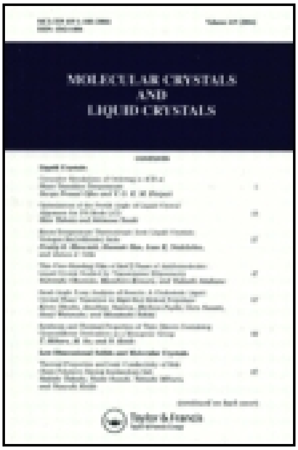


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# Studies on the Effect of Compost Made of Post-Use Wood Waste on the Growth of Willow Plants

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*Post-use wood waste from municipal landfill was separated from other materials (metal, glass, plastic) and crumbled, and then it was composted in the form of open piles (~4 m$^3$). Quality assessment of composts obtained after a year and two years of composting was done based on their chemical composition (content of macronutrients and micronutrients) and results of vegetative pot tests. Willow Salix purpurea L. was cultivated on substrata composed of pure soil and composts in the following doses 50%, 25% and 10%, and also on substrata containing 100% of soil and 100% of compost. 25% dose of compost (75% soil, 25% compost) proved to be the most conducive to the growth of willow plants in height. The yield of willow from substrata containing two-year-old composts was higher than in the case of willow cultivated on substrata containing one-year-old composts.*

**Keywords:** biological utilization; composting; macronutrients; micronutrients; post-use wood waste; *Salix purpurea* L.



## INTRODUCTION

Since the mid-20th century composite wood products have been a very common material used in the production of furniture, builder's carpentry and joinery, and packaging. After the life cycle of these products is finished they become very troublesome waste. Post-use wood waste cannot be deposited on landfills due to their high content of organic matter (~90%). It is recommended that they are used for energy or material purposes. The second option complies with EU directives which are the basis of the Member States legislation in the scope of environmental protection and waste management [1]. The recommended methods of organic waste utilization include biological methods: aerobic (composting) and anaerobic (fermentation) [2,3].

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Wood contains over 20% of lignin which is the main source of humus during natural aerobic wood decay. Therefore composting is an appropriate method of biological utilization of wood waste. This process consists in humification and mineralization of lignin-cellulose complex by a set of microorganisms (actinomycetes, bacteria and fungi) in conditions which are optimum in respect of temperature, moisture content and aeration [2].

The compost is suitable to be used in the environment if it meets quality and quantity standards. As an organic fertilizer mature compost must contain at least 40% of organic substances and it cannot contain plant pathogens and parasites, and pathogenic bacteria. Content of heavy metals in compost (dry mass) cannot exceed 3mg/kg of cadmium, 100 mg/kg of chromium, 400 mg/kg of copper, 30 mg/kg of nickel, 100 mg/kg of lead, 1500 mg/kg of zinc, and 2 mg/kg of mercury [1,3].

Chemical composition and the resulting quality of composts depend on the chemical composition of composted waste. Post-use wood waste is morphologically heterogeneous. It is a mixture of various raw and finished composite wood products and solid wood which in most cases is preserved against atmospheric and biological factors. Finishing materials and wood preservatives include paints, lacquers, wood stains, foils, laminates, films, artificial veneers, and impregnants. Together with resins used for wood particles gluing in the production of composite wood products, they account for around 10% of wood product mass. These materials constitute an integral part of post-use wood waste and have an influence on the quality of composts from post-use wood waste. Cichy and Wróblewska [4] observed that in Poland post-use wood waste from old, around 50-year-old, windows, doors and furniture does not contain excess amounts of the abovementioned heavy metals. An exception from that is impregnated wood used in building and garden structures which contains significant amounts of copper (up to 3629 ppm) and chromium (up to 639 ppm).

Elementary analysis (C, H, N, S) shows that composite wood products glued with urea-formaldehyde resins differ from raw wood mainly by nitrogen content. An example of this can be particleboards which contain about 4.5% of nitrogen, dry-process fiberboards (MDF) containing over 5% of nitrogen, and interior plywood in which nitrogen content is 8.4%. In raw pine wood nitrogen content is approximately 0.2%. Equally low content of this element is characteristic for composite wood products manufactured without amine resins. This product group includes wet-process fiberboards (0.19% N) and exterior plywood (0.6% N) [4,5].

