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Utilization of Fast Growing Plantation Timber as Bioenergy in Hungary

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Abstract. The enhanced utilization of plant biomass for bioenergy is a key factor to contribute to a sustainable development. In this research work 3 Hungarian hardwood species *Populus x euramericana*. cv. 'I-214', *Populus x euramericana*. cv. 'Pannonia', *Robinia pseudoacacia* (2 Poplars and Black locust) were investigated on heating value and ash content. 3 age classes were defined (from 7 years up to 29 years) in order to analyse the effect of the tree's age on the investigated properties. Significant differences were found between the bark, the sapwood and the heartwood. Age influenced the heating value to, but differently for bark, heartwood and sapwood. The 10 years old Black locust's bark showed the highest heating value (21,53 MJ/kg), while the 19 years old Pannónia poplar heartwood gave the lowest value (17,68 MJ/kg). In terms of ash content dramatic differences have been proven between bark and xylem (sapwood and heartwood). The 26 years old Black locust heartwood had 0.2 % ash content only, while the 10 years old Pannonia bark 5.2%.

1. Introduction

There are more scientific evidences proving that the intensive (over) use of Earth's energy resources will lead to exhaustion of natural and fossil resources (e.g. forests biomass, coal, crude oil, natural gas). The pollution of the environment has also dramatic consequences for the society and different industries. Sustainability has not been reached yet, as the human society is facing to global problems, like overpopulation, climate change through greenhouse gas emissions. Realizing these challenges researchers are globally working on solutions developing technologies which are using renewable energies. One of the renewables is the plant biomass. The utilization of biomass as energy resource has been always a method in the history of mankind, as it was the energy solution for households and smaller farms [1]. Recent research works have definitely proved the plant biomass as a potential energy resource for the future.

Energy forests and energy plantations are the main resources for organic products from biological origin in Europe. Energy forests are forests which were planted and are managed with specific purpose, while the energy tree plantations were established for energy production [2]. The main species are: willow (*Salix*), alder (*Alnus*), improved Poplars (*Populus*) and Black locust (*Robinia*). Mostly fast growing species can be considered on the plantations with high sprouting potential.

Important characteristics of the woody biomass are: bark percentage, percent moisture, specific gravity, heating value, amount of extractives, concentration of inorganic elements including alkali metals, ash content and cellulose/lignin ratio [3]. The energetic properties of a given wood species with a genetic heritage are influenced by the micro- and the macrostructure and the age of the tree. According to



earlier investigations [4] [5] the calorific value of the bark is lower compared to the wood material, but the first shows considerable higher ash content [6][7].

The main goal of the presented research work was to determine the effect of the age of plantations of different tree species on their calorific value.

2. Experimental

Tree species suitable for energy plantations and forest plantations in Hungarian were investigated, namely two improved Poplars (*Populus* spp.) and Black locust (*Robinia pseudoacacia*). The species and age classes are summarized in Table 1.

Table 1. Forming of age classes

Wood species	Age classes (years)		
	I.	II.	III.
<i>Populus x euramericana</i> . cv. 'I-214'	7	10	19
<i>Populus x euramericana</i> . cv. 'Pannonia'	6	10	19
<i>Robinia pseudoacacia</i>	10	17	26

For each species and age class combinations 6 trunks were selected randomly from the different plantations. The trees were harvested of the plantations managed by the Forest Directorate "Kisalföldi Erdőgazdaság és Dendrofitológiai Erdészete" in the north-west part of Hungary. The sites (soil, hydrology, et.) were determined as average for Hungarian conditions. The sample discs were cut from each of the trunks at breast height, from which the test pieces were produced. As the heartwood of the Black locust is rather narrow (2-5 annual rings, ca. 1 cm), thus the practical relevance is low, the investigations here were limited to the heating value.

