Polish J. of Environ. Stud. Vol. 17, No. 6 (2008), 975-980

Letter to Editor

The Effect of Sludge on Initial Growth and Development of Lawn Grasses in Background of Different Mix Types and Sowing Times

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Received: 25 February, 2008
Accepted: 23 September, 2008

Abstract

This paper presents the results of research concerning the initial growth and the development of selected species (varieties) of law grasses sown on extensive lawns. The research studied the effects of various doses of sludge (0, 70, 140, 210, 280 t/ha), lawn grass mixes (fescue and tussock-grass) times of sludge application and times of sowing seeds on the development of lawn grasses in the Department of Grasslands, University of Warmia and Mazury in Olsztyn. The following features were assessed in the sowing year: beginning and peak of emergence, plant tilling and the general aspect of the grass at the end of a vegetative season, using the 9º scale. A significant impact of domestic sewage sludge on plant tilling and the general appearance of the grass was observed. As regards the mixes under examination, the fescue mix developed more favourable qualities, such as plant emergence and peak of emergence, than the tussock-grass mix. The plant tilling and general aspect of both lawn grass mixes sown was similar. Plant emergence (beginning and peak), plant tilling and the general aspect of the grasses was better under the combination of springtime sludge application and summer sowing.

Keywords: sludge, lawn grass mixes, useful values

Introduction

The final accumulation of sewage sludge is an important problem in municipalities. Application of sewage sludge to agricultural land is a convenient method for disposal of a waste product [1, 2]. Sewage sludge is a source of organic matter and nutrients such as nitrogen, phosphorus, magnesium, calcium and other microelements. Biosolids may improve soil organic matter, soil physical and chemical properties (increased soil aggregate formation, aggregate stability, sorption capacity, increase of pH) and microbiological activity [3-5]. But there is a risk and disadvantage of using sewage sludge because of a too high content of heavy metal [6, 7]. Sewage sludge application to the soil involves a danger of soil environmental pollution with toxic substances but also supplies considerable amounts of organic matter, which may balance the negative effect of these substances [8].

Lawns fulfill multiple functions in the urban environment. They have become an inherent element of the natural environment due to their recreational, aesthetic, health and detoxification values [9, 10]. Turfgrasses are best established during certain periods of the year, especially in spring and summer, when temperature, moisture and daylength are most favourable [11, 12]. Lawns established during autumn may be failed because of the lack of nutrients which are necessary for development of young plovers and ground frosts. Proper fertilization improves turfgrass density, color and recuperative potential. Organic fertilizer used in spring or summer protects soil and sod before drying and creates a better condition for tilling [12]. Often it eliminates the need for additional mineral fertilizing [13, 14].

Table 1. Heavy metals content in soil and sewage sludge.

	Zn	Cu	Pb	Ni	Cr	Cd	Hg
The content of heavy metals in soil (mg/kg)	131.20	11.80	7.40	3.00	9.70	0.23	0.06
The content of heavy metals in sewage sludge (mg/kg)	1340	251	52.60	44.50	47.70	3.60	10

The slow release of fertilizer elements, especially nitrogen, results in grass growth and reduces the possibility of leaching loss caused by heavy rain. The level of doses of sewage sludge must be controlled to avoid harmful effects on soil, vegetation, animals and humans. The establishment of grass surfaces on substrates fertilized with sludge will contribute to improve the sludge management system. This method will partially solve the problem with layers of sludge filling the area of sewage treatment plants, since the content of macro and microelements will be returned to the soil and grasses will contribute to covering the area and the improvement of its aesthetic qualities.

The aim of the present research was to determine the impact of varied doses of sludge, types of grass mixes, times of applying sludge and times of sowing seeds on the initial growth and the development of selected species (varieties) of lawn grasses under the conditions of the Olsztyn Lake District.

Materials and Methods

An exact, four-factorial micro-plot experiment (1m x 1m) was established in the "split-split-block" design, in four replications, on anthropogenic soil formed of light loamy sand, in the area of the Educational and Research Station at the University of Warmia and Mazury in Olsztyn.

