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## VARIABILITY OF TAXODIUM AS A BASE FOR EVALUATION OF ITS GENETIC POTENTIAL IN THE AREA OF GREAT WAR ISLAND

### SUMMARY

The genus *Taxodium* Rich. was widely located in Europe and North America in the past. Nowadays there are only three species from the southern parts of North America and Mexico: *Taxodium ascendens* Brogn., *Taxodium distichum* (L.) Rich. and *Taxodium mucronatum* Ten. The natural habitats of taxodium are some temporary wet soils in south-eastern part of the USA, from Louisiana to Florida. In Serbia there is mainly *Taxodium distichum* (L.) Rich. which grows on some wet habitats – there are a number of single trees located on some green surfaces of urban areas. There is a seed plantation in Backa Palanka in the northern part of Serbia. There are some representatives of *Taxodium distichum* (L.) Rich. on the “The Great War Island” area, too, where a great variability of Bald cypress introduces special genetic potential that includes more than 80 well-adapted genotypes. The evaluation of morphological characteristics variability of twigs and needles was measured on 48 genotypes from the “Great War Island” area. The chosen genotypes belong to the higher diameter and grow outside the influence of some other trees that take sunlight from them. There is a sample consisted of 100 twigs and needles, taken from each genotype, and there were measured length of twigs, and length and width of needles, as well. The data collected on 1440 performed measurements were processed by the computer program *Statgraph* 6.0, the descriptive statistics, analysis of variance and LSD-test were performed.

The Average values of the twigs length are from 69.52 mm to 152.16 mm, of the needles length are from 11.64 mm to 16.69 mm, and finally of needles width from 1.00 mm to 1.49 mm. This values show that there is a significant intra-provenance variability, which introduces a good base for conservation and sustainable using of genetic potential of this rare tree that originates from Serbia.

**Keywords:** *Taxodium distichum* (L.) Rich., twigs length, length and width of needles, variability, genetic potential

### INTRODUCTION

The genus *Taxodium* Rich. belongs to the *Taxodiaceae* family, deciduous conifers with exotic decorative qualities. *Taxodium* natural sites are wetlands and

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river flows in the southeast of the USA and Mexico and East Asia (Dražić and Batos, 2002). Today only three species are known from the genus *Taxodium*: *Taxodium ascendens* Brogn., *Taxodium distichum* (L.) Rich. and *Taxodium mucronatum* (Vidakovic, 1982).

It is introduced into Europe in 1640 and since then it has been grown as an ornamental plant. It can be used for the establishment of forest plantations (Vidakovic, 1982). *Taxodium* wood is highly prized due to its high quality and durability, for which it is used for building construction and shipbuilding.

In Serbia there is mainly *Taxodium distichum* (L.) Rich. but *Taxodium ascendens* Brogn. was also found in the park of Banja Koviljaca (Ocokoljić and Tucović, 2005). *Taxodium distichum* is also located on some green surfaces in Belgrade, Novi Sad, Vrsac, Kraljevo and Vrnjacka Banja. In the area of Lumber Camp "Novi Sad", in the surroundings of Backa Palanka, there is a seed plantation of *Taxodium distichum* (Petrović, 1951; Tucović i Stilinović, 1970). Some tree groups are registered within the Institute Vinca and in the hunting ground Plavna. *Taxodium* population which was the subject of this study, was described in the area of protected nature reserve "Great War Island" in Belgrade, a city municipality of Zemun (Šijačić-Nikolic et al., 2011).

## MATERIAL AND METHODS

A protected natural area "Great War Island" is located between the 1169th and 1172nd kilometre of the river Danube near Belgrade. It has the characteristics of a plain, with an average altitude of about 72 meters above sea level. The surface layers of Great War Island are alluvial formations of the Danube River. The occurrence of different plant communities is, for the most part, dependent on the regime of the Danube and Sava rivers, and, in relation to that, on the groundwater regime. The area is covered by riparian forests of willows and poplars. Through the process of recognising, 83 *taxodium* trees were identified in the middle area of island headland, individually or in groups, as the remains of the former culture. On the basis of the average and dominant height and diameter at breast height, it was found that they have a satisfactory growth in the studied habitat conditions (Šijačić-Nikolić et al., 2011).

