Productivity of willow coppice plants grown in short rotations

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ABSTRACT

In the paper yield of dry matter and some morphological features of four fast growing willow coppice genotypes harvested in one, two, three and four years harvesting cycles are presented. In the experiment an average yield amounted to 16.79 t/ha/year. The highest yield was recorded for *Salix viminalis* × *S. viminalis lanceolata* (22.89 t/ha/year). Genotype *Salix triandra* gave a yield lower by factor 3 compared to *Salix viminalis* × *S. viminalis lanceolata*. For the following genotypes: *Salix viminalis* × *S. viminalis lanceolata*, *Salix viminalis* var. *gigantea* and *Salix viminalis* var. *regalis* it was found the yield increased as harvesting cycle increased from one to four years while the opposite was found for genotype *Salix triandra*. It can indicate that *Salix triandra* is not suitable for intensive growing on arable lands, especially in two, three or four years harvest cycles. Mean plant height amounted to 4.63 m and stem diameter 20.48 mm. The tallest plants (769 cm) with the thickest stem (diameter of 37.43 mm) were found for genotype *Salix viminalis* × *S. viminalis lanceolata* harvested quadrennially. At harvest water content amounted to 49.87% and the highest value was found for the shortest harvesting annually.

Keywords: arable land; willow; harvest cycle; yield of dry matter; bioenergy

Strategy in the development of renewable energy elaborated in Poland assumes that the share of renewable energy in the structure of crude energy utilisation should amount to 7.5% and 14% in 2010 and 2020, respectively. Presently this figure is estimated only to 2.6% what shows the needs of a 3-fold increase during this decade (Wiśniewski and Guzek 2003).

In Poland the generation of energy has been based on fossil fuels: black coal, brown coal, oil and natural gas. In 2002 the share of black coal among all carriers of crude energy amounted to 49.9%, brown coal 13.3% and oil and natural gas 19.9 and 12.0%, respectively (according to Polish Official Statistics 2003). From wood and peat 4.3% of crude energy was generated while the share of other renewable sources (water, wind, sun and geothermal sources) amounted only to 0.2% of total crude energy. Poland in comparison to some EU countries has a very high share of coal in the structure of crude energy utilisation. For example a share of coal in energy utilization in France, Spain and the UK amounted to 5.4, 17.1 and 16.6%, respectively. Therefore the share of oil in the same countries is much higher i.e. 36.8, 55.7 and 34.3% then 19.9% in Poland (Ney 2003).

In the structure of utilization of sources of renewable energy in Poland biomass has a leading position. For energy generation the following plant materials have been used: forestry residues, wood wastes from wood processing plants, agricultural wastes and wastes from green areas. In the close future the important source of biomass supplying will be energy plantations of perennial crops as: willow (*Salix* spp.), Virginia mallow (*Sida hermaphrodita* Rusby), miscanthus (*Miscanthus sinnensis giganteus*). Among the mentioned energy crops under the conditions of the Polish climate the best results can be obtained using fast growing willow coppice (*Salix* spp.) (Szczukowski et al. 2003).

Biomass harvested at arable land can be utilised as wood chips for heat generation for local communities (Kisiel et al. 2001). Presently, there is a good technological solution of co-combustion of willow

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wood chips together with coal in big municipal heat generation plants (Zawistowski 2003). Willow wood can be processed into pellets (wood granulate) for combustion in home ovens (Stolarski et al. 2003). At the beginning of the next decade biomass can be converted into hydrogen fuels (hydrogen or methanol) which will be widely used in vehicles driven by polymer fuel cells (Szczukowski et al. 2003).

The other very promising field of willow utilisation seems to be growing this plant on contaminated land. There are many reports suggesting that willow can be applied to phyormediation of soil contaminated with heavy metals. Pulford et al. (2002) found a particular usability for growing willow on soil contaminated with Cd and Zn. They reported that among 20 tested clones 11 of them appeared to combine high productivity with high metal uptake. Other reports (Vysloužilová et al. 2003a, b) indicate a high variation of phytoextraction potential among *Salix* spp. clones and it can be concluded that the willow is able to be grown well on moderately contaminated sites. The results of the mentioned studies show phytoremediation as one of the most promising aim of willow growing.

