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GROWTH RINGS WIDTH OF BALD CYPRESS STEMS FROM TWO ALLUVIAL SITES IN SERBIA

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ABSTRACT

The paper shows the differences in growth rings width between bald cypress stems grown on two alluvial sites in Serbia – Veliko ratno ostrvo and Backa Palanka. Performing this anatomical research included falling of overall six trunks (3 from one and 3 from another location). After that, appropriate wood cross-sections were made and they served for making permanent anatomical preparations. Obtained results proved a big dependence between radial increment from one side and available water content together with nutrients content on the other side. It caused a very significant correlation between growth rings width and qualitative site features. Bearing on mind this fact, it was established that Veliko ratno ostrvo is more suitable for bald cypress growing. As for behavior of radial increment with ages, there are some differences between these locations, first of all because stems from Veliko ratno ostrvo still did not reach its culmination.

KEYWORDS:
bald cypress, growth rings width, Veliko ratno ostrvo, Backa Palanka, soil

INTRODUCTION

In the paper [1], cambial activity and ending of that process has been researched. On the other hand, some papers [2] claim that cambial activity finishes first on the top and later at the base of the stem. However, the others described more intensive ending of cambial activity at the base during the autumn, and after that the process gradually expands to the top of the crown [3], [4], [5].

[6], [7] explained that reactivation of cambium occurs as a result of produced auxine quantity in the young shoots and this causes xylem production. This processes regulate xylem growth [8], [9].

Some papers connect growth speed, and the ending of xylogenesis, with climate and physiological factors. [10] concluded that growth rate culminates during the summer, when photoperiod reaches maximum, while the others [11] found that high quantity of abscisive acid in the stem after cells division indicates the ending of cells production.

Cambial activity depending on sites conditions has also been researched in fir plantations [12]. Obtained results of this paper deduced that intensity of cambial activity depends a lot on stems position in the population. It started earlier and lasted longer by dominant stems.

Based on some papers [13], it has been established that cambial activity lasts longer by stems with wider than by the others with narrower growth rings, so duration of cambial activity depends a lot on growth rate.

Radial increment changes have often been caused by changing of hydrological conditions in the environment [14], [15].

Processes of cambial reactivation are related to light and temperature control [16], [17].

Some papers [18] established that different species from the same genus react very plastically to changed environmental conditions and it is related to its phenotypic reaction. Another paper [19] related to Douglas-fir, that is also deciduous conifer like bald cypress, concluded that Douglas-fir is not resistant on air-pollutants influence.

MATERIALS AND METHODS

Objects of the research. Research of wood anatomy structure means choosing of representative stems that have to satisfy some criterias: generative origin, good health and physiological state, absence of any technical deformation. Bald cypress stands with these characteristics are located in Backa Palanka and Veliko ratno ostrvo – therefore these two locations have been chosen as objects of the research.

The aim of the paper was to determine radial increment of bald cypress stems on two alluvial sites whose soil characteristics differ a bit between each other.

Veliko ratno ostrvo is protected natural area situated between 1169 and 1172 km of the river Danube flow. It is characterized by flat orography with an average height of about 72 m above the sea level. There are three zones established inside this location:

zone of nature preservation, zone of recreation and zone of tourisms.

The soil belongs to alluvium with different texture and it was used for agriculture production in the past. The stand is between 25 and 35 years old [20] with satisfied radial and height dimensions.

Backa Palanka is the only location in Serbia where exists seed stand of bald cypress. There are currently 111 trunks with an average age of about 70 years [21]. Based on some papers [22], for bald cypress in Backa Palanka could be deduced following:

- it is very important, not only decorative, but also forest species suitable for planting on *Salix alba* habitats
- in Serbian environment, bald cypress belongs to fast-growing species and is one of rare conifers used for lowland areas afforestation
- this population is significant seed base, not only because of seed quantity and quality, but also because of superior plus stems present there
- natural regeneration of bald cypress depends on hydrological conditions

Study area. Choosing of the stems. Overall six stems (three from one and three from another location) had to be fallen in order to perform appropriate morpho-anatomical analysis. Bearing on mind that position of the stem plays an important role, it was needed to avoid samples surrounded by many others, then these situated at the edge of the stand, and these completely free from another individuals, because it could negatively affect to both radial and height increment. Selection of representative stems contributes a lot to determining of radial increment very precisely.

