in this region (Manju *et al*., 2004). Chi 51 is another clone which had been reported to be less susceptible which fell under second quarter

Table 9. **Seasonal yield of promising clones (g t^{-1} t^{-1}) over 11 years**

Clone	Summer yield (Feb - May)	Monsoon yield (Jun-Sep)	Post-Monsoon yield (Oct-Jan)	Annual mean yield	Drop in summer yield (%)
O39	30.8	53.7	65.7	49.8	38.0
RRII 105	42.1	54.4	68.9	52.7	20.1
Tly 55	38.9	60.4	90.8	63.4	38.3
CES 140	40.3	54.9	76.2	60.9	34.0
Kly 26	40.7	47.9	50.0	51.6	21.1
GT1	39.5	51.3	94.4	70.9	44.3
Tly 56	46.9	56.0	65.8	58.6	20.0
Rni 64	28.9	49.3	62.7	48.6	40.6
Alk 49	43.2	46.8	66.0	56.7	15.7
Kly 30	28.8	46.9	63.9	51.8	45.0

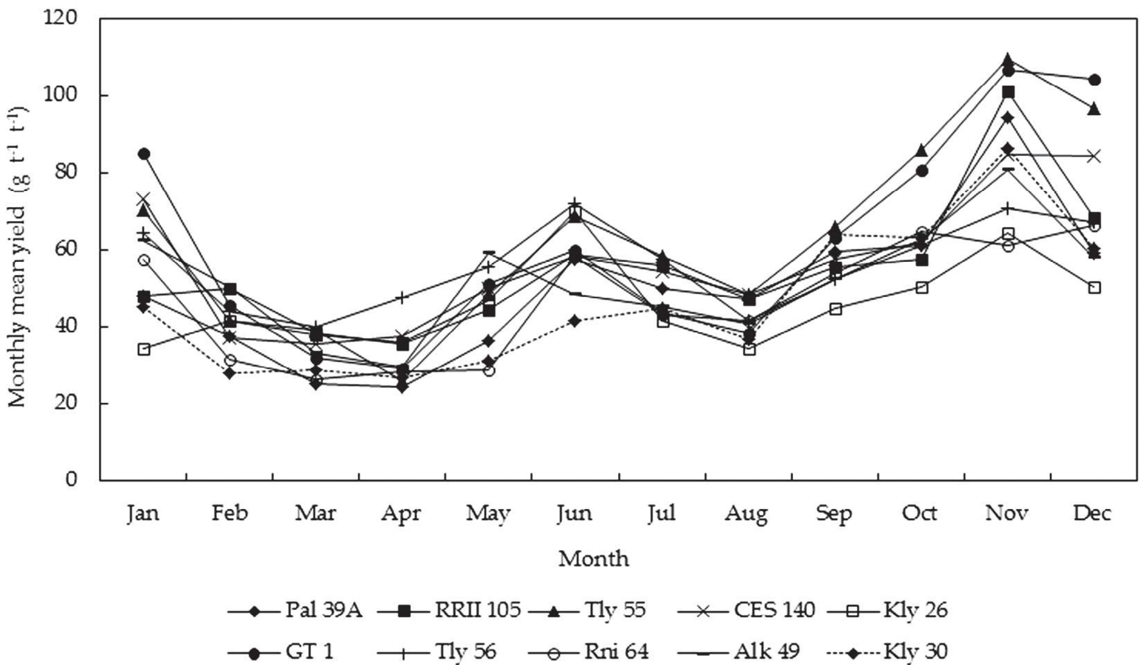

Fig 2. Pattern of mean monthly yield of selected ortets

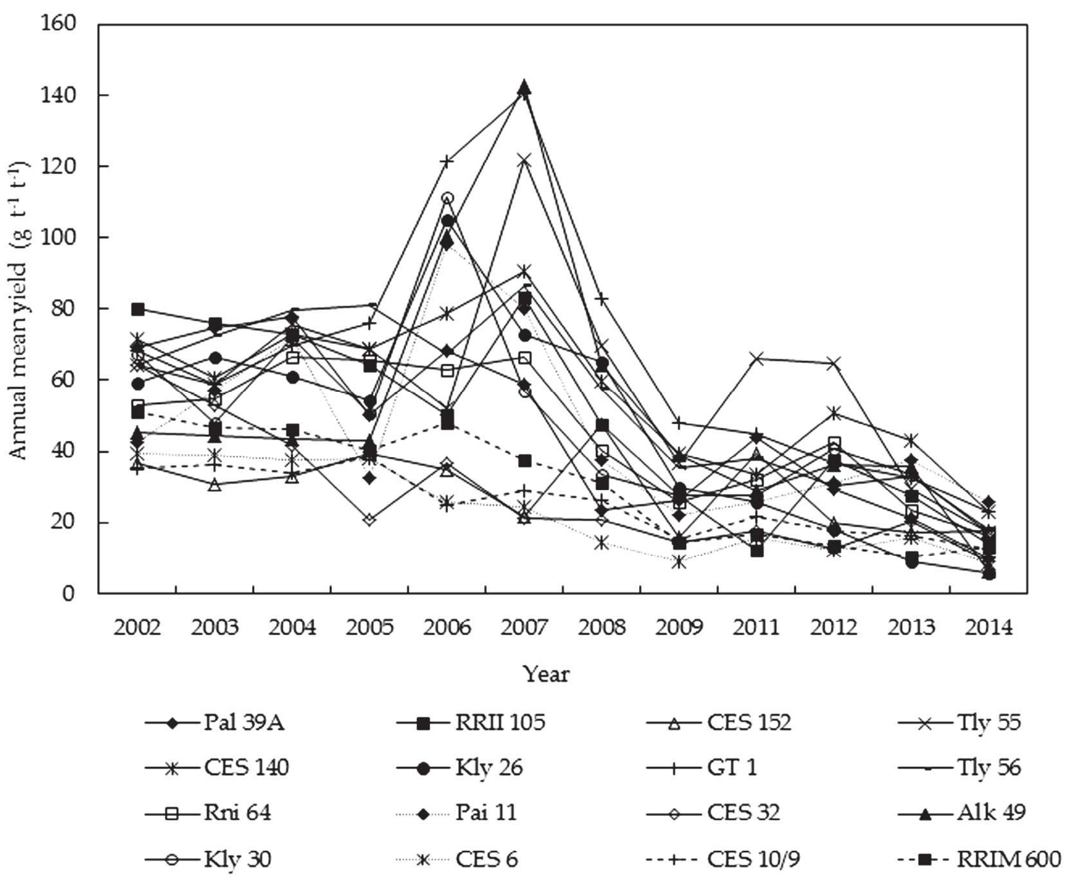

Fig. 3. Pattern of annual yield of selected high yielding ortet clones

Table 10. **Yield stability of clones**

Clone	Annual average over 11 years			Annual average of BO-1 panel			Annual average of BO-2 panel		
	Shukla's stability variance	F value	Mean yield (g t^{-1} t^{-1})	Shukla's stability variance	F value	Mean yield (g t^{-1} t^{-1})	Shukla's stability variance	F value	Mean yield (g t^{-1} t^{-1})
