GROWTH ELEMENTS OF ITALIAN ALDER (ALNUS CORDATA /LOISEL./ DESF.) TREES - POTENTIALLY APPLICABLE SPECIES IN SERBIA

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Abstract: The paper presents the growth elements of foreign trees species Alnus cordata (Loisel) Desf., (Italian alder), (Betulaceae /Loisel./ Duby) in experimental plantation in the area of Erdevik, where the presence of this species in allochthonous dendroflora of Serbia was first recorded. Based on the measurement of diameter and height of 40 trees at the end of 2014, in the age of 11 years, mean height of trees was 13.2 m and dominant was 14.6 m, mean diameter at breast height was 24.8 cm, and dominant 32.1 cm, mean tree volume was 0.54 m$^3$, and dominant 0.81 m$^3$. The mean height increment of a medium tree was 0.95 m$\cdot$year$^{-1}$, and dominant 1.47$\cdot$year$^{-1}$. Height and diameter structure of the trees in the plantation is unimodal. Height structure has a strong positive asymmetry, with asymmetry coefficient 0.41, while the diameter structure has less expressed positive asymmetry. Both structures have platykurtic flatness. Variability of height structure is 13.6% and almost twice lower than the variability of diameter structure (22.3%). The degree of slenderness is 38-74, with an average of 54, and is characteristic for planting with no expressed competition among trees for living space. According to the growth elements of trees in the studied plantation at the age of 2+9 years Italian alder has the characteristics of rapid growth and could represent potentially applicable species in the Serbian area: as fast-growing species in forest plantations for biomass production.

Key words: Alnus cordata, growth elements, allochthonous tree species, introduction, Serbia.

INTRODUCTION

The distribution of Italian alder (Alnus cordata /Loisel./ Desf.) is limited. It occurs primarily in Italy, in southern Apenines (provinces Basilicata, Calabria and Campania), and it can be found in mountains of northeastern Corsica in France also. It grows at altitudes 200-1600 m (Ducci and Tani 2009). It is cultivated in forest plantations in Italy and France (Mitchell 1979).
*Alnus cordata* (Loisel.) Desf. is a deciduous tree of medium height, it attains 17-25 m, and up to 28 m under favourable conditions. Italian alder is a fast growing species, it can reach 15 m in 20 years (Mitchell 1979, Shaw et al. 2014). It is less related to wet sites than majority of other species in genus *Alnus* Mill. (*Betulaceae* (Loisel.) Duby), and it grows successfully on limestone (Russel et al. 2007, Shaw et al. 2014). In native stands, wet soils, rich in humus are prefered, but it adapts itself to various soils, and it can be found in dry forests in lowlands or mountains also. Italian alder is a pioneer species and rapidly colonizes forest clearings, formed after cutting of beech and sweet chestnut stands, as well as burned areas, and it forms pure stands in such conditions (Ducci and Tani 2009). It is frosthardy, and it can withstand sea salt in air (Botanica 2004, Shaw et al. 2014).

Its significance reflects in improving soil fertility through symbiotic activity with nitrogen-fixing bacterium *Actinomyces alni* (*Frankia alni*), which is located on roots, and through produced leaf litter, which improves soil humus (Benson et al. 2004). The wood quality is similar to that of hybrid poplars, but the Italian alder wood is heavier, it shrinks to a higher degree, but is more resistant to bending. Wood is not durable in atmospheric conditions, but is durable if it is submerged in water and in that case it is not susceptible to rot. It was used for the foundations of houses and bridges in Venice. Wood is used in carpentry, carving, turnery, as well as furniture production, panneling and plywood production, and as a firewood also (Ducci and Tani 2009, Shaw et al. 2014). In central Italy, Italian alder is massively used for afforestation of poorly drained and wet soils, in agroforestry, and for soil erosion protection in highland areas. It is widely applied recently for protection of plantations of walnut (*Juglans regia* L.), sweet cherry (*Prunus avium* L.), as well as other noble hardwoods (Shaw et al. 2014). It is used also as an ornamental species, since it is one of the most decorative alder species. It differs markedly from other *Alnus* L. species in crown, bark and leaves appearance, as well as by its massive flowers and fruits (Mitchell 1979, Krüssmann 1984).

