

Letter to Editor

Suitability of Cultivation of Some Perennial Plant Species on Sewage Sludge

H. Borkowska*, I. Jackowska**, J. Piotrowski**, B. Styk*

*Department of Field Crop Production, University of Agriculture, ul. Akademicka 15, 20-950 Lublin, Poland

** Department of Chemistry, University of Agriculture, Lublin, Poland

Received: 16 January, 2001

Accepted: 3 April, 2001

Abstract

In the years 1995-1998 an experiment with planting some perennial plant species on the sewage sludge purifying plant in Lublin was carried out. Since *Ligustrum vulgare* L. did not root, the studies were carried out on three species: *Helianthus tuberosus* L., *Salix viminalis* L. and *Sida hermaphrodita* R. During four years the number of *Salix* plants decreased, *Helianthus* plants showed the symptoms of damage and the *Sida* plants were a little weaker than in the field cultivation. The highest average stalk yields during the 4-year period were noted for *Sida* (6.85 t/ha of dry mass) and lowest for *Salix* (2.28 t/ha). Among the three species compared, *Sida* took up the highest amount of Cu, Ni, Zn, Pb, Co, Fe and Cr in stalks. The 4-year experimental results unambiguously point to *Sida hermaphrodita* as a useful species to grow on sewage sludge.

Keywords: sewage sludge, *Sida hermaphrodita*, *Helianthus tuberosus*, *Salix viminalis*, heavy metals.

Introduction

Large city agglomerations produce all sorts of waste that are, to some extent, harmful to the natural environment in form of liquid or sewage sludge.

In Western Europe, the most widely spread method for utilizing of such deposits is agricultural use [4, 5, 6, 7]. In Poland, this method of utilization is not commonly used. The reason is the sanitary contamination and high content of heavy metals and other toxic substances that are present in the amounts exceeding the relevant standards [2, 9]. Decrease of the toxicity will probably allow for their more extensive agricultural utilization also in Poland. One of the possible methods to realise this goal, can be a culture of plants for industrial usage. The selected plant species should be able to produce high yields of mass in conditions of a deposit substrate, and take out substantial amount of harmful components from the deposit.

Based on the above assumption, we started the experiment with culture of a few perennial plant species on the sewage sludge of the sewage treatment plant in Hajdow. The research was carried out in co-operation with the Town Enterprise for Water Supply and Sewage in Lublin.

Experimental Procedure

The experiment on growing four perennial plant species on sewage sludge was carried out in 1995-1998. The plant species used for the experiment were: *Helianthus tuberosus* L., *Salix viminalis* L., *Sida hermaphrodita* L. and *Ligustrum vulgare* L. (the last one did not root and was eliminated as an experimental object).

The final experiment comprised three plant species planted in four replications on plots 8.4 m². Plants were planted in row spacing 50 cm and 25 cm distance in rows. The experimental area was prepared by removing the surface layer of soil and putting on 60 cm layer of sewage sludge containing about 70% of moisture.

Table 1. Content of heavy metals (mg in kg of dry mass) of sludge before the experiment (1995) and after (1998).

Year	Cu	Ni	Zn	Cd	Pb	Co	Mn	Fe	Cr
1995	247-333	145-154	4147-5208	142-155	270-300	89-103	432-615	16800-17700	379-390
1998	100-264	96-103	2163-2648	96-128	101-196	23-79	215-347	10008-10985	220-310

Stalk harvest was performed every year after the substrate had been frozen.

The content of heavy metals (Cu, Ni, Zn, Cd, Pb, Co, Mn, Fe, Cr) was determined in the sludge before the experiment, and after it had finished (Table 1), as well as in the plant material every year, after the harvest. The method of determination used was atomic spectrometry absorption assay (ASA).

The results concerning yields were statistically worked out using Tukey's test.

Discussion of Results

Out of four plant species, three (*Helianthus*, *Salix*, and *Sida*) were studied to the end, as the *Ligustrum* cuttings that normally root very easily did not generate any roots on the sewage sludge. In the first experimental year, weak development of *Salix* plants (they were coloured pale green) were observed on white deviations in the development of *Helianthus* and *Sida*.

