VARIATION IN WOOD PHYSICAL PROPERTIES OF *EUCALYPTUS PELLITA* GROWING IN SEEDLING SEED ORCHARD IN PLEIHARI, SOUTH KALIMANTAN

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ABSTRACT

This study shows an effort to obtain the best performance of *Eucalyptus pellita* trees, which was conducted by examining the physical properties of wood of 116 months age *Eucalyptus pellita* trees. The trees of various families used in this study were all grown in Seedling Seed Orchard (SSO), Pleihari. A total of 10 families with 3 individual trees for each family as replication were randomly selected for the whole SSO. Selected sample trees were felled, cut and divided into three different parts (bottom, middle and top) of the stem. Each stem part was then cut into wood samples running from pith to bark portion for the examination of its physical properties according to British Standard BS 373-1957. The collected data on those properties were analyzed by using a completely randomized design (CRD). The results showed that there were significant differences in wood density and fiber length among different height, and among wood sections from pith to bark in individual trees as well as among families. Wood density showed high family heritability (0.708) and genetic correlation between wood density and fiber length were significantly different (r = 0.543).

Keywords : *Eucalyptus pellita*, physical properties, density, fiber, shrinkage

I. INTRODUCTION

The Center for Forest Plantation Research and Development (Yogyakarta) in collaboration with Japan International Cooperation Agency (JICA) established a Seedling Seed Orchard (SSO) of *Eucalyptus pellita* in Pleihari, South Kalimantan in January - March 1994. Before assigning the SSO, *E. pellita* plantation was established as a progeny test trial plot. It consisted of 155 families from 6 provenances i.e. South of Kiriwo, North of Kiriwo, Serisssa Village and Keru Tonata in Papua New Guinea (PNG); Tozers Gap in Queensland (Australia); and Bupul Muting Merauke in West Papua (Indonesia).

Up to 5 years old, performance evaluation on SSO was mostly based on growth parameters such as height and diameter (Leksono and Kurinobu, 2002; Leksono and Setyaji, 2004). Later on, Susilawati and Fujisawa (2002) had evaluated the performance of juvenile wood of 66 months old *E. pellita* growing in Pleihari's SSO, South Kalimantan and found that its wood density and fiber length were greater than high improvement criteria for wood quality.

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E. pellita did not only possess a high growth rate in height and diameter (Harwood *et al*., 1997) but also have high family heritability up to 5 years old (Leksono and Setyaji, 2004). Therefore, it is one of the potential and promising species for Timber Estate Program in Indonesia.

This paper presents a study on variation in physical properties of *E. pellita* wood of 116 months old inside stem and between families in Pleihari's SSO, South Kalimantan. Physical properties observed were limited to the parameters that could affect the end-use of *E. pellita* for pulp and paper, limited construction and furniture. They include wood density, fiber length, and shrinkage in radial, tangential and longitudinal directions.

II. METHODOLOGY

A. Sample Collection and Measurement

The sampling criterion used in selecting the sample trees was diameter class (small, medium, and large). A total of 10 families, each with 3 individual trees as replication were selected from the whole SSO.

Selected sample trees were felled, cut, and divided into three different parts (bottom, middle and top) of the stem. Each stem part was then cut into wood samples running from pith to bark portions for the measurement of their physical properties according to British Standard BS 373-1957 (Anonim, 1957). Information about selected sample trees is described in Table 1.

B. Data Analysis

The collected and examined data were referring to variation in wood physical properties inside the stem as well as among the families of *E. pellita* trees. The data variation were analyzed using a completely randomized design (CRD) with factorial pattern. The factors were family (A); vertical tree part (B) that consists of top, middle, and bottom portion; and wood section (C) that ran horizontally from pith to bark. Should any of the individual factors (A, B, or C) and their interaction (AB, AC, BC, or ABC) reveal significant effects, the analysis was continued with the Duncan Multiple Ranges Test (DMRT) for the differences among the means of wood physical properties.

Table 1. Information of sample trees for physical properties measurement of *E. pellita* in Pleihari's SSO (Seedling Seed Orchard), South Kalimantan, Indonesia.

