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Promising latex timber clones of *Hevea brasiliensis* evolved by ortet selection

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Abstract

On the basis of systematic screening of large seedling population of mature trees originated from Tjir 1 seeds and planted in 552 ha during 1961 at Plantation Corporation of Kerala, seventy-five elite trees were initially selected for a detailed study. Forty two ortets were finally selected based on yield, girth and yield per unit length of tapping cut, of which, thirty-nine ortets were cloned and evaluated in two small scale trials with one set of 27 clones and another set of 16 clones in a randomized block design with three replications. The check clones were RRII 105 and RRIM 600 in both the trials for comparison. Clonal performance was evaluated till eight years of tapping. The criteria for evaluation were yield, yield components, girth and secondary attributes. Timber yield was estimated at the 15th year of planting in terms of clear bole volume. Significant clonal variation for the traits resulted in selection of promising latex-timber clones and promising timber yielders. Three clones *viz.* KnO 39, KnO 36, KnO 49 recorded a mean yield of 55.25 g $t^{-1}t^{-1}$, 53.38 g $t^{-1}t^{-1}$ and 55.97 g $t^{-1}t^{-1}$ respectively and they were showing higher yield comparable to that of RRII 105 with 50.54 g $t^{-1}t^{-1}$. These clones appear to be promising latex-timber clones as they had recorded significantly high bole volume and possess desirable secondary characters also. Seventeen clones were promising timber yielders as evident from the higher clear bole volume. The superiority of ortets with respect to specific traits is discussed in detail with emphasis to three promising selections based on latex and timber yield.

Keywords: Hevea brasiliensis, latex-timber clones, ortet selection, timber yielders

Introduction

Ortet selection is a method of systematic screening for outstanding individuals from a mature seedling plantation, its vegetative multiplication and subsequent evaluation in comparison to the popular clones. It is one of the earliest methods of crop improvement in *Hevea brasiliensis* which has resulted in the release of number of primary clones. The term ‘ortet’ has been derived from the Latin word ‘ortus’ which means origin. Therefore, an ortet, is the original tree from which members of a clone have descended. This mass selection procedure, otherwise referred to as plus tree selection is a participatory crop improvement approach as practiced in rubber (Mydin *et al.*, 2005). Rapid strides in ortet selection were made in Indonesia and Malaysia as early as 1920s and the resultant primary clones have recorded 150 per cent yield improvement over the original unselected population (Khoo *et al.*, 1982). Tjir 1, Gl 1, PB 86, PR 107 *etc*. are some of the classic primary rubber clones. Subsequently, popular clones such as PB 28/59, GT 1 and PB 280 were released for commercial cultivation. Very recently, Malaysian Rubber Board has recommended the RRIM 2000 series clones among which RRIM 2027, evolved through ortet selection, is recognized as a promising latex-timber clone combining high latex yield and wood productivity (Anonymous, 2003).

In India, systematic screening, selection and evaluation of primary clones were started during the 1950s. The first ortet section programme has led to the release of clones of the RRII 1 series which have shown promising performance over the years (Nair

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and Jacob, 1968; Marattukalam *et al*., 1990). Since 1988, an area of 1276.75 ha comprising 3,81,505 trees were screened and based on the preliminary observation on latex yield, 649 ortets were selected for detailed studies on yield, girth and secondary attributes. Two hundred and forty-one ortets were finally selected, out of which, 182 clones were multiplied and are being evaluated in 12 small scale trials. Eleven promising selections with high yield, good response to stimulation and high timber output could be evolved from the ortet selection programme carried out at Boyce Estate, Mundakkayam (Mydin *et al*., 2005). Eight promising primary clones were evolved from the ortet selection programme carried out at Harrisons Malayalam Limited (HML), Cheruvally estate (Mercykutty *et al*., 2006). From the ortet selection programme undertaken at HML, Koney estate another set of eleven promising ortets were identified (John *et al.*, 2013). Large scale evaluation of these selections have been initiated.

