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Variation in strength properties of wood of ten selected clones of *Hevea brasiliensis*

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Abstract

Variation in certain strength properties of wood such as static bending, tensile strength, compressive strength, shearing strength, and hardness in mature trees of ten clones of *Hevea brasiliensis* viz., RRII 44, RRII 45, RRII 105, PB 235, PB 260, PB 310, PB 311, PR 255, PR 261 and RRIM 600 were studied. It was found that the modulus of rupture of the timber under static bending was significantly higher in the clone RRII 105 than that of PB 260, PB 311, PR 255, PR 261, RRIM 600, RRII 44 and RRII 45. The modulus of elasticity was significantly higher in PB 235 than that of all other clones except RRII 105.The timber of RRII 105 also showed superiority over all other nine clones for other static bending parameters such as maximum load, fibre stress at limit of proportionality, horizontal stress at limit of proportionality and horizontal stress at maximum load. The variation in the tensile strength and shearing strength properties between clones were not statistically significant. The maximum load bearing capacity under compressive strength was significantly higher in RRII 105 than PB 311, PR 255, PR 261, RRII 44 and RRII 45. The wood hardness test at various planes (radial, tangential and end) also indicated significant clonal variation. The hardness of wood at radial and tangential planes was significantly higher in RRII 105 than that of PB 260 and RRII 44.The present study revealed significant clonal variability in strength properties of different clones of rubber wood. The study also revealed that the timber quality of the popular clone RRII 105 is superior to majority of the clones studied in terms of static bending, compressive strength and hardness.

Keywords: Clonal variability, *Hevea brasiliensis*, rubber wood, strength properties

Introduction

The suitability of rubber wood for various utility applications has been well established. As an eco-friendly and low cost alternative source of timber, the future demand of rubber wood for various applications is expected to grow particularly in the context of scarcity of indigenous timber species. Information on important strength properties is essential for effective utilization of rubber wood. (Gnanaharan, 2002). Shukla (1989) reviewed the literature and compared the strength properties of rubber wood from India and Malaysia. Sanyal and Dangwal (1983); Shukla and Lal (1985, 1994); Gnanaharan and Damodaran(1993) reported that the strength properties of rubber wood is comparable with that of teak wood.

Available information in the literature on strength properties of rubber wood are normally without reference to any specific clone. Reghu *et al.* (2005) reported significant clonal variability in timber yield, wood density, and shrinkage properties in ten popular clones of *H. brasiliensis*. As different clones produce different qualities of wood, a systematic analysis on the strength properties of rubber wood from different clones assumes much importance. As information in this line have not been generated so far, the present study aims to provide information on the clonal variation in certain strength properties of rubber wood in ten selected clones of *H. brasiliensis*.

Materials and Methods

Twenty three year old trees of ten clones of *Hevea brasiliensis*, viz., PB 235, PB 260, PB 310, PB 311, PR 255, PR 261, RRIM 600, RRII 44, RRII 45 and RRII 105 were selected for the study. The trees were planted in Randomized Block Design (RBD) in three replications

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with a plot size of 25 trees per clone at the Central Experiment Station of Rubber Research Institute of India, Chethackal, Ranni, Pathanamthitta District, Kerala. The station is situated at 100 m MSL, with 9^0 22' N and 76^0 50' E in the typical traditional rubber growing tract. The soil type is ultisol and the annual rain fall ranges from 2,000 mm to 4,000 mm. Six trees from each clone (two trees each from three replications) were clear felled and wood scantlings from the breast height level of the main trunk were tested for various strength properties at 12 % moisture content following Indian Standard method, (BIS:1986), using a Universal Testing Machine. Analysis of variance (ANOVA) and test of significance was carried out on the data generated.

Results and Discussion

Static bending: Table 1 gives the mean value for the properties determined from the ten clones with respect to five static bending tests of wood samples at 12 % moisture content. Significant variation in the mean values for the derived parameters was observed for all the clones in static bending test. The modulus of rupture (MOR) of RRII 105 (953.46 kg/cm^2) was significantly higher than that of seven clones PB 260 (712.42 kg/cm^2), PB 311 (707.93 kg/cm^2), PR 255 (662.52 kg/cm^2), PR 261 (629.45 kg/cm^2), RRIM 600 (731.70 kg/cm^2), RRII 44 (650.36 kg/cm^2) and RRII 45 (629.74 kg/cm^2). Wood from the clones PB 235 (916.15 kg/cm^2) and PB 310 (847.70 kg/cm^2) does not differ significantly in their mean with that of RRII 105. The modulus of elasticity (MOE) value of wood from clone PB 235 (97.41 kg/cm^2 x 1000) was significantly higher than the other clones except RRII 105 (87.59 kg/cm^2 x 1000) which were on par. The clone RRII 105 showed significant superiority in terms of bending strength over all the other clones studied. The MOR and MOE values of all the ten clones were lower than that of teak wood. Whereas, the parameters such as horizontal shear stress at LP and horizontal shear stress at maximum load of all the ten clones were superior to that of teak wood.

