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城市污泥堆肥用作草皮基质对草坪草生长的影响

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摘要：研究了城市污泥堆肥生产草坪基质的应用效果。试验结果表明，城市污泥堆肥基质能明显提高黑麦草的地上和地下生物量和叶绿素含量；与不施化肥和施用化肥的对照相比，城市污泥堆肥可以增加土壤有效态氮、磷含量，促进植物叶片对氮的吸收，提高草坪的质量。用经过无害化处理的城市污泥生产草坪基质，既可以解决城市污泥的出路，又可以降低草坪的生产成本，是一条经济可行的途径。

关键词：污泥堆肥；草坪基质；草坪草；肥效

The Municipal Sewage Sludge Compost Used as Lawn Medium

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Abstract: Sewage sludge is a by-product of wastewater treatment plants, which receive a great deal of effluents from industrial, municipal and/or rural sources. According to the national planning, an increase of sewage sludge production will occur in China very soon. So, more attention should be paid to its disposal. Sewage sludge has several characteristics: (1) it contains organic matter; (2) the organic fraction contains humic substances coming from the degradation of organic matter; (3) it contains varying concentrations of trace elements and synthetic organic compounds.

The occurrence of disposal and utilization of sewage sludge is much later in China than in other developed countries and most of works in China focused on the sludge and compost using in vegetables and crops. Sewage sludge and compost used as medium for plant growth and fertilizer for lawny production were popular in many countries, but few was reported in China. In this experiment, the sewage sludge compost was used as lawn medium for ryegrass. The purpose was to examine the effects of sewage sludge compost on lawny-grass growth and the soil fertility.

The pot experiment was conducted in April of 2000, which was composed of 5 treatments including check (0N-0P-0K-0compost), fertilizer (N : P : K : compost = 3 : 1 : 2 : 0, 1.4t/hm^2), compost A (7t/hm^2 compost), compost B (14t/hm^2 compost), compost C (70t/hm^2 compost). Two types of soils (topsoil and subsoil) with the same experiment treatments were used. Each treatment was replicated six times. The experiments were carried out in the green house with temperature of 15～25 C and 14 hours of light per day. The relative humidity of the green house was kept between 50～60 percent. Soil and compost samples were extracted by 1mol/L NaOH for available N and by 0.5 mol/L $NaHCO_3$ for available

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P and 1 mol/L NH_4AC for available K, respectively. The elements in the extraction were determined with hydrochloric acid titration, spectrophotometer and flame photometry. Heavy metal contents were analyzed after extraction using EDTA by AAS determination (Vario 6).

The results suggested that, with the enhancement of sewage sludge compost, the biomass of the ryegrass raised. The weight of dry matter of ryegrass in compost B and C treatments were significantly higher than that in NPK and check treatments. The compost B and C also improved ryegrass root growth, especially the compost C with the highest amount of compost. After five months growing, the chlorophyllous content was enhanced obviously with the utilization of the sewage sludge compost increasing, the leaf color was deep green and chlorophyllous content reached to the first class. Compared with the control and NPK treatments, the sewage sludge compost increased the soil available N and P content. The available N concentrations of 14 and 70t/hm^2 compost treatments in subsoil was 1.6 and 2.3 times as much as the control (soil only) respectively, and were 23.9% and 78.6% higher than N P K treatment.

The sewage sludge compost could also improve the P status. Contrast to the control, the available P content in subsoil in compost B and C increased by 59.7% and 592.5%. The available P of 70 t/hm^2 compost treatment was 4.3 times as much as that in N P K treatment. The available P content of 7t/hm^2 compost in subsoil was not statistically different from the control, and was statistically lower than (α=0.05) the N P K fertilizer treatment. Concentration of available K in the soil seemed not to be affected by the compost application. The nutrient change in topsoil was similar with the subsoil.

The sewage sludge compost used as a medium for lawn growth, which can not only solve the sewage sludge outlet problem, but also reduce the lawn production cost . It is an economical and sustainable development approach.

