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城市污泥堆肥对栽培基质保水能力和有效养分的影响

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摘要:盆栽试验表明,城市污泥堆肥不仅可以明显提高栽培基质的有效氮、磷含量,而且可以增强栽培基质的保水性能和植物的抗旱能力,但是栽培基质的萎焉点也随着其用量的增加而增高。因此,从保证植物水分供应的角度考虑,虽然可以大量地使用城市污泥堆肥,但是其用量并不是越多越好;当用量超过 75%时,继续增加城市污泥堆肥的比例,则植物的吸水能力反而会略有下降。从养分供应和保水性能等角度综合考虑,采用经过堆肥化处理的城市污泥作为植物栽培基质,是城市污泥资源化和无害化的可行途径。

关键词:城市污泥; 盆栽基质; 有效养分; 萎焉点; 保水能力

Effects of Sewage Sludge Compost on Available Nutrients and Water Retention Ability of Planting Substrate

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Abstract: Sewage sludge compost is a kind of excellent fertilizer due to its abundant nutrition and organic matter. After composting, the sewage sludge could be sold as a commodity to make profits that could be improved by adding inorganic fertilizer. So land application has become one of the best ways for sewage sludge, especially for the developing countries with limited cultivated lands, expanding land application of sewage sludge is very essential with the precondition of resolution of pathogen, vector, and heavy metal.

Lots of studies have being done on the effects of sewage sludge compost on plants and environment. Some researches reported that total N, total P and organic matter of surface soils were enhanced by the application amount of sewage sludge compost. When sewage sludge compost was used as the substrate of container breeding, the chemical and biological properties of soils were improved. Few studies on the effects of sewage sludge compost on water retention ability of planting substrate have been reported by now.

In order to study the effects of sewage sludge compost on water retention ability and soil nutrient availability of planting substrate, pot experiment growing wheat was carried out in the greenhouse.

Three experimental series were designed as follows: (1) Series I—— the growing substrate without plant was incubated for 30 days, and investigated the moisture of growing substrate, available N and P on day 30; (2) Series II—— wheat plant was grown for 30 days, and investigated the soil moisture, available N and P on day 30; (3) Series III—— wheat plant was grown for 30 days, and the dynamics of the moisture of growing substrate and wilting point of the plant were tested until the wheat went to death due

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to lacking of water after stopping the irrigation on day 30. Each series consisted of five treatments, i.e., treatment 1 (100% soil), treatment 2 (25% compost + 75% soil), treatment 3 (50% compost + 50% soil), treatment 4 (75% compost + 25% soil), treatment 5 (100% compost).

The results showed that the biomass of wheat increased due to more sewage sludge compost was added ($R^2=0.998$). The more the compost was used, the higher water retention ability of plant substrate would be.

The wilting point of the all treatments with compost was found to range from 78 h in treatment 1 (without compost) to 170～220 h in treatment 3 and 4. From the view of point of the water retention ability of the planting substrate, it was better when the proportion of sewage sludge compost was 50%～75%. According to the simulation, it could be calculated that the maximum time of wilting point was 235h when the proportion of sewage sludge was 77%. It could be concluded that the water retention ability of the substrate could be improved evidently when using sewage sludge compost as plant substrate. When the proportion of sewage sludge compost was appropriate, the wheat plant could survive for 10 days without irrigation. It is indicated that sewage sludge compost could improve the drought-resistant ability of plant due to the evaporation of water of substrate was reduced. The manpower of irrigation could be reduced if sewage sludge compost was used as a plant substrate in agricultural and horticultural production.

Although more than 91% nitrogen of sewage sludge compost is organic nitrogen, it could evidently enhance available nitrogen of the growing substrate in all treatments with or without plant. The available nitrogen was found to be positively correlated to the application rate of sewage sludge compost. Not only did sewage sludge compost provide nitrogen that was necessary for plant, but also enhanced the available nitrogen of planting substrate. Similar trends were also found in available phosphorus. Using sewage sludge compost as planting substrate could provide nitrogen and phosphorus for plant and enhanced the available nitrogen and phosphorus of planting substrate. Considering the nutrient supply and water retention ability, utilization of sewage sludge compost as planting substrate is feasible way to reuse and dispose of sewage sludge.

