

INFLUENCE OF ENERGY WILLOW CROPS ON SOIL FEATURES IN THE CASE OF A CONTAMINATED LAND

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Abstract. The present paper aims to highlight the influence of energy willow growing on a land contaminated with heavy metals on the features of the soil and its minerals. For this purpose, soil profiles from the crop planting year and after two years were realised. The samples were taken from different depths and they were subjected to some investigations by using specific pedologic equipment. A series of parameters such as the soil reaction, the humus content, the ratio carbon/nitrogen (C/N), the content of sodium, nitrogen, phosphorus and potassium were determined. As a result of data interpretation, a considerable decrease of the sodium content for the first 10 cm (which is close to the higher admissible limit) and an increase of the content of nitrogen, phosphorus and potassium were noticed.

Keywords: willow, soil features, contaminated land.

AIMS AND BACKGROUND

The wooden biomass used for energy production can be provided by various sources, such as forests, residues, products from wood industry and other crops. Out of them, the short rotation willows (SRC) present the potential of a good income for the farmers¹ while they can act also as vectors for the short term carbon storage².

These cultures may be started to meet some needs, such as: the production of biomass for energy purpose^{3–10} and the improvement of some factors related to the environment pollution¹¹, as well as the recycling of residual water^{12,13} that may positively affect the growing of willow¹⁴, absorption of heavy metals¹⁵, and other common applications to obtain food from mixed cultures, inclusively¹⁶.

In Romania, the introduction of short rotation willows for energy purpose is relatively recent but significant progress was noticed as regard to its expansion in the central part of the country. Thus, from 2007 and further on between 2008 and 2010, in Romanian counties such as Covasna, Harghita, Mures, a series of pilot cultures of willows, having the reproduction resources resulted from Nordic

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countries, have started. The aim was to test such culture on its potential to give raw material for energy applications.

The aim of the present paper is to investigate the changes in the polluted soils cultivated with short rotation willows and to see how such cultures may fulfil their role as bio-repairing factors for the degraded soils.

EXPERIMENTAL

Place of research. To evaluate the impact of energy willow upon the soil characteristics, the Tarnaveni area was selected (positioned at 24.256 E and 46.324 N).

The planting was performed in March 2014, with two clones of energy willow (INGER and TORDIS), on a soil contaminated with heavy metals, located near the former chemical factory in Tarnaveni, with a surface of about 2.0 ha, in the neighbourhood of a company in Santana de Mures (Fig. 1).



Fig. 1. Location of plantation near the former chemical factory in Tarnaveni¹⁷ (Mures County – www.google.ro/maps/place)

The soil contamination was caused by the tailing pond of the industrial water that resulted from the production process of the former chemical factory, located near the area cultivated with energy willow, nowadays being partially clogged. The residue layer from the pond has a significant thickness (about few meters). Moreover, the demarcation limit between the plantation area and pond is represented by the pond perimetral area, visible in Fig. 1.

The storage area of residual substances, such as the sodium bicromate and carbide, with potential for soil contamination, groundwater and vegetation in the area, represents another source of contamination.

Research methodology. To evaluate the influence of the energy willow from a contaminated soil upon the soil properties, soil samples were taken during the last decade of March, in 2014, when the culture started and after two years, in 2016, respectively. The samples were taken by using the classical method, namely from three soil profiles (Fig. 2), positioned in 1 m² square, from different depths. These have been mixed and homogenised for each one of the depth level, achieving an average. Amounts of about 1 kg were taken and they were packed in plastic bags and then labelled (Fig. 3).



Fig. 2. Soil profiles used for the samples



Fig. 3. Packing and labelling of the samples

In 2016, once the soil samples were taken, three roots (Fig. 4) were taken in full from the two clones INGER and TORDIS, with a view to verify the hypothesis

that these do not present an invasive character and the culture could be cleared at any time. The roots belonging to the pivotal-trailing type were extracted easily and they had no extended ramifications, as can be seen in Fig. 4.



Fig. 4. Taking the roots of Inger and Tordis clones (Scriba et al., 2008)

The soil samples have been analysed at the Laboratory of Pedology of the Faculty of Forestry and Forest Exploitation, from Transilvania University of Brasov. In order to determine the nitrogen content from a soil sample, and the ammonium nitrogen, nitrites, nitrates and organic nitrogen, the Kjeldahl method was used (ISO 11262)¹⁸ with the Kjeldahl specific device, respectively (Fig. 5). An indirect titrimetric method, such as the Schollenberger-Jackson method, was approached to determine the content of organic carbon from the soil. That method is based on the oxidation process of organic carbon at high temperature, by using the chromic acid (as oxidant) and the sulphuric acid^{19,20}.



