CLONES EVOLVED BY ORTET SELECTION FROM POLYCROSS POPULATIONS OF RUBBER IN CENTRAL INDIA

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Expansion of rubber cultivation in India to non-traditional areas has necessitated selection of clones suitable for drought prone regions. Ortet selection from polycross seedling populations established at the Regional Research Station of the Rubber Research Institute of India (RRII) in Dapchari, Maharashtra, in the drought prone North Konkan led to selection of 13 elite plus trees which gave promising yield under rainfed conditions. The 13 ortets were cloned and evaluated for their yield potential under the favourable agro climatic situation in the Central Experiment Station of RRII in the traditional rubber growing region of Central Kerala.

Evaluation of the clones for yield, growth and the structural and physiological components of yield over six years of tapping in panel BO-1 under a S/2 d3 6d/7 system of tapping without stimulation led to the identification of two clones viz. D 111 and D 37 which were superior for most of the traits. Ortet clone D 111 gave a very high yield of 90.8 g $t^{-1}t^{-1}$ in panel BO-1 and had the highest summer yield of 64.4g $t^{-1}t^{-1}$which was significantly superior to the check and the rest of the ortet clones. This was followed by clone D 37 (62.7g $t^{-1}t^{-1}$) which was comparable to the check clone RRII 105 (63.9 g $t^{-1}t^{-1}$) in terms of annual mean yield in panel BO-1 and was superior to the check clone in summer yield which was as high as 44.1g $t^{-1}t^{-1}$. Four more ortet clones viz. D 236, D 95, D 35 and D 173 with yield of more than 50.0g $t^{-1}t^{-1}$were on par with the high yielding check clone RRII 105. While D 111 also possesses high summer yield, D 37 was found to be a high girthing clone. Both these clones are promising in terms of yield components like a high number of latex vessel rows and high volume of latex. No incidence of tapping panel dryness was observed in these clones after six years of tapping.

No association was found between the yield of the original ortets in Maharashtra and that of their respective clones in Kerala as evidenced non-significant correlations.The variation in yield of ortets and their clones is discussed with reference to earlier reports along the same line suggesting G x E interaction as well as random effects attributable to variation in latex yield between the main trunk and the branch propagated by bud grafting of axillary buds onto heterogenous rootstocks.

Key words: Bud-grafting effects, North Konkan region, Ortets, Polycross, Yield, Yield components.

INTRODUCTION

Genetic improvement of rubber, like any crop species is intended at harnessing / fixing desirable variants from a genetically variable base population. Natural rubber (*Hevea brasiliensis*) is a highly outbred species which is also amenable to vegetative propagation. Historically, the base

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populations for *Hevea* breeding in Asia were mother trees or ortets selected from extensive populations of seedlings in commercial plantings (Ho *et al*., 1980; Tan, 1987). In the early years of *Hevea* breeding in India too, realizing the importance of indigenously developed planting materials, ortet selection was initiated in 1954 (Nair and Jacob, 1969)whereby a large population of trees raised from seeds in various estates of South India were screened and high yielders identified. This led to the development of 46 new primary clones. Ortet selection thus constitutes participatory plant breeding as practised in rubber from the very early days of crop improvement research in India (Mydin, 2014). Essentially, ortet selection/mother tree selection/ plus tree selection consists of identifying elite trees from a large base population of genetically variable seedling trees, monitoring the selections for a period of time and finally cloning the best ortets to evaluate them for yield and secondary attributes in comparison with the best popular clones as checks (Mydin and Saraswathyamma, 2005).

In the second phase of the ortet selection program in India which was initiated in 1981 in the traditional area, systematic screening of small holdings and large estates was undertaken. Small holdings with prospective seedling areas suitable for screening were evaluated and over 112 ortet clones selected from small holdings were evaluated. Screening of over 1000 ha of seedling populations comprising 3,50,000 trees in large estates and small holdings and subsequent small scale evaluation of 530 selected ortet clones has helped to identify 31 primary clones superior in latex yield, timber yield and response to ethrel stimulation when compared with check clones *viz*. RRII 105, RRIM 600 and GT 1 (Mydin *et al*., 2005; Mercykutty *et al*., 2013; John *et al*., 2013). With the expansion of rubber cultivation in India to non-traditional regions where drought and cold winters are among the factors limiting rubber production, ortet selection programs were initiated in polyclonal seedling stands established in drought prone Central India (Chandrashekar *et al*., 2002)and cold prone North East India (Sasikumar *et al*., 2001). The present report pertains to the yield potential in the traditional region, of clones derived from ortets selected from Dapchari in Central India.