From 1996, some anomalies in plant development were observed, especially on plots with *Salix*, where plants were infected with fungi. As a result, in the last experimental year, only a few plants of this species survived. In the middle of summer, 25-30% the *Helianthus* plants started to wither too. The remaining plants of this species developed as normal, but they bloomed only sporadically at the end of vegetation. The *Sida* plants grew lower in height but more numerous sprouts with smaller leaves than in the optimum conditions for their development (mineral soils).

In conditions close to the optimum, the perennial plant species give high yield usually in the second year or in the following years of their utilization, depending on their longevity. In the first year they usually give low yields. The substrate of sewage sludge contains not only high amounts of nutrients [8, 10], but also other compo-

nents or elements that can disturb correct development in some of the species [3, 13]. *Salix viminalis* is an example of this. Low yield in the first year of the experiment (Table 2) can be assumed as normal. However, in the following years, the yield should be far higher. Contrary to expectations, the stalk yield did not even reach the level of 4 t, and in the last year of the experiment it decreased to less than 1 t/ha. In optimum conditions the *Salix viminalis* yields reach 15 t/ha [1]. Such a low level of yields in our experiment proves that the species is not tolerant of the specific conditions of the sewage sludge used in the experiment. The *Helianthus tuberosus* yields were significantly higher. This species behaves as a perennial plant as its tubers survive winter in the ground. In this case, a two-year adaptation period could be pointed to. During this period yields of stalks were low (3.66 and 2.57 t/ha). In the third year, despite of early withering of numerous plants, almost 8 t/ha of dry stalk mass was collected. In the last experimental year however, the yield decreased below 5 t/ha. Out of the three studied species, *Sida hermaphrodita* gave a yield of over 9 t/ha of dry stalk mass after two years of low yielding (4.85 and 3.93 t/ha). Note that on mineral soil yields of dry mass of *Sida hermaphrodita* stalks reach 12 t/ha [11]. The markedly lower yield of this species on municipal sewage sludge probably was the result of the harmful effects of excessive amounts of some heavy metals. According to results obtained by Jasiewicz [12] Cd content amounting to 80 mg/kg dry mass of soil negatively influenced the yield of *Sida hermaphrodita*. In our experiment the content of this element in sewage deposits exceeded that level (Tab. 1). Statistical analysis shows that there are no significant differences in the yields of the species in the first two years (1995-1996), while *Salix viminalis* gave significantly lowest yields in the last two years (1997-1998). On average, the highest yields during the four year period were obtained from *Sida hermaphrodita*. Due to the yield level, the year 1997 appeared to be most favourable; i.e. penultimate in the study period.

Table 2. Average stalk dry mass yields of *Sida hermaphrodita*, *Salix viminalis*, and *Helianthus tuberosus* (t/ha).

Species	1995	1996	1997	1998	Average value of 4 yrs
<i>Sida hermaphrodita</i>	4.85	3.93	9.28	9.35	6.85
<i>Salix viminalis</i>	2.64	2.98	2.53	0.97	2.28
<i>Helianthus tuberosus</i>	3.66	2.58	7.95	4.82	4.75
Average values	3.72	3.16	6.57	5.05	4.63
NIR _(0.05) for:					
- species	n.s.	n.s.	2.58	2.30	0.69
- year					0.90
- interaction species x yr					2.16

n.s. - no significant

Table 3. Amount of some heavy metals (g/ha) taken out from the sewage sludge in the stalk yield of the studied species.