Key words: sewage sludge; compost; lawn medium; fertility efficiency

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草坪建设是城市现代化的重要标志,它对绿化城市、保护环境和生态平衡起着重要的作用。但是目前我国草皮的生产还存在着诸多空白,无法满足草皮生产的需要,其中草皮基质的研制和供应不足是重要的限制因素之一。

在草皮生产中,为保证质量,生产草皮的土壤必须理化性状良好,每完成一次草皮生产过程,至少要铲去 2cm 以上的熟土,连续的 3～4 次操作,肥沃的农田即遭到破坏[1]。但是同时我国又有大量的城市污泥等有机固体废弃物无法处置。污泥是城市污水处理过程中的副产品,它含有大量的有机质和植物生长所需的营养元素,是可以利用的资源。将污泥堆肥化处理后可杀灭病原菌和寄生虫,消除臭味,而且由于生物的降解作用,使污泥中的养分更容易被植物吸收利用[2～4]。污泥中还含有一些有机、无机污染物,使人们担心城市污泥直接农用会造成产品品质不良[5,6],如果将堆肥产品用作草坪栽培基质,不但避开食物链,同时又解决污泥的出路问题,而且对于城市的草坪业发展(尤其是草皮卷生产)也将起到一定的推动作用[7]。这对于尚无合理处置方式的城市污泥来说,无疑是一条兴利抑弊的好途径。

本试验旨在研究污泥堆肥用作草皮基质时,草坪草的生长响应和对土壤肥力的影响。

1 材料和方法

1.1 供试材料

盆栽土壤取自中科院遗传所农场,分为表土和底土两部分,表土为 0～20 cm,底土为 20～40 cm。土壤风干后,磨碎过 2mm 筛。供试城市污泥堆肥采自北京方庄污水处理厂,经 CTB 工业化快速堆肥系统堆腐后,风干过 2mm 筛。供试土壤和污泥堆肥的基本理化性质见表 1。

1.2 试验方法

试验采用 35cm×25cm 的塑料框,每框装土 5kg。供试草种为黑麦草(*Nui*),经催芽后播种,每盆播种 100 粒。盆栽试验在温室中进行,室温控制在 15～25 C之间,光照时间 14h,相对湿度 50%～60%。试验共设 5 个处理(分为底土和表土),每个处理 6 次重复:空白对照(不施化肥,不加堆肥)、常量化肥(3N-1P-2K,不加堆肥)、堆肥 A(不施化肥,7t/hm² 堆肥),堆肥 B(不施化肥,14 t/hm² 堆肥),堆肥 C(不施化肥,70 t/hm² 堆肥)。草皮种植过程中共刈剪 6 次。

表 1　供试土壤及污泥堆肥的基本性质

Table 1　The properties of experimental soil and sewage sludge compost

	pH	有机质 Organic matter	全氮 Total -N	全磷 Total -P	Cu	Zn	Pb	Cd
		(g/kg)			(mg/kg)			
污泥堆肥①	6.8	319	16.1	1.8	121	656	61.8	0.5
表土②	7.9	14.5	1.1	0.8	28.1	80.4	37.7	0.08
底土③	7.8	14.3	1.0	0.8	23.6	71.2	34.0	0.07

① Sewage sludge compost　②Topsoil　③Subsoil

1.3　分析方法

土壤和污泥中碱解氮采用 1mol/L 的 NaOH 提取,HCl 滴定;有效磷采用 0.5 mol/L 的 $NaHCO_3$ 提取,分光光度计测定;速效 K 采用 1 mol/L NH_4Ac 提取,火焰光度计测定[8,9]。叶片中的氮素和叶绿素含量采用凯氏法[10]和比色法[9]测定。

2　结果与分析

2.1　黑麦草对污泥堆肥的生长响应

经过 6 次刈剪后,对每茬黑麦草的地上生物量进行了分析。方差分析结果表明(表 2),每茬黑麦草的鲜重在不同处理之间存在显著差异。从第 1 茬起,堆肥 B 和堆肥 C 处理黑麦草的生物量最高,而且堆肥 C 处理的优势一直保持到第 6 茬。从培肥地力、促进黑麦草快速生长的角度看,施用 14～70 t/hm² 的污泥堆肥作为草皮基质,对黑麦草的生长比较适宜,两处理与常规化肥处理相比有显著差异。本试验的结果中,堆肥 A 处理的黑麦草地上部生物量与空白对照相当,说明作为草皮基质≤7t/hm² 的污泥堆肥施用量不能完全满足黑麦草生长的需要。