Conventionally, selection programmes for genetic improvement of *H. brasiliensis* are undertaken mainly with yield related attributes. At present, the growing demand for rubber wood with the concept of value addition through the manufacture of a variety of products necessitate the need for latex timber clones. A phenomenal rise in the demand for rubber timber has been reported with the rapid growth of rubber wood industry in Malaysia (Abdul Aziz, 2002). The value of new clones should be assessed in terms of timber output also.

The present study reports the ortet selection programme undertaken in a commercial estate of Plantation Corporation of Kerala, comprising 1,80,321 seedling trees raised from Tjir 1 seeds planted in 552 ha during the year 1961. Details on small scale field evaluation of 39 ortet clones for identification of promising latex-timber clones and promising timber yielders are also furnished.

Materials and methods

The selection process in the estate was started in the year 1990, when the trees were under tapping in the B1-2 panel, adopting S/2 d2 system. Initially, the tapper was instructed to mark out exceptionally high yielding trees compared to the surrounding trees and the selected trees were monitored. A total of 75 potential plus trees were identified from the base population and subjected to recording yield over a period of one year. The yield was estimated from the recording carried out in four seasons (October, December, January and April) by measuring the latex volume and dry rubber content (DRC). Girth and yield per unit length of tapping cut of the elite mother trees were also studied along with other secondary attributes. A total of 42 high yielding plus trees were finally selected based on the afore mentioned characters. The experimental ortet clones were designed as the KnO series after the name of the estate from where the selection programme was undertaken. Branches from the elite trees were pruned for generating bud wood in order to raise source bush plants in the nursery. Thirty-nine ortet clones were multiplied and laid out in two small scale evaluation trials at the Central Experiment Station of the Rubber Research Institute of India, Chethakal, Kerala.

The materials comprised 43 clones planted in two trials with one set of 27 clones and another set of 16 clones. The check clones were RRII 105 and RRIM 600 in both the trials for comparison. A randomized block design with three replications and five plants per plot was adopted with a spacing of 4.9 m x 4.9 m. Regular tapping was carried out on attainment of seven years of growth adopting S/2 d3 6d/7 system. All cultural operations as per standard recommendation were followed (Punnose and Lakshmanan, 2000).

The clones were evaluated on the basis of yield, growth and other secondary attributes. Growth attributes studied included girth increment (GI) during immaturity, girth at opening, GI on tapping, first branching height and, clear bole volume (CBV). Yield contributing parameters recorded were yield over eight years of tapping, volume of latex, DRC, number of latex vessel rows and, bark thickness. Yield recording was carried out by cup coagulation method and weighing of dried cup lumps at monthly intervals. Yield components *viz*. volume of latex and DRC were recorded during the month of May in the fifth year after tapping. Vigour at opening and girth increment before and after tapping was determined by measuring the girth of trees at a height of

125 cm above bud union. Bark thickness was measured using Schleipers bark gauge. Total number of latex vessel rows (LVR) was ascertained by microscopic observations of the bark samples. Timber yield was estimated at the age of 15 years in terms of clear bole volume following the Hoppus method (Chaturvedi and Khanna, 1982). Incidence of pink disease, tapping panel dryness (TPD) and wind damage were recorded as percentage of affected trees.

Data on yield and growth attributes were subjected to analysis of variance to examine the clonal variability for these traits and selection of promising clones for large scale evaluation.

Results and discussion

In the selection process of elite trees from the base population, emphasis was given to yield, yield per unit length of tapping cut and girth of the elite trees. Tree-wise data on yield, yield per unit length of tapping cut and girth of the 39 ortets finally selected are presented in Table 1. Ortets with mean yield of 185.74 g $t^{-1}t^{-1}$ ranging from 105-313 g $t^{-1}t^{-1}$ were finally selected based on mean dry rubber yield recorded over four seasons. A grouping of 39 selections based on yield category revealed that maximum number of ortets of 13 nos. yielded 150 to 200 g $t^{-1}t^{-1}$. Yield per unit length of tapping cut of the selections was derived from the total panel length and dry rubber yield, which ranged from 0.75 to 1.92 g cm^{-1} with a mean of 1.23 g cm^{-1}. Average girth of the selections was 169 cm with a range from 125 to 224 cm. These observations indicate the inherent genetic variability in the population for effective selections based on these traits. Altogether, 16 mother trees were superior to the population mean in terms of yield, 21 trees in terms of yield per unit length of tapping cut and 20 trees in terms of girth. The ortets were cloned and two small scale evaluation trials were established incorporating two check clones.

