Research Article

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Performance of rubber clones in the gravelly soils of Sasthamkotta lake side in Kerala

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Abstract

Nine clones of *Hevea brasiliensis* comprising two indigenous and seven introduced were evaluated in an on farm trial in the Sasthamkotta lake basin. The gravel content of the soil here is very high (61- 76%), at a depth of 0-30 cm, which is almost double to that in normal soil. The parameters studied include mean yield, annual girth, anatomy of bark, occurrence of major diseases such as abnormal leaf fall, pink, powdery mildew, incidence of tapping panel dryness and damage caused by wind. Girth increment during immature and mature phase was worked out from the annual girth data. Discriminatory fertilizer application was done by analyzing soil and leaf samples. Texture of the soil was sandy clay. Even though the gravel content was high it was not affected the growth and yield of rubber tree. Moreover the soil nutrient status was improved after cultivating rubber in this region. Among the clones tested, PB 314 recorded the highest yield of 2094 kg $ha^{-1}yr^{-1}$ over the first five years of tapping and it was closely followed by RRII 105 (1979 kg $ha^{-1}yr^{-1}$). Other clones exhibit high yield and girth characters were PB 255, PB 311 and PR 255. Spearman's rank correlation was worked out between ranks of clones between years. There was significant association between all the years indicating that the genotypes had consistent yield performance from year to year. Girth was highest in PB 255 (65.70 cm) during the fifth year of tapping followed by RRII 203 (61.64 cm). The same clones exhibited high girth increment on tapping. Bark anatomical observations revealed that there is significant clonal difference existing between clones with regard to total bark thickness and the number latex vessel rows. Incidence of major diseases was comparatively less in this region. All the clones recorded only negligible wind damage with the minimum of 0.27% in PB 314 to 1.35% in GT 1 and PB 260. In addition to PB 314 and RRII 105, the high yield of clones PB 255, PB 311 and PR 255 together with good growth performance suggests that these are potential clones for this region. This study also emphasized the fact that rubber could be established well in the river basins.

Keywords: biotic and abiotic stresses, girth increment, *Hevea brasiliensis*, latex vessel rows, yield depression

Introduction

In a perennial tree crop like *Hevea brasiliensis* frequent exchange of potential clones among the rubber growing countries has taken place over the years as planting materials. For assessing the performance of these clones in different agro - climatic conditions prevalent in our country, conventionally, they are evaluated in three stages viz., small scale trial, large scale trial and block (on farm) trial. Rubber trees do not grow uniformly well in all regions. The growth depends on the climate and soil condition favorable for a particular clone. Evaluation and selection of clones for yield and other desirable secondary attributes are important for choosing the right clones for large scale planting in any region. The present study reports the block wise performance of nine *Hevea brasiliensis* clones in the lake basin of Sasthamkotta, where the gravel content of the soil is very high.

Materials and Methods

The materials used in this study include nine clones of *Hevea brasiliensis*, of which two are from India, two from Indonesia and five from Malaysia. (Table 1).

The experiment was conducted in 9.5ha. area at Bharanikavu near the Sasthamkotta lake in Kollam district. The area lies at a height of 20 to 50 feet from the water level of the lake. Initial physico-chemical properties of the soil are given in Table 2.

The trial was laid out in June 1994 in block wise design with three blocks of RRII 105 and one block each

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Table 1. Details of clones evaluated

Sl. No.	Clones	Parentage	Country of origin
1	RRII 105	Tjir 1 x Gl 1	India
2	RRII 203	PB 86 x Mil 3/2	India
3	GT 1	Primary clone	Indonesia
4	PR 255	Tjirl x PB 107	Indonesia
5	PB 217	PB 5/51 x PB 6/9	Malaysia
6	PB 255	PB 5/51 x PB 32/36	Malaysia
7	PB 260	PB 5/51 x PB 49	Malaysia
8	PB 311	RRIM 600 x PB 235	Malaysia
9	PB 314	RRIM 600 x PB 235	Malaysia

Table 2. Initial Physico-chemical properties of the soil (0-30 cm depth)