表 2　不同处理的黑麦草地上生物量

Table 2　The overground biomass of ryegrass with different treatments (g, wet weight, subsoil)

	时间 Time(d)					
	0～15	16～30	31～45	46～60	61～80	81～120
CK	0.75c	0.90 b	0.57c	0.33c	0.29c	1.28d
NPK	0.75c	0.95b	1.56b	1.64b	2.31b	3.50c
堆肥 A①	0.95b	1.03b	0.70c	0.44c	0.40c	1.54d
堆肥 B②	1.46a	1.86a	2.27a	2.30a	3.41ab	8.00b
堆肥 C③	1.59a	1.84a	2.30a	2.28a	4.6a	27.3a

同一列数据后标注不同字母,表示处理间达到差异 5%显著性水平. 下同. ① Compost A　②Compost B　③Compost C

比较图 1a 和表 2 可以看出,底土与表土中黑麦草的生长规律基本相同。堆肥 B、堆肥 C 和化肥处理在第 4 茬之前,生长趋势相当;但是后两茬黑麦草的生长,堆肥 B 和 C 处理较化肥处理具有明显的优势,尤其是堆肥 C 处理黑麦草地上部生长一直呈增长趋势,后效非常明显。

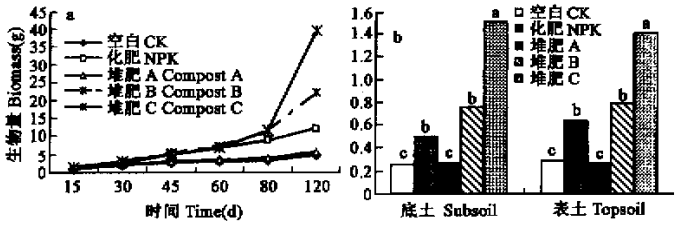

图 1　不同处理黑麦草生物量

Fig. 1　The biomass of ryegrass with different treatments

a. 地上部生物量 Overground biomass, b. 地下部生物量(干重) Underground biomass(dry weight)

污泥堆肥基质用量的不同对黑麦草地下生物量(根系)的影响也非常显著(图 1b)。方差分析表明,随着污泥堆肥施用量的增加,根系的生物量也增加。堆肥 B 和堆肥 C 处理的地下生物量明显高于空白对照和化肥对照,与地上生物量对应。这说明,污泥堆肥的施用能够促使草坪草的根系更加发达,利于培育壮株。

2.2 污泥堆肥对黑麦草叶片吸收氮素的影响

氮素是草坪草生长的重要营养元素,氮素的吸收有利于草坪草各项质量指标的提高。黑麦草对氮素的吸收可以反映不同处理之间的差异。表 3 数据显示,各处理之间叶片中氮含量存在显著的差异。由于化肥为速效肥料,在黑麦草生长的第 1 个月里,化肥处理叶片含氮量较高,但是从第 2 个月开始,底土栽培的黑麦草,堆肥 C 处理叶片中氮素含量与化肥处理已无明显差异;在表土栽培试验中,从第 2 个月开始,化肥处理的叶片氮素含量明显低于堆肥 B 和堆肥 C 处理,说明污泥堆肥基质已开始发挥作用。从第 3 个月开始,尽管每个处理叶片中氮含量都在逐渐下降,但堆肥 B 和堆肥 C 处理叶片中的含氮量仍然较高,与其他处理之间存在明显差异,表明污泥堆肥基质对黑麦草的氮素供应具有明显后效作用。

表 3 不同处理黑麦草叶片中氮素含量(%,干重)的动态变化

Table 3 The N (%, Dry weight) absorption dynamic change of the ryegrass leave

	处理 Treatment	时间 Time(d) 0～30	30～60	61～95	96～130
底土 Subsoil	CK	0.75c	0.84c	0.53c	0.23b
	NPK	1.08a	1.82a	0.62b	0.26b
	堆肥 A①	0.85b	1.12 c	0.63 b	0.22b
	堆肥 B②	0.84b	1.46b	0.76 a	0.51a
	堆肥 C③	0.85b	1.76a	0.84a	0.52a
表土 Topsoil	CK	0.77c	0.95c	0.53c	0.25b
	NPK	1.08a	1.46b	0.47c	0.24b
	堆肥 A	0.88b	1.09c	0.6b	0.24b
	堆肥 B	0.85b	1.79b	0.90a	0.43a
	堆肥 C	0.85b	2.16a	0.90a	0.47a

