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FIBER LENGTH OF CALABRIAN PINE AS RELATED TO POSITION IN CROSS SECTION AND GROWING REGION

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Abstract:
This paper provides a better understanding of the variation of growing regions and differences in distance from pith to bark on wood fiber lengths. For this aim, Calabrian pines collected from five different growth regions, namely Kahramanmaras, Burdur, Muğla, İzmir and Balıkesir, were used to determine fiber lengths. In experiment, specimens prepared from logs cross section which is taken from three different distances from pith to bark (r/6, 3r/6 and 5r/6) were evaluated. As a result of analysis, distance from pith in the same area have shown a significant effect on fiber dimensions. In the evaluation among the habitat, it was obtained that r/6 and 3r/6 have a significant effect ($p<0.001$, $p<0.05$ respectively) on fiber dimensions, however; 5r/6 has a nonsignificant. The results showed that, the quite suitable habitat in terms of fiber lenghts is Balıkesir which has high sand (64.4%), moderate clay (24.2%) and lime-poor (3.1%) soils. These results will make a positive contribution undoubtedly for the plantations will be established in the future of this species.

Key words: *distance from pith; fiber lengths; growing regions; pinus brutia.*

INTRODUCTION

Most of the researchers has focused on the effect of position within the stem and distance from pith on the length of wood fibers. The variations in the wood properties of the same species are a result of different growth factors, such as growth and ecological conditions. In addition, altitude, soil and climate are also very effective factors. Besides, tree age, sample size, ring properties (e.g. ring width, ring orientation), and the test procedure might also affect the test results (Bektaş 2015). Moreover, the separation of the influence of the individual factors, such as geographic location or silvicultural treatments on wood and fiber quality attributes, is challenging, as substantial interaction inherently exists among these factors (Mansfield *et al*. 2016).

Previous studies demonstrated that, fiber length in species increases with age or distance from the pith (Bendtsen and Senft 1986, Debell *et al.* 2002).

Juvenile wood is generally characterised by low density, thin cell walls, short fibres with small lumens, high grain angle, and high microfibril angle, with the result that it has low strength and stiffness, and poor dimensional stability compared to mature wood (Watt *et al.* 2008). This is supported by the fact that the juvenile wood is usually known to be of the lower density than the mature wood (Zobel and Buijtenen 1989, Lachenbruch *et al.* 2011).

Other researh studied by Bhat *et al.* (1988) showed that fiber length increased consistently with age and fiber of 3-year-old trees (mean 0.81mm) were about 29% shorter than those of 9-year-old trees (1.15mm).

According to Bozkurt and Erdin (1997), the lengths of tracheids or fiber in the sunny sides, can be shorter than in the shadow sides.

Due to the abovementioned reasons, the habitat is important in the formation of the physical and technological properties of trees. Consequently, the properties of Calabrian pine, just as for other tree species, vary according to growth regions (Bektaş *et al.* 2003).

The general objectives of this study was to determine fiber lengths of *Pinus brutia* Ten., cut down five different habitat. The specific objectives were (a) reveal the effect of distance from pith on fiber lengths (b) evaluate the influence of growing regions on fiber dimensions.

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MATERIAL AND METHOD

Materials

The calabrian pine logs were collected from five different growth regions as shown in Table 1 according to Turkish Standards 4176 (1984). Then, 1m long log sections were prepared from the each tree, cut from their heights of between 2-4m from the base. Then, it was obtained 15cm thickness cross section from these logs. And, specimens to be evaluated in this research were prepared from these samples (10(R)×10(T)×20(L) mm).

Table 1

Some information about the test trees and regions

	Provinces of the test areas				
	Kahramanmaraş	Burdur	Muğla	İzmir	Balıkesir
Climatic type	MMC	TCM	MMCH	MAC	MAC
Mean rainfall (kg·m^{-2})	708	744	1220	701	738
Mean relative humidity (%)	58	61	65	76	72
Mean temperature (^{o}C)	16.5	13	15	18	15
Altitude (m)	800	800	700	350	400
Exposure	south	south	south	north	south
Tree ages (Ave)	72	89	81	61	131
Tree diameters in 1.30m (Ave, cm)	40	43	43	42	51
Tree heights (Ave, m)	17.36	23.48	27.37	23.18	20.31

Measurement of fiber lengths

As shown in Fig. 1, specimens were obtained from distance r/6, 3r/6 and 5r/6 from pith (r: radius (mm)).

