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ANALYSIS OF THE GROWTH OF COMMON BEECH PROVENANCES (*Fagus sylvatica L.*) IN THE INTERNATIONAL EXPERIMENT NEAR KAKANJ

Analiza rasta provenijencija obične bukve (*Fagus sylvatica* L.) u međunarodnom pokusu kod Kaknja

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Abstract
This paper presents the results of the research of the provenances of beech (*Fagus sylvatica* L.) in an experiment near Kakanj. Experiments of the provenances were established during the spring of 2007 with 2+0 and 3+0 years-old seedings. The plants were planted in the experimental design of randomized block system in three replications. The results of the survival of plants in 2007, 2008 and 2009, and the root collar diameter of plants and plant height in 2009 are presented in this paper.
Studies of the plants' survival show that the highest percentage of survival rate had the provenance Tešanj – Crni Vrh I, while the lowest percentage of survival rate had provenance Bugojno Vranica - Bistrica. The analysis of the variance showed a statistically significant difference between the provenances, which was confirmed by the Duncan test. Romania provenance Alka - Iulia (10.14 mm) and the Swiss provenance Sihlwald (10.45 mm), had the smallest diameter of the root collar. Provenance from Croatia Dilj Čanglinski (19.43 mm) and provenance Varani kamen (18.46 mm) had the biggest diameter. The greatest average height had a provenance from Croatia Dilj Čanglinski (93.21 cm) and provenance Varani kamen (92.88 cm). The lowest level of height had provenance Alka Romania - Iulia (43.48 cm) and provenance Alesd (52.71 cm).

Keywords: common beech (*Fagus sylvatica* L.), provenances, survival, root collar diameter, height.

INTRODUCTION - *Uvod*

According to its ecological, social and economic value, common beech (*Fagus sylvatica L.*) belongs to the most important species of forest trees. In Europe, it covers an area of about 14 million hectares (VON WÜEHLISCH 2010) and it is one of the

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most important broad-leaved plants. Large areas of beech are found in the countries of the Balkan Peninsula, France, Germany, Denmark, Switzerland and Italy (VON WÜEHLISCH 2008). In Bosnia and Herzegovina (MATIĆ ET AL. 1971), the total forest area, which is 2.5 million hectares, consists of beech 13.3%, mixed fir and beech with spruce about 22.4% and beech coppice and scrub around 12.6%, which means that the beech is represented in Bosnia and Herzegovina in about 48.35% of forest areas, while FUKAREK described its spreading (1970).

The importance of beech and beech forests can also be seen from its representation in the wood for cutting in Bosnia and Herzegovina. Thus, about 90% of the total cutting volume of broad-leaved plants in BiH goes on beech wood, which is approximately 2.5 million m^3 per year (MATIĆ ET AL. 1971), and as such is irreplaceable.

Unfortunately, the health status of beech is not good and has a tendency of continuous deterioration. Weak and unstable system of management might impact the stability of beech forests which results in the appearance of a red heart and wood rots and fungal diseases of beech which in Croatia was reported by GLAVAŠ ET AL. (1997), while for Bosnia and Herzegovina we do not have specific information.

Historically, here and in Europe, beech survived extremely unfavourable climatic and geological changes during the Quaternary, but survived in the so-called glacial refuges. These are direct ancestors of the present population of beech (GÖMÖRY 1999), which was confirmed at the genetic level and in several other studies. Similar results were found by BRUS (1999) when the study included the Bosnian populations, which show a large variability in contrast to other studied populations.

The first studies with provenances of common beech have started by establishing the first experiment in Germany KIENITZ (1886), and later the experiment was established in Belgium, Denmark, France and other European countries (VIDAKOVIĆ AND KRSTINIĆ 1985), and in Croatia, which was reported by GRAČAN AND IVANKOVIĆ (2001).

The importance of provenance research, suggests that individual variability derived morphological, physiological and economically important capacities of beech, has great importance for the selection and the subsequent recognition of seed stands and breeding beech, which reported GRAČAN (2003) for Croatia.

The aim of this study is to examine provenance variability of common beech originating from 22 European provenances.

MATERIALS AND METHODS – *Materijal i metoda rada*

Field experiment with 22 provenance of common beech (Table 1)was established in spring 2007 in the Forest management unit (FMU) number 41 which belongs to "G.J. Donja Trstionica - Goruša. Š.G.P Kakanjska". It is located at 510 to 540 meters above sea level in the catchment area of the Lužnički potok, which is the

right tributary of the river Goruša and Goruša is the right tributary of the Bosna River (44°04'18'', 18°11'39'', altitude 538 m s.l.). Exposure is generally northeast.