Key words: sewage sludge; planting substrate; available nutrient; wilting point; water retention ability

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城市污泥含有丰富的有机质和植物所需的氮、磷等多种营养元素,还含有钾和其它微量元素,是一种经济有效的肥料资源[1]。特别是城市污泥与化肥制成复混肥后还能使其商品化,为城市污泥处理带来一定利润。因此,城市污泥土地利用已成为其资源化的重要途径,通过这种途径既有效地解决城市污泥的出路,同时可以实现城市污泥的资源化。尤其是象我国这样一个人均耕地少、资金短缺的发展中国家,在解决好重金属和病原菌、寄生虫和杂草种子等污染问题的前提下,推广城市污泥土地利用的必要性则更显突出。

国内外许多学者曾从城市污泥农用对植物生长和环境的影响等方面做过大量研究。张天红等人指出:随城市污泥施用量的增大,表土(0～20cm)中的全氮、全磷和有机质的含量增加[2,3]。薛澄泽等人的研究认为:城市污泥堆肥施用于林木、花卉、草坪及用作林木容器育苗基质,对土壤的化学及生物学性质均有所改善[4,5]。但是到目前为止,尚未见关于作为植物培养基质时,城市污泥堆肥对土壤养分和土壤保水性能的影响。本文通过研究大量(如占土壤重量的25%以上)施用城市污泥堆肥对土壤速效氮磷、水分含量和凋萎点的影响,以便为利用城市污泥堆肥作为植物培养基质的可行性提供科学依据。

1　材料和方法

1.1　供试材料

供试土壤为取自北京地区的潮土(表1)。供试城市污泥取自北京方庄污水厂,试验前城市污泥经过堆肥过程进行无害化处理(表1)。

表 1 供试土壤及城市污泥堆肥的主要理化性质

Table 1 Properties of the studied soil and sewage sludge compost

供试样品 Samples	pH	有机质 Organic matter (g/kg)	全 N Total N (g/kg)	全 P Total P (g/kg)	CEC (cmol/kg)	$CaCO_3$ (g/kg)	机械组成(%)* Mechanical composition 砂粒 Sand	粉粒 Silt	粘粒 Clay
土壤 Soil	7.98	10.5	0.93	1.95	14.82	96.0	45.7	27.0	27.3
城市污泥堆肥 Sewage sludge compost	6.87	589	43.5	12.1	—	—	—	—	—

* 砂粒 Sand>0.02mm,粉粒 Silt 0.02~0.002mm,粘粒 Clay<0.002mm

1.2 盆栽试验

盆栽试验在温室中进行。为防止水分的渗漏,植物盆栽试验在 250ml 的烧杯进行,每盆装土 250g。为了保证植物的正常生长和处理的可比性,各处理均施入等量化肥,即每 1000g 土壤添加 0.15gN(尿素)、0.10gP_2O_5(磷酸氢二铵)、0.15gK_2O(氯化钾)。供试植物为小麦,播种催芽后移栽(每盆 5 株)。试验共设 3 个系列,每个系列均设 5 个处理,其城市污泥堆肥添加比例分别为:0%、25%、50%、75%和 100%,3 个系列共 15 个处理,各处理均设置 5 个重复。3 个系列的具体试验方案如下:

系列 1 对照系列(不种植物),培养 30d,按照与系列 3 同样的条件进行管理,测定土壤含水量和速效氮、磷。

系列 2 种植植物,按照与系列 3 同样的条件进行管理,培养 30d 后收获,测定土壤含水量和速效氮、磷。

系列 3 种植植物,培养 30d 后停止浇水,使植物因干旱缺水而死亡,测定土壤的含水量以研究各处理的保水性能和植物凋萎情况。

在植物生长过程中,根据系列 3 中盆栽的水分蒸散情况定量补充水分,以充分保证植物生长的水分要求。当盆栽试验培养到第 30 天时,系列 3 的各处理均补充等量水分,以便研究其相应的萎焉点(植物凋萎时栽培基质的含水量)。

1.3 测定方法与数据处理

小麦生长 30d 后,收获生物量并取样测定土壤水分(烘干法)、速效氮(扩散法)和速效磷(Olsen 法)[6]。

对于测定凋萎系数的系列 3,当种植植物 30d 并停止浇水后,每隔 12h 取样测定土壤水分含量的动态变化,并同步记录植物开始凋萎的时间。

2 结果与讨论

2.1 对生物量的影响

图 1 是小麦种植 30d 后,系列 2 的各个处理中地上部的生物量。从该图可以看出,城市污泥堆肥的添加量越大,则植物的生长越好。相关分析表明,地上部生物量与城市污泥堆肥的添加量呈显著的正相关($R^2=0.998$,$N=5$)。因此,施用城市污泥堆肥,能够显著促进植物的生长。这与目前国内外关于城市污泥土地利用研究结果的趋势基本一致[7]。