After desirable stems were fallen, their age was calculated by growth rings counting at the base. Stems from Veliko ratno ostrvo were 36, 34 and 29 years old. On the other side, samples from Backa Palanka were much older – 54, 74 and 74 years old.

Taking of the wood cross-sections. Before stems were fallen, an appropriate side of the world was labeled. After falling down process, it was necessary to take the wood cross-sections in order to have an insight in a wood macro-structure. Cross-sections were taken on two heights – on the base (0.3 m) and on the breast height (1.3 m). Its thickness was about 2 cm. Thereafter, cross-sections were cut through the radius off due to performing all necessary measurements on the segment including n growth rings from the pith to the bark.

Taking of soil samples. In order to perform appropriate pedological research, pedological profiles were open on both locations. There were overall 4 profiles opened – 3 on Veliko ratno ostrvo and 1 in Backa Palanka. The main purpose of soil samples taking was determining of soil texture and its chemical features.

Laboratory work. Wood cross-sections were brought to the Lab of Wood Anatomy of Faculty of Forestry from Belgrade University. There was done insight in its macroscopic structure and permanent anatomical preparations making. Before permanent anatomical preparations were made, some wood segments with the length equal to the cross-section diameter and width of about 8 mm were cut off [23]. These segments were taken in following directions – north-south or east-west.

Cross-sections grinding. This operation needs to be done in order to make not only growth rings as more visible as possible, but also the border between each other, as well. This has a big influence on permanent anatomical preparations quality. Some structural mistake present in the wood, that is hard to diagnosticate on the usual cross-section, by grinding performing can be eliminated.

Making of permanent anatomical preparations. Depending on research type, preparations could be temporar or permanent. For this research, permanent anatomical preparations were made in all anatomical directions – transversal, radial and tangential. With regard to the fact that bald cypress belongs to soft woods, it was not necessary softening on high temperatures. Sliding microtome „Reichert“ was used for making permanent anatomical preparations in all directions. Growth rings width was measured on these preparations in two perpendicular directions [24]. Obtained medium value from these measurements is actually desirable growth rings width.

RESULTS AND DISCUSSION

As for growth rings width, it depends on many factors: soil, climate, orography, site. Species with wider growth rings are marked as fast-growing species, and these with narrow growth rings are slow-growing species. Individuals grown completely free will have increased radial increment because of the lack of competitive vegetation [21]. Contrary, individuals surrounded by numerous neighbours will have an intensive growth in the height.

Based on results in Table 1, for average growth rings width at two heights on two different locations, it can be deduced that growth rings are on average wider at Veliko ratno ostrvo than in Backa Palanka. This is directly connected to, before all, soil texture that determines quantity of available water to the plants. Soil on Veliko ratno ostrvo is characterized by presence of two texture classes – sandy loam and loam – that contain a big quantity of physiologically available water. On the other side, sand and loamy sand are two the most common texture classes in Bačka Palanka, so therefore is content of available water to the plants much lower.

TABLE 1
Growth Rings Width at Different Heights

location	stem number	an average width at 0.3 m (mm)	minimal width at 0.3 m (mm)	maximal width at 0.3 m (mm)	an average width at 1.3 m (mm)	minimal width at 1.3 m (mm)	maximal width at 1.3 m (mm)
VRO	1	3.43	1.76	5.76	3.10	1.48	5.41
VRO	2	3.41	1.85	6.21	3.21	1.62	6.02
VRO	3	3.29	1.99	5.08	3.11	1.86	4.95
BP	1	2.63	1.32	4.10	2.47	1.42	3.87
BP	2	2.51	1.56	3.92	2.33	1.41	3.77
BP	3	2.49	1.48	3.91	2.39	1.46	3.80

