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EUROPEAN WHITE ELM: POTENTIAL FOR WETLANDS REFORESTATION

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Abstract: The aim of this study was to investigate the potential of European white elm (*Ulmus laevis* Pall.) for wetland reforestation across the Europe. For this purpose, seed was collected from 13 maternal European white elm trees on Veliko ratno ostrvo island near Belgrade, Serbia. Seeds were used to produce bareroot seedlings (1+2) that were planted at Veliko ratno ostrvo (20˚25'40'' E; 44˚50'18'' N) on fall (689 seedlings) and at Manić-Bostanište (20˚25'02'' E; 44˚30'54'' N) on spring (260 seedlings).
After the first growing season in the field, seedlings survival was estimated and seedling growth was measured. Survival was relatively similar and high on both sites (~90%). Wildlife was the most common reason for seedling mortality and damage (100% of dead seedlings at Manić-Bostanište). Seedling growth was strongly influenced by time of planting and site conditions. Seedlings planted on autumn at Veliko ratno ostrvo island showed approximately double growth compared to seedlings planted at spring at Manić-Bostanište. The highest value of diameter increment (24 mm), total diameter (39 mm), height increment (252 cm) and total height (432 cm) were recorded on the site Veliko ratno ostrvo, while the lowest values of total diameter (9,29 mm) and total height (65 cm) were recorded at Manić-Bostanište, also as the absence of growth in some plants.
Due to high survival rate and large growth at both sites, European white elm can be considered a species with high potential for reforestation of wetlands for conservation and productive purposes.

Key words: seedlings, European white elm, reforestation, survival, growth performance.

INTRODUCTION

European white elm (*Ulmus laevis* Pall.) is a hardwood deciduous tree which grows in river banks, lake shores and other wetlands (Collin et al. 2000). Areal of European white elm is from Ural Mountain on the east to eastern France on the west, and from southern Finland on the north to the Caucasus, Balkans and southern France (Collin 2003). Natural populations of European white elm are rare in Europe and number of trees in these populations is reduced as a result of Dutch elm disease (DED) and human-induced changes in riparian forest (Machentun 2000) and measures for conservation are provided (Collin et al. 2004).

Wetlands in Europe include river deltas, coastal lagoons, riverine floodplains, inland freshwater lakes, man-made reservoirs, a thalassic salt basins, intertidal systems, permanent river channels, and seasonally-flooded river channels (Crivelli and Britton 1993). People have great influence on these habitats and in some parts of Europe are occurring dramatic changes in landscape, which causing great damage in these ecosystems (Hook 2006, Pfadenhauer and Grootjans 1996). Riparian forests throughout the world provide important ecosystem services such as flood abatement, water-quality improvement, wildlife habitat, and biogeochemical cycling (Haycock et al. 1993, Mitsch and Gosselink 2000). Restoration and reforestation of wetlands should be possible with native species like European white elm which would help conservation except restoration.

MATERIAL AND METHOD

Study Site

The field experiment was established on two sites: Veliko ratno ostrvo island (E 20˚25'40''; N 44˚50'18''; 73 m above sea level) and Manić-Bostanište (E 20˚25'02''; N 44˚30'54''; 121 m above sea level), which are included on the same climate region, with small oscillations and microclimatic variations between sites.

Both sites belongs area of Belgrade with average of temperature 12.2° C, during vegetation 18.9° C and with extreme temperatures on July (average 22.5° C) and January (average 0.8° C), average annual rainfall is 693,3 mm, during vegetation 392.5 mm with a lack of humidity during July, August and September (154 mm). Average value of the General climate index for Belgrade is 0.80065 for the period 1946-2010, which indicates a sub-humid humid climate (C2). The normal growing season is from April until October (http://www.hidmet.gov.rs/podaci/meteorologija/Klima_Srbije eng.pdf).

Site Veliko ratno ostrvo belongs protected natural area "Veliko ratno ostrvo" on confluence Sava and Danube River near Belgrade. Before planting, weeds were cut with absence of agricultural activities, and planting was done on November 2013th. Soil type is fluvisol. This area is influenced by Danube and oscillations of the stage have great influence on the ground water level. Flooding is common during spring (one time on April or May, during 7-15 days), also as driest period during July and August when ground water level is lowest (deeper than 1 m).