Sample no.	Row	Column	Family number	FTIP* no	Seed Lot no	Tree no	Seed sources / origin	Planting year
1	25	14	2	366	18197	CG 1893	S OF KIRIWO WP	93/94
2	38	8	2	366	18197	CG 1893	S OF KIRIWO WP	93/94
3	49	15	2	366	18197	CG 1893	S OF KIRIWO WP	93/94
4	7	24	3	367	18197	CG 1894	S OF KIRIWO WP	93/94
5	10	11	3	367	18197	CG 1894	S OF KIRIWO WP	93/94
6	50	27	3	367	18197	CG 1894	S OF KIRIWO WP	93/94
7	6	22	8	372	18197	CG 1900	S OF KIRIWO WP	93/94
8	15	27	8	372	18197	CG 1900	S OF KIRIWO WP	93/94
9	34	29	8	372	18197	CG 1900	S OF KIRIWO WP	93/94
10	14	17	14	378	17854	MM 001298	BUPUL-MUTING, IRIAN JAYA	93/94
11	22	23	14	378	17854	MM 001298	BUPUL-MUTING, IRIAN JAYA	93/94
12	33	19	14	378	17854	MM 001298	BUPUL-MUTING, IRIAN JAYA	93/94
13	11	24	23	387	17854	MM 001309	BUPUL-MUTING, IRIAN JAYA	93/94
14	28	20	23	387	17854	MM 001309	BUPUL-MUTING, IRIAN JAYA	93/94
15	49	24	23	387	17854	MM 001309	BUPUL-MUTING, IRIAN JAYA	93/94
16	6	30	24	388	17854	MM 001310	BUPUL-MUTING, IRIAN JAYA	93/94
17	37	14	24	388	17854	MM 001310	BUPUL-MUTING, IRIAN JAYA	93/94
18	47	20	24	388	17854	MM 001310	BUPUL-MUTING, IRIAN JAYA	93/94
19	6	16	48	412	18197	BVG 2146	S OF KIRIWO WP	93/94
20	12	23	48	412	18197	BVG 2146	S OF KIRIWO WP	93/94
21	23	26	48	412	18197	BVG 2146	S OF KIRIWO WP	93/94
22	16	17	51	415	18197	CG 1867	S OF KIRIWO WP	93/94
23	32	23	51	415	18197	CG 1867	S OF KIRIWO WP	93/94
24	43	19	51	415	18197	CG 1867	S OF KIRIWO WP	93/94
25	21	26	60	424	18197	CG 1876	S OF KIRIWO WP	93/94
26	41	17	60	424	18197	CG 1876	S OF KIRIWO WP	93/94
27	46	30	60	424	18197	CG 1876	S OF KIRIWO WP	93/94
28	8	28	62	426	18197	CG 1878	S OF KIRIWO WP	93/94
29	14	11	62	426	18197	CG 1878	S OF KIRIWO WP	93/94
30	34	16	62	426	18197	CG 1878	S OF KIRIWO WP	93/94

Remarks: *FTIP = Forest Tree Improvement Project

Heritability was calculated from component of variance of each of the tested traits in accordance with Zobel and Talbert (1984). Heritability estimates were derived from the relative performance of the progenies within and between parent trees. The formula used to calculate family heritability was simplified from Wright (1976). The formula used for family heritability is as follow :

$$h_F^2 = \frac{\sigma^2_F}{(MS_F / \text{coef}\,\sigma^2_F)}$$

where h_F^2 = family heritability; MS_F = mean square of variance component of family; coef σ^2_F = coefficient of variance component of family.

III. RESULTS AND DISCUSSION

The results of measurement on wood density, fiber length, and shrinkage of *E pellita* are shown in Figures 1 and 2 for variation inside the stem, and Figure 3 for variation between families. The statistical analysis is summarized in Table 2 and the estimated mean value of the genetic parameter and family heritability are described in Table 3. The result of DMRT analysis is attached in Appendix 1.

A. Variation in Wood Physical Properties Inside *E. pellita* Stems

Wood density and fiber length of *E. pellita* in axial and radial direction are shown in Appendix 2 and 3, while, tangential, radial and longitudinal shrinkage are shown in Appendix 4.

Wood density and fiber length inside stem, as it is described in Table 2, vary significantly both in axial and radial positions. In term of shrinkage, the significant variation is limited only for radial and tangential shrinkages in radial position (running horizontally from pith to bark). On the contrary, longitudinal shrinkages were not significantly different either in axial or radial positions.

Table 2. Analysis of variance on physical properties of *E. pellita* in Pleihari's SSO Pleihari, South Kalimantan

Source of variation	Examined physical properties parameters				
	Wood density	Fiber length	Shrinkages		
			Tangential	Radial	Longitudinal
	Probability of F -test (Pr >)				
Family , A	0.0001**	0.0001**	0.2193	0. 0050**	0.0347*
Axial tree part (from bottom, middle to top portion) , B	0.0001**	0.0001**	0.2336	0.1808	0.5868
Horizontal wood section (pith to bark) , C	0.0001**	0.0001**	0.0001**	0.0097**	0.3305
Interactions :					
A x B	0.6739	0.1389	0. 1909	0.0002**	0.0001**
A x C	0.0346*	0.0001**	0.153	0.496	0.1132
B x C	0.8095	0.5116	0.9776	0.0975	0.3015
A x B x C	1	0.6695	0.9738	0.7272	0.9559

Remarks : *) significantly difference (95%)
**) highly significant difference (99%)

Based on Duncan's Multiple Ranges Test (DMRT) as described in Appendix 1, it is found that in axial position, wood density gives opposite response as compared to fiber length. In radial position, however, all the tested parameters showed similar trends in that they tended to increase from pith to bark. Further, Figures 1, 2 and 3 describe clearly the variation in wood density, fiber length and shrinkages inside the stem when viewed either axially (bottom, middle and top) or radially (from pith to bark).