Small scale evaluation

In the two small scale trials, altogether 41 clones were evaluated in terms of growth, yield, timber yield, anatomical parameters and tolerance to tapping panel dryness, pink disease and wind damage. The clonal variations for each of the trait are shown in Tables 2-6.

Table 1. Characteristics of ortets in the base population

Ortet	Yield (g $t^{-1}t^{-1}$)	Yield per unit length of tapping cut (g cm^{-1})	Girth (cm)
KnO 50	159	1.28	155.5
KnO 4	126	1.92	140.0
KnO 73	223	1.02	179.5
KnO 51	288	0.79	212.0
KnO 38	206	1.03	179.0
KnO 10	147	1.55	192.2
KnO 29	170	1.68	205.0
KnO 32	169	1.23	175.0
KnO 17	159	1.32	168.0
KnO 68	273	0.89	170.5
KnO 61	179	1.21	143.0
KnO 26	233	0.75	163.0
KnO 15	138	1.36	156.0
KnO 37	165	1.24	170.0
KnO 2	117	1.53	140.0
KnO 36	107	1.68	142.0
KnO 49	313	0.90	224.0
KnO 44	131	1.41	143.0
KnO 48	196	1.14	184.0
KnO 46	188	1.25	215.0
KnO 41	173	1.25	159.0
KnO 24	105	1.63	144.0
KnO 55	182	1.06	180.5
KnO 23	139	1.41	148.5
KnO 35	116	1.45	125.0
KnO 28	295	0.78	172.0
KnO 11	246	1.25	194.0
KnO 59	143	1.53	199.0
KnO 54	179	1.17	176.0
KnO 63	157	1.43	151.0
KnO 75	289	0.77	151.5
KnO 22	151	1.37	128.5
KnO 25	125	1.57	141.5
KnO 1	124	1.71	165.0
KnO 12	221	1.04	188.0
KnO 39	205	0.90	148.0
KnO 4	268	0.85	217.0
KnO 27	209	0.91	188.0
KnO 19	241	0.86	175.0

All the clones exhibited significant variations for the growth parameters analysed in the present study (Table 2). Though yield is the primary character of economic importance, vigour is the most important secondary character in a clone. The better girth increment during immaturity was reflected in the early attainment of tappable girth and higher percentage of tappability. Several ortets showed significantly higher girth and growth attributes than

Table 2. Growth characteristics of ortet clones

Clone	GI at immaturity (cm yr^{-1})	GI under tapping (cm yr^{-1})	Girth at opening (cm)
KnO 50[a]	7.69	4.24	53.83
KnO 4[a]	8.20	4.62	57.43
KnO 73[a]	7.08	4.75	49.60
KnO 51[a]	6.50	3.26	45.53
KnO 38[a]	7.13	2.41	49.93
KnO 10[a]	6.99	2.58	48.90
KnO 29[a]	6.53	2.27	45.70
KnO 32[a]	7.83	1.56	54.80
KnO 17[a]	8.25	2.71	57.77
KnO 68[a]	5.94	3.01	41.60
KnO 61[a]	5.83	3.11	40.83
KnO 26[a]	7.15	4.26	50.07
KnO 15[a]	6.92	1.61	48.43
KnO 37[a]	7.58	3.22	53.03
KnO 2[a]	7.38	2.69	51.67
KnO 36[a]	8.48	2.48	59.40
KnO 49[a]	7.55	4.11	52.83
KnO 44[a]	7.60	1.83	53.20
KnO 48[a]	6.79	4.34	47.50
KnO 46[a]	6.59	3.72	46.13
KnO 41[a]	9.48	2.04	66.40
KnO 24[a]	6.40	3.59	44.80
KnO 55[a]	7.22	4.13	50.60
KnO 23[a]	6.36	2.84	44.53
KnO 35[a]	6.88	1.87	48.13
KnO 28[b]	8.81	3.28	61.70
KnO 11[b]	7.45	3.63	52.13
KnO 59[b]	7.28	3.09	50.97
KnO 54[b]	8.95	2.88	62.63
KnO 63[b]	7.10	2.17	49.70
KnO 75[b]	8.42	3.11	58.93
KnO 22[b]	7.67	2.26	53.70
KnO 25[b]	7.21	2.34	50.47
KnO 1[b]	5.83	2.73	40.80
KnO 12[b]	7.75	3.15	54.23
KnO 39[b]	8.60	3.16	60.17
KnO 74[b]	6.65	3.51	46.53
KnO 27[b]	7.62	2.09	53.37
KnO 19[b]	5.80	4.24	40.60
RRIM 600[ab]	7.04	2.45	49.28
RRII 105[ab]	7.03	2.13	49.22
G. Mean	7.32	3.01	51.15
V.R. Trial 1	3.32	1.64	3.29
V.R. Trial II	2.62	1.13	5.01
C.D. Trial I (0.05)	1.23	0.58	8.86
C.D. Trial II (0.05)	1.21	0.51	8.45

