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# TENDING OPERATION MODELS FOR LEUCE POPLAR STANDS GROWING ON SANDY SOILS IN HUNGARY

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**Abstract:** A more intensive integrated research and development approach to the work carried out on the growth on sandy soils of stands of Leuce poplars, primarily the white poplar (*Populus alba*) and its natural hybrid the grey poplar (*Populus x canescens*), has been adopted in recent years, revealing several factors influencing stand growth. The fact that certain ecological factors influencing fundamentally the growth of trees have become unfavourable in Hungary in recent years has led to the more extensive use of white poplar (and its hybrids) in the course of afforestation and forest regeneration schemes. The study presents a new, simplified tending operation model for Leuce poplar stands and age, growing space and target diameter models suitable for qualitaty log production and for mass assortments. The simplicity of these practice-oriented models may foster the qualitative development of Leuce poplar management in Hungary.

**Key words:** Leuce poplars, tending operation models, growing space regulation

*MODELI OPERACIJA NEGE U PLANTAŽAMA LEUCE TOPOLA NA PESKOVITIM ZEMLJIŠTIMA MAĐARSKE*

***Izvod:*** *Sve intenzivniji pristup putem integrisanih istraživanja i razvoja radu na rastu na peskovitim zemljištima zasada Leuce topola, primarno bele topole (Populus alba) i njenog prirodnog hibrida, sive topole (Populus x canescens) je usvojen prethodnih godina, otkrivajući nekoliko faktora koji utiču na rast zasada. Činjenica da su pojedini ekološki faktori koji fundamentalno utiču na rast drveća u poslednje vreme postali nepovoljni u Mađarskoj je dovela do sve ekstenzivnijeg iskorišćavanja bele topole (i njenih hibrida) kada su u pitanju pošumljavanja i planovi regeneracije šuma. Studija predstavlja novi, pojednostavljeni model operacija nege za zasade Leuce topola i daje modele zasnovane na starosti, razmaku sadnje i ciljanom prečniku stabl, pogodnim za proizvodnju kvalitetnih trupaca i za masovnu proizvodnju drveta. Jednostavnost ovih modela koji su namenjeni praksi bi mogla da podstakne razvoj u kvalitativnom smislu u gazdovanju Leuce topolama u Mađarskoj.*

***Ključne reči:*** *Leuce topole, modeli operacija nege, regulacija vegetacionog prostora*

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## INTRODUCTION

Leuce poplars, primarily white poplar (*Populus alba*) and its most important natural hybrid the grey poplar (*Populus* x *canescens*), are tree species native to Hungary (Kopecky, 1962, 1978; Szodfridt and Palotás, 1973; Rédei, 1991). Due to their favourable silvicultural and growth characteristics, as well as the possibilities for the utilisation of their wood, the area they occupy is increasing continuously. The most important task facing Hungarian poplar growers is improving the quality and increasing the quantity of poplar stands for wood production (Rédei, 2000).

The area occupied by the two species in 2006 was 65 000 ha (3.2 % of the total forest area), with a standing volume of 9.8 million $m^3$ (163 $m^3$ $ha^{-1}$) (Führer et al., 2009). Their importance will continue to increase across the large areas of marginal land not suitable for the cultivation of hybrid poplars but able to accommodate these native species (Rédei, 1991; 1994; 2000).

Other species that may be used for the purposes of plantation forestry in addition to these poplar species are black locust, red oak and black walnut. Common walnut plantations may also play a role, but the silvicultural significance of this tree species is negligible.

From among the above listed tree species the models for tending operations and the tables for age-growth space-target diameter models are suitable for production of large, quality wood material as well as mass assortments produced in white and grey poplar stands.

## MATERIALS AND METHODS

The models developed are based on a yield table for white and grey poplars (Rédei et al., 2012). It was constructed from data gathered from 50 permanent and 20 temporary forest inventory sample plots (500-1000 $m^2$). The stands sampled were located in the vicinity of N 46° 31' 10" and E 19° 26' 46" (Fig.1). The age of the stands varied between 5 and 45 years.

