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Original article

Preliminary results of common oak (*Quercus robur* L) provenance experiments in Croatia

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Summary — The first experiment with 16 provenances of *Quercus robur* L from Croatia was established in the nursery of the Forest Research Institute in Jastrebarsko in the spring of 1986. Field experiments with 4 randomized blocks in 2 localities were laid out in 1988. After 5 years (1990), the Spačva provenance performed best in terms of height growth. Survival varied from 34.0% (Motovunska Šuma at Slavir) to 98.5% (Gunja at Gajno).

provenance / *Quercus robur* / height growth / survival / Croatia

Résumé — Résultats préliminaires de plantations comparatives de provenances de chêne pédonculé (*Quercus robur* L) en Croatie. *La première comparaison de provenances de* Quercus robur *L de Croatie a été mise en place dans la pépinière de l'Institut de recherches forestières de Jastrebarsko au printemps 1986. Elle comprend 16 provenances. Les tests en forêt ont été installés dans 2 stations; chacune comprend 4 blocs randomisés. À l'issue de la cinquième année de végétation, la provenance Spačva s'est avérée la plus vigoureuse (croissance en hauteur). Les taux de survie varient de 34% (provenance Motovunska Šuma dans la station Slavir) à 98,5% (provenance Gunja dans la station Gajno).*

provenance* / Quercus robur / *croissance en hauteur* / *survie* / *Croatie

INTRODUCTION

Common oak (*Quercus robur* L) is one of the most valuable and the most important forest trees in Croatia. The value and quality of the wood of the famous "Slavonian oak" is well known in Croatia and in world markets. However, difficulties with natural regeneration and forest decline require more extensive production of oak seedlings from forest nurseries (Dokuš and Komlenović, 1979; Androić, 1987; Prpić, 1987). Considering these facts, proper provenance sources are very important (Komlenović *et al*, 1988). The main natural range of *Quercus robur* in Croatia is along the Sava river (45° latitude), about 400 km long. The total woodland area of *Quercus robur* in Croatia is 170 000 ha containing 40 million m^3 of solid wood (Kovačić, 1990).

Oak provenance research was started in 1985–1986. The purpose was to study variability and wood productivity of different provenances in Croatia. It is very important for forestry practice to determine which oak provenances are productive and most suitable for different forest regions (Gračan, 1986).

MATERIALS AND METHODS

The collection of seed was started in the autumn of 1985. Samples of 150–200 kg/provenance were collected. Eleven provenances from Croatia and 1 from Serbia were included in the nursery phase of the experiment. The field experiment also includes seedlings from 4 commercial provenances. These were grown in commercial nurseries and were used as controls. The general information about the provenances (latitude, longitude, elevation, and soil) is given in table I.

Seed from 12 provenances was sown in the nursery of the Forest Research Institute at Jastrebarsko in the spring of 1986. The experiment was laid out in a randomized block design with 4 blocks, using 20–25 kg of acorns from each provenance/block. The seedlings were grown in the nursery for 2 years until the autumn of 1987. Heights were measured in the autumns of 1986 and 1987. Survival was assessed in the autumn of 1987.

Field experiments of 16 oak provenances were laid out at 2 different localities in the autumn of 1987 and in the spring of 1988. The experiments were established in complete randomized block designs each with 4 replications, with 100 oak seedlings/provenance/replication. Spacings were 1.5 x 1.5 m. In total, 12 800 oak seedlings were planted, *ie* 6 400 per locality (16 x 100 x 4). The experiments are located at Slavir and Gajno (fig 1).

Heights and survival were recorded at both sites in the autumns of 1988, 1989 and 1990. All data were submitted to analyses of variance (Steel and Torrie, 1960) at the computing center of Zagreb.

Table I. Origins of oak provenances.

