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Letter do Editors

Some Effects of *Sida hermaphrodita* R. Cultivation on Sewage Sludge

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Abstract

In the years 1996-1998 in the sewage treatment plant in Hajdów an experiment was set up in order to determine the optimal number of plants and the method of proliferation of *Sida hermaphrodita* R. on sewage sludge. The cultivation of *Sida* was carried out on especially prepared plots with an added 50 cm thick layer of sewage sludge. Two methods of plantation establishing (propagation) were used - generative and vegetative. Three plant densities were used per 1 ha: 3 kg of seeds or 33,000 seedlings; 6 kg of seeds or 50,000 seedlings; and 9 kg of seeds or 100,000 seedlings. A higher yield of stems and greater amounts of Fe extracted from the sludge were obtained from vegetative plant propagation. In the conditions of greater number of plants, considering stem yield, *Sida* took from the sludge more Co, Fe, and Ni. The three-year cultivation of *Sida hermaphrodita* caused positive changes in the structure of the sewage sludge.

Keywords: sewage sludge, *Sida hermaphrodita R.*, propagation method, stem yield, heavy metals.

Introduction

Some negative results of the civilisation and urbanisation is the increasing amount of wastes in the form of sewage. Despite progress in the methods and techniques of sewage sludge treatment, there still is an open issue of their safe utilisation [6]. In Western Europe, an average of 38% of total sludge production is used by agriculture [4, 5, 9]. Such use of part of the sludge in our conditions also seems to be rational [11]. However, they have to fulfil the admissible norms concerning the content of various hazardous substances, including heavy metals [1-3, 6]. A decrease in the concentration of some of the metals may be achieved by cultivating plants which are capable of uptaking those elements, and which are later used for non-nutritional purposes, for example as heating fuel. According to Siuta [13], the conditions on the sludge substrates are suitable for intensive growth of many plant species which, by taking up great amounts of water and nutrients, transform the slimy sludge ground into compost. Such "first stage treatment" plant species are willow, Australian sedge, and other macrophyte plants [8, 12]. *Sida hermaphrodita* could also be included in this group because it tolerates excessive amounts of various elements and water in the substrate [15]. According to the comparative studies on the possibilities of cultivation of such species as *Salix viminalis* L., *Helianthus tuberosus* L., and *Sida hermaphrodita* R. on sludge, the latter can be indicated as the one that yields the best and extracts the most of Zn, Pb, Fe, Cr, Cu, and Ni from the substrate [16]. The positive result of that research indicate the necessity to determine the optimal parameters concerning establishing the cultivation of *Sida* for rehabilitation purposes. The basic parameters that should be considered are the number of plants

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and method of planting derived from the propagation method: generative or vegetative. *Sida hermaphrodita* R. can be propagated using both methods. Easier and less work-consuming is sowing the seeds into the substrate. However, the plants that come from the vegetative method in the first year of vegetation are stronger and more tolerant of the diffcult conditions [14].

This paper presents the results of research concerning the impact of *Sida hermaphrodita* R. cultivation on the sewage sludge depending on the number of plants and the propagation method.

Material and Methods

In 1996-1998 in the sewage treatment plant in Hajdów, an experiment on *Sida hermaphrodita* R. cultivation on sewage sludge was carried out. The substrate for the plants was an overlaid 50 cm thick layer of sludge. The experiment was set up using the randomised block method, in four repetitions. The experiment comprised two factors:

1st - plantation establishment (propagation) method: a - generative, b - vegetative;

2nd - plant density per 1 ha: I - 3 kg of sprouting seeds or 33,000 root seedlings, II - 6 kg of seeds or 50,000 seedlings, III - 9 kg of seeds or 100,000 seedlings.

The seeds of a mass of 1,000 - 3.2 g originated from the 1995 harvest, while the root seedlings (8-10 cm long pieces with growth gems) were prepared directly prior to planting.

Before the establishment of the experiment, the content of some elements in the sludge was analysed (mg/kg of dry mass): Co - 57-924, Cd - 120-131, Pb - 116-299, Fe - 1452-17000, Ni - 109-129 (total content of studied elements was determined after wet digestion in spectrally pure acids: HF, HNO_3 and $HClO_4$ in volume ratio 4:3:1).

In 1996 field sprouting ability was determined and the number of shoots was calculated each year. After harvest, the yield of dry mass of stems was evaluated. The contents of Co, Cd, Pb, Fe and Ni in stems were analysed. This allow us to calculate the amounts of elements extracted from the sludge by the growing plants.

The content of elements was analysed using absorption atomic spectrometry (AAS).

Prior to the set-up of the experiment and after its completion the granulometric composition of the sewage sludge was determined.

Discussion of Results

The results indicated that fresh sewage sludge does not provide good conditions for plant sprouting (Table 1). It is proved by only a 10% field sprouting ability of the seeds, which in the grey-brown podzolic soil is 3 times as high [15]. The root seedlings managed much better in the sludge. Over half of them (52.6%) entered the sprouting phase. The result of the fact that only a half of the seedlings developed root systems, was a very small number of shoots during harvest in the first year. In successive years no differences were found between vegetative and generative propagation. This resulted from more massive shoots being developed by stronger plants derived from root seedlings [7].

Despite the much lower number of shoots in the first year (1996) in the vegetative propagation as compared to the generative one, no differences were found in the yield of stem dry mass (Table 2). The shoots which grew from the root seedlings (especially in the first year) were much thicker and better branched than those that grew from seeds [7]. In successive years of the study both methods of propagation provided the same amount of shoots, while

Table 1. Field sprouting ability (%) and number of *Sida hermaphrodita* R. shoots per 1 m^2 during harvest depending on propagation method, plants density and number of years.

