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STRUCTURAL CHARACTERISTICS OF SILVER LIME AND BLACK LOCUST PLANTATIONS IN DELIBLATO SANDS AREA (SERBIA)

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ABSTRACT

The choice of tree species for afforestation of Deliblato Sands, which was declared as the Special Nature Reserve in Serbia, is a complex issue today. In established plantations on Deliblato Sands, the dominate tree species today on more than 90% of the area are: black locust (*Robinia pseudoacacia* L.) 65% and Austrian and Scots pine (*Pinus nigra* Arn. and *Pinus sylvestris* L.) 27%.

Black locust and pine species are susceptible to fires, and because of short rotation and application of clear-cutting in black locust plantations, maintaining their presence is not in accordance with the modern conservation objectives of Deliblato Sands. It is necessary to pay more attention to the selection of species for afforestation, which are edificators of habitat and can maintain ecosystem stability over a longer period.

Key words: Deliblato Sands, black locust (*Robinia pseudoacacia* L.), silver lime (*Tilia argentea* Desf.), growth elements, afforestation.

INTRODUCTION

Since the beginning of organized work on afforestation of Deliblato Sands (Serbia), from 1818 until today, different stages in the selection of tree species, which are primarily used for afforestation, were present. The selection of species decided different possibilities of arid habitats, historical circumstances, professional attitudes and tendencies in the choice of tree species for afforestation under similar conditions as in the European region. In the period of about 150 years, the afforestation were carried out with the aim of stopping the wind erosion and transformation of Deliblato Sands in the fertile soil and were carried out mostly with poplars and black locust and less with pines (Španović, 1936). After the establishment of the commercial function in the newly afforested forests, and especially since the mid-twentieth century, the afforestation was mainly with pine trees (Popov, 1994). Today, forest vegetation occupies 61.7% (17,552 ha) of total area of the MU „Deliblato Sands“, and within this area the culture of black locust (*Robinia pseudoacacia* L.) are represented on the area of 11,320 ha (64.49%), stands of Austrian and Scots pine (*Pinus nigra* Arn. and *Pinus sylvestris* L.) and other

coniferous trees on the area of 4,748 ha (27.05%), while other species occupying an area of 1,483 ha (8.45%) of forest area. Stands of silver lime in the area of Deliblato Sands are represented on 376 ha (Letić and Malešević, 2005).

The structure of forest areas in the Deliblato Sands indicate that, after reaching the main goal to stop wind erosion, determination of planned forest management have largely not focused on the formation of stands with more or less natural species composition and thus are not significantly more supported the process of progressive succession as a logical continuity after fixing soil formations and microclimate by pioneer species (Bobinac, 2005).

This has had significant negative consequences in the history of contemporary Deliblato Sands, because in the period from 1948 to 2009, it was found 259 fires, with a total areas affected by fire of 11,923 ha, and forest area affected by fires of 6,129 hectares (Milenkovic, 2010).

In order to achieve protective but also productive role of forest ecosystems in the Deliblato Sands, which was declared as a Special Nature Reserve in Serbia, the choice of tree species that can meet these basic objectives and also ensure the longevity of stands and their natural continuity, today is an important issue. This paper presents a comparison of the growth elements and structure of white lime and black locust cultures as the most common deciduous species, similar age and silvicultural treatments in the area of Deliblato Sands.

OBJECT OF RESEARCH AND WORK METHOD

In the area of Deliblato Sands, on downy oak (*Quercetum Rhamneto virgiliana*) site, the elements of growth and structure were compared in cultures of silver lime and black locust which are established with seedlings, planting 3×1 m, or 3333 trees per hectare (Bobinac, 2005; Andrašev et al., 2014). Culture of white lime was founded on soil type sierozem, on loosely carbonate eolian sand and at the measurement of trees was 44 years old (OP-1), and the black locust culture was established on chernozem soil type, subtype on carbonate eolian sand and at the measurement of trees was 39 years old (EP-2), (2008).

Experimental plots were established in part of stands with the complete canopy and have a size of 30×15 m (EP-1) and 30×50 m (EP-2). On the experimental plots, on all living trees, the two perpendicular diameters at breast height were measured, with an accuracy of 1 mm and measurement of the height were made with an accuracy of 0.1 m. Based on the three-degree classification on each tree was estimated crown class (CC) and stem quality (SQ), and in trees with CC-1 degree of isolation of the crown (IC) was estimated (Assmann, 1970).