Sl. No.	Parameters	Content
1	Gravel (%)	61- 76
2	Texture	Sandy clay
3	Organic carbon (%)	0.62
4	Available Phosphorus (mg/100g soil)	0.35
5	Available potassium (mg/100g soil)	1.08
6	Available Magnesium (mg/100g soil)	0.01
7	pH	4.8

with other clones. The gross stand per block ranged from 350 to 420 trees. The trees were opened for tapping during 2003. The exploitation system followed was 1/2S d/2 in the first three years and 1/2S d/3 in the last two years. The monthly yield was recorded in all tapping days based on volume yield and drc. Annual girth measurements and secondary characters were recorded from the third year of planting. Girth was recorded at a height of 150 cm from the bud union. Rain guards have been provided in all tapping trees. Yield during drought period (February to May) was considered for ascertaining the relative production during the summer period. The characters recorded were monthly yield, annual girth, anatomy of bark, major incidence of diseases such as abnormal leaf fall, pink, powdery mildew, tapping panel dryness and damage caused by wind. From the annual girth data, girth increment during the immature and mature phase was worked out. The clones were ranked based on the performance in each year. To check the consistency of ranking, the Spearman's rank correlation was worked out between ranks of clones between years. Bark samples were collected in the fifth year of tapping at a height of 150 cm, bark thickness measured, the number of latex vessel rows counted by microscopic observations of thin sections and the data was statistically analysed. Soil and leaf samples were analysed periodically from all experimental plots. The samples were collected from three locations of each plot and subjected to statistical analysis.

Results and Discussion

Yield of clones

Mean rubber yield in kg $ha^{-1}yr^{-1}$ for the first five years of tapping, mean yield over 5 years and summer yield depression are given in (Table 3). Spearman's rank correlation between ranks of clones yield over five years was given in (Table 4).

Mean yield over five years revealed PB 314 (2030 kg $ha^{-1}yr^{-1}$) the highest yielder followed by RRII 105

Table 3. Yield performance of clones

Sl. No.	Clones	Annual Yield (kg $ha^{-1}yr^{-1}$) First year)	Second year	Third year	Fourth year	Fifth year	Mean over 5 years	Summer yield depression (%)
1	RRII 105	1447 (4)	1602 (2)	1850 (1)	2220 (4)	2775 (1)	2094 (2)	18.79
2	RRII 203	988 (9)	1010 (9)	1435 (7)	1719 (8)	2133 (6)	1459 (8)	28.00
3	GT 1	1076 (8)	1093 (8)	1248 (8)	1448 (9)	2015 (8)	1376 (9)	31.03
4	PR 255	1263 (6)	1401 (4)	1810 (3)	2297 (3)	2377 (4)	1830 (5)	16.19
5	PB 217	1230 (7)	1232 (6)	1240 (9)	1794 (6)	1974 (9)	1494 (7)	31.77
6	PB 255	1273 (5)	1413 (3)	1685 (5)	2450 (1)	2572 (2)	1878 (3)	14.90
7	PB 260	1769 (2)	1219 (7)	1582 (6)	1765 (7)	2059 (7)	1678 (6)	30.26
8	PB 311	1572 (3)	1350 (5)	1768 (4)	2217 (5)	2246 (5)	1831 (4)	18.00
9	PB 314	1793 (1)	1637 (1)	1827 (2)	2433 (2)	2460 (3)	2030 (1)	15.24

Values in parentheses refers to rank of the clones within each year

Table 4. Spearman's rank correlation between ranks of clones yield over five years

	Year 1	Year 2	Year 3	Year 4
Year 2	0.650*			
Year 3	0.633*	0.817*		
Year 4	0.517**	0.900**	0.683**	
Year 5	0.433**	0.800**	0.883**	0.783**

*Significant at 5%; **Significant at 1%

(1979kg $ha^{-1}yr^{-1}$), PB 255 (1878 kg $ha^{-1}yr^{-1}$) PB 311(1831 kg $ha^{-1}yr^{-1}$) and PR 255 (1830 kg $ha^{-1}yr^{-1}$). Clone GT 1 ranks the lowest position (1376 kg $ha^{-1}yr^{-1}$). In the fifth year of tapping all the clones except PB 217 exhibited yield above 2000 kg $ha^{-1}yr^{-1}$. RRII 105 ranks first (2775 kg $ha^{-1}yr^{-1}$) followed by PB 255 (2572 kg $ha^{-1}yr^{-1}$) and PB 314 (2460 kg $ha^{-1}yr^{-1}$). The peak yielding season was July to January and low yielding was during February to May. There was a rising yield trend for all the clones from the third year. The rank correlation value showed significant association between all the years indicating that the genotypes had consistent yield performance from year to year.

Yield of rubber is the major objective in commercial cultivation of this crop. The present study indicated that, all the PB clones except PB 217 is performing well in this region. Clone PB 314 was the highest yielder followed by the control RRII 105. In the second evaluation trial also the clone PB 314 exhibited higher yield (Alice *et al.*, 2004). The superiority of the clone PB 314 in Malaysia has already been reported (Ghani, 1991). Among the PB clones, PB 217 recorded the lowest yield of 1494 kg $ha^{-1}yr^{-1}$. The same trend was noticed in the evaluation trial established at RRII in 1989.

