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ELEMENTS OF GROWTH, BIOLOGICAL AND QUALITATIVE STRUCTURE OF TREES IN VEGETATIVE ORIGIN BLACK LOCUST STANDS ON CHERNOZEM

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ABSTRACT

The researches were conducted on the permanent sample plots in two vegetative origins black locust stands close in age (31 and 33 years), which were established on chernozem soil type. The stands were under different silvicultural treatment and differ in the number of trees per hectare, mean and dominant heights and diameters, whilst not differ in volume per hectare.

In thinned stand (EP-2), the total number of trees per hectare is in accordance with the number of trees in the modelled stands, and in unthinned stand (EP-1) number of trees per hectare is twice higher.

Based on determined number of trees in the sample plots the share of the dominant trees was closely, and by the biological structure on the EP-1 there were a significantly greater number of trees with slow in growth. Qualitative structure of stems shows not enough equal participation of trees with the first quality of stems on both experimental plots, but much lower participation of trees with the third quality of stems on the tended experimental plots in relation to the untended plot.

Key words: black locust, vegetative origin, elements of growth, crown class structure, stem quality structure.

INTRODUCTION

Black locust (*Robinia pseudoacacia* L.) is an introduced species of trees (neophytes) from North America in the early seventeenth century, and today in Europe and Serbia is economically important species. It was used in the reforestation of different habitats due to good adaptability, fast growth and significant yield, possibilities of vegetative regeneration, very hard and long-lasting wood, nitrogen fixation from the air with the help of *Rhizobium* bacteria on the roots, drought tolerance, honey and decorative qualities (Keresztesi, 1983; Barrett et al, 1990; Guzina et al., 1997; DeGomez i Wagner , 2001; Redei et al., 2012).

In the area of today's Serbia black locust have largely used in binding "live sand" in Deliblato and Subotica sands in the middle of XIX century (Guzina, 2006).

At the same time with the afforestation of Deliblato Sands, black locust was afforested and throughout Vojvodina and other parts of Serbia. In the structure of forests in Serbia black locust, with birch and aspen as pioneering companions, occupies an area of 223.200 ha or 8.5% of the total area of forests and forest land of 2,634,800 hectares (Banković et al, 2009).

Researches in black locust stands on the Deliblato Sands (Vucetic, 2009) and the wider area of the Vojvodina Province outside the Subotica and Deliblato Sands (Andrašev et al., 2014) indicate the presence of a large number of trees per hectare compared to the modelled stands in the region (Rede et al. 2014) in similar climatic and edaphic conditions. The presence of a large number of trees in the study stands of black locust, compared to modelled stands of similar origin, indicates the lack of adequate tending in the stands. In the study black locust stands was found unfavourable quality structure of stems so the tending measures in the stands need to focus on improving the quality structure of stems (Andrašev et al., 2014b). Based on the research conducted so far the effects of the application of tending to the development of black locust stands have been insufficiently known.

The task of the research is to study the elements of growth and structure of black locust stands, which differ in the previous tending treatment, and are located in similar site conditions in age that is close to the length of the production cycle.

THE OBJECT OF RESEARCH AND WORK METHODS

The researches were conducted in two vegetative origin black locust stands in Management Unit (MU) "Bagremara" (Public Company "Vojvodinašume" Forest Holding Novi Sad, Forest Administration Backa Palanka): experimental plot 1 (EP-1) and section 8, subdivision and, 31 years old , and experimental plot 2 (EP-2) and section 2, subdivision and 33 years old.

In the stands were made cleaning measures in the age between 5 and 10 years, and after this period on EP-1 thinning have not been carried out, while on EP-2 two thinning were conducted: the first in the age of 20 years and the other in the age of 30 years (so-called "increment thinning" by Rede et al, 2011).

