

MORPHOLOGICAL TRAITS OF SCOTS PINE (*Pinus sylvestris* L.) IN INTERNATIONAL PROVENANCE TESTS IN BOSNIA AND HERZEGOVINA

MORFOLOŠKE LASTNOSTI RDEČEGA BORA (*Pinus sylvestris* L.) V MEDNARODNIH PROVENIENČNIH TESTIH V BOSNI IN HERCEGOVINI

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ABSTRACT

Scots pine (*Pinus sylvestris* L.) is one of the most important tree species in European forests. This study aims to determine whether there is inter-provenance variability in researched morphological traits in two international provenance tests of Scots pine in Bosnia and Herzegovina.

We measured height, root collar diameter, and latest shoot length and counted branches on the latest branch whorl of Scots pine plants in two provenance tests. The provenance tests are located in Kupres and Žepče, in different climatic, edaphic, and orographic conditions. Kupres and Žepče contain 15 and 14 provenances, respectively, eleven of which are mutual to both sites. Descriptive statistics and analysis of variance showed differences among provenances in all investigated morphological traits. These differences were attributable to provenance test, provenance, and interaction between provenance test and provenance. The average values were higher in Žepče for all provenances and all studied traits. The Austria A1, Austria A2, Austria A3, and Poland P1 provenances showed the best growth in both tests, while the Italy I1 provenance showed good growth in Žepče but not in Kupres.

Key words: Scots pine, provenance tests, morphological traits

IZVLEČEK

Rdeči bor (*Pinus sylvestris* L.) je ena izmed najpomembnejših drevesnih vrst v Evropi. Pričujoča raziskava ugotavlja, ali med proveniencami, uporabljenimi v dveh provenienčnih testih rdečega bora v Bosni in Hercegovini, obstaja variabilnost preučevanih morfoloških lastnosti. Izmerili smo višino dreves, premer koreninskega vratu in dolžino terminalnega poganjka ter prešteli veje na najmlajšem vencu vej v dveh provenienčnih testih. Provenienčna testa sta locirana v Kupresu (15 provenienc) in Žepčah (14 provenienc) v različnih podnebni, edafskih in orografskih razmerah. Obema provenienčnima testoma je skupnih 11 provenienc.

Deskriptivna statistika in analiza variance kažeta na razlike med proveniencami pri vseh preučevanih morfoloških lastnostih, ki jih pripisujemo provenienčnim testom, proveniencam in interakciji med provenienčnim testom in provenienco. Povprečne vrednosti so bile za vse provenience in vse preučevane lastnosti višje v Žepčah. Provenience Avstrija A1, Avstrija A2, Avstrija A3 in Poljska P1 so v obeh testih izkazale najboljšo rast, medtem ko je bila izmerjena rast Italije I1 dobra v provenienčnem testu v Žepčah, ne pa tudi v Kupresu.

Ključne besede: rdeči bor, provenienčni testi, morfološke značilnosti

GDK 164+174.7Pinus sylvestris L.(497.6)(045)=111

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1 INTRODUCTION

1 UVOD

Scots pine (*Pinus sylvestris* L.) is one of the most important tree species in European forests (Mátyás et al., 2004) and is characterized by high genetic variability and complex population structure. In the Balkans, Scots pine is in a succession species, while populations of Scots pine in the Mediterranean region and Central Europe represent relict communities from the Pleistocene era (Mirov, 1967). Scots pine has a wide

geographical distribution - from the Iberian Peninsula and Scotland to the Far East and from Scandinavia to Asia Minor (Boratinsky, 1991). Therefore, Scots pine is one of the most studied forest tree species in Europe (Giertych and Matyas (eds.), 1991). The first international experiment, a progeny test, was established in 1907 by the International Union of Forest Research Organizations (IUFRO). Scots pine has been the subject of numerous morphological studies in Europe (Alia et al., 2001; Ballian et al., 2009; Cvjetković et al., 2014;

Barzdajn et al., 2016; Ballian and Šito, 2017; Gülcü and Bilir, 2017; Ballian and Lizdo, 2019).

The territory of Bosnia and Herzegovina represents the southern border of the natural distribution of Scots pine. Provenance tests in Bosnia and Herzegovina, therefore, represent an opportunity to determine the adaptability and variability of different provenances of Scots pine from all over Europe, at the southern border of its natural distribution. Thus, two international provenance tests were established in Bosnia Herzegovina (Kupres and Žepče) in 2012.

The study aims to determine whether there is inter-provenance variability in researched morphological traits in the Kupres and Žepče provenance tests in Bosnia and Herzegovina. The results of this study will enable the selection of Scots pine provenances with the best growth and adaptability and thus contribute to the in-situ and ex-situ conservation of the species.