In order to learn the variability of morphometric traits of twigs and needles (leaves) at the level of the examined population, a total of 48 trees of nearly the same age (30 years) were selected. The sample of 100 twigs was taken from the outer west-facing side of the crown of each genotype. Twigs length ( $D_g$ ) was measured in mm. The length ( $D_č$ ) and the width of the needles ( $Š_č$ ) were measured on a sample of 100 needles, which were collected from the central part of the branches ( $S_g$ ), Figure 1. The collected data, a total of 14 400 measurements have been processed in a computer program "Statgraph 6.0". This paper presents the results of summary statistics, variance analysis and LSD test.

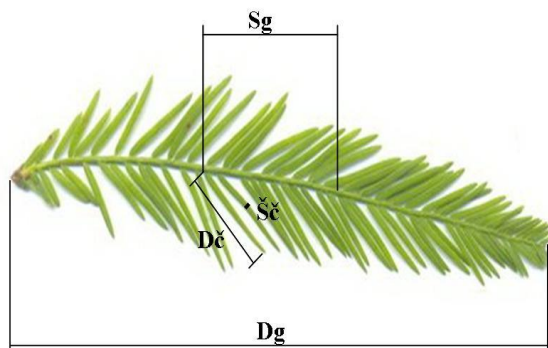


Figure 1: The analyzed morphometric traits of taxodium twigs and needles

## RESULTS AND DISCUSSION

Summary statistics, analysis of variance and LSD test for the length of the branches of various test trees of taxodium from Great War Island are shown in Table 1.

Table 1: Summary statistics, analysis of variance and LSD test for the twigs length of various test trees of taxodium from Great War Island

Number of test tree	Min (mm)	Max (mm)	Average value (mm)	Standard deviation
2	81	92	84.84	3.25
3	97	113	104.00	5.42
4	90	113	100.08	6.46
5	79	101	85.96	5.89
6	80	90	84.60	3.15
7	93	119	104.60	7.11
8	81	90	84.56	2.75
9	81	97	87.80	4.31
10	80	92	84.88	3.33
11	101	126	113.88	6.33
12	78	87	82.28	2.62
13	80	90	84.64	3.13
14	80	93	85.80	4.09
15	101	118	107.72	4.14
16	94	111	101.28	4.37
17	90	104	96.20	4.02
19	79	88	83.72	2.82
20	78	95	84.48	4.80
21	93	112	102.44	6.23
22	54	85	69.52	7.06
23	72	95	82.60	5.57
24	93	109	101.32	4.60
25	80	92	84.64	3.26
26	107	125	114.80	5.07
27	80	117	96.24	9.44
28	100	120	108.40	6.00
29	80	90	84.36	2.75

30	65	100	88.64	9.73
31	80	89	83.80	2.99
32	91	119	102.84	8.26
33	65	85	74.32	5.51
34	80	100	92.64	5.39
35	71	88	78.60	4.86
36	55	87	72.08	8.14
37	122	144	131.60	7.30
38	90	113	101.32	6.42
39	81	91	85.20	3.08
40	70	89	77.56	5.74
41	80	91	84.64	3.11
43	70	100	84.56	8.65
44	60	100	70.68	7.93
56	92	157	116.84	18.99
62	70	140	104.08	17.64
63	80	100	88.60	6.16
68	132	169	152.16	12.16
76	72	90	80.60	4.90
78	67	104	84.36	10.75
82	94	121	109.20	7.22
<b>Variance analyses</b>				
Among provenances		Mean Square	F-Ratio	P-Value
		6309.26	129.64	0.0000
<b>LSD test</b>				
	Average value		Homogenous groups	
22	69.52		X	
44	70.68		XX	
36	72.08		XX	
33	74.32		XX	
40	77.56		XX	
35	78.60		XX	
76	80.60		XXX	
12	82.28		XXX	
23	82.60		XX	
19	83.72		XX	
31	83.80		XX	
29	84.36		XXX	
78	84.36		XXX	
20	84.48		XX	
8	84.56		XX	
43	84.56		XX	
6	84.60		XX	
41	84.64		XX	
25	84.64		XX	
13	84.64		XX	
2	84.84		XXX	
10	84.88		XXX	
39	85.20		XXX	
14	85.80		XXX	
5	85.96		XXX	
9	87.80		XX	
63	88.60		X	
30	88.64		X	
34	92.64		X	
17	96.20		X	
27	96.24		XX	
4	100.08		XX	

