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DIMENSIONAL VARIATIONS OF NORMAL AND TENSION WOOD FIBRES IN FOUR CLONES OF *HEVEA BRASILIENSIS*

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Variations in the length, width and wall thickness of normal wood fibres (NF) and tension wood fibres (GF) were studied at different height levels of four clones *viz.* Tjir 1, GT 1, RRIM 600 and RRII 105 of *Hevea brasiliensis*. Length and width of both types of fibres showed a fluctuating trend from pith to periphery. In all these clones the average length of NF was more than that of GF. The variation in length and width of NF and GF between clones and different height levels was not statistically significant. However, highly significant variations were observed in length, width and wall thickness of normal and tension wood fibres within all the four clones.

Keywords: Fibre wall, G-fibre, *Hevea brasiliensis*, Tension wood, Wood fibre.

INTRODUCTION

Hevea brasiliensis (Para rubber) belonging to the family of Euphorbiaceae, is a major source of natural rubber and timber. The occurrence of tension wood is a natural defect, which adversely affects the strength properties of rubber wood to a great extent. In tension wood fibres, certain layers of the secondary wall are not lignified or only partially lignified. Such fibres are composed of crystalline cellulosic microfibrils. This gives the characteristic 'gelatinous' or sticky nature to tension wood fibres and hence are generally designated as gelatinous fibre or G-fibre. Generally tension wood is considered as the abnormal tissue produced by the cambium in tune with the reorientation of the axis from its normal equilibrium position (Wardrop, 1964; Cote *et al.*, 1969; Fisher and Stevenson, 1981). The wood fibre during tension wood formation undergoes modifications with respect to structural and mechanical properties. Therefore all the modifications that have occurred in wood fibres must be considered to explain the behavior of tension wood and its derivatives (Kaeiser and Boyce, 1965). The thickness of G-layer is variable and normally it replaces the innermost (third) layer of the secondary cell wall (S_3 layer) in *H. brasiliensis*. In other species, it may replace the secondary S_2 layer or may get incorporated with S_3 layer (Wardrop and Dadswell, 1955; Cote *et al.*, 1969; Scurfield, 1973).

In many hardwood species, tension wood fibres are longer than normal wood fibres (Chow, 1946; Onaka, 1949; Kaeiser and Boyce, 1965). Jourez *et al.* (2001) reported that G-fibres are more than 4.5% longer than normal wood fibres in poplar.

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Wardrop (1964) reported that the G-fibres may be longer, shorter or may have the same length of normal fibres in different trees. The tension wood fibres are shorter than normal fibres in the *H. brasiliensis* clone PB 86 (Reghu *et al.*, 1989). In rubber clones PR 107 and RRIM 600 (Amin, 1986) and PB 86 (Reghu *et al.*, 1989) the length and width of both NF and GF have been observed to increase from the pith to the periphery. The present study is an attempt to understand the dimensional variation in normal and tension wood fibres of four *H. brasiliensis* clones.

MATERIALS AND METHODS

Four mature trees each of *Hevea clones viz.* Tjir 1. GT 1, RRIM 600 and RRII 105 of age 22-26 years grown in the Central Experimental Station of Rubber Research Institute of India were selected and clear felled. Wood disc at samples A, B and C (7.5 cm thickness) were collected from the bole at three heights of 60, 210 and 300 cm respectively from the ground. Cubic wood blocks 2 x 2 x 2 cm were prepared from the discs along their entire diameter excluding pith. Ten samples were prepared, comprising five samples each from opposite radii one each representing the zone contiguous to the pith and the extreme periphery and the other three from the intermediate zones at equal distance and were labeled as shown in Fig. 1. The samples were fixed in formalin–acetic acid-alcohol mixture (FAA) (Jahansen, 1940), macerated in Jeffrey's fluid (Berlyn and Miksche, 1976), stained with toludine blue 'O' (O Brien *et al.*, 1964) and mounted in 10% glycerin for dimensional studies. The length and width of NF and GF were