2 MATERIAL AND METHODS

2 MATERIALI IN METODE

In this study, we measured height, root collar diameter, and latest shoot length and counted the branches on the latest branch whorl on eight-year-old Scots pine

plants in two international provenance tests in Bosnia and Herzegovina. Height was measured to an accuracy of one cm using a wooden measuring stick. Root collar diameter was measured to an accuracy of 0.1 mm using a digital caliper. Descriptive analysis, analysis of variance (one- and two-way ANOVA), and Duncan's multiple interval test were performed for different morphological traits using IBM SPSS STATISTICS 20.0.

The provenance tests were established in 2012 by planting two-year-old seedlings on two sites (Kupres and Žepče) with different climatic, edaphic, and orographic conditions. The Kupres and Žepče provenance tests contain 15 and 14 provenances, respectively, from nine countries (Table 1, Figure 1). Seedlings were planted in holes measuring 30×30×30cm, with a planting distance of 2×2m. In Kupres, 36 seedlings in five repetitions per randomized scheme were planted for each provenance (2700 seedlings in total), and in Žepče, 25 seedlings were planted in four repetitions (1400 seedlings in total).

The provenances originate from areas with different climates. Provenances from Austria, Slovakia, Poland, and Romania are from a temperate continental climate and those from Bosnia and Herzegovina from a

Table 1: List of investigated provenances in the Kupres and Žepče provenance tests

Preglednica 1: Seznam preučevanih provenienc v provenienčnih testih v Kupresu in Žepčah

Provenance Test(s)	Country	Provenance Label	Locality	Latitude	Longitude
Kupres Žepče	Austria	A1	Kobersdorf/Lackenbach	47°53'12«	15°31'39«
Kupres Žepče	Austria	A2	Panholz	47°07'14«	15°17'14«
Kupres Žepče	Austria	A3	Lans/Tirol	47°13'49«	11°26'12«
Kupres Žepče	Bosnia & Herzegovina	B1	Bugojno	44°03'00«	17°27'00«
Kupres Žepče	Germany	NJ2	Trippstadt	49°21'35«	7°46'29«
Kupres Žepče	Italy	I1	Ca Del Lupo	44°45'25«	9°05'07«
Kupres Žepče	Italy	I2	Fenestrelle (TO)	45°01'47«	7°03'38«
Kupres Žepče	Italy	I3	Valda (TN)	46°13'00«	11°16'00«
Kupres Žepče	Poland	P1	Ruciane – Nida	53°37'00«	21°29'00«
Kupres Žepče	Romania	R1	Sacueni	47°21'09«	22°05'29«
Kupres Žepče	Slovakia	SL1	Hanušovce	49°01'35«	21°30'01«
Kupres	Germany	NJ1	Teisendorf	47°51'00«	12°49'00«
Kupres	Norway	N1	Malvik	63°22'22«	10°45'03«
Kupres	Norway	N2	Arnes	60°07'20«	11°27'55«
Kupres	Ukraine	U1	Delyatyn	48°32'41«	24°30'10«
Žepče	Norway	N3	Narvik	68°25'14«	17°33'10«
Žepče	Scotland	S1	Shieldaig	57°36'24«	5°55'17«
Žepče	Ukraine	U2	Ivano Frankivsk	48°56'22«	24°31'52«