Nitrogen content in post-use wood waste is a derivative of material composition of this waste. The more composite wood products glued with urea-formaldehyde resins are there in a batch of waste, the more nitrogen a mixture of waste contains. The crucial thing for composting process is relation between carbon and nitrogen (C:N) which according to most authors should range from 25:1 to 30:1. In research concerning microbiological decomposition of waste from particleboards and pine sawdust with addition of finishing materials such as laminating film and edge band, Wróblewska observed that samples characterized by a narrow ratio of carbon to nitrogen (C:N = 10:1) were decomposed faster, and that nitrogen from hardened amine resins was not completely available for microorganisms. Thus there was the necessity to supplement nitrogen in the composted mixtures through adding urea [2,6].

Composts obtained from industrial waste from composite wood products such as particleboards, fiberboards and MDFs were characterized by a high content of organic matter. The crop of tested plants cultivated on soil fertilized by these composts was bigger [5,7,8,9]. Obtained results encouraged the author to conduct research on composting of post-use wood waste which must be removed from municipal landfills within the next years. The idea of the research was to convert old, unwanted and worn out items, in other words burdensome wood waste, into new material, i.e. recycled wood, which after biological processing should be suitable to fertilize soil with organic humus substances.

The aim of the tests was to evaluate the quality of one-year-old and two-year-old composts obtained from post-use wood waste. Vegetative tests using willow *Salix purpurea* L. were the basis for the evaluation [3,10,11].

## MATERIALS AND TEST METHODS

Composts subjected to vegetative tests were obtained from post-use wood waste selected from municipal waste landfill. This waste included worn out furniture, doors, windows, building structures, and other goods made of composite wood products (raw and finished particleboards – laminated, veneered, lacquered; painted flaxboards, hardboards and softboards – lacquered and raw; MDFs finished with artificial veneers and laminates, furniture panels, plywood, and boards on frame), and also worn out products made of solid wood – raw and preserved – with painting coatings and containing wood preservatives (fungicides and pesticides). All wooden objects were crushed in a machine by Hammel and then the wood was separated from elements made of metal, glass, plastic, and PU foams. At the next stage the wood was sawn and ground in a knife mill fitted with an exit screen of mesh size 10 mm. So obtained recycled wood was used for forming composting piles.

Composting process was carried out in natural conditions in two piles of $\sim 4\,m^3$ marked A and B. Compost mixtures were prepared from grounded waste of post-use wood (70% d.m.), dusty waste from machining of MDFs (6% d.m.), mature compost from fiberboard waste (19% d.m.), and high peat (4% d.m.). Water was added to each pile with the aim of obtaining 60% moisture content of the composted mass. A two-component biological inoculum containing selected microorganisms (fungi, bacteria, and actinomycetes) was also added to the piles. Moreover, 20 kg of urea was added to A pile, and 3.6 kg of mixture of mineral salts (1.5 kg – ammonium nitrate, 0.4 kg – magnesium sulfate, 0.8 kg – potassium phosphate, and 0.9 kg – calcium phosphate) containing nitrogen, phosphorus, magnesium, sulfur, potassium and calcium to B pile.

During composting process temperature, moisture content and pH of the piles were controlled, as well as their aeration through mechanical pouring of their contents. Depending on the season, pile temperature ranged within the scope of 2 to 56°C. Acidity (pH) of composted mixtures in A pile changed in the scope from pH = 3.3 to pH = 8.9, and in B pile from pH = 3.7 to pH = 6.2. Moisture content of piles was kept within the range from 50 to 70%. Composting was carried out for two years.

Quality of composts obtained from waste of composite wood products was evaluated based on vegetative tests using fast-growing willow *Salix purpurea* L. Pot tests of willow cultivation were carried out after 12 months (in 2005) and 24 months of waste composting (in 2006).

In the experiment started in 2005 planting material (willow *Salix purpurea* L. of 'Ferrinea' variety) was taken from Jan Białobok willow collection in Zielonka Experimental Forest District of August Cieszkowski Agricultural University of Poznań, and in the experiment started in 2006 (willow *Salix purpurea* L. clone number 1101) – from the Collection of the Department of Plant Breeding and Seed Production of University of Warmia and Mazury in Olsztyn.

Substrata for cultivation were prepared by mixing pure soil with composts (A or B) in the following volumetric proportions: compost 100%, compost 50% + soil 50%, compost 25% + soil 75%, compost 10% + soil 90%, and soil 100%. 9 versions of experimental substrata in 2005 and 9 versions in 2006 were prepared in the same way from two composts and soil. Five sets of 14-liter pots were filled with the substrata (5 pots per one version of substratum – 5 replicates). Three 20-centimeter cuttings from freshly taken one-year-old willow shoots were planted in each pot, which gave a total number of 15 plants per one version. Pots with cuttings were placed in a sunny place. Experiments were carried out for 6 months of spring and summer vegetative periods. Plants were watered with tap water to keep the moisture content of the substrata at a constant level. Once a month the growth in height of plants was measured.