The study was conducted on permanent sample plots, EP-1 with an area of 0.16 ha, and EP-2 with an area of 0.18 ha. On the sample plots two perpendicular diameters were measured on all trees, with an accuracy of 1 mm, and at least 5 trees height in diameter degrees of 5 cm wide with hypsometer type Vertex III, with accuracy of 0.1 m. On each sample plot, pedological profile was opened and collected data for the assessment of morphological description and systematic affiliation of soil.

Measured diameters and heights were used for the construction of height curves (model: $h = 1.3 + a \cdot e^{-b/dbh}$, h - height, dbh – breast height diameter, a, b - parameters to be estimated) for each stand and assessment of stands volume.

Assessment of site classes at each experimental plot was based on the comparison of mean height by Lorey (h_L) with mean height from growth models by Redei et al. (2014) for modelled tended black locust stands in Hungary. Since mentioned height growth models are proportional site class models, i.e., heights of individual site classes of the same age have the same relationship, so assessment of particular site class was determined by the ratio of mean Lorey's height from experimental plot and mean height of the first site class from growth model for the appropriate age, in percentages.

The volume of trees was obtained on the basis of volume tables by Redei et al., (2012), while total volume per hectare was obtained as the sum of the volume of trees on experimental plots multiplied by the appropriate factor.

During the measurement, crown class (CC) and stem quality (SQ) was estimated for every tree based on the classification by Assmann (1970):

– Crown class (CC): tree crown is in upper storey (1), tree crown is in middle storey (2), tree crown is in lower storey (3);

– Stem quality (SQ): (1) evidently straight, smooth utilizable stem, at least one-third of the tree length being free from branches, (2) a bole which, owing to minor faults, does not entirely fulfil the stipulations made for the 1st class, being not entirely straight or slightly inferior in quality owing to a maximum of three thin branches or one thicker branch within the lower one-third of the tree length or some other defect slightly spoiling the quality of the stem, and a curved but utilizable bole of medium quality; (3) a bole which is bent or coarse or has too many branches and with fairly serious technical faults.

RESULTS

By classification of Škorić et al (1985) soils on experimental plots belong to the same systematic unit: chernozem type, subtype on loess and loess-like sediments, variety brownised, form medium deep. Differences in mean heights (h_L) for a given age, or reduced to approximately the same age of 33 years[1] amount to over 4 m, which was considerably higher than the difference between the two site classes that for the specified age is 2.6 m (Redei et al, 2014). The differences in the top heights (H_{100}) approximately reduced to the age of 33 years was 2.1 m which is less than the difference between the two site classes and indicates that the stated habitats are close by productivity (Table 1).

On the EP-1 mean height by Lorey (h_L) is 73.1% of the amount of height of the first site class by Redei et al (2104) and stand belonged to IV site class, while on the EP-2 mean height is 92.6% of height of the first site class and stand belonged to the II site class (Table 2).

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

EP	Age	H_{100}	h_L	D_{100}	d_g	N	G	V	I_{Vp}	Site class				
	[year]	[m]	[m]	[cm]	[cm]	[trees ha^{-1}]	[m^2 ha^{-1}]	[m^3 ha^{-1}]	[m^3 ha^{-1} year^{-1}]	1	2	3	4	5
EP-1	31	21.16	18.25	25.2	14.7	1756	29.84	320.23	10.33				*	
EP-2	33	24.67	23.55	32.4	26.5	469	25.96	310.34	9.40		*			

Legend: EP - experimental plot; *Age* – age of culture since establishment; H_{100} – top height; h_L – mean Loray's height; D_{100} – diameter at breast height of dominant tree; d_g – diameter at breast height of mean tree; *N* – number of trees per hectare; *G* – basal areas per hectare; *V* – volumes per hectare; I_{Vp} – mean volume increments per hectare; *Site class* – site class by Redei et al. (2014).

[1] Adding twice the amount of average height increment at the age of 31 years is reasonably possible considering the early culmination of height increment of black locust (up to 10 years) and the small size of current height increment, as well as its variation in the age of 31-33 years (Vučetić, 2009).