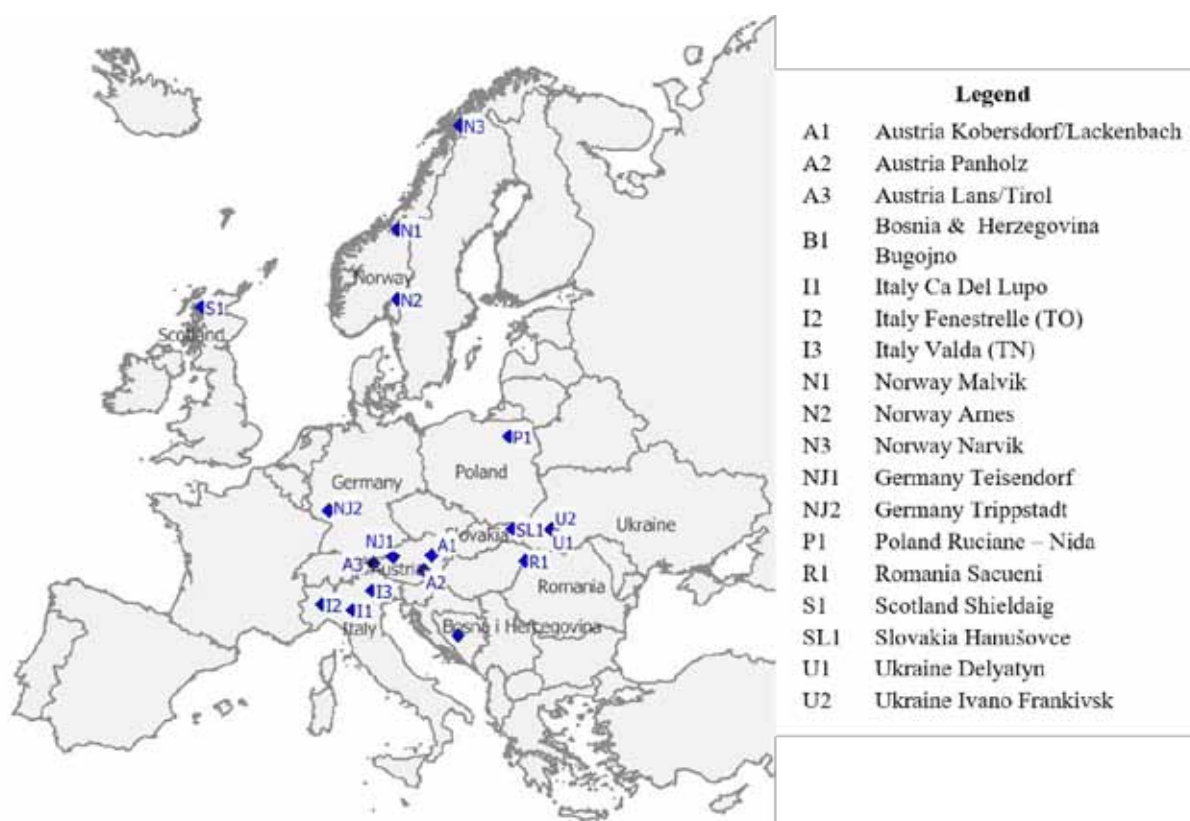


Fig. 1: Map of the spatial distribution of the studied provenances

Slika 1: Zemljevid prostorske razporeditve preučevanih provenienc

subalpine temperate continental climate. Provenances from Italy are from a continental climate and those from Germany from a moderately warm and humid climate influenced by the Atlantic Ocean. Provenances from Ukraine are from a continental climate, but from one of the coldest regions in Ukraine with an average daily maximum temperature of only 12 °C and frequent rainfall and wind. The Shildaig provenance from Scotland is from an oceanic climate.

The Kupres provenance test is located at an altitude of 1140 m, on terrain characterized by sinkholes and numerous hills and valleys. The soil type is calcocambisol or brown soil, and the geological substrates are limestones and dolomites. According to the classification of climate types in BiH (Milosavljević, 1973), this area belongs to the mountain climate, with short summers and long, cold, and very snowy winters. The mean annual air temperature is 6.2 °C. The minimum temperature was measured in January (-26.8 °C) and the maximum in September (34.9 °C). The annual average of registered frosts is 155 days. The average annual precipitation is 1221 mm, and its distribution varies slightly by season.

The Žepče provenance test is located at an altitude of 600 m in the oak and beech forest belt. The soil type is dystic cambisol. The climate (Milosavljević, 1973) in this area is temperate continental, with warm sum-

mers and harsh winters. The average annual air temperature is 10.7 °C, with the minimum temperature measured in January (-27.5 °C) and the maximum in August (39.5 °C). The annual average of registered frosts is 85 days. The average annual precipitation is 1040 mm.

3 RESULTS

3 REZULTATI

3.1 Plant height

3.1 Višina rastlin

Average plant height per provenance and provenance test is presented in Figure 2. The average height of all measured plants in Kupres and Žepče was 181.0 cm and 294.9 cm, respectively. Average height was higher in Žepče for all provenances. The Italy I1 provenance in Žepče had the highest average height.

The analysis of variance for height (Table 2) showed a statistically significant difference between provenances in both tests, with a probability of 95 %. Duncan's multiple interval test showed grouping of provenances in Kupres and Žepče into seven and eight overlapping groups, respectively.

Two-way analysis of variance (Table 3) showed statistically significant differences for provenance test (Sig. = 0.000), provenance (Sig. = 0.000), and provenance test × provenance interaction (Sig. = 0.000).