No	*Provenance*	*Latitude (North)*	*Longitude (East)*	*Elevation (m)*	*Soil*	*Forest enterprise*
1	Motovunska šuma	45° 20'	13° 50'	90	Fluvisols	Buzet
2	Skakavac (Domačaj lug 14)	45° 29'	15° 42'	112	Eugleys	Karlovac
3	Orlovac * Rečički lug 48)	45° 33'	15° 44'	112	Pseudogley	Karlovac
4	Velika Gorica * (Tur lug, 8a, 9b)	45° 40'	16° 10'	98	Fluvisols	Zagreb
5	Novska (Trstika 20b)	45° 21'	16° 55'	143	Eugleys	Nova Gradiska
6	Lipovljani ('J Kozarac', 43a)	45° 26'	16° 49'	143	Eugleys	Nova Gradiska
7	Okučani (Ljeskovača, 8b, 12b)	45° 11'	17° 10'	95	Eugleys	Nova Gradiska
8	Durdenovac (Dur Niz sume)	45° 34'	18° 08'	97	Eugleys	Vinkovci
9	Gušević (Trstenik)	45° 13'	18° 29'	96	Eugleys	Vinkovci
10	Spačva (SJ Radisevo)	44° 56'	18° 50'	85	Eugleys	Vinkovci
11	Gunja (Desičevo)	44° 57'	18° 49'	86	Eugleys	Vinkovci
12	Morovic (SR Mitrovica)	45° 02'	19° 11'	82–85	Metamorphosed Loess	Srem Mitrovica
13	Dubica (Pos šume) **	45° 17'	16° 44'	98	Eugleys	Sisak
14	Zden Gaj (Prespinjača, 2a) **	45° 37'	17° 04'	160	Eugleys	Bjelovar
15	Ključevi (34a) **	45° 11'	17° 21'	95	Eugleys	Nova Gradiska
16	Vrbanja (Vrbanjske šume) 102a–1, 113a–f, 114a–g)**	45° 01'	18° 59'	85	Eugleys	Vinkovci

* *Q robur* var *tardissima*. ** Comercially grown provenances.

RESULTS AND DISCUSSION

Summaries of heights and survival of seedlings in the nursery during 1986 and 1987 are given in table II. It is evident, that provenances 10 Spačva (35.6 cm), 12 Morovic´ (35.7 cm), 9 Guševac (35.6 cm) and 8 Durdenovac (35.5 cm) achieved the best average heights at 2 years of age. Average survival of all seedlings in the nursery phase in the autumn of 1987 was 86.5%, and it varied from 69.3% for provenance 8 Durdenovac to 96.4% for provenance 5 Novska.

In a fertilizing experiment (Komlenovic *et al,* 1988) with 4 oak species and 6 provenances of *Quercus robur* (Motovun, Orlovac, Novska, Durdenovac, Spačva and Morovic´), provenances Spačva (22.6 cm) and Morovic´ (22.3 cm) had the greatest heights. These seedlings had been raised in paper pots on 3 different substrata. In 5 out of the 6 provenances there was no frost damage. Only the Motovun provenance lost 23% of the total number of seedlings. These data are very important for the choice of suitable provenances for reforestation. From the results of these nursery experiments and the fertilizing experiment, it is evident that provenances 10 (Spačva) and 12 (Morović) are among the best at 1 and 2 years of age. The quality of nutrition is of great importance for oak seedling production in forest nurseries, but the proper provenance choice is even more. Little research has been done on fertilization of oak provenances (Anić, 1963; Dekanić, 1971; Džekova, 1976; Komlenović, 1981; Komlenović and Rastovski, 1982; Komlenović and Cestar, 1984; Komlenović *et al,* 1988).

Summaries of average heights and survival in the field experiments Gajno and Slavir are given in table III and figure 2. Table III gives the average heights and survival in the autumns of 1988, 1989 and 1990. The *F*-test values from analyses of variance are also presented.

From table III it is evident that provenance 10 (Spačva) had the greatest average height at Slavir (37.1 cm) but at this

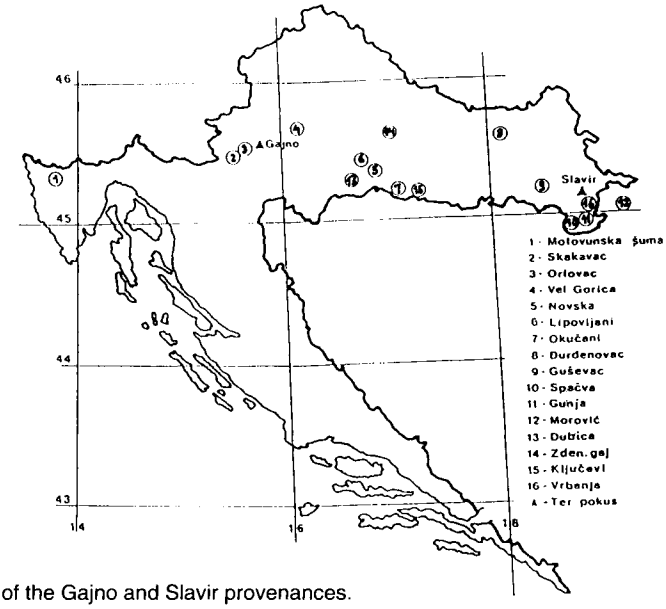

Fig 1. Locations of the Gajno and Slavir provenances.