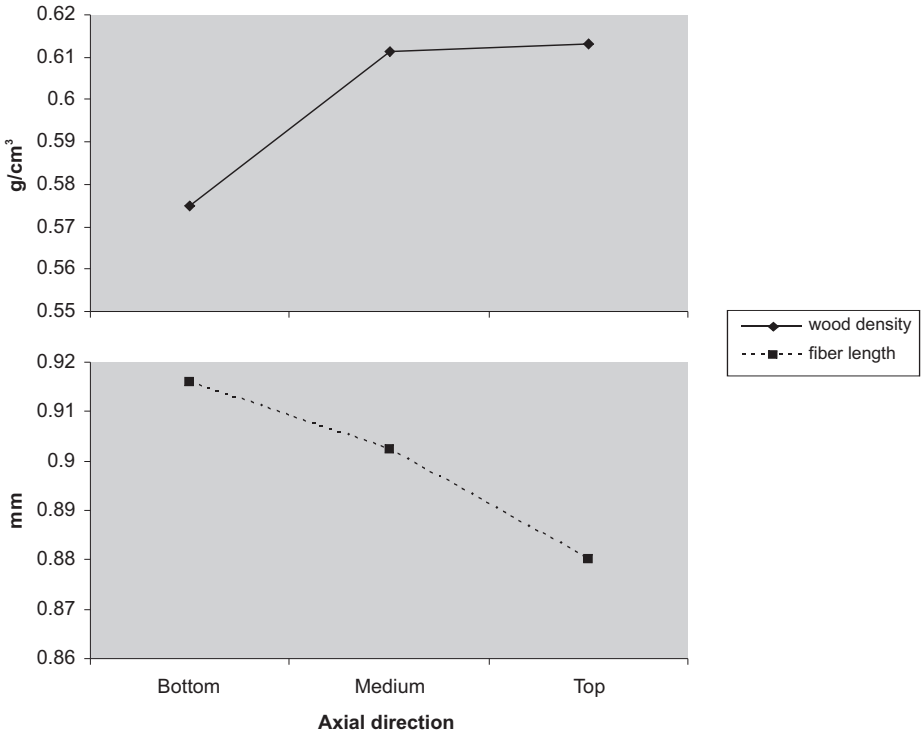

Figure 1. Variation in wood density (above) and fiber length (bottom) of *E. pellita* in axial direction of Pleihari's SSO, South Kalimantan

B. Family Variation and Heritability of Physical Properties Parameter

Referring to Table 2, it turned out that there were highly significant differences among families in terms of wood density, fiber length, and both radial and longitudinal shrinkages. However, the differences in tangential shrinkage among families were not significant.

Based on the DMRT for family-accounted variation as described in Appendix 1 and the overall mean of genetic parameter test in Table 3, it showed that family-accounted variation revealed different trend or specific patterns in each of the overall tested parameter (wood density, fiber length, and shrinkages). Wood density, for example, had an average mean of 0.598 g/cm^3, which ranged from 0.556 (family no 51) to 0.652 g/cm^3 (family no 60). On the other hand, the best performance of fiber length was attributed by family no 48 (0.939 mm) followed in decreasing order by family no 24 (0.918 mm), and the shortest was family no 2 (0.874 mm). The overall mean of fiber length was 0.904 mm.

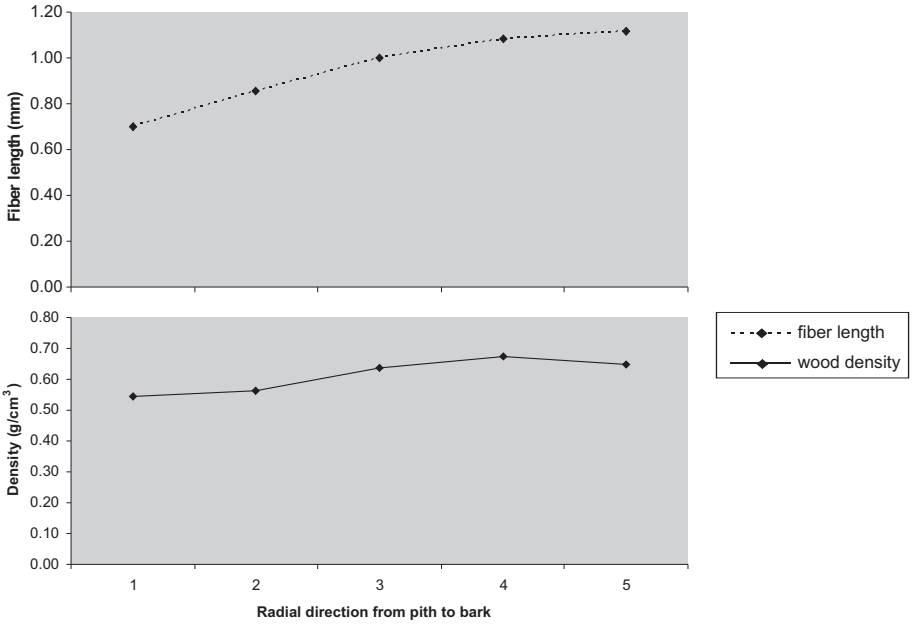

Figure 2. Variation in wood density (above) and fiber length (bottom) of *E. pellita* in radial position (from pith to bark) of Pleihari's SSO, South Kalimantan