Pal 39A	171.1	1.15 ns	49.4	85.95	0.53 ns	68.1	137.44	0.99 ns	33.8
RRII 105	197.9	1.33 ns	52.7	274.71	1.70 ns	68.8	111.47	0.80 ns	39.3
CES 152	273.2	1.83 *	30.6	38.42	0.24 ns	34.9	429.98	3.10 **	26.9
Tly 55	369.5	2.48 **	64.4	170.48	1.05 ns	63.9	342.81	2.47 **	64.7
CES 140	17.9	0.12 ns	60.9	-2.34	-0.01 ns	70.7	32.42	0.23 ns	52.8
Kly 26	247.1	1.66 ns	51.6	247.96	1.53 ns	69.3	188.56	1.36 ns	36.8
GT 1	519.0	3.48 **	70.9	433.17	2.68 **	78.9	673.30	4.86 **	64.2
Tly 56	74.1	0.50 ns	58.6	119.20	0.74 ns	72.9	22.21	0.16 ns	46.7
Rni 64	35.8	0.24 ns	48.6	47.36	0.29 ns	60.6	26.45	0.19 ns	38.6
Pai 11	215.2	1.44 ns	48.8	452.97	2.80 **	60.4	62.43	0.45 ns	39.0
CES 32	263.7	1.77 *	29.8	311.12	1.92 *	43.3	253.51	1.83 *	17.8
Alk 49	728.6	4.89 **	56.7	442.93	2.74 **	55.4	802.54	5.79 **	57.7
Kly 30	273.4	1.83 *	51.8	422.39	2.61 **	70.0	88.69	0.64 ns	36.7
CES 6	139.4	0.94 ns	24.6	120.48	0.75 ns	35.8	178.35	1.29 ns	15.3
CES 10/9	139.0	0.93 ns	26.8	112.96	0.70 ns	33.8	155.55	1.12 ns	21.0
RRIM600	42.0	0.28 ns	32.4	7.16	0.04 ns	46.5	50.34	0.36 ns	20.6
Chi 51	38.1	0.26 ns	31.6	1.31	0.01 ns	37.8	31.00	0.22 ns	26.4