The volume of trees on experimental plots is determined based on volume tables of total volume up to 3 cm for silver lime (Banković et al., 1989), and black locust (Rede et al., 2012). Assessment of site classes for black locust was based on the comparison of mean height by Lorey (h_L) with growth models of mean height by Redei et al. (2014), for tended (modelled) stands of black locust in Hungary. Diameters and height structures of trees are defined based on statistical indicators: mean (\bar{x}), standard

deviation (s_x), the coefficient of variation ($c_v\%$), minimum (min) and maximum (max), variation width (vw), the skewness (α_3) and kurtosis (α_4).

RESULTS

Top height of 20% of the thickest trees in the culture of silver lime (EP-1), in the age of 44 years, was 18.6 m, and in the culture of black locust (EP-2), at the age of 39 years, was 19.0 m, and the mean heights by Lorey in the cultures were close and amounts 17.2 to 17.4 m. Mean diameters of 20% of the thickest trees had a similar size and amounts 26.5 to 26.6 cm, and the mean quadratic diameter in the culture of silver lime was 18.7 cm and 17.2 cm in culture of black locust. In the culture of silver lime was found 1534 trees per hectare, basal area 41.94 $m^2 \cdot ha^{-1}$ and volume 397.28 $m^3 \cdot ha^{-1}$, and in the culture of black locust was found 1,600 trees per hectare, basal area 37.24 $m^2 \cdot ha^{-1}$ and volume 322,89 $m^3 \cdot ha^{-1}$. Based on the mean Lorey's height (h_L) black locust stands belongs to IV site class, by Redei et al., 2014) (Table 1).

Table 1. Growth elements of trees and stands on experimental plots

Species	EP	Age	H_g	h_L	D_g	d_g	N	G	V	Iv_p	Site class				
		[year]	[m]	[m]	[cm]	[cm]	[trees·ha ⁻¹]	[m ² ·ha ⁻¹]	[m ³ ·ha ⁻¹]	[m ² ·ha ⁻¹ ·year ⁻¹]	1	2	3	4	5
Silver lime	1	44	18,6	17,4	26,5	18,7	1534	41,94	397,28	9,03					
Black locust	2	39	19,0	17,2	26,6	17,2	1600	37,24	322,89	8,28				*	

The distribution of height in the culture of lime has a pronounced left asymmetry and mesokurtic flatness, and in culture of black locust left asymmetry and platykurtic flatness are less pronounced. In the culture of black locust a higher variability of height (49.5%) was found, in relation to culture of lime (21.0%) (Table 2). The cumulative curve of height structure indicate that 1/3 of trees in culture of black locust have height less than 8 m, and in the culture of lime below 15 m, that indicates a bimodal height structure in the culture of black locust, that is, in a culture of black locust substantial number trees have slow height growth (Figure 1, left).

Table 2. Numerical indicators of height structure on experimental plots

Species	n	h_a	s_d	c_v	h_{min}	h_{max}	vw	α_3	α_4
	[trees]	[m]	[m]	[%]	[m]	[m]	[m]		
Silver lime	230	15,74	3,31	21,0	6,00	19,80	13,80	-0,991	2,962
Black locust	72	12,70	6,29	49,5	2,07	21,58	19,51	-0,389	1,664

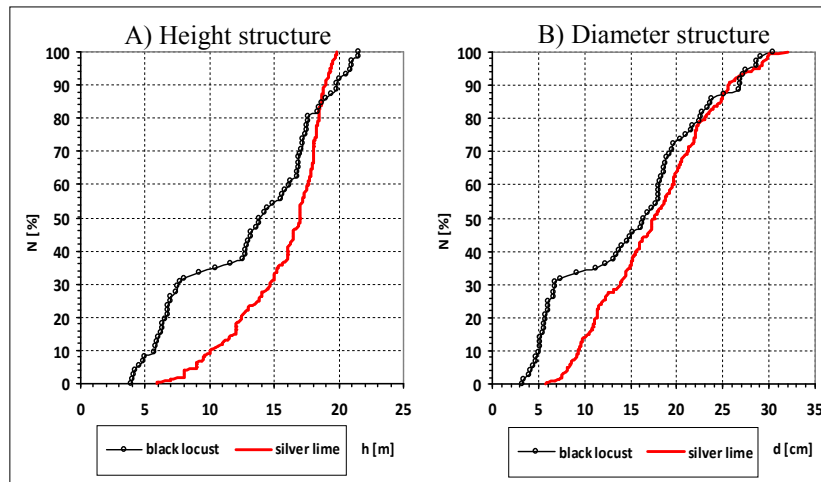


Figure 1. Cumulative curves of height (left) and diameter (right) structure

Diameter structure, both lime and black locust has a poorly expressed positive asymmetry and platykurtic flatness. High variability of diameters at breast height in culture of black locust (52.3%) and expressed platykurtic flatness of diameter distribution, as well as the participation of 1/3 of trees with breast height diameter below 8 cm, indicating the bimodal diameter structure (Table 3, Figure 1, right).