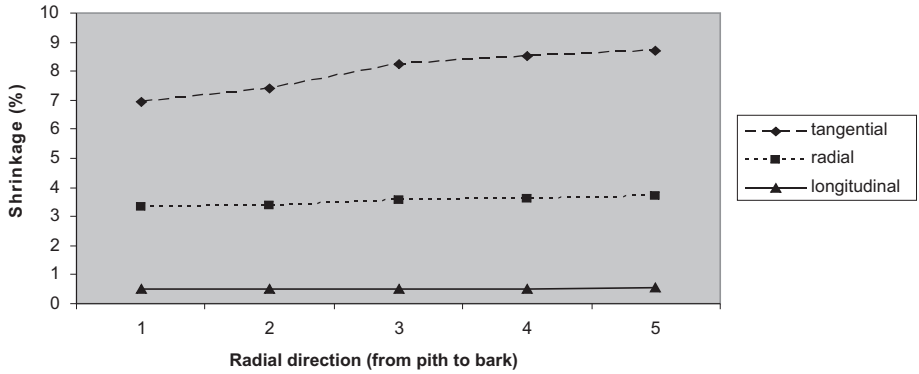

Figure 3. Variation in shrinkage of *E. pellita* in radial direction of Pleihari's SSO, South Kalimantan

Radial shrinkage ranged from 3.24% (family no 62) to 3.88% (family no 2) with average of 3.48%. Longitudinal shrinkage also varied from 0.44% (family no 48) to 0.56% (family no 2), with an average of 0.51%. Figure 4 showed clearly that radial and longitudinal shrinkages were significantly different among families of *E. pellita,* while tangential shrinkage on the contrary was not different.

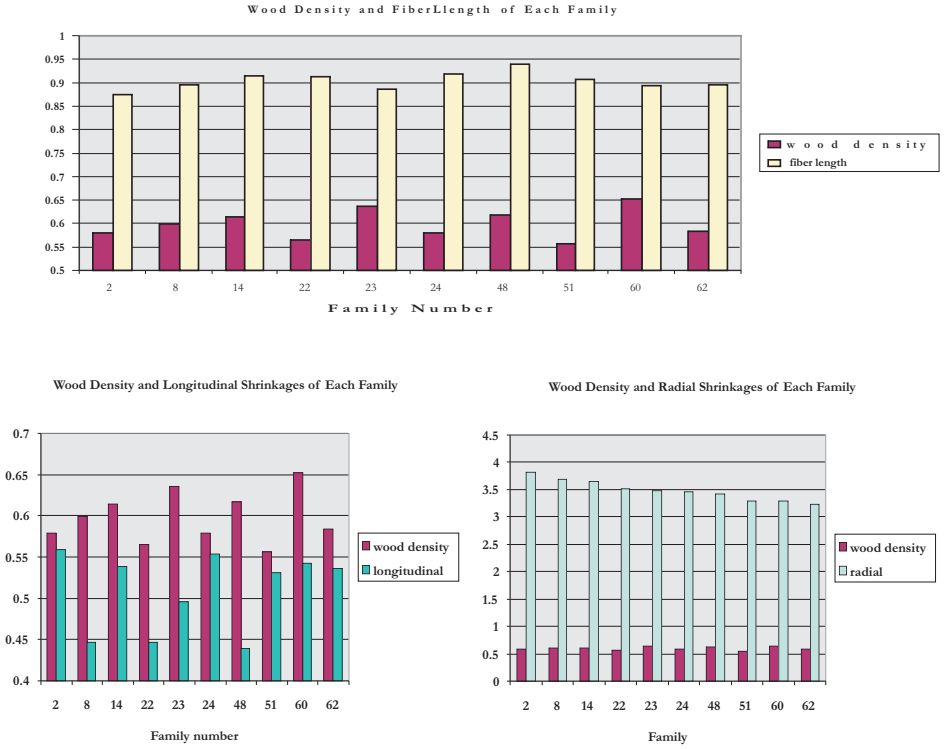

Figure 4. Variation in wood physical properties among family of *E. pellita* in Pleihari's SSO, South Kalimantan

Estimation of family heritability as described in Table 3 showed that only wood density had a high family heritability (0.709). For the other genetic parameter, even though their family heritability showed highly significant difference, unfortunately it could not be calculated due to the negative value of their family variance component value.

