ORTET SELECTIONS FROM SMALL HOLDINGS IN KERALA - LONG TERM GROWTH AND YIELD UNDER SMALL SCALE EVALUATION IN KARNATAKA

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Clones derived from selected ortets were tested in a field trial at the experimental farm of the *Hevea* Breeding Sub-Station at Nettana in Dakshina Kannada district of Karnataka. Fifteen clones were planted in the trial. Girth and yield of the clones were recorded. Girth increment during the immature and mature phases, yield of the clones over the first four years, long term yield over 11 years and yield in the BO-1 and BO-2 panels were analyzed to identify the superior clones in the trial. Girth at opening and tappability attained by the clones were also recorded. Clones with superior yield during summer, monsoon and post-monsoon seasons, and those with stability in growth and yield were selected. Drop in the rate of girth increment due to crop harvest and drop in the summer yield were also determined. Highest mean monthly yield was recorded during November. The highest yielding season was post-monsoon. In this trial, seven clones *viz*. Ayr 2, Pai 17, Pal 15, CES 42, CES 70, Alk 47 and CES 1/2 were identified for their improved attributes over the check clones. High yield and high girth were recorded in Ayr 2 and Pai 17. Alk 47 was identified as a potential timber-latex clone. Five clones were medium yielders with high girth (Pal 15, CES 42, CES 70, Alk 47 and CES 1/2). These clones were found superior to RRII 105 in the non-traditional Dakshina Kannada district of Karnataka

Key words: Ortet, *Hevea* breeding, Clones, Stability, Growth, Yield

INTRODUCTION

Success in *Hevea* breeding, as in any other crop plant, depends on the extent of variability in the breeding population. In India, the most important objective of *Hevea* breeding is generation of genetically improved cultivars for the farming community. Both conventional and non-conventional methods are employed in *Hevea* breeding (Simmonds, 1989; Arokiaraj *et al*., 1994; 1996; Mydin, 2014). However, almost all the popular clones available to the farming community in the rubber growing countries are developed exclusively through conventional breeding methods. Hybridization involving selected parents, evaluation of poly-cross progenies, half-sibs, and evaluation ofexotic clones are

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the major *Hevea* genetic improvement programmes in India. A large number of reports are available on conventional breeding programmes and clones developed through it (Panikkar *et al.,* 1980; Nazeer *et al*., 1989; 1991; Mydin *et al.,* 1990; Saraswathyamma and George, 1992; Mydin and Saraswathyamma, 2005). Ortet selection, also known as mother tree selection, is one of the oldest conventional breeding methods in *Hevea* which is still relevant in crop improvement programmes.

Ortet selection is essentially selection of individual seedling trees from a seedling population based on yield and secondary characters, which upon vegetative multiplication retains its superiority. 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). Clones developed through ortet selection fall into the category of primary clones. Some of the primary clones, developed through ortet selection, are still being cultivated in small holdings and large estates and also have become parents for the next generation of secondary clones. 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, Mil3/2 and Haiken 1. Some of the most popular secondary clones like RRII 105, RRII 203, RRII 208, RRIC 100 and RRIM 600 have either one or both of their parents as primary clones.Clones developed by the Rubber Research Institute of India in the RRII series from one to hundred (RRII 1 - RRII 100) are ortet clones (Marattukalam *et al.,* 1980). A systematic screening programme of seedling rubber plantations in order to develop ortet clones began in Kerala in the early 1980s in large estates (Mydin *et al.,* 2005b)and subsequently in the small holdings. Selected ortets were bud-grafted and evaluated in different agro-climatic zones for developing location specific clones. With a view to screen clones and identify suitable clones for the South Karnataka region, three batches of ortet clones were planted in the experimental farm. This paper discusses the performance of one of the three batches of ortet clones in the Dakshina Kannada district of Karnataka.

MATERIALS AND METHODS

The *Hevea* Breeding Sub Station in Nettana, Dakshina Kannada district, Karnataka is part of the Coastal Karnataka region. This region receives heavy rainfall during the south- west monsoon with a weak north-east monsoon and the annual rainfall ranging from 3000 to 5000 mm. Weather parameters recorded from the region from 1989 to 2009 are given in Table 1. Most of the rain fall was restricted to the period from June to September. The area also experiences five months of dry period from December to April.The maximum temperature in the area ranged from 27.6°C in July to 36.2°C in March, and minimum temperature from 15.6°C in January to 22.7°C in May. Total annual rainfall recorded for twenty one years was 4696 mm and the average daily bright sunshine hours recorded was six.The experimental farm lies in the latitude of 12^0 43'N and longitude of 75^0 32' E. Elevation of the area is 120m above the MSL. Soil is lateritic and the texture is sandy clay loam.