Fig. 5. The Kjeldahl device

The photocolorimeter (Fig. 6) was used to determine the content of phosphorus from the soil samples while the spectrometer with atomic absorption (Fig. 7) was employed to determine the sodium and potassium.



Fig. 6. Cecil photocolorimeter



Fig. 7. Spectrometer with atomic absorption

RESULTS AND DISCUSSION

Pedologic analysis of soil samples taken in 2014. The pedological analysis of the soil samples taken in 2014 from the contaminated soil indicated a soil reaction that varies from low alkaline level for the first 30 cm in depth, to a high alkaline level, for the next 40 cm in depth. The mull humus content is reduced for the first 20 cm (2.76%) while the carbon/nitrogen ratio is of about 11.34.

As regard to other elements, the samples presented a low nitrogen content, while the assimilable phosphorus reached a middle level, and the one of potassium presented a reduced ratio. The sodium content increases with the soil depth, starting from the surface level (Table 1), from 188.5 ppm (0–20 cm) to 543.7 ppm (60–70 cm). Such values are much higher than the maximum limit of 22.5 ppm mentioned in the specialty literature^{1,20}.

Pedologic analysis of soil samples taken in 2016. The soil samples taken after two years from the same culture of energy willow present a low alkaline reaction for the first 30 cm in depth and a moderate one for the next 50 cm. The soil presents a low content of mull humus, having the C/N ratio of about 13.06 (Table 1).

It is moderately supplied with nitrogen, very well-supplied with assimilable phosphorus and presents a reduced content of assimilable potassium.

Table 1. Laboratory results of the samples taken in 2014 and 2016

Character- istics	Samples taken in 2014				Samples taken in 2016				
	depth of sampling (cm)				depth of sampling (cm)				
	0–10	20–30	40–50	60–70	0–10	20–30	30–40	45–55	65–75
pH	8.10	8.16	9.27	9.37	8.30	8.38	8.45	8.50	8.64
Humus	2.76				3.60				
Carbon	1.60				2.09				
N (%)	0.14				0.16				
C/N	11.43				13.06				
P (ppm)	25.00				80.00				
K (ppm)	76.33				107.16				
Na (ppm)	188.50	157.70	479.60	543.70	35.21				

An increase of the content in nitrogen, phosphorus and potassium was noticed when compared with the samples taken in 2014 (Table 1). An additional amount of chemicals given by the plantation owner was also possible. A consistent decrease in the sodium content for the first 10 cm in depth was noticed. It was reduced from 188.5 ppm (in 2014) to 35.21 ppm (in 2016) close to the maximum admissible limit²⁰.

Furthermore, it was noticed that in 2016 the humus content increased for the 10 cm of the soil profile, aspect justified by the content of organic substance resulted from the litter decomposition, knowing that the willow litter decomposes in 1–2 years.

The C/N ratio increased as a result of the incomplete litter decomposition. On the other hand, it was noticed an increase of the phosphorus content due to the additional amount of organic substance in soil. Such aspect is also highlighted by the fact that the soil with willow plantation of rotation type had had no culture for many years.

Other differences that appeared between the soil characteristics determined for the samples taken in 2014 and 2016 (pH increased for the first two horizons, etc.) may be due both to the error of sampling and the horizons modification by processing (they were processed during autumn before the planting).

A high value of sodium (188.5 ppm), which characterises an alkalinisation process not particularly specific to the soil type (faeoziom) and which highlights some infiltrations from the pond in the vicinity, was determined. Its massive de-

crease to 35.12 ppm in two years, most possibly absorbed into the culture biomass, was noticed.

CONCLUSIONS

– The short rotation willow crops have a significant importance in the carbon storage, but also in energy production, being a consistent source of wooden biomass.

– In both collected samples (from 2014 and 2016), the reaction of soil was low alkaline for the first 30 cm of the profile, but the soil presented an increased humus content for the first 10 cm of the soil profile, after 2 years of culture.

– Comparing the collected samples, it can be observed that those taken in 2014 indicated a soil with poor pedological characteristics while after two years of culture the features of soil were improved, the culture playing a significant role in this respect.

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