16	101.28	XX
24	101.32	XX
38	101.32	XX
21	102.44	XX
32	102.84	XX
3	104.00	XX
62	104.08	XX
7	104.60	XXX
15	107.72	XXX
28	108.40	XX
82	109.20	X
11	113.88	X
26	114.80	X
56	116.84	X
37	131.60	X
68	152.16	X

On the basis of these results, we can say that the length of the analyzed twigs range from 69.52mm to 152.16 mm. The minimum value of this trait is 54 mm and it was found out in a tree number 22, and maximum one is 169 mm and it was found in a tree 68. Differences between mean values were statistically significant. Based on the results of LSD tests, it can be concluded that there is a grouping of trees in several homogeneous groups.

Summary statistics, the analysis of variance and LSD test for the length of needles of various test trees of taxodium from Great War Island are shown in Table 2.

Table 2: Summary statistics, the analysis of variance and LSD test for the length of needles of various test trees of taxodium from Great War Island

Number of test tree	Min (mm)	Max (mm)	Average value (mm)	Standard deviation
2	9	18	13.24	1.80
3	13	18	16.03	1.31
4	12	19	15.23	1.22
5	12	18	14.99	1.03
6	13	17	14.86	0.97
7	12	18	14.62	1.11
8	12	18	15.19	1.19
9	13	18	15.19	1.19
10	12	18	15.19	1.27
11	12	18	15.09	1.36
12	12	18	14.81	1.45
13	12	19	14.97	1.30
14	12	18	15.18	1.37
15	12	17	14.95	1.14
16	12	18	14.98	1.24
17	12	18	15.11	1.56
19	11	18	14.75	1.81
20	11	19	15.28	1.88
21	11	19	15.00	1.86
22	11	19	14.72	1.79
23	9	14	12.06	1.42
24	8	18	13.44	2.29
25	11	19	15.35	1.99

26	11	19	16.04	1.66
27	11	19	14.61	1.83
28	9	17	12.01	1.57
29	10	15	12.06	1.29
30	10	16	12.36	1.25
31	10	16	12.53	1.46
32	10	15	12.08	1.18
33	10	19	12.41	1.60
34	10	16	12.74	1.39
35	10	15	12.05	1.49
36	5	15	11.69	1.65
37	8	17	12.35	2.00
38	8	16	11.87	1.66
39	9	15	12.20	1.31
40	10	19	16.69	2.09
41	10	16	12.33	1.28
43	10	19	13.09	1.76
44	10	19	12.76	2.02
56	9	19	12.37	1.75
62	10	16	12.44	1.37
63	8	16	11.73	1.58
68	10	19	13.44	2.48
76	10	14	12.23	1.20
78	7	17	11.64	2.05
82	8	14	11.93	1.40
<b>Analyses of variance</b>				
Among provenances	Mean Square	F-Ratio	P-Value	
	225.074	90.52	0.0000	
<b>LSD test</b>				
	Average value	Homogeneous groups		
78	11.64	X		
36	11.69	XX		
63	11.73	XX		
38	11.87	XXX		
82	11.93	XXXX		
28	12.01	XXXXX		
35	12.05	XXXXX		
29	12.06	XXXXX		
23	12.06	XXXXX		
32	12.08	XXXX		
39	12.20	XXXX		
76	12.23	XXXX		
41	12.33	XXXX		
37	12.35	XXXX		
30	12.36	XXXX		
56	12.37	XXX		
33	12.41	XXX		
62	12.44	XXX		
31	12.53	XX		
34	12.74	XX		
44	12.76	XX		
43	13.09	XX		
2	13.24	X		
24	13.44	X		
68	13.44	X		
27	14.61	X		
7	14.62	X		
22	14.72	XX		