Site Manić-Bostanište present abandoned agriculturally area where was doing cleaning of weeds and plowing and after that soil was disk. This area have big influence of local small rivers around them and flooding is common (average one or two per year on May or June, during 1-7 days), except ground water level is high (about 30-50 cm below ground on July). Soil type is eugley, sub type amfigley. Planting of seedlings were done on spring 2014th.

During May 2014th on both sites were flooding. Veliko ratno ostrvo site was flooding during 2 weeks and Manić-Bostanište during 5 days.

Seedling Production and planting

Europan white elm seeds for this study were collected from the natural stand found on Veliko ratno ostrvo island in May 2011th. After short drying in same month it is

sown on seedbeds in nursery Manić (E 20˚25'41''; N 44˚30'54''; 188 m above sea level) near site Manić-Bostanište. About 1200 seeds per m^2 were sown, and after first growing season seedlings were planted in rows at a spacing 20 cm between seedlings and 70 cm between rows. Two years after, bareroot seedlings (1+2) were planted by hands on two sites. All seedlings were tallest than 140 cm.

Sample of 689 seedlings were planted in 3 blocks on the Veliko ratno ostrvo at spacing 3.0 x 3.0 m in mid-November 2013th.

Sample of 260 seedlings were planted as one block on the Manić Bostanište at spacing 2.0 x 3.0 m in early March 2014th.

Measurements

Initial seedlings diameter (2 cm above root collar) and height were determined of each seedling in the all rows on the both sites after planting (December 2013th – Veliko ratno ostrvo; March 2014th – Manić-Bostanište). During growing season seedlings were monitored on both sites, survival counts and diameter and height measurements were taken on December 2014th.

Statistical Analiyses

Descriptive statistic parameters were used to show average diameter and average height before and after first growing season on sites, diameter and height increment was observed and survival of seedlings. Analysis of variance (One-Way ANOVA) was used to indicate differences between sites. Significant differences between variables are determined by Tukey HSD post-hoc test ($p<0.05$). Statistical analyses were performed with the help of the computer software package Statistica 7.1.

RESULTS

Survival is similar after the first growing season on the field, on the Veliko ratno ostrvo is 90% and on site Manić-Bostanište is 90.38%, but seedling diameter increment, height increment and total height are significantly different. Total diameter average is not statistically different between sites (Table 1).

Wildlife was the most common reason for seedling mortality and damage, 100% of dead seedling on the site Manić-Bostanište and about 50% on the site Veliko ratno ostrvo.

Table 1. Survival counts and growth measurements of Europen white elm seedlings on two sites after first growing season

Site	Survival (%)	Diameter increment (mm)	Height increment (mm)	Total diameter (mm)	Total height (mm)
Veliko ratno ostrvo	90[a]	7,63[b]	71,98[b]	20,83[a]	203,27[b]
Manić-Bostanište	90,38[a]	4,32[a]	19,37[a]	20,45[a]	169,25[a]

*Means within each column followed by the same letter are significantly different ($p<0,05$)

The highest value of diameter increment (24 mm), total diameter (39 mm), height increment (252 cm) and total height (432 cm) were recorded on the site Veliko ratno ostrvo, while the lowest values of total diameter (9 mm) and total height (65 cm) were recorded at Manić-Bostanište, also as the absence of growth in some plants.

DISCUSSION

Wetlands have condition for fast and easy weed growth and in this case tall seedlings have priority relative to traditional seedlings which are height 20-40 cm (Cicek et al. 2007a). High survival after first growing season on the both sites indicates possibility for reforestation wetlands with European white elm.

Increment of height and diameter are high on both sites and are consistent with some earlier research (Cicek et al. 2007b). Flooding have bad influence on shoot and root growth and can caused death of seedlings (Kozlowski 1997, Sena Gomez and Kozlowski 1980), but frequency and intensity of flooding and plant species are very important (Vreugdenhil et al. 2006). European white elm seedlings have high degree of tolerant on flooding (Li et al. 2015) and flooding during 3 weeks on site Veliko ratno ostrvo or 5 days on site Manić-Bostanište did not cause high consequences. Differences between site conditions probably cause differences of increment. Seedlings on site Manić-Bostanište have less value of all observed parameters as a cause of combination clay soil and spring out planting.

CONCLUSIONS

High rate of survival on both sites show high potential of European white elm for reforestation of wetlands using tall seedlings. Diameter and height increment indicate possibility for next research and using European white elm for biomass production on wetlands.

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