Year	Cu	Ni	Zn	Cd	Pb	Co	Mn	Fe	Cr
<i>Sida hermaphrodita</i>									
1995	19.74	18.77	698.93	27.50	30.85	10.96	222.61	652.37	5.43
1996	16.75	14.67	105.45	7.27	16.08	5.77	58.99	158.82	0.40
1997	40.18	42.04	233.76	27.10	46.12	14.94	157.94	421.03	10.67
1998	35.90	53.29	510.51	41.14	15.52	11.33	187.94	490.88	8.13
TOTAL	122.57	128.77	1548.65	103.01	108.57	43.00	627.48	1723.10	24.63
<i>Salix viminalis</i>									
1955	26.53	12.06	597.77	18.51	10.53	3.17	320.44	149.87	2.40
1996	15.61	4.45	86.77	39.35	5.44	4.61	99.22	140.54	2.00
1997	21.76	6.55	75.17	29.47	11.36	3.54	93.74	102.64	3.16
1998	4.33	2.39	27.64	5.69	1.09	0.93	42.10	63.63	0.84
TOTAL	68.23	25.54	787.35	93.02	28.42	12.25	555.50	456.68	8.40
<i>Helianthus tuberosus</i>									
1995	14.79	13.58	531.29	8.42	13.94	8.42	268.50	235.19	3.18
1996	15.93	6.12	69.27	10.93	3.78	3.22	155.34	109.56	2.09
1997	52.07	40.70	238.18	45.31	28.46	12.32	655.64	473.02	8.27
1998	31.43	51.09	31.43	40.25	9.16	27.91	382.23	265.10	5.69
TOTAL	114.22	111.49	870.17	104.91	55.34	51.87	1461.71	1082.87	19.23

The ability of a given species to give high yield in difficult growing conditions (after-sewage deposit) and the uptake of harmful substances by this species is a chance to take a substantial amount of these substances out of the substrate. Table 3 presents the amount of 9 heavy metals taken out with the stalk yield. During the four year breeding period on sewage sludge, the highest amount of heavy metals was taken out of the substrate by *Sida hermaphrodita*. In the case of lead, these amounts are several times higher than in the case of the remaining species. Only the amount of manganese in the *H. tuberosus* yield were more than twice higher, and the amount of Co and Cd only slightly exceeded the amount of these elements in the *S. hermaphrodita* yield. Low yield of *Salix viminalis* result in lower amounts of metals taken out from the deposit. In the case of Ni, Pb, Co, Fe, and Cr, these amounts are many times lower.

Conclusions

1. The *Salix viminalis* plants are characterised by low survival rate in the cultivation of sewage sludge that results in extinction of a plantation.

2. *Helianthus tuberosus* with mean level of stalk dry mass yield is especially usable in releasing excess of manganese from the sewage sludge.

3. The highest yield of dry mass was obtained from *Sida hermaphrodita* grown on sewage sludge. It took the

highest amounts of Pb, Zn, Fe, Cr, Cu, and Ni from sewage sludge.

4. The obtained results prove that *Sida hermaphrodita* is a valuable species to grow on sewage sludges in order to derive substantial amounts of heavy metals.

References

1. BUKIEWICZ H., ZWOLINSKI S., Uprawa i eksploatacja wikliny, Warszawa **1979**.
2. BRIX H. Wat. Sci. Tech., **19**, 107 **1987**.
3. HALL J. E. Pergamon Press, Oxford - New York, **1991**.
4. LINDER K. H. Humboldt Verl. AG Koln, **1992**.
5. Federal register Part 503 Standards for the Use or Disposal of Sewage Sludge, EPA, 19.02.1993.
6. HERMAN J., Ekologia i technika, **1**, 22, **1993**.
7. WASIAK G., Ekoinżynieria, **3**, 8, **1995**.
8. MAZUR T., Zesz. Probl. Post. Nauk Roln., **437**, 13, **1996**.
9. SIUTA J., Zesz. Probl. Post. Nauk. Roln., **437**, 23, **1996**.
10. SIUTA J. Krajowa Konf. Nauk.-Techn., Wykorzystanie osadów ściekowych - techniczne i prawne uwarunkowania, Czestochowa, 209-218, **1996**.
11. BORKOWSKA H., STYK B. Slazowiec pensylwanski (*Sida hermaphrodita* R.) Uprawa i wykorzystanie, WAR Lublin, **1997**.
12. JASIEWICZ CZ., ANTONKIEWICZ J. Chemia i Inzyn. Ekol., **6**, 419, **1999**.
13. BORKOWSKA H., JACKOWSKA I., PIOTROWSKI J., STYK B, Annales UMCS, s. E, **7**, 59, **2000**.