Based on the statistical analysis shown in Table 2, there was a highly significant interaction between family and axial positions in the stem (bottom, middle and top) for radial and longitudinal shrinkages. In addition, the significant interaction also occurred between family and radial position in the stem from pith to bark for fiber length (P=99%) and for wood density (P=95 %).

Table 3. The Estimated mean value of the genetic parameter, probability, variance component (family), means square of variance component (family), coefficient of component variance (family) and family heritability

Genetic Parameters	Mean	Probability Pr > F	Variance (F)	M S (F)	Coefficient Var iation (F)	Heritability (h^2)
Wood density	0. 60 gr/cm ^{3}	0.0001**	0.00066657	0.o3148815	33.476	0.70865063
Fiber length	0.90 mm	0.0001**	-0.00004647	0.01220673	34.080	0
Tangential shrinkage	7.76 %	0.0001**	-0.01725562	1.09180094	34.883	0
Radial shrinkage	3.48 %	0.0087**	-0.00340275	1.24716467	34.88 3	0
Longitudinal shrinkage	0.51 %	0.0043**	-0.00336298	0.08180951	34.883	0

Note : **) highly significant difference (99%)

Although wood density and fiber length reveal opposite (reverse) trends in axial direction as described in Figure 1, in all there was significant correlation (r) between wood density and fiber length (r = 0.534) as seen in Figure 5. Therefore, it implies that either wood density or fiber length could be used as a genetic parameter in evaluating performance of SSO for tree selection

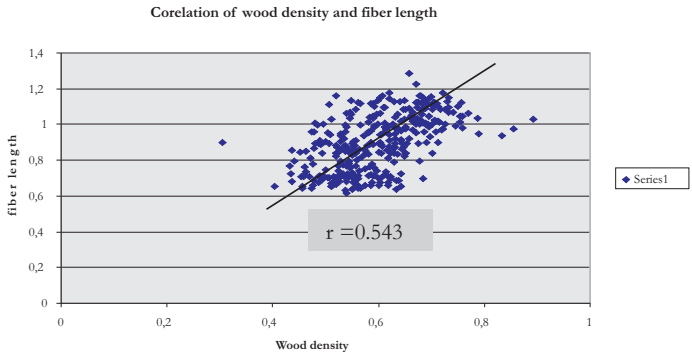

Figure 5. Relationship between wood density and fiber length

As compared to the work done by Susilawati and Fujisawa, (2002), who reported average of wood density and fiber length of 0.68 g/cm^3 and 0.98 mm respectively, it seems that the results of this study showed a lower average wood density and fiber length i.e. 0.60 g/cm^3 and 0.90 mm respectively. These discrepancies could happen due to different sampling method implemented in the collection of research (wood) sample. Susilawati and Fujisawa (2002) collected as many as 191 selected tree samples comprising 24 family using increment borer. Meanwhile, this study only used 10 families of *E. pellita*, and moreover the sampled trees (which allowed) to be felled were in the worst condition. As a result, it was reflected to the lower average value of wood density and fiber length.

IV. CONCLUSION

There were highly significant differences in wood density and fiber length of *Eucalyptus pellita* in Pleihari's SSO and in axial (from bottom, middle and top part) as well as in radial direction (from pith to bark). Meanwhile, tangential and radial shrinkages showed highly significant differences only for radial (section) position. Highly significant differences were also found among the families of the trees for wood density, fiber length and radial shrinkage, while its longitudinal shrinkage only showed significant differences. Wood density revealed high family heritability and it could be used as selection parameter in tree improvement program for *E. pellita*.

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Appendix 1. Result of Duncan's Multiple Range Test (DMRT) of physical properties of *Eucalyptus pellita* from SSO in Pleihari, South Kalimantan

1. DMRT on Wood density of *Eucalyptus pellita* in family

Duncan class	Mean	N	Family Number *)
A	0.65193	35	60
AB	0.63165	28	23
B	0.61719	39	48
BC	0.61417	34	14
BCD	0.59928	33	8
CDE	0.58383	31	62
DE	0.57953	34	3
DE	0.57905	33	24
E	0.56496	33	22
E	0.55630	35	51

*) Total number of family was 10, each code-named as family number (60, 23,...,51); N = total number of sample in each family

2. DMRT on wood density of *Eucalyptus pellita* in axial position (bottom, middle and top)

Duncan class	Mean	N	Part *)
A	0.612159	98	Top
A	0.610525	111	Middle
B	0.575383	126	Bottom

*) Total number of axial position was 3, each part code named as top, middle and bottom stem ; N = total number of sample in each part

3. DMRT on wood density of *Eucalyptus pellita* in radial direction from pith to bark

Duncan class	Mean	N	Section *)
A	0.66707	52	3
AB	0.64222	15	4
B	0.63729	89	2
C	0.56197	90	1
C	0.54653	89	E

*) From pith to bark corresponds to section number E, 1, 2,3 and 4. N= Number of sample in each section