The type of soil that prevails are the complex of rendzina and acid brown soil; complex of acid brown and luvisol soil; brown soil (on a smaller surface area) follow. With regard to geographical location and altitude, we can say that the section belongs to the temperate continental climate characterized by cold winters and moderately warm summers with high precipitation.

Table 1. Investigated provenances of beech *Fagus sylvatica* L. in the Kakanj experiment
Tablica 1. Istraživane provenijencija bukve Fagus sylvatica L. u pokusu Kakanj

No	Code of provenance.	Provenance	Olds	Country
1	9624	Croatia Dilj Čanglinski	3+0	Croatia - HR
2	9625	Croatia Varani kamen	3+0	Croatia - HR
3	9630	BiH Tajan – Zavidovići	3+0	Bosnia and Herzegovina - BIH
4	9631	BiH Konjuh - Kladanj	3+0	Bosnia and Herzegovina - BIH
5	9632	BiH Crni Vrh – Tešanj I	3+0	Bosnia and Herzegovina - BIH
6	9633	BiH Grmec - Jasenica	3+0	Bosnia and Herzegovina - BIH
7	9642	Hungary Valkonya	3+0	Hungary - HU
8	9643	CH Herzogenbuchsee	3+0	Swiss - CH
9	9646	D-BW Wildbad.	3+0	Germany - DE
10	9647	D-BW Schwaeb. Alb	3+0	Germany - DE
11	9648	D-BY Hoellerbach	3+0	Germany - DE
12	9649	D-NS Hasbruch	3+0	Germany - DE
13	9659	BiH Bugojno Vranica-Bistrica	2+0	Bosnia and Herzegovina - BIH
14	9660	BiH Tešanj Crni vrh II	2+0	Bosnia and Herzegovina - BIH
15	9661	BiH Bosanska Krupa Bastra Čorkovaća	2+0	Bosnia and Herzegovina - BIH
16	9662	BiH Devrek Tefen Dinara	2+0	Bosnia and Herzegovina - BIH
17	9663	RO Alesd	2+0	Romania - RO
18	9664	RO Alka-lulia	2+0	Romania - RO
19	9665	CH Sihlwald	2+0	Swiss - CH
20	9666	Serbia Avala	2+0	Serbia - SR
21	9668	Serbia Fruska gora	2+0	Serbia - SR
22	9669	Serbia Cer	2+0	Serbia - SR

This site is characterised by appearance of temperature inversions and the formation of frost area because the trail is located in a valley from where the colder heavier air to lower elevations is prevented by surrounding hills, and this leads to "accumulation" of cold air and the occurrence of extremely low temperatures in winter, which have much lower values than in the surrounding areas.

9624	9625	9630	9631	9632	9633	9642	Block I
9643	9646	9647	9648	9649	9659	9660	
9661	9662	9663	9664	9665	9668	9669	
9632	9633	9642	9643	9646	9647	9648	Block II
9649	9659	9660	9661	9662	9663	9664	
9665	9666	9668	9669	9624	9625	9630	
9646/63	9647	9648	9649	9659	9660	9661	Block III
9662	9663	9664	9665	9665	9669	9624	
9625	9630	9632	9633	9642	9643	X	

Figure 1 Schematic diagram of the experimental plot Kakanj
Slika 1. Shematski prikaz pokusne plohe Kakanj

The field experiment was set up with plants 2+0 and 3+0 years old. Plants are planted in systematic arrangement of the space of 10 by 10 m. The plants were planted at a distance 2 x 1 m. Fifty plants were planted in a provenance, 20 provenances with three replications and two provenances with one replications, and those provenances are Konjuh and Avala. Provenance Wildbad, has only 20 plants and we supplemented it with a proven Alesd which has 30 plants. A total of 3100 plants were planted (Fig.1).

To avoid confusion during the measurements with the natural newly grown plants, the planting of each plant done according to a predetermined schedule. Moreover, most of natural, newly grown plants were removed. To avoid damage from domestic animals, the area is surrounded by a wooden fence.

Field work and statistical analysis of data - *Rad na terenu i statistička obrada podataka*

In order to determine the variability between provenances in the experiment of their establishment, observations of some morphological characteristics were performed (height, root colar diameter). Recording of survival, autumn 2007, 2008 and 2009, the measured height of plants and root collar diameter, autumn 2009.

The obtained data were statistically analyzed through analysis of variance on provenance and the areas, and they were tested by Duncan-test.

