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12. Natural production of the calorific value from poplar clones and socio-economic aspects of its wider use in Slovakia

PETRÁŠ Rudolf[1] , MECKO Julian[2] , OSZLÁNYI Július[3*] , PETRÁŠOVÁ Viera[4]

[1]National Forest Centre – Forest Research Institute, T. G. Masaryka 22, 960 92 Zvolen, Slovakia; e-mail: petras@nlcsk.org
[2]National Forest Centre – Forest Research Institute, T. G. Masaryka 22, 960 92 Zvolen, Slovakia; e-mail: mecko@nlcsk.org
[3]Slovak Academy of Sciences-Institute of Landscape Ecology, Štefániková 878/3, 811 06 Bratislava, Slovakia; e-mail: julius.oszlanyi@savba.sk
[4]Rural parlament in Slovakia, Pod Bánošom 6376/80, 974 11 Banská Bystrica, Slovakia; e-mail: vpetras13@gmail.com
**Address of author responsible for correspondence: OSZLÁNYI Július, Slovak Academy of Sciences-Institute of Landscape Ecology, Štefániková 878/3, 811 06 Bratislava, Slovak Republic; e-mail: julius.oszlanyi@savba.sk*

Abstract: The calorific value produced from the poplar clone stands' above-ground biomass was derived from its volume production, and calculated by mathematical model growth tables of I-214 and Robusta poplar clones' biomass density and dry biomass calorific value. Calorific values at 35 year stand age and site indices of 20, 30 and 40 were approximately 2,700, 6,000 and 9,300 GJ ha^{-1} respectively and the I-214 clone had minimally higher production than Robusta in the first half of growth. Lowland forest locations with 25,600 ha area and high groundwater level are most suitable for Slovak poplar production, and this enabled us to calculate mean annual production of 3,566 TJ of gross calorific value obtained from above-ground biomass. This is divided into 64% wood, 14% bark and 22% small-wood. Up to 85% of this production potential is situated in the Danube Lowland with the remainder in the Slovak southern middle and eastern regions. Natural production of poplar clones increases the possibilities of economic activity diversification and supports govermental policy of eliminating socio-economic disparities in regional population high long-term unemployment due to low qualifications. Finally, the least developed Slovak regions have a high proportion of agricultural and forest land, so governmental support is now also encouraging the green economy.

Keywords: calorific value production, poplar clones, green economy, economy activities diversification, Slovak regions

INTRODUCTION

Most Slovak poplar clones are fast-growing tree species achieving several times higher and faster wood production than other naturally extended tree species. Their mean volume production is normally 2.4-times higher and 4-times faster than spruce which is one of the most productive tree species in Slovakia. Although poplar clone stands account for only 0.6 % of Slovak tree species, they have dominant commercial importance in the nation's lowlands and flood plain forests.
While initial poplar clone research in Slovakia dates from the 1960's to '70s when progressive silviculture was introduced in forest agriculture and focused on individual verification of growth and health conditions (Cifra, 1971), systematic research of bred poplar clones began in 1991. This resulted in the following initiatives; creation of tree volume models (Mecko et al., 1994); bark diameter (Petráš et al., 1998); height curves (Petráš and Mecko, 2001, 2005); growth and entire stand production (Petráš and Mecko, 2001, 2005); assortment production models (Petráš et al., 2007, 2008a); value production (Petráš et al., 2002, 2008b) and finally, maturity rotation age and calorific value production (Petráš et al., 2010, 2012, 2013a, 2013b). In addition to production of wood for the processing industry, there was also small-wood and bark production for energy use. Petrášová (2011, 2012) provided detailed analysis of biomass as the potential for increased diversified economic activity and the source of innovative processes in Slovak's regional policy. The author also examined self-

government participation in rural area business processes. This was based on poplar clones' natural production in specific regions and their energy potential.
The aim of this work is to summarize current knowledge in this area and to highlight possibilities provided by efficient use of natural resources in cultivating poplar clones for improved socio-economic development of the landscape.

MATERIAL AND METHODS

Calorific value produced from above-ground tree biomass is determined by calculating the volume production with the following variables: (i) biomass density values (Petráš et al., 2010), (ii) calorific values of dry matter (Petráš et al., 2013a) and (iii) Robusta and I-214 poplar clone growth table models (Petráš and Mecko, 2001, 2005).
The experimental material was obtained from the set of tree sample cuttings to establish Robusta and I-214 poplar clone basic biomass density components (Petráš et al., 2010, 2013a). The 41 studied trees, comprising 21 I-214 clones and 20 Robusta clones, grew in 11 lowland forest stands in Western, Central and Eastern Slovakia at approximately 48° northern geographical latitude and 100-200m altitude (Fig. 1). This climatic zone has average annual temperature of 9.0-10.0°C and180 day vegetation period. All poplar stands were fed by ground water from surrounding rivers; the Danube and Vah in Western Slovakia, the Hron in Central areas and Bodrog tributaries in the East.