19	14.75	XXX
12	14.81	XXXX
6	14.86	XXXXXX
15	14.95	XXXXXXX
13	14.97	XXXXXXX
16	14.98	XXXXXXX
5	14.99	XXXXXXX
21	15.00	XXXXXXX
11	15.09	XXXXXX
17	15.11	XXXXXX
14	15.18	XXXX
8	15.19	XXX
10	15.19	XXX
9	15.19	XXX
4	15.23	XXX
20	15.28	XX
25	15.35	X
3	16.03	X
26	16.04	X
40	16.69	X

Based on these results, we can conclude that the mean length of the needle range from 11.64 to 16.69 mm. The minimum average value of 11.64 mm was found in the tree number 78, and a maximum value of 16.69 mm was found in the tree number 40. Differences between mean values were statistically significant, and the trees are grouped into several homogeneous groups.

Summary statistics, the analysis of variance and LSD test for the width of needles of various test trees of taxodium from Great War Island are shown in Table 3.

Table 3: Summary statistics, the analysis of variance and LSD test for the width of needles of various test trees of taxodium from Great War Island

Number of test tree	Min (mm)	Max (mm)	Average value (mm)	Standard deviation
2	1	1.5	1.06	0.17
3	1	1.6	1.16	0.18
4	1	1.6	1.14	0.18
5	1	1.6	1.14	0.18
6	1	1.5	1.05	0.15
7	1	1.7	1.19	0.18
8	1	1.5	1.03	0.12
9	1	1.5	1.12	0.22
10	1	1.0	1.00	0.00
11	1	1.6	1.22	0.19
12	1	1.0	1.00	0.00
13	1	1.5	1.24	0.25
14	1	1.5	1.11	0.21
15	1	1.6	1.18	0.18
16	1	1.7	1.20	0.20
17	1	1.7	1.15	0.17
19	1	1.6	1.06	0.14
20	1	1.0	1.00	0.00
21	1	1.6	1.24	0.16
22	1	1.6	1.09	0.16

23	1	1.6	1.14	0.17
24	1	1.6	1.10	0.16
25	1	1.5	1.12	0.21
26	1.1	1.6	1.31	0.15
27	1	1.8	1.49	0.21
28	1	1.5	1.09	0.19
29	1	1.0	1.00	0.00
30	1	1.8	1.33	0.25
31	1	1.0	1.00	0.00
32	1.1	1.8	1.39	0.17
33	1	1.0	1.00	0.00
34	1	1.8	1.30	0.22
35	1	1.7	1.24	0.24
36	1	1.8	1.22	0.27
37	1	1.9	1.30	0.24
38	1.1	1.8	1.35	0.17
39	1	1.5	1.14	0.22
40	1	1.8	1.10	0.19
41	1	1.0	1.00	0.00
43	1.1	1.8	1.38	0.18
44	1	1.8	1.17	0.22
56	1	1.8	1.22	0.24
62	1	1.0	1.00	0.00
63	1	1.5	1.16	0.24
68	1	1.5	1.05	0.15
76	1	1.7	1.13	0.21
78	1	1.6	1.05	0.14
82	1	1.8	1.19	0.22
<b>Analyses of variance</b>				
Among provenances		Mean Square	F-Ratio	P-Value
		1.43636	44.58	0.0000
<b>LSD test</b>				
	Average value	Homogeneous groups		
33	1.00	X		
41	1.00	X		
31	1.00	X		
29	1.00	X		
12	1.00	X		
10	1.00	X		
62	1.00	X		
20	1.00	X		
8	1.03	XX		
78	1.05	XX		
6	1.05	XX		
68	1.05	XX		
19	1.06	XXX		
2	1.06	XXX		
24	1.10	XXX		
22	1.10	XXXX		
28	1.10	XXXX		
40	1.10	XXX		
14	1.11	XXX		
25	1.12	XXXX		
9	1.12	XXXX		
76	1.13	XXXXX		
39	1.14	XXXXXX		
23	1.14	XXXXXXXX		
5	1.14	XXXXXXXX		