Prior to planting out of the willows, chemical composition of the substrata was carried out. The following components were determined:

- macronutrient content: nitrogen, phosphorus, potassium, calcium, magnesium, and sulfates,
- micronutrient content: iron, manganese, zinc, boron, copper,
- contamination content: chlorine and sodium,
- pH, and salinity (EC mS/cm).

Macronutrients were analyzed using a universal extract (0.03 N $CH_3COOH$), and micronutrients using Lindsay extract. Ammonium nitrogen ($N-NH_4$) was determined by means of distillation in Bremner apparatus in Starck modification, and nitrate nitrogen ($N-NO_3$) – by means of selection of ions in apparatus by Orion. Phosphorus was determined colorimetrically, potassium, calcium and sodium photometrically, and magnesium, iron, manganese, zinc, copper, lead, and cadmium by AAS. Sulfur as sulfates and chlorine in the form of chlorides were determined nephelometrically, whereas pH was determined potentiometrically, and salinity conductometrically.

After the vegetation period ended leaves of cultivated willows were cropped and shoots cut. Length and diameter of shoots at the thicker end were determined as well as the fresh mass of shoots and leaves (directly after harvest).

## TEST RESULTS

Composts obtained from post-use wood waste after the first and second year of composting differed from each other and from pure soil by content of macronutrients and micronutrients (Tables 1 and 2). The greatest differences were observed in the case of content of nitrogen compounds.

Composts contained much more nitrogen than the soil. After one year of composting A12 compost ($N = 1054\,mg/dm^3$) differed also from B12 compost ($N = 232\,mg/dm^3$) in respect of nitrogen content (Table 1). Nitrogen content in two-year-old composts A24 ($690\,mg/dm^3$) and B24 ($609\,mg/dm^3$) was similar (Table 2).

**TABLE 1** Characteristics of Substrata Prepared from Mineral Soil and Tested One-Year-Old Composts A12 and B12 Before Planting out of Willow *Salix purpurea* L.

| | | Substrata containing compost | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A12 in doses | | | | B12 in doses | | | | |
| Element | Unit | 100% | 50% | 25% | 10% | 100% | 50% | 25% | 10% | Soil |
| N | $mg \cdot dm^{-3}$ | 1054 | 504 | 277 | 169 | 232 | 123 | 78 | 43 | 18 |
| P | | 41 | 37 | 16 | 37 | 37 | 27 | 14 | 10 | 6 |
| K | | 74 | 29 | 19 | 12 | 78 | 32 | 20 | 11 | 5 |
| Ca | | 336 | 443 | 465 | 488 | 373 | 485 | 527 | 559 | 572 |
| Mg | | 18 | 13 | 11 | 9 | 20 | 15 | 11 | 11 | 8 |
| S | | 11 | 6 | 5 | 1 | trace | 14 | trace | trace | 2 |
| Na | | 61 | 23 | 15 | 10 | 32 | 20 | 11 | 9 | 5 |
| Cl | | 75 | 43 | 40 | 36 | 65 | 45 | 43 | 41 | 24 |
| Fe | | 25 | 113 | 118 | 123 | 24 | 113 | 120 | 124 | 121 |
| Mn | | 17 | 8 | 6 | 7 | 14 | 12 | 12 | 9 | 3 |
| Zn | | 57 | 47 | 43 | 32 | 58 | 51 | 44 | 35 | 9 |
| Cu | | 0.3 | 0.2 | 0.2 | 0.2 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 |
| B | | 1.2 | 1.0 | 0.7 | 0.4 | 0.5 | 0.5 | 0.3 | 0.5 | 0.5 |
| Salinity | EC $mS \cdot cm^{-1}$ | 1.82 | 0.95 | 0.35 | 0.20 | 0.73 | 0.36 | 0.22 | 0.12 | 0.10 |
| pH | | 6.99 | 6.39 | 6.09 | 5.97 | 5.70 | 5.61 | 5.61 | 5.62 | 5.96 |

Compared to the salinity of mineral soil ($0.09\,mS \cdot cm^{-1}$) salinity of the obtained composts was high and after the first year of composting it was 1.82 mS/cm for A12 compost and 0.73 mS/cm for B12 compost, whereas after the second year of composting (A24 and B24) it was 1.91 mS/cm and 1.52 mS/cm, respectively. pH of composts after the first year of composting was higher than after the second year and it was respectively pH = 6.99 for A12 compost, pH = 5.70 for B12 compost, pH = 5.11 for A24 compost, and pH = 4.79 for B24 compost. Acidity (pH) of soil ranged between pH = 5.96 and pH = 6.57 (Tables 1 and 2).

