Principles of circular economy applied to energy plants in culture. The correlation of soil quality with the valuation potential of willow by-products.

Gabriela Vlăsceanu, Floarea Florea, Nicole Mate, Marian Petculescu

Abstract. The principles of circular economy are applied to energy plants in their culture, with the correlation of soil quality with the potential valuation of willow by-products. The study aims to highlight the potential of various energy plant crops, which are eligible for both direct and indirect valorization of ecosystem services. The eco-introduction of energy plants and the development of a bio-technical hub for the valorization of biomass and the development of biogas production and distribution systems, at the scale of Romania, different energy willow crops, designed to rebuild natural capital, and without entering the biosphere. Thus, the EU’s transition to a circular economy will find in the proper management of the cultivated soil, in the manufacture of stan, briquette, reading or compression mixture, with real effects on health. 

1. Introduction

The eco-introduction of energy plants and the development of a bio-technical hub for the valorization of biomass and the development of biogas production and distribution systems, at the scale of Romania, different energy willow crops, designed to rebuild natural capital, and without entering the biosphere. Thus, the EU’s transition to a circular economy will find in the proper management of the cultivated soil, in the manufacture of stand, briquette, reading or compression mixture, with real effects on health. 

The bark, which comes off easily, can be exploited depending on the area of use. Willow is cultivated primarily as an energy plant (bio
culture).

The dynamic study aims to highlight the potential of various energy plant crops, which are eligible for both direct and indirect valorization of ecosystem services. The eco-introduction of energy plants and the development of a bio-technical hub for the valorization of biomass and the development of biogas production and distribution systems, at the scale of Romania, different energy willow crops, designed to rebuild natural capital, and without entering the biosphere. Thus, the EU’s transition to a circular economy will find in the proper management of the cultivated soil, in the manufacture of stand, briquette, reading or compression mixture, with real effects on health.
2. Materials and methods

2.1. Soil analysis

In the study, the soil fertility of an ecologically certified greenhouse field area in Romania (zone A) was compared with chernozem with a high input of humus from the Meadow Natural Reserve in Slobozia Mare, Republic of Moldova (zone B). The study was carried out in the laboratories of the Ecological University of Bucharest. 5 samples were collected from area A and 5 samples from the territory of the natural reserve, in the southeast (area B); all samples were extracted from a depth of 20 cm. The content of major macronutrients (N, P, K) and pH were analyzed.

2.1.1. Determination of mineral nitrogen

The NO₃ reduction method was used in the presence of sulfanilic acid and naphthylamine. The pink color, of different intensities, was highlighted by colorimetric analysis.

2.1.2. Determination of inorganic phosphorus

Was used the method of reducing phosphomolybdic acid with SnCl₂, with the appearance of a dark blue color of different intensities.

2.1.3. Determination of potassium

The analysis was based on the reaction with magnesium dipicrylaminate in an acidic medium (HCl), when a red-orange-yellow color appears, which can be analyzed colorimetrically.

2.1.4. Determination of pH

Made by comparing colors. (Fig. 1)

Figure 1. Colorimetric determination of pH
https://agrobiznes.md

2.2. Determination of salicin by analyzing the bark (a vegetable by-product from the processing of eco-energetic willow), extracts, and compressing powders based on Salicys cortex.

2.2.1. Bark analysis

The bark and branches of young and mature white willow trees (Salix alba) were harvested in June (the optimal period of maturity). The samples were manually separated, dried and ground. The working parameters were the following: plant material - brought to an advanced degree of shredding; extraction method - maceration; the extraction solvent – purified water; extraction temperature – room temperature; extract concentration – 10% (g plant/mL water); extraction time – 24 hours.

The following equipment was used for the preparation of the raw material: analytical balance Partner AS 310.R2; Biovita DEH600D plant dryer; laboratory mill Retch GM 200; Retch AS 200 Basic sieve machine.

To prepare the samples to be analyzed, we used the following equipment: ultrasonic bath Elmasonic P180 H; Julabo TW8 water bath; centrifuge Ortoalresa 21 R; rotavapor Buchi R-300 EL, equipped with water bath B-300 Base, vacuum pump V-300 and chiller with recirculation F-308; thermobalance VWR MB 160;
The quality of the bark was analyzed by determination of the content of salicylic derivatives, expressed in salicin, according to the European Pharmacopoeia (EF), current edition, "SALICIS CORTEX" monograph, by liquid chromatography (3 samples, area: Breaza, Furculesti, Gheorghieni).

The NIST spectra library was available for the peaks corresponding to the chromatographically analyzed compounds.

2.2.2. Analysis of extracts

A 1:8 plant:solvent ratio was kept constant during the experiment. Water bath reflux extraction was performed at a temperature of 60°C for 60 minutes. The salicin aqueous extract was determined according to EF, by thin-layer chromatography (TLC).