VRO – Veliko ratno ostrvo
BP – Bačka Palanka

TABLE 2
Soil Texture

depth	big sand	small sand	dust	clay	overall sand	overall clay	Texture class
(cm)				%			
				Veliko ratno ostrvo			
				Pedological profile number 1			
0-10	1.90	51.50	23.90	22.70	53.40	46.60	sandy loam
10-40	1.40	51.70	22.20	24.70	53.10	46.90	sandy loam
40-70	0.30	79.40	7.70	12.60	79.70	20.30	sandy loam
				Pedological profile number 2			
0-10	2.70	46.60	24.20	26.50	49.30	50.70	loam
10-40	1.90	48.40	24.80	24.90	50.30	49.70	loam
40-70	1.20	50.50	22.50	25.80	51.70	48.30	loam
				Pedological profile number 3			
0-10	2.70	47.70	23.60	26.00	50.40	49.60	loam
10-40	1.50	48.60	22.20	27.70	50.10	49.90	loam
40-70	1.30	49.90	22.30	26.50	51.20	48.80	loam
				Bačka Palanka			
				Pedological profile number 4			
0-15	1.50	59.80	19.30	19.40	61.30	38.70	sandy loam
15-40	0.30	90.30	2.90	6.50	90.60	9.40	sand
40-100	0.20	84.80	7.00	8.00	85.00	15.00	loamy sand
> 100	0.20	82.20	9.10	8.50	82.40	17.60	loamy sand

This was confirmed by the author [25] who did a research in the protected part of the Danube river alluvium and obtained results are very similar. Content of physiologically available water depends on different texture classes [25] – 25.97 % for sandy loam, 24.10 % for loam, 12.31 % for sand, and 15.89 % for loamy sand.

[26] researched soil features influence on the growth of poplar cultivars at unprotected alluvium of the Danube river. Obtained relations about available water content between some texture classes were similar – 36.2 % for sand, 40.2 % for loamy sand, 42.6 % for sandy loam, and 45.8 % for loam. Bigger values obtained in this paper compared to [25] are caused by the fact that this zone was not protected, so flooding of the Danube river affects a lot these results.

Results obtained for growth rings width of bald cypress on both locations are very similar to [25] and [26]. Bald cypress needs the soil optimaly provided with the water and the adequate oxygen exchanging, as well. Based on above mentioned facts, it can be concluded that wider growth rings are going to be formed on the soil with bigger quantity of available water.

Bigger growth rings width on average, and bigger radial increment in a whole, depend a lot on soil fertility more expressed on the soil of Veliko ratno ostrvo. Content of some fractions (dust, clay, N, humus, P_2O_5, K_2O) showed in the Table 2 and 3 confirms this claim.

Growth rings width are decreasing with the height, so therefore are growth rings wider on the base than on the breast height (figures 1-4). [27] obtained the same results by *Pinus brutia* T. They namely concluded that growth rings width by the individuals grown on sites with good quality features firstly decrease from the base to the 2 m height, after that it gradually goes up to the central part of the tree, and from it to the top of the crown, growth rings width decreases again.

TABLE 3
Chemical Features of The Soils

depth	pH		$CaCO_3$	overall		C/N	easy-available	
				humuse	N		P_2O_5	K_2O
cm	H_2O	KCl	%				mg/100g	
			Veliko ratno ostrvo					
			Pedological profile number 1					
0-10	7.40	6.99	7.64	13.93	0.88	9.13	38.18	25.22
10-40	8.00	7.22	13.50	1.50	0.39	3.84	11.25	10.87
40-70	8.01	7.53	13.49	0.65	0.27	2.42	5.94	5.65
			Pedological profile number 2					
0-10	7.42	7.01	10.06	8.61	0.96	8.96	25.07	27.47
10-40	7.85	7.32	13.38	1.55	0.38	4.12	10.48	13.68
40-70	7.96	7.30	15.47	1.12	0.29	3.91	8.64	11.90
			Pedological profile number 3					
0-10	7.44	7.00	8.82	10.05	1.02	9.85	38.18	31.00
10-40	7.62	7.17	12.63	3.47	0.64	5.39	25.76	21.62
40-70	7.69	7.19	14.02	2.69	0.54	5.02	20.14	18.17
			Bačka Palanka					
			Pedological profile number 4					
0-15	7.91	7.54	5.62	9.76	0.40	14.22	23.43	11.54
15-40	8.83	8.38	8.43	0.41	0.01	18.41	1.04	2.68
40-100	8.83	8.31	10.68	0.41	0.01	17.87	0.00	2.02
> 100	8.66	8.00	10.24	0.48	0.01	20.40	0.00	1.70

