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CONTENT OF MACRO- AND MICROCOMPONENTS IN WILLOW (*SALIX PURPUREA* L.) GROWN IN SUBSTRATES WITH COMPOSTS OF POST-USE WOOD WASTE

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SYNOPSIS. Studies were carried out on composts obtained from post-use wood waste after one year of composting in compost heaps. In pot tests, willow, *Salix purpurea* L. 'Ferrinea' was applied. Cultivation was carried out in two vegetation seasons in substrates consisting of a mixture of mineral soil and compost (v:v = 3:1). After each vegetation season, the yield effectiveness and the content of macro- and microcomponents in the leaves and shoots of the studied plants were determined.

KEY WORDS: post-use wood waste, compost, willow *Salix purpurea* L.

INTRODUCTION

Presently, binding regulations referring to waste materials, environmental protection and sustainable development determine that the practical utilization of waste (including composting) has the priority before energetic utilization (incineration) (Dyrektywa Rady 99/31 UE 1999). These principles refer in particular to organic waste to which one can include wood waste created in the production process, in wood processing and in the use of products made of wood.

Jędrczak (2007) reported that waste from wood processing and from the production of boards and furniture, pulp, paper and cardboard contain 62-95% of organic substance. These waste are included in the list of organic waste suitable for biological transformation with a potential possibility of utilizing the obtained products for agricultural purposes (Rozporządzenie... 2001).

Cichy and Wróblewska (2004) found that post-use wood waste (worn out furniture, doors, windows and wooden construction elements) also contain a very high percentage (about 90%) of organic substance. According to current regulations, such materials cannot be deposited on waste landfills, but they should be biologically managed (Dyrektywa Rady 99/31 UE 1999, Ustawa... 2001 a, b). The application of composts obtained from waste biomass for soil enrichment with organic matter should be preceded by vegetation tests on different plants.

The objective of the presented studies was the estimation of growth and nutritional status of willow (*Salix pupurea* L.) cultivated in substrates with an admixture of composts obtained from post-use wood waste. Willow was selected for these studies because of its quick growth and wide possibilities of its wood utilization, also as an energetic raw material.

MATERIALS AND METHODS

Pot experiments with willow *Salix purpurea* L. 'Ferrinea' cultivar were carried out in the years 2005-2006. Willow plants were grown in containers of 14 dm^3 capacity filled with substrate consisting of a mixture of composts obtained from post-use wood waste mixed with mineral soil (slightly loamy sand). Composts were obtained from selected wood waste taken from municipal landfill. Before the beginning of the composting process, wood waste were separated from elements made of glass, metal, plastic, and PU foams and they were ground to the granulation size of over 10 mm.

The composting process was carried out in natural conditions, in two open compost heaps forming a trapezoid of about 5 m^3. The compost heaps were piled up on woven polyethylene mats placed directly on the ground and they were covered with a black horticultural fibre sheet which was partially permeable for water and air, but it protected the compost against excessive drying. The compost heaps contained:

1. OP variant A – post-use wood waste (OPA) (775 kg – 70% d.m.), waste from the machining process of MDF boards (65 kg – 6% d.m.), mature compost from fibreboard waste (210 kg – 19% d.m.), sphagnum peat (45 kg – 4% d.m.) and urea (20 kg).
2. OP variant B – post-use wood waste (OPB) (775 kg – 70% d.m.), waste from machining process of MDF boards (65 kg – 6% d.m.), mature compost from fibreboard waste (210 kg – 19% d.m.), sphagnum peat (45 kg – 4% d.m.) and ammonium nitrate (1.5 kg), magnesium sulphate (0.4 kg), potassium phosphate (0.8 kg) and calcium phosphate (0.9 kg).

During the composting process, the optimal moisture of 60% was maintained by sprinkling the compost heaps with tap water and periodical mixing up the composted materials in order to supply oxygen to the heaps which is necessary for the development of aerobic microorganisms.