The four treatment factors were: varied doses of sludge (0, 70, 140, 210, 280 t/ha), lawn grass mixes (fescue and Kentucky bluegrass) developed in the Department of Grassland of UWM in Olsztyn (Table 2), times of sludge application (autumn 29.11.2004, spring 28.04 and summer 30.07.2005) and the times of sowing lawn grass mixes (spring 23 and 24.04, summer 30.07. and autumn 09.09.2005) were examined. The soil for the experiment was fertilized with sludge originating from the "Łyna" Municipal Sewage Treatment Plant in Olsztyn, by mixing it with soil at a depth of 10 cm. After sowing the seeds, the plots were raked and covered with a thin (0.2 cm) layer of dry sand (0.5-0.6 mm).

The soil before fertilization was characterized by a very high content of assimilable phosphorus (determined by the Egner-Riehm method) - 16.28 g/kg d.m., and magnesium - 7.8 g/kg d.m.), an average content of potassium - 9.13 g/kg d.m. and calcium - 0.71 g/kg d.m. and a low content of sodium - 0.01 g/kg d.m. Total nitrogen content was at the level of 2.59% d.m., and organic matter was at 8.25%. Soil pH_{KCL} was 7.30.

Dry matter content in sludge was 27.61%, and the content of organic substances was 32.16%, at pH_{KCL} 8.49.

Table 2. Composition of lawn grass mixes.

Species	Variety	Seed percentage in mixes	
		A	B
Festuca rubra L., ssp. commutata Gaud.	DOROSA	10	-
Festuca rubra L., ssp. trichophylla Gaud.	NAPOLI	25	10
Festuca rubra L., ssp. rubra Hack.	BARMA	10	10
	GROSS	10	5
Poa pratensis L.	BILA	15	15
	NANDU	10	20
	ALICJA	-	20
Festuca ovina L., sensu lato	SIMA	10	10
Agrostis capillaris Huds.	NIWA	2	2
Lolium perenne L.	NIRA	8	8

A - fescue mix
B – Kentucky bluegrass mix

The amount of nitrogen in sludge was higher than in organic fertilizers, and it amounted to 33.3 g/kg d.m. The content of other macro-components was the following: total P (determined by molybdenum-vanadium method) – 1.44, K – 0.12, Na – 0.16, Ca – 2.79 and Mg – 0.50% d.m.

The content of heavy metal in soil and in sewage sludge did not exceed accepted norms specified in the *Regulation of the Ministry of Environmental Protection* of 1 August 2002 (Dz. U. 02.134.1140) (Table 1).

Turf quality is measured by the most common visual rating system with 9 (the best) and 1 (the poorest). In the year of sowing (2005), the following features were assessed:

- plant emergence (beginning after 10 days and peak after 30 days of the sowing day);
- plant tillering (after 10 weeks of sowing day) in 9º scale (1– an undesirable feature, 5 – an intermediary feature and 9 – the most favourable feature);
- general aspect, i.e. the appearance of the grass at the end of a vegetative season, in 9º scale.

The sward was cut when grasses were 12 cm high. During the vegetation period of the year mixes sown in spring were cut six times at a height of 6-7 cm, whereas mixes sown in summer and autumn were cut approximately

Table 3. Plant emergence (pcs/100 cm²).

Time of using sludge application (factor III)	Time of sowing seeds (factor IV)	Type of mix (factor II)	Sludge dose (t/ha) (factor I)					$\bar{x}$ for type of mix	$\bar{x}$ for time of using sludge application	$\bar{x}$ time of sowing seeds
			0	70	140	210	280			
autumn	autumn	a	31.08	33.75	29.58	36.58	29.33	32.06	31.81	27.66
		b	14.83	27.58	22.25	26.75	24.92	23.26		
	spring	a	55.25	45.75	39.41	35.91	27.66	40.80		35.96
		b	39.42	30.08	37.58	28.00	20.58	31.13		
spring	spring	a	23.57	27.58	36.22	37.47	31.63	31.29	39.91	26.98
		b	19.83	14.49	27.16	24.08	27.81	22.67		
	summer	a	63.75	56.00	53.83	50.25	63.25	57.41		52.83
		b	49.75	50.91	52.41	43.25	44.92	48.25		
summer	summer	a	70.74	68.31	67.57	59.00	44.17	61.96	38.70	58.11
		b	57.48	67.22	48.64	44.90	53.08	54.26		
	autumn	a	19.16	20.33	22.50	23.08	25.25	22.06		19.29
		b	16.25	14.58	15.83	21.08	14.83	16.51		
$\bar{x}$ for sludge dose			38.42	38.05	37.75	35.86	33.95			

$LSD_{(p=0.05)}$ for factor I – n.s.
$LSD_{(p=0.05)}$ for factor II – 4.82
$LSD_{(p=0.05)}$ for factor III – 5.91
$LSD_{(p=0.05)}$ for factor IV - 3.96

Table 4. Peak of emergence (pcs/100 cm²).

