Comparison of physical properties of White Poplar and clone ˈVillafrancaˈ wood

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ABSTRACT

Differences between plantantion grown and natural poplars are a subject of limited number of investigations. Acquiring genotypes of forest trees with properties better than the existing is the main aim of the breeding application. Another important goal is the increase in wood quality. In this article, preliminary results on physical properties of white poplar and clone 'Villafranca' wood are presented. Five representative trees of both origin were collected. The site is located near the city of Varaždin in Republic of Croatia, within Varaždin Podravina forests. The investigations were carried out using segments with north and south orientation in the wood at the breast height of each tree. The results of average values indicate there is a significant difference in wood density, longitudinal, tangential, radial and volume shrinkage and maximal moisture content between white poplar and clone 'Villafranca' wood. For a better prediction of white poplar and clone 'Villafranca' wood quality further research on mechanical properties is needed.

Key words: Physical properties, clone ˈVillafrancaˈ, white poplar

1. INTRODUCTION

Global poplar resources are rapidly increasing in the last few decades, due to increasing demand for raw material. Poplar wood provides numerous product options, ranging from lumber to veneer, plywood and composites as wood-based products, as well as pulp and paper as fiber-based products. It is well known that different end uses require certain wood characteristics (Zhang *et al.*, 1997).

Wood density is considered to be one of the most important factor affecting wood quality (Zobel and van Buijtenen, 1989). Is strongly related to other wood properties, such as mechanical strength (Panshin and de Zeeuw 1980). Poplar wood has low density similar to that of softwoods, but with high strength values related to their limited density (Isebrands and Richardson, 2014).

The best known within-tree variability in wood is the change from the pith to the bark. The low density, diffuse-porous woods, such as *Populus*, seem to have a somewhat higher density at the pith (Zobel and van Buijtenen, 1989).

So far, 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; Ištok *et al*., 2018; Sedlar *et al*., 2018).

The capacity of white poplar to grow in a wide range of soils and to propagate easily contributes highly to its cultivation (Ištok *et al*., 2017). For that reason, existing data on its wood properties should be completed. The area of Varaždin and Međimurje or north-western part of Croatia has a lot of land that can be used for growing poplar or poplar clones. For developing poplar clones, it is important to create a database on physical and mechanical properties of white poplar from the natural stands (Šefc, 2009; Ištok *et al*., 2016).

Aim of this study was to investigate physical properties of clone ˈVillafrancaˈ wood and compare them with physical properties of white poplar wood.

2. MATERIAL AND METHODS

For the purpose of this research, five representative trees of white poplar and clone 'Villafranca' were taken from Varaždin podravina forests, department 3a (*Figure 1*). The test trees were chosen as representative of the stand according to HRN ISO 3129:2015.

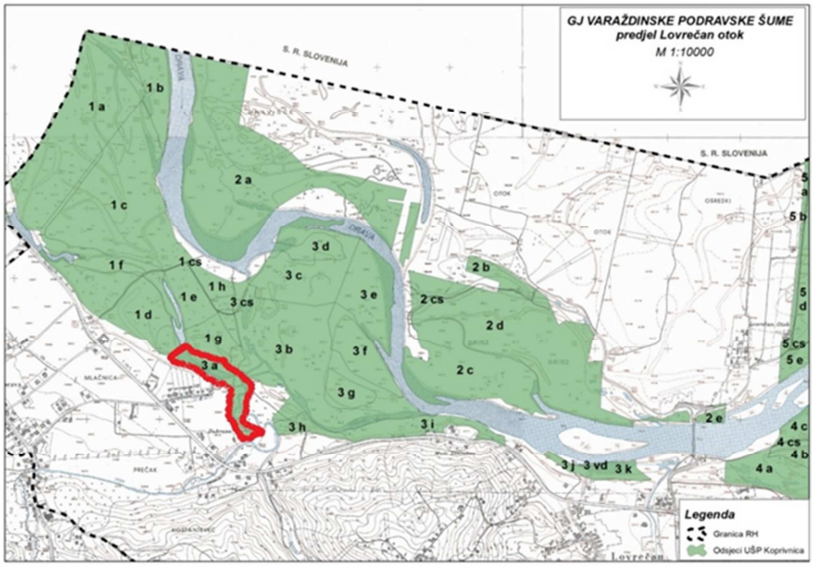


Figure 1. *Map of the location the test trees* (***Source****: Ištok, 2016*)

