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A STUDY ON DISTRIBUTION OF PORES IN TENSION WOOD AND NORMAL WOOD OF *HEVEA BRASILIENSIS*

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SUMMARY

The distribution pattern, number and area occupied by pores per unit cross sectional area of wood in normal and tension wood zones of four clones of *Hevea brasiliensis viz.* Tjir 1, GT 1, RRIM 600 and RRII 105 were studied with special emphasis on clonal variability. The number of pores per cm^2 in both normal and tension wood zones was considerably lower in RRII 105. The variation in number of pores per cm^2 between normal and tension wood was statistically significant only in RRII 105. None of the clones showed significant differences in pore frequency between different height levels as well as between wood types. The total area occupied by pores in both normal and tension wood was maximum in RRII 105 and minimum in Tjir 1. The difference in the total pore area between normal and tension wood was statistically significant only in GT 1. Of the four clones studied, the average pore area in normal and tension wood was the highest in RRII 105 and the lowest in Tjir 1. In comparison between wood types, in GT 1 and Tjir 1 the average pore area was higher in normal wood, where as the trend was just the reverse in RRII 105 and RRIM 600. However the difference was statistically significant only in RRII 105 and GT 1.

Key words : Rubber wood, Hevea, tension wood , pores

INTRODUCTION

Tension wood formation is considered to be a natural defect which results in abnormal structure of wood in hard wood species (Fisher and Stevenson, 1981; Fahn, 1982; Reghu, 1983; Rao and Hemavathi, 1990;. Jourez *et al.*, 2001). The modification in the morphology, distribution, structure and dimension of pores has been reported earlier in many hard wood species (Rao, 1983; Reghu 1983; Jorez *et al.*, 2001). It has been reported that the increase in the frequency and dimension of pores will reduce the density and strength of wood to a greater extent (Jourez *et al.*, 2001).

Hevea brasiliensis (Para rubber) belonging to the family Euphorbiaceae is widely cultivated for natural rubber. Rubber wood, the by-product of rubber plantations, is a diffuse porous, light hard wood, being widely used as a versatile raw material for various wood based industries. The incidence of tension wood is relatively high in *Hevea*. Major anatomical modifications due to tension wood formation include the development of unlignified or partially lignified gelatinous fibers, changes in the distribution and proportion of vessel elements, frequency and dimension of rays etc. (Rao *et al.*, 1982 and Jourez *et al.*, 2001). The present investigation is aimed at understanding variation in the distribution and area occupied by pores in tension wood (TW) and normal wood (NW) of *Hevea brasiliensis* in different clones.

MATERIALS AND METHODS

Mature trees of four *Hevea clones viz.* Tjir 1. GT 1, RRIM 600 and RRII 105 were selected from the Central Experimental Station of Rubber Research Institute of India at Chethackal, Ranni, Kerala. Four trees were selected from each clone and clear felled. Wood discs of 7.5 cm thickness were cut from the bole at three height levels *viz.* 60 cm, 210 cm and 300 cm from the ground, hereafter designated as disc A, disc B and disc C, respectively.

Cubic blocks of wood of size 2 x 2 x 2 cm were prepared from each disc along its entire diameter , excluding the pith as shown in Figure 1. Ten samples were prepared from each disc, comprising five samples each from both radii. Of the five samples, one represented the zone contiguous to the pith and another from the extreme periphery. Three more samples were taken from the zone in between these samples at equal distance. The blocks prepared from one side of the disc were labeled as B1, B2, B3, B4 and B5 from pith to periphery, and the blocks from the corresponding positions in the opposite side were labeled as b1, b2, b3, b4 and b5, respectively (Fig. 1). Wood samples thus prepared were fixed in Formalin–Acetic–Alcohol.

Sledge microtome sections at cross- sectional plane were taken from the samples at 30 µ m thickness and stained in toludine blue 'O' (O' Brien *et al.*, 1963). Microscopic observations were carried out using a Leitz Aristoplan research microscope attached to Leica Q500W image analysis system, and measurements were taken with Leica Qwin image analysis software. The total number and area occupied by pores per unit C.S. area were recorded separately from normal and tension wood. Measurements were taken from 10 microscopic fields at random. The average area of pores was calculated by dividing the total C.S. area of pores per cm^2 with the number of pores per cm^2.

