UDC: 582.681.81:632.112

Original scientific paper

Fiber Length in Clone 'L-12' Juvenile Wood

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Abstract: Nowadays, white poplar is becoming more interesting for breeding as a drought tolerant species. There is a considerable knowledge on certain fast-growing poplar species that are widely used, while insufficient is known about many potential clones, such as white poplar clone 'L-12'. Among wood anatomical characteristics, fiber length is considered to be most significant for utilization of poplar wood. Understanding size and range of wood variability is important for its proper use. In this study, variation in fiber length from pith to bark, within and between two sites, one in the Republic of Croatia and one in the Republic of Serbia was investigated. Five trees of clone 'L-12' were collected from each site. From each tree on both sites, growth rings 2, 4, 6, 8 and 10 from pith were selected for further wood anatomical analysis. For fiber length measurements, maceration was performed. From each growth ring, 40 unbroken fibers were measured.
The mean fiber length of clone 'L-12' juvenile wood from Osijek site was 0.910 mm and from Kać site was 0.896 mm. Repeated measures analysis of variance (ANOVA) was used to test significance of mentioned differences. Results indicate that fiber length varied significantly from pith to bark. The variation in radial pattern was characterized by increase in fiber length with cambial age. Variation in fiber length within both sites was more significant than between sites. Due to highly significant variability, nonhomogeneous fiber length within juvenile wood from both sites was detected. Results indicate the need for further research on anatomical characteristics of wood for better interpretation of wood quality.

Keywords: clone 'L-12', fiber length, juvenile wood, wood anatomical properties variation.

1. Introduction

Nowadays the use of poplar wood is becoming more diverse. Its wide utilization contributes to breeding importance of different poplar species and clones. There is an increase in tree improvement of various poplar species. Improvement with the aim of increasing the quality of raw material cannot be implemented without understanding wood structure.

The attention devoted to research of wood anatomical characteristics of various poplar species is not eqvivalent. White poplar (*Populus alba* L.) has been considered for a long time as tree species with no significant market value. However, recognized great ecological importance as a drought tolerant species (Gilman and Watson, 1994; Richardson et al. 2014), should

contribute to its commercial importance. In relation to that, it is essential to complete the information on its wood properties and quality. In previous paper, Ištok et al. (2017) investigated fiber characteristics of white poplar juvenile wood. White poplar clone 'L-12' is determined to be especially promising for quality wood production under arid hydrological conditions (Rédei et al. 2010). Drought tolerant tree selection is a long-term solution to low maintenance landscapes (Coder, 2011). In both the Republic of Croatia and Serbia, there are suitable habitats for poplar breeding. Certain other poplar species have been well investigated, whereas anatomical properties of potential clones, such as 'L-12' have not been investigated at all.

The volumetric composition of poplars is dominated by wood fibers (Balatinecz et al. 2014). Studies have shown the importance of fiber morphology as one of the most important parameters of wood quality, due to demands of most common use in paper and pulp industry (Pande, 2012). As well, Logan (2006) highlights the link between wood mechanical properties and fiber characteristics.

Wood is inherently a variable matter as a product of living tree metabolism. Numerous wood characteristics can vary in different parts of the tree, as well as between individual trees and between different sites. Trees that are grown in short rotations produce wood with a high proportion of juvenile wood (Bendtsen, 1978). Juvenile wood is characterized by rapid changes in wood structure (Tsoumis, 1991). Main wood anatomical characteristic that changes within this zone is fiber length. This highligts the importance of determining the size of variability in fiber length.

The aim of this study was: (a) to determine fiber length in clone 'L-12' juvenile wood from two sites, one in the Republic of Croatia and one in the Republic of Serbia; (b) to investigate variations in fiber length from pith to bark, within and between two sites.