In many countries there are a lot of investigation works focused on increase yield of fast growing willow coppice by using relatively short harvest cycles lasting from one to four growing seasons (Kopp et al. 1997a, Danfors et al. 1998, Bullard et al. 2002a, b). In Sweden triennial or quadrennial harvest cycles are preferred for willow plantations planted at a density of 15 000–20 000 plants/ha (Danfors et al. 1998). The willow is then harvested using a Jaguar-Class harvested equipped with a special header. Under Polish conditions there are a lot of relatively small farms where the annual harvest cycle of fast growing willows planted at the density of 50 000 plants/ha may be reasonable. If willow is harvested every season farmers will be able to use fodder green harvesters instead of specialized and expensive Jaguar-Class harvesters and willow can bring them income every year.

The aim of our studies was to evaluate the potential of productivity and basic morphological features of four willow genotypes in relation to a lenght of harvesting cycle.

MATERIAL AND METHODS

A field trial with willow coppice was established in 1996 at the Experimental Station in Tomaszkowo near Olsztyn on soil classified as Eutric Cambisols developed from silty light loam (content of clay particles of diameter < 0.002 mm equal to 7%), and underlaid with clayey deposits (content of clay particles of diameter < 0.002 mm equal to 21%). The soil showed a medium level of available nutrients and a high capacity of sorption complex (160 mmol+/kg), neutral soil reaction (pH in 1M KCl of 7.0) and medium C_{ox} content (1.09%). Up to 1999 stems from all plots were harvested in one-year harvesting cycle. Forecrop was winter triticale.

In 2000 the two factorial field trials was started in four replications and stems were harvested in four harvesting cycles lasting from one to four years up to season 2003. The first experimental factor was the willow genotype: *Salix triandra*, *Salix viminalis* × *S. viminalis lanceolata*, *Salix viminalis* var. *gigantea*, *Salix viminalis* var. *regalis*. The second factor was cutting frequency.

Willow cuttings were planted at the density of 50 000 per 1 ha using space between rows of 0.5 m and in the row 0.4 m. Plots size was 2.5 × 4 m. Cuttings (20 cm long) were planted manually to the depth of 17–19 cm with one bud above the ground surface.

Plots were fertilized every year just before willow growth renewal using the following rates of nutrients: N = 90 kg/ha (ammonium sulphate), P = 30 kg/ha, (single superphospate), K = 85 kg/ha (potassium chloride).

Just after plating to control dicotyledonous weeds the soil was sprayed with herbicide Azotop 50 WP and manual weeding was performed twice. Then neither any weeding or pest control practices was performed until the end of the experiment.

During the growing period plant observations were conducted. At the beginning of November in each season 10 plants at each plot plant height and diameter of stems measured 10 cm above ground level were registered.

Harvest was every year performed in the first week of January and all leaves were fallen and snow cover occurred. Cutting was performed each time using manual saw equipped with disc blade at height of 5–10 cm (depending on snow cover). To determine the yield of fresh mater weight of all stems per plot was recorded. Then samples were taken to determine the content and the yield of wood dry matter. Samples were dried at 105°C. Results were subjected to analysis by STATISTICA® StatSoft Polska 6.0 PL software.

RESULTS AND DISCUSSION

A pattern of weather conditions during the trial (in seasons 2000–2003) is presented according to data recorded at Meteorological Station in Tomaszkowo and respective data were compared to those obtained in reference period i.e. 1961–2000 (Table 1).