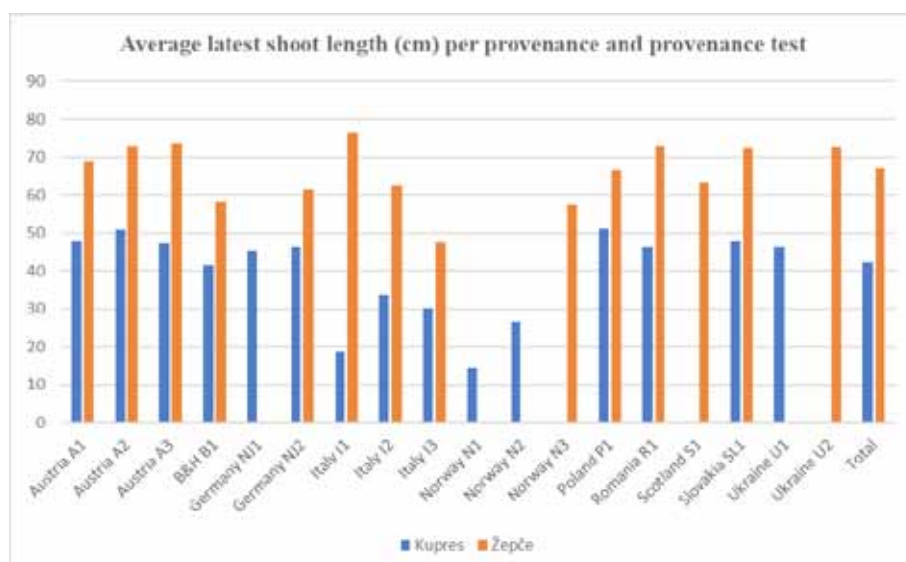


Fig. 2: Average height per provenance and provenance test

Slika 2: Povprečna višina glede na provenienco in provenienčni test

Table 2: Analysis of variance for height

Preglednica 2: Analiza variance višine

Source of Variation	Sum of Squares	Df	Mean Squares	F	Sig.	Duncan's Test Number of Groups
Kupres Provenance Test						
Between Groups	1961118.082	14	140079.863	60.743	0.000	7
Within Groups	3701289.841	1605	2306.100			
Total	5662407.923	1619				
Žepče Provenance Test						
Between Groups	878310.996	13	67562,384	10.434	0.000	8
Within Groups	4668816.369	721	6475.473			
Total	5547127.366	734				

Table 3: Two-way analysis of variance for height

Preglednica 3: Dvofaktorska analiza variance višine

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Provenance Test	5084878.343	1	5084878.343	1393.634	0.000	0.438
Provenance	802327.846	10	80232.785	21.990	0.000	0.110
Provenance Test × Provenance	791165.236	10	79116.524	21.684	0.000	0.108

Table 4: Analysis of variance for root collar diameter

Preglednica 4: Analiza variance premera koreninskega vrat

Source of Variation	Sum of Squares	Df	Mean Squares	F	Sig.	Duncan's Test Number of Groups
Kupres Provenance Test						
Between Groups	155866.958	14	11133.354	51.175	0.000	7
Within groups	349177.103	1605	217.556			
Total	505044.061	1619				
Žepče Provenance Test						
Between Groups	46328.465	13	3563.728	9.166	0.000	6
Within groups	280328.020	721	388.804			
Total	326656.484	734				

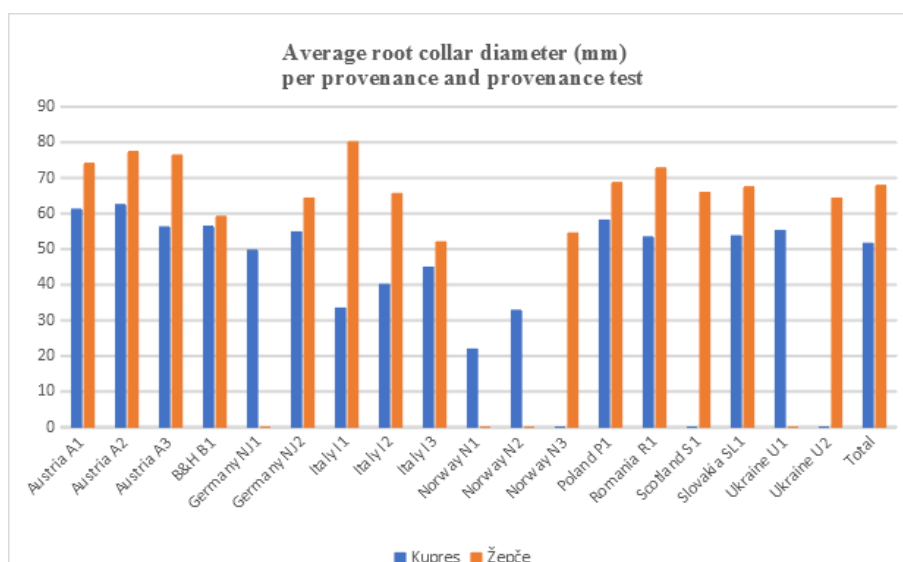


Fig. 3: Average root collar diameter per provenance and provenance test

Slika 3: Povprečen premer koreninskega vratu glede na provenienco in provenienčni test

Table 5: Two-way analysis of variance for root collar diameter

Preglednica 5: Dvofaktorska analiza variance premera koreninskega vratu

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Provenance Test	105152.836	1	105152.836	377.244	0.000	0.174
Provenance	54523.937	10	5452.394	19.561	0.000	0.099
Provenance Test × Provenance	40859.133	10	4085.913	14.659	0.000	0.076

3.2 Root collar diameter

3.2 Premer koreninskega vratu

Average root collar diameter per provenance and provenance test is presented in Figure 3. Average root collar diameter was 51.6 mm in Kupres and 67.9 mm in Žepče. Average root collar diameter was larger in Žepče compared to Kupres for all provenances. The Italy I1 provenance in Žepče had the largest average root collar diameter.