ANOVA was done to analyze the variation in number of pores, total area and average area of pores in NW and TW zones. The data obtained from four clones were considered together to ascertain the variation between different height levels. Paired t-test was done to compare the characters in normal and tension wood zones.

RESULTS AND DISCUSSION

The understanding of distribution of pores, especially the number and area occupied by them in tension wood and normal wood assumes significance considering the chemical impregnation capacity of rubber wood during wood preservation.

The number, total area and average cross-sectional area of pores in normal and tension wood zones in four clones were presented in Table 1. The number of pores per cm^2 in tension wood was lower than that of normal wood in RRII 105 and RRIM 600, where as in GT 1 and Tjir 1, a reverse trend was observed (Fig. 2). However, the difference between the two wood types was significant only in RRII 105 (Table 4). Irrespective of wood type, the number of pores was maximum in RRII 105 and minimum in GT 1 (Table 2). At different height levels the number of pores showed an increasing trend from base to top of the trunk in RRII 105 and RRIM 600 where as a fluctuating trend was observed in GT 1 and Tjir 1 (Table 2), though, the variation was not

statistically significant (Table 3). The recent study made by Mathew and Reghu (2006) proved that the proportion of tension wood was increased in RRII 105 and RRIM 600 and decreased in GT 1 and Tjir 1. In this context the present study revealed that the number of pores was negatively correlated with the quantity of tension wood formed in *Hevea brasiliensis*.

In comparison with normal wood, the area occupied by pores per cm^2 cross sectional area of wood was also reduced in tension wood zones of all the four clones studied (Fig 3), however, the variation was significant only in GT 1 (Table 4). The clone averages for this trait was maximum in RRII 105 and minimum in GT 1 (Table 2). When both wood types were considered together, the total area occupied by pores was increased from base to top of the tree trunk (Table 2) though this difference was not statistically significant (Table 3). In *Hevea*, the pores are evenly distributed as solitary or radial multiples of 2 to 3 or rarely more (Reghu, 2002). It has already been reported that in many hardwood species. The number, size and area occupied by pores in tension wood zone were reduced in comparison with normal wood (Rao, 1983; Reghu, 1983; Jourez *et al.*, 2001). The present study also confirmed that tension wood formation in *Hevea* is associated with the reduction in wood porosity. This phenomenon may have certain negative influence on the impregnation capacity of wood preservatives during rubber wood processing.

Of the four clones studied, the average pore area was the highest in RRII 105 and the lowest in Tjir 1 (Fig 4). The average pore area was comparatively higher in NW zone than TW zone in GT 1 and Tjir 1, whereas it was just the reverse in RRII 105 and RRIM 600 and the variation was significant only in RRII 105 and GT 1 (Table 4). Irrespective of wood types the average area (clone average) was maximum in RRII 105 and minimum in GT 1 (Table 2). With respect to different height levels the pore area showed an increasing trend from base to top in RRII 105 and RRIM 600 where as in GT 1 and Tjir 1 it showed a fluctuating trend (Table 2) but the difference was not statistically significant (Table 3). Jourez *et al.* (2001) reported an increase in the average pore area in tension wood than normal wood in poplar (*Populus euramericana*) and this result is in accordance with the present findings in RRII 105 and RRIM 600. However, in GT1 and Tjir 1, the average pore area was reduced in tension wood zone as reported earlier in various hardwood species (Hoster, 1972). It is important to note that in GT 1 and Tjir 1, though the number of pores per unit area in tension wood was increased, the total area occupied by them was decreased due to the reduction in the average pore area. Where as in clone like RRII 105 and RRIM 600, the reduction in the total area of pores in tension wood zone was mainly attributed to the reduction in the total number of pores per unit area.

CONCLUSION

In general, the present study revealed that the formation of tension wood leads to various structural modifications in rubber wood to a great extent. As an increase in wood porosity is a desirable character for rubber wood processing especially for the easy impregnation of preservatives, those clones having high quantity of tension wood may have some adverse impact on the penetration and impregnation of preservatives.