In addition, Cluster analysis was performed in order to have a grouping of the studied provenances. The statistics program was applied for the analysis, as well as the software package SAS System for Windows VER.8.02 software.

RESULTS OF RESEARCH – *Rezultati istraživanja*

Survival of plants - *Preživljavanje*

The largest percentage of survival in 2007 was registered in the provenance from Bosnia and Herzegovina - Tešanj- Crni Vrh I (99.3%) and Croatia - Dilj Čanglinski (98.7%). The lowest survival rate was registered in the provenance from Bosnia and Herzegovina (Bugojno Vranica - Bistrica) with only 67.3% of surviving plants and Switzerland (Sihlwald) with survival rate of 72.5%. In conclusion, the overall planting success rate of the experiment was 87.83% (Table 2).

The highest percentage of survival in 2008 was registered in the provenance from Germany (D-Hasbruch NS) - 93.4%, and provenance from Bosnia and Herzegovina (Crni Vrh - Tešanj I) with survival of 91.4%. The lowest survival rate of plants had a provenance from Bosnia and Herzegovina (Tuzla Vranica - Bistrica) only 50% and (Tesanj- Crni Vrh II) with survival rate 52%. The planting survival rate of the overall experiment in 2008 was 75.8% (Table 2).

Table 2. Survival of plants in 2007, 2008 and 2009
Tablica 2. Preživljavanje biljaka u 2007, 2008 i 2009 godine.

					2007.		2008.		2009.	
No.	Code of provenance.	Provenance	Country	No. plants	Pieces	% survival	Pieces	% survival	Pieces	% survival
1	2	3	4	5	6	7	8	9	10	11
1	9624	Croatia Dilj Čanglinski	HR	150	148	98.7	135	90	131	87.4
2	9625	Croatia Varani kamen	HR	150	145	96.7	130	86.7	126	84
3	9630	BiH Tajan – Zavidovići	BIH	150	144	96	134	89.4	110	73.4
4	9631	BiH Konjuh - Kladanj	BIH	50	48	96	43	86	43	86
5	9632	BiH Crni Vrh – Tešanj I	BIH	150	149	99.3	137	91.4	134	89.4
6	9633	BiH Grmec - Jasenica	BIH	150	137	91.3	125	83.4	114	76

1	2	3	4	5	6	7	8	9	10	11
7	9642	Hungary Valkonya	HU	150	145	96.7	133	88.7	128	85.4
8	9643	CH Herzogenbuchsee	CH	150	145	96.7	111	74	106	70.7
9	9646	D-BW Wildbad.	DE	120	116	96,7	108	90	102	85
10	9647	D-BW Schwaeb. Alb	DE	150	147	98	129	86	124	82.7
11	9648	D-BY Hoellerbach	DE	150	139	92.6	113	75.4	111	74
12	9649	D-NS Hasbruch	DE	150	146	97.3	140	93.4	136	90.7
13	9659	BiH Bugojno Vranica Bistrica	BIH	150	101	67.3	75	50	65	43.4
14	9660	BiH Tešanj Crni vrh II	BIH	150	120	80	18	52	75	50
15	9661	BiH Bosanska Krupa Bastra Čorkovaća	BIH	150	135	90	117	78	113	75.4
16	9662	BiH Devrek Tefen Dinara	BIH	150	121	80.7	112	74.7	106	70.7
17	9663	RO Alesd	RO	180	139	77.2	115	63.9	136	75.6
18	9664	RO Alka-Iulia	RO	150	111	74	81	54	80	53.7
19	9665	CH Sihlwald	CH	200	145	72.5	134	67	130	65
20	9666	Srbija Avala	SR	50	46	92	38	76	36	72
21	9668	Srbija Fruska gora	SR	100	82	82	75	75	71	71
22	9669	Srbija Cer	SR	150	114	76	89	59.4	84	56
			Total	3100	2723	87.83	2352	75.8	2261	72.9

The highest percentage of survival in 2009 was registered in the provenance from Germany (D-NS Hasbruch) - 90.7% and provenance from Bosnia and Herzegovina (Crni Vrh - Tešanj I) with survival of 89.4%. Lowest survival rate of plants had the provenance from Bosnia and Herzegovina (Tuzla Vranica - Bistrica) with only 43.4 of plant's survival. It was followed by the provenance from Switzerland (Sihlwald) with plant survival of 72.5%. The planting survival rate of the overall experiment in 2008 was 72.9%.