Fifteen 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 various parts of 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

Table 1. **Weather parameters at the experimental farm during the study period**

Month	Air temperature (^{O}C)		Sunshine	Rainfall	Relative humidity (%)	
	Maximum	Minimum	(hours/day)	(mm/month)	Morning	Evening
January	34.1	15.6	8.8	3.7	85.6	40.6
February	35.0	16.7	8.8	9.4	87.8	41.2
March	36.2	20.0	8.6	15.1	87.7	39.4
April	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
June	29.5	21.6	2.7	874.5	92.1	79.6
July	27.6	21.5	1.3	1370.0	92.8	84.2
August	27.9	21.8	2.0	1070.9	92.0	80.6
September	29.8	21.7	4.5	470.9	91.5	73.6
October	31.4	21.6	5.6	412.2	90.9	68.3
November	32.8	19.8	7.1	112.0	86.8	57.2
December	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

Table 2. **Clones evaluated and location of base populations**

Sl. No.	Ortet clones	Place of selection
1	CES 42	Chethackal
2	CES 70	Chethackal
3	CES 1/2	Chethackal
4	CES 7/2	Chethackal
5	Pai 17	Paika
6	Pai 19	Paika
7	Pal 15	Pala
8	Kan 44	Kannur
9	Kan 46	Kannur
10	Bhg 45	Bharanaghanam
11	Chi 50	Chemberi
12	Edm 34	Edamaruke
13	Ert 41	Erattayar
14	Alk 47	Alackode
15	Ayr 2	Ayarkunnam
Check clones		
16	RRIM 600	Malaysia
17	RRII 105	India
18	GT 1	Indonesia

system. The ortet clones were Ayr 2, Pal 15, Pai 17, Pai 19, Edm 34, Ert 41, CES 42, Kan 44, Bhg 45, Kan 46, Alk 47, Chi 50, CES 70, CES 1/2 and CES 7/2,and the check clones were RRII 105, GT 1 and RRIM 600.

Girth was recorded quarterly from the third year of planting during the immaturity period. Annual girth recording at 125cm height from the bud-union was carried out since the opening of the trees for crop harvest. Girth at opening and tappability attained by the clones were recorded.Girth increment during the immature and mature phases, and drop in girth increment due to crop harvest 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 in the trial were opened for tapping in September 2001 under S/2 d/3 6d/7 tapping system when all the clones attained tappable girth. The rubber yield was recorded as dried rubber from the cup coagulum collected from 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 (Gomez and Gomez, 1989). The dry rubber yield from the BO-1 panel (2002 - 2006), BO-2 panel (2007 – 2013), average yield of the first four years of tapping, annual yield for the period from 2002to 2013, yield during the summer months (February-May), monsoon period (June-September) and post-monsoon period (October-January) were analysed to assess the yielding potential and yield pattern of the ortet clones. Stability variance was computed for yield of the clones on both BO-1 and BO-2 panels and over the long term for eleven years of tapping. Tapping in the BO-2 panel was prolonged due to the non-tapping of the trees in 2010 under unavoidable circumstances.

RESULTS AND DISCUSSION

Dakshina Kannada district of Karnataka is a non-traditional rubber growing area. Generally, regions situated above 10^{O}N latitude are considered non-traditional for rubber cultivation, and though these regions receive sufficient rainfall, severe moisture deficits occur four to six months (Sanjeeva Rao and Vijayakumar, 1992). Evaluation of clones in this region can lead to the selection of clones adaptable to this area as well as other regions of the South Canara tract. Ortet evaluation trials established in this region provide scope for the identification and selection of clones suitable for the prevailing climatic conditions in the region. Early

Table 3. **Girth and tappability of clones**

Clone	Girth (cm)		Tappability attained by the clones (%)		
	25th year of planting (13th year of tapping)	Girth at opening	7th year	8th year	9th year
Alk 47	128.6a	84.2a	21	70	100
Ayr 2	115.5ab	83.5ab	21	71	100
Pai 17	113.7ab	81.4ab	79	79	86
CES 42	103.9ab	80.1ab	43	78	78
Pal 15	101.5bc	65.3fg	15	54	70
CES 70	93.1bc	74.3bc	7	60	92
CES 1/2	92.4bc	74.9ab	14	36	57
Ert 41	91.9cd	70.5de	43	78	93
Edm 34	88.9cd	73.1cd	27	53	80
Kan 46	88.1cd	70.2ef	7	21	64
Bhg 45	84.7de	69.3ef	9	46	79
CES 7/2	81.6de	65.8fg	8	23	69
Kan 44	80.2de	65.4fg	8	46	87
Pai 19	74.2ef	56.0i	15	27	27
Chi 50	68.6f	59.8hi	6	15	17
RRIM 600	73.8ef	62.9gh	14	14	36
RRII 105	75.1ef	71.2de	10	27	64
GT1	84.1de	76.5ab	8	69	92
General mean	90.5	71.35			
CV	14.76	7.24			

Means followed by the same letters do not differ significantly.

attainability of tappable girth and better dry rubber yield than that of the existing popular clones formed the basic criteria for selection of superior clones. Seasonal yield and stability in growth and yield were also considered for clonal selection.