This research work focuses on the calorific value and the ash content of the Poplars and Black locust in different age classes, with special emphasises on the different anatomic tissues. Thus from each sample disc the heartwood, the sapwood and the bark were investigated separately.

3. Results and discussion

The results of the calorific value is summarized in Table 2.

Table 2. Heating values of Poplars and Black locust

Species / Age class		Heating value (MJ/kg)		
		Heartwood	Sapwood	Bark
'Pannonia' (Poplar)	I.	18,96	19,24	17,92
	II.	18,15	18,55	17,68
	III.	17,68	18,95	18,09
'I-214' (Poplar)	I.	19,04	19,26	18,03
	II.	18,34	18,71	18,44
	III.	18,82	18,99	18,23
Black locust	I.	18,89	18,49	21,53
	II.	19,00	18,41	20,50
	III.	19,39	18,96	20,36

In case of 'Pannonia' Poplar the highest heating values were measured in the sapwood, regardless the age class, while the lowest values were determined for the bark, see figure 1. An exemption here is the oldest age class, where the heating value of heartwood was even lower. Comparing the age classes the

youngest plantations showed the highest values, excluding the bark. In the age classes II and III the ranking of the heartwood and the bark is different, thus in higher ages the bark contains more energy (related to mass) compared to the younger barks. The heating value of the heartwood is declining with the age.

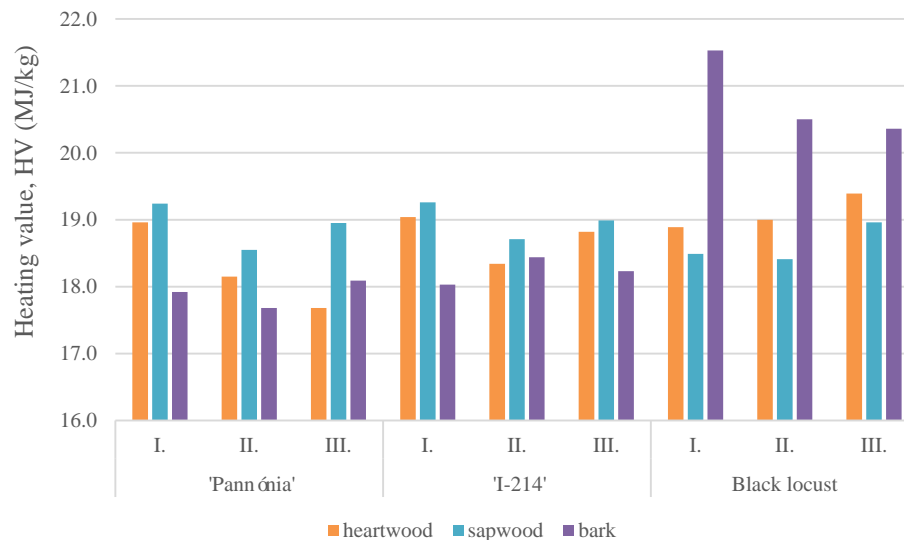


Figure 1. Heating values of Poplars and Black locust for different age classes and tissues.

The measured values and tendencies for the 'I-214' Poplar are similar to the 'Pannónia'. The highest heating values were measured for the sapwood and the lowest for the bark. However in the age class II the heartwood's value falls off the bark. The highest heating values were determined for the youngest plantation materials (Class I). Similar to the other Poplar, the oldest materials' values exceed that of the middle age (Class II). Analysing the two Poplars, it can be stated, that there are only minor differences between them. Thus, they give the same bioenergy at the same site under the same management.

In figure 1. the data for Robinia are shown. Surpassing values can be observed for the bark, followed by the heartwood and the sapwood. Studying the age classes reverse tendencies can be observed for the bark and the wood tissues (sap and heart). While the sapwood's and the heartwood's heating values are enhancing with the age, the bark's values are declining considerably.