Precipitation in the 2000 growing season amounted to 370.9 mm which was lower by 39.7 mm from the respectively value in the reference period. This

Table 1. Weather pattern in seasons 2000–2003 (according to Meteorogical Station in Tomaszkowo)

Season	January	February	March	April	May	June	July	August	September	October	November	December	Whole year	Period 1.4.–31.10.
Mean temperature (°C)														
2000	0.1	1.0	2.0	10.7	14.0	16.0	15.9	16.9	10.3	10.7	2.6	–5.2	7.9	13.5
2001	–1.1	–1.6	0.7	7.2	12.8	13.9	20.0	18.1	11.4	10.1	2.1	–4.3	7.4	13.4
2002	–1.0	2.8	3.6	7.8	16.2	16.5	20.1	19.8	12.0	6.2	2.9	–6.7	8.4	14.1
2003	–3.6	–4.7	1.2	6.0	14.1	16.6	19.2	17.4	12.9	4.7	3.6	–2.1	7.1	13.0
Mean for 1961–2000	–2.9	–2.4	1.2	6.9	12.7	15.9	17.7	17.2	12.5	7.8	2.7	–1.3	7.3	13.0
Precipitation sum (mm)														
2000	35.3	39.8	48.5	20.8	53.5	34.8	98.7	110.8	49.6	2.7	35.0	23.9	553.3	370.9
2001	16.7	13.4	41.2	54.9	33.2	77.9	148.6	53.0	110.4	28.3	45.4	25.5	648.5	506.3
2002	41.6	53.4	43.2	14.2	81.5	48.6	27.5	61.0	56.4	141.5	21.3	9.6	599.8	430.7
2003	32.9	4.9	14.9	35.5	30.2	72.0	79.2	56.5	32.2	88.6	38.2	36.5	521.6	394.2
Mean for 1961–2000	28.8	20.4	26.8	36.1	51.9	79.3	73.8	67.1	59.0	43.4	47.7	36.2	570.5	410.6

season (2000) was characterised by a higher mean temperature then in the reference period by 0.5°C. In the growing season of 2001, more rainfalls were noted that in reference period by 95.7 mm and 44.7% of total precipitation was recorded in June and July and air temperature was lower by 0.4°C then in the reference period. In the season 2002 mean air temperature was higher by 1.1°C then respective value for reference period while precipitation amounted to 430.7 mm. In the season 2003 mean temperature was equal to respective value in the reference period and lower precipitation sum was recorded by 16.4 mm comparing to the value from the period 1961–2000.

The highest yield of wood dry matter was found for genotype *Salix viminalis* × *S. viminalis lanceolata* (22.89 t/ha/year) and it was proven in statistical analyse (Table 2). Three fold lower yield than genotype *Salix viminalis* × *S. viminalis lanceolata* was recorded for *Salix triandra*.

Comparing treatments of different harvest frequency the highest yield was found for willow harvested quadrennially and it amounted to 20.04 t/ha/year. Statistically significant lower yield was found for one year harvesting cycle i.e. 13.69 t/ha/year. Genotype *Salix viminalis* × *S. viminalis lanceolata* harvested annually gave a significantly higher yield of wood dry matter (18.22 t/ha/year) compared with other studied willow genotypes what means than can be recommended for commercial willow plantations of density of 50 000 plants/ha. In biannual and triennial harvest cycles genotype *Salix viminalis* × *S. viminalis lanceolata* also showed the highest wood yield among studied forms. The highest yield in the experiment was found for the genotype *Salix viminalis* × *S. viminalis lanceolata* (29.56 t/ha/year) when harvested quadrennially. A high yield of wood dry matter was also recorded for genotypes *Salix viminalis* var. *regalis* and *Salix viminalis* var. *gigante*a harvested quadrennially. For the following genotypes: *Salix viminalis* × *S. viminalis lanceolata*, *Salix viminalis* var. *gigantea* and *Salix viminalis* var. *regalis* it was noted that the yield increased as harvesting cycle increased from one to four years. The opposite was found for the *Salix triandra*. It can indicate that *Salix triandra* is not suitable for intensive growing of willow coppice on arable lands, especially harvested biannually, triennially and quadrennially.

