

Basic chemical composition of selected species of bush willows

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Abstract: *Basic chemical composition of selected species of bush willows.* The content of cellulose, lignin and holocellulose was determined in wood of bush willows cultivated using the Eco-Salix method. The following willow clones were selected for experiments: K-TURBO, K-1054, K-DUOTUR, TUR-KOCIBÓRZ, CORDA and K-EKOTUR. The performed analyses were conducted employing standard methods commonly used in wood chemistry.

Keywords: cellulose, lignin, holocellulose.

Willows belong to the *Salix sp.*, genus in which over 300 species as well as numerous sub-species are distinguished. They settle a wide range of sites beginning from very moist, even inundated and fertile to very dry and poor with respect to nutrients. They occur in the form of trees, bushes and shrubs and can be found from the Arctic, right across the zone of temperate climate up to the hot equatorial region (Białobok et al., 1990).

In recent years, an increasing interest has been observed in Poland in bush willows as fast-growing species associated with possibilities of their utilisation for energy purposes as ecologic raw material and as a raw material for chemical industry to obtain cellulose (Staffa 1965) and bioalcohol (Ciechanowicz, Szczukowski 2010). In addition, willows can also be utilised in industry to manufacture particleboards. Bush forms of willows can also be utilised in wickerwork to manufacture ornamental or household articles.

As a result of centuries of willow cultivation and breeding wicker, twig and fascine forms of willow species were developed producing huge quantities of raw material of appropriate quality for the requirements of a given buyer.

Willow extraordinary adaptational qualities to a wide range of different environmental conditions make this species exceptionally valuable to be employed in environmental protection, among others, to develop along motor ways as well as dual carriage ways protection zones against motor-car emissions – green screens protecting against noise. In addition, the *Salix viminalis* L. species is utilised for reclamation of areas degraded and destroyed by human industrial and urban activities (Waliszewska, Podobiński, Bobkiewicz, 1999).

Biomass production obtained from 3 to 4-year plantations of fast-growing, selected *Salix spp.* clones can yield 10 to 14 times greater volumes of biomass in comparison with the biomass increment produced during the same period of time in the forest. Expansion of willow cultivations would make it possible to supplement wood obtained from forests. This kind of wood could provide raw material for the production of thermal energy in a sustainable way friendly for the environment.

Willow species are characterised by high yielding potentials, fast growth during the vegetation period and considerable regeneration capabilities after cutting. They can grow well both in conditions of water excess and its shortage. However, in order to ensure production of large biomass quantities, the growing site should be characterised by appropriate water reserves (Sowiński 1988). In Sweden, intensively fertilised and watered plants were reported to yield annually even 15 Mg of wood dry matter per hectare. In two-year cultivations, 35-39

Mg/ha DM yields were recorded, whereas from three-year plantations – 60 Mg/ha wood dry matter was harvested. In Poland, valuable species and hybrids of fast-growing shrub willows were selected yielding in three-year cultivation even 86 Mg/ha fresh biomass, i.e. 36 m³ annually. The best ‘Harrison’ *Salix viminalis hybrida* clone yielded 110 Mg/ha fresh biomass in a 3-year cultivation, i.e. approximately 55 Mg dry matter of wood (Szczukowski et al., 2002).

The objective of the presented investigations was to determine the content of primary wood constituents of selected *Salix sp.* clones obtained from an experimental plantation of Warmia-Mazury University in Olsztyn.

EXPERIMENTAL MATERIAL AND RESEARCH METHODOLOGY

Investigations were carried out on five-year willow twigs collected from an experimental plantation cultivated according to the Eko-Salix method situated in Obory near Kwidzyna in Warmia-Mazury Voivodeship. The following clones were investigated: K-TURBO, K-1054, K-DUOTUR, TUR-KOCIBÓRZ, CORDA and K-EKOTUR.

The experimental material was collected before the onset of vegetation in February 2011 and ground initially into chips together with bark. The initial moisture content of the raw material was determined and then the material was subjected to seasoning in a well-aerated facility at room temperature until it reached constant moisture content. Dried material was comminuted with the assistance of a laboratory mill Pulverisette 15 of Fritsch Company and 0.5-1.0 mm analytical fraction was separated using appropriate laboratory sieves.

Chemical analyses were conducted in accordance with the PN-92/P-50092 methodology and the following parameters were determined:

- Cellulose content by Seifert method,
- Lignin content by Tappi method,
- Holocellulose content using sodium chlorite,
- Pentosan content by Tollens method.

All results were calculated in relation to wood dry matter.

RESEARCH RESULTS AND DISCUSSION

Table 1. Content of principal wood constituents in examined willow clones.

Name of raw material	Initial moisture content [%]	Moisture content following seasoning [%]	Cellulose [%]	Lignin [%]	Holocellulose [%]
K-TURBO	46,4	6,58	42,58	24,68	73,71
K-1054	47,5	6,71	42,30	24,35	77,36
K-DUOTUR	44,5	5,89	44,16	22,59	77,47
TUR KOCIBÓRZ	43,9	6,62	42,30	24,49	75,13
CORDA	47,1	6,74	44,80	24,63	77,52
K-EKOTUR	36,7	6,88	43,00	22,68	78,60

The initial moisture content of freshly-cut raw material was high and fluctuated in a wide range from 36.7% to 47.5% (Tab. 1). The highest moisture content was determined in the clone designated as K-EKOTUR, while the highest – in K-1054. Two clones: TUR KOCIBÓRZ and K-DUOTUR were found to contain similar quantities of free water: 43.9% and 44.5%, respectively. The willow clone designated as K-TURBO contained slightly more water – 46.4%, whereas clone CORDA was found to contain 47.1% water.

