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Landscape of Danube inland-delta and its potential of poplar bioenergy production

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ABSTRACT

The Slovakian portion of the Danube inland-delta represents a unique landscape. Branches of the Danube and more or less regular flooding with its alluvial deposit have created the most fertile soils which are partly forested. The greatest portion of the area is the crop land, while the forests are man-made with the poplar clones representing the stand-forming tree species. The present study investigates the influence of 7 predictors composed of the 3 biomass fractions, location on tree and clone factors and the 4 variables of stand index and age of stand and the height and diameter of tree on the calorific values of Robusta and I-214 (*Populus x euramericana*) clones in Slovak territory. A statistical significance influence resulted for all predictors except for the clone factor. The average calorific value of all biomass fractions is approximately in the range of 17.8–18.4 MJ kg^{-1} and statistical tests showed that wood has the highest calorific values while the thick bark on the lower parts of the stems had the least.

1. Introduction

The area of the Danube inland-delta was severely influenced by the building of dikes against floods around 1850. This dike system still exists and it is the most effective protection against floods between Vienna and Budapest. The inter-dike area has excellent and luxurious conditions for fast-growing poplar plantations, which cover the greatest part of this area.

The landscape consists of river isles and peninsulas of different acreage surrounded by water bodies. These consist of the main stream of the Danube and also lakes and branches, which are partly silted but mostly active and at least sometimes directly connected with the main stream of the Danube. There is little agricultural utilization here in the inter-dike area comprised only of moist meadows and pastures with small acreage. Intensive forestry has taken advantage of the luxurious growing conditions of the high quality soils, the high level of ground water and favourable climatic conditions. Poplar clones, which started to be planted here in the 1950s replaced the original forests and now they represent almost 95% of the forested area. Various poplar clones, both imported ones and also those of local origin have different qualities including growth rate and utilisation which offer possibilities for the production of bioenergy.

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A most important preference for poplar clones is the rapid production of quality biomass. Trees in favourable locality conditions in a temperate climatic zone reach considerable size within 10–15 years. Petráš and Mecko [1] for example, report a I-214 clone of this age with a stand mean diameter for the best site indices in the range of 40–50 cm and annual increment in above-ground biomass of 55–65 m^3 ha^{-1}. Poplar clones growth and production in comparison to other economically important tree species is 5–10 times greater and faster. For biomass utilization for energy purposes, it is necessary to know not only the volume production but also its calorific value. Therefore, it is not necessary to determine the primary production of the calorific value for each individual by destructive methods in the entire trees and stands; it is enough to re-calculate their known volume in relationship to their calorific value capacity. For this procedure, it is necessary to evaluate the specific biomass components, their density in kg m^{-3} and their calorific value in MJ kg^{-1}.

The density of pure wood from tree biomass was examined, and according to several current authors, soft leafed tree species have the lowest wood density values, followed by coniferous and hardwood species. Požgaj et al. [2] state the following values of wood density: for spruce, fir and poplar of 370 kg m^{-3}, for pine of 440 kg m^{-3}, for beech of 560 kg m^{-3} and for black locust and hornbeam of 600–650 kg m^{-3}. Trendelenburg [3] shows these values of density: for coniferous species 370–470 kg m^{-3} and for hardwood species 510–570 kg m^{-3}. Knigge and Schulz [4] show similar values: 377 kg m^{-3} for poplars, 380–490 kg m^{-3} for coniferous species, 520–560 kg m^{-3} for hardwood species and 650 kg m^{-3} for False acacia. Some studies have shown that density changes not only according to tree species but also according to the tree location [2,5]. For most species there is a tendency for a decrease in density from the base to the tip of the stem and an increase from the pith to the cambium in stem cross section. It is paramount to know the density of single components of trees for accurate re-computation of the forest biomass from the volume to weighted units. These have the density of large timber, bark and small-wood (small timber with bark to 7 cm). Petráš et al. [6] report the density of the bark of Robusta and I-214 poplar clones at about 370–415 kg m^{-3}, for wood of Robusta at about 400–450 kg m^{-3} and for I-214 only 50 kg m^{-3} less. Thin branches from the crowns have the highest density at approximately 470-450 kg m^{-3}.

Lieskovský et al. [7] published the average values of calorific value of the biomass of the black locust within 16.2–20.1 MJ kg^{-1}. The annual shoots have the lowest value and the bark has the highest. The calorific value of wood with a value of 18.2 MJ kg^{-1} is approximately in the middle of the interval. Ellenberg [8] determined *Norway spruce* at 20.36–20.79 MJ kg^{-1} for wood in stems, branches and roots, 20.34–21.14 MJ kg^{-1} in the bark, 20.74–20.79 MJ kg^{-1} in the needles, 21.25 MJ kg^{-1} in needle litter, and 36.87 MJ kg^{-1} in the resin. The calorific values for European beech were 19.72–20.10 MJ kg^{-1} for stem, branch and root wood, 20.78–23.13 MJ kg^{-1} for bark, 20.30–21.63 MJ kg^{-1} for leaves, 21.07 MJ kg^{-1} for leaf litter and 23.08 MJ kg^{-1} for beechnuts. Klašnja and Kopitovič [9] gave a calorific value for wood from willow at 16.4–23.2 MJ kg^{-1} and for black locust at 21.9–24.2 MJ kg^{-1}. Their values of calorific value of bark are lower by 1.5–5.5 MJ kg^{-1}. Oszlányi [10] evaluated calorific value for wood, bark and leaves of hornbeam, field maple, sessile oak and Turkey oak in the range of 18.12–20.65 MJ kg^{-1}. They confirmed significant differences between wood species primarily in the wood calorific value, but also in some cases in the bark and leaves.

The aim of this work was to investigate the calorific value of the basic components of the above-ground biomass of trees in the wood, bark and small-wood of Robusta and I-214 poplars clones. Consequently, this involved reviewing their variability and evaluating the model values necessary for re-computation of their volume production to primary production of the calorific value of the tree biomass.

2. Material and methods

The experimental material was obtained from a set of tree sample cuttings to research the density of the basic components of biomass in Robusta and I-214 poplar clones [6]. From entire set of 41 trees, 6 tress from the I-214 clone and 5 trees from the Robusta clone were selected. The trees grew in 11

Table 1 – The basic characteristics of the sample trees of poplar clones.

Tree number	Age	DBH	Height	Site index	Longitude	Latitude	Felling sampling	Weigh
Robusta clone								
5	30	38	35	34	17.77989°E	47.74888°N	Dec 2008	Jan 2009
15	22	35	30	34	17.79189°E	48.26543°N	Dec 2008	Jan 2009
17	43	49	41	32	18.59455°E	48.15429°N	April 2009	May 2009
23	44	48	31	24	21.92215°E	48.51494°N	Oct 2009	Oct 2009
27	44	34	32	24	21.92148°E	48.51744°N	Oct 2009	Oct 2009
I-214 clone								
1	39	43	25	22	17.68439°E	47.86439°N	Dec 2008	Jan 2009
3	19	34	33	32	17.49261°E	47.88796°N	Dec 2008	Jan 2009
8	30	56	40	34	17.78528°E	47.75137°N	Dec 2008	Jan 2009
20	38	53	35	40	18.58941°E	48.15996°N	April 2009	May 2009
28	47	47	38	28	21.74593°E	48.57296°N	Oct 2009	Oct 2009
32	47	36	35	28	21.74670°E	48.56811°N	Oct 2009	Oct 2009