The analysis of variance for root collar diameter (Table 4) showed a highly statistically significant difference between provenances in both provenance tests, with a probability of 95 %. Duncan's multiple interval test showed grouping of provenances in Kupres and Žepče into seven and six overlapping groups, respectively.

Two-way analysis of variance (Table 5) showed statistically significant differences for provenance tests (Sig. =

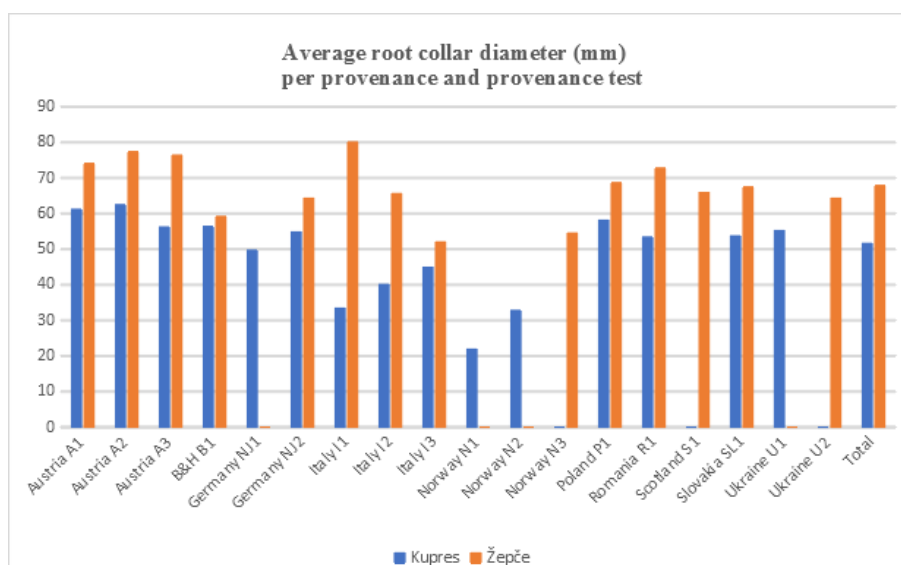


Fig. 4: Average latest shoot length per provenance and provenance test

Slika 4: Povprečna dolžina terminalnega poganjka glede na provenienco in provenienčni test

0.000), provenances (Sig. = 0.000), and provenance test × provenance interaction (Sig. = 0.000).

3.3 Latest shoot length

3.3 Dolžina terminalnega poganjka

Average latest shoot length per provenance and provenance test is presented in Figure 4. Average latest shoot length for all plants was 42.3 cm in Kupres and 66.8 cm in Žepče. Similar to height and root collar diameter, average latest shoot length was higher in Žepče compared to Kupres for all provenances. The Italy I1 provenance in Žepče had the highest average latest shoot length.

The analysis of variance for latest shoot length (Table 6) showed a highly statistically significant difference between provenances in both provenance tests, with a probability of 95 %. Duncan's test for latest shoot length showed grouping of provenances in Kupres and Žepče into eight and five overlapping groups, respectively.

Two-way analysis of variance (Table 7) showed statistically significant difference by provenance tests (Sig. = 0.000), provenances (Sig. = 0.000), and provenance test × provenance interaction (Sig. = 0.000).

3.4 Number of branches on the latest branch whorl

3.4 Število vej na najmlajšem vencu vej

The average number of branches on the latest branch whorl is presented in Figure 5. The average number of branches on the latest whorl was six in

Kupres and eight in Žepče. The average number of branches on the latest branch whorl was higher in Žepče for all provenances.

The analysis of variance for the number of branches on the latest whorl (Table 8) showed a highly statistically significant difference between provenances in Kupres and a statistically significant difference between provenances in Žepče, with a probability of 95 %. Duncan's multiple interval test showed a grouping of provenances in Kupres and Žepče into five and four overlapping groups, respectively.

Two-way analysis of variance (Table 9) showed statistically significant differences for provenance tests (Sig. = 0.000), provenances (Sig. = 0.008), and provenance test × provenance interaction (Sig. = 0.000).