Content of particular elements in substrata prepared for cultivation of willow, as well as pH and substratum salinity was a result of the proportion between soil and compost in a given substratum (Tables 1 and 2).

Chemical composition of tested substrata influenced the growth of plants of willow *S. purpurea* L. Plants cultivated on one-year-old, and especially on two-year-old, composts without a supplement of soil (A and B 100%) grew poorly. In the case of two-year-old composts unfavorable trophic conditions were accompanied by destructive

**TABLE 2** Characteristics of Substrata Prepared from Mineral Soil and Tested Two-Year-Old Composts A24 and B24 Before Planting out of Willow *Salix purpurea* L.

| | | Substrata containing compost | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A24 in doses | | | | B24 in doses | | | | |
| Element | Unit | 100% | 50% | 25% | 10% | 100% | 50% | 25% | 10% | Soil |
| N | $mg \cdot dm^{-3}$ | 690 | 186 | 119 | 57 | 609 | 336 | 175 | 130 | 18 |
| P | | trace | 21 | 17 | 15 | 26 | 25 | 20 | 19 | 13 |
| K | | 36 | 92 | 119 | 107 | 56 | 118 | 117 | 123 | 110 |
| Ca | | 385 | 405 | 612 | 435 | 315 | 401 | 465 | 445 | 504 |
| Mg | | 40 | 58 | 76 | 67 | 36 | 65 | 69 | 71 | 70 |
| S | | 21 | 23 | 12 | 24 | 20 | 18 | 12 | 20 | 22 |
| Na | | 50 | 25 | 14 | 11 | 32 | 24 | 16 | 14 | 7 |
| Cl | | 71 | 48 | 28 | 34 | 55 | 44 | 31 | 30 | 21 |
| Fe | | 18 | 160 | 169 | 169 | 24 | 162 | 182 | 164 | 184 |
| Mn | | 10 | 47 | 52 | 36 | 11 | 58 | 51 | 35 | 31 |
| Zn | | 63 | 51 | 46 | 37 | 62 | 53 | 47 | 40 | 16 |
| Cu | | 1 | 3 | 3 | 3 | 0.7 | 3 | 3 | 3 | 4 |
| B | | 0.7 | 0.3 | 0.1 | trace | 0.6 | 0.4 | 0.3 | 0.1 | trace |
| Salinity | EC $mS \cdot cm^{-1}$ | 1.91 | 0.55 | 0.31 | 0.29 | 1.52 | 0.59 | 0.39 | 0.26 | 0.09 |
| pH | | 5.11 | 5.80 | 5.73 | 5.97 | 4.79 | 5.62 | 5.92 | 6.06 | 6.57 |

activities of magpies which were destroying the cuttings while looking for insect larvae in the pots filled with composts. Leaves of these plants, especially in the top part of shoots, were pale, almost transparent, devoid of chlorophyll and small. The plants survived till the end of vegetative season but their growth was slight and their appearance pathologic.

The use of compost not as a substratum but as a fertilizer for pure soil had a positive effect on the growth of willow plants (Figs. 1–4). Figures illustrating growth dynamics of *S. purpurea* in 2005 and 2006 present differences in the growth of willows depending on doses of compost in soil. The highest plants grew on substrata containing 25% dose of A24 compost (on average their height was over 160 cm), and the shortest on substrata containing 50% dose of A12. After 24 months of composting all doses of A and B composts (10%, 25% and 50%) added to soil improved the growth of plants compared to soil without composts. Plants of willow *S. purpurea* cultivated on substrata containing two-year-old compost from waste of composite wood products (A24 and B24) were higher than plants cultivated on