Girth recorded in the 25th year of planting (13th year of tapping) showed Alk 47 (128.6 cm) in the first rank followed by Ayr 2 (115.5 cm), Pai 17 (113.7 cm), CES 42 (103.9 cm), Pal 15 (101.5 cm), CES 70 (93.1 cm) and CES 1/2 (92.4 cm). All these clones were superior to GT 1 (84.1 cm) which was the most vigorous among the check clones (Table 3). Girth at opening was also the highest in Alk 47 (84.2 cm) followed by Ayr 2 (83.5 cm), Pai 17 (81.4 cm), CES 42 (80.1 cm), CES 1/2 (74.9 cm) and CES 70 (74.3 cm). Girth at opening of these clones was on par with that of GT 1 (76.5 cm) while superior to RRII 105 (71.2 cm). Normally, when 70 per cent of the trees attain girth of 50 cm at a height of 125cm from the bud-union in plantation, the treescan be opened for tapping (Vijayakumar *et al*., 2000). In this trial, Pai 17 (79%) attained tappability in the 7th year after planting. In the 8th year Ayr 2 (71%), CES 42 (78%), Alk 47 (70%), and Ert 41 (78%) attained tappability. In the 9th year CES 42 (78%), Pal 15 (70%), CES 70 (92%), Edm 34 (80%), Bhg 45 (79%), GT I (92%) and Kan 44 (87%) attained tappability. Eleven ortet clones and one check clone attained tappability by the 9th year after planting. The early tappability of clone Pai 17 is note worthy. However, opening of the clones in the trial was delayed until the 13th year to enable simultaneous opening of trees from the other two batches of the ortet trials planted in the same year.

Girth increment during the immature and mature phases was computed (Table 4). During the immature phase, clones Pai 17 (6.2 cm), Alk 47 (6.2 cm), Ayr 2 (6.1 cm), CES 42 (6 cm), CES 70 (5.7 cm), Edm 34 (5.4 cm), Kan 46 (5.3 cm), Ert 41 (5.3 cm), CES 1/2 (5.2 cm), Bhg 45 (5.1cm) showed superior performance to RRIM 600 (4.7 cm) and RRII 105 (4.5 cm), however, their performance was on par with GT 1 (5.6 cm). In the mature phase, girth increment of Alk 47 (3.7 cm), Pai 17 (2.8 cm) and Ayr 2 (2.8 cm) was superior to GT 1 (1.2 cm). Mean of the girth increment during the immature period was 5.2 cm and that of the mature period was only 1.8 cm. This difference in the girth increment between the immature and mature periods may be attributed to the initiation of tapping of the trees. Clonal variation in girth increment

Table 4. **Girth increment of clones**

Clone	Girth increment (cm/yr)		Drop in rate of girth increment due to crop harvest (%)
	Immature phase	Mature phase	
Pai 17	6.2a	2.8b	54.8
Alk 47	6.2a	3.7ab	40.3
Ayr 2	6.1a	2.8b	54.1
CES 42	6.0ab	1.9cd	68.3
CES 70	5.7ab	1.9cd	66.7
Edm 34	5.4ab	1.6cd	70.4
Kan 46	5.3ab	1.7cd	67.9
Ert 41	5.3ab	1.8cd	66.0
CES 1/2	5.2ab	1.6cd	69.2
Bhg 45	5.1ab	1.4cd	72.6
Pal 15	4.9bc	2.2bc	55.1
Kan 44	4.9bc	1.5cd	69.4
CES 7/2	4.6cd	1.9cd	58.7
Chi 50	4.5de	0.8e	82.2
Pai 19	3.7e	1.7cd	54.1
RRIM 600	4.7cd	1.3cd	72.3
RRII 105	4.5de	1.1de	75.6
GT 1	5.6ab	1.2cd	84.6
GM	5.2	1.8	
CV	11.1	26.9	

Means followed by the same letters do not differ significantly.