Table 2. The relationship between mean heights and mean diameters of the study stands and data from the table by Redei et al (2014).

EP	Age	N	Height		Diameter		Difference	
			1^{st} y.c.	Y.cl.	1^{st} y.c.	Y.cl.	Δy.c.	Δd_h
	year	[trees·ha^{-1}]	[%h]	[h_L]	[%d_g]	[d_g]	[h_L-d_g]	[cm]
EP-1	31	1756	73,1	IV	56,1	V	-1	-3,2
EP-2	33	469	92,6	II	97,6	I	1	2,2

***Legend**:* EP - experimental plot; *Age* – age of culture since establishment; *N* – number of trees per hectare; *1^{st} y.c._h* – mean tree height by Lorey's in relation to the height of the first site class by Redei et al., (2014) for the corresponding age in percentages; *Y.cl._h* – corresponding height growth model of mean tree by Redei et al. (2014); *1^{st} y.c._d* – mean tree quadratic diameter in relation to the diameter of the first site class by Redei et al., (2014) for the corresponding age in percentages; *Y.cl._d* – corresponding diameter growth model of mean tree by Redei et al. (2014); *Δy.c.* – differences in site classes on the basis of achieved mean height and mean diameter at breast height by Redei et al., (2014); *Δd_h* – difference between achieved breast height diameters and breast height diameters by Redei et al., (2014) for the corresponding site class.

Mean diameter (d_g) on EP-1 is 56.1% while on EP-2 average diameter is 97.6% of the of the mean diameter of the first site class by Redei et al (2014). Average diameter on EP-1 is 3.2 cm less than the mean diameter of the IV site class, while on the EP-1 is increased by 2.2 cm of mean diameter of the II site class by Redei et al (2014) (Table 1, 2).

In the unthinned stand (EP-1) at 31 years it was determined fixed number of trees per hectare of 1756, that is higher by 891 tree per hectare or 103% compared to modelled tended black locust stands of the IV site class. In the thinned stand (EP-2) at 33 year it was determined only 469 trees per hectare, which is 44 trees per hectare or 10.5% more than the number of trees per hectare the second site class by Redei et al (2014), (Table 3).

The number of trees per hectare is in strong dependence on the mean diameter at breast height (*$N_0=f(d_g)$*). For the modelled values of the number of trees per hectare of different site classes by Redei et al (2014) was constructed the dependence of the number of trees from mean diameter at breast (Andrašev et al, 2014). For such a defined modelled number of trees per hectare on EP-1, was found 1058 trees per hectare or 151.5% more, while on EP-2 was determined 20 trees per hectare or 4.1% less than the number of trees for proper site classes by Redei et al, (2014) (Table 3) .

In the relation to the volume displayed on the site class by Redei et al (2014) volume per hectare on EP-1 of 320 m^3·ha^{-1} is higher by 162 m^3·ha^{-1}, while the volume per hectare on EP-2 is higher by 50 m^3·ha^{-1} (Table l, 3).

Table 3. The relationship between numbers of trees and volumes per hectare of the study stands and data from the table by Redei et al (2014).

EP	Age	N	*$N_0=f(Age)$*			*$N_0=f(d_g)$*			*Volume per hectare*				
			N_{0_Age}	ΔN_{Age}	*$(N-N_0)/N_0$*	*N_{0_dg}*	ΔN_{dg}	*$(N-N_0)/N_0$*	1^{st} y.c.	Y.cl.	Δy.c.	ΔV	ΔV
	year	[trees·ha^{-1}]	[trees·ha^{-1}]	[trees·ha^{-1}]	[%]	[trees·ha^{-1}]	[trees·ha^{-1}]	[%]	[%V]	[V]	[h_L-V]	[m^3·ha^{-1}]	[%]
EP-1	31	1756	865	891	102,9	698	1058	151,5	106,0	I	3	161,71	102,0
EP-2	33	469	425	44	10,5	489	-20	-4,1	98,7	I	1	50,30	19,3