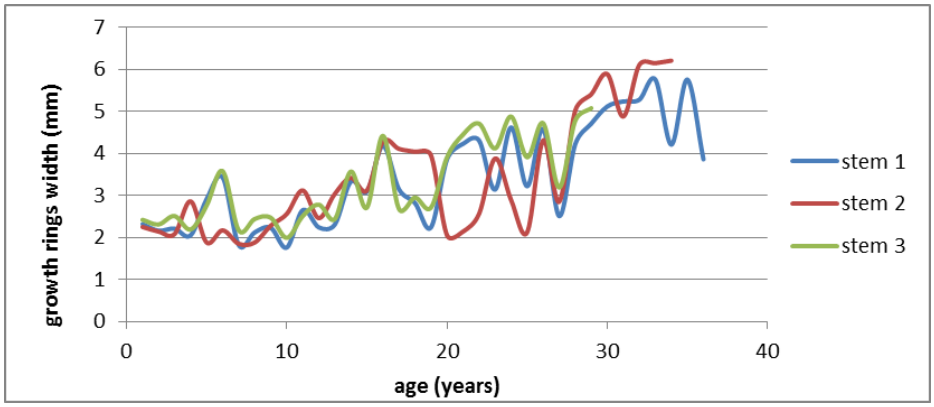

FIGURE 1
Location-Veliko ratno ostrvo, 0.3m

Growth rings width by Pančić spruce (*Picea omorika*) from National Park „Tara“ shows that, on the breast height, it varies from 0.5 mm to 1.5 mm, with an average value of about 0.8 mm [28]. On the other side, by fir from Veliki Jastrebac mountain, values of growth rings width are between 2 mm and 7 mm, depending on soil qualitative features, and its average value is about 4.5 mm [29]. Based on obtained results, it can be concluded that growth rings by bald cypress are much wider then by Pančić spruce and similarly wide to fir.

[30] claimed that radial increment is not the same at all heights of the trunk – by all spruces grown in the dense environment, growth rings width falls from the base to the minimum occurance situated between 1 m and 12 m height, then it rises to the beginning of the crown, and after occurance of the maximum, one more reduction follows. [31] noticed by locust tree that radial increment increases in the first 5-9 growth rings from the pith, and after that it gradually falls. [27] concluded that growth rings width rises going to the top of the crown, that is incompatible with results obtained for bald cypress [21]. As for thinning influence on growth rings structure by Japanese larch, [32] established that application of thinning measures causes increasing of the overall growth rings width.

Obtained results for bald cypress from Veliko ratno ostrvo show that minimal values of growth rings width occur in the first 10 growth rings from the pith, that can be related to gradual radial increment; maximal values of growth rings width are present in the final growth rings; an expressed increasing of the radial increment is remarkable after 30 age; extreme values of the growth rings width coincide almost completely apart from the stem number 2 (Figures 1-2).

On the other side, there are some different

tendencies recorded in Bačka Palanka (figures 3-4) – maximal values of growth rings width are much bigger at Veliko ratno ostrvo; by individuals from Bačka Palanka, minimal values of the width occur in the final growth rings; in Bačka Palanka, culmination of the radial increment reaches at about 60 age and after that comes to reduction.

