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CLONAL APPROACHES TO GROWING LEUCE POPLARS (*LEUCE* DUBY) IN HUNGARY AND SERBIA

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Abstract – Leuce poplars, above all white poplar (*Populus alba*) and its natural hybrid, grey poplar (*Populus x canascens*) are native stand-forming tree species in Hungary and Serbia. More than 70 per cent of their stands and plantations can be found on calcareous sandy sites in the Danube–Tisza region, so they play a significant role in the poplar management of this part of the country. One of the most important tasks ahead of Hungarian and Serbian poplar growers is to improve the quality of poplar stands and plantations for wood production based on selecting relatively drought-tolerant clones and cultivars. In the paper the juvenile growth and the morphological characteristics of five micropropagated Leuce poplar clones have been evaluated on a marginal site in central Hungary. The clones *'H-337'* (*P. alba x P. grandidentata)*, *H-384*' (*P. alba x P. grandidentata)* and *Populus alba* L-12 can be especially promising for quality wood production under arid hydrological conditions.

Key words: Leuce poplars, clone selection, early evaluation

KLONSKI PRISTUPI UZGOJU BELIH TOPOLA (LEUCE DUBY) U MAĐARSKOJ I SRBIJI

Abstrakt – *Leuce topole, posebno bela topola (Populus alba) i njen prirodni hibrid, siva topola (Populus x canascens) su autohtone vrste koje formiraju sastojine u Mađarskoj i Srbiji. Više od 70 procenata njihovih sastojina i plantaža mogu da se nađu na kalcifikovanim peskovitim lokalitetima u regionu Dunav-Tisa, te igraju značajnu ulogu u uzgoju topola u ovom delu države. Jedan od najvažnijih zadataka mađarskih i srpskih uzgajivača topola jeste da unaprede kvalitet topolarskih zasada topolovih sastojina i plantaža za proizvodnju drveta na osnovu selekcije klonova i sorti tolerantnih na sušu. U radu su pocenjeni juvenilni porast i morfološke karakteristike pet Leuce klonova, umnoženih mikropropagacijom, na marginalnim staništima centralne Mađarske. Klonovi 'H-337' (P. alba x P. grandidentata), H-384' (P. alba x P. grandidentata) i Populus alba L-12 bi mogli da budu posebno interesantni za proizvodnju kvalitetnog drveta u uslovima aridne klime.*

Ključne reči: *Leuce topole, klonska selekcija, rani testovi*

INTRODUCTION

White poplar (*Populus alba* L.) and its most important natural hybrid, the gray poplar (*Populus x canescens* (Ait). Sm.) are native poplar species in Hungary and Serbia. The standing volume of white poplar are 10.2 million m^3 in Hungary and 607.150 m^3 in Serbia.

More than 70% of the white and grey poplar stands can be found on calcareous sandy sites on the Danube–Tisza region in Hungary. Native poplars have been regarded for several decades as weed tree species without any value for timber market. In spite of this fact about 35% of the new afforestation and artificial regenerations is carried out presently with white poplar in the Danube-Tisa region in Hungary. Productivity of poplar growing is often limited, in some cases even excluded, by soil defects, namely compact clay rich layers, coarse sandy layers of considerable thickness, limestone pan, ironpan, gleyic layers, $CaCO_3$ accumulation, and the most dangerous of all, the accumulation of alkaline salts. To consider the similar ecological conditions in Serbia mostly other stand forming tree species have been used for afforestation. White poplar has a rich gene pool on the sand dune region in the middle of the Pannonian Plain and on the bottomland of big rivers (Szodfridt, Palotás 1973). In the near future, due to the establishment of national parks in these regions, considerable increases can be expected in the area of native poplars. At the same time their importance will be increasing in the large areas of marginal sites which are not suitable for hybrid poplars but can accommodate native ones.

In Hungary and in Serbia the range of sites optimal for poplar growing is rather limited. In the Danube–Tisza region some very important ecological factors have become unfavourable for poplar growing in the last two decades. There is no sufficient precipitation during the growing season (appr.200–300 mm), and the rivers' control and canalisation have caused a drastic lowering of the ground-water table in many places. In such spots the water supply for poplars depends on the moisture content of soils, accumulating waters on the surface and on the water-storing capacity of soils. Therefore, the main aim of the selection work is to find and improve relatively drought-tolerant Leuce-poplar clones and cultivars that have good stem form providing good-quality wood material for industrial purposes (without false heartwood) and that can adapt to the changed ecological conditions (Rédei 1994).