ns: non-significant, * significantly unstable (P=0.05)

in this study. The overall girth data indicates that girth at opening was much higher in Tly 55, Pai 11, Kly 26 and CES 140 while it was much lesser in GT1. But the 25th year, the clones Tly 55, Kly 26, Tly 56, and CES 140 were superior and GT1 was on par with these clones. Tappability was much higher in clones Tly 55, CES 140, Kly 26 and Tly 56 and on par with GT1.

A comprehensive perception of various parameters (Table 11) on selected ortets indicates control clone GT1 as the highest yielder while Tly 55, CES 140 and Tly 56 were superior among the ortets. Clones CES 140, Pal 39A, Rni 64 and Tly 56 were more stable yielders among the ortets, and among the check clones RRIM 600 was highly stable. In terms of girth, clones Kly 26, Tly 55, Tly 56, CES 140 and GT1 were superior while CES 140 and Tly 55 were superior in terms of tappability. Drop in girth increment due to crop harvest was least in clone Tly 55 while it was at the maximum in the best performing clone GT1. The summer yield depression was much lesser in Alk 49 followed by Tly 56 and Kly 26 while RRII 105 was better among the check clones. The overall data indicate clones Tly 55 and CES 140 as superior among the ortet clones and to a lesser degree clone Tly 56 while they maintained yield on par with the control clone GT1 which happened to be the best performer too. The clone Tly 55 which maintained highest girth and lesser drop in girth increment due to crop harvest while maintaining better tappability can be