4 DISCUSSION

4 RAZPRAVA

Scots pine has been the subject of numerous studies in Europe, both morphological and genetic, and there is a need for continued research, as the species is of very high value in modern forestry (Pintarić, 2002). Although molecular methods are dominant in population studies, morphometric methods still play a significant role in illustrating patterns of intra-provenance and inter-provenance variability (Zebec et al., 2010; Brus et al., 2011; Galvan et al., 2012; Jasińska et al., 2012; Paridari et al., 2013; Poljak et al., 2014; Zebec et al., 2014; Popović and Kerkez, 2016).

This study included 15 provenances in the Kupres

Table 6: Analysis of variance for latest shoot length

Source of Variation	Sum of Squares	Df	Mean Squares	F	Sig.	Duncan's Test Number of Groups
Kupres Provenance Test						
Between Groups	146373.477	14	10455.248	48.283	0.000	8
Within Groups	347328.328	1604	216.539			
Total	493701.805	1618				
Žepče Provenance Test						
Between Groups	43040.534	13	3310.810	9.371	0.000	5
Within Groups	254734.032	721	353.307			
Total	297774.566	734				

Preglednica 6: Analiza variance dolžine terminalnega poganjka

Table 7: Two-way analysis of variance for latest shoot length

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Provenance Test	229601.577	1	229601.577	883.389	0.000	0.331
Provenance	69108.271	10	6910.827	26.589	0.000	0.130
Provenance Test × Provenance	40897.904	10	4089.790	15.735	0.000	0.081

Preglednica 7: Dvofaktorska analiza variance dolžine terminalnega poganjka

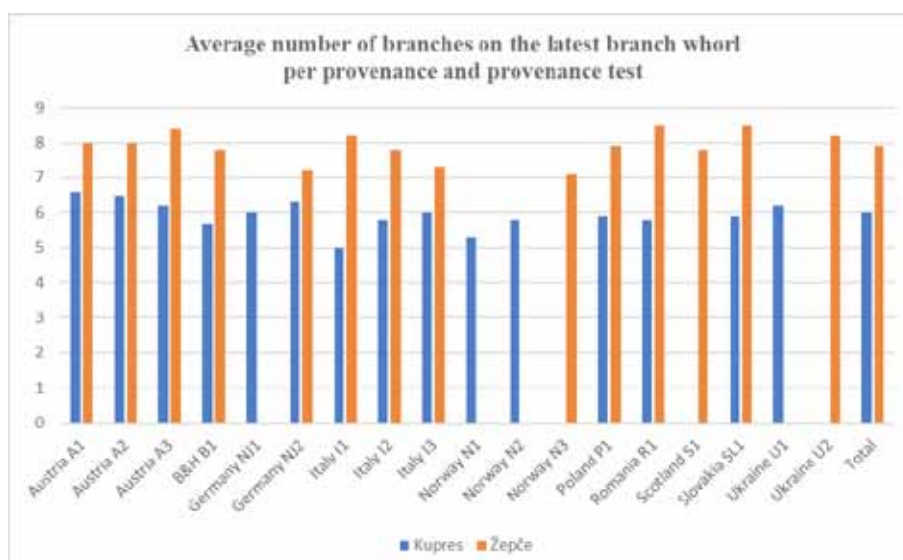


Fig. 5: Average number of branches on the latest branch whorl per provenance and provenance test

provenance test and 14 provenances in the Žepče provenance test. The average values for all measured morphological traits (height, root collar diameter, and latest shoot length) were higher in Žepče compared to Kupres for all provenances. These results indicate that habitat conditions, in addition to genetic constitution, are of great importance in the growth of different provenances. The better success of all provenances in Žepče was expected given the more favorable habitat conditions prevailing there. The average number of branches on the latest whorl was also higher per provenance in Žepče, indicating lower quality of wood mass in Žepče compared to Kupres.

Table 8: Analysis of variance for the number of branches on the latest whorl

Source of Variation	Sum of Squares	Df	Mean Squares	F	Sig.	Duncan's Test Number of Groups
Kupres Provenance Test						
Between Groups	203.544	14	14.539	3.478	0.000	5
Within Groups	6709.656	1605	4.180			
Total	6913.200	1619				
Žepče Provenance Test						
Between Groups	139.375	13	10.721	2.125	0.011	4
Within Groups	3636.946	721	5.044			
Total	3776.321	734				

Table 9: Two-way analysis of variance for the number of branches on the latest whorl

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Provenance Test	1470.017	1	1470.017	322.060	0.000	0.153
Provenance	109.557	10	10.956	2.400	0.008	0.013
Provenance Test × Provenance	154.156	10	15.416	3.377	0.000	0.019