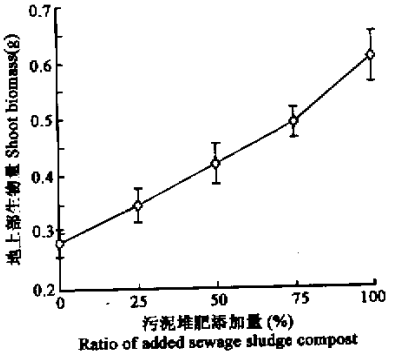

图 1 城市污泥堆肥添加量对小麦生长影响(种植 30d)

Fig. 1 Response of wheat plant to sewage sludge compost(30 days after planting)

2.2 对栽培基质保水性能的影响

从图 2 可以看出,停止浇水以后的 7d 时间内,系列 3(种植植物)各处理的含水量每天都明显减少;城市污泥堆肥用量越高,则栽培基质的保水能力越强,但是这种差异随着时间的推移趋势而不断缩小。因此,本文将城市污泥堆肥用作植物栽培基质的研究结果,与国

外学者关于施用污泥[8,9]和污泥堆肥[10]能显著提高土壤含水量和田间持水量的大田试验结果相符。这可能是与施用污泥能够改良土壤物理性质,降低土壤容重,增加土壤团粒结构和孔隙率有关[9~11]。因此,采用城市污泥堆肥作为基质材料能提高栽培基质的保水性能,有利于提高植物的抗旱能力。

2.3　对植物凋萎时间的影响

从图 3 可以看出,与不添加城市污泥堆肥的对照处理相比,添加 25%～100%的城市污泥堆肥可以使出现凋萎的时间由 78h 延长到 170～220h 左右。该图的结果还显示,城市污泥堆肥的添加比例为 50%～75%时,植物的抗旱性能最强,但是并不是城市污泥堆肥的用量越多抗旱能力越强。与不添加城市污泥堆肥的对照处理相比,其余 4 个处理分别使植物发生凋萎的时间延长 4～6d。根据曲线拟合的结果,城市污泥添加量与植物出现凋萎的时间之间符合抛物线方程(图 3)。从该方程可以计算出,当城市污泥堆肥的添加量为 77%时,其最大值为 235h。即当城市污泥堆肥的添加比例最合适时,最多可以连续 10d 时间不浇水也能保证植物(小麦)不会因干旱而死亡。因此城市污泥堆肥作为基质具有明显的抗旱效果。如果在园林和农业生产中采用城市污泥堆肥作为栽培基质,则可以大量减少浇水方面的人工;如果用于家庭养花,则可以避免因无人浇水时导致植物干死。

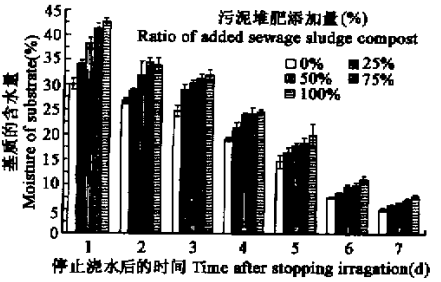

图 2　城市污泥堆肥对停止浇水后栽培基质持水量影响

Fig. 2　Dynamics of moisture of growth medium made from sewage sludge compost after stopping irrigation

进一步分析植物发生凋萎时栽培基质的含水量(萎焉点)则表明(图 4),在种植植物和不种植植物的系列中,2 者的对照处理的萎焉点都非常接近,分别为 4%和 5%;如果城市污泥堆肥施用为 100%,则其相应的萎焉点分别升高 5 倍和 7 倍。因此,城市污泥堆肥能够显著增加土壤的保水能力,提高土壤持水量,同时也提高栽培基质的萎焉点。因此,在相同含水量的条件下,植物从城市污泥堆肥(栽培基质)中吸收水分的能力其比从土壤基质中吸收水分要相对困难一些,尤其是不种植植物时这种影响更加明显。国外也曾有人发现,施用污泥显著提高植物的萎焉点[10]。由此可以推定,用城市污泥堆肥作为栽培基质能够提高植物的抗旱能力,主要是减少基质中的水分蒸发的缘故。