TAXONOMY AND DISTRIBUTION OF POPLARS

The genus *Populus* is widespread through the north temperate zone and has about 35 species inhabiting vast areas from the boreal tree line down to Mexico, North Africa, Himalayas, Japan and China. The genus is divided into 5 sections: Turanga, Leuce, Aigeiros, Tacamahaca and Leucoides. The Leuce Duby section consists of the following tree species: European aspen (*P. tremula*), Quaking aspen (*P. tremuloides*), Bigtooth aspen (*P. grandidentata*), white poplar (*P.alba*) and grey poplar (*P. x canescens*).

Interspecies hybridisation have yielded up to now the best results. It has to be mentioned, that the direction of crossing has importance in poplars, i.e. reciprocal crosses are genetically different. Hybrid vigour was observed in the crosses *P.alba x*

P. grandidentata and *P. tremula x P. tremuloides,* which means that genetically close species, originating from different continents (usually Europe – N. America), are the most suitable partners. Such crosses may happen in nature, when the species are planted by accident close to each other *(*Mátyás 1983, Guzina 1986).

BRIEF SUMMARY ON BREEDING AND IMPROVEMENT OF POPLARS IN HUNGARY

The basis for the breeding and improvement programme was a series of clones given in the frame of co-operation, during the 1950's by the Poplar Research Institute of Italy, Belgium, the Netherlands, France, Germany and Yugoslavia, combined with the genetic heritance of Hungarian forests (*Populus nigra and Populus alba*). This research programme was started by the prominent scientists of the Hungarian Forest Research Institute (ERTI), Gy. Koltay and F. Kopecky. In Hungary ERTI is the most important national institution for poplar breeding and improvement. It took part in provenance testing experiments of *Populus trichocarpa*, *Populus deltoides* and *Populus nigra,* launched by FAO and IUFRO. In the course of breeding activities over four decades, about 80 000 seedlings were produced and tested by ERTI, of which 50% were among interspecific and intraspecific hybrids of the Aigeiros section, 15% of the Leuce section and 35% of the Tacamahaca section.

The number of clones selected out of progenies amounts to more than 1000. These clones, screened by early testing methods, make up a considerable part of the collection of ERTI and at the same time primary materials for clonal testing experiments. This poplar cross-breeding resulted in several excellently growing euramerican poplar clones, of which *Populus x euramericana 'Pannonia', 'Kopecky' and 'Koltay'* have been admitted to the official national poplar clone-choice and are integral parts of the state approved and tested varieties.

Selection breeding was mostly directed to native poplars (Kopecky 1962, 1978). According to his research on native poplar hybrids, the *P. alba x P. grandidentata* '*H 422-1',* the '*H 422-6'*, the *P. alba x P. alba* '*H 425-4'* and the *'H 325-10'* clones could have some growing-importance. The *P. alba cv. 'Bolleana' 'H 427-3'*, the *P. alba x P. grandidentata* '*H 422-1'* and the '*H 422-6'* clones can be planted in roadside plantations and parks for their decorative value on the whole range of suitable sites (Rédei 2000). On the calcareous sites of the Pannonian Plain only the *P. canescens x cv. 'Bolleana'*, the *'H 372-1'* and the *'H 372-2'* can be planted.

Selection investigations on marked individuals and populations of native poplars laid the foundation for their possible *in situ* and *ex situ* conservation. Marked gene-reserves extend to roughly 100 ha and the number of registered plus-trees is about 200 (*in situ* gene preservation). In Hungary the area of native and hybrid poplar experiments amounts to 800 ha. Geographically they are dispersed in the poplar growing regions, and therefore are suitable for drawing conclusions on clone-site relations under the typical conditions of the country (Tóth 1996).

BRIEF SUMMARY ON BREEDING AND IMPROVEMENT OF WHITE POPLARS IN SERBIA

In Serbia, the work on the breeding of white poplar related to the Institute of Lowland Forestry and Environment, Novi Sad (Guzina (edit.), 1986; Guzina and Tomovic, 1989; Tomovic, 1994; Guzina et al. 2000; Orlovic, 2003).

The main courses while working on the breeding of tree species is related to:
- The study of variability and heritability (Guzina and Bozic, 1984, Tomovic and Orlovic, 1994; Orlovic et al. 2003), variability of isozymes (Orlović et al. 2003)
- Breeding hybridization and selection (Guzina et al. 1998; Guzina et al. 2000; Orlovic et al. 2003)
- Vegetative reproduction and clonal selection (Pletikapić-Kolevska, 1985; Guzina and Tomovic, 1989)
- Attempt of induction and use of mutation (gama 137 C) (Guzina 1986; Orlovic et al. 2003).