4	1.14	XXXXXXXX
17	1.15	XXXXXX
3	1.16	XXXXXX
63	1.16	XXXXX
44	1.17	XXXXX
15	1.18	XXXX
7	1.19	XXXX
82	1.19	XXX
16	1.20	XXX
56	1.22	XX
36	1.22	XX
11	1.22	XX
35	1.24	X
13	1.24	X
21	1.24	X
37	1.30	X
34	1.30	X
26	1.31	XX
30	1.33	XX
38	1.35	XX
43	1.38	X
32	1.39	X
27	1.49	X

Based on the results of needles width, it can be concluded that the mean values of the analyzed traits range from 1.00 mm to 1.49mm. The minimum value is 1 mm, while the maximum one is 1.9 mm. Differences between mean values were statistically significant.

## DISCUSSION

The results of this study can be used as a basis for evaluation of taxodium adaptive capacity in the area of Great War Island through a comparative analysis of results obtained in similar studies in a more or less homogeneous environment conditions. Table 4 shows the mean values of the analysed morphometric characteristics of twigs and needles in 48 test trees from the area of Great War Island as well as their variability range (min-max).

Table 4: Comparative analysis of the twigs length, length and width of needles of *Taxodium distichum* (L.) Rich.

Trait (average value, min-max)	The city of Belgrade (Dražić <i>et al.</i> , 2002)			Literature data (Jovanović, 1991)	Great War Island
	Topčider	Sajam	Sokobanjska		
Twigs length (mm)	87.4 44-211	76.2 41-121	91.2 41-146	50-100	<b>78.6</b> <b>69.5-</b> <b>152.16</b>
Needles length (mm)	9.6 8.5-11.2	8.3 6.8- 12.1	9.6 8.6-11.8	10-17	<b>13.71</b> <b>11.64-</b> <b>16.69</b>
Needles width (mm)	-	-	-	1	<b>1.15</b> <b>1-1.49</b>

Based on the aforesaid, it can be concluded that the values of the analysed parameters correspond to the ones found in literature. The twig length is a characteristic with a mean value of 78.6 mm at the population level, which is less than the mean value of trees growing on the green areas of Belgrade (Dražić et al., 2002). The mean value of the needle length (13.71 mm) in 48 trees from the area of Great War Island is significantly higher compared to average values of trees growing at different locations in Belgrade. The same can be said for the width of the needle as its average value is higher than the mean literature value.

The interaction of genetic resources and environmental conditions in which the trees are growing resulted in the larger sizes of twigs in the green areas of Belgrade where the trees grow individually or in small groups, and have enough light. This is not the case with trees on Great War Island, which often grow in a dense stand and which, until recently did not have the appropriate care.

Dimensions of needles (length and width) can be considered as traits that are less affected by environmental factors, and that more are under genetic control, so a higher mean values of these traits at the level of population on Great War Island demonstrate a significant gene pool of this species.

