Physical Properties of Wood in Poplar Clones ‘I-214’ and ‘S1-8’

Fizikalna svojstva drva klonova topole ‘I-214’ i ’S1-8’

ABSTRACT • Physical properties play an important role in predicting the quality of wood raw material. Variation in wood density and wood shrinkage of two different poplar clones cultivated on plantation “Drnje” near Koprivnica in Croatia was measured. One of poplar clones is ‘I-214’, whose wood properties have already been studied and often compared. Other poplar clone is ‘S1-8’, whose wood properties have been poorly researched, despite its good survival and growth rate. The results indicate that wood density of clone ‘I-214’ is significantly higher in comparison to clone ‘S1-8’, but the difference, as far as practice is concerned, is negligible. In both clones, wood density increases and shrinkage decreases from pith to bark. Increased growth rate has a negative effect on wood density of researched clones.

Key words: Poplar clones, ‘I-214’, ‘S1-8’, wood density variation, wood shrinkage variation


1 INTRODUCTION

1. UVOD

Trends in forestry are towards shorter rotations and more complete utilization of trees. Global poplar resources have been rapidly increasing in the last few decades, due to increasing demand for raw material. Rotations in poplar breeding are, depending on purpose, up to 15 years (DeBell et al., 2002). In relation to their rapid growth, poplar plantations can produce large volumes of wood in a short period of time. Considering the fact that future wood supplies may become more scarce, poplar clonal plantations present great domestic breeding potential in Croatia.

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 specific wood characteristics (Zhang et al., 1997). The selected clones must meet the needs of processing industry. Ongoing cultivar evaluation criteria are mainly growth rate, coppicing ability, adaptability and disease resistance. However, little attention has been paid to the wood quality of selected poplar clones. This is why additional emphasis needs to be placed on the utilization properties of the material, such as physical properties.

In general, wood density is considered to be the most important factor affecting wood quality (Zobel and van Buijtenen, 1989). Wood density is strongly related to other wood properties, such as mechanical strength (Panshin and de Zeeuw, 1980). Poplar wood is very versatile, with low density similar to that of softwoods, but with high strength values related to their limited density (Isebrands and Richardson, 2014). Wood density also responds well to genetic improvement (Zobel and Jett, 1995), such as in poplar breeding.

Additionally, wood dimensional stability is another significant physical property, mainly for the manufacture of solid wood products. Wood shrinkage is affected by a number of variables, density being one of them. According to Tsounis (1991), greater shrinkage is generally associated with greater density. Until now, only a few studies on wood shrinkage in poplars have been carried out (Karki, 2001; Pliura et al., 2005; Kord et al., 2010).

For best utilization of wood, it is also important to know the effect of age on wood properties. Large portion of wood produced in poplar clones is in the juvenile core (Balatinecz et al., 2001). The juvenile wood properties generally change from pit outward.

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).

Significant clonal variation in wood density of poplars has been reported by many authors (Yanchuk et al., 1984; Fang and Yang, 2003; Zhang et al., 2003; Kord and Samdaliri, 2011; Huda et al., 2014). Properties of poplar wood, showing significant interclonal variation, could indicate the possibility of identifying clones with superior wood properties.

Among registered cultivars in Croatian Populus culture, two poplar clones ‘I-214’ and ‘S1-8’, have been planted on the experimental site near the Drava river and previously investigated by means of wood anatomical properties (Šefc et al., 2009). On that site, clone ‘S1-8’ showed superior growth increment and better survival compared to clone ‘I-214’ (Pfeifer, 1994). The Italian clone, ‘I-214’, is a good example of an exceptional clone adapted to a large variety of sites and growing conditions (Ahuja and Libby, 1993). From the technological point of view, density of the wood produced is low compared to most other cultivated clones (Peszlen 1994). It shows density values of 300 kg/m³ (Isebrands and Richardson, 2014). On the other hand, the results point to the intensive development of the Serbian clone, ‘S1-8’, in the juvenile phase of development (FAO 1998). Until now, physical properties of clone ‘S1-8’ have not been investigated.

The aim of this study is to determine physical properties of poplar clones ‘I-214’ and ‘S1-8’ from one site in Croatia, to investigate variations in wood density and shrinkage of the mentioned poplar clones and to investigate the relationship between the two properties.

2 MATERIAL AND METHODS
2. MATERIJAL I METODE

For the purpose of this study, three test trees of poplar clone ‘I-214’ and three of poplar clone ‘S1-8’ were selected according to the standard HRN ISO 3129:1999. Both poplar clones came from the same habitat. They were cultivated on plantation “Drnje” near Koprivnica in Croatia, located along the natural flow of the Drava River. The site is characterized by a continental climate and the soil is alluvial soil, more gravely and sandy. Both clones were planted in deep planting technique and with the density of 3.5 × 3.5 m.