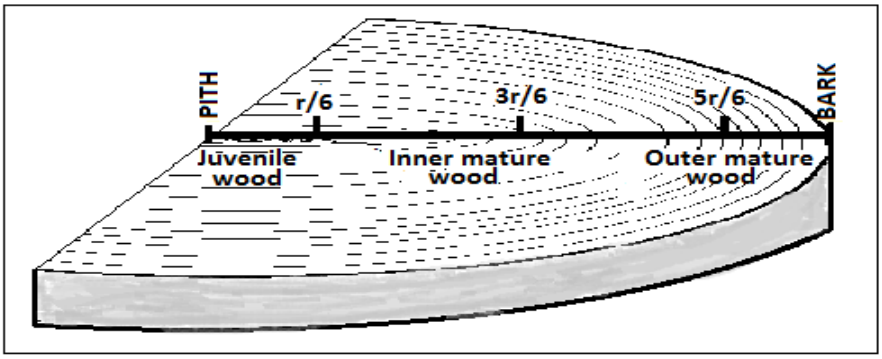

Fig. 1.
A schematic view in cross section of obtaining test samples from tree.

And, to measure fiber lengths of them (0.5mm thickness and 2cm long in parallel to grain), Jeffrey's method using equal volumes of 10% chromic acid and 10% nitric acid was applied (Richard 1986). In this method, specimens were immersed into Jeffrey's solution until they were defibered and later, fiber lengths were measured with the microscope of Richard after they were washed with pure water.

Soil texture

The soils of the growing regions were classified as Haploxerept (Gundogan 1998). The soil samples for laboratory analysis were taken from the 50cm depth. Soil texture was determined using the Bouyoucos Hydrometer method (Bouyoucos 1936, Day 1965) and lime content was measured with a Scheibler calcimeter (Loeppert and Suarez 1996).

RESULTS & DISCUSSIONS

Following laboratory measurement of test materials, they were subject to statistical analysis and then the results were managed as tables and figures. Results of ANOVA and Duncan analysis obtained from classification of fiber length in regard to distance from pith were presented in Table 2.

Table 2

The statistical analyses results of fiber lengths according to distance from pith in regions

Regions	Fiber lengths (mm)							Significance level
	DFP	N	Mean	SD	SE	COV	Range	
Kahramanmaraş	r/6	120	2.3a	1.211	0.111	52.65	8.0	*p*<0.001
	3r/6	120	4.7b	1.663	0.152	35.38	8.1	
	5r/6	120	5.1c	2.294	0.209	44.98	9.4	
	Total	360	4.3	1.998	0.105	46.47	9.8	-
Burdur	r/6	120	3.8a	0.790	0.072	20.89	4.0	*p*<0.001
	3r/6	120	4.6b	1.256	0.116	27.46	5.0	
	5r/6	120	5.4c	2.382	0.216	43.85	8.8	
	Total	360	4.6	1.751	0.092	38.10	8.9	-
Muğla	r/6	120	3.7a	0.672	0.061	18.16	2.8	*p*<0.001
	3r/6	120	4.6b	1.955	0.176	42.50	8.4	
	5r/6	120	5.3c	2.932	0.268	55.32	13.7	
	Total	360	4.5	2.170	0.114	48.22	14.0	-
Kemalpaşa	r/6	120	3.0a	0.991	0.090	33.03	4.3	*p*<0.001
	3r/6	120	4.0b	1.707	0.156	42.68	8.5	
	5r/6	120	5.0c	2.753	0.251	55.06	11.6	
	Total	360	4.0	2.111	0.111	52.78	12.0	-
Balıkesir	r/6	120	3.6a	0.867	0.079	23.12	4.1	*p*<0.001
	3r/6	120	4.7b	1.085	0.099	22.89	5.0	
	5r/6	120	5.6c	2.069	0.189	37.01	7.2	
	Total	360	4.7	1.620	0.085	34.47	8.0	-

r: Radius of log, DFP: Distance from pith, N: Number of sample, SD: Standard deviation, SE: Standard error, COV: Coefficient of variation, means with the same capital letter are not significantly different in Duncan's mean separation test.

According to the ANOVA analysis and Duncan's mean separation presented in Table 2, 'distance from pith' has also created significant differences $p<0.001$ in the five habitat on the fiber lengths. It has been determined that, as goes away from the pith, fiber lengths increases in all habitat as well. This results, have parallels with statement 'as goes away from pith to bark in tree trunk, it has seen increases in cell sizes' located in Berkel (1970). It was also corrected by Tavares *et al.* (2011), whose results showed that fiber length and wall thickness have increased from the pith to the bark.