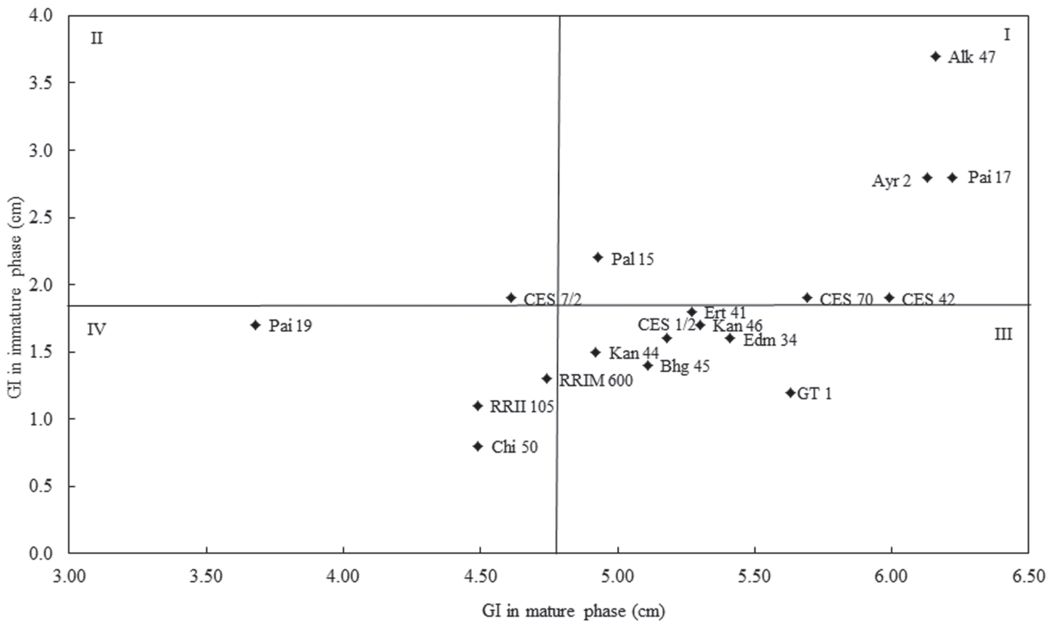

Fig. 1. Girth increment (GI) of clones during mature and immature phases

during the mature phase (CV = 26.9%) was more than that in the immature phase (CV=11.1%), this in turn may be attributed to the varying yielding potential of the clones in the trial and their varying response to tapping. Drop in the rate of girth increment due to crop harvest was also computed. Clone Alk 47, a high girthing clone, exhibited minimum loss in girth increment (40.3%) due to crop harvest. Maximum loss in girth increment was recorded in Chi 50 (82.2%). Among the check clones, maximum loss was in GT 1 (84.6%). Ortet clones Ayr 2 (54.1%), Pai 17 (54.8%) and Pal 15 (55.1%) which are also high girthing and high yielding clones showed comparatively less drop in the rate of girth increment. Clones having high girth at opening, comparatively less drop in girth increment in the mature phase and the high yielding potential may be considered as latex timber clones. High growth rate in the mature phase is an indication of high timber yielding potential of these clones (Alice *et al.*, 2013). The scatter diagram of girth increment during the immature and the mature phases showed Alk 47, Ayr 2, Pai 17 and Pal 15 in quadrant I of the high ranking clones (Fig. 1).

Stability analysis for growth showed a different picture of the performance of the clones (Table 5). In the immature phase, only two clones of high yielding potential and growth showed stable growth performance (Ayr 2 and Pal 15) while most of the remaining promising clones exhibited significant variation in growth and thus less stable. In the mature phase, one promising ortet clone Ert 41 showed growth stability, and among the check clones GT 1 was a stable performer.

During the first four years of tapping, nine ortet clones showed yield on par with the check clones (Table 6). Highest yield was recorded in Ayr 2 (64.4 g $t^{-1}t^{-1}$), followed by

Table 5.**Growth stability of clones**

Girth increment during immature phase (cm/yr)				Girth increment during mature phase (cm/yr)			
Clone	Shukla's stability variance	F value	Mean	Clone	Shukla's stability variance	F value	Mean
Bhg 45	0.073	0.358ns	5.1	Edm 34	0.144	0.443ns	1.6
Kan 46	0.090	0.445ns	5.3	CES 1/2	0.147	0.453ns	1.6
Pal 15	0.208	1.022ns	4.9	Bhg 45	0.298	0.917ns	1.4
Pai 19	0.241	1.184ns	3.7	Chi 50	0.470	1.447ns	0.8
Ayr 2	0.298	1.469ns	6.1	Kan 46	0.475	1.463ns	1.7
CES 1/2	0.371	1.827*	5.2	CES 70	0.591	1.819*	1.9
CES 7/2	0.386	1.901*	4.6	Kan 44	0.812	2.498*	1.5
Pai 17	0.446	2.194*	6.2	CES 7/2	0.903	2.778*	1.9
Chi 50	0.601	2.961*	4.5	Pai 19	0.951	2.928*	1.7
Edm 34	0.651	3.206*	5.4	RRII105	1.172	3.606*	1.1
CES 42	0.682	3.359*	6.0	RRIM600	1.392	4.285*	1.3
CES 70	0.722	3.556*	5.7	Pai 17	1.918	5.903*	2.8
Alk 47	0.763	3.754*	6.2	CES 42	2.048	6.304*	1.9
Ert 41	0.824	4.055*	5.3	Ayr 2	2.670	8.216*	2.8
Kan 44	0.856	4.214*	4.9	Alk 47	4.702	14.473*	3.7
RRIM 600	0.722	3.553*	4.7	Pal 15	1.737	5.346*	2.2
RRII 105	0.229	1.128ns	4.5	Ert 41	0.308	0.947ns	1.8
GT1	0.237	1.167ns	5.6	GT1	0.395	1.215ns	1.2
General mean			5.2	Mean			1.8
CV			11.1	CV			26.92

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

CES 1/2 (63.6 g $t^{-1}t^{-1}$), GT 1 (63.2 g $t^{-1}t^{-1}$) and CES 42 (63.0 g $t^{-1}t^{-1}$). Lowest yield was recorded in Pai 19 (25.0 g $t^{-1}t^{-1}$). Yield in the BO-1 panel showed the same trend as that in the first four years. Highest yield was in Ayr 2 which was on par with that of GT 1. However, there was a clear change in the yield performance of clones in the BO-2 panel. Ayr 2 (95.4 g $t^{-1}t^{-1}$) continued to be the top yielder and significantly superior to GT 1(59.7 g $t^{-1}t^{-1}$), the top yielder among the check clones. Pai 17 (86.9 g $t^{-1}t^{-1}$) and Pal 15 (78.0 g $t^{-1}t^{-1}$) also were superior to GT 1. Clones Ert 41 (68.8 g $t^{-1}t^{-1}$), CES 70 (65.6 g $t^{-1}t^{-1}$), Alk 47 (65.2 g $t^{-1}t^{-1}$) and CES 42 (64.9 g $t^{-1}t^{-1}$) were also promising clones, their yield was on par with GT 1 while superior to RRII 105 (41.1 g $t^{-1}t^{-1}$) and RRIM 600 (30.0 g $t^{-1}t^{-1}$). The stable and high growth rate of clone Ayr 2 continued into their superior yield over the years.