4. DMRT on fiber length of *Eucalyptus pellita* in family

Duncan class	Mean	N	Family Number
A	0.93941	39	48
AB	0.91793	35	24
B	0.91464	33	8
B	0.91236	35	14
BC	0.90723	35	51
BCD	0.89532	32	62
BCD	0.89462	33	3
BCD	0.89323	37	60
CD	0.88674	30	23
D	0.87382	32	2

*) Total number of family was 10, each code-named as family number (60, 23,...,51); N = total number of sample in each family

5. DMRT on fiber length of *Eucalyptus pellita* in axial position (bottom, middle and top)

Duncan class	Mean	N	Part
A	0.920341	126	Bottom
B	0.906111	114	Middle
C	0.882774	101	Top

*) Total number of axial position was 3, each part code named as top, middle and bottom stem ; N = total number of sample in each part

6. DMRT on fiber length of *Eucalyptus pellita* in radial position from pith to bark

Duncan cla ss	Mean	N	Section
A	1.110520	15	4
B	1.087607	57	3
C	1.002362	90	2
D	0.857596	90	1
E	0.700811	89	E

*) From pith to bark corresponds to section number E, 1, 2,3 and 4. N= Number of sample in each section

7. DMRT on tangential shrinkage of *Eucalyptus pellita* in radial position from pith to bark.

Duncan class	Mean	N	Section
A	8.7177	21	4
AB	8.4899	58	3
B	8.2425	90	2
C	7.3856	90	1
D	6.9482	90	E

*) From pith to bark corresponds to section number E, 1, 2,3 and 4. N= Number of sample in each section

8. DMRT on radial shrinkage of *Eucalyptus pellita* in family

Duncan class	Mean	N	Family Number
A	3.8195	34	2
AB	3.6816	35	24
ABC	3.6418	35	51
ABCD	3.5139	34	62
ABCD	3.4869	30	23
BCD	3.4508	39	48
BCD	3.4291	37	60
CD	3.2819	35	14
CD	3.2818	33	8
D	3.2403	37	3

*) Total number of family was 10, each code-named as family number (60, 23,...,51); N = total number of sample in each family

9. DMRT on radial shrinkage of *Eucalyptus pellita* in radial position from pith to bark

Duncan class	Mean	N	Section
A	3.7413	21	4
AB	3.6468	58	3
ABC	3.5521	90	2
BC	3.3690	90	1
C	3.3534	90	E

*) From pith to bark corresponds to section number E, 1, 2,3 and 4. N= Number of sample in each section

10. DMRT on longitudinal shrinkage of *Eucalyptus pellita* in family

Duncan class	Mean	N	Family Number
A	0.55883	34	2
AB	0.55321	35	24
ABC	0.54188	37	60
ABC	0.53835	33	8
ABC	0.53570	34	62
ABC	0.53053	35	51
ABC	0.49574	30	23
BC	0.44676	37	3
BC	0.44642	35	14
C	0.43926	39	48

*) Total number of family was 10, each code-named as family number (60, 23,...,51); N = total number of sample in each family

Appendix 2. Wood density and fiber length of 116 months *E. pellita* in axial direction from Seedling Seed Orchard, Pleihari, South Kalimantan

No	Row	Column	Family	Density (g/cm^3)			Fiber Length (mm)		
				Bottom	Medium	Top	Bottom	Medium	Top
1	25	14	2	0. 52	0.53	0.54	0.903	0.833	0.856
4	38	8	2	0.56	0.63	0.63	0.863	0.914	0.846
7	49	15	2	0.53	0.60	0.57	0.919	0.867	0.834
10	7	24	3	0.55	0.57	0.61	0.845	0.843	0.877
13	10	11	3	0.58	0.62	0.61	0.912	0.898	0.928
16	50	27	3	0.53	0.54	0.61	0.922	0.901	0.897
19	6	22	8	0.58	0.59	0.59	0.959	0.906	0.887
22	15	27	8	0.55	0.63	0.63	0.879	0.880	0.904
25	34	29	8	0.59	0.62	0.63	0.950	0.921	0.895
28	14	17	14	0.61	0.64	0.73	0.910	0.909	0.873
31	22	23	14	0.61	0.58	0.62	0.958	0.928	0.870
34	33	19	14	0.52	0.61	0.59	0.862	0.947	0.915
37	11	24	23	0.63	0.64	0.67	0.900	0.865	0.901
40	28	20	23	0.62	0.58	0.60	0.918	0.853	0.866
43	49	24	23	0.64	0.66	0.66	0.878	0.908	0.870
46	6	30	24	0.63	0.65	0.61	0.901	0.941	0.887
49	37	14	24	0.56	0.63	0.66	0.980	0.941	0.881
52	47	20	24	0. 50	0.53	0.52	0.939	0.891	0.879
55	6	16	48	0.61	0.67	0.62	0.973	0.936	0.852
58	12	23	48	0.55	0.63	0.63	0.973	0.916	0.837
61	23	26	48	0.58	0.64	0.64	0.957	0.971	0.964
64	16	17	51	0.60	0.65	0.59	0.914	0.920	0.857
67	32	23	51	0.52	0.57	0.57	0.943	0.907	0. 838
70	43	19	51	0.51	0.45	0.57	0.945	0.919	0.883
73	21	26	60	0.65	0.72	0.65	0.871	0.882	0.831
76	41	17	60	0.60	0.72	0.64	0.911	0.863	0.875
79	46	30	60	0.62	0.66	0.61	0.907	0.930	0.954
82	8	28	62	0.57	0.60	0.61	0.915	0.892	0.831
85	14	11	62	0.53	0.56	0.60	0.842	0.920	0.928
88	34	16	62	0.59	0.62	0.59	0.933	0.866	0.886
	Average			**0.57**	**0.61**	**0.61**	**0.916**	**0.902**	**0.880**