The yield of wood dry matter of short rotation willow coppice in the trial can be considered as relatively high. Presented data are comparable with results reported from field trials in other countries (Jossart and Ledent 1999, Cook and Beyea 2000, Randerson et al. 2000). Productivity of commercial willow plantations on arable land in Sweden harvested triennially was reported

Table 2. Yield of *Salix* spp. dry matter (t/ha/year)

Botanic name or cultivar (a)	Harvest frequency (b)				
	1 year	2 years	3 years	4 years	mean
Salix triandra	9.87 ± 1.75	8.74 ± 0.65	6.88 ± 0.47	5.20 ± 3.38	7.67 ± 0.98
Salix viminalis × S. viminalis lanceolata	18.22 ± 0.90	21.34 ± 1.26	22.84 ± 0.54	29.56 ± 2.47	22.89 ± 1.26
Salix viminalis var. *gigantea*	13.11 ± 1.42	14.99 ± 2.05	18.98 ± 0.45	20.17 ± 4.94	16.81 ± 1.45
Salix viminalis var. *regalis*	13.55 ± 0.88	18.61 ± 1.09	21.30 ± 0.64	25.24 ± 4.12	19.68 ± 1.47
LSD (*P* = 0.05)	3.99	4.20	1.64	11.84	
Mean	13.69 ± 0.96	15.92 ± 1.36	17.50 ± 1.64	20.04 ± 2.93	16.79 ± 0.96
LSD (*P* = 0.05)	a = 3.06, b = 3.01, a × b = 6.12				

± = standard error

between 12 and 18 t/ha/year of wood dry matter (Gigler et al. 1999).

Kopp et al. (1997a, b) reported that in triennial harvest cycle willow gave yield ranging from 15 to 20 t/ha/year. Under conditions of irrigation and intensive fertilisation yield level increased to 25 t/ha/year. Adegbidi et al. (2001) reported that the annual yield of wood dry matter in northeastern region of the United States ranged from 15 to 22 t/ha/year. The highest yielding genotype appeared to be SVI (*Salix dasyclados*) harvested triennially at the planting density of 36 960 cuttings/ha.

Kajba (1999) found out that the best among tested genotypes appeared to be the three species hybrid (*Salix alba* × *Salix fragilis* × *Salix caprea*) harvested every fifth season, which gave yield of 26 t dry matter/ha/year.

In our earlier paper we have reported that *Salix viminalis* var. *gigantea* at the density of 100 000 cutting/ha grown on organic soil gave a yield of 15.6 t dry matter/ha/year while harvested triennially (Szczukowski and Tworkowski 2000). In another study willow harvested annually gave a yield ranged from 11.0 to 18.2 t dry matter/ha/year while in three years the cutting cycle yield level was considerably higher i.e. from 18.5 to 26.4 t dry matter/ha/year (Szczukowski et al. 2002).

Labrecque and Teodorescu (1999) reported that in southern Quebec in three years rotation yield of 15–20 t dry matter/ha/year, at the planting density of 20 000 willow plant/ha can be obtained. In Wales some attempts to cultivate coppice willow at the highlands were made at the planting density of 20 000 willow plant/ha. In quadrennial harvest cycles yield ranging from 6 to 12 t dry matter/ha/year was reported (Randerson et al. 2000). McCracken et al. (2001) from their experiments with growing of several willow genotypes growing in pure standings or in mixtures at different planting density reported a wide range of obtained yield of willow wood dry matter 6.5 to 30.0 t dry matter/ha/year when willow was grown in different harvest cycles.