The test trees were chosen as the best represent of the stand with their age, size, habitus, dendrometric elements and outer trunk properties. They were healthy, normal, with regular crowns, straight stems, average flawlessness and fullness of bole, as well as grain texture (*Tables 1* and *2*).

Table 1. *Basic data on White poplar trees*

Number of test trees	**Height of the tree** (m)	**Height to the first thick branch** (m)	**diameter on breast height** (cm)
27	16	7.5	50.5
28	14	6	51
29	14.3	8	41
30	14.1	8.2	44.5
31	13	7.3	39.2

Table 2. *Basic data on clone Villafranca trees*

Number of test trees	**Height of the tree** (m)	**Height to the first thick branch** (m)	**Diameter on breast height** (cm)
14	21.4	2	30.5
18	21.2	1.9	26
22	19.9	1.7	24.5
26	21.5	2	27.5
32	23.1	1.6	25.4

After cutting down, one test trunk of 1m length was sawn from each test tree. Length of test trunk started at breast height (1.3 m), downwards to root collar. Afterwards, these 1 m long trunks were sawn into bark to bark cores approximately 6 cm thick. One core was

oriented north-south, and the others from east and west side (*Figure 2*). Cores were then submitted to natural drying on dry and drafted stock. After the cores had dried to a water content of about 12%, test samples were sawn. Test samples for investigation of physical properties were made according to HRN ISO 13061-2: 2015.

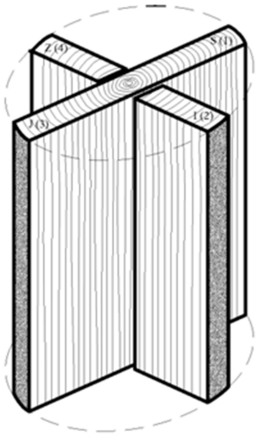


Figure 2. *Bark to bark cores (north – south, east and west)*

3. RESULTS AND DISCUSSION

Table 3. *Statistical values of physical properties of Villafranca and white poplar wood*

property	unit	count	min value	max value	average value	standard deviation	variation coefficient
Villafranca							
ρ_o	g/cm^3	85	0.236	0.369	0.286	0.0243	8.50
ρ_{max}	g/cm^3	85	0.792	1.063	0.902	0.056	6.17
ρ_y	g/cm^3	85	0.213	0.338	0.259	0.0218	8.42
$\beta_{l\,max}$	%	85	0.1	0.8	0.2	0.030	86.95
$\beta_{r\,max}$	%	85	2.0	4.9	3.2	0.66	20.78
$\beta_{t\,max}$	%	85	4.4	9.6	7.4	0.76	10.24
β_{vmax}	%	85	7.6	15.6	10.7	1.25	11.66
W_{max}	%	85	184	315	250	29.0	11.84
Rw	mm	85	4.9	10.2	8.0	1.677	21.03
White poplar							
ρ_o	g/cm^3	146	0.293	0.493	0.393	0.047	11.93
ρ_{max}	g/cm^3	146	0.808	1.161	0.994	0.064	6.44
ρ_y	g/cm^3	146	0.260	0.433	0.345	0.039	11.22
$\beta_{l\,max}$	%	146	0.04	0.8	0.3	0.21	74.89
$\beta_{r\,max}$	%	146	2.5	8.8	4.5	1.21	27.09
$\beta_{t\,max}$	%	146	3.3	11.8	8.8	1.44	16.33
β_{vmax}	%	146	8.7	27.4	13.9	3.16	22.81
W_{max}	%	146	121	286	191	28.65	15.01
Rw	mm	146	2.2	10.1	4.2	1.56	37.07