The root collar diameter – *Promjer korijenskog vrata*

In the provenance experiment for the plant age, four and five years provenance Alka – Iulia had 10.14 mm and Sihlwald 10.45 mm, had a minimum of the rot collar diameter. The largest diameter had provenances Dilj Čanglinski (19.43 mm) and Varani kamen (18.46 mm). The coefficient of variability of the root collar diameter ranged between 20.93 in the Varani kamen provenance and 41.08% for the Tešanj – Crni Vrh II provenance.

Table 3: Details of the root neck diameter of 22 provenances (mm)
Tablica 3: Podaci promjera korijenskog vrata za 22 provenijencije (mm)

Code of provenance	Provenance	Average	Min	Max	Std. Dev	C.V.%
9642	Hungary Valkonya	17.51	7.00	27.00	4.29	24.53
9633	BiH Grmec - Jasenica	17.49	8.00	29.00	4.38	25.04
9632	BiH Crni Vrh – Tešanj I	16.54	5.00	27.00	3.89	23.56
9631	BiH Konjuh - Kladanj	18.27	10.00	26.00	4.13	22.62
9630	BiH Tajan – Zavidovići	17.50	8.00	29.00	4.35	24.86
9625	Croatia Varani kamen	18.46	10.00	27.00	3.86	20.93
9624	Croatia Dilj Čanglinski	19.43	6.00	41.00	5.07	26.10
9660	BiH Tešanj Crni vrh II	11.89	4.00	27.00	4.88	41.08
9659	BiH Bugojno Vranica Bistrica	12.72	4.00	22.00	3.89	30.59
9649	D-NS Hasbruch	15.41	8.00	23.00	3.55	23.03
9648	D-BY Hoellerbach	14.25	5.00	24.00	3.84	26.93
9647	D-BW Schwaeb. Alb	15.56	9.00	28.00	3.80	24.43
9646	D-BW Wildbad	15.14	8.00	28.00	3.75	24.76
9643	CH Herzogenbuchsee	16.32	7.00	28.00	4.44	27.25
9669	Srbija Cer	11.53	5.00	20.00	3.55	30.80
9668	Srbija Fruska gora	12.51	4.00	20.00	3.39	27.16
9665	CH Sihlwald	10.45	4.00	19.00	2.95	28.27
9664	RO Alka-Iulia	10.14	3.00	19.00	3.17	31.32
9663	RO Alesd	10.96	5.00	20.00	3.01	27.49
9662	BiH Devrek Tefen Dinara	13.72	4.00	26.00	4.21	30.67
9661	BiH Bosanska Krupa Bastra Čorkovaća	13.09	6.00	21.00	3.29	25.18
9666	Srbija Avala	15.34	4.00	24.00	3.76	24.54

The analysis of the variance showed statistically significant differences between provenances for the root collar diameter (Table 4).

Table 4. Analysis of variance for the root neck diameter
Tablica 4. Analiza varijanse za svojstvo promjera korijenskog vrata

Variability	D.F.	Sum	Average of sum	F	Pr>F
Provenance.	22	23833.209	1134.914	6.976	<0.0001
Error	2137	347637.34	162.675		
Total	2158	371470.55			

Provenances were grouped into nine groups by Duncan test (Table 5). From the results it can be seen that provenance Croatia Dilj Čanglinski did not have links with other provenances. Other provenances showed great variability in terms of the diameter. The highest variability was found in group 4 which has seven common provenances with other groups.

Table5. Overview of groups according to the average diameter of root collar of the studied provenances (Duncan Test)
Tablica 5: Prikaz skupina prema prosječnim promjerima korijenskog vrata istraživanih provenijencija (DUNCANOV TEST)

No.	Code of provenance	Provenace	Group								
			1	2	3	4	5	6	7	8	9
1	9665	CH Sihlwald	A								
2	9663	RO Alesd	A								
3	9668	Srbija Fruska gora	A								
4	9664	RO Alka-Iulia	A	B							
5	9669	Srbija Cer		B	C						
6	9661	BiH Bosanska Krupa Bastra Čorkovaća		B	C						
7	9659	BiH Bugojno Vranica Bistrica		B	C	D					
8	9662	BiH Devrek Tefen Dinara			C	D	E				
9	9660	BiH Tešanj Crni vrh II			C	D	E				
10	9647	D-BW Schwaeb. Alb			C	D	E				
11	9666	Srbija Avala				D	E	F			
12	9649	D-NS Hasbruch				D	E	F			
13	9648	D-BY Hoellerbach				D	E	F			
14	9646	D-BW Wildbad					E	F			
15	9642	Hungary Valkonya						F	G		
16	9632	BiH Crni Vrh – Tešanj							G	H	
17	9631	BiH Konjuh - Kladanj							G	H	
18	9630	BiH Tajan – Zavidovići							G	H	
19	9633	BiH Grmec - Jasenica							G	H	
20	9643	CH Herzogenbuchsee							G	H	
21	9625	Croatia Varani kamen								H	
22	9624	Croatia Dilj Čanglinski									I