Generally rubber trees exhibit a depression in yield during summer (February to May), the period of refoliation after wintering. The depression in yield varies from clone to clone (Nair and Marattukalam, 1981). Yield in *Hevea brasiliensis* is a manifestation of various morphological, anatomical, physiological and biochemical characters of the trees (Pollinere, 1966). Yield superiority of a clone is influenced by its capacity to maintain considerable yield levels during stress period also. In the present study, summer yield depression ranged form 15% in PB 255 to 32% in PB 217. In general, yield drop during stress period was high in low yielding clones such as PB 217, PB 260, GT 1 and RRII 203. Alice *et al.* (2004) also reported high summer yield depression of PB 217.

Growth parameters

The growth parameters are presented in (Table 5). There was clonal variation with respect to girth at opening, girth increment in the immature phase and on tapping. Mean girth at opening ranged from 45.84 cm in GT 1 to 53.35 cm in PB 255.

Clones PB 255, RRII 203, PR 255 and PB 217 were superior in terms of vigour. In the fifth year of tapping, the same clones continued to be the vigorous clones. PB 255 exhibited the highest girth (65.70 cm) followed by RRII 203 (61.64 cm) and PR 255 (61.06 cm). The vigorous nature of the clones RRII 203 was reported earlier by Saraswathyamma *et al.* (1994). Similarly high vigour of PB 255 was reported by Alice *et al.* (2004) in the large scale trial. Girth increment before opening was high in PB 255 (6.41 cm) followed by PR 255 (6.30 cm). The trend was same after opening, with PB 255 recorded the highest value (2.74 cm) followed by RRII 203 (2.38 cm) and PR 255 (2.24 cm). GT 1 and PB 260 were low in vigour before opening as well as on tapping. In general, the girth increment rate in the tapping phase was low as expected.

Table 5. Important growth parameters

Sl. No.	Clones	Mean girth at opening (cm)	Mean girth in the fifth year of tapping (cm)	Mean girth increment in the immature phase (cm/yr)	Mean girth increment over first five years of tapping (cm/yr)
1	RRII 105	50.03	56.49	5.78	1.58
2	RRII 203	51.61	61.64	6.14	2.38
3	GT 1	45.84	55.67	5.33	1.30
4	PR 255	50.67	61.06	6.30	2.24
5	PB 217	50.09	60.54	5.97	2.09
6	PB 255	53.35	65.70	6.41	2.74
7	PB 260	46.09	56.10	5.22	2.10
8	PB 311	48.12	57.42	5.81	1.38
9	PB 314	50.18	57.95	5.64	2.15

According to Ferwerda (1969), there is marked variation with regard to girth increment under tapping and its effect on yield. Here there are clones such as PB 255 and PR 255 having good vigor with high yield. The rising yield trend in these clones could possibly be contributed by their higher girth increment. The positive inference of girth increment rate on yield of clones has been reported by Mydin *et al.* (1994). Low girth increment on tapping in PB 314 has been reported earlier (Ong and Khoo, 1990). Even though girth increment was not very high, this clone yields better than other clones with high girth. Good early yield and vigorous growth of clones PB 255 and PB 260 were reported in block trials in Malaysia (Arshad *et al.*, 1995). Clone PB 255 and PR 255 showed high girth increment on tapping and good yield. According to Kavitha *et al.* (2005), good growth under tapping is vital to the maintenance of yield levels.

The total trees planted in each block, number of trees in each block at opening, tappability percentage at opening, total trees under tapping in the fifth year are given in (Table 6). Trees in each block at the time of planting ranged from 350 to 412. RRII 203 recorded the highest percentage tappability of 72.86 % followed by PB 255 (71.31 %). The lowest percentage was exhibited by GT 1 (32.61 %) and PB 260 (37.94 %).

Table 6. Details of tree stand and tappability % in each block at different stages

Sl. No.	Clones	Total trees planted	Trees attained tappable girth (2003)	Tappability (%)	Total trees under tapping (2007)
1	RRII 105	373	240	64.34	330
2	GT 1	368	120	32.61	340
3	RRII 105	376	170	45.21	322
4	RRII 203	350	255	72.86	333
5	PB 217	372	215	57.80	355
6	PB 255	352	251	71.31	315
7	PB 260	369	140	37.94	350
8	PB 311	379	230	60.85	355
9	PB 314	373	213	57.10	325
10	PR 255	398	240	60.30	348
11	RRII 105	412	175	42.48	384

The number of trees in each blocks in the fifth year of tapping ranged from 315 in PB 255 to 384 in RRII 105.