As is known, effect on the fiber length of tree age is also varied depend on the tree species, genetic ability of trees and long or to the short of tree life (Bhat *et. al* 1988, Abasali 2012). ANOVA analysis and Duncan mean separation results obtained from according to the distance from pith to the bark of test specimens evaluated on the basis of habitat were given in Table 3.

Table 3

The results of the ANOVA and Duncan's mean separation test for fiber lengths growing regions as a function of distances from pith

DFP (mm)	N	Fiber lengths in regions (mm)						SL
		K.Maraş	Burdur	Muğla	İzmir	Balıkesir	Total	
r/6	120	3.0 (1.21)a	3.8 (0.79)b	3.7 (0.67)b	3.0 (0.99)a	3.8 (0.87)b	3.5	*p*<0.001
3r/6	120	4.7 (1.66)a	4.6 (1.25)a	4.6 (1.71)a	4.0 (1.71)b	4.7 (1.08)a	4.5	*p*<0.05
5r/6	120	5.1 (1.29)a	5.4 (2.38)a	5.3 (2.93)a	5.0 (2.75)a	5.6 (2.07)a	5.3	NS

DFP: Distance from pith, N: Number of sample, K.Maraş: Kahramanmaraş, SL: Significance level, r: Radius of log, Values in parentheses are standard deviation, means with the same small letter are not significantly different in Duncan's mean separation test, NS: Nonsignificant.

Based on distances from pith, the fiber lengths applied ANOVAs and Duncan analysis, it was determined significantly differences among the habitats between samples taken from r/6 mm ($p<0.001$) and 3r/6 mm ($p<0.05$). It was understood that seeing to Table 3, test specimens, obtained distance from 5r/6 pith, have insignificant differences in terms of growing areas. Malan (1991) stated that fibre wall thickness, diameter and fibre length increase rapidly with increase distance from pith. Also, Onilude (2001) expressed that the increases in fibre length from pith to bark are due to the increasing age of the tree with a resulting effect on cell wall development.

According to the same table, it can be seen that the presence of a proportional increase between distance from pith and fiber length. Because, it was an expected result that closed by pith fiber, forming

young wood, have more least dimension than mature wood fibers. The results of ANOVA analysis results of the evaluation of entire fiber lengths were given in Table 4.

Table 4

The fiber lengths measurements according to test regions

Regions	Fiber lengths (mm)							Significance level
	N	Mean	SD	SE	COV	Min	Max	
Kahramanmaraş	360	4.3ab	1.998	4.051	46.47	1.1	10.9	
Burdur	360	4.6c	1.751	4.414	38.07	2.4	11.3	
Muğla	360	4.5bc	2.170	4.307	48.22	2.2	16.2	p<0.001
İzmir	360	4.0a	2.111	3.806	52.78	1.2	13.2	
Balıkesir	360	4.7c	1.620	4.528	34.47	2.2	10.3	
Total	1800	4.4	1.955	4.331	44.43	1.1	16.2	-

N: Number of sample, SD: Standard deviation, SE: Standard error, COV: Coefficient of variation, means with the same small letter are not significantly different in Duncan's mean separation test.

All the fiber lengths applied ANOVA analysis given in Table 4 were analyzed, it was seen that significant differences among fiber length according to habitat. These differences have occured between İzmir (4.0mm) and Balıkesir habitat (4.7mm). Among the factors that affect this situation, the area's ecological and topographical structure can be counted (Bozlar *et al.* 2014). Table 5 was created to comparison of the soil texture taken from the habitats of sample collection and measurement of fiber length based on regions.

Table 5

The relations between of fiber lengths and soil texture in five different regions

Growing regions	Fiber lengths (mm)	Soil texture at the depth of 50 cm			Amount of lime (%)	Soil type
		Silt (%)	Clay (%)	Sand (%)		
Kahramanmaraş	4.3	26.51	16.50	57.03	4.37	sandy loam
Burdur	4.6	18.23	17.42	64.40	9.21	sandy loam
Muğla	4.5	35.70	17.53	46.82	14.56	sandy loam
İzmir	4.0	32.54	16.50	51.03	52.71	sandy loam
Balıkesir	4.7	11.4	24.2	64.4	3.09	sandy clay loam

As seen in Table 5 the maximum fiber length was measured in Balıkesir habitat (4.7mm) consisting of sandy loam soil, however minimum fiber length was measured in İzmir habitat (4.0mm) consisting of sandy clay loam soil. The interesting subject can be understood from the same table is Balıkesir, where the maximum fiber length measured, has the lowest percentage of lime (3.1%), while İzmir, where the minimum fiber length measured, has the highest percentage of lime (52.71%). This result matches up with the statement that Calabrian pine does not grow well on the soil with calcium-poor parent rocks, which is emphasized in Kantarcı (1984). Because some literatures (Samariha, 2011, Bhat *et al.* 1988) indicate that the fiber length increases as the tree age increases.