Table 3. Number of plants (10^3/ha)

Botanic name or cultivar (a)	Harvest frequency (b)				
	1 year	2 years	3 years	4 years	mean
Salix triandra	46.25 ± 1.93	41.38 ± 3.02	38.75 ± 4.17	16.00 ± 8.38	35.59 ± 3.74
Salix viminalis × S. viminalis lanceolata	49.50 ± 0.29	46.88 ± 2.37	46.00 ± 1.00	44.75 ± 2.17	46.78 ± 0.88
Salix viminalis var. *gigantea*	46.25 ± 1.10	42.00 ± 4.08	40.31 ± 6.45	30.00 ± 7.79	39.64 ± 2.94
Salix viminalis var. *regalis*	47.50 ± 1.55	46.25 ± 2.16	45.25 ± 1.79	44.75 ± 2.25	45.94 ± 0.92
LSD (*P* = 0.05)	ns	ns	ns	18.29	
Mean	47.38 ± 0.70	44.13 ± 1.49	42.58 ± 2.24	33.88 ± 4.07	41.99 ± 1.36
LSD (*P* = 0.05)	a = 5.62, b = 5.60, a × b = 12.24				

± = standard error, ns = not significant

Table 4. Number of stems per stool

Botanic name or cultivar (a)	Harvest frequency (b)				
	1 year	2 years	3 years	4 years	mean
Salix triandra	15.38 ± 0.69	7.14 ± 0.95	5.61 ± 0.27	3.50 ± 1.47	7.91 ± 1.23
Salix viminalis × *S. viminalis lanceolata*	10.88 ± 0.43	6.69 ± 0.55	3.88 ± 0.29	2.75 ± 0.04	6.05 ± 0.83
Salix viminalis var. *gigantea*	12.60 ± 1.44	8.65 ± 0.54	4.55 ± .51	2.68 ± 0.05	7.12 ± 1.05
Salix viminalis var. *regalis*	9.73 ± 0.62	7.05 ± 0.43	3.85 ± 0.26	2.61 ± 0.19	5.81 ± 0.74
LSD (*P* = 0.05)	2.71	ns	1.07	ns	
Mean	12.14 ± 0.68	7.38 ± 0.35	4.47 ± 0.24	2.88 ± 0.34	6.72 ± 0.49
LSD (*P* = 0.05)	a = 0.97, b = 0.90, a × b = 1.94				

± = standard error, ns = not significant

The number of willow plants in the experiment amounted to 41 900 per ha (Table 3). The mean survival rate was then 84%. The highest number of plants per area unit was found from the genotype of *Salix viminalis* × *S. viminalis lanceolata* with the survival rate of 93.6%. For the genotype *Salix triandra* the lower number of plants per unit area was found compared to genotype *Salix viminalis* × *S. viminalis lanceolata*. It was found that a reduction of plant number occurred as harvesting cycle was increased. Plant losses compared to planned planting density amounted to 5.2, 11.7, 14.8 and 32.2% for annual, bi-, trie- and quadrennial harvest cycles, respectively. It resulted from increasing competitiveness in the willow stand in the course of plant growth.

Bullard et al. (2002b) showed that among the 110 000 willow cuttings planted per 1 ha to the fourth year 95 000 survived, so plant loss rate amounted to 15% during the four seasons. In the other experiment the other genotype was tested i.e. SV1 (*Salix dasyclados*). After five seasons the average survival rate amounted to 75% of planted plants. However, statistically proven differences were found for tested planting densities survival rates were as follows: 88, 80 and 57% for the density of 15 000, 37 000 and 111 000 cuttings/ha (Kopp et al. 1997a). In our earlier studies it was shown that the losses of willow plants amounted to 18.02, 18.08 and 19.65% for one, two and three years harvesting cycles, respectively (Stolarski et al. 2002).