Time of sludge application (factor III)	Time of sowing seeds (factorIV)	Type of mix (factor II)	Sludge dose (t/ha) (factor I)					$\bar{x}$ for type of mix	$\bar{x}$ for time of sludge application	$\bar{x}$ for time of sowing seeds
			0	70	140	210	280			
autumn	autumn	a	57.83	61.00	51.33	56.83	44.75	54.35	52.57	48.67
		b	42.67	39.25	44.83	49.66	38.58	43.00		
	spring	a	62.80	54.50	50.70	49.38	56.48	54.77		56.48
		b	65.80	63.45	55.93	54.40	51.40	58.20		
spring	spring	a	73.15	73.23	48.82	50.15	51.89	59.45	81.22	53.03
		b	56.83	54.57	33.07	41.15	47.46	46.61		
	summer	a	103.07	105.49	110.80	111.98	123.05	110.88		109.42
		b	89.73	113.98	103.72	115.55	116.80	107.96		
summer	summer	a	85.75	92.90	93.58	93.16	91.41	91.36	68.55	87.61
		b	73.75	87.83	86.00	77.91	93.82	83.86		
	autumn	a	61.41	62.42	53.25	56.33	57.66	58.21		49.50
		b	36.33	41.83	36.91	41.91	46.91	40.78		
$\bar{x}$ for sludge dose			67.43	70.87	64.08	66.53	68.35			

$LSD_{(p=0.05)}$ for factor I – n.s.
$LSD_{(p=0.05)}$ for factor II – 3.88
$LSD_{(p=0.05)}$ for factor III – 8.15
$LSD_{(p=0.05)}$ for factor IV – 4.75

Table 5. Plant tilling (9º scale).

Time of sludge application (factor III)	Time of sowing seeds (factorIV)	Type of mix (factor II)	Sludge dose (t/ha) (factor I)					$\bar{x}$ for type of mix	$\bar{x}$ for time of sludge application	$\bar{x}$ for time of sowing seeds
			0	70	140	210	280			
autumn	autumn	a	6.25	6.25	7.00	7.00	6.75	6.65	6.95	6.40
		b	6.25	6.00	6.50	5.75	6.25	6.15		
	spring	a	6.75	8.00	7.25	7.75	8.00	7.55		7.50
		b	7.00	7.25	7.50	8.00	7.50	7.45		
spring	spring	a	6.50	7.25	7.00	7.25	7.00	7.00	7.54	7.03
		b	6.75	7.25	6.75	7.50	7.00	7.05		
	summer	a	8.25	8.00	8.25	8.25	8.25	8.20		8.05
		b	7.50	7.75	7.75	8.50	8.00	7.90		
summer	summer	a	7.25	7.00	8.00	8.00	8.25	7.70	6.78	7.75
		b	7.25	7.00	8.25	8.00	8.50	7.80		
	autumn	a	4.25	4.25	7.00	6.50	7.00	5.80		5.80
		b	4.75	5.25	6.25	6.25	6.50	5.80		
$\bar{x}$ for sludge dose			6.56	6.77	7.29	7.40	7.42			

$LSD_{(p=0.05)}$ for factor I – 0.29
$LSD_{(p=0.05)}$ for factor II – n.s.
$LSD_{(p=0.05)}$ for factor III – 0.33
$LSD_{(p=0.05)}$ for factor IV – 0.22

Table 6. General aspect (9º scale).

Time of sludge application (factor III)	Time of sowing seeds (factorIV)	Type of mix (factor II)	Sludge dose (t/ha) (factor I)					$\bar{x}$ for type of mix	$\bar{x}$ for time of sludge application	$\bar{x}$ for time of sowing seeds
			0	70	140	210	280			
autumn	autumn	a	5	6	6.5	6	6.5	6	6.48	5.73
		b	5.25	5.25	5.75	5.5	5.5	5.45		
	spring	a	6	7	7.5	7.5	7	7		7.23
		b	7	7	8.25	7.5	7.5	7.45		
spring	spring	a	7	7	6.75	7.25	8	7.2	7.56	7.3
		b	6.5	7.5	7.5	7.75	7.75	7.4		
	summer	a	7	7.75	7.75	8.25	8	7.75		7.83
		b	7.5	7.5	8.25	8	8.25	7.9		
summer	summer	a	6.75	8.25	8	8	8	7.8	6.61	7.75
		b	6.25	8	7.75	7.75	8.75	7.7		
	autumn	a	3.25	5.75	6.25	6.25	6.5	5.6		5.48
		b	3.25	5.5	6	6.25	5.75	5.35		
$\bar{x}$ for sludge dose			5.9	6.88	7.19	7.17	7.29			