In the summary distribution of height and diameters about 85% of lime trees has a greater height and breast height diameters than black locust, and about 15% of the highest and the thickest lime trees have less height and similar breast height diameters in relation to the black locust.

Table 3. The numerical indicators of diameter distributions of the experimental plots

Species	n	d_a	s_d	c_v	d_{min}	d_{max}	vw	α_3	α_4
	[trees]	[cm]	[cm]	[%]	[cm]	[cm]	[cm]		
Silver lime	230	17,6	6,13	34,8	5,9	32,1	26,2	0,150	2,147
Black locust	72	15,3	8,00	52,3	3,4	30,4	27,0	0,044	1,798

In the culture of black locust, tree differentiation by crown classes is more pronounced in the relation to the culture of lime. The largest number of trees in the researched cultures has a dominant position (1st crown class), 940 trees per hectare (61.3%) in the culture of lime and 667 trees per hectare (41.7%) in the culture of black locust. These are the trees that are in the diameter degrees of 12.5 cm to 32.5 cm. (Figure 2).

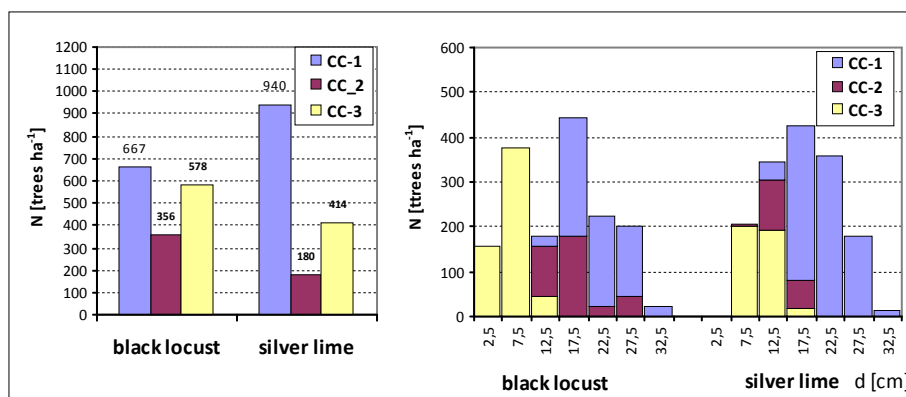


Figure 2. Number of trees per hectare of different crown classes (left) and their distribution through the diameters (right) in the experimental stands

In the culture of silver lime there are 233 trees per hectare with first degree of stem quality, which is 15.2% of the total number of trees, and in the culture of black locust, there are only 67 such trees per hectare, or 4.2% of the total. In black locust culture, trees of the first degree of stem quality are present in medium in of black locust and stronger diameter degrees (17.5 to 27.5 cm), and in silver lime culture, trees of the first quality of stem are present in all diameter degrees (7.5 to 27.5 cm). A large number of trees, 694 tree per hectare or 45.2% of the total number of trees in the culture of lime and 533 per hectare or 33.3% in the culture of of black locust, have a second quality of stem. In the culture of black locust largest number of trees, 1,000 trees per hectare or 62.8% of the total number of trees have poor trunk, and in silver lime culture number of trees with low quality of stem is 607 or 39.6% of the total number of trees (Figure 3).

In the studied cultures, within the trees of the 1st crown class (CC-1), the relative participation of trees with different degree of isolation of the crown (IC) is equal. Trees with a free-standing crown (IC-1) is represented with around 26%, trees with unilaterally reduced crown (IC-2) is represented with around 64%, and the trees with multilateral reduced crown (IC -3), is represented with around 10%. In lime culture trees with IC-1 has 240, and in black locust culture 178 per hectare. In the culture of silver lime trees of IC-1 are represented in diameter degrees from 17.5 to 32.5 cm, and in the culture of black locust in diameter degrees from 17.5 to 27.5 cm. The largest number of trees of the 1st crown class has unilaterally reduced crown class (IC -2), in the lime culture 600 per hectare and in black locust culture 422 per hectare. In the studied stands trees of IC -2 are present in a wide range of breast height diameter (12.5 to 32.5 cm) (Figure 4).