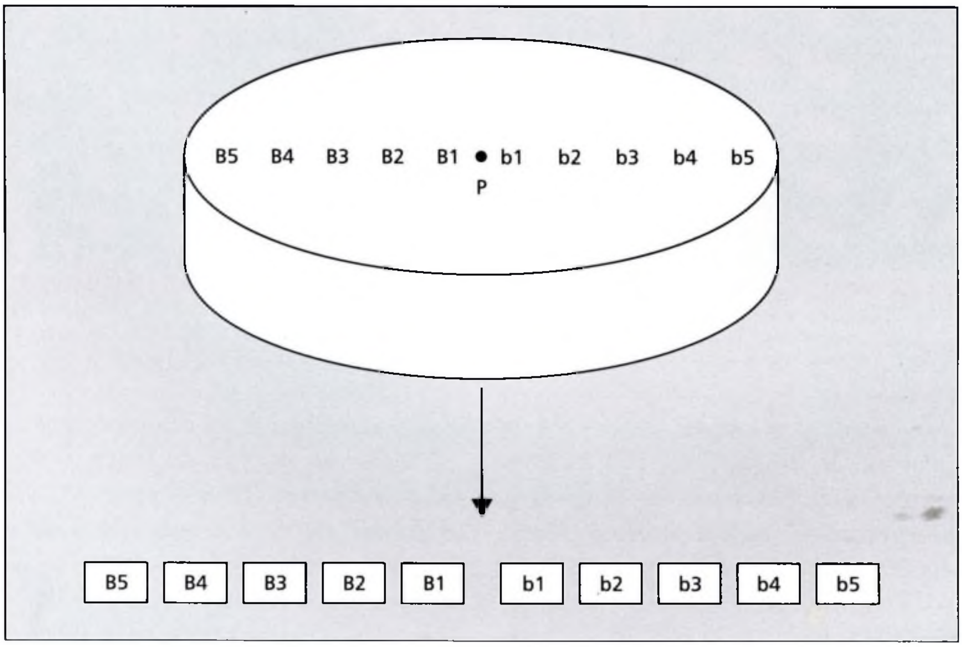

Fig. 1. Diagrammatic representation of sample blocks from wood disc

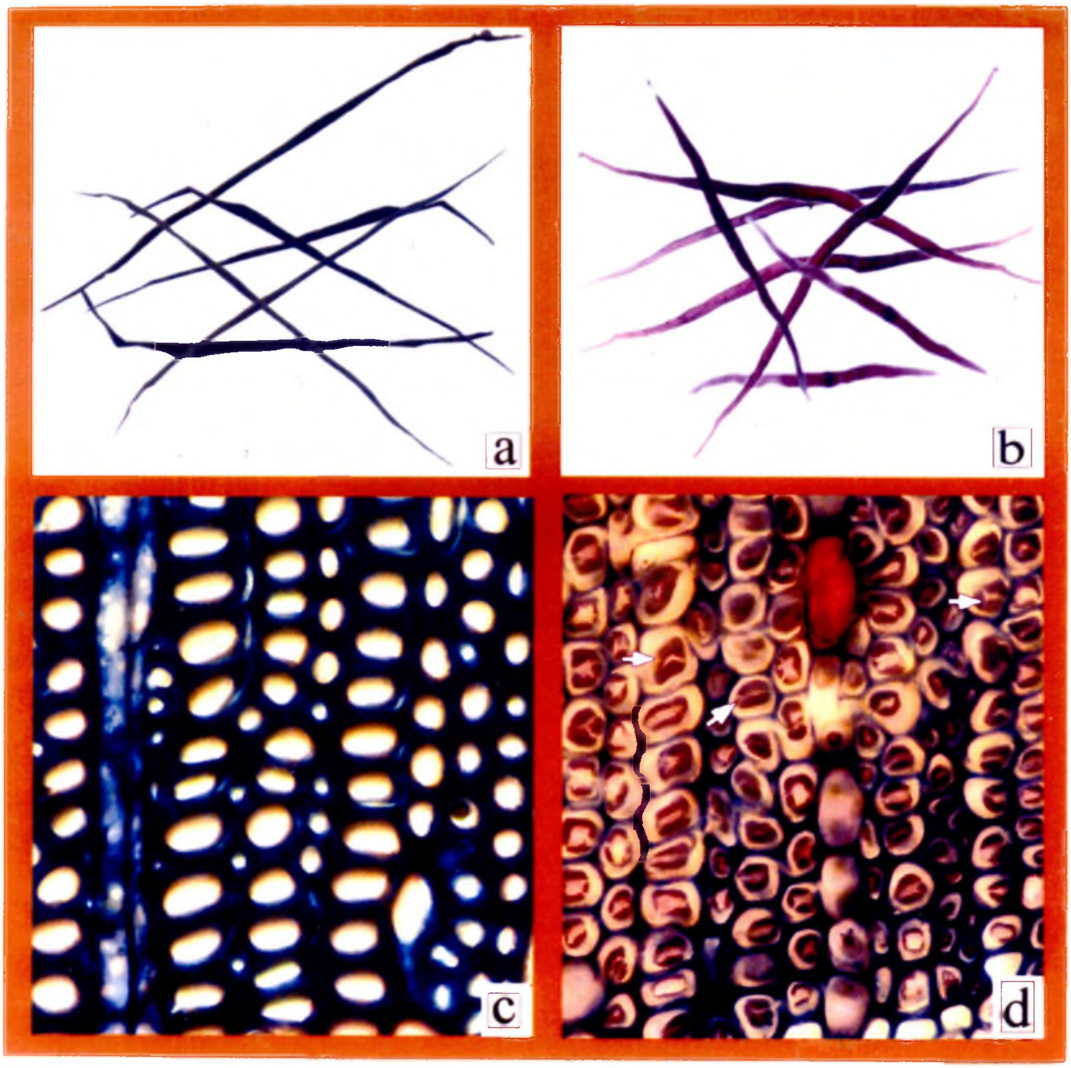

Fig. 2. Morphology and structure of normal and tension wood fibres stained in toludine blue O; a. Macerated normal wood fibres. X 55; b. Macerated tension wood fibres. X 55; c. C.S. of normal wood fibres. X 500; d. C.S. of tension wood fibres showing detachment of G-layer (arrow). X 500.

measured using a microscope (Leitz Aristoplan) under bright field. 100 readings per sample were considered for computing the mean values of each parameter. Cross sections of wood at 30 mm thickness were used for recording the fibre wall thickness. The total wall thickness of normal and tension wood fibres were recorded separately.

As the samples collected from each radius were from identical positions, in terms of growth, the data recorded from the corresponding samples of the disc were pooled together to compute the mean. The disc mean value was computed from the average values

