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PRODUCTION OF SEEDLINGS OF WHITE WILLOW (*SALIX ALBA* L.) ON EUGLEY SOIL

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Abstract

The paper presents research results of morphological, physical and chemical properties of eugley soil in a protected part of alluvial plains of the Danube River. Research was conducted in the nursery "Kacka suma", where the seedlings of white willow (*Salix alba* L.) were produced. The following hydrological soil characteristics were studied in detail during the vegetation period: immediate moisture content by depth profile, the dynamics of movement of groundwater and its interaction with water level of Danube. In order to assess the benefits of this soil type for the production of willow seedlings, the height of seedlings of five white willow genotypes (*S. alba*: cl. '107/65/9', cl.'347', cl.' V-158', cl. '79/64/2' and cl. 'V-55') was measured at the end of the vegetation period. Genotype '107/65/9' exhibited the largest amount of seedlings with proper dimensions and genotype 'V-55' exhibited the smallest one. The results suggest that high quality *S. alba* seedlings may be successfully used on eugley soils.

Key words: eugley soil, soil moisture, seedlings, plant height, *Salix alba*.

Introduction

The genus Salix includes about 450 willow species: shrubs or trees, some reaching 40 m in height (Keoleian and Volk 2005*)*. In European flora there are 70 species of allochtonos and autochtonos willows, (Rechinger 1964, ex Krstinic 1986a). According to Krstinic (1986a) only two autochthonous species (*S. alba* L. and *S. fragilis* L.) can grow as tall trees in lowlands of Europe, white willow being considered of the greatest economic significance. It is due to the great areas it covers, rapid volume growth in natural stands and plantations, and the high revenue from timber production (Krstinic 1986b)*.* Zalesny and Bauer (2007) showed that some willow genotypes exhibited goodgrowth on polluted soils, and considered them suitable for phytoremediation of polluted areas. Because of the mentioned advantages of the willow, this study focused on the production of white willow seedlings. Volk et. al. (2004) found that the phase related to establishment of quality stands of white willow genotypes was critical for the biological and economical success, and that special attention should be paid, among other things, to the storage of reproduction material.

In order to obtain quality willow planting material, it is necessary to choose a soil suitable for the considered species. Since willows are part of alluvial hygrophilic forests (Jovic et al. 1991) occupying narrow or wide belts along the larger rivers, the production of willow planting material is organized in that very area. Barsoum (2002), studying the natural regeneration of willows and poplars mentioned that the unseasonal flood waters in the area of river terraces harmed the regeneration from seed, but helped the vegetative regeneration. Soils to be used for production of willow seedlings should have a high fertility potential, reflected in their textural composition (Roncevic et al. 2002).

According to (Roncevic et al. 2002), the eugley soils and hypogley moistening system with increased clay content are used for production of willow planting material. These soils usually contain more silt and clay than the soils in poplar nurseries, and most often belong to the class of clay loam (table 1). Since these soils are found on the lowest micro cites they are exposed in nature to increased moistening by flood or ground water.

Due to the construction of protective embankments along the Danube River, eugley soils in the central Danube basin are protected from flooding, and are mostly exposed to excessive moistening only by underground waters. Underground water level is generally high with approximate depth 1 m below surface, depending mainly on the Danube water level.

The aim of this study was to investigate properties of eugley soils in the protected part of alluvial plain in the central Danube basin, and the possibility of nursery production of white willow (*Salix alba* L.) clones.

Materials and Method

The experiment was located in the protected part of the alluvial plain in the central Danube basin in the Experimental estate of the Institute of lowland forestry and environment. The field experiment was carried out in spring 2006 using five *S. alba* genotypes free grown on eugley soil. The following clones were used in the experiment: *S. alba*: cl. '107/65/9', cl. '347', cl. 'V-158', cl. '79/64/2' and cl. 'V-55'. The experiment consisted of five replications with 30 plants per plot and random design. Spacing was 0.8 m between the rows, and 0.3 m within the row, tus resulting in 41.625 plants per hectare. At the end of 2009 vegetation period the heights of one year old sprouts from four year old root stocks were measured. Soil profile was created at the experimental site and its morphological characteristics were described. Soil samples were analyzed in the Laboratory for soil properties of the Institute of lowland forestry and environment, and physical and chemical properties of the soil samples were determined using the following methods:

- Mechanical soil composition according to B-pipette method – extracted with sodium-pyrophosphate;
- Moisture soil content up to the depth of 60 cm – thermogravimetric method;
- Differential porosity calculated from total porosity value and moisture retention using different procedures;
- Humus content in soil using Tjurin method modified by Simakov;
- Soil $CaCO_3$ content was analyzed volumetrically using a Scheibler calcimeter;
- Soil chemical reaction, pH of water determined electrometrically using a glass electrode;

Table 1. Mechanical soil composition.