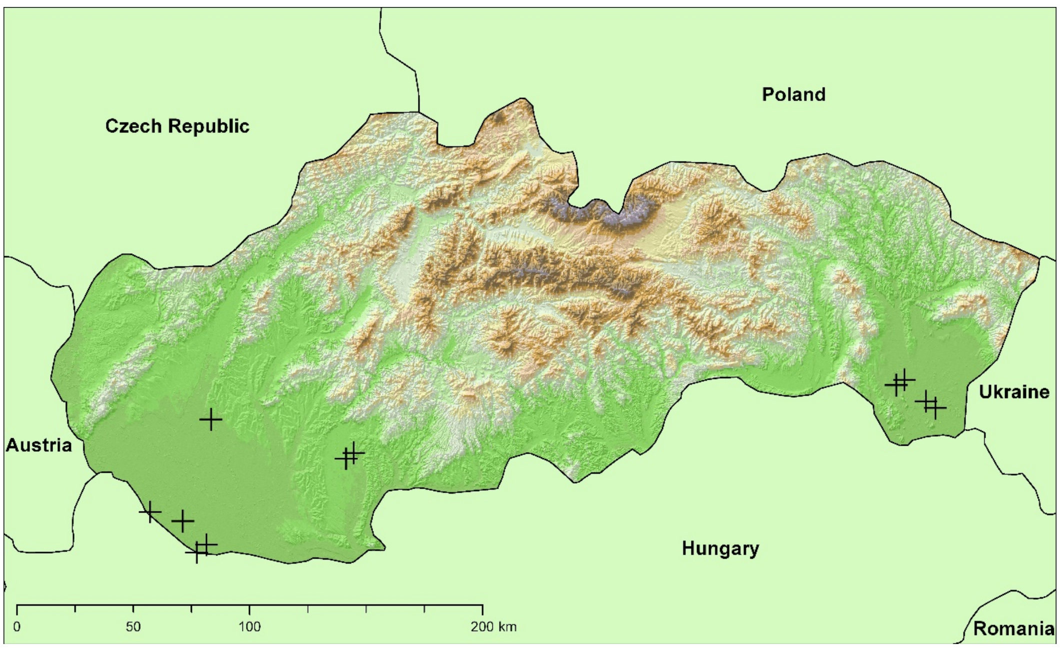

Figure 1 Location of the 11 lowland forest stands employed as experimental material

Calorific value capacity per volume unit *CV [GJ m³]* was calculated from individual mean biomass fraction density values *D [kg m⁻³]* (Petráš et al., 2010) and dry matter calorific value *CVDM [J g⁻¹]* (Petráš et al., 2013a):

$$CV\ [GJ\ m^{-3}] = D[kg\ m^{-3}] \cdot CVDM[J\ g^{-1}] \cdot 10^{-6} \qquad (1)$$

Crown tree small-wood provided the highest calorific capacity per unit volume. Here, the I-214 clone had 8.4 GJ m^{-3} and Robusta 8.7 GJ m^{-3}. These were followed by wood with 7.3 and 7.8 GJ m^{-3} while bark recorded the lowest 6.9 and 7.0 GJ m^{-3} values. The Robusta clone returned higher values than I-214 for all fractions; 8% more for wood, 4% for small-wood and 2% for bark. These differences are due to the higher density of all the Robusta clone biomass fractions (Petráš et al., 2010), and the higher calorific value in small-wood is most likely caused by higher percentages of chemicals such as lignin, lipids and terpenes. All biomass fractions have relatively low calorific variability; with coefficients mostly ranging from 6% to 10%.

The above-ground tree biomass calorific production values were ascertained by transferring the Formula 1 average calorific values into growth table models. Dependent on age '*t*' and site index '*q*', these simulated tree biomass volume '*VB*' [m^3 ha^{-1}].

$$VB[m^3\ ha^{-1}] = f(t, q) \quad (2)$$

The resulting model (3) then expresses the production of calorific value *CV* [*GJ ha*$^{-1}$] of the poplar clones stands, dependent on age '*t*' and site indices '*q*' in the following equation:

$$CV[GJ\ ha^{-1}] = f(t, q) \quad (3)$$

The stand site index is defined by its mean height [m] at 30 years of age, and calorific values are defined for compound, main and intermediate stand, total production and total current and total mean increment.
Analytic and synthetic use of available knowledge and analysis of its implementation under current Slovak regional policy conditions revealed socio-economic aspects of the use of poplar clones production. Comparison of current legislation in different sectors of the economy was then performed to optimize potential outcomes and to achieve synergy of regional policies.

