ABSTRACT

SHORT ROTATION DENDROMASS BIOACTIVE COMPOUND CONTENTS, THERMOPHYSICAL PROPERTIES AND ELEMENTARY COMPOSITION

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This thesis is based on the results of a three-year field and laboratory experiment on dendromass obtained from a plantation of perennial industrial plants, conducted in north-eastern Poland. A two-factorial field experiment was carried out in 2017-2019. It comprised fourteen genotypes of fast-growing trees and bushes, including one *Robinia* genotype, five *Populus* genotypes, seven clones and one cultivar of genus *Salix* and two rotations of biomass harvest: annual and quadrennial.

The main objective of the study, which was part of the doctoral thesis, was to evaluate the usability of biomass of the studied woody genotypes, grown on agricultural land in short rotations, for diverse use (i.e. as a source of bioproducts and as energy feedstock). The specific objectives were to determine the proportion of bark and wood in fresh and dry dendromass, bioactive substance content in bark, thermophysical properties and the elemental composition of wood, fresh and dry dendromass yield, fresh and dry bark and wood yield, potential bioactive substance yield, the energetic value of wood yield and its carbon equivalent.

Biodiversity, harvest rotation and the shoot diameter had a significant impact on the bark and wood content in fresh and dry biomass of the studied genotypes. The mean bark content in dry biomass ranged from 15.18% in four-year-old shoots of *S. triandra* UWM 198 to 47.97% in shoots of *P. nigra* × *P. maximowiczii* Max-5 obtained in an annual harvest rotation. The genetic variability had a significant impact on the qualitative and quantitative composition of the bioactive substances in the bark of the studied plants, whereas the biomass harvest cycle determined the quantitative content of individual bioactive substances. Extending the biomass harvest rotation decreased the mean content of the substance under analysis by ca. 20%. The highest total content of bioactive substances (118.39 mg g^{-1} d.m.) was found in poplar bark obtained from *P. balsamifera* UWM 2 shoots, whereas the lowest amounts were determined in the bark of *S. dasyclados* UWM 155 (0.32 mg g^{-1} d.m.). Among the seven bioactive substances analysed in the experiment, the highest mean content was determined for salicin (20.61 mg g^{-1} d.m.), followed by salicortin (12.58 mg g^{-1} d.m.). A significantly lower content was determined for salicylic acid (2.74 mg g^{-1} d.m.) and salireposide (2.51 mg g^{-1} d.m.), whereas kaempferol and quercetin were determined in trace amounts (0.046 mg g^{-1} d.m. and 0.032 mg g^{-1} d.m., respectively). The content of populin in dry bark was below the level of detection of the analytical procedure applied.

The wood moisture content of the genotypes under study was significantly diverse and ranged from 31.61% (*R. pseudoacacia*) to 56.01% (*P. nigra* × *P. maximowiczii* Max-5). The wood of black locust was characterised by the highest calorific value (13.24 MJ kg^{-1} d.m.), but it also contained the highest level of ash and of the elements that limit wood usability as an energy feedstock, such as sulphur and nitrogen. Extending the harvest cycle significantly improved the energy properties of wood. The biomass obtained from four-year-old shoots had a lower moisture content, higher heat of combustion and calorific value, higher carbon content as well as a lower content of ash and other substances containing undesirable elements, such as sulphur, nitrogen and chlorine.

The yield level was diverse significantly, not only within the genotype but also between the biomass harvest rotations. The largest yield of fresh dendromass was obtained for *S. viminalis* cultivar Żubr (29.71 Mg ha^{-1} $year^{-1}$) in a four-year harvest rotation, whereas the lowest yield was for *R. pseudoacacia* (7.63 Mg ha^{-1} $year^{-1}$) in an annual harvest cycle. The significantly highest mean yield of dry bark and dry wood was obtained from the Żubr cultivar, harvested in annual and in four-year rotations, with a higher yield being obtained in the four-year rotation.

The total potential yield of the analysed bioactive compounds was significantly varied, both with respect to genetic variability and depending on the biomass harvest rotation. The total potential yield of the obtainable substances ranged from 0.59 kg ha^{-1} $year^{-1}$ for the bark yield from four-year-old shoots of *S. dasyclados* UWM 155 to 325.83 kg ha^{-1} $year^{-1}$ for the bark yield from one-year-old shoots of *P. maximowiczii* × *P. trichocarpa* Hybryda275. The highest mean yield of the bioactive substances was given by the UWM 2 clone of *P. balsamifera*, whose total average weight was 295.23 kg ha^{-1} $year^{-1}$.

Willow of the Żubr cultivar had the highest mean wood energy value – 208.95 GJ ha^{-1} $year^{-1}$, and, consequently, the highest mean carbon equivalent – 8.36 Mg ha^{-1} $year^{-1}$. The UWM 2 clone of balsam poplar, whose bark contained the highest concentrations of the substances under analysis and whose yield was potentially the highest, was the most suitable for obtaining bioactive substances and further as a source of bioproducts, with the most advantageous composition of natural phenolic compounds. The Żubr cultivar of *S. viminalis* gave the highest yield of dry wood of good parameters and the highest energy value of yield and, consequently, the highest carbon equivalent.

The poplar *P. maximowiczii* × *P. trichocarpa* Hybryda 275 had the best energy and bioproduct-related characteristics, as its bark was rich in bioactive compounds (mean total content of the substances under analysis – 68.47 mg g^{-1} d.m.). It gave the highest total yield of bioactive substances from bark in one-year-old plants (325.83 kg ha^{-1} $year^{-1}$) and had a high mean yield of dry wood (8.48 Mg ha^{-1} $year^{-1}$) with good properties and a high mean energy value (165.16 GJ ha^{-1} $year^{-1}$) and carbon equivalent (6.61 Mg ha^{-1} $year^{-1}$).