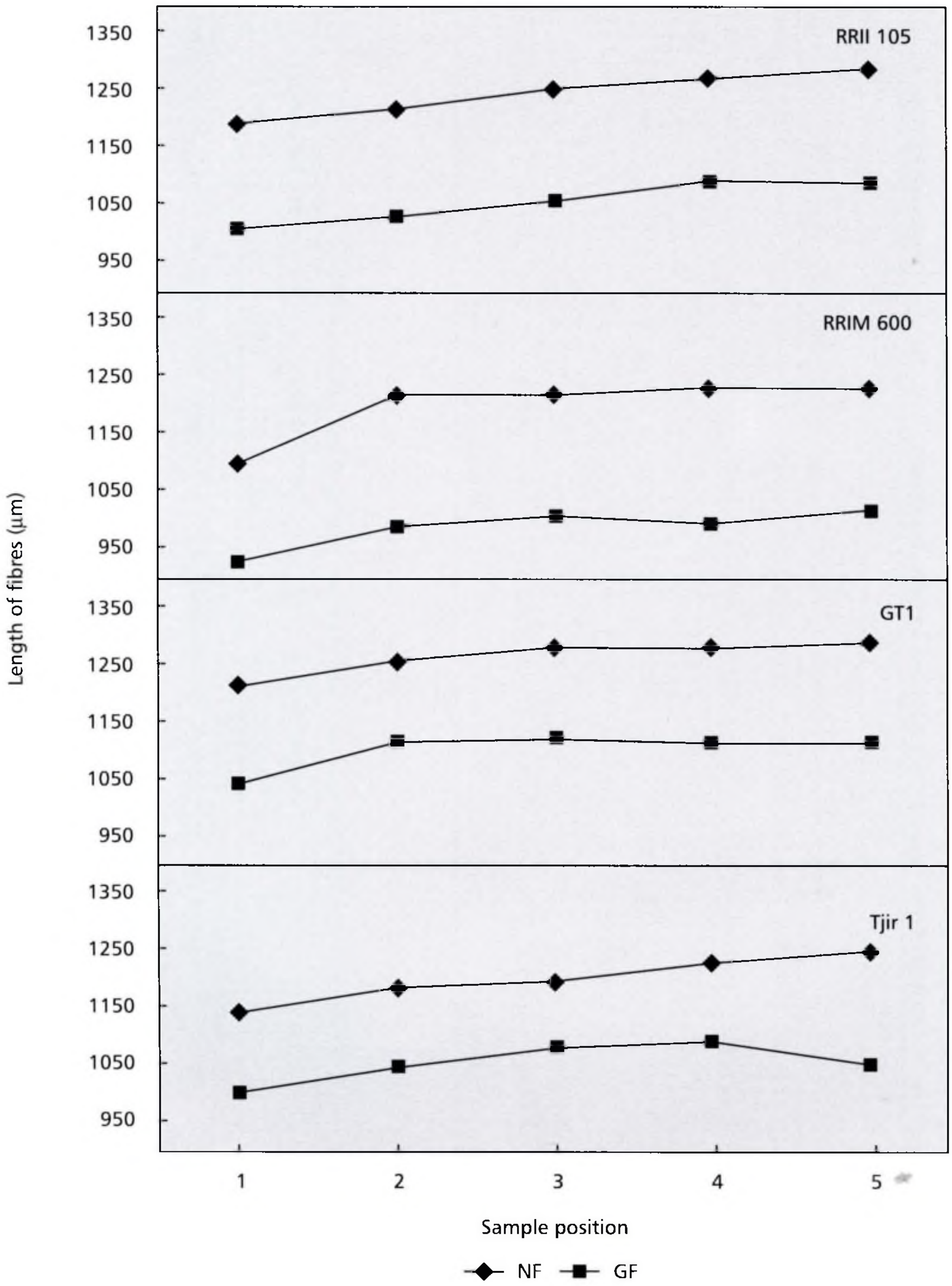

Fig. 3. Length of normal and tension wood fibres from different sample positions

Table 1. **Length, width and wall thickness of normal and gelatinous fibres at three height levels**

Clone	Disc	Length of fibre (μm)				Width of fibre (μm)				Wall thickness (μm)			
		NF		GF		NF		GF		NF		GF	
		Disc average	Clone average	Disc average	Clone average	Disc average	Clone average	Disc average	Clone average	Disc average	Clone average	Disc average	Clone average
RRII 105	A	1245.95	**1248.90**	1046.75	**1058.56**	20.12	**20.27**	23.22	**22.57**	3.36	**3.39**	4.26	**4.14**
	B	1236.63		1059.45		20.66		22.47		3.45		4.12	
	C	1264.12		1069.45		20.04		22.01		3.35		4.04	
RRIM 600	A	1169.68	**1205.74**	962.05	**994.83**	20.03	**20.25**	22.18	**22.25**	3.34	**3.38**	4.07	**4.05**
	B	1203.25		989.03		20.23		22.27		3.40		4.08	
	C	1244.30		1033.40		20.40		22.31		3.41		4.09	
GT 1	A	1248.82	**1268.89**	1082.84	**1102.60**	19.38	**19.70**	20.96	**21.03**	3.24	**3.29**	4.39	**4.32**
	B	1260.82		1123.47		20.05		21.09		3.35		4.24	
	C	1297.05		1101.50		19.67		21.03		3.29		4.33	
Tjir 1	A	1169.53	**1192.92**	1076.60	**1066.59**	20.95	**20.88**	23.93	**23.56**	3.50	**3.49**	4.39	**4.32**
	B	1168.35		1074.95		20.72		23.14		3.46		4.24	
	C	1240.88		1048.23		20.95		23.62		3.52		4.33	

Table 2. **ANOVA for length, width and wall thickness of normal and gelatinous fibres**

Character	Source	Length of fibre				Width of fibre				Wall thickness			
		SS	df	SS	F	SS	df	MS	F	SS	df	MS	F
Variations between height levels (irrespective of clones)	Treatment	5043.66	2	2521.83	1.17	8.98	2	4.49	5.16 *	7.21	2	3.60	2.23
	Error	19266.28	9	2140.69	NS	16.53	9	0.87		13.60	9	1.51	NS
Variations between clones (irrespective of height levels)	Treatment	14551.60	3	4850.53	2.56	13.17	3	4.39	6.55 *	10.82	3	3.60	2.88
	Error	22705.64	12	1892.13	NS	8.04	12	0.67		15.08	12	1.25	NS