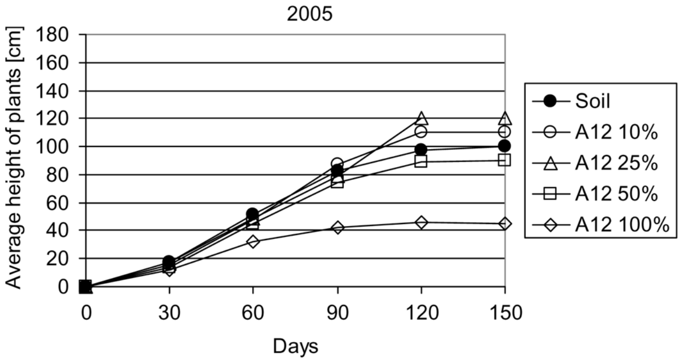


**FIGURE 1** Growth of *Salix purpurea* L. willow plants in mineral soil enriched with different doses (0%, 10%, 25%, 50%, 100%) of one-year-old compost A12 made of post-use wood waste.

substrata containing these composts but one-year-old (A12 and B12) (Figs. 1–4).

Results of vegetative tests (length, diameter at the thicker end, mass of cropped shoots, and mass of cropped leaves) were subjected to statistical analysis. A variation analysis was done and the difference between mean values was determined based on Newman-Keuls test at the significance level of $\alpha = 0.05$.

It was shown that the total length of shoots, shoot diameter, fresh mass of shoots and leaves of single plant of willow *S. purpurea* L. depended on the type of compost, its share in the substratum, as well

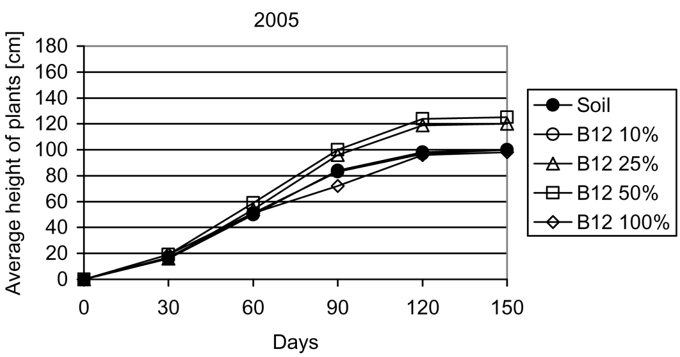


**FIGURE 2** Growth of *Salix purpurea* L. willow plants in mineral soil enriched with doses (0%, 10%, 25%, 50%, 100%) of one-year-old compost B12 made of post-use wood waste.

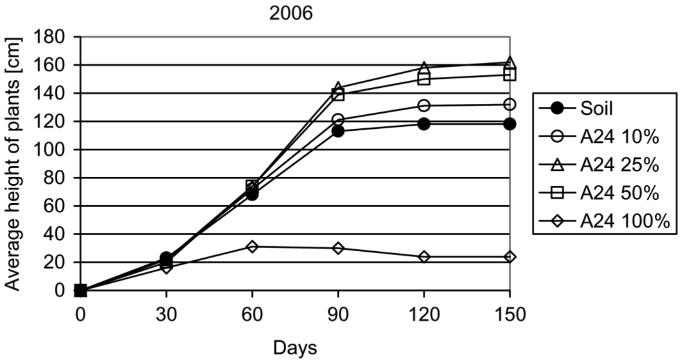


**FIGURE 3** Growth of *Salix purpurea* L. willow plants in mineral soil enriched with doses (0%, 10%, 25%, 50%, 100%) of two-year-old compost A24 made of post-use wood waste.

as on the interaction between these factors (Tables 3–6). The share of compost had the greatest influence, expressed as $F_{emp}$ value, on the total length of shoots, shoot diameter, and the fresh mass of shoots. At the significance level of $\alpha = 0.05$ the total shoot length of plants cultivated on substrata containing A24 compost in the doses of 25% and 10% was significantly greater than the total shoots length of plants cultivated on soil and the other substrata. The smallest total shoot length was observed in the cease of A12 100% and A24 100% substrata and B24 100% substratum. This length was considerably

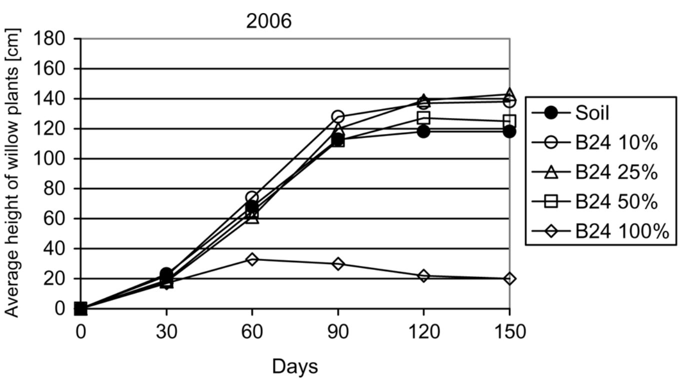


**FIGURE 4** Growth of *Salix purpurea* L. willow plants in mineral soil enriched with different doses (0%, 10%, 25%, 50%, 100%) of two-year-old compost B24 made of post-use wood waste.