After 12 months, each of the obtained composts was mixed with mineral soil in volumetric proportion of 1:3 and the substrate obtained in this way was placed into containers for willow growing. The control variant consisted of a combination with mineral soil only.

The experiment was established in five replications. The replication consisted of a container with three plants. Cuttings (of 20 cm length) were prepared from one-year-old shoots of willow *Salix purpurea* L. 'Ferrinea' cv. originating from Jan Białobok willow collection – Salicarium – in the Experimental Forest Inspectorate Zielonka belonging to Poznań University of Life Sciences. After six months of willow cultivation, the plant shoots were cut off and the green and dry masses of shoots and leaves were determined. In the second year of growing, analogical biometrical measurements of plants, which shoot up from the roots that overwintered in the containers, were carried out.

Prior to cultivation, in composts, in mineral soil and in substrates, the contents of macrocomponents were determined in the universal extract (0.03 M CH_3COOH), the content of microcomponents was determined in Lindsley's extract; pH was determined in H_2O and EC was determined conductometrically. In the dry matter of leaves and shoots, after wet mineralization, the content of macro- and microcomponents was analysed. Total nitrogen was determined by distillation method; phosphorus was colorimetrically identified. For the determination of potassium, calcium, magnesium and sodium, the ASA method was applied. For sulphur, the nephelometric method with BaCl2 was used. Microcomponents were determined by ASA method after wet mineralization in a mixture of acids HNO_3 and $HClO_4$ in 3:1 proportion (NOWOSIELSKI 1988).

The obtained results were statistically analysed using the analysis of variance. The significance of differences was estimated on the basis of Duncan's test at the significance level of $\alpha = 0.05$.

RESULTS AND DISCUSSION

After twelve months of composting, the composts obtained from post-use wood waste were characterised by a high content of mineral nitrogen and a small content of the remaining macro- and microelemements (Table 1). Nitrogen content in the composts resulted from the presence of urea-formaldehyde resins used in the production of composite wood products, being the main component of composts. WRÓBLEWSKA at AL. (2007) called attention to the fact that the release of nitrogen in the composting process of wood products lasts several years.

The content of mineral nitrogen in the substrate with the addition of OPA compost was 3.5-times greater than in the substrate with OPB compost. The least nitrogen content was found in mineral soil. The substrate with OPB compost contained more manganese and less boron than the OPA compost. On the other hand, in mineral soil, there was found a very small content of manganese and zinc. The reaction (pH) of substrates with compost and mineral soil was from 5.61 to 6.09 and it corresponded with the level recommended for willow growing which is 5.5-6.5 (DUBAS 2006).

In both years of studies, the application of the composts obtained from post-use wood waste as substrate components contributed to increased yields of plants in comparison with yields of willows grown in mineral soil (Table 2). The greatest mass was created by plants grown in a substrate with an addition of the OPA compost. In this substrate, in the first year of studies, the obtained yield of green mass

Table 1. Content of components and characteristics of pH and EC in composts obtained from post-use wood waste, in mineral soil and in mixtures of compost with mineral soil (v:v = 1:3)

Compost – substrate	$N\text{-}NH_4$	$N\text{-}NO_3$	P	K	Ca	Mg	$S\text{-}SO_4$	Na	Cl	Fe	Mn	Zn	Cu	B	pH	EC
	$mg \cdot dm^{-3}$ substrate														(H_2O)	$mS \cdot cm^{-1}$
Compost OPA	749	305	41	74	336	18	11	61	75	24.7	17.4	56.9	0.3	1.20	6.99	1.82
Compost OPB	116	116	37	78	373	20	traces	32	65	23.9	13.8	58.3	0.1	0.48	5.70	0.73
OPA + mineral soil (1:3)	193	84	16	19	465	11	5	15	40	118.4	6.1	42.9	0.2	0.66	6.09	0.35
OPB + mineral soil (1:3)	32	46	14	20	527	11	traces	11	43	119.6	11.7	43.5	0.2	0.32	5.61	0.22
Mineral soil	7	11	6	5	572	8	2	5	24	121.3	3.3	8.9	0.2	0.49	5.96	0.10

