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Physical Properties of Wood in White Poplar Clone 'L-12' Grown in Republic of Croatia and Serbia

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Abstract: Due to increasing demand for forest products, fast-growing species such as poplars are grown in plantations to a larger extent. The quality of wood raw material depends to a greater extent on its physical properties. The available data on physical and mechanical properties of white poplar wood grown in Republic of Croatia and Serbia are insufficient. In this article, preliminary results on physical properties of white poplar clone 'L-12' wood grown in Republic of Croatia and Serbia are presented. Five representative trees of white poplar clone 'L-12' from two sites were collected. One is located near the city of Osijek in the Republic of Croatia, within Osijek Podravina forests and the other one is located at Experimental Estate of the Institute of Lowland Forestry and Environment "Kaćka šuma" near the city of Novi Sad in the Republic of Serbia. Both sites are representatives of breeding poplar plantations. The investigations were carried out using only segments with north and south orientation in wood at the breast height of each tree. The results of average values indicate that there is no significant difference in wood density in clone 'L-12' between two sites. There is significant difference in longitudinal, tangential and volume shrinkage and maximal moisture content between sites, but the difference, as far as practice is concerned, is negligible. For a better prediction of wood quality of clone 'L-12' further research on mechanical properties of wood is needed.

Keywords: physical properties, sites, white poplar clone 'L-12'.

1. Introduction

Increased demand for forest products will cause lack of quality wood on the market in the future. To satisfy demands, fast-growing genetically improved wood species have been introduced. One of them are hybrid poplars. Poplars are one of more easily cloned wood species. Usually their rotations are up to 15 years. There are many researches on hybrid poplars. Mostly, investigations were focused on growth rate, coppicing ability, adaptability and disease resistance while investigations about wood quality of selected poplar clones were investigated to a lesser extent. The wood of poplars is predicted for numerous uses, such as lumber and veneer production, production of composite and wood-based products, pulp and paper etc. Physical

properties are important for better understanding and prediction of wood quality (Zobel and van Buijtenen, 1989), especially wood density and wood shrinkage. Poplar wood density is similar to that of softwoods, but with high strength values related to their limited density (Isebrands and Richardson, 2014). Wood shrinkage is influenced by its density. Greater shrinkage is usually associated with greater density (Tsoumis, 1991). Many studies on wood shrinkage on poplars have been carried out (Pliura et al. 2005; Kord et al. 2010, Ištok et al. 2016; Sinković et al. 2017).

White poplar (*Populus alba* L.) is native wood species in Europe. Considering constant climatic changes, white poplars are resistant to drought (Eggens et al., 1972, Isebrands and Richardson, 2014) and tolerant to changes in groundwater levels (Rédei and Keserü, 2008). In Republic of Croatia, it could be found in mixed stands together with other species such as white willow and black poplar. Pure stands of white poplar could be found along the course of Danube, Sava and Drava (Franjić and Škvorc, 2010). Until now, research has been carried out on anatomical, physical and mechanical properties of white poplar wood (*Populus alba* L.) in Croatia (Horvat, 1960; Ištok et al. 2017; Sinković et al. 2017). The capacity of white poplar to grow in a wide range of soils and to propagate easily contributes highly to its cultivation. White poplar clone 'L-12' has been planted in the Republic of Croatia and Serbia. Data on anatomical, physical and mechanical properties of clone 'L-12' are missing.

The aim of this preliminary study was: (a) to determine wood physical properties of white poplar clone 'L-12' from two sites, one in Croatia and the other one in Serbia; (b) to investigate variations in mentioned properties between two sites.

2. Materials and Methods

For the purpose of this research, five representative trees of white poplar clone 'L-12' from two sites were collected. One 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. The second site is located at 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.

Table 1. Tree characteristics of white poplar clone 'L12' from two sites.

Tree species	Tree mark	Site	Total tree height (m)	Height up to first living branch (m)	Diameter at breast height (cm)	Disk thickness (cm)
'L12'	1K	Osijek	22.3	4	28.7	5
'L12'	2K	Osijek	25	3	35.7	5
'L12'	3K	Osijek	19.5	8	28.4	5
'L12'	4K	Osijek	20	8	28.7	5
'L12'	5K	Osijek	18	12	25	5
'L12'	11	Novi Sad	30	6	36	5
'L12'	12	Novi Sad	35.5	10	37.3	5
'L12'	13	Novi Sad	38	8	35.5	5
'L12'	14	Novi Sad	40	10	40.3	5
'L12'	15	Novi Sad	39	8	36.5	5

Each test tree was marked on the side facing north. They were chosen as representative of the stand according to ISO 3129:2012. Relevant parameters were collected and measured on growth locations of all test trees (Table 1).