Note: *ρ_o - density in absolutely dry condition, ρ_{max} - density at maximal moisture content, ρ_y – basic density, $\beta_{l\,max}$ - total longitudinal shrinkage, $\beta_{r\,max}$ - total radial shrinkage, $\beta_{t\,max}$ - total tangential shrinkage and $\beta_{v\,max}$ - total volumetric shrinkage, W_{max} – maximal moisture content, Rw – average ring width of sample.*

Wood quality is affected by many factors. One of them are physical properties of wood, especially wood density and dimensional stability. Average wood density in absolutely dry

condition of white poplar from Varaždin region is 27% higher than in clone 'Villafranca' from the same site (*Table 3* and *Figure 3*). Average wood density at maximal moisture content of white poplar is 9% higher than in clone 'Villafranca' (*Table 3* and *Figure 3*). Average basic density of white poplar is 25% higher than in clone 'Villafranca' (*Table 3* and *Figure 3*).

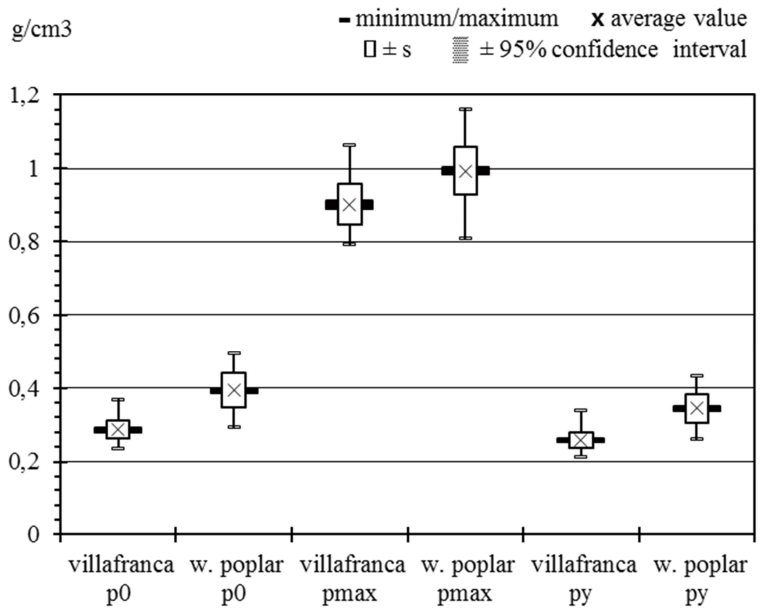
Average basic density values in 'Villafranca' is 0.26 g/cm^3. The values from our results are smaller than findings of other authors for hybrid poplars (Beaudoin *et al.,* 1992; Hernández *et al.,* 1998; Zhang *et al.*, 2003). According to them, basic wood density ranges between 0.3 and 0.4 g/cm^3. Average total shrinkages of white poplar wood are 20 to 30% higher than in clone 'Villafranca' (*Table 3* and *Figure 4*).

The average values of shrinkages in clone 'Villafranca' wood are similar to some native poplars (Peck, 1957; Jessome, 1977) and poplar clones (Koubaa *et. al.*, 1998).

All investigated properties are significantly different between white poplar wood and clone 'Villafranca' (*Table 4*).