Horizon	Depth, cm	Total sand > 0.02 mm, %	Total clay <0.02 mm, %	Textural Classes
Aa,p	0–30	24.28	75.72	Dusty loam
AaGso	30–60	34.84	65.16	Loam
Gso	60–90	88.08	11.92	Sandy loam

- Nitrogen according to Kjedahl;

- Easily available phosphorous and potassium according to Al-method, Egner-Riehm–Dominigo;

- Ground water levels measured in the piezometers.

Depth of ground water was measured and soil samples for immediate moisture determination were taken each month. Heights of seedlings were measured at the end of vegetation period. Data were processed using standard method of statistical analysis for mean value comparison (ANOVA, LSD-test at the probability level of 0.05).

Results

Soil characteristics

Analysis of eugley soil composition (Table 1) revealed high content of total clay in surface horizon and in transition AaGso horizon down to the depth of 60 cm. The lowest content of total clay was found in the gleyic subhorizon (Gso). On the other hand, total sand content was the lowest in the surface and transitional horizons, and was extremely high in Gso subhorizon. Due to the share of mechanical fraction the soil of these horizons were classified as silty loam, loam, and loamy sand textural classes, respectively.

Table 2. Differential porosity.

Horizon	Depth, cm	Pore share, % vol.		
		Coarse (>10 μm)	Medium (0.2-10 μm)	Fine (<0.2 μm)
Aa,p	0–30	2.86	21.58	33.15
AaGso	30–60	5.17	28.92	23.66
Gso	60–90	27.25	16.10	6.82

Differential porosity (Table 2) was closely related to the share of granulometric fraction. In the surface Aa,p horizon fine pores (<0.2 μm) prevailed; in transition AaGso horizon the medium pores (0.2–10 μm), while in Gso subhorizon the coarse pores (>10 μm) prevailed.

The analysis of the soil chemical composition (Table 3) revealed a higher share of carbonates in the transitional AaGso horizon in comparison to the humus horizon and the Gso subhorizon. It is thus classified as very limy. Soil alkalinity increased with depth, and on average, was low. Organic matter content was highest in the surface horizon, and its share declined with depth. Due to its average organic matter content this soil is classified as poor in humus. Also, nutrient concentration was the highest in the surface horizon and declined with soil depth.

Since the soil moisture content in the first 10 cm

Table 3. Chemical soil composition.

Horizon	Depth, cm	$CaCO_3$, %	pH of H_2O	Humus, %	Total N, %	P_2O_5, mg per 100g	K_2O, mg per 100g
Aa,p	0–30	17.9	7.40	2.59	0.08	5.4	17.3
AaGso	30–60	23.3	7.80	1.21	0.04	2.8	8.2
Gso	60–90	15.4	7.82	0.96	0.02	2.9	4.0
Average	0–90	18.9	7.67	1.59	0.05	3.7	9.83

Table 4. Hydrological properties.

Date of observation		**15.06.**	**01.07.**	**03.08.**	**07.09.**	**23.09.**	**09.10.**
Danube water level, cm		**246**	**442**	**282**	**140**	**205**	**185**
Soil profile layer	**Depth, cm**	**Soil moisture, vol. %**					
Aa,p	0–30	26.26	35.60	23.59	22.73	23.11	28.24
I Gso	30–60	32.17	36.41	23.59	29.76	28.79	27.92
II Gso	60–90	36.41	43.72	32.33	24.11	44.64	40.17
Underground water level, cm		120	120	180	210	190	200

was low, roots could not absorb any water. At the depth of 30–60 cm the content of current soil moisture was available to seedlings and at the depth of 60–90 cm, current soil moisture was also easily available to the seedlings.