***Legend**: EP* - experimental plot; *Age* – age of culture since establishment; *N* – number of trees per hectare; *N_{0_Age}* – number of trees per hectare obtained by model: *$N_0=f(Age)$*; *ΔN_{Age}* – difference between achieved number of trees per hectare and number of trees obtained by model; *$(N-N_0)/N_0$* – the percentage difference between achieved number of trees per hectare and number of trees obtained by model; *N_{0_dg}* – number of trees per hectare obtained by model: *$N_0=f(d_g)$*; *1^{st} y.c.* – volume per hectare in relation to volume per hectare of the first site class by Redei et al., (2014) for the corresponding age in percentages; *Y.cl.* – the corresponding growth model of volume per hectare by Redei et al. (2014); *Δy.c.* – differences in site classes on the basis of achieved volume per hectare and volume per hectare by Redei et al., (2014); *ΔV* – difference between achieved volume per hectare and volume per hectare by Redei et al., (2014) for the corresponding site class.

Of the total number of trees in the EP-2 416 trees per hectare were found in the upper storey (89%) and only 53 trees (11%) in the middle storey, while in the EP-1 725 trees per hectare (41%) were in the upper storey, 244 trees per hectare (14%) in the middle storey, and 788 trees per hectare (45%) in the lower storey.

Diameters of trees in the upper storey on the EP-1 were 12.5-32.5 cm, with the largest share in the diameter degree of 17.5 cm, while on the EP-2 trees in the upper storey had diameters of 17.5-37.5 cm, with the largest share in the diameter degree of 27.5 cm. On the EP-1, 54% of trees from the lower storey had a diameter less than 5 cm (Figure 1).

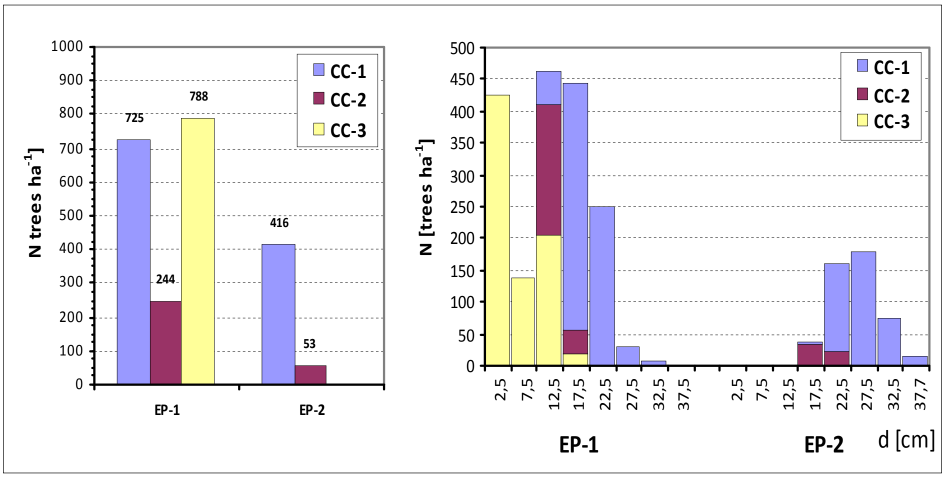

Figure 1. Number of trees per hectare of different crown classes (left) and their diameter distribution (right) on the studied plots.

Of the total number of trees in the EP-1 306 trees per hectare (17%) were found with the first stem quality, 500 trees (29%) with II stem quality and 950 trees (54%) with III stem quality, while in the EP-2 213 trees per hectare (45%) were found with I stem quality, 219 trees (47%) with II stem quality and 37 trees (8%) with III stem quality.