[a]Clones in Trial I; [b]Clones in Trial II

the control clones. GI rate at immaturity among different ortets ranged from 5.80 cm (KnO 19) to 9.48 cm (KnO 41) with a general mean of 7.32 cm year^{-1}. A total of 22 clones registered higher GI than the general mean and eight clones showed almost 100 per cent tappability at the year of opening. GI under tapping ranged from 1.56 cm (KnO 32) to 4.75 cm (KnO 73) with a general mean of 3.01 cm yr^{-1}.

There was a significant clonal variation for girth at opening and ranged from 41.6 cm to 66.4 cm. At the time of opening the trees for tapping, 18 clones recorded higher girth compared to general mean of 51.15 cm and 25 clones recorded higher girth compared to the check clone RRII 105. KnO 41 recorded the highest girth at opening (66.40 cm) followed by KnO 54 (62.63 cm), KnO 28 (61.70 cm) and KnO 39 (60.17 cm).

Table 3 shows the performance of clones with respect to first branching height, girth and clear bole volume at the age of 15 years. Branching height ranged from 2.4 m to 4.6 m with a mean of 3.2 m. Majority of the selections were found to be high branching. Twenty clones in both the trials showed a high branching nature when compared to the control clone RRII 105.

Girth data recorded on the 15th year of tapping combined with stem wood (clear bole) determines the bole volume, which in turn contributes to timber yield. Clones in both the trials exhibited significant variation for girth. The clone KnO 4 showed the highest girth (94.35 cm) followed by KnO 28 (87.91 cm) as against a mean girth of 66.28 cm recorded by RRII 105 and 68.91cm recorded by RRIM 600. Thirteen clones which recorded girth significantly superior to RRII 105 could be classified as vigorous clones. Nineteen clones recorded higher girth during 15th year than the population mean of 74.77 cm (Table 3).

Timber is an important by product which gives an additional income. In general, clones which registered significantly better girth recorded higher bole volume. There was significant clonal variation for clear bole volume which ranged from 0.05 to 0.21 m^3 in trial I and from 0.09 to 0.28 m^3 in trial II. KnO 39, KnO 36 and KnO 49 appear to be promising latex-timber clones as they had recorded significantly high bole volume compared to RRII 105 and also possess desirable secondary characters. Seventeen ortets were promising timber yielders as evident from the higher clear bole volume compared