2. Material and Methods

Five trees of clone 'L-12' were collected from two sites, one in the Republic of Croatia and one in the Republic of Serbia. First site is located near the city of Osijek in the Republic of Croatia, within Osijek Podravina forests. The site is characterized by alluvial loamy-sandy soils, where humus is being formed, with mean annual temperature of 11.6 °C and total annual precipitation of 694.4 mm. Second site is Experimental Estate of the Institute of Lowland Forestry and Environment "Kaćka šuma" (N 45°17'; E 19°53'; 76 m a.s.l.) near the city of Novi Sad in the Republic of Serbia. It is characterized by undeveloped alluvial soil (fluvisol), sandy loam form. Mean annual temperature is 11.1°C, while the annual sum of precipitation is 624 mm. During the vegetation period (April-September) mean air temperature is 17.8°C and the sum of precipitations amounts 369 mm.

Each selected tree was marked on the side facing north because of further investigations on physical and mechanical properties. Disks approximately 5 cm thick were cut at breast height (1.3 m) from each tree. Radial segments (north – south orientation) were cut from each disk and annual growth rings were marked along one radius. From each tree on both sites, growth rings 2, 4, 6, 8 and 10 from pith were selected for wood anatomical analysis.

For fiber length measurements, wood from each of the previously selected growth rings was separated with a razor blade and placed into an individual test tube. Maceration was performed according to Franklin's method (Franklin, 1945). Macerated material was stained using safranin, then placed on microscope slides and mounted in glycerin gelatin. From each growth ring, 40 unbroken fibers were measured using light microscope, digital camera and DinoCapture 2.0 program.

Statistical analysis of results was carried out in Statistica 10. Repeated measures analysis of variance (ANOVA) was used to test significance of differences in radial distribution in fiber length, as well as its variations within and between two sites.

3. Results and Discussion

Results indicate wood structure related qualitative and wood variation related quantitative preliminary study. Table 1 lists statistical values of fiber length in clone 'L-12' juvenile wood from two sites.

Table 1. Statistical values of fiber length in clone 'L-12' juvenile wood from Osijek and Novi Sad.

Site	Number of trees	Source	Fiber length (mm)
Osijek (CRO)	5	*N*	40
		MIN	0.446
		MEAN	0.910
		MAX	1.591
		STDEV	0.193
Novi Sad (SRB)	5	*N*	40
		MIN	0.337
		MEAN	0.896
		MAX	1.733
		STDEV	0.229

Key: N – number of specimen, MIN – minimum value, MEAN – mean value, MAX – maximum value, STDEV – standard deviation.

Mean value of fiber length in clone 'L-12' juvenile wood from Osijek was 0.910 mm and from Novi Sad was 0.896 mm (Table 1 and Figure 1). Both values from this study are less than 1 mm, but slightly longer fibers were measured in juvenile wood from Osijek. The difference in fiber length between two sites is statistically significant (Table 2).

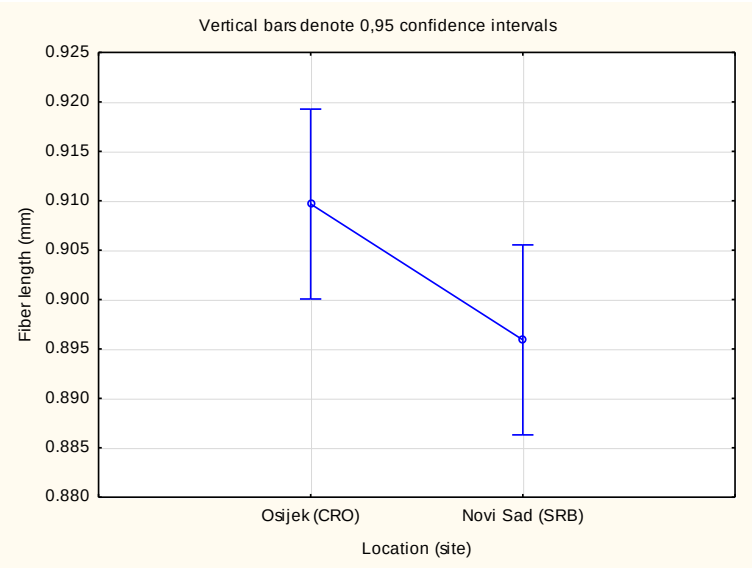

Figure 1. Fiber length in clone 'L-12' juvenile wood from Osijek and Novi Sad.