Long term yield of the ortet clones over eleven years showed the superiority of Ayr 2 (81.7 g $t^{-1}t^{-1}$) over GT 1 (61.3 g $t^{-1}t^{-1}$). Five ortet clones *viz*. Pai 17 (75.2 g $t^{-1}t^{-1}$), Pal 15 (68.5 g $t^{-1}t^{-1}$), CES 42 (64.0 g $t^{-1}t^{-1}$), Ert 41 (63.1 g $t^{-1}t^{-1}$) and CES 70 (62.1 g $t^{-1}t^{-1}$) showed yield superior to RRII 105 (47.2 g $t^{-1}t^{-1}$) and RRIM 600 (43.8 g $t^{-1}t^{-1}$). The lowest yield was recorded in Pai 19 (23.2 g $t^{-1}t^{-1}$). Long term

Table 6. **Yield performance of clones**

Clone	Average yield of clones ($g\ t^{-1}t^{-1}$)			
	Average of first 4 years	BO-1 Panel	BO-2 Panel	Annual mean yield over 11 years
Ayr 2	64.4a	65.2a	95.4a	81.7a
Pai 17	61.2ab	61.0ab	86.9ab	75.2ab
Pal 15	57.1ab	57.0ab	78.1ab	68.5ab
CES 42	63.0a	63.0a	64.9cd	64.0bc
Ert 41	56.2ab	56.2ab	68.8bc	63.1bc
CES 70	57.1ab	57.9ab	65.6cd	62.1bc
Alk 47	45.9bc	46.4bc	65.2cd	56.7cd
CES 1/2	63.6a	63.7a	50.5de	56.5cd
Edm 34	55.3ab	55.9ab	48.8de	52.0cd
Kan 44	40.3cd	40.2cd	36.3fg	38.1fg
CES 7/2	33.9cd	34.4cd	36.4fg	35.5fg
Chi 50	33.4cd	33.2cd	30.6fg	32.0gh
Kan 46	35.3cd	35.4cd	28.4fg	32.0gh
Bhg 45	29.0de	29.4d	25.8g	27.3hi
Pai 19	25.0e	25.3d	21.5g	23.2i
RRIM 600	58.2ab	60.4ab	30.0fg	43.8ef
RRII 105	54.7ab	54.5ab	41.1ef	47.2de
GT 1	63.2a	63.2a	59.7cd	61.3bc
General mean	49.8	50.1	51.9	51.1
CV	16	16.1	22.7	18.2

Means followed by the same letters do not differ significantly.

yield performance of the clones is an indication of the yielding potential of the clones. Superior yield performance in the long term, and high girth can form the basis for identification of clones suitable for a particular region as most of the clones selected through ortet selections are primarily based on yield performance and girth. Yield of clones during summer (February - May), monsoon (June -September) and post-monsoon (October-January) seasons were computed. The clones showed highest mean yield in the post-monsoon period (61.9 $g\ t^{-1}t^{-1}$) followed by monsoon (49.5 $g\ t^{-1}t^{-1}$) and summer seasons (37.2 $g\ t^{-1}t^{-1}$). Yield drop during the summer season in comparison to the annual average yield was highest in GT 1 (38.9%) and lowest in RRII 105 (16.2%) (Table7). Summer yield drop may be attributed to the prevailing climatic conditions of the region which is characterized by high temperatures in summer, absence of rainfall, low relative humidity, de-foliation and re-foliation pattern and leaf maturation of the clones. In the summer season, four clones *viz.* Ayr 2 (61.4 $g\ t^{-1}t^{-1}$), Pai 17 (55.5 $g\ t^{-1}t^{-1}$), Ert 41 (49.4 $g\ t^{-1}t^{-1}$) and CES 70 (47.5 $g\ t^{-1}t^{-1}$) showed superiority over all the check clones (RRII 105) (39.5 $g\ t^{-1}t^{-1}$), GT 1 (37.4 $g\ t^{-1}t^{-1}$) and RRIM 600 (36.4 $g\ t^{-1}t^{-1}$). It is reported that, in regions of