Table 3. Timber traits of ortet clones at the age of 15th year

Clone	CBV (m^3)	Branching height (m)	Girth at 15th year (cm)
KnO 50[a]	0.18	3.3	87.76
KnO 4[a]	0.20	2.8	94.35
KnO 73[a]	0.17	3.0	87.63
KnO 51[a]	0.10	3.3	71.63
KnO 38[a]	0.13	2.8	69.17
KnO 10[a]	0.08	3.0	69.53
KnO 29[a]	0.08	2.7	63.83
KnO 32[a]	0.14	3.0	67.30
KnO 17[a]	0.21	2.9	79.43
KnO 68[a]	0.08	2.9	65.70
KnO 61[a]	0.05	2.8	46.93
KnO 26[a]	0.15	3.1	84.17
KnO 15[a]	0.07	2.6	61.33
KnO 37[a]	0.11	2.6	78.77
KnO 2[a]	0.10	2.4	73.20
KnO 36[a]	0.14	3.1	79.20
KnO 49[a]	0.14	3.0	85.63
KnO 44[a]	0.14	3.2	67.83
KnO 48[a]	0.12	3.3	82.25
KnO 46[a]	0.09	2.4	75.85
KnO 41[a]	0.15	3.0	82.70
KnO 24[a]	0.09	2.6	73.53
KnO 55[a]	0.12	2.9	83.60
KnO 23[a]	0.09	2.5	67.23
KnO 35[a]	0.09	2.9	63.07
KnO 28[b]	0.28	3.9	87.91
KnO 11[b]	0.19	4.3	81.17
KnO 59[b]	0.14	3.4	75.64
KnO 54[b]	0.18	4.1	85.70
KnO 63[b]	0.11	3.1	67.02
KnO 75[b]	0.19	3.6	83.80
KnO 22[b]	0.15	3.9	71.81
KnO 25[b]	0.12	3.5	69.22
KnO 1[b]	0.09	3.4	62.65
KnO 12[b]	0.18	3.5	79.43
KnO 39[b]	0.21	4.1	85.45
KnO 74[b]	0.14	3.8	74.62
KnO 27[b]	0.12	3.2	70.07
KnO 19[b]	0.18	4.6	74.42
RRIM 600[ab]	0.12	3.8	68.91
RRII 105[ab]	0.09	3.0	66.28
G. Mean	0.13	3.2	74.77
V.R. Trial 1	5.35	1.63	3.78
V.R. Trial II	2.92	1.56	2.19
C.D. Trial I (0.05)	0.04	NS	14.97
C.D. Trial II (0.05)	0.08	NS	15.25

[a]Clones in Trial I; [b]Clones in Trial II

to the general mean (0.13 m^3). High girthing clones with high branching height gave high clear bole volume.

There was a significant variation for yield and yield attributes among the clones. Mean yield and yield attributes of the ortets are presented in Table 4. Mean yield over eight years of tapping ranged from 19.68 to 55.97 g $t^{-1}t^{-1}$ with a general mean of 33.97 g $t^{-1}t^{-1}$. Three high girthing clones such as KnO 36, KnO 49 and KnO 39 exhibited yield improvement

Table 4. Yield and yield components of ortet clones

Clone	Mean yield over 8th years (g $t^{-1}t^{-1}$)	Volume of latex (ml $tree^{-1}tap^{-1}$)	DRC (%)
KnO 50a	29.44	67.42	38.88
KnO 4 a	28.99	100.73	38.93
KnO 73 a	48.19	109.13	39.68
KnO 51 a	42.72	107.83	38.62
KnO 38 a	37.63	149.56	34.48
KnO 10 a	22.69	68.50	38.36
KnO 29 a	33.20	85.57	32.49
KnO 32 a	28.23	73.73	35.56
KnO 17 a	33.87	92.96	36.79
KnO 68 a	23.83	65.43	33.45
KnO 61 a	22.32	84.08	29.79
KnO 26 a	35.62	99.59	32.60
KnO 15 a	21.58	75.50	23.15
KnO 37 a	31.05	80.19	36.71
KnO 2 a	33.11	148.55	29.76
KnO 36 a	53.38	205.31	40.31
KnO 49 a	55.97	221.22	38.45
KnO 44 a	32.04	95.79	31.82
KnO 48 a	38.31	96.71	37.62
KnO 46 a	24.94	87.19	28.19
KnO 41 a	48.02	158.87	38.27
KnO 24 a	37.68	118.76	31.52
KnO 55 a	28.64	101.34	29.73
KnO 23 a	29.03	88.54	35.87
KnO 35 a	34.16	112.18	30.56
KnO 28 b	40.23	137.40	36.78
KnO 11 b	32.45	93.36	35.31
KnO 59 b	22.77	80.09	31.05
KnO 54 b	27.80	102.74	35.17
KnO 63 b	30.98	108.11	39.74
KnO 75 b	33.35	67.41	38.74
KnO 22 b	41.20	115.30	38.90
KnO 25 b	22.48	120.68	33.24
KnO 1 b	21.85	88.15	29.55
KnO 12 b	30.79	102.24	36.12
KnO 39 b	55.25	214.34	35.84
KnO 74 b	35.15	101.70	35.52
KnO 27 b	31.29	103.37	36.79
KnO 19 b	19.68	94.11	34.54
RRIM 600 a b	43.57	138.72	35.02
RRII 105 a b	50.54	186.21	37.11
G. Mean	33.97	110.94	35.22
V.R. Trial 1	10.60	17.50	6.37
V.R. Trial II	14.13	14.46	1.37
C.D. Trial I (0.05)	8.43	27.80	4.88
C.D. Trial II (0.05)	8.22	30.13	NS