The linear equations derived from all the regression analyses for fiber lengths and soil characteristics were illustrated in Table 6.

Table 6

Equations derived from regression

Properties	Equations	Coefficient of regression (b)	Coefficient of correlation (r)	r^2	Significance level
Fiber length-Silt	Y=132.8 -24.4x	–	0.67	0.45	p<0.01
Fiber length-Lime	Y=289.1-61.6x	–	0.83	0.69	p<0.001
Fiber length-Clay	Y=-16.1+7.8x	+	0.66	0.44	p<0.01
Fiber length-Sand	Y=-16.4+16.5x	+	0.58	0.34	Nonsignificant

When Table 6 and Fig. 2 are evaluated together, except for sand percentages, it can be seen that there are a significant relationship between fiber lengths and silt-, clay- as well as lime percentages. However, Kalıpsız (1994) expressed that r^2>0.30 can be regarded as a significant relationship. At the same time, it was determined that there is a significant relationship (p<0.001) between fiber lengths and lime

percentages, while there is a poor relationship (r^2<0.50) between fiber lengths and silt-, clay percentages compared to lime percentage.

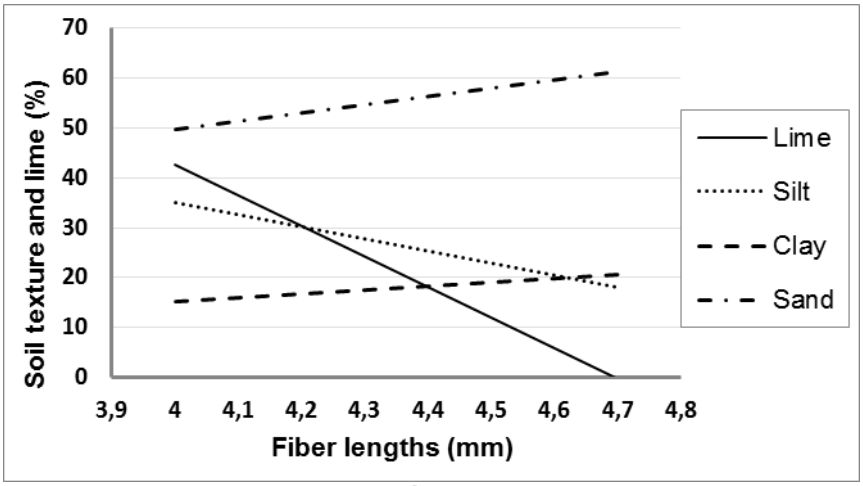

Fig. 2.
The comparison of the averages values of fiber lengths and soil texture as well as lime pergantage.

These evaluations prove that it will be obtained the best fiber yield from mature pine trunks. At the same time, it is understood that, calabrian pine growing high percentage of silt and lime soil, has shorter fiber length. Finally, it can be said that, feasible soils for this tree specie could high percentage of sand and moderate clay as well as non-calcareous soils. As it is known, fiber dimensions, strength, variability, and structure are important considerations for wood quality in using areas (Bektaş *et al.* 2016). For example, paper strength properties dependent upon fiber-to-fiber bond formation, combination of fiber length and cell wall thickness (Horn and Setterholm 1990). In addition, long fibers are preferred in production of high strength paper (Francis *et al.* 2006).

CONCLUSION

In this study was targeted that the effects of growing region and distance from pith on fiber lengths of calaprian pine wood. Obtained from results of analysis were revealed that except for 5r/6 distances from pith r/6, 3r/6 and growth areas have shown a significant effect (p<0.001, p<0.05, p<0.001, respectively) on fiber dimensions. Based on the region, the average maximum fiber lengths were measured in Balıkesir (4.7mm) and in respect to distances from pith maximum value (5.3mm) was measured 5r/6. In the light of Table 2 and 3, it can be said that as goes away from the pith, fiber lengths increases in all habitat as well. The results showed that, Balıkesir region which has high sand (64.4%), moderate clay (24.2%) and lime-poor (3.1%) soils is quite suitable habitat in terms of fiber lengths. In other words, it is understood that, calabrian pine growing high percentage of silt and lime soil, has shorter fiber length. Research results showed that it can be obtained the best fiber lengths (5.3mm) from mature wood (5r/6) as shown in Table 3 and Fig. 1. After all, high percentage of sand and moderate clay as well as non-calcareous soils can be more suitable for calabrian pine trees.

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