**TABLE 3** The Influence of the Compost Type (A and B), its Proportion in the Substratum (100%, 50%, 25%, and 10%), and Compositing Time (12 and 24 months) on a Total Length of Shoots from One Plant of Willow *S. purpurea* L.

| Compost | Proportion of compost in the substratum (%) | Total length of shoots [cm] Composting time 12 months | 24 months | Average |
|---|---|---|---|---|
| A | 100 | 96.2 c° | 46.6 c° | 71.4 b° |
| | 50 | 192.6 b | 292.4 a | 242.5 a |
| | 25 | 270.4 ab | 312.7 a° | 291.6 a° |
| | 10 | 272.6 ab | 258.3 ab | 265.4 a |
| B | 100 | 192.0 b | 31.4 c° | 111.7 b° |
| | 50 | 246.0 ab | 257.2 ab | 251.6 a |
| | 25 | 217.7 ab | 271.7 ab | 244.7 a |
| | 10 | 231.3 ab | 308.2 a° | 269.7 a |
| Average for compost | A | 207.9 a | 227.5 a | 217.7 a |
| | B | 221.7 a | 217.1 a | 219.4 a |
| Average for proportion | 100 | 144.1 c° | 39.0 d° | 91.5 b° |
| | 50 | 219.3 b | 274.8 ab° | 247.1 a |
| | 25 | 244.1 ab | 292.2 a° | 268.1 a |
| | 10 | 251.9 ab | 283.3 a° | 267.6 a |
| Average for year | | 214.8 a | 222.3 a | 218.5 |
| Control – soil | 0 | 210.6 | 224.1 | 217.3 |

Average values marked with the same letter in particular fields do not differ significantly from each other at a level of $\alpha = 0.05$.
° – an average value significantly different from control at a level of $\alpha = 0.05$.
n.s. – insignificant at a level of $\alpha = 0.05$.

| Parameter | Changeability source: Compost (a) | Proportion (b) | Year (c) | a × b | a × c | b × c | a × b × c |
|---|---|---|---|---|---|---|---|
| $F_{emp}$ | 0.03 | 61.89** | 0.48 | 2.77* | 1.24 | 12.2** | 4.66** |
| $LSD_{\alpha=0.05}$ | n.s. | 30.04 | n.s. | 42.48 | n.s. | 42.48 | 60.08 |

* – significant at a level of $\alpha = 0.05$.
** – significant at a level of $\alpha = 0.01$.

smaller than in the case of control plants cultivated on soil. The total shoots length of plants cultivated on the other substrata did not differ significantly from control plants. The type of compost contained in substratum had a slight bearing on tested shoot features, while the impact of cultivation year was of average significance. The total shoots length, diameter and mass of shoots concerning one plant were to the greatest degree differentiated by the impact of the interaction between

**TABLE 4** The Influence of the Compost Type (A and B), its Proportion in the Substratum (100%, 50%, 25%, and 10%), and Compositing Time (12 and 24 months) on the Diameter of Shoots from One Plant of Willow *S. purpurea* L.

| Compost | Proportion of compost in the substratum (%) | Average diameter of shoots [mm] Composting time 12 months | 24 months | Average |
|---|---|---|---|---|
| A | 100 | 3.1 f° | 2.8 fg° | 2.9 c° |
| | 50 | 4.4 e | 7.3 a° | 5.8 a° |
| | 25 | 5.4 b–e | 6.2 bc° | 5.8 a° |
| | 10 | 5.2 c–e | 5.1 de | 5.1 ab° |
| B | 100 | 4.4 e | 2.0 g° | 3.2 c° |
| | 50 | 5.2 c–e | 5.7 b–d | 5.5 ab° |
| | 25 | 5.0 de | 6.4 b° | 5.7 a° |
| | 10 | 4.4 e | 5.5 b–e | 4.9 b° |
| Average for compost | A | 4.5 b | 5.3 a | 4.9 a |
| | B | 4.7 b | 4.9 b | 4.8 a |
| Average for proportion | 100 | 3.7 c° | 2.4 d° | 3.0 c° |
| | 50 | 4.8 b | 6.5 a° | 5.6 a° |
| | 25 | 5.2 b° | 6.3 a° | 5.8 a° |
| | 10 | 4.8 b | 5.3 b | 5.0 b |
| Average for year | | 4.6 b | 5.1 a | 4.85 |
| Control – soil | 0 | 4.5 | 4.6 | 4.6 |