Table 2. Effect of compost (OPA and OPB) prepared from post-use wood waste on the yield of willow, *Salix purpurea* L. 'Ferrinea'

Vegetation year	Substrate	Shoots		Leaves	
		fresh matter	dry matter	fresh matter	dry matter
		g·container^{-1}			
2005	OPA + mineral soil (1:3)	83.35 b	44.79 b	46.20 c	17.40 c
	OPB + mineral soil (1:3)	62.13 a	32.55 a	33.86 b	12.08 b
	mineral soil	49.13 a	25.75 a	20.08 a	7.98 a
2006	OPA + mineral soil (1:3)	90.65 b	47.01 b	42.16 b	16.03 b
	OPB + mineral soil (1:3)	82.74 b	42.45 b	43.18 b	17.39 b
	mineral soil	46.38 a	23.46 a	18.77 a	7.01 a

Means denoted by the same letters are not significantly different at $\alpha = 0.05$.

of shoots was greater by 25 and 41%, than in the substrate with OPB compost and in mineral soil respectively. However, differences, both in the green and in the dry mass of shoots between the plants grown in the substrate with OPB compost and in mineral soil have not been statistically confirmed. On the other hand, the green and the dry mass of willow leaves from the cultivation in the substrate with OPA and OPB composts differed significantly and they were greater than those obtained in the control combination. One can suppose that the better growth of *Salix pupurea* L. 'Ferrinea' in the substrate with OPA compost was the effect of a significantly greater initial content of nitrogen in that substrate. A favourable effect of the increasing nitrogen doses in the sewage sludge on the yield increase of shrubby willow (*Salix viminalis* and *Salix viminalis* × *Salix purpurea*) was shown in earlier studies by KALEMBASA et AL. (2006 b). At the same time, the mentioned authors (KALEMBASA et AL. 2006 a) obtained a greater yield of dry matter from 2-year-old shoots of *S. caprea*, *S. alba* and *S. purpurea* after the application of 150 kg N than after the application of 200 kg N in sewage sludge. In the second year after our own experiments, in substrates with an addition of OPA composts and OPB composts, similar yields of green and dry mass of shoots and leaves were obtained and they were significantly higher than the yields of plants grown in mineral soil. Our own studies find confirmation in the literature reporting information about the influence of organic substance contained in composts on the growth and development of plants (WRÓBLEWSKA and CZAJKA 2007, WRÓBLEWSKA at AL. 2008).

The content of macrocomponents in willow shoots, independent of the applied substrate and the year of studies, was similar with the exception of phosphorus and sodium, but it was significantly lower than in the leaves (Table 3). Shoots of willow grown in a substrate with an addition of composts contained more manganese (particularly in the first year of studies after the application of OPA compost), zinc and boron than in the control combination (Table 4). The content of nitrogen in willow leaves collected after the first year of growing, depending on the applied substrate, was within the limits from 1.44 to 2.31% of dry matter. The greatest amounts of nitrogen were contained in the leaves of willow grown in the substrate with OPA compost, while the least N amount was found in the mineral soil. In the second year of growing, independent of the applied substrate, the content

Table 3. Content of macrocomponents in shoots and leaves of willow, *Salix purpurea* L. 'Ferrinea' from a substrate containing 1 part of compost (OPA and OPB) and 3 parts of mineral soil (MS), in the first and in the second year of plant vegetation