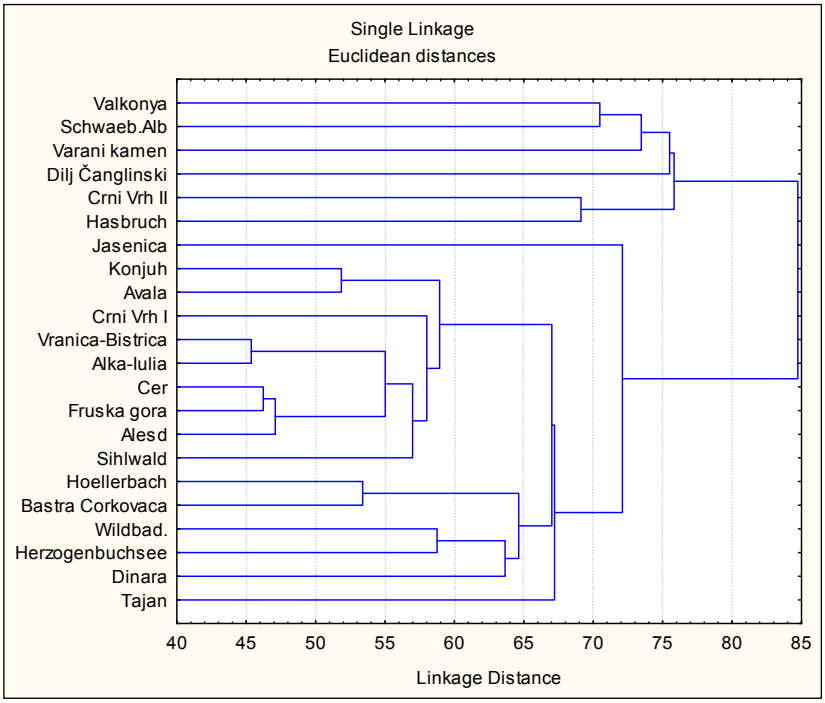

Figure 2. Dendogram of the cluster analysis for the status of the root collar diameter
Slika 2. Dendogram klaster analize za svojstvo promjera korijenskog vrata

If we evaluate the results of cluster analysis (Figure 2) for diameter of the root collar, we could also notice two distinct groups of provenances.

Having in mind the distance between provenances within these two groups, it can be concluded that the distance is fairly homogeneous.

Height of plants – *Visine biljaka*

In the provenance trial in 2009, Dilj Čanglinski was highest with 93.21 cm and provenance Varani kamen with 92.88 cm. The lowest height had the provenance Alka-Iulia (43.48 cm) and a provenance Alesd (52.71 cm). The coefficient of variation of the studied provenances for the height ranges between 33.89% in provenance Sihlwald to 49.08% in the Tešanj - Crni Vrh I provenance (Table 6).

Table 6: Data of height for 22 provenance (cm)
Tablica 6: Podaci visina za 22 provenijencije (cm)

Code of provenance	Provenance	Average	Min	Max	Std. Dev	C.V.%
9642	Hungary Valkonya	84.36	20.00	161.00	31.90	37.81
9633	BiH Grmec - Jasenica	76.22	18.00	161.00	29.41	38.59
9632	BiH Crni Vrh – Tešanj	75.71	20.00	157.00	29.15	38.50
9631	BiH Konjuh - Kladanj	78.53	12.00	145.00	36.12	45.99
9630	BiH Tajan – Zavidovići	86.63	11.00	159.00	36.04	41.61
9625	Croatia Varani kamen	92.88	11.00	175.00	35.58	38.31
9624	Croatia Dilj Čanglinsk	93.21	11.00	195.00	37.56	40.29
9660	BiH Tešanj Crni vrh II	79.65	15.00	154.00	39.10	49.08
9659	BiH Bugojno Vranica Bistrica	68.94	20.00	128.00	29.80	43.23
9649	D-NS Hasbruch	76.13	22.00	145.00	28.88	37.93
9648	D-BY Hoellerbach	64.66	20.00	138.00	26.78	41.42
9647	D-BW Schwaeb. Alb	69.52	15.00	149.00	26.32	37.86
9646	D-BW Wildbad	70.23	11.00	170.00	29.66	42.23
9643	CH Herzogenbuchsee	86.42	20.00	199.00	37.33	43.20
9669	Srbija Cer	57.16	23.00	122.00	25.41	44.46
9668	Srbija Fruska gora	64.80	19.00	131.00	26.92	41.55
9665	CH Sihlwald	56.22	17.00	110.00	19.05	33.89
9664	RO Alka-Iulia	43.48	10.00	104.00	20.57	47.31
9663	RO Alesd	52.71	14.00	121.00	21.40	40.59
9662	BiH Devrek Tefen Dinara	66.50	11.00	150.00	26.81	40.31
9661	BiH Bosanska Krupa Bastra Čorkovaća	62.37	20.00	110.00	22.17	35.54
9666	Srbija Avala	79.52	18.00	146.00	29.50	37.09