Table 7. **Seasonal yield of clones**

Clone	Seasonal yield of clones (g $t^{-1}t^{-1}$)			
	Summer (February – May)	Monsoon (June – September)	Post-Monsoon (October – January)	Drop in summer yield (%)
Ayr 2	61.4a	74.4a	95.1a	24.8
Pai 17	55.5ab	65.0ab	93.1ab	26.1
Ert 41	49.4ab	56.6bc	72.8ab	21.7
CES 70	47.5ab	55.7bc	74.2ab	23.5
CES 1/2	45.4bc	57.6bc	67.9cd	19.7
Pal 15	44.7bc	58.8ab	92.8ab	34.7
CES 42	42.3bc	65.2ab	76.4ab	33.9
Alk 47	40.3cd	44.2de	71.9bc	28.8
Edm 34	36.4cd	50.1bc	66.5cd	30.0
CES 7/2	28.9de	34.0fg	39.6ef	18.7
Kan 44	25.2ef	40.2ef	48.0de	33.8
Kan 46	23.2fg	33.8fg	37.3ef	26.5
Chi 50	20.0g	33.55fg	37.2ef	37.5
Pai 19	19.1g	24.8g	25.5g	17.9
Bhg 45	17.0g	34.2fg	27.3fg	37.7
RRIM 600	34.9cd	52.4bc	54.7cd	20.5
RRII 105	39.5cd	48.1cd	56.3cd	16.2
GT 1	37.4cd	62.2ab	77.7ab	38.9
General mean	37.2	49.5	61.9	
CV	21.5	17.3	19.5	

Means followed by the same letters do not differ significantly.

drought, clones with high yield possess certain degree of tolerance to drought (Sethuraj, 1992). Summer yield drop ranged from 16.2 to 37.5per cent in the clones and was moderate in certain high yielding clones like Ayr 2 (24%), Pai 17 (26.1%), Ert 41 (21.7%) and CES 70 (23.5%). These four ortet clones could be considered fairly tolerant to drought. In the monsoon period, Ayr 2 (74.4 g $t^{-1}t^{-1}$) was superior to RRII 105 (48.1 g $t^{-1}t^{-1}$) and RRIM 600 (52.4 g $t^{-1}t^{-1}$). CES 42 (65.2 g $t^{-1}t^{-1}$), Pai 17 (65.0 g $t^{-1}t^{-1}$) and Pal 15 (58.8 g $t^{-1}t^{-1}$) were superior to RRII 105, but on par with GT 1 (62.2 g $t^{-1}t^{-1}$) and RRIM 600. During high yielding post-monsoon season Ayr 2 (95.1 g $t^{-1}t^{-1}$), Pai 17 (93.1 g $t^{-1}t^{-1}$), Pal 15 (92.8 g $t^{-1}t^{-1}$), CES 42 (76.4 g $t^{-1}t^{-1}$), CES 70 (74.2 g $t^{-1}t^{-1}$) and Ert 41(72.8 g $t^{-1}t^{-1}$) were superior to RRII 105 (56.3 g $t^{-1}t^{-1}$) and RRIM 600 (54.7 g $t^{-1}t^{-1}$). Scatter diagram of yield and girth at opening of the clones also showed these clones in quadrant I of top performers (Fig. 2). High yield of clones during the post-monsoon season may be attributed to the conducive climatic conditions prevailing in the region during the season, compared to the rest of the seasons.

Stability analysis for yield revealed the stable performance of some of the high yielding clones in the BO-1 panel (Table 8).

Table 8. **Yield stability of clones**

Clone	Annual average over 11 years			BO-1 panel			BO-2 panel		
	Shukla's stability variance	F value	Mean	Shukla's stability variance	F value	Mean	Shukla's stability variance	F value	Mean
Chi 50	12.27	0.28ns	31.9	0.956	0.114ns	33.19	23.648	0.662ns	30.9
Pai 19	20.01	0.45ns	23.2	31.042	3.699*	25.34	3.685	0.103ns	21.5
CES 7/2	24.30	0.55ns	35.5	7.151	0.852ns	34.44	51.609	1.445ns	36.4
Edm 34	28.92	0.66ns	52.0	3.673	0.438ns	55.86	51.905	1.456ns	48.8
Kan 46	29.22	0.66ns	31.6	3.986	0.475ns	35.35	19.258	0.539ns	28.4
Kan 44	41.63	0.94ns	38.1	9.317	1.110ns	40.17	101.503	2.843*	36.3
CES 70	43.02	0.98ns	**62.1**	23.111	2.754*	57.89	55.833	1.564ns	**65.6**
CES 42	47.37	1.07ns	**64.0**	9.202	1.096ns	**63.02**	95.284	2.668*	**64.9**
Bhg 45	50.64	1.15ns	27.5	11.525	1.373ns	29.42	94.196	2.638*	25.8
Ert 41	83.81	1.90*	63.1	2.796	0.333ns	56.22	114.150	3.197*	68.8
CES 1/2	102.95	2.33*	56.5	22.190	2.644*	**63.73**	169.019	4.733*	50.5
Alk 47	125.99	2.86*	56.7	25.407	3.027*	46.42	61.191	1.714*	**65.2**
Pal 15	156.72	3.56*	**68.5**	3.733	0.445ns	**57.00**	245.123	6.865*	**78.0**
Pai 17	181.27	4.11*	**75.2**	8.153	0.971ns	**61.03**	14.109	0.935ns	**86.9**
Ayr 2	241.37	5.47*	**81.7**	8.763	1.044ns	**65.19**	38.628	1.082ns	**95.4**
RRIM 600	360.87	8.18*	43.8	63.078	7.516*	60.41	63.345	1.774*	30.0
RRII 105	94.67	2.15*	47.2	35.641	4.247*	54.45	30.100	0.843ns	41.1
GT 1	72.00	1.63ns	61.3	32.628	3.888*	63.24	137.235	3.843*	59.7
G M			51.1			50.13			51.9
CV			31.9			33.19			30.9