* Significant at 5% level; NS: Not significant

Table 3. **Variation in characters between normal and gelatinous fibres (t-test)**

Clone	Length		Width		Wall thickness	
	df	t	df	t	df	t
RRII 105	11	18.38**	11	-7.40**	11	-13.85**
RRIM 600	11	23.60**	11	-10.64**	11	-25.37**
GT 1	11	10.48**	11	- 8.68**	11	-15.83**
Tjir 1	11	3.68**	11	- 9.00**	11	-26.07**

** Significant at 1% level; t value with –ve sign indicates that the value were higher for G-fibres

of samples. Likewise, the tree and clone mean values were calculated from the disc and tree mean values respectively.

Data on length, width and wall thickness of fibres were subjected to analysis of variance (ANOVA) (Singh and Chowdhary, 1985). Pooled data from four clones were used to ascertain the dimensional variation between fibres at different height levels. The characters for normal and tension wood zones were compared using paired t-test.

RESULTS AND DISCUSSION

The NF stained blue (Fig. 2a and 2c) and the GF stained purplish red (Fig. 2b and 2d) with toludine blue 'O'. In all the four clones studied the length of NF and GF varied from pith to periphery and in general it was maximum in the peripheral and minimum near the pith zone (Fig. 3). Similar observations were made earlier for the clones PR 107 and RRIM 600 for PB 86 (Amin, 1986; Reghu *et al.*, 1989) and in certain other hardwood species (Dinwoddie, 1961; Taylor and Wooten, 1973). Amin (1986) opined that at a certain stage of fibre development, the ultimate length is contributed by the fusiform initials of the cambium. In rubber tree, the factors such as tapping, climatic changes, occurrence of abnormal leaf fall disease etc. during the development of fibres was suggested to cause variation in fibre length.

Table 1 depicts the mean length of NF and GF at the three levels from the ground. In all the clones, the average length of NF was higher than that of GF as reported by Reghu *et al.* (1989) for the clone PB 86. Analysis of variance indicated that the differences were not statistically significant (Table 2). However, the variation between NF and GF was statistically significant within all the four clones under t-test (Table 3). Amin (1986) and Bhat *et al.* (1984) did not find any significant difference in the fibre length of *H. brasiliensis* trees at different height levels. The variation in the fibre length between normal and tension wood fibres may be attributed to the variation in the rate of division and intrusive growth of fibre primordia. The fibre length is inversely related to the radial growth of the axis (Wardrop, 1964). An increase in the duration of cambial activity brings about the differentiation of longer fibres and variability in radial growth of axis, whereas an increase in the rate of cambial activity causes radial growth increment and differentiation of shorter fibres (Wardrop, 1964). Therefore, it appears that the decrease in the length of tension wood fibres may be due to the increase in the rate rather than duration of cambial division during the differentiation of tension wood.