2.2.3. Analysis of powders

The determination of the content of active principles (salicin) in the dry and pulverized plant material was carried out by quantitative analysis, depending on the subsequent specific solubility of the compounds. To compress mixture and salicin tablets were determined according to EF, by liquid chromatography.

3. Results and discussions

3.1. Soil analysis

The analytical values obtained in the experimental laboratory of the Ecological University of Bucharest were interpreted in accordance with the limits of soil nutrient levels established on the basis of legislation and standards in force, highlighting qualitative similarities between the two types of soil analyzed. The evaluation of the content of main macronutrients was done based on OG MAPPM no. 756/1997 regarding the evaluation of environmental pollution specific to soils with less sensitive use. Law no. 74/2019 regarding the management of potentially contaminated sites and those contaminated and GEO no. 92/2021 regarding the waste regime.

3.2. Determination of salicin

3.2.1. Determination of salicin in the bark

White willow bark is the main source of salicin and other salicylic derivatives – salicortin, 2'-O-acetylsalicortin and tremulacin – compounds similar in structure to aspirin (acetylsalicylic acid), often white willow being referred to as "vegetable aspirin". Salicin, through enzymatic hydrolysis induced by emulsin and diastase, splits into glucose and saligenin, also known as o-oxybenzyl alcohol or saligenol. Saligenin in turn produces, through oxidation, salicylic acid, with notable analgesic, antipyretic and antirheumatic properties, thus achieving a gradual, prolonged effect. Also, the tannins present in the bark.

Figure 2. Graphical comparison of Nitrogen (total N) values in the soil – EUB Lab. Res

It is observed that 4 of the 5 samples (from Romania) analyzed comparatively are similar in terms of percentage nitrogen content (less P2 from Romania), compared to the N levels in the soil samples from the Republic of Moldova).

Figure 3. Graphical comparison of Phosphorus (mobile P) values in the soil – EUB Lab. Res

Among the 5 comparatively analyzed samples, 3 are similar in percentage phosphorus content (less P1 and P3 from Romania), compared to the P levels in the soil samples from the Republic of Moldova).

Figure 4. Graphical comparison of the values of Potassium (mobile K) in the soil – EUB Lab. Res

All 5 samples from Romania showed similar potassium content (P2 and P3 from Romania), or much higher (P1, P4, P5 from Romania), compared to the K levels in the soil samples from the Republic of Moldova).
willow bark have a tonic, astringent, coagulant and slightly hemostatic action (Assessment Report on Salicis Cortex (Willow Bark) and Herbal Preparation (S) thereof with Well Established Use and Traditional Use. Doc.Ref.: EMEA/HMPC/295337/2007, 2009).

Table 1.

<table>
<thead>
<tr>
<th>Cultivation/harvesting area</th>
<th>Content in salicin %</th>
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<tr>
<td>1_Breaza</td>
<td>0.50</td>
</tr>
<tr>
<td>2_Furculesti</td>
<td>1.70</td>
</tr>
<tr>
<td>3_Georgihi</td>
<td>1.26</td>
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</table>

The quality of its back expressed in salicin, for all 3 samples, the only corresponding one being the one from Furculesti, with a salicin content > 1.5%.

3.2.2. Determination of salicin in extracts

In extracts (dry, aqueous) from willow bark, salicin was determined according to E.F., by subtle layer chromatography (TLC). (Fig. 8, 9).

Figure 5. Salicilin determination in Salix cortex – Breaza

Figure 6. Salicilin determination in Salix cortex – Furculesti

Figure 7. Salicilin determination in Salix cortex – Georgihi

Figure 8. Salicilin determination in the dry extract

Figure 9. Salicilin determination in the aqueous extract

The chromatogram obtained with the reference solution shows in the middle third a red-violet spot determined by salicin. In the chromatogram obtained with the test solution, the spot determined by salicin is clear and more intense, and above it, another spot determined by salicortin or 2'-O-acetyl salicortin. Other yellow, blue, or brown spots may appear in both chromatograms.
3.2.3. Determination of salicin in the compressed mixture and in tablets

![Figure 10](chart.png)

Figure 10.

![Figure 11](chart.png)

Figure 11.

<table>
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<tr>
<th>The sample analyzed</th>
<th>Content min. salicin % in the technical specification</th>
<th>Content in salicin % determined</th>
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<tr>
<td>A</td>
<td></td>
<td>1.10</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>1.09</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>0.28</td>
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<tr>
<td>D</td>
<td></td>
<td>1.86</td>
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4. Conclusions

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<td>Energy willow-salix-viminalis-biomass where you want it...</td>
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<td>Shara, 2010</td>
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</table>

References

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