Table II. Number of seedlings, survival and average heights in the nursery.

No	Provenance	Number of seedlings		Survival (%)	Heights (cm)			
		1986	1987		1986	Rank	1987	Rank
1	Motovunska šuma	1 434	1 177	82.1	13.0	10	32.9	9
2	Skakavac	1 788	1 624	90.8	13.5	8	33.9	7
3	Orlovac	2 124	1 641	77.3	11.7	12	62.6	11
4	Velika Gorica	1 896	1 677	89.4	13.6	6	33.3	8
5	Novska	2 668	2 572	96.4	13.5	7	32.5	12
6	Lipovljani	1 393	1 218	87.4	14.4	2	34.4	5
7	Okučani	2 384	2 042	85.6	13.8	3	34.0	6
8	Durdenovac	2 217	1 537	69.3	13.8	4	35.5	4
9	Guševac	2 136	1 908	89.3	12.2	11	35.6	3
10	Spačva	2 160	1 792	83.0	15.6	1	35.6	2
11	Gunja	2 222	2 084	93.8	13.2	9	32.7	10
12	Morovič	2 375	2 168	91.3	13.7	5	35.7	1
Mean		24 797	21 440	86.5	13.6		33.8	

provenance Gajno was in second place in 1988 with a height of 39.5 cm. At Gajno the tallest provenance in 1988 was 16 (Vrbanja (42.3 cm), but at Slavir with a height of 31.7 cm it was 10th. The lowest average height at Gajno was for provenance 9 (Guševac) (31.2 cm) and at Slavir provenance 14 (Zdenački Gaj) (26.7 cm). The average height of all 16 provenances was 36.1 cm at Gajno and 32.6 cm at Slavir.

Average survival in the autumn of 1988 was relatively high: 97.9% at Gajno ranging from 96.0 to 99.7%, and 90.2% at Slavir ranging from 86.0 to 98.5%. There were no significant differences between provenances.

From table III it is evident that provenance 10 (Spačva) was tallest in 1989 at both Gajno (58.7 cm) and Slavir (39.9 cm) but in 1990, as shown in table III and figure 1 it fell to 3rd place at both locations with heights of 72.5 cm (Gajno) and 40.8 cm (Slavir). The greatest average height in 1990 at Gajno was exhibited by provenance 7 (Okučani) (74.4 cm) and at Slavir by provenance 14 (Ključevi) (42.4 cm). The average height of all 16 provenances at Gajno in 1989 was 51.8 cm, while at Slavir it was 36.7 cm. In the autumn of 1990, these averages were 65.7 and 38.7 cm, respectively. The smallest average height in the autumn of 1990 at Gajno (52.2 cm) and Slavir (35.1 cm) was in provenance 13 (Dubica).

Average survival in 1989 and 1990 was higher at Gajno (96.2 and 95.8%) than at Slavir (74.6 and 36.7%). The seedlings of all 16 provenances at Slavir had been heavily attacked by mice. From table III it is evident that there were few significant differences between provenance means for heights and none for survival.

CONCLUSION

The first results from the experiment with 16 *Quercus robur* L provenances at Gajno and at Slavir have shown that Spacva

Table III. Average heights and survival at Gajno and Slavir (1988, 1989 and 1990).