[a]Clones in Trial I; [b]Clones in Trial II

of 5.62, 10.74 and 9.37 per cent respectively than RRII 105. These clones recorded a mean yield of 53.38 g $t^{-1}t^{-1}$, 55.97 g $t^{-1}t^{-1}$ and 55.25 g $t^{-1}t^{-1}$ respectively and could be selected as high latex timber clones. Three clones with better yield than RRIM 600 could be classified as medium yielders. These include clones KnO 73, KnO 51 and KnO 41.

Volume of latex ranged from 67.41 to 221.22 ml $tree^{-1}tap^{-1}$. Thirteen clones recorded volume yield higher than the general mean of 110.94 ml. KnO 49 recorded the highest volume yield of 221.22 ml followed by KnO 39 with 214.34 ml, KnO 36 with 205. 31 ml. Mean volume yield of RRII 105 was 186. 21 ml $tree^{-1}tap^{-1}$ and RRIM 600 was 138.72 ml $tree^{-1}tap^{-1}$.

DRC measured during the 5th year of tapping ranged from 23.15 to 40.31 per cent with a general mean of 35.22 per cent. Twelve clones exhibited DRC better than RRII 105 with a DRC of 37.11 per cent. Among these, KnO 36 was noted for its high DRC of 40.31 per cent. The clones KnO 50, KnO 4, KnO 73, KnO 51, KnO 10, KnO 36, KnO 49, KnO 48, KnO 41, KnO 63, KnO 75 and KnO 22 could be selected for their high dry rubber content. When the yield of dry rubber is taken into consideration total volume and DRC should also be considered as the most important components of yield (Markose, 1984; Sethuraj, 1992).

The number of latex vessel rows (Table 5) ranged from 14.23 to 29.00 in trial I (in the eighth year of tapping) and 6.97 to 13.40 in trial II (in the first year of tapping). Top yielding clones KnO 49 and KnO 39 recorded relatively high number of latex vessel rows. Bark thickness ranged from 6.77 mm to 13.06 mm with a general mean of 10.05 in trial I. Range in variation was 5.57 to 7.87 mm with a general mean of 6.49 in trial II. KnO 49 and KnO 36 showed bark thickness comparable to RRII 105 and KnO 39 was significantly superior to RRII 105 for this trait. Structural attributes like bark thickness and number of latex vessel rows are clonal characters which influence rubber yield (Premakumari, 1992).

Resistance to various biotic and abiotic stresses is of great significance in the performance of *H. brasiliensis* clones. The incidence of tapping panel dryness, wind damage and pink disease are shown in Table 6. Incidence of pink disease ranged from 0 to 26.66 with a general mean of 10.89 per cent. RRII 105, a clone highly susceptible to pink disease, recorded 20 per cent pink incidence. Seven clones recorded no incidence of pink disease (Table 6).