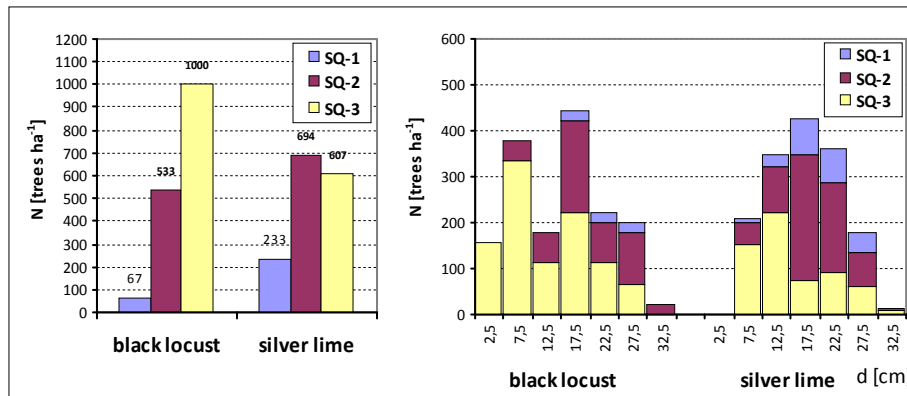


Figure 3. Number of trees per hectare with varying degrees of stem quality (left) and their distribution through the diameters (right) on the experimental plots

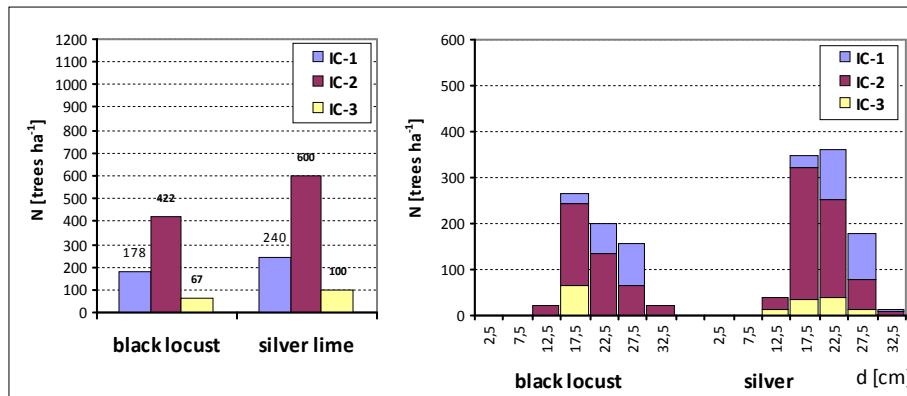


Figure 4. Number of trees of 1st crown class per hectare with different degrees of isolation of the crown (left) and their distribution through the diameter (right) on the experimental plots

CONCLUSION

Based on a comparison of growth elements and structures in cultures of silver lime and black locust in the Deliblato Sands, which are established in the same habitat, with planting 3×1 m, or with 3333 plants per hectare, and which were similar age and silvicultural treatments, may be the following conclusions:

- Cultures are characterized by a large number of trees per hectare, 1534-1600 trees·ha⁻¹ and similar growth potential: with basal area of 37.2 to 41.9 m²·ha⁻¹, volume 322.9 to 397.3 m³·ha⁻¹ and average growth from 8.3 to 9.0 m²·ha⁻¹·year⁻¹;
- In the cultures were determined close amount of growth element and similar diameter and height structure. Mean height by Lorey was 17.2 to 17.4 m, the dominant height from 18.5 to 18.9 m, and the dominant diameter from 26.5 to

26.6 cm. Based on the mean height (h_L) stand of black locust belongs to IV site class, by Rede et al., (2014);

- In the cultures, a different participation of tree qualitative class is determined. Stands of the first stem quality had participation of 15.2% (233 trees per hectare) in the culture of lime and 4.2% (67 trees per hectare) in black locust culture;
- Within trees of the first crown class in both cultures is equally relative participation of trees with different degrees of isolation of the crown. Trees with a free-standing crown (IC-1) are represented by 26% (from 178 to 240 per hectare), a tree with a unilaterally reduced crown (IC-2) are represented with 64% (from 422 to 600 per hectare), and tree with multilateral reduced crown (IC-3), is represented with 10% (67-100 per hectare);
- With the same treatment in the studied cultures, greater participation of silver lime trees which belong to the first stem quality, defines management objectives towards the production of high-quality assortment in considerably longer rotation than black locust, and, therefore, emphasizes the importance of biomeliorative and production of silver lime in relation to the locust.

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