①Compost A ②Compost B ③Compost C

2.3 污泥堆肥对黑麦草叶绿素含量的影响

叶绿素含量是草坪草的评价指标和重要的质量指标,它反映草坪的观赏质量,也反映草坪的生长状态。试验最终收获时对黑麦草的叶绿素含量进行了测定(图 2),随着污泥堆肥施用量的增大,黑麦草的叶绿素含量明显增加。特别是堆肥 C 处理黑麦草的叶绿素含量明显高于空白对照和化肥处理,其叶色深绿,叶绿素含量达到一级水平。说明污泥堆肥具有明显的缓释肥料功能,对增加草坪草的叶绿素含量同样具有明显的效果。

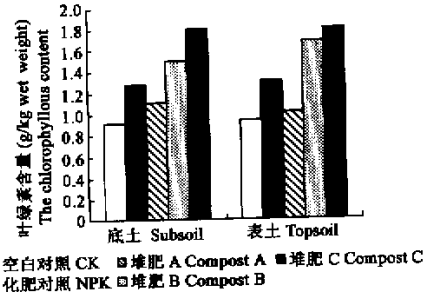

图 2 不同施肥处理黑麦草中叶绿素含量

Fig. 2 The chlorophyllous contents in ryegrass leave

2.4 污泥堆肥对土壤养分状况的影响

黑麦草收获后,测定了土壤中速效养分的含量(表 4),发现施用污泥堆肥可以提高土壤中的速效氮、磷的含量,但对速效钾含量无明显的影响。底土栽培的试验中,堆肥 B 和堆肥 C 处理的速效氮含量分别比空白对照土壤提高 61.3%和 133%,比化肥处理提高 23.9%、78.6%,且差异均达到显著水平;堆肥 B 和

表 4 黑麦草收获后土壤速效养分含量 (mg/kg)

Table 4 The available nutrient contents in soil after ryegrass harvested

处理 Treatment	速效 N Available N	速效 P Available P	速效 K Available K
底土 Subsoil			
CK	26.3d	19.9c	68.3a
NPK	34.3c	31.9b	67.0a
堆肥 A①	32.4c	20.5c	64.3a
堆肥 B②	42.5b	31.8b	63.7a
堆肥 C③	61.3a	137.7a	67.0a
表土 Topsoil			
CK	35.0c	28.4d	74.3a
NPK	37.9b	28.8d	76.3a
堆肥 A	35.0c	34.9c	73.6a
堆肥 B	43.8b	56.7b	72.3a
堆肥 C	67.1a	137.7a	75.0a

①Compost A ②Compost B ③Compost C

堆肥 C 处理的速效磷含量同样比空白对照土壤提高 59.7%、592.5%，堆肥 C 处理比化肥提高 331%，堆肥 A 处理的速效磷含量与空白对照无明显差异，比化肥对照土壤中的速效磷含量低 29.7%，且差异比较显著；各处理之间速效钾的差异均不显著。表土土壤试验结果与底土试验结果相类似。

3　结论

（1）采用城市污泥堆肥作为草皮基质，可以明显促进黑麦草的生长。施用 14～70t/hm^{2}的污泥堆肥，能够提高黑麦草生物量及促进其根系生长，草坪的密度和盖度明显提高。

（2）用城市污泥堆肥作为基质可以使黑麦草叶片对氮的吸收显著增加，特别是黑麦草生长后期，其叶片中氮和叶绿素的含量明显高于化肥对照处理，草坪草的品质达到一级水平。

（3）城市污泥堆肥基质，可以提高土壤速效氮和速效磷含量，有利于改善草坪的土壤肥力，但是对土壤中速效钾的含量无显著性的影响。

（4）采用城市污泥堆肥作为草坪基质，可以拓宽城市污泥的处理途径，降低草皮生产成本，而且也有利于保护耕地和提高土壤肥力，是一条经济可行的途径。

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