Comparing the Poplars and the Black locust the bark of the last species shows extraordinary high values, exceeding any tissue by the investigated tree species. In case of Poplars the sapwood show higher values compared to the heartwood, while for Robinia the heartwood's values are higher.

Table 3. Ash content

Species / Age classes		Ash content (%)		
		Heartwood	Sapwood	Bark
'Pannonia'	I.	-	0,36	4
	II.	1,2	0,32	5,2
	III.	0,78	0,48	4,6
'I-214'	I.	-	0,4	4,6
	II.	1,2	0,38	4,3
	III.	1,2	0,43	4,7
Black locust	I.	0,43	-	3,9
	II.	0,24	-	4,3
	III.	0,2	-	4,2

Table 3. shows the ash content for the investigated species, for all three age classes and for the different tissues.

The ash content of different tissues show similar for the two poplars (figure 2.). The lowest values could be detected by the sapwood, while the heartwood has 3x and the bark 10x more ash content. Regarding the influence of age, the sapwood's ash content is increasing, while the heartwood's value is decreasing in case of poplars. No clear tendency could be observed for the barks. The two poplars do not show significant differences to each other.

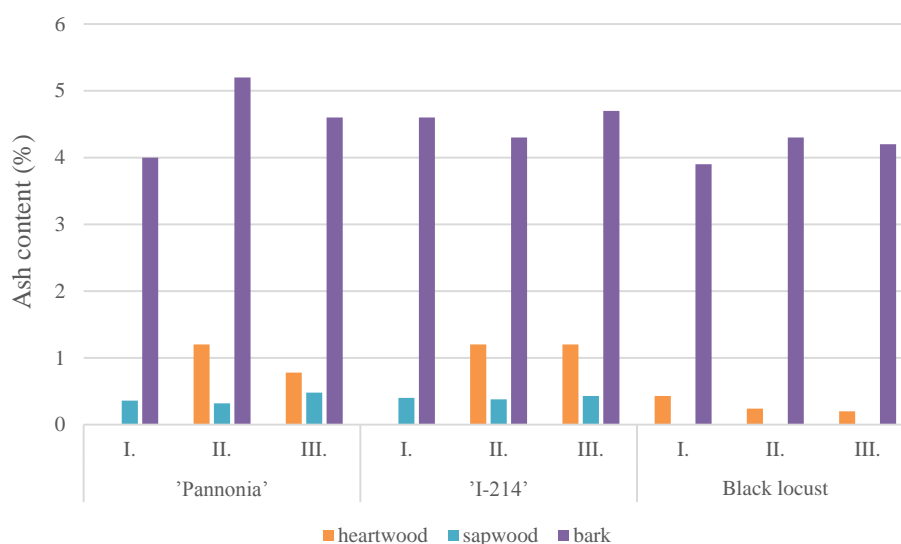


Figure 2. Ash content of Poplars and Black locust for different age classes and tissues.

In figure 2. it is well demonstrated that in case of Robinia the bark's ash content is much higher compared to the heartwood. The bark's heating value is slightly increasing from the younger Class I to the oldest Class III, while the heartwood shows opposite tendency.

Comparing the two species it can be stated, that the bark Black locust has slightly lower ash content compared the two Poplars, while in case of heartwood Poplars show much higher values.

4. Conclusions

In terms of heating value no significant differences could be found between the investigated tree species' xylem (sap and heart). Considering the age classes usually the youngest samples showed the highest heating values in case of Poplars. Excluding the bark, the oldest materials delivered higher values in case of Black locust.

While the Poplars' and Black locust's sapwood heartwood values do not differ considerably, remarkable differences could be found for the barks, as the Black locust's bark is significantly superior compared to the other tissues' values.

The ash content of bark is several times higher compared to the sap and to the heart. The ash content of the heartwood is similar by the two investigated Poplars despite to the age class, and in all cases higher than by Black locust. Poplars do not differ significantly in their sap woods' ash content. The Poplars' bark usually contains more ash compared to Black locust.

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