Factors	Field sprouting ability	Number of shoots			Average
		1996	1997	1998	value of 3 years
Propagation method					
a	10.39	18.9	32.5	21.4	24.3
b	52.62	3.9	31.2	21.7	18.9
$LSD_{(0.05)}$	9.98	2.6	n.s.	n.s.	1.0
Plants density					
I		6.4	33.4	21.7	20.5
II	32.09	11.7	30.7	21.3	21.2
III	28.69	16.3	31.5	21.5	23.1
$LSD_{(0.05)}$	n.s.	4.3	n.s.	n.s.	n.s.
Mean value	31.50	11.4	31.8	21.5	21.6
$LSD_{(0.05)}$ for years					1.5

a - generative, b - vegetative, I - 3 kg of seeds or 33,000 seedlings, II - 6 kg of seeds or 50,000 seedlings, III - 9 kg of seeds or 100,000 seedlings per 1 ha, n.s. - no significant.

the yield was a little higher in the vegetative propagation. In 1997, this difference was significant. It turns out that it is better to plant root seedlings than to sow seeds, which is proved by the mean values of stems dry mass yield over 3 years.

The differentiated density of plants in an area unit did not cause any significant changes in stem yield. This can be due to the ability of the plants to develop more stems when the number of plants is lower.

Previous research [10] proved the great ability of *Sita hermaphrodita* R. to take up many elements and to cumulate them in stems. During the 3 years of the experiment, similar amounts of Co, Cd, Pb, and Ni were taken up from the sludge, regardless of the propagation method, while significantly higher amounts of Fe were taken up by the *Sida* of the vegetative propagation (Table 3).

The greatest density of plants (III) caused a significant increase in the amount of cobalt and iron taken up from the sludge. The smallest amount of nickel was taken up by the stems of plants growing in medium density (II).

Considering the energetic purposes, the height of the crop of *Sida* stems is also important. Other studies indicated good combustion heat efficiency of this material, expressed in kJ/kg. This efficiency reached 88.0% of pine wood efficiency and 80.1% of beech wood [14].

Table 2.Yields of stems dry mass (t/ha) of *Sida hermaphrodita* R. depending on propagation method, plants density and number of years.

Factors	1996	1997	1998	Average value of 3 years
Propagation method				
a	3.62	9.36	7.80	6.94
b	4.10	11.02	8.17	7.66
$LSD_{(0.05)}$	n.s.	0.83	n.s.	0.24
Plants density				
I	3.50	10.60	8.52	7.54
II	3.53	10.23	7.50	7.09
III	4.10	9.78	7.93	7.27
$LSD_{(0.05)}$	n.s.	n.s.	n.s.	n.s.
Mean value	3.71	10.20	7.99	7.30
$LSD_{(0.05)}$ for years				0.36

a - generative, b - vegetative, I - 3 kg of seeds or 33,000 seedlings, II - 6 kg of seeds or 50,000 seedlings, III - 9 kg of seeds or 100,000 seedlings per 1 ha, n.s. - no significant.

Table 3. Amounts (g/ha) of some elements taken up from the sewage sludge with the 3-year yield of *Sida hermaphrodita* R. stems depending on propagation method.

Factors	Co	Cd	Pb	Fe	Ni
Propagation method					
a	17.91	100.31	94.83	1881.3	71.09
b	17.31	92.36	100.38	2822.2	67.35
$LSD_{(0.05)}$	n.s.	n.s.	n.s.	174.4	n.s.
Plants density					
I	16.46	101.68	100.98	2059.5	70.13
II	17.63	86.25	91.94	2075.3	62.46
III	18.73	101.08	99.90	2920.6	75.08
$LSD_{(0.05)}$	1.84	n.s.	n.s.	366.5	7.08
Mean value	17.61	96.33	97.61	2351.8	69.22

a - generative, b - vegetative, I - 3 kg of seeds or 33,000 seedlings, II - 6 kg of seeds or 50,000 seedlings, III - 9 kg of seeds or 100,000 seedlings per 1 ha, n.s. - no significant.

Table 4. Granulometric composition of sewage sludge before the experiment (1996) and after its completion (1999) depending on propagation method.

Fraction content in %			
Factors	1 - 01 mm	0.1 - 0.02 mm	< 0.02 mm
Before experiment	0	0	0
After experiment			
a	81 - 87	6 - 10	7 - 11
b	75 - 83	8 - 16	6 - 9

a - generative, b - vegetative propagation method

Apart from cleaning the substrate of the excess elements, the cultivation of *Sida hermaphrodita* had a positive effect on the granulometric composition of the sludge (Table 4). Before the experiment, the sludge was an amorphous muddy mass, in which no structures typical of soil were stated. After 3 years of cultivation of *Sida*, aggregates of various size started to appear in the sludge. The fraction of 1-0.1 mm prevailed in the substrate (75-83% in the vegetative propagation and 81-87% in the generative one).

The up-to-date research indicate that the cultivation of *Sida hermaphrodita* on sewage sludge makes it possible not only to improve the physicochemical properties of this waste material, but can also be a source of renewable energy.

Conclusions

1. In treatments with sewage sludge the higher stem crop of *Sida hermaphrodita* R. was obtained from vegetative propagation.
2. The number of plants per unit area did not have an impact on stem crop.
3. More Fe was taken up from the sludge by plants grown from vegetative propagation.
4. At higher density of plants, *Sida hermaphrodita* took up more Co, Fe, and Ni into the stems.
5. After three years of *Sida hermaphrodita* R. cultivation on the sewage sludge, positive changes in the structure of the sludge were stated.

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