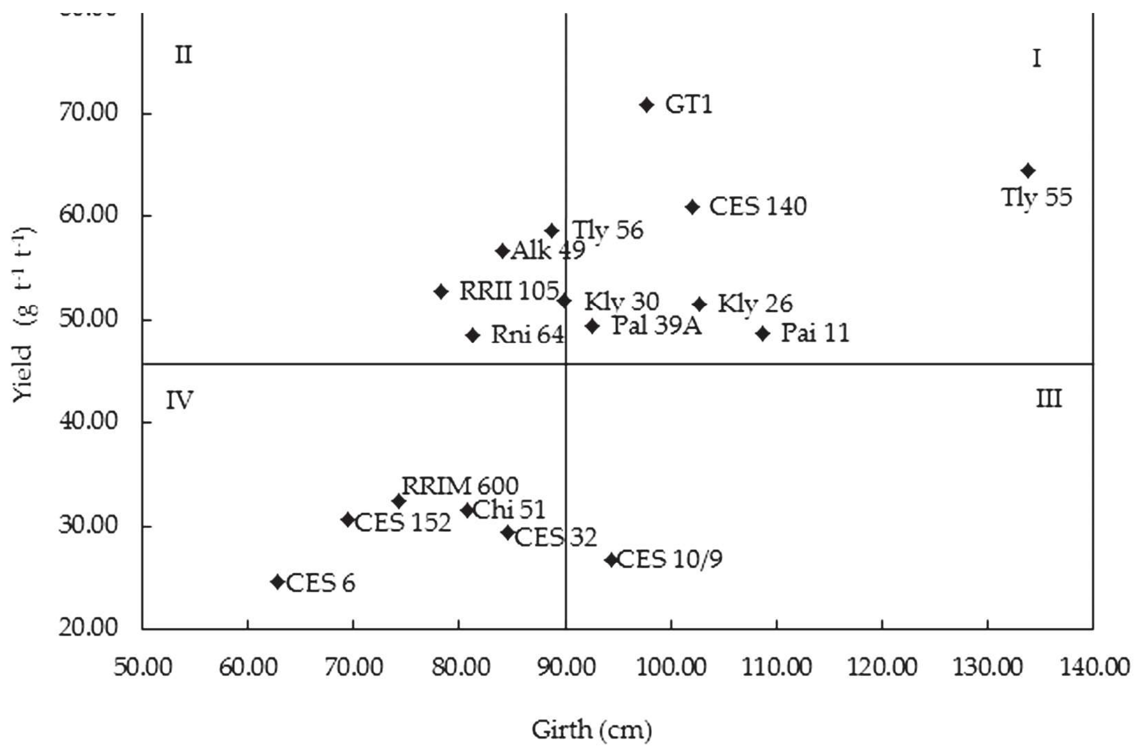

Fig. 4. Selection of clones for high yield and girth

selected as latex/timber clone also. Pipeline clones that have resulted from the findings of this study along with selections reported by Reju *et al*. (2016) and Gireesh *et al*. (2016) from the same region can be further extended with large scale and farmer participatory on- farm trials to ascertain their superiority apart from the possibility of employing them as improved genetic materials in further breeding programmes. The

Table 11. **Performance of selected ortets based on growth and yield parameters**

Clone	Yield ($g\ t^{-1}\ t^{-1}$)	Yield stability	Girth (25 yrs) (cm)	Tappability (%)	Drop in girth increment due to crop harvest (%)	Summer yield depression (%)
GT1	70.9	519.0	77.9	48.5	73.7	44.3
Tly 55	63.1	369.5	81.6	51.1	40.4	38.3
CES 140	60.9	17.9	78.8	52.6	68.3	34.0
Tly 56	58.6	74.1	79.3	47.7	71.1	20.0
RRII 105	52.7	197.9	70.7	43.5	73.7	20.1
Kly 30	52.4	273.4	71.5	46.4	54.6	45.0
Kly 26	51.6	247.0	82.3	47.3	60.8	21.1
Alk 49	51.2	728.6	62.8	41.6	69.9	15.7
Pal 39A	50.0	49.2	69.9	44.4	57.0	38.0
Rni 64	48.6	35.8	65.4	42.0	55.1	40.6
RRIM 600	32.4	42.0	64.3	45.0	80.5	21.0

promising ortets reported by Mydin *et al*. (2016) also hold importance for this region as they are selections from drought prone region and would be more suitable for Dakshin Kannada which undergoes severe drought stress during summer.

CONCLUSION

In terms of the investigated parameters such as girth and tappability, yield, yield stability and summer yield stability, the ortets Tly 55, Tly 56, CES 140, Kly 30, Pal 39A and Kly26 were found superior among the ortets studied which were comparable in yield to the top performing control clone GT1 in the agro-climatic conditions of the DK District of Karnataka. Among the above promising clones, Kly 30 has been reported to be tolerant to abnormal leaf fall disease in this hot spot region.These clones can be added to the pipeline and further subjected to large scale as well as farmer participatory trials to identify their region specificity for clone recommendation.

ACKNOWLEDGEMENT

The authors thank Dr. Kavitha K. Mydin, Joint Director (Crop Improvement), for her encouragement and support, Ms. T. Sailajadevi, Agrometeorologist, for providing the weather data and Mr. P. Aneesh, statistician for his support with statistical analysis of data.

REFERENCES

Chandrasekhar, T.R., Prakash, G. P. and Saraswathyamma, C.K. (2002). Yield performance of trees grown from polycross seeds of rubber (*Heveabrasiliensis*) in a dry sub-humid climate in India. *Indian Journal of Natural Rubber Research*, **15**(1): 19-27.

Gireesh, T., Nazeer, M.A., Chandrasekhar, T.R., Manju, M.J., and Mydin, K.K. (2016). Performance of ortet clones of *Heveabrasiliensis* in Dakshin Kannada. *Abstracts of PLACROSYM 22, 22nd Biennial Symposium on Plantation Crops,* 15-17 Dec 2016, ICAR – Central Plantation Crops Research Institute, Kasaragod, India. pp. 58

Gomez, K.A. and Gomez, A.A. (1989).*Statistical Procedures for Agricultural Research,* New York, John Wiley, pp. 207-215.