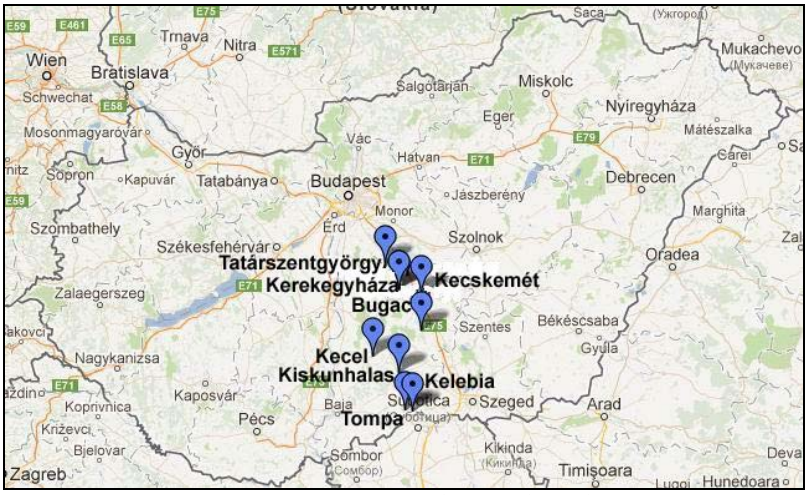


**Figure 1.** Locations of the sampling plots
***Slika 1.*** *Lokaliteti oglednih površina*

During the stand surveys, the key stand characteristics were measured (surviving stem number, dbh, tree height and mean tree volume) (Laar and Akca, 1997). Stem volume was estimated using the following volume function (Sopp and Kolozs, 2000):

$$v = 10^{-8} d^2 h^1 \left(h/[h-1.3]\right)^2 \left[-0.4236\, d\, h + 12.43\, d + 4.6\, h + 3298\right]$$

where $v$ is stem volume ($m^3$), $d$ is diameter at breast height (cm) and $h$ is tree height (m).

The regression analyses were calculated using a computer-based statistics programme (STATISTICA 8.0 data analysis software system - StatSoft Inc., 2008). The expected height values of the stands at the reference age (25 years) according to the yield classes are: 24.2 m, 21.6 m, 19.0 m, 16.4 m, 13.8 m and 11.2 m. On the basis of the fitted guide curve and the reference age (100 %), a percentage value was calculated at any age and for any yield class. The yield table (Rédei et al., 2012) was constructed using the following formulae and coefficients (a detailed dataset is available from the authors):

1. Age of stand (A)

2. $H_m$ = average height of stand (height of dominant and co-dominant trees) in m:
   $H_m = 1.21592 \times (1\text{-}e^{-0.09236A})^{1.8334}$

3. $D_m$ = average DBH of stand in cm:
   $D_m = 1.58356 + 0.73502 \times H_m + 0.01571 \times H_m^2$
   with $R^2 = 0.886$

4. $V_m$ = volume of stand in $m^3$ $ha^{-1}$
$V_m = BA_m \times H \times F_m$, where
$H \times F_m$ = form-height quotient
$H \times F_m = 1.96791 + 0.40778 \times H_m$
with $R^2 = 0.923$

5. $BA_m$ = basal area of stand in $m^2$ $ha^{-1}$:

$$BA_m = \frac{D_m^2 \times \pi}{4 \times 10000} \times N_m$$

6. $N_m$ = stocking density of stand in trees $ha^{-1}$:
$N_m = e^{8.75483-0.83879 \ln Dm}$
with $R^2$=0.826

## SIMPLIFIED TENDING OPERATION MODEL FOR LEUCE POPLAR STANDS

Leuce poplars are fast-growing species. Seedlings quickly emerge from competition with weeds. In-line and inter-row weeding is required in the first years after plantation establishment by means of seeding, as is the removal of failed plants. During tending operations it is important to take into consideration the fact that plantations consist of trees of varied genetic make-up (genotype). In terms of the demand for light, it is worth remembering that Leuce poplar reacts extremely strongly to light availability. It also tolerates shade very well (Tóth, 1996; Führer et al., 2009).