MATERIALS AND METHODS

Fifteen ortets were selected from two poyclonal seedling blocks in the Regional Research Station of Rubber Research Institute of India at Dapchari in Maharashtra, Central India. The original base populations of seedlings were raised in Dapchari in 1985 from seeds collected from polyclonal seed gardens in Kanyakumari district of South India. Selection of high yielding plus trees/ ortets was done at the age of 12 years based on mean yield over the first four years of tapping, in relation to the mean yield of the respective blocks (Fig.1).Out of the 15 ortets, 13 had more than 100 percent higher yield over their respective block means. The selected ortets were cloned and established in source bushes at RRII farm, following which a small scale evaluation trial was laid out in 1998 at the Central Experiment Station of Rubber Research Institute of India situated at Pathanamthitta district of Central Kerala (44-188 m above MSL; latitude 90 25′ N and longitude 760 50′ E). Thirteen ortet clones along with two checks, *viz*. RRII 105 and RRIM 600 were planted employing a randomized block design with three replications and five trees per plot. Field

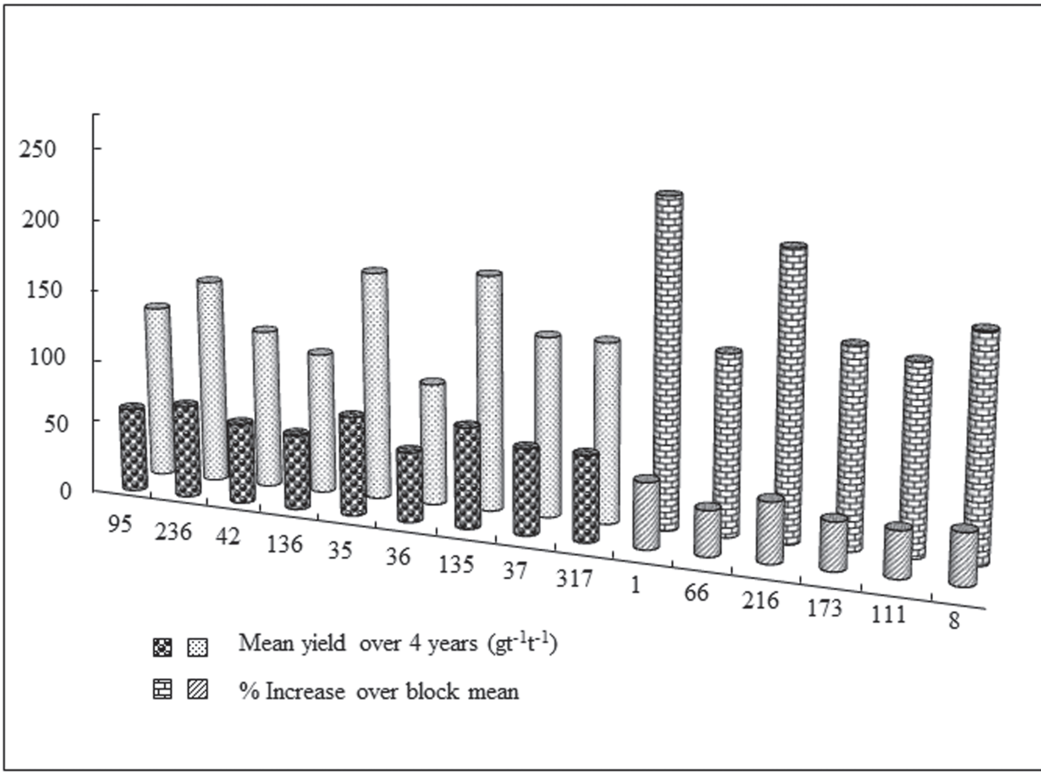

Fig. 1. Yield of ortets* at Dapchari , Maharashtra

*Ortets 95,236,42,136,35,36,135,37and317 selected from Block 1 with mean block yield of 26.92 g/t/t
Ortets 1,66,216,173,111 and 8 from Block 2 with mean block yield of 14.22 g/t/t

planting was done at 4.9 x 4.9 m spacing using two whorled polybag plants. Cultural operations as per the recommended package of practices for rubber were adopted.