Correlation between Danube water level and underground water level at the examined site was significant and high throughout the growing period ($r=0.74$). The correlation of soil moisture in the first two examined layers of profile was also significant and high with the underground water level ($r=0.65$ for Aa,p and $r=0.69$ for I Gso), but for the lowest horizon it was insignificant ($r=0.40$). This could suggest constant water supply by capillary flow in the horizon.

Plant height

The main result of this study is that plants exhibited different height at the end of the vegetation period (Table 5). Genotypes '107/65/9', 'V-158', '347' and '79/64/2' had mean height ranging from 196.5 cm to 227.8 cm and geno-

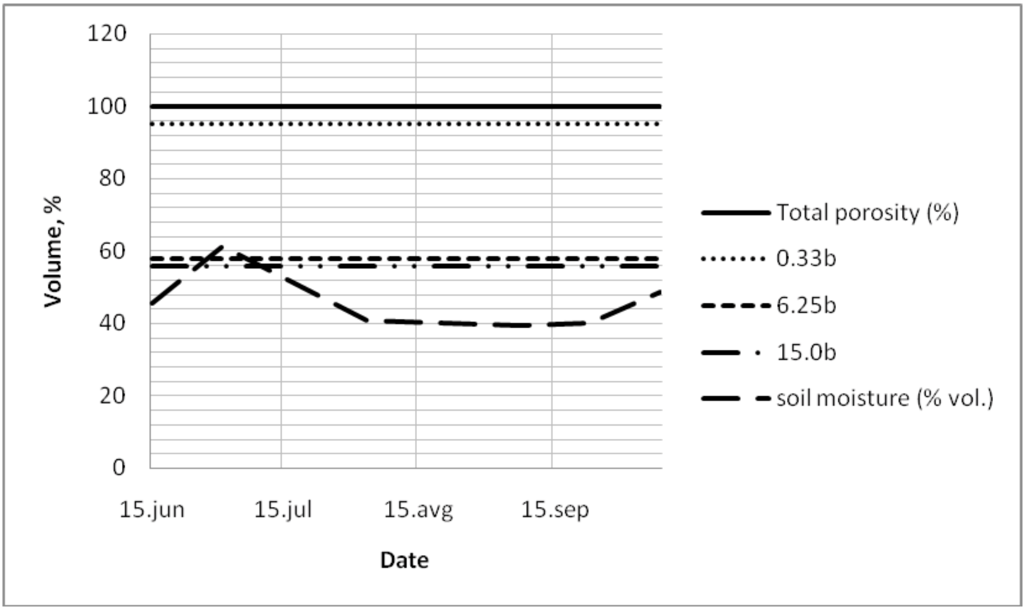

Fig. 1. Current soil moisture dynamics at 10 cm.

type 'V-55' was 156.6 cm high. Since the height limit for production

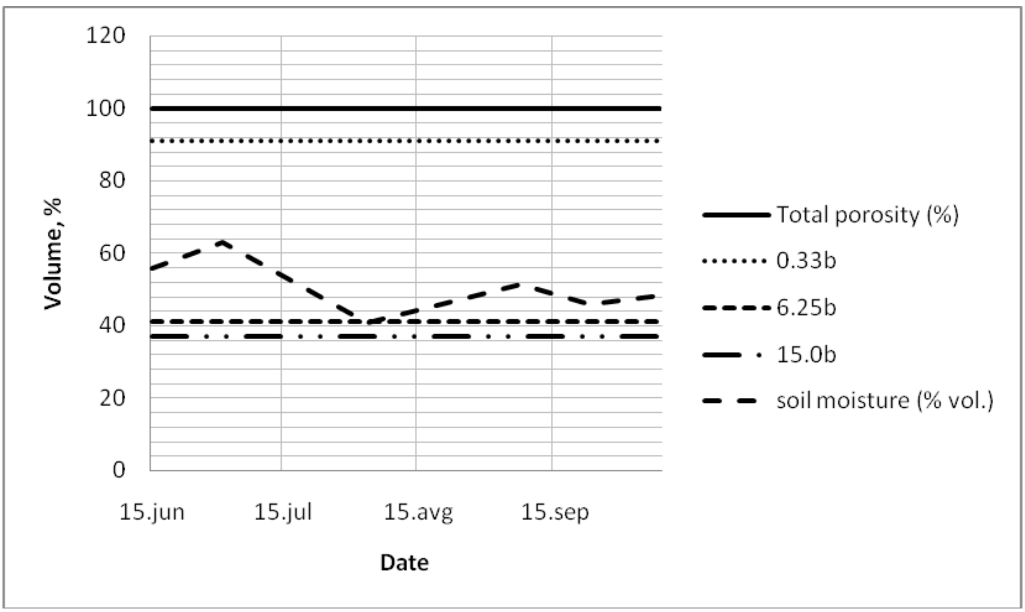

Fig. 2. Current soil moisture dynamics at 30–60 cm.

