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DIAMETER GROWTH AND INCREMENT OF ARTIFICIALLY ESTABLISHED BLACK LOCUST IN S. N. R. DELIBLATO SANDS

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ABSTRACT

The paper presents the results of studying diameter growth and increment of artificially established black locust in the Special Natural Reserve `Deliblato Sands`. To reconstruct the diameter growth and increment, 30 dominant trees from the stands on *Rhamneto – Quercetum virgilianae* forest type (better and poorer site classes) were felled. At the age of 25, black locust reached the diameter of 20 cm (better site classes) and 16.5 (poorer site classes) in this area. The lines of growth and current and average diameter increment show that black locust is a species with intensive growth in youth, early growth peak and intensive subsequent increment decline.

Key words: Deliblato sands, black locust, diameter growth and increment

INTRODUCTION

One important aspect of forest management and forestry in general is to achieve maximal production of high quality wood. Under such a management system, a range of management measures have to be in compliance with the biological patterns of tree growth as well as with the aim of achieving primary production of commercial timber. Apart from its commercial importance, the growth of forest trees is of tremendous ecological significance. Biometric description of the course of growth (growth models) is a reliable parameter for assessing the ability of different woody species to withstand the impact of various factors (climate changes and extremes, air pollution, changes in the level of groundwater, changes in certain site conditions etc). Early detection of possible devitalization is extremely important from the aspect of discovering its causes and taking control measures to minimize the damage of both commercial and ecological character (Vučković, Stajić 2001). In this context, observing the responses of individual tree species to the changes of the main environmental conditions is the most important task in the process of forest preservation and enhancement because when we talk about some phenomena, we should have proven quantitative indicators to support our assumptions (Vučković, *et al.* 2005).

In the light of the above stated problems of forest management and with the aim of their minimizing or solving, the economic and ecological importance of investigating the tree diameter growth is particularly emphasized. An area of great national importance, whose successful governing and managing requires a range of high quality information about diameter growth of different tree species, is the Special Natural Reserve "Deliblato sands". According to Medarević, *et al.,* (2005) the greatest area of Deliblato sands is covered by black locust forests (35.9% of the total volume and 45.5% of the total volume increment). The greatest part of the black locust forests belong to the protected forests of category III, which have not only the ecological, but also the production function, which makes them suitable for economic use.

MATERIAL AND METHODS

The study was carried out in the region of "high sand" (at the altitude above 150 m) of The Deliblato Sands in the Management unit "The Deliblato sands". This management unit extends between $44^0 48'$ and $45^0 01'$ of north latitude and between $20^0 56'$ and $21^0 19'$ of east longitude. January is the coldest month of the year (-1,4˚C) and July is the hottest (+21,8˚C). The pluviometric regime of The Deliblato sands has all the features of the continental middle European pluviometric type of regime which prevails in much of the continental part of our country. According to mean monthly values of relative air humidity, the wettest months are December and January, the driest April, July, August and September.

The research comprises stands of generative origin on two different soil types. For each soil type, a group (or a series) of five experimental plots was singled out (10 experimental plots in total):

- Series A – artifically established locust stands on *Rhamneto – Quercetum virgilianae* forest type, on medium deep leached chernozem,
- Series B - artifically established locust stands on *Rhamneto – Quercetum virgilianae* forest type, on the shallower variant of medium deep leached chernozem with a two-layered humus-accumulative horizon,

Table 1. Basic growth elements of the studied plots

	Plot	N/ha	V (m^3)	h_L (m)	H (m)	dg (cm)	Dg (cm)
A	1	832	211	18,2	20,0	19,0	27,6
	2	1104	231	17,9	20,8	17,3	26,2
	3	1120	247	18,6	20,3	17,3	23,8
	4	944	187	18,1	20,2	16,9	24,0
	5	832	224	18,8	21,0	19,1	25,9
B	1	1891	178	14,1	16,3	12,1	18,7
	2	1478	146	14,4	15,9	13,2	19,2
	3	2121	184	14,8	17,0	12,0	17,2
	4	1872	181	14,7	15,9	14,7	21,0
	5	1503	129	13,6	15,8	11,3	14,7

The stands are 25 (BG) and 29 (AG) years of age The size of the plots was from 250 m^2 to 625 m^2, depending on the stand density, in order to achieve a minimum of 50 trees per plot. The basic growth elements of studied experimental plots are presented in Table 1.

In order to reconstruct the growth and increment of diameter, a set of 30 trees (15 trees in each series) was felled and their cross-sections were taken at successive distances of 1 m along the stem from the bottom to the top (0.0 m, 0.3 m, 1.3 m etc.).