All above studies were conducted to create new cultivars and introduction into production.

METHODS OF VEGETATIVE PROPAGATION USED FOR LEUCE POPLARS

Clonal selection is a variant of individual selection, a very effective one, as both additive and non-additive genetic components are utilized. Asexual propagation is very important for archivation and conservation of selected genotypes. The ease of vegetative sustenance of individuals is the advantage in forest tree breeding.

The vegetative reproduction of Leuce poplars can be solved by autovegetative propagation. Cutting propagation has been practiced for centuries in horticulture and to some extent in forestry as well. Root cuttings have been proved to be the best method. Root cuttings are detached parts of root systems, generally 0.5 cm in diameter and about 5-10 cm in length. They are planted horizontally at a depth of 2 to 3 cm in a well-watered rooting medium. Good results can be achived with simple sowing of root cuttings in the nursery.

Greenwood cuttings are much more difficult to handle, as they are sensitive to drying-out. Greenwood cuttings of Leuce poplars are rooted under shaded foil cover, they have to be carefully watered. The time required for root formation varies from two weeks to twelve weeks. Clones which root the best in early summer are usually over-wintered in a greenhouse because their root systems are not adequate to support the young ramets under outdoor winter conditions.

Almost 10 Leuce poplar selected clones were micro-propagated during the last few years in the Micro-propagation Laboratory of Research Institute for Fruit growing and Ornamentals, Budapest –Érd in collaboration with the Hungarian Forest Research Institute. In Serbia selected clones were micro-propagated during the last few years in the Laboratory for micropropagates of Institute of Lowland Forestry and Environment. Four Leuce poplar selected clones are regulary micropropagated during the last few years, but the best results are with *Populus alba* L-12.

Plant tissue culture methods provide us with new means to speed up vegetative propagation of the selected clones and give us the opportunity to establish new clone

trials and seed orchards with them (Rédei, Balla, 2007). In spite of the numerous advantages of this method it has to be underlined that tissue culture plants must not be brought into cultivation before risks and costs are carefully considered.

EARLY EVALUATION OF LEUCE POPLAR CLONES

Suitable observation techniques make it possible to observe some characteristics important for breeding already at an early stage of development of trees, while other characteristics are manifested at a later age. In our selection work the main selection criteria were:

- growth rate
- adaption to site conditions
- stem form
- branching habit
- rootability of cuttings
- resistance to pests and diseases and
- wood properties.

In the past decades the Hungarian Forest Research Institute has established several comparative trials with Leuce poplar clones for investigating their site requirements, growing patterns and yield (Rédei 1994, 1999).

Description of the study area

The trial discussed in this paper was allocated in subcompartment Kecskemét 40A in the Danube – Tisza interflow region (in central Hungary) in spring 2004. According to the Hungarian classification of forest site types, the main ecological characteristics of the studied area are the following: forest steppe climate zone; humidity is less than 50% in July at 2 pm; the annual precipitation is less than 550 mm; hydrology: free draining; genetic soil type: humid sandy soil with very shallow rootable depth.

Trial discussed in this paper in Serbia was allocated in field experiment in Institute of lowland forestry and environment. The main ecological characteristics of the studied area are the following: forest steppe climate zone; humidity is less than 50% in July at 2 pm; the annual precipitation is less than 550 mm; hydrology: free draining; genetic soil type: sandy to sandy - loam soil.

Leuce poplar clones found in the trial

In the clone trial the clone of *'H 325'* (*P. alba x P. alba*), *'H 337'* (*P. alba x P. grandidentata*), *'H 384'* (*P. alba x P. grandidentata*), and *'H 425-4'* (*P. alba x P. alba*) as well as white poplar (*P. alba* L.) as control can be found. The experiment was set up with micropropagated plants (in case of the clones) and one-year-old seedlings (in case of the control). A randomised block system with three replications was used. The initial spacing was 2.5 x 2.0 m.

The experiment in Serbia was set up with micropropagated plants of *Populus alba* L-12. The initial spacing was 2.5 x 2.5 m. The trial was established in the protected part of the alluvial plain of the Middle Danube near Novi Sad at the

experimental field of the Institute of Lowland Forestry and Environment. The most common soil type is fluvisol (Galić et al. 2009).

Assessment of stand characteristics

The following stand parameters were measured and calculated at the age of 6 years: stem number, dbh.(diameter at breast height), tree height and mean tree volume. Stem volume was estimated according to the volume table for white poplar (Sopp, Kolozs 2000).