Wintering observations

Wintering observations were recorded during November to February in three consecutive years. Clonal variation in wintering pattern was observed, few are early wintering while others are late wintering. Wintering was earliest in RRII 105, and it usually begins at the end of November and was partial. while in RRII 203 it starts in the middle of December and was complete. In GT 1 wintering initiated in the end of November and it was complete. Among the PB clones wintering starts first in PB 260 in December followed by PB 311, PB 314, PB 255 and PB 217. Uniform wintering was observed in PB 314 while PB 217 exhibited uneven wintering pattern. In PR 255 late wintering with partial wintering pattern was noticed.

Anatomical observations

Total bark thickness and number of latex vessel rows are given in (Table 7). Clonal variation was observed for bark thickness and number of latex vessel rows (LVRs). Five clones recorded higher values for bark thickness and latex vessel rows than the general mean (GM). The virgin bark thickness in the fifth year of tapping ranged from 6.30 mm to 8.80 mm. The clone PB 255 recorded the highest bark thickness of 8.80 mm followed by RRII 203 (8.60 mm) and RRII 105 (8.40 mm). The least was exhibited by PB 311 (6.30 mm). The total number of LVRs ranged from 9.80 to 17.90. The highest was recorded in RRII 105 (17.90) followed by PB 311 (17.60). Clone GT 1 showed the lowest number of LVRs (9.80). According to Premakumari *et al.* (1998), yield performance of *Hevea* clones is governed by laticifer area index and the orientation of laticifers. In the present study the high yielding clones such as RRII 105, PB 314, and PB 255 recorded higher number of LVRs while the number was less in GT1, the lowest yielder. Analysis of variance revealed that there is significant clonal difference existing between clones with regard to total bark thickness and number of latex vessel rows.

Table 7. Anatomical parameters

Sl. No.	Clone	Bark thickness (mm)	Number of Latex vessel rows
1	RRII 105	8.40	17.90
2	RRII 203	8.60	12.70
3	GT 1	7.05	9.80
4	PR 255	7.98	11.58
5	PB 217	7.60	14.30
6	PB 255	8.80	16.80
7	PB 260	7.98	14.10
8	PB 311	6.30	17.60
9	PB 314	6.70	16.90
CD (P = 0.05)		3.92	4.76

Soil and leaf nutrient status

The soil samples were collected before the commencement of planting, in the immature phase and mature phase and analyzed for organic carbon, available phosphorus potassium, magnesium and pH by following standard procedure (Jackson, 1958). Leaf samples were also collected and analyzed for nitrogen, phosphorus, potassium, calcium and magnesium content (Karthikakuttyamma, 1989).

The gravel content of the soil was very high (61-76%) at a depth of 0-30cm. The texture of the soil was sandy clay. The soil fertility status of the locality was very low before planting, soil was poor in organic carbon, available phosphorus, potassium and magnesium. The soil was acidic. For increasing the soil fertility, fertilizer application was done after analysing the soil samples every year. Data on soil nutrient status of top soil collected in the mature phase is given in (Table 8).

Table 8. Soil nutrient status in the mature phase

Sl. No.	Clones	Av. Nutrients in mg/100g soil				
		% C	P	K	Mg	pH
1	RRII 105	0.64	0.31	1.14	0.51	4.57
2	RRII 203	0.86	0.09	1.49	0.61	4.73
3	GT 1	0.69	0.12	1.14	0.80	4.63
4	PR 255	0.71	0.16	1.68	0.91	4.73
5	PB 217	0.79	0.16	1.67	0.84	4.67
6	PB 255	0.86	0.23	1.72	0.82	4.67
7	PB 260	0.78	0.31	2.20	0.96	4.97
8	PB 311	0.83	0.67	1.57	1.39	4.80
9	PB 314	0.98	0.23	1.79	0.79	4.87
CD (P = 0.05)		–	–	–	0.45	–

No significant difference was noted in organic carbon. available phosphorous, potassium and pH, while significantly higher available Mg was noted in the block of PB 311.

According to NBSS report (NBSS & LUP, 1999), if the gravel content of the soil is higher than 35%, it will affect the growth and yield of rubber tree. Here in this study, even though the gravel content was very high (61 to 76%), the growth and yield were not affected. More over an improvement in soil organic carbon, potassium, and magnesium status was noted after cultivating rubber in this area. There was no considerable change in the pH. Data on leaf nutrients status during the mature phase is given in (Table 9).