The content of the main wood constituent – cellulose - was similar in all the examined willow clones and ranged from 42.30% to 44.80% (Tab. 1), which means that differences in its content differed by only 2.5%. The highest cellulose content was found in the willow clone

called CORDA, while the lowest content of 43.00% – in K-1054 and TUR KOCIBÓRZ clones. The wood of the K-DUOTUR willow clone was determined to contain 44.16% cellulose.

The quantity of lignin in the examined samples ranged from 22.59% to 24.68% (Tab. 1). Four willow clones revealed very similar levels (about 24%) of lignin, namely: K-1054 – 24.35%, TUR KOCIBÓRZ – 24.49%, CORDA – 24.63% and K-TURBO – 24.68%, whereas two shrub willows contained approximately 2% less lignin, namely: K-DUOTUR – 22.59% and K-EKOTUR – 22.68%.

The lowest holocellulose content (73.71%) was determined in the willow clone called K-TURBO, i.e. the one that was found to contain the highest level of lignin. The examined clones designated as: K – 1054, K-DUOTUR and CORDA contained very similar quantities of holocellulose: 77.36%, 77.47% and 77.52%, respectively, whereas the willow clone designated as TUR KOCIBÓRZ contained over 2% less of this constituent. The highest quantity of holocellulose was determined in the wood of the K-DUOTUR willow which was found to contain 78.60% of this constituent.

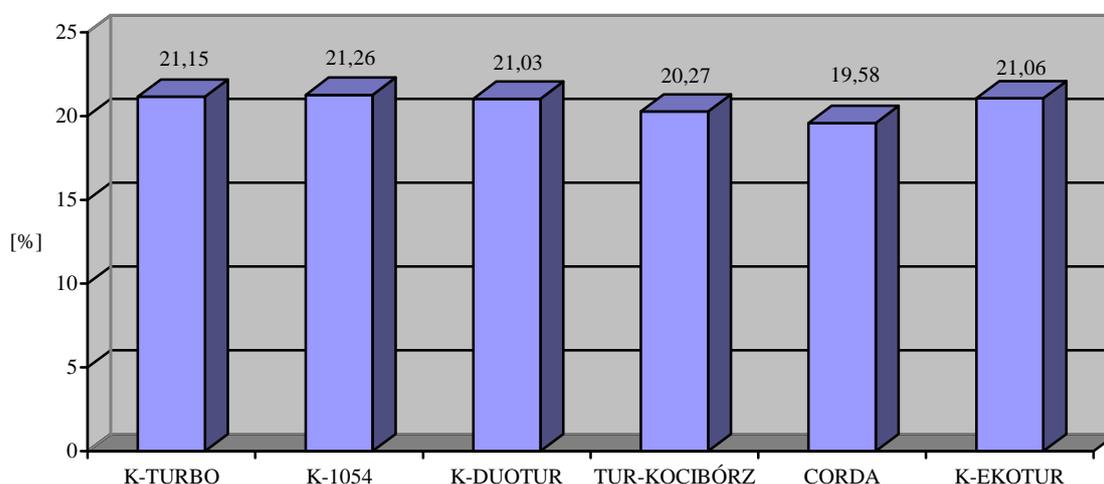


Figure 1. Pentosan content in the examined willow clones.

The content of pentosans in the wood of four of the examined willow clones was very similar and ranged from 21.03% to 21.26% (Fig. 1). The above clones included: K-TURBO – 21.15%, K-1054 – 21.26%, K-DUOTUR – 21.03% and K-EKOTUR – 21.06%. The wood of the TUR KOCIBÓRZ clone contained 20.27% pentosans, while CORDA clone was characterised by the lowest content of these compounds – 19.58%.

CONCLUSIONS

1. All the examined clones of the *Salix sp.* genus were characterised by a similar content of cellulose. The highest levels of this constituent (over 44%) were determined in CORDA and K-DUOTUR cultivars.
2. The amount of lignin in the wood of the examined willow clones was similar and differences in its content amounted to about 2%.
3. Holocellulose content in the wood of the experimental samples ranged from 73.71% to 78.60%.
4. The content of principal constituents in the wood of the examined shrub willow clones was characteristic for broad-leaved species.

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Streszczenie: *Podstawowy skład chemiczny wybranych gatunków wierzby krzewiastej*

W niniejszej pracy oznaczono ilościowo zawartość podstawowych składników drewna wierzby krzewiastej następujących klonów: K-TURBO, K-1054, K-DUOTUR, TUR-KOCIBÓRZ, CORDA oraz K-EKOTUR. Materiał badawczy pochodził z uprawianej metodą Eko-Salix plantacji doświadczalnej Uniwersytetu Warmińsko-Mazurskiego, położonej w miejscowości Obory koło Kwidzyna w woj. warmińsko-mazurskim. Oznaczono ilość celulozy, ligniny i holocelulozy w drewnie wraz z korą. Badane klony wierzbowe zawierały od 42,30% do 44,80% celulozy. Zawartość ligniny kształtowała się w granicach od 22,59% do 24,68%, a ilość holocelulozy wynosiła od 73,71% do 78,60%.

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