Table 1. Static bending properties of wood of *Hevea* clones

Clone	MOR (kg/cm^2)	Max. load (kg)	FS at LP (kg/cm^2)	HS at LP (kg/cm^2)	HS at ML (kg/cm^2)	MOE (kg/cm^2) x 1000
PB 235	916.15	175.65	588.66	20.98	33.08	97.41
PB 260	712.42	137.35	426.59	15.21	25.86	62.23
PB 310	847.70	162.27	520.52	18.66	29.94	81.40
PB 311	707.93	134.73	480.28	17.15	25.27	71.03
PR 255	662.55	123.43	333.65	13.59	23.47	60.58
PR 261	629.45	118.77	400.18	14.24	22.40	53.10
RRIM 600	731.70	138.91	451.03	16.08	26.09	74.44
RRII 45	629.74	119.09	409.06	14.44	22.81	56.40
RRII 44	650.36	125.96	411.08	14.66	23.64	51.19
RRII 105	953.46	181.33	634.86	22.66	34.04	87.59
CD(P=0.01)	124.25**	24.65**	112.90**	4.02**	4.63**	13.03**
CV (%)	9.73	10.12	13.97	13.99	10.12	10.90
Teak wood*	959.00	-	651.00	10.40	14.90	119.60

*Shukla and Lal (1985)

MOR: Modulus of Rupture, MOE: Modulus of Elasticity,

FS at LP: Fiber stress at limit of proportionality

HS at LP: Horizontal shear stress at limit of proportionality,

HS at ML: Horizontal shear stress at maximum load

Tensile strength: Table 2 gives the mean values for the tensile strength properties such as maximum load, tensile stress at limit of proportionality (TS at LP) and tensile stress at maximum load determined from the wood samples of ten clones. Analysis of variance indicated that all the parameters under tensile strength were not statistically different. In comparison with teak wood, none of the clones showed higher values with regard to TS at LP whereas, the clone PB 260 (1069. 32 kg/cm^2) had the higher mean value for tensile stress at maximum load than that of teak wood (915.00 kg/cm^2).

Table 2. Tensile strength of wood of *Hevea* clones

Clone	Max. load (kg)	TS at LP (kg/cm^2)	TS at ML (kg/cm^2)
PB 235	380.81	279.24	840.89
PB 260	478.16	355.89	1069.32
PB 310	373.37	296.79	833.98
PB 311	401.24	283.54	843.48
PR 255	342.69	358.93	735.26
PR 261	449.25	345.29	991.87
RRIM 600	404.99	323.42	907.19
RRII 45	362.23	242.49	830.82
RRII 44	307.17	239.57	665.12
RRII 105	359.69	315.75	862.63
CD (P=0.01)	NS	NS	NS
CV (%)	14.79	21.32	15.45
Teak wood*	-	376.00	915.00

*Shukla and Lal (1985)

TS at LP: Tensile strength at limit of proportionality

TS at ML: Tensile strength at maximum load

NS: Not significant

Compressive strength: Compressive strength parallel to grain measures the ability of the timber to withstand loads applied along the grain, like in the case of columns, pillar and posts. Results of tests (Table 3) revealed the maximum compressive load bearing capacity parallel to grain in RRII 105 to be 1807.61 kg, which is significantly higher than that of four clones, PR 261 (1566.92 kg), PR 255 (1457.86 kg), RRII 44 (1465.77 kg) and RRII 45 (1473.19 kg). The five clones viz., PB 235, PB 310, PB 311, PB 260 and RRIM 600 were

Table 3. Compressive strength (parallel to grain) of wood of *Hevea* clones

Clone	Max. load (kg)	CS at LP (kg/cm^2)	CS at ML (kg/cm^2)	MOE (kg/cm^2) X 1000
PB 235	1774.52	325.01	433.85	21.13
PB 260	1605.83	282.14	400.57	35.71
PB 310	1707.48	267.54	426.32	37.34
PB 311	1584.37	276.77	419.36	33.96
PR 255	1457.86	244.39	365.99	21.28
PR 261	1566.92	267.04	389.36	34.98
RRIM 600	1608.57	276.72	401.30	35.46
RRII 45	1473.19	231.04	372.88	24.69
RRII 44	1465.77	236.41	363.93	25.55
RRII 105	1807.61	312.90	451.09	40.33
CD (P=0.01)	209.54**	52.46 **	52.69 **	7.63 **
CV (%)	7.56	11.24	7.63	13.91
Teak wood*	-	376.00	532.00	137.40

*Shukla and Lal(1985)

CS at LP: Compressive stress at limit of proportionality

CS at ML: Compressive stress at maximum load

on par with RRII 105. The wood of RRII 105 showed superiority over the other clones for all other parameters related to compressive strength. None of the *Hevea* clones showed superiority over teak wood for compressive strength properties.