**MATERIAL AND METHOD**

**Research object**

Research was conducted in experimental Italian alder (*Alnus cordata* /Loisel/ Desf.) plot, in Erdevik area, on „Banja“ locality (National park „Fruška Gora“). The plot is established with two years old seedlings (2+0) at the end of the year 2005. This plantation represents the first record of this species in allochtonous dendroflora of Serbia (Bobinac et al. 2015).

Seedlings were produced from seed and donated by nurseryman-collector Đura Jorgić, forestry engineer. Seed originated from one tree in arboretum „Ličine“ in Voćin (Croatia), (Vidaković et al. 1986). Planted seedlings were 1.5-2.0 m high and had high survival rate in the first year. Seedling were planted in line, spaced partially in one, and partially in two rows, with 7 m distance between individuals.

Plot was established in wide valley at the elevation 125 m a.s.l., on the site of grey willow pioneer shrubby plant community (Alliance: *Salicion cinerea* Th. Müller and Görs 1958.). The whole area is characterized by temperate continental climate. According to
the data of the nearest meteorological station in Sremska Mitrovica, for the period 1981-2010, the mean annual air temperature was 11.3°C, mean temperature in January 0.1°C and the lowest recorded temperature was -29.5°C, which is recorded in January 1987. Mean annual precipitation is 614.2 mm, and 60% of that quantity falls in vegetation season. Vegetation season is characterized by low number of frosty days, and during years 2004-2014 the lowest recorded temperatures were in the span -5.6°C to -26.5°C.

Research method

At the end end of year 2014, when seedlings aged 11 years, the girth of 40 trees was measured at breast height, with accuracy 1 mm, as well as total tree height by Vertex III height measurer, with accuracy 0.1 m. Italian alder sample comprised dominant trees, with solitary growth until plantation was eight years old, when crowns began to interlock.

For every measured (diameter and height) and derived (slimness coefficient and volume) growth elements, basic statistical parameters were calculated: arithmetic mean (\( \bar{x} \)), standard deviation (\( s_x \)), variation coefficient (\( c_v\% \)), minimal (\( \min \)) and maximal (\( \max \)) size, variation height (\( \bar{v}\bar{h} \)), asymmetry coefficient (\( \alpha_3 \)) and flatness coefficient (\( \alpha_4 \)).

Based on stem measurement elements, the average diameter calculated by basal area (\( d_g \)), average diameter of 20% thickest trees (dominant diameter) (\( D_g \)), average height by Lorey (\( h_L \)) and average height of 20% thickest trees (dominant height) (\( H_g \)) were calculated. Tree volume was calculated on the basis of volume tables for black alder (\( Alnus glutinosa \) (L.)Gaertn.) (Mirković 1975). Measured diameters and heights were used for the construction of height curve (model: \( h=a\cdot e^{-b/dbh} + 1.3 \)).

RESULTS AND DISCUSSION

In Italian alder line planting, when trees were 11 years old, the dominant height (\( H_g \)) was 14.7 m and it was higher than average height by Lorey (\( h_L \)) for 1.5 m or 11.4%. Dominant diameter (\( D_g \)) was 32.1 cm and it was higher than average diameter (\( d_g \)) for 7.3 cm or 29.4%. Dominant tree volume (\( V_{Dg} \)) was 0.81 m\(^3\) and it was higher than medium tree volume (\( V_{dg} \)) for 0.27 m\(^3\) or 50.0% (Table 1).

<table>
<thead>
<tr>
<th>Species</th>
<th>OP</th>
<th>Age</th>
<th>N</th>
<th>( H_g )</th>
<th>( h_L )</th>
<th>( D_g )</th>
<th>( d_g )</th>
<th>( V_{Dg} )</th>
<th>( V_{dg} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italian alder</td>
<td>1</td>
<td>11</td>
<td>40</td>
<td>14.7</td>
<td>13.2</td>
<td>32.1</td>
<td>24.8</td>
<td>0.81</td>
<td>0.54</td>
</tr>
</tbody>
</table>

Height and diameter structure is unimodal (Table 2, Figure 1). Height structure possesses poorly defined positive asymmetry, with asymmetry coefficient 0.414, while diameter structure shows poorly defined positive asymmetry, with asymmetry coefficient 0.119. Both structures have platykurtic flatness. Variability of height structure is two times lower than that of diameter structure, which is a characteristic of fast growing tree species plantations (Andrašev 2008).
Table 2. Height and diameter tree structure.