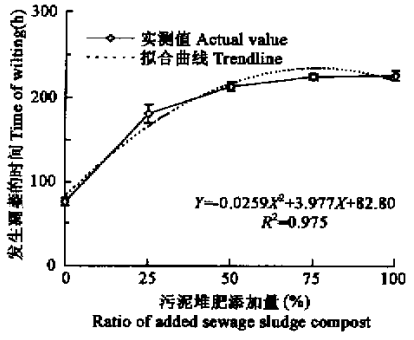

图 3　城市污泥堆肥对植物抗旱能力(凋萎)的影响

Fig. 3　Effect of sewage sludge compost on drought-resistant ability of plant

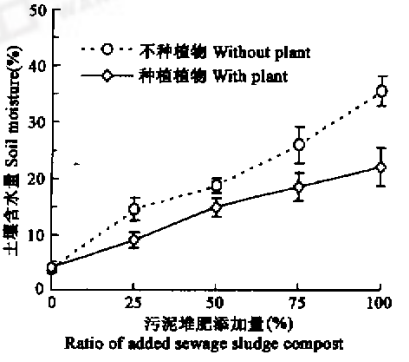

图 4　城市污泥堆肥添加量对萎焉点的影响

Fig. 4　Effect of sewage sludge compost dose on wilting point of plant

2.4　对速效氮的影响

从图 5 可以看出，虽然污泥中 91%以上的氮是以有机态存在[7]，但是无论是在种植植物的系列中还是在不种植植物的系列中，城市污泥堆肥均使栽培基质的有效氮含量显著提高，而且随着其添加量与栽培基质的有效氮含量呈正相关[12]。因此，城市污泥堆肥不仅可以提供植物生长所需的氮源[13]，而且可以明显增加土壤有效氮含量[14, 15]。

2.5 对速效磷的影响

从图 6 可以看出，虽然污泥中 95%以上的磷是以有机态存在[7]，但是无论是在种植植物的系列中还是在不种植植物的系列中，城市污泥堆肥均使栽培基质的有效磷含量显著提高，而且其添加量与栽培基质的有效磷含量呈正相关[16]。因此，城市污泥堆肥不仅可以提供植物生长所需的磷源[13]，而且可以明显增加土壤有效磷含量[10, 17]。

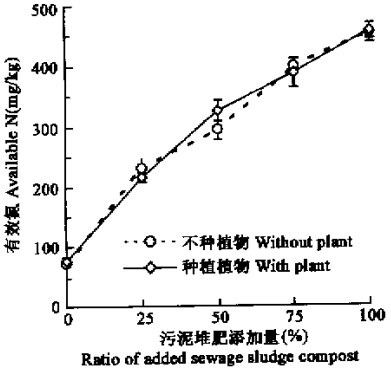

图 5 城市污泥堆肥对栽培基质中有效氮的影响

Fig. 5 Effect of sewage sludge compost on the available nitrogen of planting medium

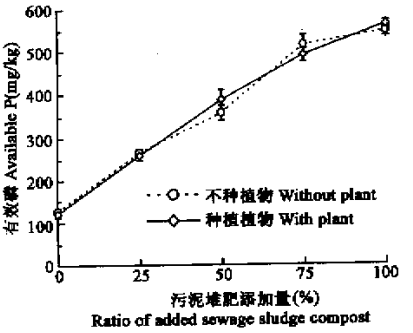

图 6 城市污泥堆肥对栽培基质中有效磷的影响

Fig. 6 Effect of sewage sludge compost on the available phosphorus of planting medium

3 结论

盆栽试验表明，城市污泥堆肥不仅可以明显提高栽培基质的有效氮、磷含量，提供植物生长所需的养分，而且可以增强栽培基质的保水性能和植物的抗旱能力。当含水量相同时，植物从城市污泥堆肥中吸收水分一般比从土壤中吸收水分要困难一些，而且采用城市污泥堆肥作为栽培基质比完全用土壤作为栽培基质时的萎焉点要高。因此，从保证植物水分供应的角度考虑，城市污泥堆肥的用量并不是越多越好，当其用量超过 75%时，继续增加城市污泥堆肥的比例，则植物的吸水能力反而会略有下降。从养分供应和保水性能角度综合考虑，采用经过堆肥化处理的城市污泥作为植物栽培基质是可行的资源化技术途径。

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