Chapman-Richards function was used for the purpose of presenting the diameter growth of black locust dominant trees. It is one of the most commonly used functions in this kind of research (Zeide 1993, Pretzsch 2001, Gadow 2002, Kotar 2005, Stajić 2003, 2011):

$$y = a \cdot \left(1 - e^{-b \cdot T}\right)^c$$

Based on the obtained growth function, the current (i_t) and the mean increment (i_p) functions were derived:

$$i_t = \frac{abc\left[e^{-bt}(e^{bt}-1)\right]^c}{e^{bt}-1} \qquad i_p = \frac{d_t}{T} = \frac{\int_0^T f(T)dT}{T} = \frac{F(T)}{T}$$

In order to determine the significance of the observed differences in the growth of trees analyzed in the same series at different ages, the analysis of variance method was applied. Testing the significance of differences in the diameters of black locust trees at certain ages (5, 10, 15, 20 and 25 years of age) between the series was done on the basis of t-statistics.

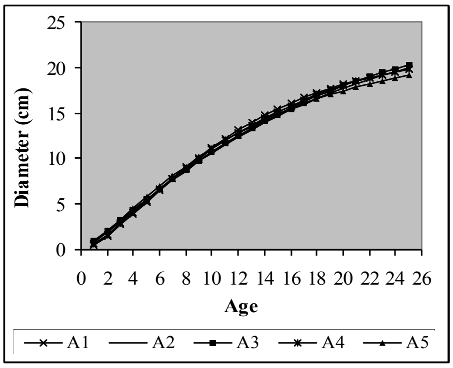
RESULTS AND DISCUSSION

The most accurate and reliable information about the growth of forests and forest stands can be obtained through continuous measurements of forest estimation elements in permanent sample plots. When such data are not available, high-quality information can be obtained by using a large number of temporary sample plots of different age (and in different stages of development) and by reconstructing the increment of the trees of the first biological position, provided that they had free and undisturbed growth (Vučković 1989, Stajić 2011).

The effect of age on the change in the diameter of dominant black locust trees was analyzed because of the fact that under the same site conditions which determine the site class, tree age is the main factor that regulates the process of growth (Vučković, *et al.*, 2000).

Diameter growth

The course of the diameter growth of the studied dominant trees are presented in Figure 1 both per sample plots and per series



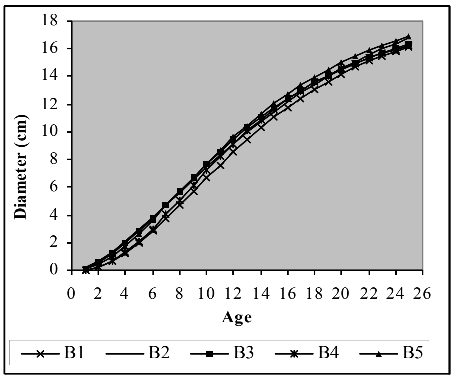


Figure 1. Diameter growth of dominant trees per sample plots and series.

Although the graph (Figure 1) suggests that there is almost no deviation between the tree diameters within the same series throughout the whole study period, the significance of differences in the height of trees was tested using the analysis of variance at a 95% confidence level within each series at the age of 5, 10, 15, 20 and 25. The results of the conducted test and F-statistics confirmed that there was no statistically significant difference in the diameters of the dominant trees within the same series of different sample plots at all ages (5, 10, 15, 20 and 25 years of age).

This means that the null hypothesis about the identical growth of tree diameter within the same series can be fully accepted. Therefore, the models of diameter growth were separately defined for each series of black locust trees. Figure 2 and Table 2 show the lines of diameter growth according to the determined models and presents the model parameters for each series. The first differences in the growth of black locust diameter between the series can be observed in the early years. The observed differences are retained until the age of 25. Based on the defined growth models, the anticipated values of diameter at the age of 25 are 19.8 cm (series A) and 16.5 cm (series B).