The collected data were analyzed by STATISTICA 8.0 (data analysis software system - StatSoft, Inc. 2008) programme including correlations and regression analysis. Analysis of variance was done for height (H) and diameter at breast height (DBH) since these parameters (particularly diameter) are highly correlated with the mean tree volume.

Tree classification

Characterization of stem quality, including their health condition was defined by using the following stem quality classes:

- *Class 1* - The stem is straight, cylindrical, healthy and reaching the top of the crown. Crooks are tolerated in one dimension only, up to a bend of less than twice the stem diameter. The lower two-third of the bole is free of live branches.
- *Class 2* - The stem is straight and healthy, forks are tolerated, but only if they are in the uppermost third of the tree. Crooks are tolerated in one dimension only, up to less than four times the stem diameter.
- *Class 3* - The stem is crooked, leaning and more or less damaged. Crooks may reach six times the stem diameter in one dimension and minor crookedness in a second dimension is tolerated.
- *Class 4* - The stem is very crooked in more than one dimension and heavy damaged. Low branching, forked trees sometimes with broken crown.

Results

Table 1 illustrates the most important stand structure parameters. On the basis of the data, considering the growth in height, the clones *'H 337'* and *'H 384'* provided the best results. They surpassed the control by 29 and 23 per cent, respectively. As regards the growth in DBH the above-mentioned clones surpassed the control by 24 and 23 per cent, the tendency was also the same with regard to the mean tree volume values. The effect of differences in DBH on the mean tree values seems to be very considerable (an additional 50 and 40 per cent for the above-mentioned clones). As the stem quality index is concerned, the succession from best to worst is: '*H 337*', '*H 384',* '*H 425-4'* and '*H 325*'. According to the significance test at P=5% level, significant differences were found in height ($SD_{5\%}$= 1.31 m), in DBH ($SD_{5\%}$=1.22 cm) and in the mean tree volume values ($SD_{5\%}$= 2.90 dm^3).

Table 1. Stands characteristics of Leuce-poplar clones at age 6 year in Hungary
Tabela 1. Svojstva sastojine u šestoj godini za Leuce klonove u Mađarskoj

Name of clone *Ime klona*	Mean H *Srednja visina* (m)	%	Mean DBH Srednji $d_{1.30}$ (cm)	%	Mean tree volume *Zapremina srednjeg stabla* (dm^3)	%	Stem-quality *Kvalitet stabla* (1-4)
'H 325'	5.1	106	6.0	97	9	90	1.7
'H 337'	6.2	129	7.7	124	15	150	1.1
'H 384'	5.9	123	7.6	123	14	140	1.4
'H 425-4'	5.6	117	6.7	108	12	120	1.5
Control *Kontrola*	4.8	100	6.2	100	10	100	1.9

Table 2. illustrates the most important stand structure parameters at age 6 in Serbia.

Table 2. Stands characteristics of Leuce-poplar clones at age 6 years in Serbia
Tabela 2. Svojstva sastojine u šestoj godini za Leuce klon u Srbiji

Name of clone	Mean H (m)	Mean DBH (cm)	Mean tree volume (dm^3)	Stem-quality (1-4)
L-12	14.6	8.5	44	1.1

At age 6 the average and maximal DBH of *Populus alba* L-12 was 8,55 and 12,00 cm respectively. According to the data from Hungary clone L-12 had a greater DBH in average 1,5 cm. The average height was 14.1 m. In the same age the maximal and average potential wood production of *Populus alba* L-12 was 15,04 m^3/ha and 25,12 m^3/ha respectiely. As a result, the greater the volume of white poplar clones in Serbia in relation to the white poplar clones in Hungary.

Comparison with data from previous periods is not possible because the clones represent a new selection.

The DBH, volume and volume increment to age 21 of *Populus alba* L-12 illustrated on figure 1, 2 and 3.

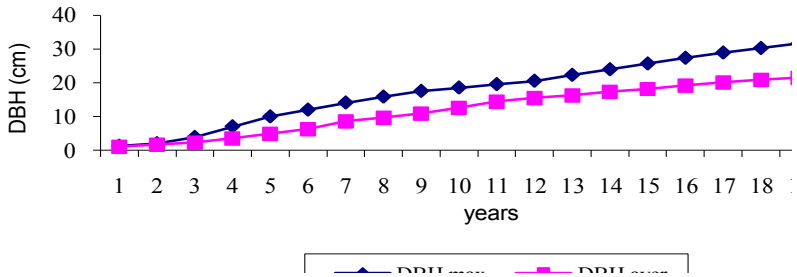

Figure 1. Maximal and average DBH of Populus alba L-12
Slika 1. Maksimalni i srednji prečnik na prsnoj visini kod Populus alba L-12