Appendix 3. Wood density and fiber length of 116 months *E. pellita* in radial direction from Seedling Seed Orchard, Pleihari, South Kalimantan

Family	Row	Column	Wood density (gram/cm^3)					Fiber length (mm)				
			Radial Position					Radial Position				
			E (pith)	1	2	3	4	E (pith)	1	2	3	4
2	25	14	0.62	0.47	0.49	0.55		0.690	0.802	0.987	1.052	
2	38	8	0.55	0.57	0.65	0.65		0.736	0.802	0.951	1. 089	
2	49	15	0.51	0.52	0.64	0.60		0.699	0.862	1.011	1.063	
3	7	24	0.52	0.57	0.64			0.731	0.867	0.966		
3	10	11	0.55	0.52	0.63	0.70		0.684	0.866	1.027	1.073	
3	50	27	0.56	0.52	0.59	0.59	0.47	0.701	0.870	0.974	1.081	
8	6	22	0.57	0.52	0.61	0.64	0.62	0.690	0.839	1.041	1.111	1.146
8	15	27	0.54	0.62	0.64			0.681	0.855	1.126		
8	34	29	0.51	0.56	0.66	0.71	0.71	0.708	0.853	1.025	1.119	1.120
14	14	17	0.54	0.62	0.74	0.73		0.685	0.825	0.995	1.083	
14	22	23	0.52	0.54	0.68	0.73	0.68	0.796	0.879	0.990	1.070	1.121
14	33	19	0.52	0.55	0.59	0.68	0.71	0.732	0.888	0.962	1.059	1.118
23	11	24	0.59	0.64	0.69	0.68		0.717	0.902	1.011	1.005	
23	28	20	0.54	0.57	0.64	0.74		0.712	0.883	0.991	1.070	
23	49	24	0.59	0.68	0.70			0.751	0.903	0.968	1.008	
24	6	30	0.61	0.58	0.69	0.68		0.701	0.820	1.050	1.155	
24	37	14	0.56	0.58	0.66	0.72		0.655	0.876	1.138	1.159	
24	47	20	0.52	0.48	0.51	0.55	0.52	0.631	0.784	1.000	1.124	1.162
48	6	16	0.60	0.60	0.61	0.69	0.72	0.697	0.872	0.987	1.090	1.125
48	12	23	0.53	0.55	0.66	0.63	0.67	0.655	0.886	0.994	1.104	1.227
48	23	26	0.56	0.62	0.62	0.67	0.63	0.703	0.878	1.007	1.096	1.222
51	16	17	0.51	0.60	0.67	0.71		0.653	0.838	1.047	1.145	
51	32	23	0.48	0.49	0.60	0.67		0.674	0.845	1.031	1.133	
51	43	19	0.47	0.42	0.52	0.60	0.52	0.666	0.852	0.954	1.102	0.940
60	21	26	0.58	0.59	0.68	0.80	0.79	0.705	0.812	0.922	1.011	1.035
60	41	17	0.54	0.62	0.74	0.68	0.73	0.661	0.844	0.942	1.024	1.093
60	46	30	0.54	0.58	0.68	0.76		0.761	0.892	1.017	1.053	
62	8	28	0.57	0.55	0.63	0.64		0.704	0.862	0.975	1.057	1.063
62	14	11	0.51	0.54	0.58	0.66		0.705	0.873	0.980	1.122	
62	34	16	0.54	0.56	0.67	0.69		0.725	0.897	1.002	1.115	
	Average		**0.55**	**0.56**	**0.64**	**0.67**	**0.65**	**0.700**	**0.858**	**1.002**	**1.085**	**1.114**

Appendix 4. Tangential, radial and longitudinal shrinkage of 116 months *E. pellita* in radial direction from Seedling Seed Orchard, Pleihari, South Kalimantan