The number of stems per stool in the trial amounted to 6.72 (Table 4). Among the tested genotypes the highest number of stems per stool was found for *Salix triandra* (7.91). The lowest number stems per stool were noted for *Salix viminalis* var. *regalis* (5.81). For the annual harvest cycle it was significantly higher (12.14) than for two, three and four years: 7.38, 4.47 and 2.88, respectively. Prolonged harvesting cycle resulted in the wilting of weak stems of *Salix* spp. what could be called as self-regulation mechanism. The decrease in the number of stems

Table 5. Height of *Salix* spp. plants (cm)

Botanic name or cultivar (a)	Harvest frequency (b)				
	1 year	2 years	3 years	4 years	mean
Salix triandra	200.20 ± 5.90	265.13 ± 2.74	278.50 ± 10.49	330.13 ± 23.50	268.49 ± 13.35
Salix viminalis × *S. viminalis lanceolata*	281.23 ± 10.57	471.50 ± 8.01	606.75 ± 36.76	769.00 ± 17.48	532.12 ± 47.20
Salix viminalis var. *gigantea*	274.45 ± 6.68	455.38 ± 3.58	622.50 ± 8.39	706.00 ± 20.14	514.58 ± 43.04
Salix viminalis var. *regalis*	288.50 ± 9.78	480.38 ± 10.56	642.50 ± 14.05	746.00 ± 15.05	539.34 ± 45.04
LSD (*P* = 0.05)	26.12	21.58	64.11	59.52	
Mean	261.09 ± 9.92	418.09 ± 23.13	537.56 ± 39.86	637.78 ± 47.03	463.63 ± 24.02
LSD (*P* = 0.05)	a = 21.61, b = 21.92, a × b = 43.23				

± = standard error

Table 6. Stem diameter of *Salix* spp. plants (mm)

Botanic name or cultivar (a)	Harvest frequency (b)				
	1 year	2 years	3 years	4 years	mean
Salix triandra	9.01 ± 0.39	10.05 ± 1.46	10.80 ± 0.59	12.98 ± 1.16	10.71 ± 0.58
Salix viminalis × *S. viminalis lanceolata*	14.84 ± 0.07	16.48 ± 1.01	29.04 ± 1.41	37.34 ± 1.05	24.42 ± 2.43
Salix viminalis var. *gigantea*	13.93 ± 0.29	17.10 ± 1.02	26.81 ± 1.30	33.24 ± 0.75	22.77 ± 2.02
Salix viminalis var. *regalis*	14.68 ± 0.44	18.04 ± 2.45	29.63 ± 1.21	33.79 ± 0.49	24.03 ± 2.14
LSD (*P* = 0.05)	1.03	4.93	3.62	2.78	
Mean	13.11 ± 0.63	15.42 ± 1.08	24.07 ± 2.06	29.33 ± 2.50	20.48 ± 1.18
LSD (*P* = 0.05)	a = 1.57, b = 1.59, a × b = 3.13				

± = standard error

per stool as harvesting cycle increased was noted also in our earlier studies (Stolarski et al. 2002).

Genotype *Salix viminalis* var. *regalis* was characterised by the significantly higher stems (539.34 cm) then *Salix viminalis* var. *gigantea* (514.58 cm) and *Salix triandra* (268.49 cm) (Table 5). Plants harvested annually were significantly shorter (261.09 cm), then harvested in two (418.09 cm), three (537.56 cm) and four years cycles (637.78 cm). Irrespectively of harvesting frequency always the shortest plants were recorded for the genotype *Salix triandra* (statistically proven). Stems of genotype *Salix viminalis* × *S. viminalis lanceolata* harvested in four-year cycle appeared to be the highest (769.00 cm). Similar plant height was recorded for genotype *Salix viminalis* var. *regalis*. Bullard et al. (2002a) reported that willow stems from biannual harvest cycle were 239–273 cm high. When harvesting cycle was prolonged to three years this value amounted to 401–515 cm. In earlier studies we found values of 284, 352 and 577 cm for one, two and three years harvesting cycles, respectively, (Stolarski et al. 2002).