John, A., Nazeer, M.A., Idicula, S.P., Thomas, V. and Varghese, Y.A. (2013). Potential new primary clones of *Hevea* evolved by ortet selection in India. *Journal of Rubber Research,***16**(2): 134-146.

Khoo, S.K., Yoon, P.K., Meignanaratnam, K., Gopalan and Ho, C.Y. (1982). Early results of mother tree (ortet) selection. *Planters Bulletin*, **171**(6): 33-49.

Manju, M.J., Idicula, S.P., Suryakumar, M. and Murthy, P.V. (2004).Responses of some *Hevea* clones to major leaf and stem diseases in higher elevations of Karnataka region. *Journal of Plantation Crops*, **32**(supplement): 388-390.

Marattukalam, J.G., Saraswathyamma, C.K. and George, P.J. (1980).Crop improvement of *Hevea* through ortet selection in India. *Proceedings of the International Rubber Conference*, 23-28 November 1980, Rubber Research Institute of India, Kottayam, India.

Mercykutty, V.C., Meenakumari, T. and Mydin, K.K. (2013). Promising high yielding clones of *Hevea brasiliensis* evolved by ortet selection programme in Central Kerala. *Rubber Science*, **26**(1): 66-77.

Mydin, K.K. and Saraswathyamma, C.K. (2005). *A Manual on Breeding of Hevea brasiliensis*. Rubber Research Institute of India, 97p.

Mydin, K.K., John, A., Nazeer, M.A., Prem, E., Thomas, V. and Saraswathyamma, C.K. (2005). Promising *Hevea brasiliensis* clones evolved by ortet selection with emphasis on latex timber traits and response to stimulation. *Journal of Plantation Crops*, **33**(1): 18-28.

Mydin, K.K., John, A. and Meenakumari, T. (2016). Clones evolved by ortet selection from polycross populations of rubber in Central India. *Rubber Science*, **29**(3): 246-255.

Nair, V.K.B. and Panikkar, A.O.N. (1966).Progress of investigations on the improvement of rubber planting materials in India. *Rubber Board Bulletin,* **8**: 201-210.

Nair, V.K.B. and Marattukalam, J.G. (1975). Report on the performance of RRIM clones in India (500 and 600 series). *Rubber Board Bulletin*, **12**(2): 41-49.

Prabhakaran, V.T. and Jain, J.P. (1994). *Statistical Techniques for Studying Genotype-Environment Interactions*. South Asian Publishers Pvt. Ltd, New Delhi, pp. 151-176.

Reju, M.J., Nazeer, M.A., Suryakumar, M., Chandrasekhar, T.R. and Mydin, K.K. (2016). Ortet selections from small holdings in Kerala-Long term growth and yield under small scale evaluation in Karnataka. *Rubber Science*, **29**(3): 224-237.

Sanjeeva Rao, P and Vijayakumar, K.R (1992). Climatic Requirements. In: *Natural Rubber: Biology, Cultivation and Technology* (Eds. M.R. Sethuraj and N.M. Mathew). Elsevier, New York, pp. 200-217.

Saraswathyamma, C.K. and George, P.J. (1992). The breeding programme of *Hevea brasiliensis* in India during early 1970s. *Rubber Reporter*, **17**: 21-23.

Saraswathyamma, C.K., Licy, J. and Marattukalam, J.G. (2000a). Planting materials. In: *Natural Rubber: Agromanagement and Crop Processing.* (Eds. P.J. George and C. Kuruvilla Jacob), Rubber Research Institute of India, Kottayam, India, pp. 59-74.

Saraswathyamma, C.K., Marattukalam, J.G., Chandrasekhar, T.R., Licy, J., Thomas, V., Premakumari, D., Mydin, K.K., Mercykutty, V.C., Meenattoor, J.R., John, A., Gireesh, T., Meenakumari, T. and Sankariammal, L. (2000b). *Rubber Clones Approved for Planting in India – A Catalogue*. Rubber Research Institute of India, Kottayam, 66p.

Tan. H. (1981).Estimates of genetic parameters and their implications in *Hevea* breeding. In "Crop Improvement Research" (Proceedings of the 4th International Congress, The Society for Advancement of Breeding Researches in Asia and Oceana, Kuala Lumpur, (Eds. T.C. Yap, K.M. Graham and JalaniSukami). pp 439-446.