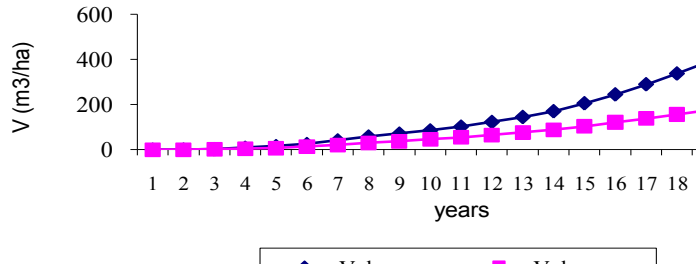

Figure 2. Maximal and average potential wood production of Populus alba L-12
Slika 2. Maksimalni i srednji potencijal proizvonje drveta kod klona Populus alba L-12

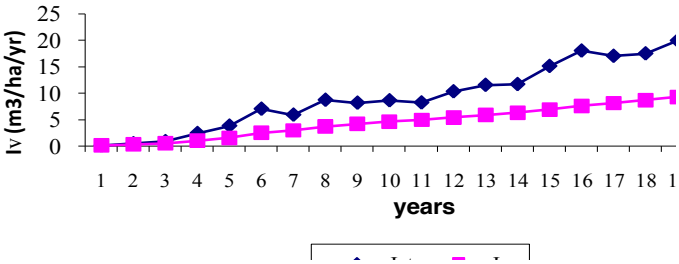

Figure 3. Annual increment in wood production of Populus alba L-12
Slika 3. Tekući prirast proizvodnje drveta kod Pupulus alba L-12

The average DBH at age 21 for clone L-12 was 23 cm, the maximal DBH was 34.3 cm and the average volume was 224 m^3ha^{-1}. The maximum of Itv was at age of 19 (19,99 m^3ha^{-1}). Comparison with data from Hungary in larger ages was not possible. The reason is lower age of the experimental plantations in Hungary.

In similar stand condtions *Populus x euramericana* clone I-214 had a maximum growth at age 18 (24,53 m^3ha^{-1}, Galic, 2003). As the results suggest, testing clone of white poplar have a great potential which is essential in poplar growing.

CONCLUSIONS

The trees in the clone trial demonstrated in the paper thrive under site conditions that are only partly favourable for poplar growing. Considering this fact, the early evaluation showed that mostly the clones *'H-337'*, *'H-384'* and *Populus alba L-12* seem to be suitable for poplar management, while the clone '*H 425-4'* could be considered an alternative one for wood production.

Experiments have also demonstrated that micropropagated plants can be successfully transplanted into soil, hardened and grown in the field. Micropropagated trees have been exhibiting normal growth and appearance since they were planted.

As the results suggest, systematic testing is essential in poplar breeding. However, results with a smaller probability of error can only be achieved after a longer period of research. The systematic evaluations of comparative trials set up in the past decades in Hungary will make it possible to select more reliably the Leuce poplar clones which can meet all the requirements drafted in the introduction to this paper.

As the results suggest, testing clone have a great potential which is essential in poplar growing. Results also showes that clone L 12 has a great potential for fast growts and wood production.

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Rezime

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Leuce topole, posebno bela topola (Populus alba) i njen prirodni hibrid, siva topola (Populus x canascens) su autohtone vrste koje formiraju sastojine u Mađarskoj i Srbiji. Više od 70 procenata njihovih sastojina i plantaža mogu da se nađu na kalcifikovanim peskovitim lokalitetima u regionu Dunav-Tisa, te igraju značajnu ulogu u uzgoju topola u ovom delu države. Jedan od najvažnijih zadataka mađarskih i srpskih uzgajivača topola jeste da unaprede kvalitet topolarskih zasada topolovih sastojina i plantaža za proizvodnju drveta na osnovu selekcije klonova i sorti tolerantnih na sušu. U radu su pocenjeni juvenilni porast i morfološke karakteristike pet Leuce klonova, umnoženih mikropropagacijom, na marginalnim staništima centralne Mađarske. Klonovi 'H-337' (P. alba x P. grandidentata), H-384' (P. alba x P. grandidentata) bi mogli da budu posebno interesantni za proizvodnju kvalitetnog drveta u uslovima aridne klime. Kako rezultati ukazuju, testiranje klonova ima veliki potencijal, što je esencijalno u uzgoju topola. Rezultati takođe ukazuju da i klon L-12 ima veliki potencijal za brzi rast i proizvodnju drveta.