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

Clones Ayr 2, Pai 17, Pal 15, Ert 41 and CES 42 showed insignificant variation for yield in the BO-1 panel. In the BO-2 panel, among the high yielding clones, only three clones *viz.* Ayr 2, Pai 17 and CES 70 showed insignificant variation for yield. However, when the long term yield was subjected to stability analysis, only two of the high yielding clones *viz.* CES 42 and CES 70 exhibited less yield fluctuations over the long term. Along with stability, mean yield is also very important for clonal selection. Therefore, in the final selection of clones for yield performance, mean yield per se of the clones is the preferred selection criterion.

Pattern of annual yield of the high yielding clones over the years shows less variation in the initial years (BO-1 panel) (Fig. 3). Clonal variation was clearly visible after 2006 which depicts yield in the BO-2 panel.RRII 105 was low yielding in comparison to the high yielding ortet selections. The high clonal variations for yield in the BO-2 panel may be attributed to the expression of the varying yielding potential of the clones. Seasonal yield

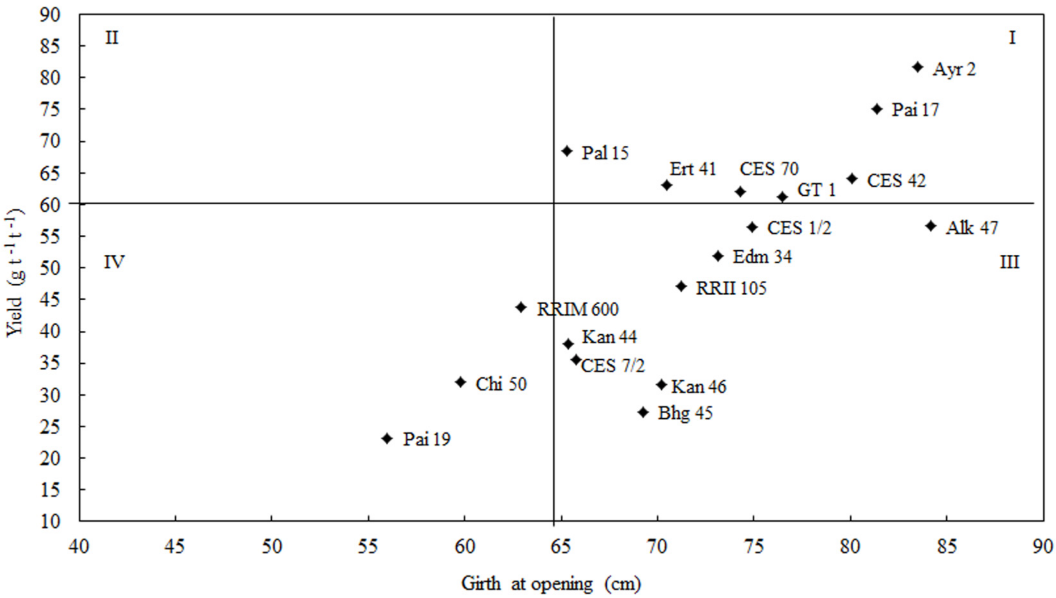

Fig. 2. Yield and girth at opening of clones

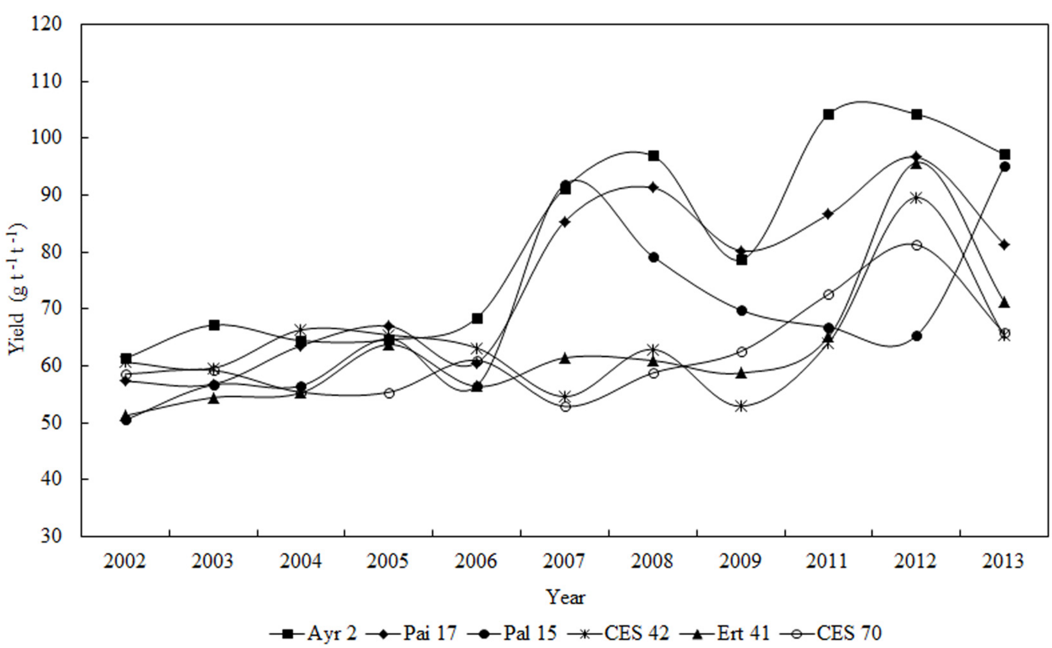

Fig. 3. Pattern of annual yield of certain high yielding ortet clones

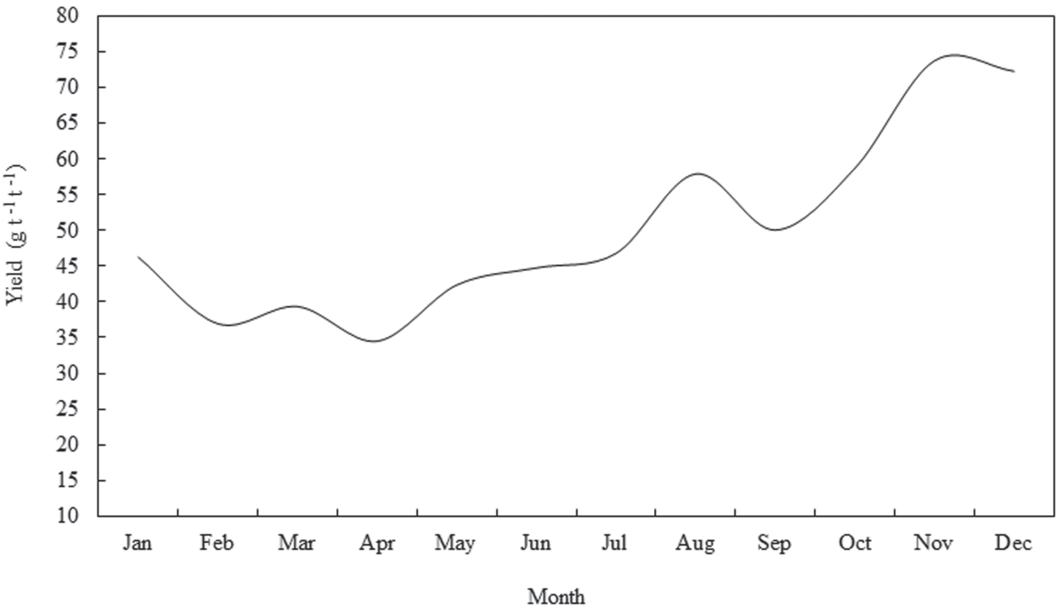

Fig. 4. Pattern of monthly yield

pattern showed two peaks in the year. August and November represented the two peaks (Fig. 4). Monthly yield showed a rising trend from September to December. The general trend of high yield in India is from September to January (Sethuraj, 1992). Highest yield was recorded in November and the lowest yield was in April as also reported earlier (Mydin and Mercykutty, 2007).