Among the studied genotypes the highest diameter was found for *Salix viminalis* × *S. viminalis lanceolata* (24.42 mm) (Table 6). *Salix triandra* showed produced the thinnest stems of diameter of 10.71 mm (significant difference). The thickest stems were recorded in quadrennial harvest cycle (diameter of 29.33 mm). Willow stem diameter was reduced when a length of harvesting cycle was decreased. In quadrennial harvest cycle for genotype *Salix viminalis* × *S. viminalis lanceolata* the thickest stems were recorded (37.34 mm). We have confirmed our earlier results when we found that stem diameter increased when harvesting cycles are longer and values amounted to 13.3, 17.9 and 29.2 mm for annual, bi- and triennial harvest cycles, respectively (Stolarski et al. 2002).

Water content in the plant tissues at harvest was 49.87% (Table 7). The lowest water content

Table 7. Water content in *Salix* spp. wood (%)

Botanic name or cultivar (a)	Harvest frequency (b)				
	1 year	2 years	3 years	4 years	mean
Salix triandra	54.46 ± 0.33	47.85 ± 0.12	45.57 ± 0.08	46.86 ± 0.13	48.68 ± 0.89
Salix viminalis × *S. viminalis lanceolata*	53.05 ± 0.50	51.94 ± 0.18	47.38 ± 0.31	48.11 ± 0.42	50.12 ± 0.64
Salix viminalis var. *gigantea*	53.64 ± 0.95	52.56 ± 0.46	48.06 ± 0.87	47.84 ± 0.86	50.52 ± 0.73
Salix viminalis var. *regalis*	53.43 ± 0.46	51.24 ± 0.05	47.69 ± 0.74	48.25 ± 0.65	50.15 ± 0.63
LSD (*P* = 0.05)	ns	0.25	ns	ns	
Mean	53.64 ± 0.30	50.89 ± 0.47	47.17 ± 0.25	47.76 ± 0.30	49.87 ± 0.37
LSD (*P* = 0.05)	a = 0.57, b = 0.60, a × b = 1.20				

± = standard error, ns = not significant was found in the tissues of genotype *Salix triandra* (48.68%). It was proven by ANOVA analysis that water content in willow stems decreased as harvesting cycle increased from one to three years and respective values were 53.64, 50.89 and 47.17%. Willow wood harvested quadrennially tended to have slightly more water then when harvested triennially. In other studies we found that wood from one year harvesting cycle contained 52.68% of water while in two and three years cycles respective values amounted to 49.62 and 46.05% (Szczukowski et al. 2002).

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ABSTRAKT

Produktivita keřových vrb pěstovaných v krátkodobých rotačních cyklech

Byl sledován výnos suché hmoty a morfologické znaky čtyř genotypů rychle rostoucích keřových vrb získaných v jedno-, dvou-, tří- a čtyřletých sklizňových cyklech. Průměrný roční výnos dřevní hmoty byl během pokusu 16,79 t/ha/rok. Nejvyšší výnos byl zaznamenán u *Salix viminalis* × *S. viminalis lanceolata* (22,89 t/ha/rok). Genotyp *Salix triandra* měl výnos třikrát nižší než *Salix viminalis* × *S. viminalis lanceolata*. U genotypů *Salix viminalis* × *S. viminalis lanceolata*, *Salix viminalis* var. *gigantea* a *Salix viminalis* var. *regalis* se výnos s prodloužením sklizňového cyklu z jednoho na čtyři roky zvyšoval, zatímco opačný proces byl zaznamenán u genotypu *Salix triadra*. *Salix triadra* není tudíž vhodná pro intenzivní pěstování na orné půdě, a to zejména ve dvou-, tří- a čtyřletých sklizňových cyklech. Průměrná výška rostlin dosahovala 4,63 m a průměr kmene činil 20,48 mm. Nejvyšší rostliny (769 cm) s nejširším kmenem (průměr 37,43 mm) se objevily u genotypu *Salix viminalis* × *S. viminalis lanceolata* sklizeném po čtyřech letech. V době sklizně činila vlhkost dřeva v kmeni 49,87 %, přičemž nejvyšší hodnota byla stanovena u jednoletého sklizňového cyklu.

Klíčová slova: orná půda; vrba; sklizňová perioda; výnos biomasy; bioenergie

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