Slika 5: Povprečno število vej na najmlajšem vencu vej glede na provenienco in provenienčni test

Our results for height in the Kupres provenance test correspond to those obtained by Lizdo (2017) and Ballian et al. (2019), in which the Poland P1 provenance had the highest and Norway N1 the lowest average height. In contrast, our results for height in the Žepče provenance test are different from those obtained by Ballian and Šito (2017) for the same provenance test. In our study, Italy I1 had the highest and Italy I3 the lowest average height, whereas Ballian and Šito (2017) found that Slovakia SL1 had the highest and Romania R1 the lowest average height. These results confirm the occurrence of provenance overtaking with respect to height growth, which was also reported by Ballian

Preglednica 8: Analiza variance števila vej na najmlajšem vencu vej

Preglednica 9: Dvofaktorska analiza variance števila vej na najmlajšem vencu vej

et al. (2009) in the Glasinac - Sokolac Scots pine provenance test. Other authors have also reported this phenomenon in provenances of other tree species, e.g. Pintarić (2000) for larch in Bosnia and Herzegovina and Jacques (1992) for larch in Western Europe.

Our results for root collar diameter in the Kupres provenance test partially correspond to those obtained by Lizdo (2017) and Ballian et al. (2019). In our study, the Norway N1 provenance had the smallest average root collar diameter, which is in agreement with Lizdo (2017) and Ballian et al. (2019). In contrast, the Austria A2 provenance had the largest average root collar diameter in our study, while Lizdo (2017) and Ballian et al. (2019) found that Austria A1 had the highest value. Our results for root collar diameter in the Žepče provenance test do not correspond to those obtained by Ballian and Šito (2017) in the same provenance test. In our study, Italy I1 had the largest and Italy I3 the smallest average root collar diameter, while Ballian and Šito (2017) found that Austria A1 had the highest value and Romania R1 the lowest. When comparing the results of studies on the same provenance tests, overtaking among provenances in root collar diameter growth is evident in both the Kupres and Žepče provenance tests.

With respect to adaptability, the results obtained by Lizdo (2017) and Ballian et al. (2019) for the Kupres provenance test showed the best survival rate for provenances from Austria (A1, A2, A3) and Poland (P1). For the Žepče provenance test, Poland (P1) followed by provenances from Scotland (S1) and Slovakia (SL1) showed the best survival rate (Ballian and Šito, 2017).

Our results did not show better growth of the geographically closest provenances because of its wide range of spatial distribution and different climates and habitat conditions. Ballian et al. (2009) and Cvjetković et al. (2014) studied the morphological traits of Scots pine in the Sokolac provenance test containing 13 provenances from Bosnia and Herzegovina. The results confirmed the existence of significant differences within and between provenances, and the provenance geographically closest to the provenance test showed the best results.

Our study showed statistically significant differences for provenance test, provenance, and provenance test $\times$ provenance interaction for most traits in both provenance tests. The results of research on the morphological traits of 16 Spanish and 6 German provenances of Scots pine in a provenance test in Spain conducted by Alia (2001) showed statistically significant differences for provenance by site interaction. Gülcü and Bilir (2017) researched the morphological traits

of Scots pine in provenance tests with 30 provenances at two sites in the southern part of Turkey. They found statistically significant differences within and between provenances for the researched traits. There were no statistically significant differences between the two sites, but the site $\times$ provenance interaction was significant.

According to Müller-Starck et al. (1992), species with a disjunctive distribution range, such as Scots pine, exhibit high inter-provenance variability at the morphological level. Our study confirmed this through the analysis of variance and Duncan's multiple interval test, which showed that there is inter-provenance variability for all four investigated morphological traits, as shown in other studies of Scots pine provenance tests by Oleksyn (1988), Giertych and Oleksyn (1992), Nilsson (1992), Ballian and Šito (2017), and Ballian et al. (2019).

Based on data on races of Scots pine, Giertych (1976) posited that the best races could be found in the eastern part of Central Europe (Latvia, Belarus, Poland) and that quality would decrease in all directions from that central region. Central European Scots pine has particularly high adaptability, especially races from Latvia and northeastern Poland. It can grow better than almost all other Scots pine races in habitats from Turkey to Norway and from Canada and the United States to Ukraine.

The results obtained in the Kupres provenance test are complementary to Giertych's statement that Scots pine originating from Central Europe, especially races from Latvia and northeastern Poland, grow better than other provenances. The results from the Žepče provenance test, however, are not completely consistent with this idea. The provenance originating from northeastern Poland (Poland P1) was only in seventh place, with average height, while one of the southernmost provenances (Italy I1) had the highest average height. The reason for this could be the similarity in the habitat conditions and elevation between the provenance area and the Žepče provenance test. The northernmost provenance (Norway N3) and southern provenance (Italy I3) showed the lowest height growth, which is in line with Giertych's ideas.