## CONCLUSION

The adaptive potential of a species is determined by variability which implies recognizing a range of environmental conditions in habitats and morpho-anatomical and phenotypic traits of individuals in these habitats (Šijačić-Nikolic et al., 2010). The conducted research aimed at determining the adaptive potential of taxodium in Great War Island, through the analysis of morphometric characteristics of twigs and needles (leaves).

A district of Belgrade has a moderate continental climate (according to Kerner), ranging from sub-humid moist (C2) to the drier sub-humid (C1) - according to Thornthwait, with an average annual temperature of 11.5 C and the average annual amount of precipitation of 669.9 mm. The hottest month is July (22.1C), and the coldest month is January (-0.3 0C). Mean air temperature during the vegetation period is 18.3 0C (Dražić et al., 2002). In the area of Great War Island, in such a climate and with periodic flooding and high groundwater level, the analyzed taxodium populations show good adaptive potential, both on the basis of growth parameters (Šijačić-Nikolic et al., 2011) and on the basis of morphological characteristics of twigs and needles, which is also confirmed with the given research results.

A high degree of inter population variability of evaluated adaptive traits indicate a significant genetic potential, contained in a number of well-adapted genotypes on Great War Island. Bearing in mind that, in addition to seed stand in Backa Palanka, this is one of two major populations of this species in our country, it can be considered a good base for the selection of well-adapted genotypes that can be used for the population conservation and breeding. This, in particular, becomes more important if we take into account climate changes and extending of the floodplain habitats, where many native species of trees lose their vitality and/or disappear, so it is necessary to look for new, alternative species.

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**VARIJABILNOST TAKSODIJUMA KAO OSNOVA  
ZA PROCENU NJEGOVOG GENOFONDA  
NA PODRUČJU VELIKOG RATNOG OSTRVA**

**SAŽETAK**

Rod *Taxodium* Rich. je nekada bio široko rasprostranjen u Evropi i Sjevernoj Americi. Danas postoje samo tri vrste iz južnih dijelova Sjeverne Amerike i Meksika: *Taxodium ascendens* Brogn., *Taxodium distichum* (L.) Rich. i *Taxodium mucronatum* Ten. Od prirode raste na zasićenim i periodično plavnim zemljištima u jugoistočnim i zalivskim oblastima SAD-a, od Luiziane do Floride. U Srbiji, uglavnom, raste *Taxodium distichum* (L.) Rich. na močvarnim i plavnim terenima. Najčešće se javlja u vidu pojedinačnih stabala, koja rastu na zelenim površinama urbanih sredina. Veće skupine stabala evidentirane su u okolini Bačke Palanke, gdje je registrovana jedina sjemenska sastojina, i na teritoriji Velikog ratnog ostrva, gdje svojom brojnošću i varijabilnošću predstavlja jedinstven genofond ove vrste u Srbiji, sadržan u preko 80 dobro adaptiranih genotipova. Procjena varijabilnosti morfometrijskih karakteristika grančica i četina obavljena je na nivou 48 genotipova koji su selekcionisani unutar postojećeg genofonda. Odabrani genotipovi pripadaju višem debljinskom stepenu i rastu van gustog sklopa. Na uzorku od 100 grančica i četina, sa svakog genotipa, analizirana je dužina grančica (mm), dužina i širina četina (mm). Prikupljeni podaci, na nivou 14400 merenja, obrađeni su kompjuterskim programom *Statgraph 6.0*. Urađena je deskriptivna statistika, analiza varijanse i LSD-test. Srednje vrijednosti se za dužinu grančica kreću u dijapazonu od 69,52 mm do 152,16 mm, za dužinu četina od 11,64 mm do 16,69 mm i za širinu četina od 1,00 mm do 1,49 mm. Ove vrijednosti ukazuju na veliku unutarpopulacionu varijabilnost, koja predstavlja polaznu osnovu za konzervaciju i usmereno korišćenje genofonda ove alohtone i retke vrste na području Srbije.

**Ključne riječi:** močvarni taksodijum, dužina grančica, dužina i širina četina, varijabilnost, genofond