Wind damage in the form of trunk snap, branch snap and uprooting, among the clones ranged from 0.0 to 26.66 per cent. Ten clones remained unaffected by wind. RRIM 600 and RRII 105 recorded 20.00 and 26.66 per cent wind damage

Table 5. Bark anatomical parameters

Clone	Bark thickness (mm)*	Number of latex vessel rows*	Clone	Bark thickness (mm)#	Number of latex vessel rows#
KnO 50[a]	12.26	22.46	KnO 28[b]	7.77	9.57
KnO 4[a]	11.89	17.73	KnO 11[b]	7.07	9.33
KnO 73[a]	10.28	25.13	KnO 59[b]	6.37	9.17
KnO 51[a]	8.39	24.46	KnO 54[b]	5.97	7.80
KnO 38[a]	9.32	16.66	KnO 63[b]	6.20	10.57
KnO 10[a]	8.87	14.66	KnO 75[b]	6.67	10.27
KnO 29[a]	9.77	22.26	KnO 22[b]	6.50	13.40
KnO 32[a]	11.90	22.86	KnO 25[b]	5.57	9.10
KnO 17[a]	11.18	29.00	KnO 1[b]	5.70	6.97
KnO 68[a]	8.12	19.40	KnO 12[b]	6.00	9.03
KnO 61[a]	6.77	14.23	KnO 39[b]	7.87	13.83
KnO 26[a]	13.06	27.86	KnO 74[b]	6.07	12.87
KnO 15[a]	10.28	18.33	KnO 27[b]	6.80	10.97
KnO 37[a]	8.05	19.20	KnO 19[b]	6.33	7.93
KnO 2[a]	10.16	21.66	RRIM 600	6.53	11.70
KnO 36[a]	9.84	18.73	RRII 105	6.57	12.37
KnO 49[a]	10.62	24.30	G. Mean	6.49	10.30
KnO 44[a]	10.16	19.50	V.R.	3.35	7.66
KnO 48[a]	10.86	18.60	C.D. (0.05)	1.00	1.49
KnO 46[a]	10.31	21.53			
KnO 41[a]	9.65	27.83			
KnO 24[a]	10.77	23.40			
KnO 55[a]	9.44	14.60			
KnO 23[a]	9.66	25.40			
KnO 35[a]	9.04	22.66			
RRIM 600	9.01	28.33			
RRII 105	11.67	25.41			
G. Mean	10.05	21.70			
V.R.	3.38	4.27			
C.D. (0.05)	2.19	5.88			

[a]Clones in Trial I; [b]Clones in Trial II

*during 8th year of tapping; # during 1st year of tapping

Table 6. Incidence of tapping panel dryness, pink disease and wind damage

Clone	Pink disease (% affected trees)	Wind damage (% affected trees)	TPD (% affected trees)
KnO 50[a]	6.66	13.33	0.00
KnO 4[a]	13.33	6.66	20.00
KnO 73[a]	6.66	0.00	6.66
KnO 51[a]	20.00	0.00	0.00
KnO 38[a]	13.33	0.00	0.00
KnO 10[a]	20.00	13.33	13.33
KnO 29[a]	6.66	6.66	6.66
KnO 32[a]	6.66	26.66	0.00
KnO 17[a]	6.66	6.66	6.66
KnO 68[a]	13.33	0.00	0.00
KnO 61[a]	0.00	0.00	6.66
KnO 26[a]	0.00	0.00	0.00
KnO 15[a]	13.33	13.33	6.66
KnO 37[a]	26.66	0.0	0.00
KnO 2[a]	13.33	20.00	0.00
KnO 36[a]	20.00	6.66	0.00
KnO 49[a]	13.33	13.33	0.00
KnO 44[a]	6.66	13.33	6.66
KnO 48[a]	0.00	0.00	6.66
KnO 46[a]	13.33	0.00	0.00
KnO 41[a]	13.33	20.00	0.00
KnO 24[a]	0.00	0.00	0.00
KnO 55[a]	20.00	0.00	0.00
KnO 23[a]	6.66	6.66	13.33
KnO 35[a]	13.33	26.66	0.00
KnO 28[b]	13.33	13.33	0.00
KnO 11[b]	6.66	6.66	6.60
KnO 59[b]	20.00	20.00	6.60
KnO 54[b]	0.00	6.66	13.33
KnO 63[b]	13.33	13.33	0.00
KnO 75[b]	6.66	6.66	0.00
KnO 22[b]	20.00	6.66	13.33
KnO 25[b]	0.00	26.66	0.00
KnO 1[b]	13.33	13.33	13.33
KnO 12[b]	13.33	20.00	0.00
KnO 39[b]	0.00	13.33	6.66
KnO 74[b]	13.33	13.33	0.00
KnO 27[b]	13.33	13.33	0.00
KnO 19[b]	6.66	6.66	0.00
RRIM 600[ab]	13.33	20.00	6.66
RRII 105[ab]	20.00	26.66	13.33
G. Mean	10.89	10.24	4.22