Relevant parameters were collected and measured on the growth location of all test trees, such as: ground plan projection canopy, trees orientation toward the cardinal points, diameter at breast height, total tree height, height up to the first living branches and stump height (Table 1).

After cutting down, a test trunk, having the length of approximately 80 cm, was sawn from each test tree. Test trunk length started at breast height (1.3 m), downwards to root collar. Afterwards, these 80 cm long trunks were sawn into bark to bark cores of approximately 6 cm in thickness (Figure 1). Cores were then submitted to natural drying on dry and drafted stock. The samples were sawn in the radial direction from heart to bark and

<table>
<thead>
<tr>
<th>Clone</th>
<th>Tree mark</th>
<th>Site</th>
<th>Total tree height</th>
<th>Trunk height</th>
<th>Height up to first living branch</th>
<th>Diameter at breast height</th>
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<td>Ukupna visina stabla</td>
<td>Visina trapćica</td>
<td>Visina do prve žive grane</td>
<td>Promjer na prsnoj visini</td>
</tr>
<tr>
<td>‘I-214’</td>
<td>18</td>
<td>Drnje (KP)</td>
<td>32.5</td>
<td>21</td>
<td>11.7</td>
<td>31</td>
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<tr>
<td>‘I-214’</td>
<td>20</td>
<td>Drnje (KP)</td>
<td>30</td>
<td>18</td>
<td>10</td>
<td>31</td>
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<tr>
<td>‘I-214’</td>
<td>21</td>
<td>Drnje (KP)</td>
<td>35</td>
<td>19</td>
<td>6.4</td>
<td>25</td>
</tr>
<tr>
<td>‘S 1-8’</td>
<td>28</td>
<td>Drnje (KP)</td>
<td>37.5</td>
<td>17</td>
<td>8</td>
<td>34</td>
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<tr>
<td>‘S 1-8’</td>
<td>29</td>
<td>Drnje (KP)</td>
<td>29.7</td>
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<td>33</td>
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<tr>
<td>‘S 1-8’</td>
<td>32</td>
<td>Drnje (KP)</td>
<td>33.3</td>
<td>23</td>
<td>6</td>
<td>26</td>
</tr>
</tbody>
</table>
3. REZULTATI I DISKUSIJA

Slika 1. Srednjača (sjever – jug) i uzorci dimenzija 20 × 20 × 25 mm iz srednja če, maksimalnoga radijalnog, tangencijalnog i volumognog utezanja klona topole 'I-214' i klona topole 'S 1-8'.

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

Table 2 Statistical values of density in absolutely dry condition, nominal density, maximum radial, tangential and volume shrinkage of poplar clone 'I-214' and poplar clone 'S 1-8'.

<table>
<thead>
<tr>
<th>Poplar (Clone 'I-214')</th>
<th>Poplar (Clone 'S 1-8')</th>
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</thead>
<tbody>
<tr>
<td><strong>Topola (klon 'I-214')</strong></td>
<td><strong>Topola (klon 'S 1-8')</strong></td>
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<td>( \rho_y ) g/cm(^3)</td>
<td>( \rho_y ) g/cm(^3)</td>
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<td>0.360</td>
<td>0.311</td>
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<td>0.388</td>
<td>0.336</td>
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<td>0.449</td>
<td>0.392</td>
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<td>0.022</td>
<td>0.022</td>
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<tr>
<td>5.77</td>
<td>6.38</td>
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</tbody>
</table>

Key/Legenda: \( \rho_y \) – density in absolutely dry condition / gustoća u apsolutno suhom stanju, \( \rho_{\text{nom}} \) – nominal density / nominalna gustoća, \( \beta_{r_{\max}} \) – total radial shrinkage / totalno radijalno utezanje, \( \beta_{t_{\max}} \) – total tangential shrinkage / totalno tangencijalno utezanje, \( \beta_{v_{\max}} \) – total volumetric shrinkage / totalno volumno utezanje, N – number of specimen / broj uzoraka, MIN – minimum value / minimalna vrijednost, MAX – maximum value / maksimalna vrijednost, STDEV – standard deviation / standardna devijacija, CVAR – coefficient of variation / koeficijent varijacije (%)

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 is 388 kg/m\(^3\) (Table 2). The value is somewhat higher than findings of other authors for the same clone (Peszlen, 1998; Balatinecz et al., 2014). Average wood density in absolutely dry condition of clone 'S 1-8' is 372 kg/m\(^3\) (Table 2).

Statistical analysis showed the difference in average wood density between the two clones (Table 2). However, the difference in wood density between clones is only about 4 %, and for the purpose of wood processing and forestry practice this could be negligible.