After cutting down, one test trunk, length of approximately 80 cm, was sawn from each test tree. Afterwards, trunks were sawn into bark to bark cores of approximately 6 cm in thickness (Figure 1). The samples were sawn in the radial direction from heart to bark and labelled with markers. After the cores had dried to a moisture content of about 12%, from the highest part of the core, which was in at breast height (1.3 m), rectangular samples of 20 mm × 20 mm × 25 mm were made (Figure 1).

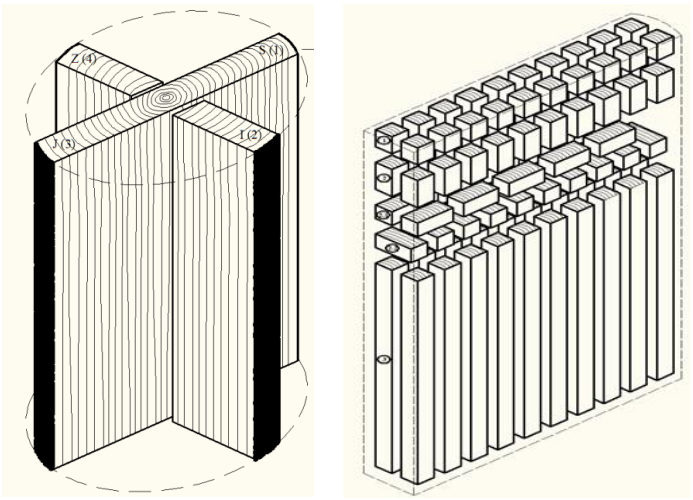


Figure 1. Bark to bark core (North – South) and samples of 20 mm × 20 mm × 25 mm from core (1).

Physical properties that were determined in this study were density in absolutely dry condition and basic density according to HRN ISO 13061-2, radial and tangential shrinkage according to HRN ISO 4869:1999 and volumetric shrinkage according to HRN ISO 4858:1999.

Statistical analysis of the results and their comparison was carried out in specialised statistical programme Statistica 8. Statistical analysis showed the number of measured samples (n), minimum (min), average (aver) and maximum (max) value of certain measured properties as well as their standard deviation (STDEV) and coefficient of variation (CVAR).

3. Results and Discussion

Physical properties of wood, especially wood density and dimensional stability are important factors affecting wood quality. Average wood density in absolutely dry condition of clone 'L-12' from Novi Sad is only 1% higher than in clone 'L-12' from Osijek (Table 2). Statistical analysis showed no difference in average wood density between sites (Table 3 and Figure 3).

Average basic density values in 'L-12' is 0.28 g/cm3. The values from our results are smaller than findings of other authors for hybrid poplars (Beaudoin et al. 1992; Hernández et al. 1998; Zhang et al. 2003). According to them, basic wood density ranges between 0.3 and 0.4 g/cm^3.

Table 2. Statistical values of density in absolutely dry condition, basic density, maximal radial, tangential and volume shrinkage of white poplar clone 'L-12' from Novi Sad and Osijek.

'L-12' - Novi Sad						'L-12' - Osijek				
ϱ_o	ϱ_y	$\beta_{r\,max}$	$\beta_{t\,max}$	$\beta_{v\,max}$		$\beta_{v\,max}$	$\beta_{t\,max}$	$\beta_{r\,max}$	ϱ_y	ϱ_o
g/cm^3	g/cm^3	%	%	%		%	%	%	g/cm^3	g/cm^3
160	160	160	160	160	N	68	68	68	68	68
0.273	0.245	2.8	5.6	9.5	MIN	9.9	6.5	2.9	0.235	0.259
0.318	0.283	4.0	8.1	12.6	AVE	11.9	7.6	3.8	0.281	0.314
0.433	0.382	8.6	9.9	17.9	MAX	15.9	9.5	8.4	0.352	0.396
0.0258	0.0221	0.98	0.85	1.48	STDEV	1.12	0.64	0.79	0.0298	0.0347
8.10	7.81	24.24	10.53	11.72	CVAR	9.42	8.50	20.68	10.62	11.03

Legend: ϱ_o - density in absolutely dry condition, ϱ_y – basic density, $\beta_{r\,max}$ - total radial shrinkage, $\beta_{t\,max}$ - total tangential shrinkage and $\beta_{v\,max}$ - total volumetric shrinkage, N – number of specimens, MIN – minimal value, MAX – maximal value, STDEV – standard deviation, CVAR - coefficient of variation (%).

There is statistical difference in tangential and volumetric shrinkage of clones between two sites (Table 3 and Figure 2). However, the difference in shrinkage is only about 6%, and for wood processing and forestry practice could be negligible. The average values of shrinkages in clone 'L-12' wood are similar to some native poplars (Peck, 1957; Jessome, 1977) and poplar clones (Koubaa et al. 1998).