RESULTS AND DISCUSSION

Production of stand calorific value

Lifelong production of the calorific value of poplar stands is depicted in Figure 2 growth curves; it graphs similarly to volume production and is distinctly gradated by stand site indices. The calorific value attains 2,700, 6,000 and 9,300 GJ ha^{-1} at 35-year stand age and 20, 30 and 40 site indices. Although I-214 clone has higher production than Robusta in the first half of life, the difference is minimal.
Figure 3 highlights that calorific value accumulates differently in individual biomass fractions. The percentage for wood increases with stand age, but decreases for bark and small-wood. At 35-year tree age, 75% of the calorific value accumulates in wood, 15% in small-wood and 10% in bark, and this is very important when considering industrial use of poplar clone biomass. Wood from the middle and base of the stem has less calorific value per cubic metre and is preferably utilised in mechanical and chemical processing. Although the bark has lower calorific value per cubic metre than wood, the energy gained in bark use increases its value to the point that it covers both its own and wood transport costs to processing. It is unfortunate, however, that tree crown small-wood energy potential is currently under-utilised, as much of it lies discarded after harvest as forest waste.

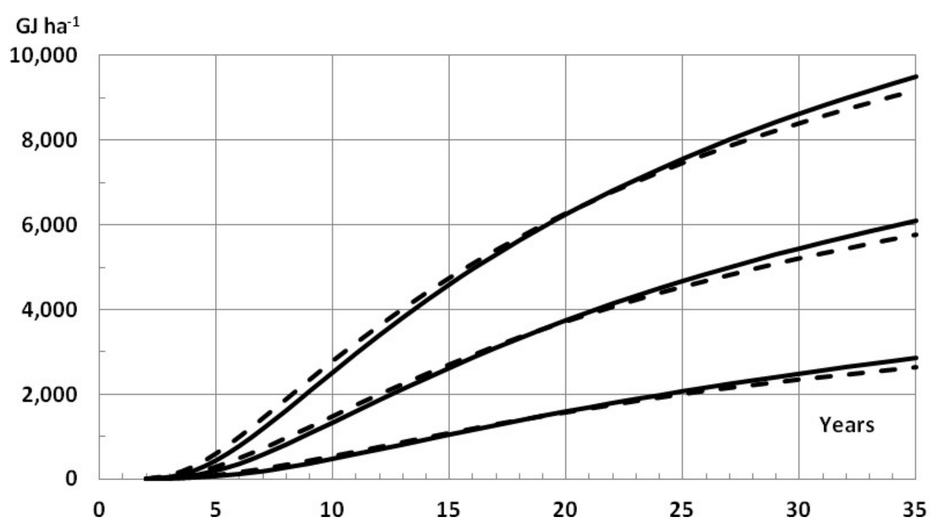

Figure 2 Total production of Robusta poplar clone calorific value (bold line) and I-214 clone (dashed line) dependent on stand age and site index (20, 30, 40 - lower, middle and upper lines).

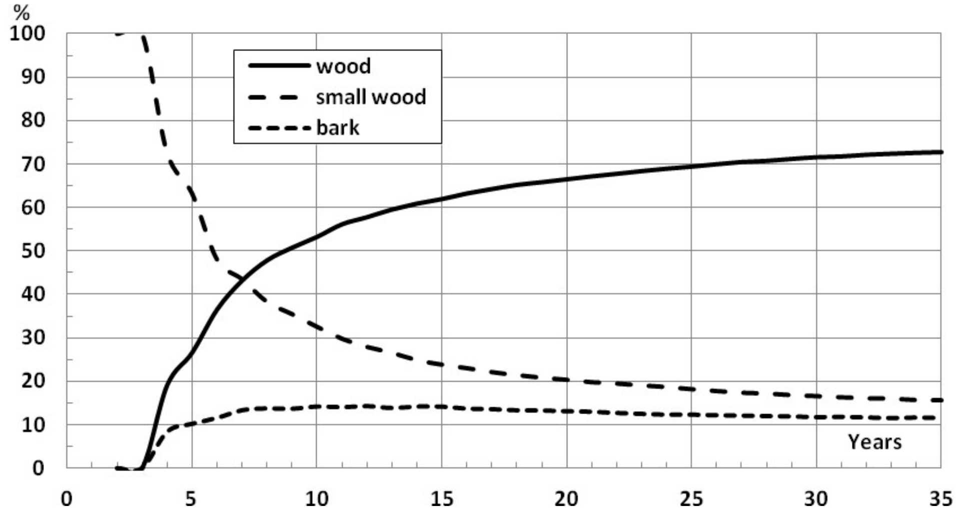

Figure 3 Development of Robusta clone wood, bark and small-wood biomass percentages of calorific value at 30 site index and stand age dependence.