Even if this variation is significant, the difference in percentage (less than 2%) and thus, in practical sense, is negligible. Generally, variations in wood properties between sites are smaller in comparison to variations within individual site or tree (Tsoumis, 1991). Similar mean values of fiber length in some hybrid poplars were determined by other authors (Koubaa et al. 1998; Huda et al. 2012). However, most authors report on fibers longer than 1 mm (Fang and Yand, 2003; Yang et al. 2006; Šefc et al. 2009). Pande (2012) ranges fibre length in different poplar species/clones from 0.550 to 1.700 mm.

Additionally, it is possible to classify given results on fiber length according to the IAWA list of microscopic features for hardwood identification (Wheeler et al. 2007). This list is a descriptive wood anatomy tool. According to it, fiber length could be classified into 3 categories. Results from Novi Sad first category of fiber length (≤ 900 μm) and from Osijek match second category of fibre length (900 – 1600 μm).

Table 2. Repeated measures analysis of variance for fiber length in clone 'L-12' juvenile wood from two sites and in direction from pith to bark from Osijek and Novi Sad.

Source of variation	Fiber length	
	F	***p***
Site	3.95	0.047507
Annual rings	555.39	0.000000
Annual rings*site	19.81	0.000000

The variation in fiber length between annual rings was highly significant and showed an increase with age (Table 2). Similar radial trends in fiber length were determined in juvenile wood from both sites. Fiber length was initially short near the pith, after which rapidly increased before showing a tendency to level off in the tenth annual ring (Figure 2).

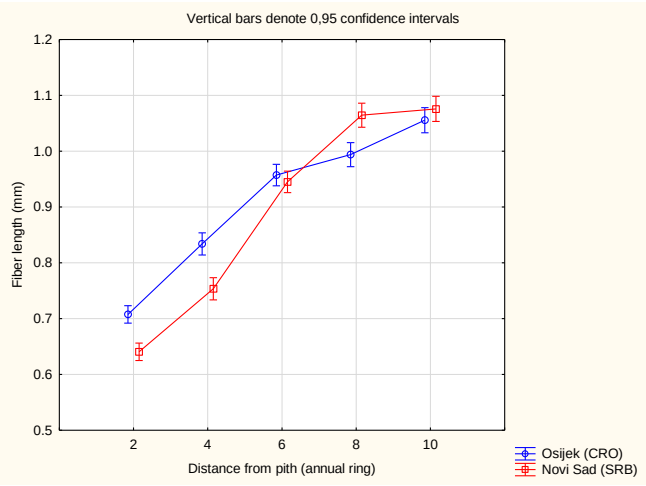

Figure 2. Radial distribution of fiber length in clone 'L-12' juvenile wood from Osijek and Novi Sad.

This indicates that wood maturity is not yet reached at age ten. Results are in agreement with general knowledge on fiber length variations in hardwood juvenile wood (Maeglin, 1987; Zobel and van Buijtenen, 1989) and earlier findings on poplars (Peszlen, 1994; Yu, 2001;

Lundqvist, 2002; DeBell et al. 2002; Šefc et al. 2009). In accordance, radial variation in fiber length as the main source of variation was concluded by Koubaa et al. (1998) and Huda et al. (2012).

Table 3. Repeated measures analysis of variance for fiber length in clone 'L-12' juvenile wood within clone from each site.

Source of variation	Site	Fiber length	
		F	*p*
Trees	Osijek (CRO)	21.91	0.000000
	Novi Sad (SRB)	10.57	0.000000