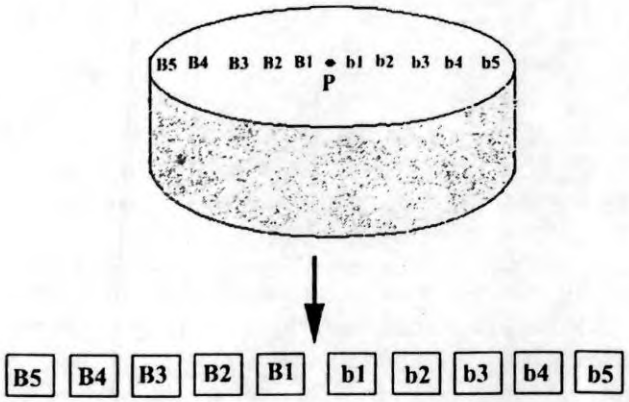

Fig. 1 - Diagrammatic representation of preparation of sample blocks from wood disc (B1, B2, B3, B4, B5; b1, b2, b3, b4 & b5 – sample block from both radii)

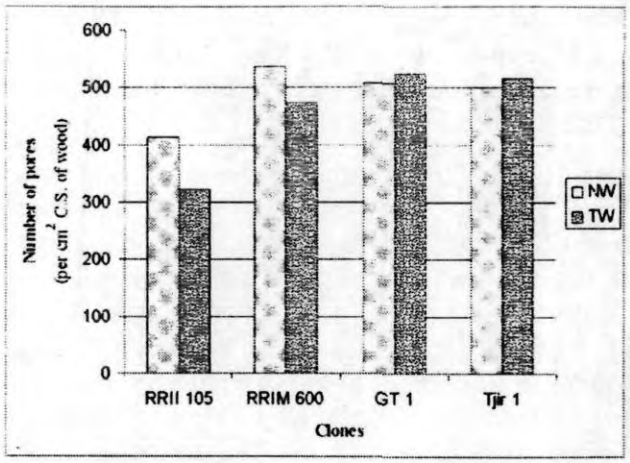

Fig. 2 - Number of pores in normal and tension wood

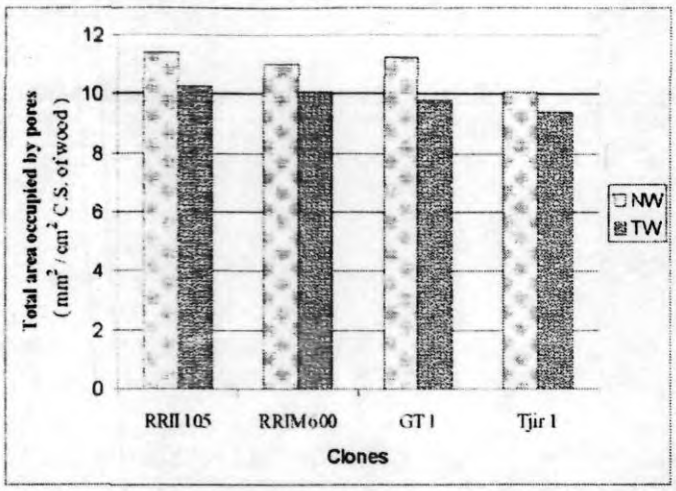

Fig. 3 - Total area occupied by pores in normal and tension wood

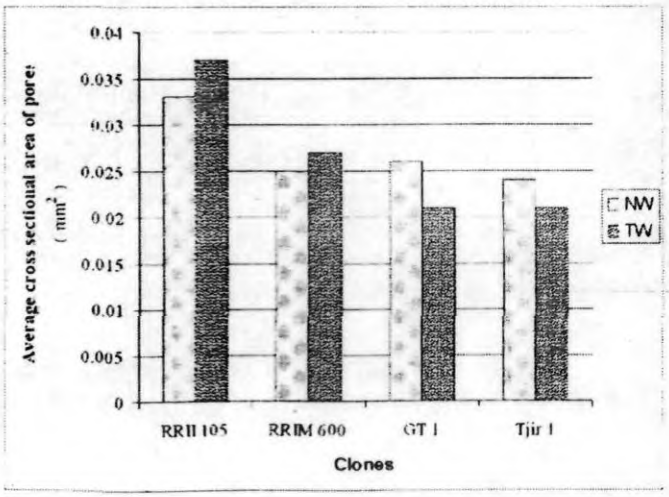

Fig. 4 - Average cross sectional area of pores in normal and tension wood

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Table 1 - Number and area of pores in tension wood and normal wood