<table>
<thead>
<tr>
<th>Growth element</th>
<th>trees</th>
<th>$\overline{X}$</th>
<th>$s_d$</th>
<th>$c_v$</th>
<th>min</th>
<th>max</th>
<th>$\bar{v}$</th>
<th>$\alpha_3$</th>
<th>$\alpha_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height – h [m]</td>
<td>40</td>
<td>12,7</td>
<td>1,73</td>
<td>13,6</td>
<td>10,4</td>
<td>16,2</td>
<td>5,8</td>
<td>0,414</td>
<td>2,052</td>
</tr>
<tr>
<td>Diameter – $d_{1,3}$ [cm]</td>
<td>40</td>
<td>24,3</td>
<td>5,40</td>
<td>22,3</td>
<td>14,6</td>
<td>34,9</td>
<td>20,2</td>
<td>0,119</td>
<td>2,128</td>
</tr>
</tbody>
</table>

Figure 1. Diameter (left) and height (right) tree structures in plantation.

Trees in line plantation have monopodial growth and intensive ramification, which already starts at the height around 2 m. With 7 m planting distance, the crowns started to interlock in the age of eight years (Picture 1).

Tree slimness coefficient is 38-74, average value is 54. It has positive asymmetry which points out that trees with slimness coefficient below average dominate (Table 3).
Height curve, as a dependence of tree heights from their diameters at the breast height, is modeled by Mihailov function. It can be noticed poorly pronounced twist in height curve, which is a consequence of tree age and poorly pronounced competition for growth space. Parameters of evaluation of height curve models show high level of concordance with the empirical data (Table 4, Figure 2).

Table 4. The model parameters of height curves and their evaluation.

<table>
<thead>
<tr>
<th>OP</th>
<th>Model: ( h = a \cdot e^{b/d} + 1.3 )</th>
<th>( s_e )</th>
<th>( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>OP-1</td>
<td>( a = 18,0314 )</td>
<td>10,8472</td>
<td>1,178</td>
</tr>
</tbody>
</table>

Legend: \( h \) - height, \( dbh \) – diameter at breast height, \( a, b, c \) – model parameters

Figure 2. Height curve with empirically measured tree heights for corresponding diameters at the breast height.

Volume structure has pronounced positive asymmetry with asymmetry coefficient 0.397 and platycurtic flatness. The volume of medium tree is 0.527 \( m^3 \)-tree, and variability of tree volume structure is 35.8% (Table 5).

Table 5. Numerical indicators of diameter distribution.

<table>
<thead>
<tr>
<th>( n )</th>
<th>( v_s ) ([m^3 \cdot tree^{-1}])</th>
<th>( s_d ) ([m^3 \cdot tree^{-1}])</th>
<th>( c_v ) ([%])</th>
<th>( v_{min} ) ([m^3 \cdot tree^{-1}])</th>
<th>( v_{max} ) ([m^3 \cdot tree^{-1}])</th>
<th>( v_$ ) ([m^3 \cdot tree^{-1}])</th>
<th>( \alpha_3 )</th>
<th>( \alpha_4 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>[tree]</td>
<td>40</td>
<td>0,527</td>
<td>0,189</td>
<td>35,8</td>
<td>0,230</td>
<td>0,945</td>
<td>0,715</td>
<td>0,397</td>
</tr>
</tbody>
</table>

CONCLUSIONS

The growth elements of foreign tree species *Alnus cordata* (Loisel) Desf., (Italian alder), (*Betulaceae* /Loisel./ Duby) were researched in experimental plot in Erdevik area, locality where this species was first recorded in allochtonous dendroflora of Serbia.

On the basis of the measurement of 40 trees at the end of year 2014, aged 11 years, average tree height was 13.2 m, and dominant tree height 14.6 m, average
diameter at the breast height measured 24.8 cm, and dominant diameter was 32.1 cm, volume of central tree was 0.54 m$^3$, and volume of dominant tree 081 m$^3$. Mean age height increment of medium tree was 0.95 m, and by dominant tree it was 1.47 m. Slimness coefficient was 38-74, average value was 54.

According to the growth elements in researched experimental plot, it can be concluded that Italian alder is characterised by fast growth and has potential to be grown in Serbia: as an ornamental species in urban areas and as a fast growing species in forestry plantations.

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REFERENCES