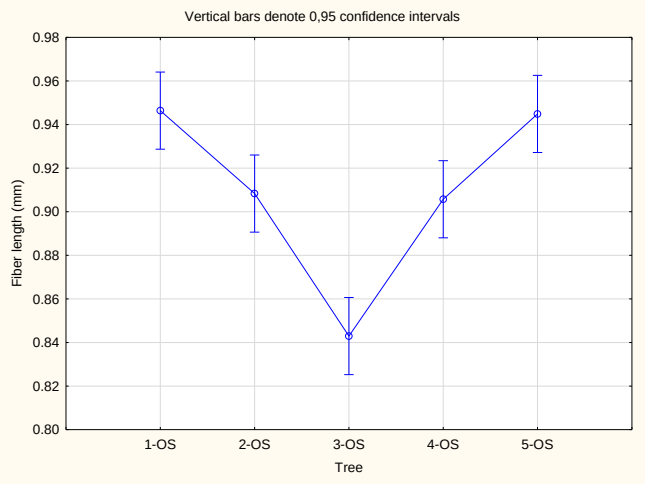

Figure 3. Fiber length in juvenile wood of five clone 'L-12' trees from Osijek.

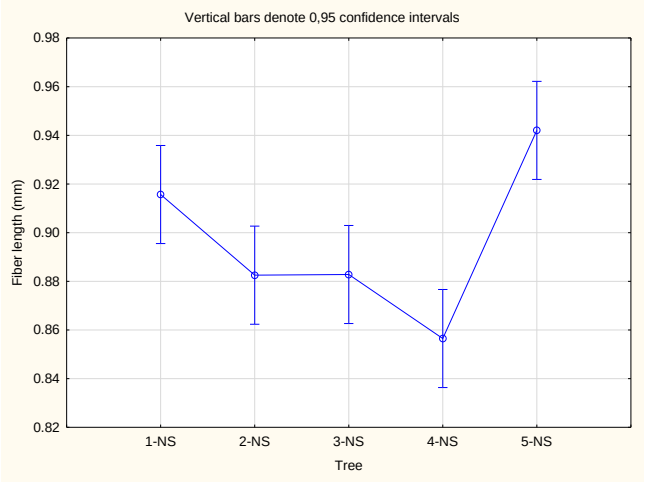

Figure 4. Fiber length in juvenile wood of five clone 'L-12' trees from Novi Sad.

There was a highly significant difference in fiber length among trees within both sites (Table 3). This may be explained by strong environmental effect on fiber length in different trees on both sites. Shortest fibers from Osijek were measured in tree 3-OS and longest fibers in tree 1-OS (Figure 3), with a 12% difference between the lowest and highest length. As well, shortest fibers from Novi Sad were measured in tree 4-NS and longest fibers in tree 5-NS (Figure 4), with a 9% difference between the lowest and highest length. While Klašnja et al. (2003) reported on significant tree-to-tree variation in fiber length of poplar clones, Koubaa et al. (1998) found no significant difference.

4. Conclusions

Certain variations were determined in fiber length in clone 'L-12' juvenile wood from Croatia and Serbia. Statistically significant difference in mean fiber length existed between sites.

Age had a highly significant effect on fiber length in clone 'L-12' juvenile wood from both sites. Fiber length increased from pith to bark and juvenile wood effect on fiber length was detected. As well, highly significant effect on fiber length was termined between trees on both sites. It could be concluded that variations in fiber length within trees and between trees of each site are more pronounced and more significant in comparison to variations between two sites.

Data on fiber length are preliminary results and further research on more wood anatomical characteristics is needed. That would offer possibility for selection of clone 'L-12' in terms of wood anatomical properties and better interpretation of wood quality.

Acknowledgements

This paper is a result of collaboration between the Faculty of Forestry of Univeristy of Zagreb and the Institute of Lowland Forestry and Environment from Novi Sad. Financial support was provided by University of Zagreb, Croatia.