Reports on performance of ortet clones in small scale trials are available from the traditional regions of Kerala (Mydin *et al.*, 2005; Alice *et al.*, 2013; Mercykutty *et al.*, 2013a; 2013b). A number of clones like CyO, MO, KnO and KOseries were reported from the ortet selections from large estates like Cheruvally, Mundakkayam and Koney in the traditional area. Some clones from these series *viz*. Cy O 48, KO 27 and MO 45 were found to be highly promising in terms of both growth and yield. Potential latex-timber clones were also identified from among the ortet clones. Some of those clones are MO 45, MO 15, MO 12, MO 28, KO 7, KO 13, Kn O 39, Kn O 49 and Kn O 36. Among the check clones, GT 1 was the most vigorous clone in various trials. Clones superior to GT 1 in terms of girth in these trials could be classified as vigorous clones. Identification of ortet clones superior to the local popular clones like RRII 105, GT 1 and RRIM 600from the small scale trials under various agro-climatic conditions offer scope for selection of clones suitable for the traditional and non-traditional areas in India.

CONCLUSION

Primarily on the basis of average annual yield of the ortet clones, and on the basis of girth and girth increment, seven clones *viz*. Ayr 2, Pai 17, Pal 15, CES 42, CES 70, CES 1/2 and Alk 47 identified from

Ayarkunnam, Paika, Pala, Chethackal and Alackode, respectively were found promising in the agro-climatic conditions of Dakshina Kannada district of Karnataka. Of these seven clones, two were identified for high yield and high girth (Ayr 2 and Pai 17) and five were medium yielders with high girth (Pal 15, CES 42, CES 70, Alk 47 and CES 1/2). Alk 47was identified as a timber-latex clone. Promising clones from this small scale trial will be subjected to further large scale and on-farm evaluations in a participatory approach to confirm the superiority of these clones for use as improved planting materials by the farmers of the region.

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