Girth of trees was recorded annually from the third year of planting. Tapping following S/2 d3 system without stimulation was initiated in 2005, seven years after planting when the trees attained tappable girth. In the year of opening, bark samples were collected in formalin-acetic-alcohol (FAA) solution and preserved for structural studies. Observations on thickness and number of laticifers in the hard and soft layers of the bark were recorded from radial longitudinal sections (RLS) of the bark. For the purpose of recording yield from each individual tree, cup coagulation of latex on a normal tapping day was done at fortnightly intervals followed by smoke drying of cup lumps which were later weighed.In the sixth year of tapping, yield components *viz*. volume of latex per tree per tapping and dry rubber content (DRC) on a dry weight by volume basis from 20 ml samples of latex were determined during the peak season (November-December). Girth increment rates during immaturity and over six years of tapping were worked out. The incidence of tapping panel dryness in the clones was also recorded. Data on 16 attributes were subjected to analysis of

Table 1 .**Variability for yield in the Ortet clones over six years of tapping**

Clone	Yield (g t^{-1} t^{-1}) in panel BO-1						Annual mean yield over 6 yrs.	Summer yield over 4 years of
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.	6th yr.	tapping (g t^{-1} t^{-1})	tapping (g t^{-1} t^{-1})
D 1	39.2	33.7	28.4	31.1	43.5	42.0	36.3 defg	24.7 c
D 35	61.7	52.0	37.5	39.4	62.7	58.1	51.9bcd	29.5 bc
D 36	22.8	23.9	17.0	25.3	29.6	46.5	27.5 fg	14.3 c
D 37	60.7	56.5	61.5	52.0	73.7	71.9	62.7 b	44.1 b
D 42	30.3	33.1	20.8	19.8	35.1	48.0	31.2efg	19.1 c
D 95	54.1	61.0	38.8	40.9	64.3	61.3	53.4bcd	28.5 bc
D 111	94.4	98.5	81.8	64.8	97.6	107.8	90.8 a	64.4 a
D 135	37.1	37.1	29.3	35.5	54.0	52.3	40.4 cdef	24.1 c
D 136	33.3	40.2	34.5	31.5	40.5	49.4	38.5cdef	20.7 c
D 173	58.5	44.8	42.4	52.2	65.8	77.2	56.6bcd	30.4bc
D 216	21.2	13.3	16.7	17.3	28.9	50.2	23.4 fg	15.0 c
D 236	52.1	39.3	42.6	45.3	79.9	82.5	56.9 bc	31.0bc
D 317	38.7	43.7	31.7	37.0	43.1	49.8	40.7cdef	23.6 c
RRIM 600	41.8	54.2	32.2	40.5	60.6	72.7	50.3 bcde	28.0bc
RRII 105	57.8	39.9	42.9	61.7	81.8	99.3	63.9 b	30.0 bc
GM	46.9	43.7	35.4	37.0	53.5	60.3	45.2	26.8
V.R.	23.9**	8.3**	11.4**	9.1**	9.3**	7.8**	15.9**	9.2**
G.C.V.(%)	39.2	41.2	45.0	38.9	39.2	34.7	39.5	43.8
P.C.V.(%)	41.7	48.9	51.1	45.6	45.7	41.7	43.3	51.3
H^2	0.9	0.7	0.8	0.7	0.7	0.7	0.8	0.7

** significant at P<0.01; Values followed by the same letters are on par as per DMRT
GM : General Mean; V.R.: Variance Ratio; G.C.V.: Genotypic coefficient of variation;
P.C.V.: Phenotypic co-efficient of variation; H^2 : Heritability in the broad sense

variance. Superior clones were identified employing Duncan's Multiple Range Test. Correlation among yield of original ortets and their resultant clones was estimated.

RESULTS AND DISCUSSION

The mean yield over the first four years of tapping of the original ortets selected from the two base populations established in RRS, Dapchari and their improvement over the respective block mean yields are represented in Figure 1. While block 1 had a mean yield of 26.9g $t^{-1}t^{-1}$, block 2 which was situated in a less favourable site had a block yield of only 14.2g $t^{-1}t^{-1}$.Nine ortets *viz*. D 95, D 236, D 42, D 136, D 35, D 36, D 135, D 37and D 317 were selected from Block 1, while six ortets, D 1, D 66, D 216, D 173, D 111 and D 8 were selected from Block 2.The selected ortets yielded more than 100 percent of the respective block yields. The ortets having established their ability to give high yield on regular tapping in Dapchari had proved to be tolerant to drought and high temperature stress prevailing in the North Konkan belt. Their yield potential in the traditional region under congenial