Average values marked with the same letter in particular fields do not differ significantly from each other at a level of $\alpha = 0.05$.
° – an average value significantly different from control at a level of $\alpha = 0.05$.
n.s. – insignificant at a level of $\alpha = 0.05$.

| Parameter | Changeability source: Compost (a) | Proportion (b) | Year (c) | a × b | a × c | b × c | a × b × c |
|---|---|---|---|---|---|---|---|
| $F_{emp}$ | 0.6 | 78.83** | 11.8** | 0.81 | 5.65* | 21.69** | 10.42** |
| $LSD_{\alpha=0.05}$ | n.s. | 0.39 | 0.28 | n.s. | 0.39 | 0.56 | 0.79 |

* – significant at a level of $\alpha = 0.05$.
** – significant at a level of $\alpha = 0.01$.

cultivation year and share of compost in substratum. The said impact was expressed as $F_{emp}$ value (Tables 3–5).

The fresh mass of shoots of plants cultivated on substrata fertilized with A and B composts was in all cases significantly different from the fresh mass of plant shoots grown on soil. For these shoot feature considerable differences were also noted between particular versions of substrata. The highest yield was cropped from substratum in which the proportion of A24 compost to soil was 50% and 25% (Table 5).

**TABLE 5** The Influence of the Compost Type (A and B), its Proportion in the Substratum (100%, 50%, 25%, and 10%), and Compositing Time (12 and 24 months) on a Fresh Mass of Shoots from One Plant of Willow *S. purpurea* L.

| | | Fresh mass of shoots [g] | | |
|---|---|---|---|---|
| | | Composting time | | |
| Compost | Proportion of compost in the substratum (%) | 12 months | 24 months | Average |
| A | 100 | 4.5 g° | 1.6 g° | 3.0 e° |
| | 50 | 15.0 f° | 44.1 a° | 29.6 b° |
| | 25 | 27.9 b–d° | 39.8 a° | 33.9 a° |
| | 10 | 29.1 bc° | 23.5 c–e° | 26.3 bc° |
| B | 100 | 15.3 f° | 1.0 g° | 8.1 d° |
| | 50 | 25.3 b–e° | 30.7 bc° | 28.0 bc° |
| | 25 | 20.7 d–f° | 33.8 b° | 27.2 bc° |
| | 10 | 17.9 ef° | 29.1 bc° | 23.5 c |
| Average for compost | A | 19.1 c | 27.2 a° | 23.2 a° |
| | B | 19.8 c° | 23.6 b | 21.7 a |
| Average for proportion | 100 | 9.9 d° | 1.3 e° | 5.6 c° |
| | 50 | 20.2 c° | 37.4 a° | 28.8 a° |
| | 25 | 24.3 bc° | 36.8 a° | 30.5 a° |
| | 10 | 23.5 bc° | 26.3 b° | 24.9 b° |
| Average for year | | 19.5 b | 25.4 a° | 22.4 |
| Control – soil | 0 | 16.4 | 18.2 | 17.3 |

| | Changeability source | | | | | | |
|---|---|---|---|---|---|---|---|
| Parameter | Compost (a) | Proportion (b) | Year (c) | a × b | a × c | b × c | a × b × c |
| $F_{emp}$ | 1.92 | 121.72** | 32.91** | 5.51** | 4.34* | 30.1** | 17.33** |
| $LSD_{\alpha=0.05}$ | n.s. | 2.95 | 2.08 | 4.17 | 2.95 | 4.17 | 5.89 |

Average values marked with the same letter in particular fields do not differ significantly from each other at a level of $\alpha = 0.05$.
° – an average value significantly different from control at a level of $\alpha = 0.05$.
n.s. – insignificant at a level of $\alpha = 0.05$.
* – significant at a level of $\alpha = 0.05$.
** – significant at a level of $\alpha = 0.01$.