of the white willow planting material type 1/0 is 2.5 m (Markovic and Roncevic 1986), it can be concluded that genotypes '107/65/9', 'V-158' and '347' reached the production limit. According to the height structure of the seedlings (Figure 4), the share of seedlings more than 2.5 m high ranged from 2.56 to 30.76%, those of 2.0–2.5 m from 33.33 to 53.84%, and those below 2.0 m ranged from 15.38 to 64.1%; for genotype 'V-55' it was even 100%. From the height structure recorded it can be seen that the genotype '107/65/9' had the highest percentage of seedlings higher than 2.5 m (30.76%), and the highest percentage of seedlings from 2.0–2.5 m high (53.84%). Genotypes 'V-158', '347' and '79/64/2' had significantly lower share of seedlings over 2.5 m (2.56–19.8%), and equal participation of seedlings from 2.0–2.5 m high (33.33–37.73%). According to the lowest final height sizes, seedlings of genotype 'V-55' were all below 2.0 m (100%).

Obtained planting material measured at the end of vegetation period had mean heights mainly lower than 2.0 m, which was the limit for the white willow seedlings classification. Although majority of seedlings were below pre-

Table 5. Mean values of total heights (h), results of ANOVA, and the least significant difference LSD-test at the level of 5%.

Clone	h, cm
107/65/9	227.84 a
V-158	210.61ab
347	206.75 abc
79/64/2	196.50 bc
V-55	156.60 d
F-test	30.057*

* – very statistically significant.

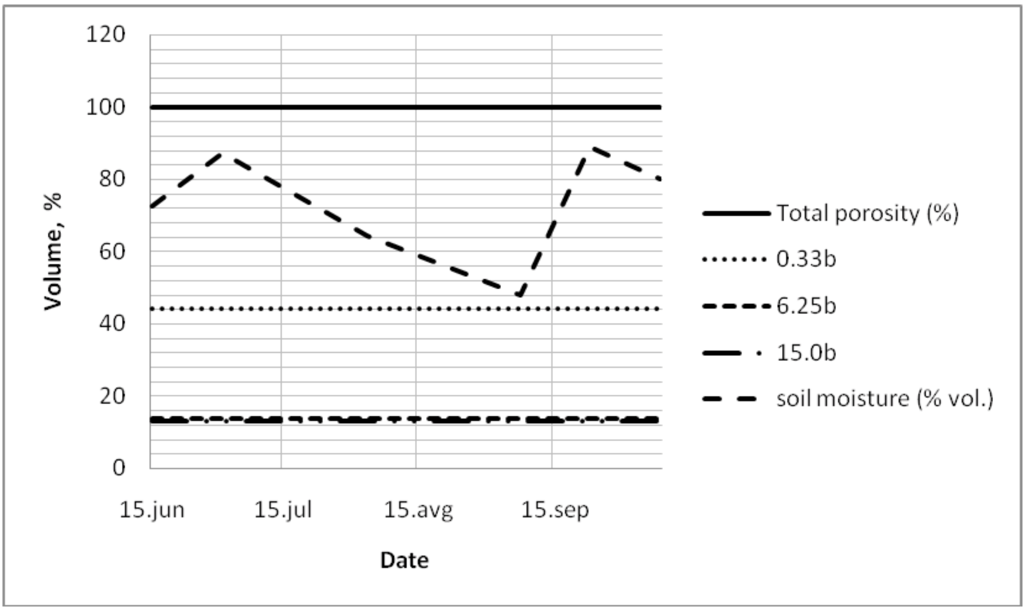

Fig. 3. Current soil moisture dynamics at 60–90 cm.