Possibilities for poplar clone production in natural Slovak conditions

Although the area of poplar stands in Slovakia has fallen by approximately 20% over the last 30 years, areas with natural conditions suitable for their cultivation, especially lowland areas with higher groundwater, still amount to 25,600 ha. Assuming that poplar clones are cultivated on this area with 26 average site index and 20-year rotation, we can ensure mean annual production of 3,566 TJ calorific value from above-ground tree biomass (Fig. 4). **This provides 64% wood with at least 7cm diameter, 14 % bark from this wood and 22% in small-wood from wood thinner than 7cm.** Our research reveals that National production areas for cultivating poplar clone comprise up to 85% production potential in the Danube Lowlands, with the remaining 15% in southern areas of middle and eastern Slovakia (Fig. 5).

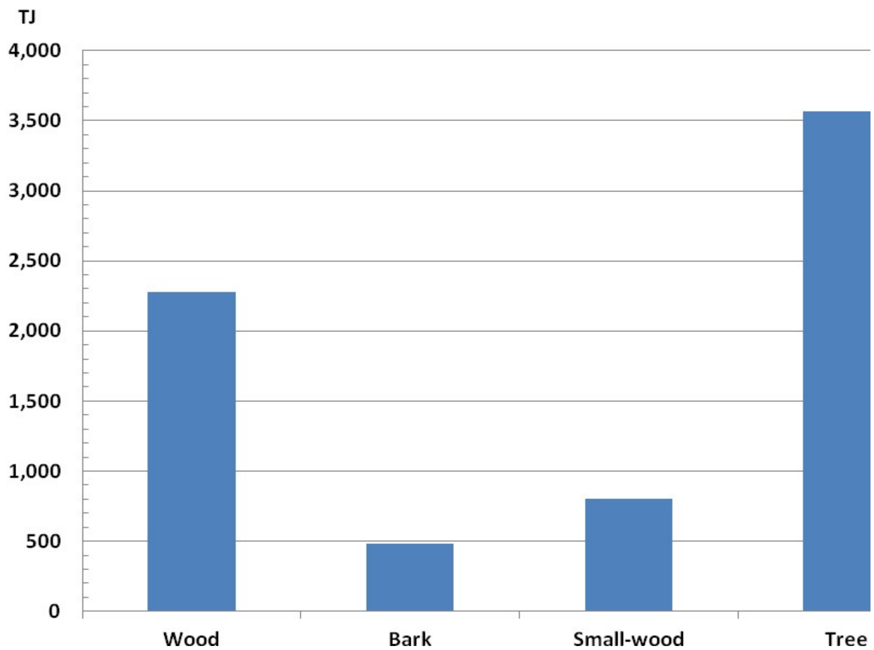

Figure 4 Mean annual production of calorific value from above-ground biomass of poplar clone stands with average 26 stand site index and 20 year rotation period.