*Table 1* contains a simplified tending operation model for Leuce poplar (white and grey poplar) stands. The choice of the most suitable spacing depends on the quality of the planting material and the particular site conditions. In the table all of the data are presented by six yield classes. The mean tree height is the most important model factor because it determines the timing of the particular tending operation. Thinnings (to expand the available growing space) must be carried out when the stocking density approaches the stem number quoted in the table. Trees of cylindrical stem-shape with straight fibre-formation, and dense foliage, monopodial growth and good health have priority when selections are made. Based on investigation results gained up to now, on good sites the stocking at final felling (35-40 years) could be 350-400 trees/ha. On medium sites the final cutting age is 30-35 years and 5-600 trees per ha can be planned. During the thinnings prunings must be done on final crop trees up to a height of 5-6 m, resulting in a branchless stem up to this height.

In the case of plantations planted at spacings of either 3 x 3 m or 3 x 2 m, there is no need for thinning, except where the sapling growth is unstable. In the event of initial spacings narrower than 3 x 1 m or 2.5 x 1 m, one or two thinnings are recommended for plantations established with white poplar clones.

**Table 1.** Simplified tending operation model for Leuce poplar (white and grey poplar) stands
***Tabela 1.*** *Pojednostavljene operacije nege u zasadima Leuce topola (bela i siva topola)*

| Tending operation *Operacija nege* | Number *Broj* | Tending operation *Operacija nege* | | | Stocking density (stems $ha^{-1}$) *Gustina zasada (stabala $ha^{-1}$)* | |
|---|---|---|---|---|---|---|
| | | To be carried out in year… *Da bude izvedena godine…* | To be carried out at $H_m$ (m) and yield class… Da bude izvedena na $H_m$ (m) i klasi … | | Tending operation *Operacija nege* | |
| | | | | | Before *Pre* | After *Nakon* |
| Cleaning | 1. | 5–10 | 6 | I–VI | >3000 | 3000 |
| *Rana proreda* | 2. | 11–14 | 8–11 | I–VI | 3000 | 1300–1800 |
| Thinning | 1. | 15–20 | 12–17 | I–V | 1300–1800 | 650–1200 |
| *Kasna proreda* | 2. | 21–25 | 16–23 | I–IV | 650–1200 | 350–600 |
| Final cutting *Završna seča* | | 40 | | I–II | | 350–400 |
| | | 30–35 | | III–IV | | 500–600 |
| | | 25–30 | | V | | 800–900 |
| | | 20–25 | | VI | | 1000–1100 |

Remarks for the use of the tending operation model:

- When planning the thinning operation, the better the estimated yield class, the lower the stem number value after thinning to be applied.
- White poplar stands in yield classes V–VI are not suitable for quality wood production.

## AGE, GROWING SPACE AND TARGET DIAMETER MODELS FOR LEUCE POPLAR STANDS

In plantation forestry *the timing of the expansion of the available growing space* is significant with respect to reaching the target assortments by maintaining the near optimal stocking density per hectare (growth space). The site (ecological) factors essentially define the target assortments; for example, whether the opportunity for the production of sizeable, quality wood material (panel log, saw-log) exists or merely thinner wood assortments (cutting, pallet and box basic material), pulp, fibre, chippings and basic wooden board materials.

The data in *Table 2* show that an opportunity for the production of quality, *sizeable logs is possible in white and grey poplar stands classified yield class I-III.* For white and grey poplar stands in yield class IV – assuming an average harvesting age of 30 years – a target diameter of 18 to 20 cm can be planned with great certainty. The sustainable stocking density per hectare depending on the yield class varies from 320 to 560 stems.