Trees with I stem quality in the EP-1 had diameters of 12.5-32.5 cm diameter degrees and the largest share in the diameter degree of 22.5 cm, while trees in the EP-2 were located in diameter degrees of 17.5-37.5 cm and had the largest share in the diameter degree of 27.5 cm. In the EP-1, more than half of the trees with III stem quality had a diameter smaller than 10 cm (Figure 2).

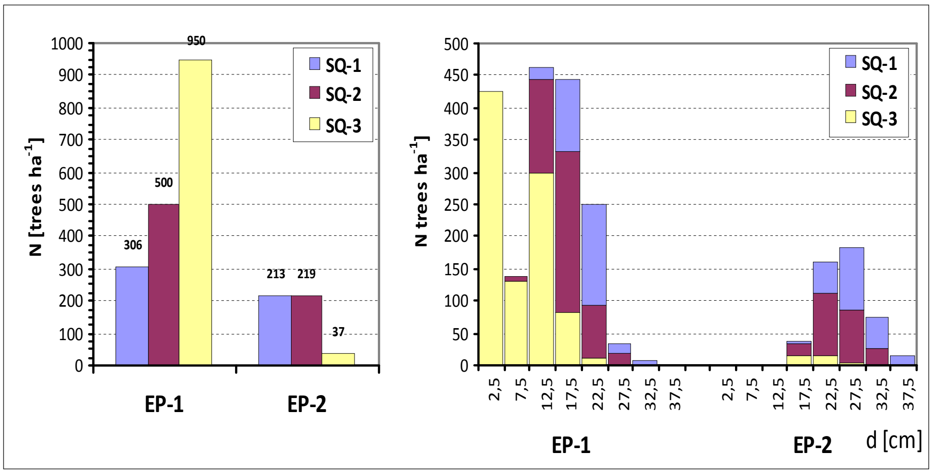

Figure 2. Number of trees per hectare of different trunk quality classes (left) and their diameter distribution (right) on the studied plots.

DISCUSSION AND CONCLUSIONS

Studied black locust stands of vegetative origin on chernozem soil, which were under different silvicultural treatment, show a strong dependence of tree growth elements from habitat and the number of trees. Differences between the heights of dominant trees of studied vegetative origin black locust stands are less than the difference between two adjacent site classes by Redei et al, (2014), which indicates that the stated habitats are close by productivity. Mean heights of study stands differ by two site classes, according to Redei et al (2014) as a result of the different number of trees or silvicultural treatment in studied black locust stands. In unthinned stand (EP-1) top height (H_{100}) are greater than the mean heights (h_L) by 16%, and in thinned stand (EP-2) by only 5%. Greater differences between dominant and mean heights indicate to lagged inventory in the stand.

On the EP-2 the number of trees per hectare is in accordance with modelled stands, and on the EP-1 were found more than 100% higher trees per hectare than modelled managed stands by Redei et al (2014). However, by biological classification on the both experimental plots determined number of trees per hectare in the upper storey (CC-1) is consistent with the modelled managed stands by Redei et al (2014).

As a consequence of the lack of thinning on the EP-1 has been intensified differentiation of trees. The mean diameter was in the level of 56% of the diameter of the I site class (Redei et al, 2014).

Increased participation of black locust trees with I stem quality can be expected only in cultures established with known genotype (Keresztesi, 1983). The research results are consistent with the above and show that in the studied stands 213-306 trees per hectare has a trunk with I stem quality, which enables the production of so-called. "industrial wood". The research results show that in the thinned stand total number of trees decreased by more than 70%, and the number of trees with I stem quality decreased by 30%. In thinned stand (EP-2) more than 200 trees per hectare had diameters above 20 cm, of which more than 60 trees per hectare is thicker than 30 cm, as opposed to the unthinned stand (EP-1) where 175 trees per hectare is thicker than 20 cm, and only 6 trees per hectare are thicker than 30 cm.

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