Family	Row	Column	Tangential shrinkage (%)					Radial shrinkage (%)					Longitudinal shrinkage (%)				
			Radial Position					Radial Position					Radial Position				
			E (pith)	1	2	3	4	E (pith)	1	2	3	4	E (pith)	1	2	3	4
2	25	14	7.68	6.78	7.83	8.32		4.18	3.67	3.89	4.28		0.76	0.51	0.56	0.69	
2	38	8	6.34	6.89	7.48	7.97		3.74	3.23	3.31	3.84		0.75	0.57	0.39	0.41	
2	49	15	7.90	6.89	7.98	8.85		3.47	3.94	4.20	4.24		0.64	0.45	0.48	0.41	
3	7	24	6.95	8.62	8.41	9.73		3.13	2.72	2.93	3.21		0.50	0.63	0.72	0.66	
3	10	11	6.59	7.47	7.98	7.84	8.56	3.58	3.11	3.31	3.55	3.89	0.28	0.34	0.27	0.27	0.44
3	50	27	7.89	7.60	7.54	8.07	9.16	2.82	2.99	3.56	3.82	2.31	0.46	0.39	0.56	0.27	0.91
8	6	22	7.28	7.10	7.64	8.80	8.50	2.56	3.50	3.46	3.46	2.55	0.70	0.52	0.57	0.46	0.56
8	15	27	5.98	7.44	7.87			3.25	3.56	3.42			0.55	0.49	0.41		
8	34	29	7.29	7.62	8.49	8.98	8.96	3.09	3.21	3.44	3.33	3.71	0.72	0.47	0.47	0.5 6	0.43
14	14	17	5.98	6.83	8.46	9.02		3.15	2.93	3.12	3.15		0.67	0.29	0.46	0.19	
14	22	23	6.61	7.30	8.77	8.59	7.00	3.28	3.30	3.48	2.47	4.69	0.55	0.47	0.28	0.34	0.15
14	33	19	6.59	7.58	7.49	8.69	8.89	3.42	3.44	3.53	3.77	2.38	0.50	0.45	0.64	0.55	0.34
23	11	24	6.90	7.52	7.89	5.61		3.07	3.20	4.05	3.35		0.48	0.40	0.52	0.54	
23	28	20	7.34	7.60	8.58	8.85		3.91	3.41	3.06	3.23		0.40	0.38	0.48	0.34	
23	49	24	7.78	7.10	8.61			3.54	3.64	3.73			0.76	0.59	0.55		
24	6	30	6.60	7.54	8.75	7.56		3.56	3.79	3.33	3.55		0.45	0.39	0.39	0.90	
24	37	14	6.64	8.54	8.92	8.75	9.67	3.27	3.73	3.48	4.54	4.51	0.41	0.52	0.62	0.58	0.57
24	47	20	7.90	7.52	8.19	8.22	8.22	2.84	3.37	4.12	4.56	4.56	0.69	0.56	0.66	0.66	0.39
48	6	16	7.18	8.51	8.68	9.20	9.15	2.70	3.43	3.36	2. 86	3.22	0.50	0.46	0.46	0.46	0.47
48	12	23	6.36	7.40	8.31	8.84	9.38	3.68	3.62	4.15	3.95	3.96	0.26	0.48	0.30	0.42	0.63
48	23	26	5.98	7.37	8.83	8.54	9.96	3.36	3.12	3.53	3.51	4.33	0.29	0.30	0.62	0.56	0.64
51	16	17	6.75	7.01	8.96	9.27	9.19	3.47	3.09	3.59	3.5 2	4.59	0.64	0.63	0.72	0.79	0.95
51	32	23	7.64	7.22	7.48	8.45		3.59	2.99	3.89	4.03		0.39	0.54	0.45	0.28	
51	43	19	6.27	6.53	7.90	8.24	8.64	3.75	3.63	3.83	3.85	4.06	0.27	0.56	0.45	0.50	0.66
60	21	26	6.21	7.54	8.10	8.63	8.88	2.81	3.56	3.79	3.85	4.16	0.5 2	0.55	0.53	0.32	0.54
60	41	17	7.32	6.79	8.60	8.85	9.31	3.16	3.56	3.38	3.49	4.13	0.56	0.64	0.59	0.29	0.67
60	46	30	6.79	7.32	8.50	8.86		2.81	3.21	3.27	3.65		0.55	0.71	0.70	0.37	
62	8	28	8.57	7.46	8.02	7.80	8.25	3.61	3.30	3.73	3.37	3.65	0.50	0.47	0.57	0.41	0.31
62	14	11	6.95	8.21	8.68	7.94	6.10	4.33	3.65	3.57	4.16	2.55	0.42	0.57	0.59	0.48	0.60
62	34	16	6.21	6.27	8.34	9.43		3.47	3.18	3.06	2.50		0.70	0.44	0.61	0.93	
Average			**6.95**	**7.39**	**8.24**	**8.50**	**8.70**	**3.35**	3.37	**3.55**	**3.61**	**3.72**	**0.53**	**0.49**	**0.52**	**0.49**	**0.54**