5 CONCLUSIONS

5 ZAKLJUČKI

The results obtained from this study enable us to determine the suitability of provenances for various habitat types and thus increase the productivity and optimal use of forest habitats. The analysis of variance showed statistically significant differences be-

tween provenances for all morphological traits for the Kupres and Žepče provenance tests, as confirmed by Duncan's multiple interval test. Two-way analysis of variance showed statistically significant differences for provenance tests, provenances, and provenance test $\times$ provenance interaction for all researched traits. Analyses for mutual provenances in both tests showed that the average values of morphological traits (height, root collar diameter, and latest shoot length) were greater in Žepče for all provenances, indicating higher productivity for all provenances in Žepče. The average number of branches in the latest whorl was greater in Žepče for all provenances, implying better quality of wood mass per provenance in Kupres. With respect to height and root collar diameter, the Austria A1, Austria A2, Austria A3, and Poland P1 provenances showed the best results, indicating higher productivity. The Italy I1 provenance showed the best growth in Žepče but not in Kupres. For plant height and root collar diameter, "provenance overtaking" occurred in both provenance tests, confirming the rule that valid conclusions from provenance tests can only be drawn after 1/3 of the production period of the tested tree species has elapsed.

6 SUMMARY

6 POVZETEK

Provenienčni testi v Bosni in Hercegovini so priložnost za ugotovitev prilagodljivosti in variabilnosti različnih provenienc rdečega bora iz celotne Evrope na južni meji naravne razširjenosti vrste. Pričujoča raziskava ugotavlja, ali med proveniencami, uporabljenimi v dveh provenienčnih testih rdečega bora v Bosni in Hercegovini, obstaja variabilnost preučevanih morfoloških lastnosti.

V pričujoči raziskavi smo analizirali drevesa rdečega bora v dveh provenienčnih testih v Bosni in Hercegovini, ki sta locirana v Kupresu in Žepčah v različnih podnebnih, edafskih in orografskih razmerah. Provenienčni test v Kupresu vključuje 15 provenienc, provenienčni test v Žepčah pa 14. Obema vzorčnima ploskvama je skupnih 11 provenienc. V obeh provenienčnih testih smo izmerili višino dreves, premer koreninskega vratu in dolžino terminalnega poganjka ter prešteli veje na najmlajšem vencu vej. Z uporabo programa IBM SPSS STATISTICS 20.0 smo opravili deskriptivno analizo, analizo variance in Duncanov preizkus mnogoterih primerjav.

Povprečna višina vseh izmerjenih dreves je bila 181,0 cm v Kupresu in 294,9 cm v Žepčah. Povprečen obseg koreninskega vratu je bil 51,6 mm v Kupresu in 67,9 mm v Žepčah. Povprečno število vej na najmlaj-

šem vencu vej je bilo šest v Kupresu in osem v Žepčah.

Analiza variance je pokazala statistično značilne razlike med proveniencami za vse morfološke lastnosti tako v Kupresu kot v Žepčah. Dvofaktorska analiza variance je za vse preučevane lastnosti pokazala statistično značilne razlike med provenienčnima testoma, proveniencami in interakcijo med provenienčnim testom in provenienco. Povprečne vrednosti morfoloških lastnosti (višina, premer koreninskega vratu, dolžina terminalnega poganjka) so bile za vse provenience višje v Žepčah, kar kaže na boljšo produktivnost vseh provenienc v provenienčnem testu v Žepčah. Povprečno število vej na najmlajšem vencu vej je bilo pri vseh proveniencah višje v Žepčah kot v Kupresu, kar kaže na boljšo kakovost lesne mase na provenienco v provenienčnem testu v Kupresu. Kar se tiče višine dreves in premera koreninskega vratu, ki sta kazalnika produktivnosti, so najboljše rezultate izkazale provenience Avstrija A1, Avstrija A2, Avstrija A3 in Poljska P1, ki so v obeh testih izkazale najboljšo rast. Izmerjena rast provenience Italije I1 je bila najboljša v provenienčnem testu v Žepčah, ne pa tudi v Kupresu. Pri višini dreves in premeru koreninskega vratu je v obeh provenienčnih testih prišlo do »prehitevanja provenienc«, kar potrjuje pravilo, da je rezultate provenienčnih testov mogoče utemeljeno tolmačiti šele po preteku 1/3 produkcijske dobe preučevane drevesne vrste. Rezultata pričujoče raziskave se lahko uporabita za selekcijo najboljše rastočih in najbolj prilagodljivih provenienc, kar lahko prispeva k in situ in ex situ ohranitvi te drevesne vrste.

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