Shearing strength: It measures the splitting behavior of timber under forces parallel to grain, especially in the field of joinery, construction, flooring etc. All the parameters under radial and tangential shearing strength were not statistically significant (Table 4). However, the wood of all ten clones showed higher values with respect to maximum radial shear stress than that of teak wood. In the case of maximum tangential shear stress, except two clones PB 235 and PR 261, all the other clones had comparable values with teak.

Table 4. Shearing strength of wood of *Hevea* clones

Clone	Radial		Tangential	
	Max. load (kg)	Max. shear stress (kg/cm^2)	Max. load (kg)	Max. shear stress (kg/cm^2)
PB 235	2817.97	112.7 0	2473.17	99.10
PB 260	2747.03	109.90	2597.90	103.93
PB 310	3120.70	125.30	2837.70	113.50
PB 311	2827.57	112.33	2590.50	103.67
PR 255	2710.87	108.43	2512.40	100.50
PR 261	2713.93	108.10	2448.60	96.00
RRIM 600	2941.40	117.70	2743.30	109.77
RRII 45	2855.13	114.20	2662.80	106.53
RRII 44	2839.03	112.07	2630.20	105.23
RRII 105	2819.33	113.33	2719.67	106.97
CD (P=0.01)	NS	NS	NS	NS
CV (%)	6.87	6.83	6.25	6.08
Teak wood*	-	96.60	-	108.00

*Shukla and Lal (1985)

NS: Not significant

Hardness: It indicates the ability of the timber surface to withstand hard and tough loads both parallel and perpendicular to grain. It also reflects the abrasion, wear and tear properties, especially for applications like flooring, sports goods, furniture, joinery, carving, and tool handle etc. Table 5 gives the results of the hardness test at timber surfaces (radial, tangential, end and side) of ten clones. Results indicated significant variation in the values for all derived parameters in hardness test. Hardness at radial (492.86 kg) and end surfaces (645.43 kg) was maximum for PB 310 whereas, RRII 105 (549.81 kg) has shown the highest tangential hardness. The clone RRII 105 was superior to two clones viz., PB 260 and RRII 45 for radial hardness; superior to five clones viz., PB 235, PB 260, PR 261, RRII 45 and RRII 44 for tangential hardness; superior to one clone viz., PB 260 for end hardness. Side hardness is the average of radial and tangential hardness values. In comparison with teak wood, three clones viz., PB 310, RRII 105 and RRII 44 had comparable tangential hardness whereas, all the ten clones showed higher values for end hardness than that of teak wood.

Table 5. Hardness of wood of *Hevea* clones

Clone	Radial (kg)	Tangential (kg)	End (kg)	Side (kg)
PB 235	440.64	437.52	569.88	439.03
PB 260	404.57	442.62	534.39	423.60
PB 310	492.86	529.17	645.43	511.05
PB 311	486.32	522.36	639.36	504.25
PR 255	472.58	522.72	602.59	417.86
PR 261	464.99	468.22	583.72	466.61
RRIM 600	483.55	502.03	613.70	492.79
RRII 45	411.87	423.84	519.39	497.65
RRII 44	475.19	530.99	610.70	503.04
RRII 105	485.85	549.81	638.23	517.83
CD (P=0.01)	54.07**	60.81**	69.31**	54.56**
CV (%)	6.83	7.19	6.78	6.66
Teak wood*	502.00	524.00	488.00	-

*Shukla and Lal (1985)

It has been reported earlier that rubber wood is having high bending strength, low tensile strength, shearing strength, and hardness than teak wood (Gnanaharan and Damodaran 1993). The present study revealed that except for static bending (HS at LP & HS at ML), radial shear stress and end hardness and all the other strength parameters of rubber wood were lower than that of teak wood. Reghu *et al.* (2005) studied the timber yield, wood density and volumetric shrinkage of the same ten clones used in the present study and reported significant variability. They further observed that the timber of RRII 105 showed superiority over other nine clones for physical properties such as basic density, volumetric shrinkage and low level of tension wood formation (natural defect) though the timber yield is very low. The present study has revealed that except for static bending (MOE) and compressive strength, other parameters such as tensile strength, shearing strength and hardness in RRII 105 were similar to that of teak wood indicating the superiority of the timber of RRII 105 in terms of strength properties. In general, the strength properties of rubber wood showed considerable variation among different clones.

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