Table 2.**Variability for growth parameters in the ortet clones**

Clone	Girth at opening (cm)	Girth increment at immaturity ($cmyr^{-1}$)	Girth increment under tapping ($cmyr^{-1}$)	Girth after 6 yrs. of tapping (cm)
D 1	42.8 abc	7.6	3.0	54.8abc
D 35	47.1 a	9.0	4.2	63.8 a
D 36	45.0ab	8.1	3.8	60.0 abc
D 37	45.7 a	8.7	4.3	62.9 ab
D 42	40.4abcd	7.0	3.9	56.0 abc
D 95	47.1 a	8.1	3.5	61.0abc
D 111	43.9 abc	7.8	4.3	61.2abc
D 135	38.2 abcd	7.6	3.9	53.9 abc
D 136	34.6 cd	6.3	3.9	50.1 bc
D 173	45.2 ab	8.2	3.9	60.9 abc
D 216	42.6abc	7.7	5.0	62.5 abc
D 236	45.5 a	7.9	4.6	64.0 a
D 317	43.2abc	7.7	4.1	59.4 abc
RRIM 600	43.6 abc	7.6	4.5	61.6abc
RRII 105	47.9 a	8.7	4.8	67.1 a
GM	42.4	7.7	4.2	59.0
V.R.	2.4*	NS	NS	3.0**
G.C.V.	8.3	-	-	7.0
P.C.V.	14.6	-	-	11.0
H^2	0.3	-	-	0.4

** significant at P<0.01 ; * significant at P<0.05; NS –Not significant
Values followed by the same letters are on par as per DMRT
GM : General Mean; V.R.: Variance Ratio; G.C.V.: Genotypic coefficient of variation;
P.C.V.: Phenotypic co-efficient of variation; H^2 : Heritability in the broad sense

conditions, in comparison to the high yielding check clone RRII 105 could be studied from the small scale clonal evaluation.

Variability in yield over the first six years of tapping in panel BO-1 and summer yield over four years of tapping are given in Table 1.Genetic variability in annual mean yield and summer yield among the ortets every year was evident. The phenotypic and genotypic coefficients of variation and high estimates of broad sense heritability for yield every year support the same. Rubber yield has been established to be a highly heritable trait (Tan, 1981; Mydin *et al.*, 1992; Narayanan and Mydin, 2011) which indicates scope for direct selection based on rubber yield. Clone D 111 with a mean yield of 90.8g $t^{-1}t^{-1}$ in panel BO-1 and the highest summer yield of 64.4g $t^{-1}t^{-1}$ was significantly superior to the check and the rest of the ortet clones. This was followed by clone D 37 (62.7g t^{-1} t^{-1}) which was comparable to the check RRII 105 (63.9g t^{-1} t^{-1}) in terms of annual mean yield in panel BO-1 and was superior to the check in summer yield which

Table 3.**Variability for structural and physiological components of yield in the ortet clones**

Clone	Bark thickness (mm)	No. of latex vessel rows	Volume of latex in the peak season (ml t^{-1} t^{-1})	Dry rubber content in the peak season (%)
D 1	6.4 c	13.7 a	125.0 cde	34.6
D 35	6.8bc	9.8 b	120.3 cde	38.4
D 36	6.8 bc	10.9ab	58.7 e	37.6
D 37	6.3 c	11.5ab	190.8 abc	40.1
D 42	6.8bc	13.9 a	157.5 bcde	39.0
D 95	7.5 ab	11.0ab	223.3 abc	35.3
D 111	6.2 c	12.1ab	280.0 ab	36.2
D 135	7.7 a	11.1ab	153.3 cde	37.0
D 136	6.3 c	8.9 b	102.6cde	40.3
D 173	7.5 ab	10.3ab	212.0 abc	42.7
D 216	6.6 c	11.4 ab	133.8 cde	36.4
D 236	6.7 c	12.4 ab	298.3 a	42.8
D 317	6.3 c	9.0 b	160.1 bcde	36.9
RRIM 600	6.3 c	9.4 b	283.7 a	34.3
RRII 105	6.6 c	10.4 ab	186.2abcd	38.5
GM	6.7	11.1	171.9	38.3
V.R.	5.7**	3.4**	3.9*	NS
G.C.V.	6.7	11.6	36.9	-
P.C.V.	8.6	17.4	52.6	-
H^2	0.7	0.5	0.5	-

** significant at P<0.01; * significant at P<0.05; NS – Not significant

Values followed by the same letters are on par as per DMRT

GM : General Mean; V.R.: Variance Ratio; G.C.V.: Genotypic coefficient of variation; P.C.V.: Phenotypic co-efficient of variation; H^2 : Heritability in the broad sense

was as high as 44.1g $t^{-1}t^{-1}$. Four more ortet clones *viz*. D 236, D 95, D 35 and D 173 with yield of more than 50g $t^{-1}t^{-1}$ were on par with the high yielding check clone RRII 105 as well as with the drought tolerant check clone RRIM 600.