Clone	Disc	Number of pores (per cm^2 C.S of wood)				Total area occupied by pores (mm^2 / cm^2 C.S. area)				Average area of pores (mm^2)			
		NW zone		TW zone		NW zone		TW zone		NW zone		TW z	
		Disc average	Clone average	Disc average	Clone average	Disc average	Clone average	Disc average	Clone average	Disc average	Clone average	Disc average	
RRII 105	A	384.48	**414.10**	280.40	**321.23**	9.44	**11.40**	8.85	**10.28**	0.029	**0.033**	0.037	
	B	446.83		314.18		12.26		10.61		0.032		0.038	
	C	413.10		369.13		12.49		11.40		0.036		0.036	
RRIM 600	A	529.91	**535.94**	423.66	**474.74**	9.27	**10.90**	9.27	**10.08**	0.021	**0.025**	0.028	
	B	540.07		452.37		11.45		10.34		0.025		0.026	
	C	537.85		548.20		12.25		10.66		0.031		0.026	
GT 1	A	464.69	**506.02**	479.42	**523.89**	10.04	**11.24**	8.91	**9.79**	0.024	**0.026**	0.021	
	B	557.42		566.88		11.74		10.23		0.026		0.022	
	C	495.93		525.36		11.96		10.24		0.028		0.020	
Tjir 1	A	477.39	**500.63**	523.28	**516**	8.86	**10.08**	8.49	**9.40**	0.021	**0.024**	0.019	
	B	486.10		478.02		10.34		10.01		0.024		0.024	
	C	538.40		547.68		11.04		9.70		0.026		0.020	

Table 2 - Number and area of pores irrespective of wood types (at different height positions and clone averages)

Clone	Number of pores (per cm^2 C.S of wood)				Total area occupied by pores (mm^2 / cm^2 C.S. area)				Average area of pores (mm^2)			
	A	B	C	Clone average	A	B	C	Clone average	A	B	C	
RRII 105	332.44	380.51	391.12	368.02	9.145	11.435	11.945	10.84	0.033	0.035	0.036	
RRIM 600	476.78	496.22	543.03	505.34	9.27	10.895	11.455	10.54	0.025	0.026	0.029	
Tjir 1	472.05	562.15	510.65	514.95	9.475	10.985	11.1	10.52	0.023	0.024	0.024	
GT 1	500.34	482.06	543.04	508.48	8.675	10.175	10.37	9.74	0.020	0.024	0.023	

Table 3 - ANOVA for number and area of pores in normal and tension wood

Character	Source	Number of pores				Total area occupied by pores				Average cross sectional are pores			
		SS	df	SS	F	SS	df	MS	F	SS	df	MS	
Variation between height levels (irrespective of clones)	Treatment	17821.32	2	8910.66	0.77 NS	19.10	2	9.55	2.74 NS	0.186	2	0.093	
	Error	104136.59	9	11570.73		31.27	9	3.47		0.33	9	0.037	
Variation between clones (irrespective of height levels)	Treatment	32538.06	3	10846.02	2.03 NS	4.16	3	1.38	1.28 NS	0.194	3	0.064	
	Error	64052.83	12	5337.73		13.01	12	1.08		0.291	12	0.024	

NS : Non-significant

Table 4 - t- test for number and area of pores in normal and tension wood

Clone	Frequency of pores		Total area occupied by pores		Average cross sectional area of pores	
	df	t	df	t	df	t
RRII 105	11	3.20 * *	11	1.80	11	-2.44 *
RRIM 600	11	0.96	11	1.60	11	-0.05
GT 1	11	-0.74	11	5.47 * *	11	3.30 * *
Tjir 1	11	-1.52	11	2.07	11	1.435

* : Significant at 5% level

* * : Significant at 1% level

t value with –ve sign : the value was higher for G-fibers