The fresh mass of leaves expressed as $F_{emp}$ value was influenced by a few factors, whereas the influence of compost type was the least, of cultivation year – mean, and of compost proportion – the greatest. The thing that differentiated the fresh mass of leaves to the greatest extent was the impact, expressed as $F_{emp}$ value, of the interaction between compost type, its proportion and cultivation year. The fresh mass of leaves of willow plants grown on substrata containing A12 compost in the doses of 50%, 25% and 10%, B12 compost in the doses of

**TABLE 6** The Influence of the Compost Type (A and B), its Proportion in the Substratum (100%, 50%, 25%, and 10%), and Compositing Time (12 and 24 months) on a Fresh Mass of Leaves from One Plant of Willow *S. purpurea* L.

| Compost | Proportion of compost in the substratum (%) | Fresh mass of leaves [g] Composting time 12 months | 24 months | Average |
|---|---|---|---|---|
| A | 100 | 1.8 h° | 0.6 h° | 1.2 e° |
| | 50 | 11.3 b–e° | 11.9 b–d° | 11.6 ab° |
| | 25 | 15.4 a° | 9.5 d–f° | 12.4 a° |
| | 10 | 13.5 ab° | 5.9 g | 9.7 b° |
| B | 100 | 7.9 fg | 0.7 h° | 4.3 d |
| | 50 | 13.0 a–c° | 10.1 c–f° | 11.6 ab° |
| | 25 | 11.3 b–e° | 9.6 d–f° | 10.4 ab° |
| | 10 | 8.5 e-g | 7.0 fg° | 7.7 c |
| Average for compost | A | 10.5 a° | 7.0 b° | 8.7 a° |
| | B | 10.2 a° | 6.8 b° | 8.5 a° |
| Average for proportion | 100 | 4.8 e | 0.7 f° | 2.7 c° |
| | 50 | 12.2 ab° | 11.0 bc° | 11.6 a° |
| | 25 | 13.4 a° | 9.5 c° | 11.4 a° |
| | 10 | 11.0 bc° | 6.5 d° | 8.7 b° |
| Average for year | | 10.3 a° | 6.9 b° | 8.6° |
| Control – soil | 0 | 6.7 | 4.9 | 5.8 |

Average values marked with the same letter in particular fields do not differ significantly from each other at a level of $\alpha = 0.05$.
° – an average value significantly different from control at a level of $\alpha = 0.05$.
n.s. – insignificant at a level of $\alpha = 0.05$.

| Parameter | Changeability source: Compost (a) | Proportion (b) | Year (c) | a × b | a × c | b × c | a × b × c |
|---|---|---|---|---|---|---|---|
| $F_{emp}$ | 0.34 | 113.29** | 77.66** | 9.77** | 0.04 | 3.94* | 14.6** |
| $LSD_{\alpha = 0.05}$ | n.s. | 1.1 | 0.78 | 1.55 | n.s. | 1.55 | 2.2 |

* – significant at a level of $\alpha = 0.05$.
** – significant at a level of $\alpha = 0.01$.

50% and 25%, as well as A24 compost in the doses of 50% and 25% and B24 compost (50%, 25% and 10%) was considerable bigger than the fresh mass of leaves of plants grown on soil. The fresh mass of plant leaves cultivated on A 100% and B 100% substrata was statistically significantly lower than the mass of willow leaves cultivated on soil (Table 6).

If we do not take into consideration the data concerning plants grown on pure composts (100%) it was observed that composting time and thus compost maturity has an influence on the growth of willow *S. purpurea* L. The total length, diameter and the fresh mass of shoots from one plant grown on substrata containing A24 and B24 (two-year-old compost) in the doses of 50%, 25% and 10% were greater than in the case of plants grown on substrata containing the same doses of A12 and B12 (one-year-old compost) (Tables 3–5).

## SUMMARY AND CONCLUSIONS

On the basis of carried out vegetative pot tests it was proved that one-year-old and two-year-old composts obtained from post-use wood waste and added to pure mineral soil stimulated the growth of willow *S. purpurea* L. plants, whereas composts without soil supplement inhibited growth of the plants.

Tests showed differences between one-year-old and two-year-old composts obtained from post-use wood waste. Higher plants with thicker shoots grew on substrata containing two-year-old compost.

The proportion of compost in the substrata had the most significant influence on the total length of shoots, diameter and the fresh mass of shoots and leaves at the significance level of $\alpha = 0.05$.

The choice of optimum doses of composts obtained from waste of post-use composite wood products is a condition of using these composts for plant cultivation.

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