In terms of growth (Table 2), four of the ortet clones *viz*. D 95, D 35, D 37and D 236 were comparable with RRII 105 which was also the most vigorous in terms of girth at opening. While clones D 35 and D 236 maintained good growth under tapping and had girth comparable to RRII 105 which was among the best in terms of girth after 6 years of tapping, D 95 and D 37 were not able to maintain the good girth increment rate. However the clones did not show any significant variation in girth increment rate either at immaturity or under tapping. In general there was 45.8 percent drop in girth increment rate of clones under tapping, but specific response of clones to tapping were not evident. The highest yielding clone D 111 did not show high vigour in terms of

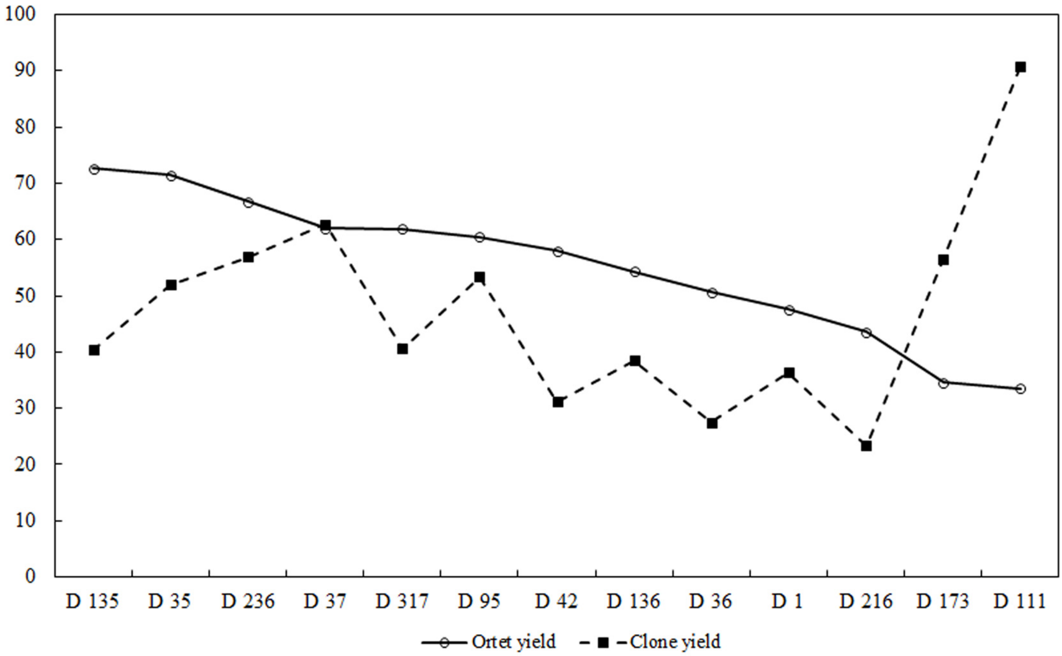

Fig. 2. Yield of original ortets and resultant clones

girth, but was only comparable to RRII 105. Clone D 37 combined high yield and vigorous growth. Clones D 236, D 35 and D 95 were above average in both growth and yield.

The important structural and physiological components of yield were also studied (Table 3). The clones exhibited significant variability for bark thickness, number of latex vessel rows and volume of latex, but not in terms of the dry rubber content which was 38 per cent in general. Volume yield of latex ranged from 58.7 to 298.3 $mlt^{-1}t^{-1}$. Clones D 236 (298.3 mlt^{-1} t^{-1}) and RRIM 600 (283.7 mlt^{-1} t^{-1}) were superior to the rest followed by clone D 111 (280 mlt^{-1} t^{-1}). Clones D 37, D 95, D 173 and RRII 105 were comparable with clone D 111 in terms of volume yield of latex. At the time of initiation of tapping, clones D 42 and D 1 with a mean number of latex vessel rows of 13.9 and 13.7, respectively were superior to the rest, followed by nine clones which included all the high yielders and RRII 105. In the year of initiation of tapping, clone D 135 was superior to the rest in bark thickness (7.7 mm) followed by D 95 and D 173 (7.5 mm). Clones D 111 (6.2 mm) and D 37 (6.3mm) exhibited thin bark which was comparable to the rest of the clones including the checks, RRII 105(6.6 mm) and RRIM 600 (6.3mm).