Statistically significant differences between the studied provenances were obtained by analysis of variance for the height of the studied provenances (Table 7).

Table 7. Analysis of variance for the height
Tablica 7. Analiza varijanse za svojstvo visina

Variability	D.F.	Sum	Average of sum	F	Pr>F
Provenance.	21	366823,04	17467,764	19,537	<,0001
Error	2206	1972298,3	894,06		
Total	2227	2339121,3			

Analysis of the total height done by Duncan test (Table 8) also shows that there are significant differences between provenances. Provenances were formed into ten groups by Duncan test. From the results we can see that provenance RO Alka-Iulia has not links with other provenances. It has the lowest plants, and the highest was reported for provenance 9624. Other provenances show great variability in terms of height. The most variable is group 6 which has seven common provenances with other groups.

Based on previously obtained results it is evident that there is a major variation between provenances in their height. The obtained results are presented in the form of dendrograms (Figure 3.) where the branching of particular provenances is done, or better to say their linking into specific clusters. Provenances from different geographic areas participated in the formation of clusters.

If we evaluate the results of cluster analysis for the height, we will notice two distinct groups of provenances with smaller subgroups, but one group consists only two provenances.

The first group consists of Valkonya, Herzogenbuchsee, Varani kamen, Fruska gora, Schwaeb. Alb, Wildbad, Crni vrh II, Alka – Iulia, Bastra Corkovaca, Cer, Sihlwald, Dinara, Hasbruch, Hoellerbach, Vranica-Bistrica, Tajan, Jasenica, Avala, Alesd and Dilj Čanglinski provenances. The closest connection within this group is made by Valkonya and Herzogenbuchsee provenances.

The other group comprise Crni Vrh I and Konjuh provenances.

Based on the results, only Crni Vrh I and Konjuh provenances show a logical connection, that cannot be said for other provenances.

These results also show that beech has been not genetically differentiated according to ecological and vegetation division, and that beech shows similar morphological and production characteristics from various fields, which means that many other factors affect the morphological productivity of beech.

It is also necessary to continue with this research to get accurate results, because the main conclusions can be made only after 1/3 of rotation/s for the given species.

Table 8. Overview of groups to the height of plants of the studied provenances (Duncan Test)
Tablica 8: Prikaz skupina prema visina biljaka istraživanih provenijencija (DUNCANOV TEST)

No.	Code of provenance	Provenance	Group									
			1	2	3	4	5	6	7	8	9	10
1	9664	RO Alka-Iulia	A									
2	9663	RO Alesd		B								
3	9665	CH Sihlwald		B	C							
4	9669	Srbija Cer		B	C	D						
5	9661	BiH Bosanska Krupa Bastra Čorkovaća			C	D	E					
6	9648	D-BY Hoellerbach			C	D	E					
7	9668	Srbija Fruska gora			C	D	E					
8	9662	BiH Devrek Tefen Dinara				D	E					
9	9659	BiH Bugojno Vranica Bistrica				D	E	F				
10	9647	D-BW Schwaeb. Alb					E	F				
11	9646	D-BW Wildbad					E	F	G			
12	9632	BiH Crni Vrh – Tešanj I						F	G			
13	9649	D-NS Hasbruch						F	G			
14	9633	BiH Grmec - Jasenica						F	G	H		
15	9631	BiH Konjuh - Kladanj						F	G	H	I	
16	9666	Srbija Avala						F	G	H	I	
17	9660	BiH Tešanj Crni vrh II							G	H	I	
18	9642	Hungary Valkonya								H	I	
19	9643	CH Herzogenbuchsee									I	J
20	9630	BiH Tajan – Zavidovići									I	J
21	9625	Croatia Varani kamen										J
22	9624	Croatia Dilj Čanglinsk										J