5. References

1. Balatinecz, J., Mertens, P., De Boever, L., Yukun, H., Jin, J., van Acker, J. (2014): Properties, Processing and Utilization. In Poplars and willows: trees for society and the environment, Isebrands, J.G., Richardson, J., (Eds.), CAB International and FAO: 527-561.
2. Bendtsen, B.A. (1978): Properties of wood from improved and intensively managed trees. Forest Products Journal 28 (10): 61-72.
3. Coder, K.D. (2011): Tree selection for drought resistnce. University of Georgia, Daniel B. Warnell School of Forest Resources 4(99): 1-3.
4. DeBell, D. S., Singleton, R., Harrington. C.A., Gratner, B.L. (2002): Wood density and fiber length in young *Populus* stems: relation to clone, age growth rate and pruning. Wood and Fiber Science 34 (4): 529-539.
5. Fang, S., Yang, W. (2003): Interclonal and within-tree variation in wood properties of poplar clones. Journal of Forestry Research 14(4): 263-268.
6. Franklin, G.L. (1945): Preparation of thin-wood sections of synthetic resins and wood-resin composites, and a new macerating method for wood. Nature 155: 51.
7. Gilman, E.F., Watson, D.G. (1994): *Populus alba* – White Poplar. Fact Sheet ST-499. Environmental Horticulture Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Services, Florida, USA.
8. Huda, A.S.M., A., Koubaa, A., Cloutier, A., Hernández, R.E, Périnet, P. (2012): Anatomical properties of selected hybrid poplar clones grown in Souther Quebec. BioResources 7(3): 3779-3799.

9. Ištok, I., Šefc, B., Hasan, M., Popović, G., Sedlar, T. (2017): Fiber characteristics of white poplar (*Populus alba* L.) juvenile wood along the Drava river. Drvna industrija 68(3): 241-247.
10. Klašnja, B., Kopitović, S., Orlović, S. (2003): Variability of some wood properties of eastern cottonwood (*Populus deltoides* Bartr.) clones. Wood Science and Technology 37: 331-337.
11. Koubaa, A., Hernández, R.E., Beaudoin, M., Poliquin, J. (1998): Interclonal, intraclonal, and within-tree variation in fiber length of poplar hybrid clones. Wood and Fiber Science 30(1): 40-47.
12. Logan, J.D. (2006): Sensitivity to Fundamental Wood Properties in the Metriguard Model 7200 HCLT and the CLT. Metriguard INC, Pullman, WA. (http ://www.metriguard.com/fiber.php, Access October 10, 2018)
13. Lundqvist, S.O. (2002): Efficient wood and fiber characterization – a key factor in research and operation. Ann. For.Sci. 59: 491-501.
14. Maeglin, R. (1987): Juvenile wood, tension wood, and growth stress effects on processing hardwoods. U Applying the latest research to hardwood problems, Proceedings of the 15th annual hardwood symposium of the Hardwood Research Council; Memphis, TN: 100-108.
15. Pande, P.K. (2012): Status of Anatomy and Physical Properties of Wood in Poplars. Forestry Bulletin 12 (1): 132-150.
16. Peszlen, I. (1994): Influence of age on selected anatomical properties of populus clones. IAWA Journal 15 (3): 311-321.
17. Rédei, K., Keserű, Z., Szulscán, G., Orlović, S. Galić, Z., Juhász, L., Győri, J. (2010): Clonal approaches to growing Leuce poplars (*Leuce* Duby) in Hungary and Serbia. Topola 185/186: 15-25.
18. Richardson, J., Isebrands, J.G., Ball. J.B. (2014): Ecology and Physiology of Poplars and Willows. In Poplars and willows: trees for society and the environment, Isebrands, J.G., Richardson, J., (Eds.), CAB International and FAO: 92-123.
19. Šefc, B., Trajković, J., Govorčin, S., Despot R., Hasan, M. (2009): Selected tree characteristics and wood properties of two poplar clones. Wood Research 54(1): 1-8.
20. Tsoumis, G. (1991): Science and technology of wood: structure, properties, utilization. Chapman & Hall, New York.
21. Zobel, B.J., van Buijetenen, J.P. (1989): Wood variation. Its causes and control., Springer-Verlag, Berlin, Heildeberg.
22. Wheeler, E.A.; Baas, P., Gasson, P.E. (eds.) (2007): IAWA List of Microscopic Features for Hardwood Identification. IAWA Bulletin 10(3): 219-332.
23. Yang, S., Lu, L., Ni, Y. (2006): Cloned poplar as a new fibre resource for the Chinese pulp and paper industry. Pulp Pap-Canada 107(2): 34-37.