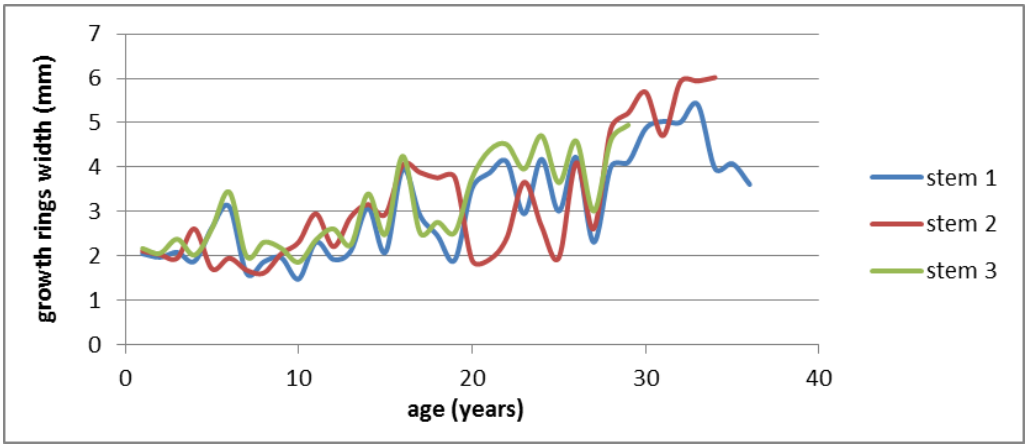

FIGURE 2
Location-Veliko ratno ostrvo, 1.3m

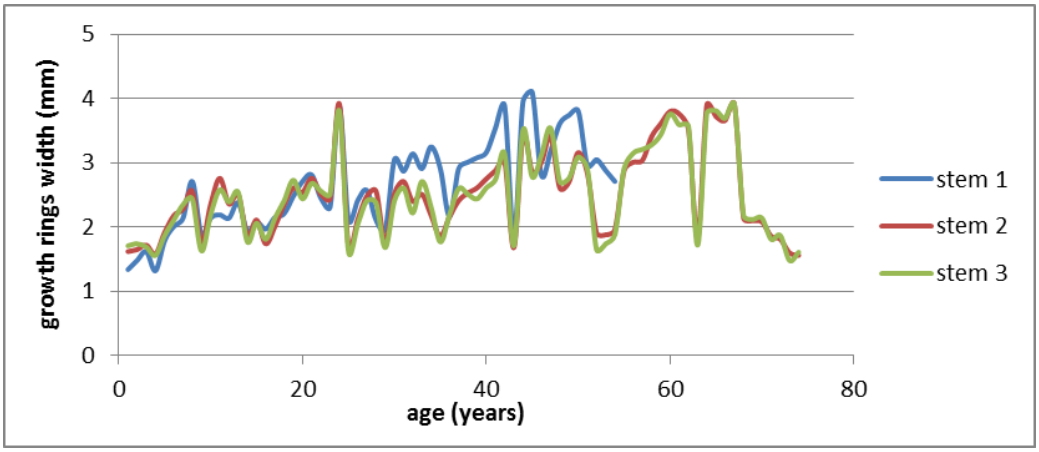

FIGURE 3
Location-Bačka Palanka, 0.3m

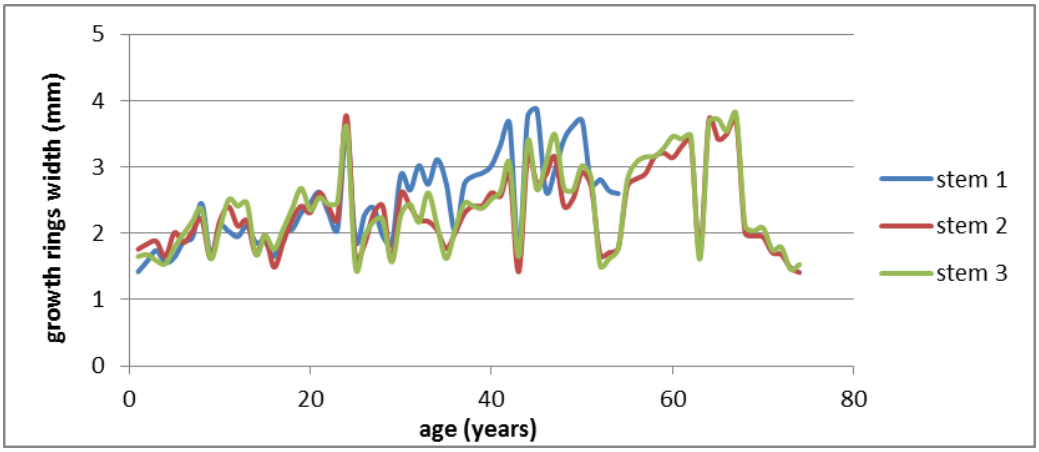

FIGURE 4
Location-Bačka Palanka, 1.3m

CONCLUSIONS

As for the radial increment of bald cypress from two alluvial sites in Serbia, it can be deduced:

- growth rings width depends a lot on soil texture and its chemical features, as well
- quantity of available water, related to soil texture, directly affects radial increment of bald cypress
- Veliko ratno ostrvo is more suitable for bald cypress development than Bačka Palanka
- above mentioned fact is confirmed by wider growth rings formed at Veliko ratno ostrvo
- unlike Bačka Palanka, Veliko ratno ostrvo has been characterized by gradual radial increment
- bald cypress needs to be provided with optimal quantity of available water and oxygen

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