$LSD_{(p=0.05)}$ for factor I – 0.33
$LSD_{(p=0.05)}$ for factor II – n.s.
$LSD_{(p=0.05)}$ for factor III – 0.37
$LSD_{(p=0.05)}$ for factor IV – 0.25

3 and 1 times at a height of 6-7 cm. The grass was sprinkled by the whirling head when the soil was dry under 3 cm. The irrigation dose was 3-4 l/m^2.

Differences among accessions were tested by analysis of variance. Means were compared using least significant difference (LSD) and were numbered according to Duncan's multiple range test.

Results and Discussion

In the begining and the peak of plant emergence, no significant differences in number of seedlings were found on plots fertilized with sludge (Tables 3, 4). Moreover, a reduction in the number of seedlings was observed in the begining of emergence as sludge doses increased. Similar interrelations in emergence inhibition under increased doses of sewage sludge were obtained in research by Grabowski et al. [15]. As reported by Cheng et al. [16], increasing doses of biowaste (composted sludge) retards the initial growth of plants. The sewage sludge application probably poses a high risk for leaching losses of macroelements (N, P, K) in the soil, leading to poor usage by plants in the initial growth phase [17]. It was demonstrated that increasing sludge doses, especially 280 t/ha of the biowaste, as compared to the control object, had a significant effect on plant tilling and on the general aspect of the grass (Tables 5, 6). Surface coverage by plants ranged from 75 and 85% at the highest doses of sludge. In the research conducted by Kiryluk [18], over 60% of plant tilling on plots fertilized with sludge was obtained as compared to the control object.

The Kentucky bluegrass mix demonstrated a low ability to emerge and poorer initial growth than the Fescue grass mix (Tables 3, 4). Research by Larsen [19] and Larsen and Bibby [20] revealed that *Poa pratensis* L., sowed particularly in mixes with *Festuca rubra* L. and *Lolium perenne* L., was characterized by much lower competitive abilities, hence the poorer initial growth and development of the tussock-grass mix. As reported by Góral [21], this species emerged after 4 weeks, reaching the peak of its development after 3-5 years. The fescue grass mix demonstrated better plant tilling than the Kentucky bluegrass mix (Table 5). The general appearance of both lawn grass mixes was similar (Table 6).

It was demonstrated that the date of sludge application had a significant impact on the growth and development of lawn grasses. The most favourable emergence (beginning and peak), tilling and the general aspect of the grass was achieved while fertilizing the plots with sludge in spring (7.56 in the 9° scale) (Tables 3, 4, 5, 6).

The highest growth in the initial (55.47 pcs/100 cm^2) and the peak (98.51 pcs/100 cm^2) phase of emergence, good plant tilling (7.9 in the 9° scale) and the most attractive grass (7.29 in the 9° scale) were characteristic for the objects sown with lawn grasses in summer, rather than in spring and autumn (Tables 3, 4, 5, 6). This results from, among other things, a favourable set of weather conditions (air temperature and rainfall). Air temperature and rainfall in July and September, which were higher than the average values from the multi-annual period, had a favourable effect on the growth and development of plants that were sown in summer and autumn. The shortage of rainfall and low air temperatures in April, May and June slowed the initial growth and development of the species (varieties) of lawn grasses under examination, which particularly concerned the grass sown in spring. Weather changes, especially air temperature, rainfall and soil temperature, play an important role in the initial phase of growth and development of grasses [20, 22]. Mixes sown in spring and autumn reached significantly lower parameters such as plant and the peak of emergence, plant tilling and the general aspect of the lawn.

Conclusions

1. All doses of applied sludge had a favourable effect on plant tilling of the surface and the general aspect of the grass in the sowing year. The best dose is 280 t/ha although the plant and the peak emergence decreased under increased fertilization.
2. Under Olsztyn Lake District conditions, springtime is best for sludge application, along with the summertime for sowing the seeds of lawn grasses, with better results obtained in the case of the fescue mix.

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