[a]Clones in Trial I; [b]Clones in Trial II

respectively. Latex timber clones recorded comparatively low incidence of wind damage.

Incidence of TPD was noticed in certain clones. Twenty three clones were free from TPD and the incidence among the clones ranged from 0 to 13.33 per cent. RRII 105, however, recorded relatively higher incidence of TPD.

Results from the girth, yield and related parameters showed effectiveness of ortet selection programme with respect to vigour, high yield and high bole volume. High vigour render scope for reduction in immaturity period. However, the tapping stress results in a set back in girth increment rate of rubber trees, in general (Simmonds, 1989). In order to obtain sustainable yield over a long period, a satisfactory rate of growth of trees are to be maintained (Vijayakumar *et al*., 2000). This study showed that stable and vigorous ortet clones like KnO 49 and KnO 39 were less affected by the tapping stress and maintained a high growth rate. Mydin *et al.* (2005) and Mercykutty *et al*. (2006) also recorded higher growth rate under tapping in certain ortet clones.

Though the rubber tree is valued for its yield of latex, timber yield has also become important selection parameter in *Hevea* breeding programme. The present study attempts quantification of the timber yield of clones developed under the ortet selection programme. An increase in first branching height coupled with high girth is preferred in the selection of high timber output apart from yield. Clones combining high girth and high branching are suitable for use as timber clones since the waste generated while felling, logging and sawing could be relatively less (Viswanathan *et al*., 2002). The yield of timber obtained from a rubber tree comprises mainly of the clear bole volume (Najib *et al*., 1995), which in turn is dependent on the first branching height and girth of the tree. Among the 39 clones under observation three clones *viz*., KnO 36, KnO 49 and KnO 39 were the final selections identified with respect to yield, girth at opening and high bole volume. All the three clones exhibited a higher clear bole volume compared to PB 235, a clone reported for its yield and high volume of timber in India (John *et al*., 2003). The high yielding capacity of these clones combining high bole volume offers potential candidate latex timber clones for future large scale evaluation and release of new clones with the advantage of early attainment of tappability. The timber production potential along with yield, assume much significance on maximizing the economic returns from rubber plantations (Najib *et al*., 1995).

Ortet selection programme from a seedling population generated from a popular clone Tjir 1 offers scope for evolving promising latex timber primary clones and timber primary clones compared to any other conventional breeding methods. In rubber, hybridization and clonal selection continues to be the mainstay in producing high yielding clones. However, Abdul Aziz (2002, 2005) emphasized that while yield of rubber is the major consideration of improved clones, characters such as girth, girth increment before and after tapping are equally important in ensuring the stability in yield and thereby enhancing the value of rubber tree. In the present day scenario, when the priorities of rubber breeding is shifted to diverse applications apart from yield, exploitation of genetic variability through ortet selection programmes for selection of clones combining several desirable traits appears to be promising. Among the 39 clones, under observation three clones *viz*., KnO 39, KnO 49, KnO 36 are promising selections identified for high yield, good vigour and relatively higher clear bole volume. These three high yielding clones could also be categorized as latex timber clones. These clones possess desirable secondary characters also. Among these clones, KnO 39 is the most outstanding ortet clone showing high yield with high bark thickness and number of latex vessel rows, high girth at opening, high GI on tapping, high bole volume and no incidence of pink disease. Several clones were promising timber yielders. The results may further be confirmed in the large scale and commercial evaluations.

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