The opportunity of biomass production with the application of new poplar, willow and black locust clones

(A biomassza termelés lehetőségei új nyár és fűz klónokkal)

Dr. Sasa Orlović – Dr. Bojana Klasnja
Institute of Lowland Forestry and Environment,
Antona Čehova 13, Novi Sad,
Serbia and Montenegro

Abstract

In this study, the wood of Populus x euramericana cl.1, aged one, two and 12, Populus deltoides cl.2, aged one, two and eight, Salix alba L. aged one, two and 14, and Robinia pseudoacacia , aged one, two and ten was examined. After the selection of characteristic sample trees (three trees in each species and age) measured parameters of growth elements were determined and the trees were felled. The following caracteristics of the trees were examined: diameter in 130 cm height, the total height of the tree, the bark share, the wood density, the stem mass and teh ash content of wood and bark. The total biomass production per hectar and the calorific value of the wood of the above mentioned clones was also determined.

Keywords*: clones of poplar, willow and black locust;biomass production; calorific value.*

MATERIAL AND METHODS

The wood of *Populus x euramericana* cl.1, aged one, two and 12, *Populus deltoides* cl.2, aged one, two and eight, *Salix alba* L. aged one, two and 14, and *Robinia pseudoacacia* , aged one, two and ten was examined. After the selection of characteristic sample trees (three trees in each species and age) measured parameters of growth elements were determined and the trees were felled. Sample trees were chosen as average plants based on average diameter and height on the experimental plot.The weight of each tree was measured, separately for wood and bark and the proportion of bark calculated. Immediately after felling, samples discs (discs cut at breast height - 130cm) were taken to assess moisture content and wood and bark densities. After natural seasoning of samples for one month at room temperature, wood was ground into wood flour suitable for pellet pressing.

When a moisture content of about 10% was achieved, ash content was determined and the exact moisture content according to standard methodology.

The density was determined on the basis of oven-dry weight per green volume of an individual disk segment. Green volumes were obtained by soaking disk segments for 10 days in water until constant volume was achieved. Excess moisture was removed from the surface of the sample, and each sample's water displacement (volume) was measured. The sample then was oven-dried to constant weight at 104^0C and weighed to determine the dry weight.

For the determination of moisture content wood and bark samples were oven dried at 104^0C to a constant weight. The ash content was determined by burning 5g of oven-dried and ground sample in a platinum crucible in a muffle furnace at $550^0C \pm 25^0C$. All analyses were done in duplicate and the results were expressed on a dry weight basis.
The calorific value was determined for ground air-dried samples. Pellets were made in a special device, which produced pellets ranging from 0.35 to 0.64g. Samples were combusted in a Parr 1341 adiabatic calorimeter. Correction factors for the formation of acids were not included in the gross heat of combustion (higher heating value) calculations. However, calorific values were corrected for moisture regained during storage. There were three replications for each sample.

Based on taxation elements of the selected trees, their oven dry mass was determined per age (Table 1). Mature trees in both clones are from plantations with 400 trees per hectare, while the plantation density of one-year old trees is 10,000, and two-year old trees 4,444 per hectare. Production capacity of wood volume per unit area of plantations can also be calculated, both depending on the clone and on tree age.

With age, tree size increases and the share of bark decreases and also average densities of wood and bark decrease. The differences in taxation elements of study clones are significant, so that the amounts of oven dry mass of one-year and two-year trees for the clone 2 are twice as high as those for the clone 1. Oven dry mass of black locust stem is min. In older trees these differences are still higher, which is also contributed by the higher densities of the clone 2.

Table 1: Taxation elements and stem mass by species and clones
(A mért elemek és a törzs tömege fajonként és klónonként)

Species	Age yyear	DBH cm	Height m	Bark share %	Wood density kg/m^3	Stem mass kg	Ash content, % wood	bark
Poplar cl.1	1	1,9	2,6	19,0	338	0,31	1,16	6,84
	2	3,8	5,6	18,0	336	1,26	0,73	5,56
	12	12,2	22,4	12,0	320	86,75	0,82	5,32
Poplar cl. 2	1	2,5	3,3	18,6	403	0,62	1,13	5,95
	2	4,4	5,6	18,2	402	2,53	0,73	5,95
	8	26,2	23,7	11,0	388	206,26	0,47	6,26
Willow	1	1,0	3,4	26,7	402	0,11	0,67	4,77
	2	2,4	3,9	16,7	381	0,75	0,89	4,92
	14	18,8	23,2	15,2	377	122,11	0,52	5,94
Black locust	1	0,7	1,5	38,5	580	0,035	0,88	7,34
	2	1,8	2,6	20,0	578	0,38	0,70	6,64
	10	8,4	14,4	16,8	576	45,97	0,52	5,94