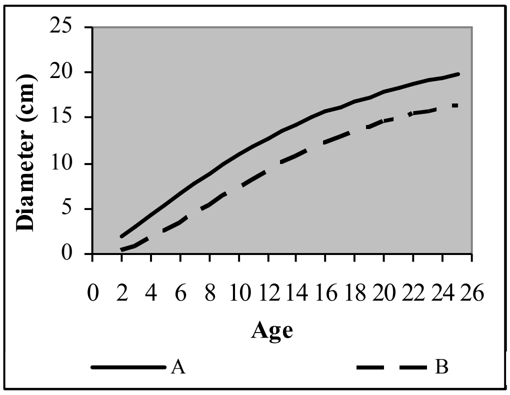


Figure 2. Diameter growth of dominant trees pe rseries

Table 2. Parameters of Chapman-Richards' function and index of curvilinear correlation

Series	Model: $y = a \cdot \left(1 - e^{-b \cdot T}\right)^c$			
	Parameters			Index
	a	b	c	ρ
A	23,59977	0,084311	1,367395	0,97333
B	19,36382	0,108640	2,353830	0,96899

Current and mean diameter increment

The lines of current (i_t) and average tree increment (i_p) in both series are presented in Figure 3. The current diameter increment of all analyzed dominant trees in both series peaked between the age of 4 and 9 (Table 3). In series A, this increment peaked between the age of 4 and 5 and it amounted to 1.17-1.31 cm/year, while in series B it happened between the age of 7 and 9 and the increment ranged from 0.92 to 1.06 cm/year. According to the determined models of tree diameter growth per series this increment reached its highest value at the age of 4 in series A (It_{max} = 1.23 cm) and at the age of 8 in series B (It_{max} =0.99 cm).

The average diameter increment of all trees (in both series) peaked between the age of 6 and 15 (Table 3). In series A, this increment peaked between the age of 6 and 9 and amounted to 1.09-1.16 cm/year, while in series B it peaked between the age of 12 and 15 with an amount of 0.74 to 0.81 cm/year. Based on the determined models of tree diameter growth per series, the peak of the average increment was reached at the age of 7 in series A (Ip_{max} = 1.12 cm) and at the age of 14 in series B (Ip_{max} =0.77 cm).

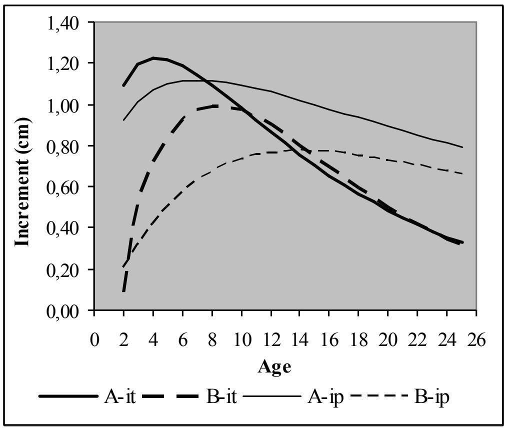


Figure 3. Current and mean diameter increment of dominant trees per series

Table 3. Age culmination and maximum values of increment per sample plots and series

Sample Plots	Current increment		Mean increment	
	Age of culmination (year)	It_{max} (cm)	Age of culmination (year)	Ip_{max} (cm)
A1	5	1,31	9	1,13
A2	4	1,17	6	1,09
A3	4	1,18	6	1,11
A4	5	1,25	8	1,11
A5	4	1,26	6	1,16
Model	**4**	**1,23**	**7**	**1,12**
B1	9	0,98	15	0,74
B2	8	0,92	13	0,77
B3	7	0,99	12	0,79
B4	9	1,06	14	0,78
B5	8	1,03	14	0,81
Model	**8**	**0,99**	**14**	**0,77**

It can be noticed that the better the site conditions, the sooner the peak time of the black locust diameter increment is reached. Furthermore, the values of the increment at the peak time are lower if the site class is lower.

The determined peak time of the black locust diameter increment coincide with the time stated in other literature sources. Rédei (2002) states that the black locust current increment peaks in the first decade. Ristić (1978) found that in Sombor the current diameter increment peaked between the age of 5 and 7 and the average increment at the age of 9.

CONCLUSION

The lines of growth, as well as of current and average diameter increment have a shape which shows that black locust is a tree species with intensive growth in youth that leads to early growth peak and intensive subsequent increment decline. Its early attainment of usable size makes black locust a very interesting species from the aspect of forest operations (Vučetić 2009). Therefore, the defined models of diameter growth provide a range of useful information about the size of diameter that black locust can reach in these two characteristic sites in Deliblato sands and about the time needed to attain these dimensions. They further contribute to proper planning of the optimal rotation age that is market-oriented and aimed at achieving the maximum revenue or economic yield. Its intensive growth and high increment of dendromass in the early youth, high total production of biomass, extraordinary coppice vigour and high wood density are the characteristics that make it suitable for the establishment of fast-growing energy plantations and for biomass production.

Having all these facts in mind, we can conclude that studying the growth and increment of this economically and ecologically significant species is of great importance for the forestry of the areas such as Deliblato Sands, which is, according to Vučković *et al.* (2005), so impressively `between the ecology and the economy` that it cannot be compared to any other place.

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