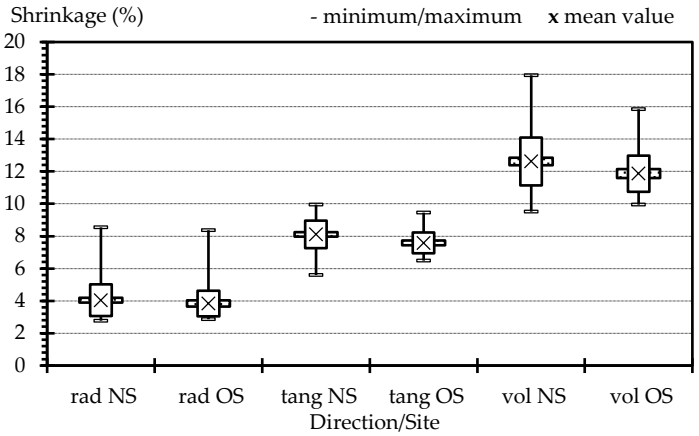
Table 3. Pearson's correlation coefficients for the relationship between mean values of researched physical properties of poplar clone 'L-12' from Novi Sad and Osijek.

'L-12' - Osijek / 'L-12' - Novi Sad	Density in the absolutely dry condition	Basic density	Total radial shrinkage	Total tangential shrinkage	Total volumetric shrinkage
Density in the absolutely dry condition	p=0.179 Z=1.343				
Basic density		p=0.388 Z=0.862			
Total radial shrinkage			p=0.307 Z=1.020		
Total tangential shrinkage				**p<0.001** **Z=5.080**	
Total volumetric shrinkage					**p<0.001** **Z=3.961**

Note: Correlations are significant at p<0.05.

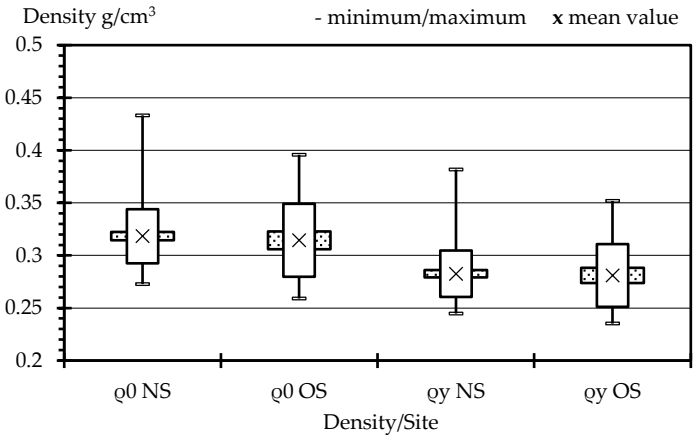
The effect of environmental conditions on 'L-12' clone wood physical properties was evaluated across two sites situated in Croatia and Serbia. Negligible clone differences observed between sites concerning wood shrinkage, as well as absence of differences in average wood density suggest relatively stable performance of 'L-12' in two environments. Such a performance is probably the result of similar environmental conditions in Kaćka šuma and Osijek Podravina forests, since previous studies demonstrated that majority of variation depends on the

environment. Indeed, Yan and Kang (2002) believe that environmental effect contributes more than 80 % of totally observed variation.



Legend: rad – radial shrinkage, tang – tangential shrinkage, vol – volumetric shrinkage, NS – Novi Sad, OS – Osijek.

Figure 2. Statistical analyzes of radial, tangential and volumetric shrinkage between clone 'L-12' from two sites.



Legend: ϱ0 – density in absolute dry condition, ϱy – basic density, NS – Novi Sad, OS – Osijek.

Figure 3. Statistical analyzes of density between clone 'L-12' from two sites.

4. Conclusions

Clone performances generally remain constant from one environment to another. Although significant differences in tangential and volumetric shrinkage of white poplar clone 'L-12' were observed between two sites, these differences amounted only about 6%, which is for the purpose of wood processing and forestry practice negligible. Likewise, no difference was found in wood density between sites.

Similar performances of white poplar clone 'L-12' across two sites probably rely on the low environmental variation (i.e. soil conditions and microclimate) between sites where the plantations have been cultivated. Nevertheless, the stability observed for wood shrinkage and density might be the results of certain morphological and physiological aspects which hold these traits in a fixed state, while allowing other characters to vary (Allard and Bradshaw, 1964).

Therefore, for better understanding of wood structure in white poplar clone 'L-12', as well as the effect of local environment on them, mechanical properties should be investigated in the future.

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