The higher heating values calculated for whole stem (with corresponding proportion of bark) were lower than for wood . The highest calorific value of whole stem, were refered from two year old trees (24275 kJ/kg for cl. 1, 23392 kJ/kg for black locust, 22572 kJ/kg for willow, and 20817 kJ/kg for cl.2). This is due to the higher proportion of bark and juvenile wood with high lignin content. The minimum values were measured for poplar clone 1 (one year), and for willow mature wood (14 year), 15787kJ/kg and 16169 kJ/kg respectively.

Table 2: Average calorific values of wood and bark ()
(A fa és kéreg átlagos hőértéke)

a) one year (*egy éves korban)*

Higher heating value, MJ/kg			
Clone	**Wood**	**Bark**	**Stem with bark**
cl.4	17.131	19.808	17.583
cl.5	18.747	16.757	18.293
cl.2	17.420	15.539	17.070
cl.1	15.680	16.245	15.787
cl.3	21.145	17.685	20.505
cl. 6	19.698	19.084	19.559
Black locust	22.240	19.555	20.784
Willow	19.487	18.457	18.460

b) two year (*két éves korban*)

Higher heating value, MJ/kg			
Clone	Wood	Bark	Stem with bark
cl.4	-	-	-
cl.5	-	-	-
cl.2	21487	17803	20817
cl.1	24758	22076	24275
cl.3	-	-	-
cl. 6	-	-	-
Black locust	24212	20114	23392
Willow	23177	19555	22572

c) **mature (*idős korban*)**

Higher heating value, MJ/kg			
Clone	Wood	Bark	Stem with bark
cl.4	-	-	-
cl.5	-	-	-
cl.2	19089	16016	18751
cl.1	18934	17473	18759
cl.3	-	-	-
cl. 6	-	-	-
Black locust	21945	16555	21039
Willow	16379	14996	16169

CONCLUSIONS

Poplars and willows, as the most represented species grown very successfully in short rotation plantations, as well as black locust, can be a significant source of thermal energy, being a relatively quickly renewable energy raw material. Calorific value of wood was researched on the clones *Populus x euramericana* (cl.1) one, two and 12 years*; Populus deltoides* (cl. 2) one, two and 8 years*; Salix alba* one, two and 14 years*; Robinia pseudoacacia* one, two and 10 years old respectively. As the share of bark depends on the age of wood, calorific values were determined separately for bark and for wood. Based on the share of bark, calorific value was assessed for individual trees of the analyzed clones. Average higher heating value for poplar stem is about 19600 kJ/kg (cl.1) and 18900 kJ/kg (cl.2); for willow about 19000 kJ/kg, and for black locust about 21700 kJ/kg. It is inetersting that the highest calorific value of whole stem were for two year old trees (24275 kJ/kg for cl.1, 23392 kJ/kg for black locust, 22572 kJ/kg for willow, and 20817 kJ/kg for cl. 2). This is due to the higher proportion of bark and juvenile wood with high lignin content The bark of all species has a lower calorific value than wood. Primarily, it should be noted that wood of greater density has a higher calorific value. If we consider a tree as a whole, these differences are lower due to lower deviations of bark density values compared to wood, depending on the clone. It should be pointed out that the calorific value of wood is more favorable than that of bark. Consequently, higher densities of wood and bark, as well as lower moisture and ash contents, have a positive effect on heating value. Density is primarily characterized by the species of wood, then by site, climatic conditions and increment, as well as by planting density.

On the whole, and also based on the above research, it can be concluded that black locust wood, because of highest density, has the highest heating value, and that fast growing broadleaf tree species can be a significant raw material for energy, primarily due to its relatively short rotation and owing to its very acceptable wood volume increment.