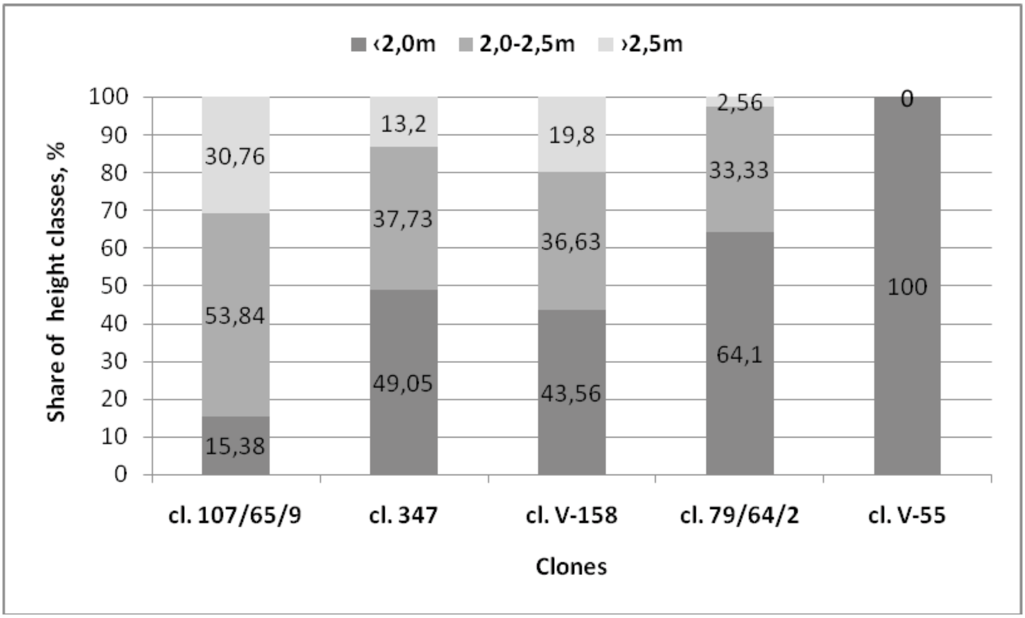

Fig. 4. Share of different height classes in the total number of seedlings.

scribed height, these which ranged from 2.0–2.5 m could be used for plantation establishment.

Discussion

Lower heights of white willow genotypes grown in studied eugley soil could be related to the characteristics of this soil type. By analyzing the content of current soil moisture (Figure 1, 2, 3) it can be concluded that at depth of 10 cm the moisture content in the soil was unavailable to plants for most of the time of the growing period. At the depth of 30–60 cm, in the root system area the moisture content increased, but in the best conditions 15–45% of capillary pores were water filled for a short period of time, while during some periods the moisture content was almost close to lento-capillary moisture. Even non-capillary pores were water filled. Since the study area was the protected part of alluvial plain the primary form of eugley soil moisturing was by underground water. Roncevic et al. (2002) mentioned that these soils should be in close contact with underground water to be suitable for production of willow seedlings. Underground water level ranged from 120–210 cm, or on average 165 cm from the surface soil, which is in fact a low level of ground water, and moisturizes only the lowest layer in the area below the rhizosphere. The low underground water level has resulted in the small amount of water available to seedlings in the soil, which resulted in smaller height of white willow seedlings. Several studies have shown that the early life stages of floodplain forest species are susceptible to the fluctuating hydrological conditions (Sacchi and Price

1992, Segelquist et al. 1993, Shafroth et al. 1994, Douglas 1995). Rapidly declining river levels and underground water levels can result in limited water availability for development of seedlings of white willow (Van Splunder et al. 1996).

Conclusion

The tested eugley soil was characterized by high content of total clay fraction, which ranged from 65.16–75.72% down to the depth of 60 cm. Textural class ranged from loam to dusty loam. Decreased level of water available to plants in the rhizosphere zone, linked with heavier mechanical composition resulted in smaller height of seedlings. Genotypes ‘107/65/9’, ’V-158’ and ’347’ reached the production limit, and confirmed the fact that one-year old seedlings of appropriate quality could be grown on this soil. According to height structure, genotype ‘107/65/9’ had the greatest number of seedlings over 2.5 m (30.76%), and genotipes ‘V-158’, ‘347’ and ‘79/64/2’ had much lower share of such seedlings (2.55-19.8%). All seedlings of genotype ‘V-55’ were below 2.0 m. Continuous production process for obtaining two-year old sprouts is needed to provide sufficient quality of planting material of the studied clones.

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