SEWAGE SLUDGE AS AN ORGANIC SOIL AMENDMENT FOR GROWTH OF LOBLOLLY PINE SEEDLINGS

Charles R. Berry[1]

Abstract.--Different amounts of sewage sludge from Norman, Oklahoma and Athens, Georgia, and inorganic fertilizer were compared as soil amendments for growing loblolly pine seedlings in pots. Norman sludge contained higher concentrations of major plant nutrients than Athens sludge, but also contained higher concentrations of the undesirable elements sodium and cadmium. Seedlings grew as well in Athens sludge at 15 tons/acre as in 500 lbs/acre of 10-10-10 fertilizer. Significantly larger seedlings, however, were produced when the rate of Athens sludge application was 30 tons/acre rather than 15 tons/acre. Seedlings grew significantly larger and heavier with 15 tons/acre of Norman sludge than with 30 tons/acre of Athens sludge. Seedlings also grew larger in 15 tons/acre than they did in 30 tons/acre of Norman sludge. These data indicate that Norman sludge is an excellent soil amendment at a rate of application of about 15 tons/acre. Above this rate however, some other factor, or factors interfere with pine seedling growth.

Additional keywords: Cadmium, sodium, nutrients, *Pinus taeda*.

A comprehensive discussion of the functions and maintenance of organic matter in forest nursery soils was recently presented by Davey and Krause (1980). Although sewage sludge can supply organic matter as well as nutrients to nursery soils, many sludges contain heavy metals, excessive amounts of salts, and high concentrations of sodium that are potentially harmful to seedling growth (Bickelhaupt 1980). Favorable results were obtained in Florida where sewage sludge produced larger slash pine seedlings than the standard nursery fertilizer applications (Berry 1981). Screened compost (sewage sludge composted with wood chips) has been used successfully for production of high quality hardwood seedlings in Maryland (Gouin and Walker 1977, Gouin and others 1978).

This pot experiment was carried out in Athens, Georgia to compare the effects of sewage sludge from Norman, Oklahoma and Athens, Georgia on growth of loblolly pine seedlings as a preliminary test of the suitability of Norman sludge for use in forest nurseries.

MATERIALS AND METHODS

Batches of dried sewage sludge from Norman, Oklahoma and Athens, Georgia were mixed with a basic soil-mix (2:1:1, forest clay loam:sand:milled pine bark) at rates of 15 and 30 tons/acre. Athens sludge had been stockpiled out of doors for 1 year before use. Control pots received 500 lbs/acre of 10-10-10 fertilizer. Before amendments were added, the soil mix was chemically analyzed after extraction with a double acid solution (0.05 N HCl + 0.025 N (H_2SO_4). Phosphorus was determined colorimetrically and cations by atomic absorption spectroscopy. Total N was determined by Kjeldahl, organic matter by wet oxidation chromic acid digestion, and pH by glass electrode in a mixture of 2 parts water in 1 part soil (v:v).

[1]Plant Pathologist, Institute for Mycorrhizal Research and Development, Southeastern Forest Experiment Station, Forestry Sciences Laboratory, Athens, Georgia.

Soil analyses are as follows:

Elements	ppm	Elements	ppm
N	330.0	Na	7.3
P	13.6	Fe	45.3
K	68.0	Cu	2.7
Ca	189.4	Zn	7.7
Mg	30.0	Cd	0.03
Mn	114.6		

The soil had a pH of 5.2, organic matter was 2.3 percent, and a mechanical analysis of 83:7:10 (sand:silt:clay). Soil analyses were performed by C. C. Wells, USDA Forest Service, Forestry Sciences Laboratory, Research Triangle Park, North Carolina.

Sewage sludge analyses were carried out as follows: Total N by Kjeldahl, organic matter by gravimetric analysis after ashing at 500°C for 4 hours, and P and cations by extraction with concentrated HNO_3 followed by plasma emission spectroscopy (Table 1).

Table 1.--Comparison of sewage sludges from Norman, Oklahoma and Athens, Georgia[1]

N	P	K	Ca	Mg	Mn	Fe	OM	Na	Cu	Zn	Cd
%								ppm			
Norman, Oklahoma											
2.24	1.79	0.07	2.1	0.38	0.012	0.43	45	436	164	793	22
Athens, Georgia											
1.50	0.45	0.01	0.4	0.02	0.004	0.38	50	10	110	418	4

[1]Sewage sludge analyses were performed by the Institute of Ecology and the Laboratory for Soil and Plant Analysis, University of Georgia, Athens.

The soil mix, with amendments added, was placed in six-inch black plastic pots. Stratified loblolly pine seed, obtained from the Norman nursery, were germinated in flats of moist vermiculite and transplanted three to a pot in mid-July. After survival was assured the two smallest seedlings were cut from each pot. Five pots for each of the five treatments were then placed in each of five replicate blocks in a lath house. All pots were watered to saturation two or three times a week as needed. In January seedlings were carefully removed from each pot, separated from the growing medium and growth data were recorded.