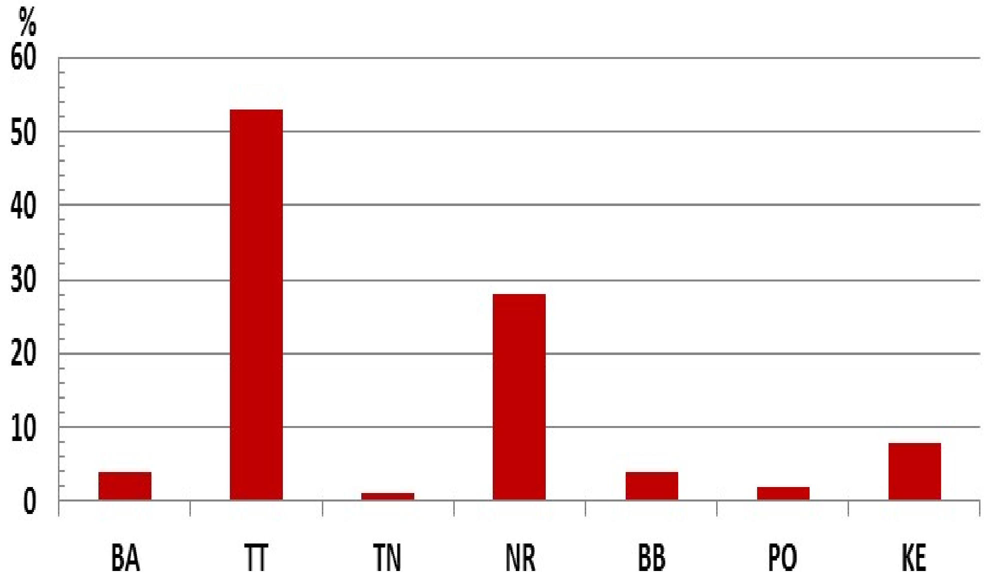

Figure 5 Percentage of poplar clone potential production by district. Pecentage of agricultural land in the region´s area: Trnava region – TT, Bratislava region - BA, Nitra region - NR, Košice region – KE, Banská Bystrica region – BB, Trenčín region –TN and Prešov region - PO

Current Slovak Republic support policy for poplar clone production

The main aim of the current Slovak Republic regional policy is to lower regional disparities. While the area around the Bratislavan capital is one of the most developed areas, other regions are less developed through disadvantaged categorization for receipt of European money. These regions have even smaller districts characterized by high unemployment, and national support measures are now being promoted to reduce long-term unemployment. This particularly applies to young people and those over 50 who cannot find a job in their immediate area. Regional action plans with targeted support for underdeveloped regions now focus on:

- Investment support dependent on regional conditions,
- Increased social enterprise, focused on the use of natural resources, land maintenance and the green economy,
- Consultation business centres
- Education investment in schools specialising in trades and non-tertiary professions.

Green economy activities are supported in rural areas to provide employment in important environmental protection schemes. This applies especially to the landscape maintenance necessary to adapt to climate change, and includes maintenance of watercourses and hydraulic structures and increased forest planting. These initiatives provided non-skilled agricultural and forestry employment for over 100,000 people between 1950 and 1995 by municipal and private entities and resulted in well-maintained rural landscapes.

Solutions for rural employment in agriculture, landscape conservation and maintenance require consideration of the following aspects to fulfil rural land productive and social functions:

- ‘Untended land’ implies uncultivated land,
- Relocating people from regions which lack employment opportunities,
- Directing rural policy activities according to rural area type,
- Ensuring cross-sectional and all-encompassing rural policy, thus attaining synergistic effects in all activities related to natural land resources,
- Addressing potential neglect of human capital ; especially lowly-qualified inhabitants
- Necessity for multifunctional agriculture development and activity diversification.

A sufficiency of food resources and less emphasis on use of quality land for agriculture has enhanced farmers conservation of agricultural land resources. Thus, current legislation has endorsed non-agricultural use of rural land, and the Act on Agricultural Land Conservation has enabled diversified agricultural activities including cultivation of fast-growing tree species.
Act No. 220/2004 Coll. on the conservation and use of agricultural land specifies the following rules for cultivating fast-growing tree species on agricultural land:

- Fast-growing tree species on agricultural land are regulated as ‘stands of fast-growing tree species intended for production of wood biomass on greater than 1,000 m^2 areas for a maximum 20-year period’.
- Flood areas retaining groundwater or excess moisture and areas exposed to wind erosion are granted priority in planting permission.
- Fast-growing tree species stands cannot be established on lands located in the Act’s third to fifth protection zones for nature and land conservation.
- There is obligation to re-cultivate agricultural land at least during the last year of fast-growing tree species growth, and also necessity to ensure protection of surrounding agricultural land from self-seeding fast-growing tree species stands.

CONCLUSION

Mathematical growth table models determined the calorific value production of I-214 and Robusta poplar clones. This also included their biomass density values and the calorific values of above-ground biomass dry matter. The calorific values at 35-year stand age and 20, 30 and 40 site indices were approximately 2,700, 6,000 and 9,300 GJ ha^{-1} respectively, and while the I-214 clone returned higher production than Robusta in the first half of growth, the difference was minimal.

Slovak lowland forest locations of 25,600 ha area with a high level of ground water were established as the most suitable for poplar production, because this readily enabled calculation of current mean annual production of 3,566 TJ of gross calorific value from above-ground biomass, and allows for future variations. This production comprised 64% wood, 14% bark and 22% small-wood, with up to 85% of production potential situated in the Danube Lowlands and the remainder in southern areas of middle and eastern Slovakia.

This natural production of poplar clones increases diversification of economic activities in the green economy and has a significant role in renewable natural resources through biomass carbon-binding ability. Finally, poplar production increases employment opportunities for low-skilled labour, thus reducing long-term rural unemployment, and combined with govermental targeted support in regional policy, this has reduced socio-economic disparity in rural Slovakia.

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