No Provenance	*Gajno*								*Slavir*							
	Heights (cm)				*Survival (%)*				*Heights (cm)*				*Survival (%)*			
	1988	*1989*	*1990*	*Rank*	*1988*	*1989*	*1990*	*Rank*	*1988*	*1989*	*1990*	*Rank*	*1988*	*1989*	*1990*	*Rank*
1 Motovunska šuma	33.9	47.4	58.2	(15)	97.9	96.3	95.0	(12)	29.2	34.0	37.0	(13)	87.0	71.7	34.0	(16)
2 Skakavac	32.4	47.5	60.8	(13)	96.0	94.0	91.0	(16)	33.0	35.1	36.1	(15)	91.3	74.5	35.1	(12)
3 Orlovac	37.6	52.7	69.6	(5)	98.5	94.0	97.7	(3)	34.4	35.8	37.9	(11)	90.5	72.0	35.8	(11)
4 Velika Gorica	36.9	54.4	67.7	(7)	97.5	96.8	95.0	(13)	34.5	37.7	38.8	(8)	91.5	75.8	37.7	(5)
5 Novska	38.0	52.9	65.3	(9)	98.7	96.8	96.5	(7)	31.6	35.0	37.6	(12)	98.3	78.5	35.0	(13)
6 Lipovljani	34.5	49.2	65.3	(10)	99.8	96.0	96.7	(6)	35.4	38.7	39.7	(4)	86.0	72.3	38.7	(3)
7 Okučani	38.3	55.8	74.4	(1)	98.3	97.5	97.5	(5)	34.9	36.8	38.3	(10)	90.2	70.7	36.8	(9)
8 Durdenovac	33.7	55.7	73.6	(2)	96.0	96.3	95.5	(9)	34.1	39.4	41.8	(2)	90.0	66.8	39.4	(2)
9 Guševac	31.2	46.5	60.8	(14)	98.2	95.3	93.8	(14)	30.6	36.8	39.8	(5)	92.0	76.0	36.8	(8)
10 Spačva	39.5	58.7	72.4	(3)	97.0	94.5	95.3	(11)	37.1	39.8	40.8	(3)	92.5	75.8	39.8	(1)
11 Gunja	37.5	56.5	69.5	(6)	99.7	99.5	98.5	(1)	31.4	36.9	38.4	(9)	94.5	81.5	36.9	(7)
12 Morović	38.3	57.5	65.4	(8)	98.5	97.2	97.8	(4)	33.6	36.4	39.1	(7)	87.8	65.7	36.4	(10)
13 Dubica [a]	31.8	41.3	52.2	(16)	99.3	94.0	96.0	(8)	30.4	34.5	35.1	(16)	89.2	71.0	34.5	(15)
14 Zdenački Gaj [a]	35.0	51.1	65.0	(11)	99.5	98.0	98.0	(2)	26.7	34.9	36.3	(14)	89.3	46.3	34.9	(14)
15 Ključevi [a]	34.6	48.2	61.0	(12)	95.5	93.3	93.0	(15)	32.2	38.6	42.4	(1)	98.5	80.5	38.6	(4)
16 Vrbanja [a]	42.3	57.9	69.1	(4)	96.2	97.8	95.3	(10)	31.7	37.3	39.3	(6)	94.2	84.5	37.3	(6)
Mean	36.1	51.8	65.7		97.9	96.2	95.8		32.6	36.7	38.7		90.2	74.6	36.7	
F-values (calculated)	1.5	2.6*	2.6*		1.6	1.1	1.6		1.1	0.7	1.4		0.6	1.2	1.1	

* Significant heterogeneity at the 5% level (F_{15} for 5% = 2.2). [a] Commercially grown provenances.

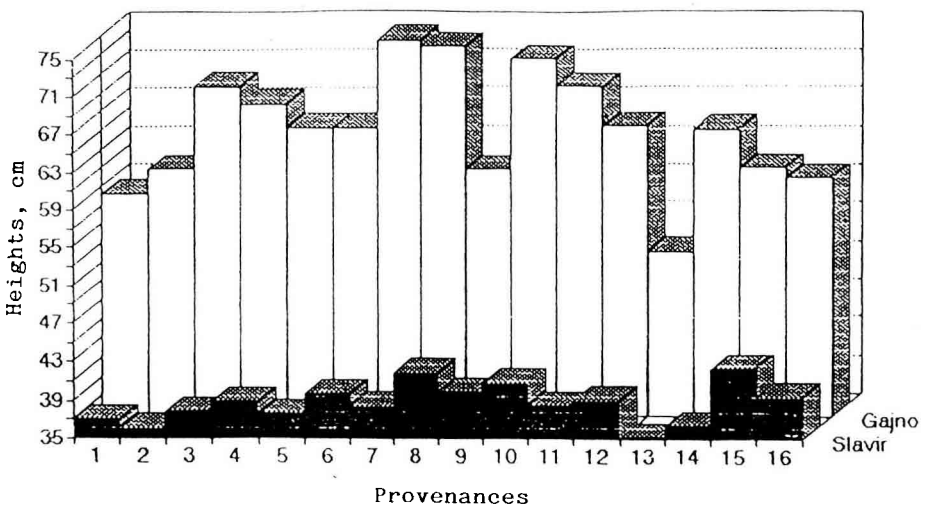

Fig 2. Average heights in 1990 at Gajno and Slavir locations.

provenance is better than the other 15. Because these oak provenance experiments are very young (5 yr) it is necessary to be cautious in interpreting the results and to continue with these investigations.

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