RESULTS AND DISCUSSION

Athens sludge, at the lowest rate used (15 tons/acre) induced about the same rate of growth of loblolly pine seedlings as a single pre-plant application of 10-10-10 fertilizer, equal to 500 lbs/acre (Table 2). Seedlings in pots with fertilizer or with 15 tons/acre of Athens sludge were small and had signs of nitrogen deficiency. Athens sludge at 30 tons/acre, however, permitted growth of slightly larger and heavier seedlings which, though of only medium size, did not display signs of nutrient deficiencies.

The 15 tons/acre rate of Norman sludge stimulated more seedling growth than 30 tons/acre of Athens sludge, reflecting the higher concentrations of nutrients in the Norman sludge. Increasing the rate of application of Norman sludge to 30 tons/acre, however, did not cause the seedlings to grow faster; instead they were smaller, did not weigh as much and displayed some foliar chlorosis (indicating a nutrient deficiency, nutrient imbalance, or microelement toxicity) compared to seedlings in pots amended with 15 tons/acre. The possibility of toxicity caused by the high concentration of sodium in the Norman sludge (60 times more than the Athens sludge) needs further study.

Table 2.--Effects of dried sewage sludge on loblolly pine seedlings in pots[1]

Treatment	Stem height (cm)	Stem diameter (mm)	Green weight (g)		
			Tops	Roots	Total
Fertilizer					
10-10-10 at 500 lbs/A	7.1cd	2.0d	0.6c	1.3b	1.8c
Athens sludge					
15 tons/A	6.2 d	1.8e	0.4c	1.1b	1.5c
30 tons/A	8.1c	3.2c	1.7b	3.2b	4.9bc
Norman sludge					
15 tons/A	13.1a	3.7a	2.8a	6.2a	9.0a
30 tons/A	11.0b	3.6b	2.5a	3.6b	6.1ab

[1]Means within a column followed by the same letter do not differ significantly at $P = 0.05$.

While cadmium is also somewhat higher in the Norman sludge, it is not regarded as a cause of reduced growth since in other work (unpublished), normal size seedlings were produced with a sludge containing 10 times more cadmium than Norman sludge.

Sewage sludge can be a worthwhile amendment that will furnish nutrients and organic matter for forest nursery soils. The amount of nutrients available, however, in sludges from different localities, or in batches of sludge of different ages from the same source may differ. In this experiment, it was found both from soil analyses and from seedling growth that the Norman sludge contained more nutrients than the Athens sludge. In later work (unpublished), it was found, however, that fresh Athens sludge contained more nutrients and induced a greater growth response of pine seedlings than Athens sludge that had been stored uncovered out of doors a year or more.

Therefore a direct comparison of chemical analyses of sewage sludge from different sources should be made only on samples fresh from the digestors, or at least stored under similar conditions for the same length of time. The primary reason for including Athens sludge in this experiment was to permit comparison of Norman sludge with a sludge of similar bulk density and organic matter content.

A small pot experiment similar in design to the one reported here is recommended as a study preliminary to applying sludge to a nursery. Since it is so difficult to duplicate field conditions, extreme caution is advised in field trials even after the completion of a pot experiment. There is a good probability that the local water supply would tend to accentuate many problems detected in sludges. In this case, Athens water is relatively low in sodium and dissolved salts and would tend to lessen the effects of these factors in Norman sludge by leaching. Norman sludge coupled with Norman water might induce worse symptoms of salt or sodium toxicity.

In summary, these data show that Norman sewage sludge has an adequate supply of nutrients to support good seedling growth for at least 1 year when applied at the 15 tons/acre rate. It appears, however that a small scale field test should precede full scale use of this sludge in order to understand better the factor or factors that limited growth of seedlings when the sludge was applied at 30 tons/acre.

LITERATURE CITED

Berry, C. R. 1981. Sewage sludge affects soil properties and growth of slash pine seedlings in a Florida nursery. p. 46-51. In: Proc. 1980 Southern Nursery Conference, Lake Barkley, Ky., Sept. 2-4, 1980. Tech. Publ. SA-TP 17, 123 p.

Bickelhaupt, D. H. 1980. Potential hazards of some organic wastes that may be used in nurseries. p. 166-173. In: Proc. North Am. Forest Tree Nursery Soils Workshop, Syracuse, N.Y., July 28-August 1, 1980. Sponsored by USDA Forest Serv., State & Private Forestry, Canadian Forestry Serv., and State Univ. of N.Y., College of Environmental Science and Forestry. 333 p.

Davey, C. B. and H. H. Krause. 1980. Functions and maintenance of organic matter in forest nursery soils. p. 130-145. In: Proc. North Am. Forest Tree Nursery Soils Workshop, Syracuse, N.Y., July 28-August 1, 1980. Sponsored by USDA Forest Serv., State & Private Forestry, Canadian Forestry Serv., and State Univ. of N.Y., College of Environmental Science and Forestry. 333 p.

Gouin, F. R. and J. M. Walker. 1977. Deciduous tree seedlings response to nursery soil amended with composted sewage sludge. Hort. Sci. 12:45-47.

Gouin, F. R., C. B. Link and J. F. Kundt. 1978. Forest seedlings thrive on composted sludge. Compost Sci./Land Utilization 19:28-30.