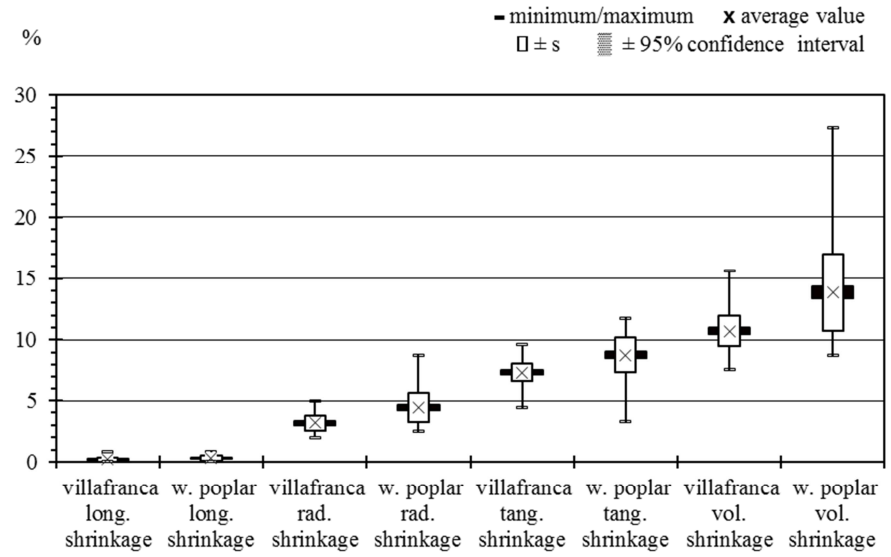
Table 4. *Mann Whitney test of difference between physical properties of Villafranca and white poplar wood*

Property	Rank Sum 1	Rank Sum 2	Z	p
ρ_o	3953.000	22843.00	-12.0595	0.00
ρ_{max}	5463.000	21333.00	-8.97671	0.000000
ρ_y	4041.000	22755.00	-11.8798	0.00
$\beta_{l\,max}$	8605.000	18191.00	-2.56215	0.010403
$\beta_{r\,max}$	5463.500	21332.50	-8.97569	0.000000
$\beta_{t\,max}$	6006.000	20790.00	-7.86815	0.000000
β_{vmax}	5776.000	21020.00	-8.33770	0.000000
W_{max}	15088.00	11708.00	10.67324	0.000000
Rw	15086.00	11710.00	10.66916	0.000000



Note: *p0 – density in absolute dry condition, pmax - density at maximal moisture content, py – basic density*

Figure 3. *Statistical analyzes of density between white poplar and clone 'Villafranca'*



Note: *long - longitudinal, rad - radial, tang - tangential, vol –-volumetric*

Figure 4. *Statistical analyzes of longitudinal, radial, tangential and volumetric shrinkage between white poplar and clone 'Villafranca'*

4. CONCLUSIONS

Clone performances generally remain constant from one environment to another. Significant differences in densities and shrinkages between white poplar and clone 'Villafranca' were occurred.

The differences between investigated properties wary from 10 to 30%. Although clone 'Villafranca' wood has lower density it has higher dimensional stability than white poplar wood.

Therefore, for better understanding of wood structure in white poplar clone 'Villafranca', mechanical properties should be investigated in the future.

Acknowledgements: The examined issues constitute a part of the project: Kratkoročna financijska potpora istraživanju 2015; Anatomska, fizikalna, mehanička i kemijska svojstva drva bijele topole (*Populus alba* L.) i klonova bijele topole uz rijeku Dravu.

This work was financed by University of Zagreb, Croatia.

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EDITION
300 copies
ISBN: 978-953-292-059-8

FOREWORD

Continuous changes on international market open up new horizons and opportunities, and the new strategies adopted by Europe and the world bring new concepts that need to be adapted and followed. This concept seeks increased social cohesion, striking with the harmful effects of climate change, nature preservation and the creation of a healthy environment. At the same time, creative potentials are open to new knowledge and innovative processes whose primary objective is to adapt to the needs of customers and the environment.

One of the activities carried out in recent years in order to preserve and stimulate rational utilization of raw material is certainly the traditional international scientific conference AMBIENTA. During its continuous sequence in the last 28 years it has become a platform for meeting and networking among scientists, teachers, researchers, students and professionals.

This year's conference, the third held under the title "*The implementation of science in the woodworking sector*" aims to ensure a multidisciplinary forum where all the participants have the opportunity to present and discuss innovations, trends and practical challenges they have faced in the world of wood science and technology, but also in relation to other materials, technologies, design and other related topics whose aim is to upgrade the wood industry.

We hope that this year's conference will contribute to awareness raising about the significance of wood as an irreplaceable natural raw material, and that the application of scientific research has a positive impact on the wood sector as well as any user of wood.

Assoc. Prof. Ivica Župčić, PhD

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