The correlation estimates (Table 4) revealed that girth at opening and growth in terms of girth increment at immaturity were correlated with yield over the years. Yield in the third year was correlated with yield in subsequent years. But the correlation of yield of the original ortet with yield of the resultant clones, though positive in general was not significant indicating no relationship of seedling and clonal performances. This could be attributable to GxE effects since the original ortets were

Table 4.**Correlations among girth and yield in the original ortets and resultant clones**

	GI at immaturity	Yield 3rd yr.	Yield 4^{th} yr.	Yield 5^{th} yr.	Yield 6^{th} yr.	Mean yield over yrs.	Yield of original Ortet
Girth at opening	0.91**	0.40	0.60*	0.61*	0.59*	0.57*	0.33
GI at immaturity		0.41	0.60*	0.58*	0.54*	0.53*	0.39
Yield 3^{rd} yr.			0.92**	0.91**	0.93**	0.96**	-0.04
Yield 4^{th} yr.				0.95**	0.96**	0.97**	0.11
Yield 5^{th} yr.					0.97**	0.97**	0.20
Yield 6^{th} yr.						0.98**	0.07
Mean yieldover yrs.	0.08						

** significant at P<0.01; * significant at P<0.05

grown under rainfed conditions in the drought prone North Konkan while their cloned counterparts were evaluated in the traditional region. Significant variation in yield due to GxE interaction has been reported in rubber (Meenakumari *et al.*, 2011) even when the same clone is grown in geographically divergent locations. Another aspect that needs detailed study in this regard is the effect of bud grafting.

Figure 2 which plots the yield of the original ortets along with the yield of their respective clones also shows lack of a specific association of seedling and clonal yields. The highest yielding ortets D 135, D 35 and D 236 turned out to be only moderately high yielders on cloning by bud grafting onto heterogenous root stocks, a phenomenon which has been reported earlier from Sri Lanka by Pathiratna *et al.* (2007). Corroborating the earlier report, two of the lowest yielding ortets D 111 and D 173 developed into high yielding clones. The moderate yielding ortets, D 37, D 317, D 95, D 42, D 136, D 36 and D 1 when cloned by bud grafting exhibited moderately high yields. Pathiratna *et al.* 2007 has opined that the deviation of yields of budgrafts with respect to mother tree yields show that this is a phenomenon of random occurrence which can be the case with stock-scion interactions. Dijkman (1951) had reported that 26 per cent of the budgrafts yielded as much or more than their mother trees. Stock scion interaction can be variable depending on the genotypes of both the stock and scion and the compatibility between the two. Another angle to this phenomenon is that it could be due to the difference in yield of the trunk of a mother tree and its branch which is propagated by cloning using axillary buds. As revealed in Figure 2, the yield of a majority of the ortets could not be reproduced *in toto* by the resultant clones, while two of the lesser yielders exhibited very high yields on cloning. This also points to the importance to be given to position effect while selecting ortets from seedling stands. D 111 and D 173 were selected from block 2 located in a less favourable site, where its full yield potential could not be realised. An earlier study on juvenile mature correlations in respect of test tap yield of seedlings and yield of their cloned counterparts at maturity (Mydin, 2012) also showed that only 24.3 per cent of the moderate to high juvenile yielders exhibited high yield as clones in the mature phase. Thus seedling performances are only indicative and does not confirm the yield potential of a genotype. This reiterates the essentiality of conducting large scale clone trials to confirm the yielding ability of genotypes in rubber, which is a plantation crop where vegetative propagation by bud-grafting onto variable rootstock is an integral part of the process.

The present study has identified two high yielding ortet selections *viz.* D 111 and D 37 which are also drought tolerant, being of proven performance as mature trees in the drought prone area of Dapchari in North Konkan. While D 111 also possesses high summer yield, D 37 is a high girthing clone. Both these clones are promising in terms of yield components like a high number of latex vessel rows and high volume of latex. No incidence of tapping panel dryness was observed in these clones after six years of tapping. These clones are now in the pipeline for the final multi-locational participatory clone evaluations.

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