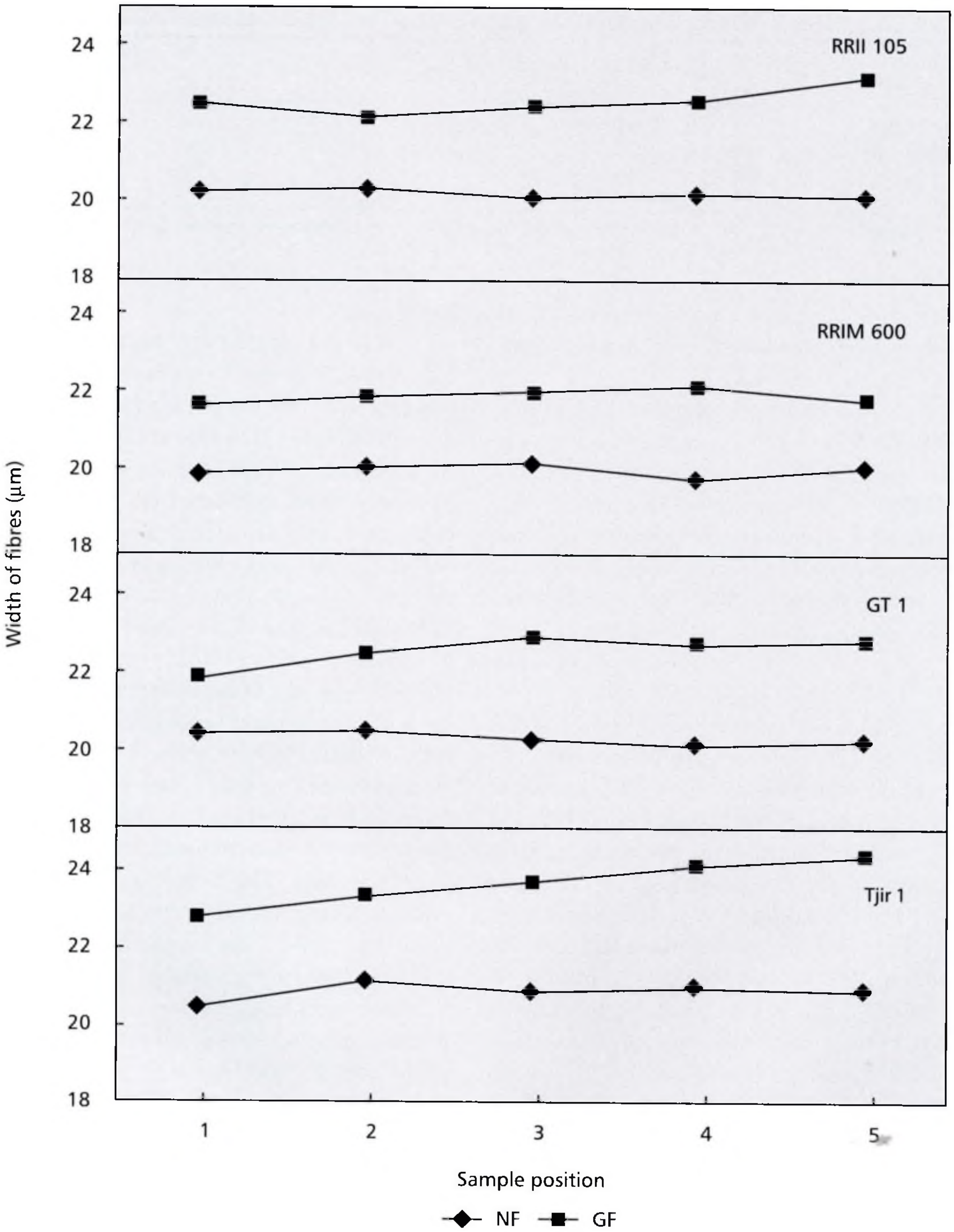

Fig. 4. Width of normal and tension wood fibres from different sample positions

The variations in the length and width of NF and GF at different sample positions within wood discs are shown in Fig. 3 and 4. In all the clones the width of NF and GF showed slight variation from the pith to periphery. However, in majority of cases the length and width of fibre were maximum in samples collected from the periphery and minimum near the pith zone.

In all the clones studied, the mean width of NF was lower than that of GF. Similar trend was reported by Reghu *et al.* (1989) for clone PB 86. The width of NF ranged from 19.7 to 20.88 μm whereas the mean width of GF ranged from 21.03 to 23.56 μm (Table 1). While the width of NF was more or less the same in all the clones the width of GF was higher in Tjir 1 (23.56 μm). The width of fibres varied significantly between clones as well as between different height levels within the clones (Table 2). The variation in width between NF and GF was highly significant within all the clones (Table 3). The increased fibre width and wall thickness observed in the basal portion of the tree trunk may be attributed to the increase in the thickness of secondary walls due to ageing (ontogenic maturity).

The average fibre wall thickness of NF and GF at different height levels are also shown in Table 1. In all the clones, wall thickness of GF was higher than NF. Okumura *et al.* (1977) reported that the increase in the wall thickness of tension wood fibres was mainly due to the increase in the thickness of the undignified cellulosic G-layer of the secondary wall. In the present study the average wall thickness of NF was comparable for all the clones. Similar trend was observed for GF also.

ANOVA (Table 2) carried out for the wall thickness of both NF and GF indicated that the variation in the fibre wall thickness among the clones and at different height levels within clones was not statistically significant. The difference in wall thickness was statistically significant across the clones. The increase in the thickness of G-layer associated with its unlignified nature makes tension wood fibres weaker than normal wood fibers. This leads to various wood working problems such as dimensional instability, warping, shrinkage and collapse.

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