**Table 2.** Age-target diameter model for Leuce poplar (white and grey poplar) stands suitable for quality log production
***Tabela 2.*** *Model za prečnik u ciljanoj godini za zasade Leuce topola (bela i siva topola) pogodnih za proizvodnju kvalitetnih trupaca*

| Planned target diameter (DBH) (cm) *Planirani ciljani prečnik (DBH) (cm)* | Factors *Faktori* | | |
|---|---|---|---|
| | Yield class *Klasa* | Years required to reach target diameter *Godine potrebne za dostizanje ciljanog prečnika* | Stocking density (stems $ha^{-1}$) *Gustina zasada (stabala $ha^{-1}$)* |
| 18 | I | 14 | 560±5% |
| 18 | II | 17 | |
| 18 | III | 21 | |
| 18 | IV | 28 | |
| 20 | I | 16 | 515±5% |
| 20 | II | 18 | |
| 20 | III | 23 | |
| 20 | IV | 32 | |
| 25 | I | 21 | 425±5% |
| 25 | II | 25 | |
| 25 | III | 37 | |
| 30 | I | 28 | 365±5% |
| 30 | II | 42 | |

Table 3. Age-target diameter model for Leuce poplar (white and grey poplar) stands suitable for the production of mass assortments
Tabela 3. *Model za prečnik u ciljanoj godini za zasade Leuce topola (bela i siva topola) pogodnih za masovnu proizvodnju drveta*

| Planned target diameter (DBH) (cm) *Planirani ciljani prečnik (DBH) (cm)* | Factors *Faktori* | | |
|---|---|---|---|
| | Yield class *Klasa* | Years required to reach target diameter *Godine potrebne za dostizanje ciljanog prečnika* | Stocking density (stems $ha^{-1}$) *Gustina zasada (stabala $ha^{-1}$)* |
| 10 | IV | 11 | 920±5% |
| 10 | V | 14 | |
| 10 | VI | 19 | |
| 12 | IV | 13 | 790±5% |
| 12 | V | 17 | |
| 12 | VI | 25 | |
| 14 | IV | 15 | 690±5% |
| 14 | V | 24 | |
| 14 | VI | - | |
| 16 | IV | 20 | 620±5% |
| 16 | V | 31 | |
| 16 | VI | - | |

*Table 3* shows that stands of yield classes IV and V are suitable for the production of mass assortments, and possibly even white and grey poplar stands of yield class VI with a target diameter of 10 to 12 cm. However, the management of stands characterised by these two lowest yield classes are usually loss producing and so are unsuitable for plantation forestry.

White and grey poplar stands growing under unfavourable ecological conditions also have an earlier harvesting age (generally between 25-30 years). The sustainable stocking density varies between 620-920 stems $ha^{-1}$ depending on the yield class. In these stands – based on our yield studies – the reduction in stem number (thinning) carried out at age 15-17 does not lead to a significant increase in diameter growth.

## CONCLUSIONS

White and grey poplar plantation management for improved growth is becoming ever more significant in lowland forestry. This fact was taken into account in the conception of this study, and fed into the novel planning tools developed to help increase the value of the material produced in Leuce poplar stands. In recent decades, growth models based on stand level data have gradually been replaced by stand growth models predicated on stem number frequencies and individual tree growth models. Nevertheless, traditional tending operation models will remain very useful tools for forest management and forest inventory. The published models can be widely used in the following areas of Leuce poplar management and forest inventory:

- statistical appraisal of Leuce poplar stands,
- harvest scheduling for Leuce poplar stands,
- volume estimations,
- drawing up and further development of silvicultural (tending operation) models for Leuce poplar stands,
- development of guidelines for local policies promoting native species, and
- national analysis of the growth of Leuce poplar stands.

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## **R e z i m e**

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