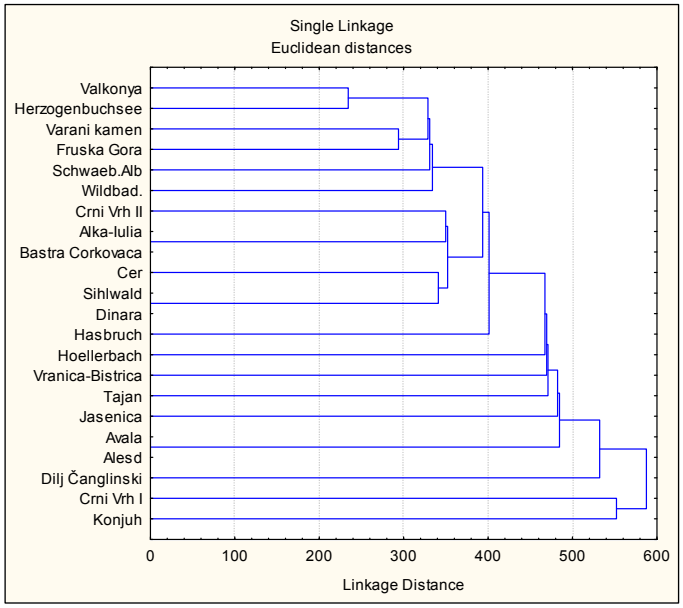

Figure 3 Cluster analysis dendrograms for the height
Slika 3 Dendogram klaster analize za svojstvo visina

DISCUSSION - *Rasprava*

Almost all studies of beech provenances are related to the problem of morphological characteristics, especially height, diameter and survival of the plants. Therefore, the studies of variability in height of beech provenance trials were established in Croatia and Slovenia (conducted by IVANKOVIĆ ET AL. 2008).

All former studies of beech provenances had the disadvantage that was reflected in the age lack of experimental surface of beech provenances. Comparing individual provenances was limited to some extent if one considers that the beech is sort that has a continuous growth.

The achieved heights at an early age may not be the measure by which one could accurately determine the growth of particular provenances, or evaluate which provenance has the fastest development, because often there is a change in the growth rate at the late age (HOFFMAN 1961). Similar results got PINTARIĆ (2000) while he was conducting research on larch.

Working on experimental areas established by KRAHL – URBAN (1958), KLEINSCHMIT (1985) we came to a significant conclusion that we cannot talk with certainty about populations of beech which grow faster until a tree on an experimental surface reaches the age of 40, or one-third of the rotation (VIDAKOVIC AND KRSTINIĆ 1985). Measuring the height of beech provenances at all age stages, proved that measurements at an early age give less reliable results. However, according to LARSEN

(1985), based on an early test, it is possible to predict that certain populations of beech will maintain good growth in later life development. His research shows that beech, going from north to south of range, consistently shows better growth. The research results obtained in this study confirm the allegations of Larsen that provenances in the southern portion grow better than those originating from the north Europe (Swiss, Germany, etc.)

The results obtained in this study of beech provenances are not valid yet, but they can be used for comparison purposes and getting an overall picture of morphological characteristics of individual provenances. The results indicate that the provenance from Croatia have the best growth, as opposed to the provenances of Romania that are the least on average. However, within a provenance, the plants show great variability in growth. Based on high variability and lack of age of the tested provenances, it cannot be concluded with certainty that the central European areal beech will grow slower or faster.

Looking through the analysis by area, for provenances from Bosnia and Herzegovina, it is also noted that the area which belongs to the provenance Tešanj - Crni Vrh I has a maximum value of height in relation to the provenance B. Krupa "Bastra Čorkova". Of the foreign provenances, the maximum value had the provenance from Croatia "Varani kamen." The values of medium heights of other provenances are in the middle with no clearly expressed significant differences and their height is average.

Researches of the diameter values for local provenances show that the maximum values have provenances "Konjuh" Kladanj, a minimum value has provenance Tešanj "Crni Vrh II" which is a year younger, and is measured at the age of four years.

Based on cluster analysis it can be seen that the provenances Crni Vrh I and Crni Vrh II are not in the same cluster, although they are originating from the same area. This is because the provenances are not of the same age and the seed was not collected in the same year in both provenances. Each year the quality of seed is different. One year, there are more male flowers than female and vice versa, and the same trees did not flourish. On the other hand the greatest familiarity is shown by provenance Crni Vrh I and Konjuh. These provenances are located at the same distance, which was expected because they descend from the same geological substrate of ofiolit zone of Bosnia and Herzegovina. At the same distance there are provenances Vranica - Bistrica, Tajan and Jasenica. Reasons for this should be searched for in the habitat from which these provenances originated.