Part of plant	Vegetation year	Substrate	Macrocomponents						
			N	P	K	Ca	Mg	Na	S
			% d.m.						
Shoots	2005	OPA + MS 1:3	0.41	0.06	0.17	0.92	0.08	0.007	0.04
		OPB + MS 1:3	0.40	0.10	0.23	1.03	0.09	0.009	0.04
		mineral soil	0.35	0.10	0.25	1.10	0.08	0.012	0.03
	2006	OPA + MS 1:3	0.47	0.11	0.24	1.39	0.10	0.018	0.04
		OPB + MS 1:3	0.41	0.11	0.23	1.31	0.10	0.020	0.05
		mineral soil	0.53	0.16	0.29	1.38	0.11	0.021	0.05
Leaves	2005	OPA + MS 1:3	2.31	0.11	1.02	2.99	0.42	0.004	0.37
		OPB + MS 1:3	1.79	0.17	1.38	3.06	0.32	0.004	0.50
		mineral soil	1.44	0.17	1.05	2.96	0.54	0.005	0.47
	2006	OPA + MS 1:3	1.54	0.10	0.85	2.74	0.31	0.006	0.36
		OPB + MS 1:3	1.54	0.11	0.87	2.76	0.30	0.007	0.33
		mineral soil	1.51	0.14	0.76	2.79	0.31	0.008	0.31

Table 4. Content of microcomponents in shoots and leaves of willow, *Salix purpurea* L. 'Ferrinea' from a substrate containing 1 part of compost (OPA and OPB) and 3 parts of mineral soil (MS), in the first and in the second year of plant vegetation

Part of plant	Vegetation year	Substrate	Microcomponents				
			Fe	Mn	Zn	Cu	B
			ppm (mg·kg^{-1} d.m.)				
Shoots	2005	OPA + MS 1:3	23.2	65.7	190.2	7.8	19.6
		OPB + MS 1:3	17.3	26.0	185.1	8.7	21.1
		mineral soil	17.3	18.4	111.8	8.3	12.9
	2006	OPA + MS 1:3	21.2	27.7	162.2	8.2	21.5
		OPB + MS 1:3	22.9	25.4	172.7	9.3	26.0
		mineral soil	25.8	19.5	118.0	10.3	23.3
Leaves	2005	OPA + MS 1:3	146.0	286.6	299.5	67.0	152.2
		OPB + MS 1:3	119.3	114.7	280.0	122.0	170.0
		mineral soil	105.0	38.4	203.0	117.1	216.9
	2006	OPA + MS 1:3	87.9	101.7	241.1	36.3	88.0
		OPB + MS 1:3	86.0	58.4	241.7	39.1	50.2
		mineral soil	118.6	41.2	176.3	57.8	108.8

of nitrogen in leaves was very similar and amounted from 1.51 to 1.54% of dry matter. Borkowska and Lipiński (2007) obtained smaller contents of nitrogen (about 0.7%) in the dry matter of *Salix viminalis* L. After the application of the substrate with an addition of OPA compost, in willow cultivation in the first year of growing, leaves contained more nitrogen, iron and zinc, but smaller amounts of sulphur, copper and boron, as compared with leaves collected from plants grown in mineral soil or in the substrate with an addition of OPB compost. The greatest content of potassium was found in the leaves of willow grown in the substrate with an addition of OPB compost. In the second year of growing, in the leaves of plant grown in mineral soil without compost addition, a higher content of iron, copper and boron was found. One should notice that an excessive content of copper found in willow leaves resulted from the application of plant protection substances with chemical agents containing copper.

CONCLUSIONS

1. Mineral soil enrichment with composts from post-use wood waste exerted a favourable effect on the yield of willow, *Salix purpurea* L. 'Ferrinea'.
2. The yield of green and dry mass of plants was significantly higher after the application of substrates containing OPA and OPB composts than when plants were grown in mineral soil.
3. The content of macrocomponents in willow shoots, independent of the applied substrate, was similar.
4. Leaves of willow grown in the first year in a substrate with an addition of OPA compost contained more nitrogen, iron and manganese and smaller amounts of sulphur, copper and boron, in comparison with leaves of willows grown in mineral soil or in the substrate with OPB compost.

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