The advantage of 'S 1-8' is its better survival, better diameter growth rate and thicker bark compared to clone 'I-214' (Šefc et al., 2009). Considering their low wood density, poplars have relatively high shrinkage values. According to some authors, this is mainly due to their chemical composition, e.g. relatively high polysaccharide content (Balatinecz et al., 2014). Average shrinkage values between the two investigated clones are insignificant (Table 3). This is in accordance with Koubaa et al. (1998a), who reported that shrinkage values are in the same range for fast-growing hybrid poplars.

There are opposite findings about radial distribution of wood density for poplars. Einspahr et al. (1972) report that in Populus tremuloides wood, density was high near the pith, lower from three to five rings, and then increased towards the bark. Similar result was reported by Yanchuk et al. (1983). Scaramuzza (1958) found uniform wood density from pith to bark in Populus euramericana clones.

In this research, wood density in absolutely dry condition increased from pith to bark in both investigated clones (Figure 2). This is in accordance with the findings of Boyce and Kaiser (1961), Curró (1960),
Farmer and Wilcox (1968) and DeBell et al. (2002). Kord (2010) also reported an increasing trend in wood density, longitudinal, radial, tangential, and volumetric shrinkage, from the pith to bark in Populus euramericana trees. This can be explained by the fact that juvenile wood is known to be of lower density than mature wood (Dadswell, 1958; Zobel and Buijtenen, 1989). Similar patterns of wood density variation in the axial direction have also been reported in hybrids involving P. alba, P. grandidentata, and P. tremuloides (Johnson, 1942), in P. trichocarpa (Okkonen et al., 1972), and in P. tremuloides (Yanchuk et al., 1984).

There are conflicting findings on the correlation between wood density and ring width in poplars. Kennedy and Smith (1995) reported that there is an increase in wood density with faster growth. Density of wood is not related to ring width according to Göhre (1960). Mutibarić (1967) wrote about a slight negative correlation between ring width and wood density in Euramerican poplar hybrids in Yugoslavia.

In this research, negative correlation between wood density in absolutely dry condition and ring width was found in both investigated clones (Figure 3). Dense wood results from fiber with thick walls and a low microfibril angle, which produces minimal longitudinal shrinkage, and increases radial and tangential shrinkage (Dadswell, 1958). Changes in wood shrinkage with cambium age are likely related to radial inter-tree variation in wood density, which often displays an inverse pattern of changes (Johnson, 1942; Okkonen et al., 1972; Yanchuk et al., 1984; Kord, 2010).

Pliura et al. (2005) found a positive correlation between wood density and both radial and tangential shrinkage. According to Koubaa and Smith (1959), there is a

![Figure 2](image-url)
The ratio between wood density in absolutely dry condition and ring width of clone 'I-214' and 'S1-8'.

Radial distribution of total radial shrinkage of wood in clone 'I-214' and 'S1-8'.

The ratio between total radial shrinkage of wood and wood density in absolutely dry condition of clone 'I-214' and 'S1-8'.

**Figure 3** The ratio between wood density in absolutely dry condition and ring width of clone 'I-214' and 'S1-8'.

**Slika 3** Odnos gustoće apsolutno suhog drva i širine goda drva klonova 'I-214' i 'S1-8'.

**Figure 4** Radial distribution of total radial shrinkage of wood in clone 'I-214' and 'S1-8'.

**Slika 4** Radijalna raspodjela totalnoga radijalnog utezanja drva klonova 'I-214' i 'S1-8'.

**Figure 5** The ratio between total radial shrinkage of wood and wood density in absolutely dry condition of clone 'I-214' and 'S1-8'.

**Slika 5** Odnos totalnoga radijalnog utezanja drva i gustoće u apsolutno suhom drvu klonova 'I-214' i 'S1-8'.
There is a significant difference in wood density in absolutely dry condition and nominal density between poplar clones ‘I-214’ and ‘S1-8’ from Osijek. However, the difference in wood density between clones is only about 4 %, and for the purpose of wood processing and forestry practice this could be negligible. Total radial, tangential, and volumetric shrinkage showed no significant difference.

There was a general trend in the radial direction in both clones, in which wood density in absolutely dry condition increased from the pith to bark. On the contrary, total radial, tangential, and volumetric shrinkage
showed a general decreasing trend in the radial direction from the pith to bark in both clones.

In general, there was a negative correlation between wood density in absolutely dry condition, and total radial, tangential, and volumetric shrinkage; although, tangential shrinkage was weakly correlated with wood density.

Forestry practice tends to provide high annual growth rate of clones and uniformity in wood density of material. The results of this research suggest the opposite. For better prediction of wood quality of these two clones, further investigation on mechanical properties should be carried out.

5 REFERENCES
5. LITERATURA

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