Therefore, it can be concluded that beech is not genetically differentiated according to ecological and vegetation division, and that beech shows similar morphological and production characteristics from various areas, which implies that many other factors affect the morphological productivity of beech.

When it comes to the survival of plants in the experiment Kakanj, the highest survival had the provenance of Bosnia and Herzegovina (Tešanj- Crni Vrh I), and the

provenance from Croatia (Dilj Čanglinski), which practically means that local provenances have good adaptability, while the results obtained by IVANKOVIĆ ET AL. (2008) showed that the highest survival was reported for the Belgian provenance (Soigenes) and the provenances from Slovenia (Postojna - Mašun). An overall higher percentage (94.0%) of survival for the entire experiment was higher in the study of IVANKOVIĆ ET AL. (2008) as they apply agro-technical measures, while in the experiment Kakanj such measures were lacking, and plants were left to the natural process of adaptation.

CONCLUSIONS – *Zaključci*

The obtained results show that the smallest percentage of surviving plants is in the provenance from Bugojno "Vranica - Bistrica" while the largest percentage of surviving plants was registered in the provenance from Tešanj "Crni Vrh I". Total average number of surviving plants for the whole surface is 72.9%.

During this experiment, statistically significant differences for the height were obtained between twenty-two studied provenances where plants were four and five years old.

Provenances from Croatia and the Dilj Čanglinski Varani kamen provenance have reached the greatest average height. The lowest level had the Romanian provenances Alka-Iulia and provenance Alesd.

The analysed provenances, where plants were four and five years old, have shown statistically significant differences for characteristic of the root collar diameter. The Romania provenance Alka-Iulia and Swiss provenance Sihlwald had the lowest values of the root collar diameter. The highest diameters had the provenances of Croatia, Dilj Čanglinski and Varani kamen.

Statistically significant differences for height and diameter characteristics were confirmed by the Duncan test.

Based on the results it can be concluded that there are differences between provenance from different ecological niches, or better to say that environmental differences in the ecology of habitat are a cause of morphological differentiation between the populations.

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SAŽETAK

U ovom radu prikazani su rezultati istraživanja raznih provenijencija bukve (*Fagus sylvatica* L.) kod Kaknja. Pokusi provenijencija osnovani su tokom proljeća 2007. godine s biljkama starosti 2+0 i 3+0 godina. Cilj je bio provesti istraživanja među provenijencijske varijabilnosti obične bukve podrijetlom iz 22 europske populacije.

Biljke su posađene u pokusnom dizajnu randomiziranog blok sistema u tri ponavljanja.

Prikazani su rezultati preživljavanja biljaka u 2007., 2008. i 2009. godini, te promjer korijenskog vrata biljaka i visina biljaka na kraju vegetacionog perioda 2009 godine.

Dobiveni rezultati preživljavanja biljaka pokazuju da je najmanji procent preživljavanja kod provenijencije iz Bugojna „Vranica – Bistrica“ dok je najveći procent preživljavanja biljaka zabilježen kod provenijencije iz Tešnja „Crni Vrh I“. Ukupni prosječni broj preživjelih biljaka za čitavu plohu je 72,9%.

U pokusu su dobivene statistički značajne razlike za svojstvo visina između dvadeset dvije istraživane provenijencije u starosti biljaka četiri i pet godina. Najveće prosječne visine dostigle su provenijencije iz Hrvatske Dilj Čanglinski i provenijencija Varani kamen. Najniže visine imale su Rumunjske provenijencije Alka-Iulia i provenijencija Alesd.

Za svojstvo promjera korijenskog vrata istraživane provenijencije u starosti biljaka od četiri i pet godina pokazale su statistički značajne razlike. Rumunjska provenijencija Alka-Iulia i Švicarska provenijencija Sihlwald imale su najmanje promjere korijenskog vrata. Najviše promjere imale su provenijencije iz Hrvatske Dilj Čanglinski i provenijencija Varani kamen. Dancanovim testom potvrđeno je postojanje statistički značajne razlika za visine i promjere.

Na temelju rezultata može se zaključiti da postoje razlike među populacijama iz različitih ekoloških niša, odnosno da ekološke razlike u ekologiji staništa uvjetuju morfološku diferencijaciju među provenijencijama.