Data on leaf nutrient status indicated that leaf N. P, Ca and Mg are in the sufficiency range, while K was in the deficiency level, which may be due to low soil K status in all the fields due to gravelly nature of the soil. Even though significant difference was noted between clones in the case of N, P and Ca content. the difference was marginal.

Table 9. Data on leaf nutrient content (%) during mature phase

Sl. No.	Clones	N	P	K	Ca	Mg
1	RRII 105	3.26	0.21	0.66	1.07	0.30
2	RRII 203	3.34	0.22	0.67	1.02	0.25
3	GT 1	3.43	0.26	0.81	1.09	0.31
4	PR 255	3.38	0.28	0.84	1.19	0.29
5	PB 217	3.39	0.27	0.80	0.85	0.27
6	PB 255	3.38	0.21	0.77	0.88	0.31
7	PB 260	3.30	0.21	0.57	1.15	0.25
8	PB 311	3.33	0.25	0.64	0.91	0.30
9	PB 314	3.10	0.21	0.79	0.91	0.35
CD (P = 0.05)		0.19	0.05	–	0.21	–

Soil and leaf analysis is useful in predicting the fertilizer requirements of rubber tree in a particular area. The phosphorus content of soil as well as leaf was less when compared to other nutrients. It ranged from 0.09 to 0.67 % in soil and 0.21 to 0.28% in leaves. Rubber trees are reported to thrive in low P areas since the fine roots of rubber trees were found colonized by arbuscular mycorrhizal fungi which have an inherent high P acquisition efficiency (Jessy *et al.*, 2007). It is also reported that in mature rubber, application of nitrogen and potassium fertilizers improved the yield, where as, phosphorus had no effect (Pushparajah, 1969).

Occurrence of various biotic and abiotic stresses

Tolerance of clones to various biotic and abiotic stresses is of great importance in assessing the performance of *Hevea* clones. Intensity/Incidence of various diseases and damage caused by wind are given in (Table 10).

Clonal variation in the incidence of major diseases, wind and TPD was observed. The intensity of abnormal leaf fall was relatively less which ranging from 11% (RRII 105) to 32% (PB 255). On the other hand the incidence of powdery mildew was high ranging from 22% (PB 314) to 73% (GT 1). Few clones were found affected by pink disease with RRII 105 recording the highest incidence of 4%. In clones RRII 203, PB 255, PB 260 and PB 314, none of the trees were affected by pink disease. PB 217, though not a high yielder recorded highest TPD (9.32%) followed by PB 314 (8.04%) and PB 311 (7.25%). Incidence of wind damage was recorded up to the 13[th] year after planting. In general, all the clones recorded only negligible wind damage with the minimum of 0.27% in PB 314 and maximum of 1.35% in GT 1 and

Table 10. Disease intensity/incidence and wind damage in various clones

Sl. No.	Clones	Abnormal leaf fall (%)	Powdery mildew intensity (%)	Pink disease incidence (%)	TPD (%)	Wind damage (%)
1	RRII 105	11	31	4.0	6.07	1.34
2	RRII 203	27	66	0.0	1.43	1.14
3	GT 1	21	73	0.7	2.72	1.35
4	PR 255	22	31	1.3	3.02	0.50
5	PB 217	23	60	1.0	9.32	0.00
6	PB 255	32	34	0.0	2.27	0.28
7	PB 260	25	41	0.0	3.12	1.35
8	PB 311	26	32	0.7	7.25	1.32
9	PB 314	25	22	0.0	8.04	0.27

PB 260 followed by RRII 105 (1.34%). No wind damage was recorded in PB 217; the wind resistant nature of this clone was reported earlier in the other trials by Alice *et al.* (2004).

The location where the trial laid out is considered as marginally suitable for rubber cultivation due to low fertility status of the soil. Manuring was done after analysing the soil and leaf samples. Soil fertility was improved after cultivating rubber in this region. The over all result in this study indicates that rubber could be established well in gravelly soil by adopting proper agro management practices. Performances of most of the clones are encouraging in this area. In addition to PB 314 and RRII 105, the high yield of the clones PB 255, PB 311 and PR 255 together with good growth performance suggests that these are potential clones for large scale planting in this region. In a tree crop like *Hevea brasiliensis,* the availability of planting materials can be attained by frequent exchange of superior clones among the rubber growing countries. Introduction of diverse genotypes also provide opportunities for evolving promising clones through hybridization and clonal selection

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