1. Make sure your source of sludge is low in soluble salts, 1500 ppm or lower.
2. The compost pile should generate heat up to 60° to 70°C in order to kill pathogenic bacteria and weed seeds; it also shows that the composting process is working.
3. Location of the composting area is important. You must prevent run-off into streams, lakes and rivers.
4. It is advisable to have no physical contact with the sludge before composting.
5. Machinery should be thoroughly washed immediately after using.
6. Always test the compost before using.
7. Leaves alone do not make a good bulky organic material to compost with.

The work of converting the human wastes and removing their offensive odor is done by microorganisms, which naturally convert wastes into plant food. Such bacteria, fungi and other organisms are an important link in the nitrogen cycle. These microorganisms can recycle human wastes rapidly if given the chance. The sad truth is, though, that the great majority of our wastes are never allowed to meet up with the microorganisms that in nature act as recycling agents. How long are we going to stand by and watch all that good nitrogen, phosphorus, potassium and humus go into landfills, oceans, bays, or into some river? Composting sludge requires some effort, but we feel it pays big dividends by being able to grow quality plant material at a nominal cost.

MARKED GROWTH RESPONSE OF WOODY PLANTS WITH SCREENED COMPOSTED SEWAGE SLUDGE[1]

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Nurserymen sell tons of top-soil with balled and burlapped crops and hundreds of cubic yards of potting mix with plants grown in containers. Peat moss, shredded bark, and greenmanure crops have been their primary sources of organic matter, while fertilizers and lime have been their principal

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sources of plant nutrients. As prices for these materials increase and supplies of peat moss and bark decline, the need for new sources of organic matter and plant nutrients is evident.

Sewage sludge when properly composted with wood chips (1,6) makes an ideal substitute for peat moss as a soil amendment (3) and in potting mixes (5). This dependable source of organic matter, once a public liability, can now be converted into a community asset through composting. Compost made from sewage sludge and wood chips is similar in appearance to a potting mixture of peat moss and pine bark with an odor nearly identical to garden compost. Safe disposal of sewage sludge continues to be an environmental problem, but composting promises to be a practical and efficient method for converting sludge into a usable product. Studies with compost made from municipal waste and sewage sludge look promising (4).

The greenhouse and nursery industry is a logical outlet for compost made from sewage sludge as both of these industries deal with non-food crops and are heavy users of organic materials and fertilizers. Because nursery and greenhouse crops are generally not edible, concern about introducing heavy metals into the food chain is unlikely.

Optimum soil application levels of screened composted sewage sludge made from digested sludge appears to be between 112 to 224 metric tons per hectar(T/ha). Studies with soil-incorporated levels of 0, 112, 224, and 448 (0, 50, 100, and 200 tons per acre) on Evesboro sandy-loam soil just prior to seeding *Liriodendron tulipifera* and *Cornus florida* resulted in increased soil pH, Mg, and P levels in the soil after the first growing season (Table 1). Because sludges are low in K, there was a decrease in the K content of the soil due to crop uptake

Table 1. The influence of screened sludge compost on soil pH, and Mg. P, and K concentrations after one growing season.[v]

		ppm		
Metric tons/ha.	pH	Mg	P	K
Original[w]	5.2 c[y]	9 c	123 b	87a
0[x]	5.2 c	7 c	132 b	39 c
112	6.7 b	70 b	174a	31 c
224	7.1ab	93 b	176a	31 c
448	7.3a	149a	170a	38 c
Compost[z]	6.9	30	230	20

[v] Analysis supplied by Soil Testing Laboratory, Dept. of Agronomy, University of Maryland, College Park, Maryland.
[w] Soil samples taken from the area before treatment in October 1973.
[x] Soil samples taken from each plot in October 1974.
[y] Mean separation for each column by Duncan's multiple range test, 99% confidence level.
[z] pH and nutrient levels of compost used.

and leaching. Although available levels of Mg in the compost were low, there appears to be a rapid release of Mg as it decomposes in the soil.

Equally important were the effects of compost on increasing the water-holding capacity of treated soils (Table 2). The addition of compost to the soil not only increased the water-holding capacity of soils at field capacity, but also increased the amount of water available for plant growth (retention difference, the difference between field capacity and wilting point).

Table 2. The water holding capacity of soils 18 months after treatment with 4 levels of screened sludge compost.[x]

	Percent Moisture		
Metric tons/ha.	Field capacity (0.33 bars)	Wilting point (15.0 bars)	Retention difference
0	9.1[y]	2.2	6.9
112	11.4	2.9	8.5
224	12.2	4.2	8.0
448	15.4	5.0	10.4

[x] Analysis supplied by A. Hart and E. Epstein, Biological Waste Management and Soil Nitrogen Laboratory. U.S. Department of Agriculture, Beltsville Agriculture Research Center, Beltsville, Maryland.
[y] Means of 2 replications.

However, the influence compost had on the soils can best be measured by the growth response of *L. tulipifera* and *C. florida* seedlings grown in compost amended soils. As the levels of compost increased from 0 to 224 T/ha there was a corresponding increase in the number of marketable seedlings harvested (Table 3). Increasing the compost levels to 448 T/ha not only reduced the number of seedlings harvested, but also reduced the total number of marketable seedlings.

Table 3. Mean number of *Cornus florida* and *Liriodendron tulipifera* seedlings in each grade harvested from soil amended with screened compost.

Size[z]	*C. florida* T/ha of compost				*L. tulipifera* T/ha of compost			
(cm)	0	112	224	448	0	112	224	448
0-10	16.0	0.5	0.5	0.5	248.5	47.0	26.5	17.0
10-20	75.0	6.5	3.5	2.0	90.0	67.5	39.0	28.5
20-30	182.5	21.0	11.5	8.0	12.5	81.0	58.5	31.0
30-40	111.5	39.0	24.5	16.5	2.5	66.5	65.0	50.0
40-50	23.5	77.5	44.5	54.0	—	46.5	78.0	45.5
50-60	2.5	151.5	138.5	155.0	—	25.5	52.5	43.5
60-70	2.5	102.0	201.0	78.5	—	12.0	36.0	31.5
70-80	—	4.0	16.5	1.5	—	0.5	15.0	6.5
80-90	—	—	1.0	—	—	—	0.5	3.0

Table 3. (Continued)

Mean number of seedlings	414ab[y]	401abc	441a	316c	353ab	347ab	371ab	258b
Mean stem length	31.6d[y]	56.4b	62.1a	58.7ab	13.3d	33.0b	43.6a	45.7a

[x] Established grades based on stem length in cm from the soil line to the uppermost live bud.

[y] Mean separation for each species by Duncan's multiple range test, 95% confidence level.

— Grade with most seedlings is underlined.

The root systems of both species were altered by the use of compost (Figure 1). *C. florida* plants growing in the 0 and 112 T/ha treatments produced the heaviest and most fibrous roots. Seedlings growing in the 224, and 448 T/ha treatments as well as in adjoining beds growing under a general fertilizer program developed coarse, limited root systems. *L. tulipifera* seedlings developed fibrous root systems in 112 and 224 T/ha treatments (Fig. 2). Seedlings growing in 0 and 448 T/ha, as well as in adjoining fertilized nursery beds, developed coarse, poorly branched roots.

L. tulipifera seedlings growing in compost-treated soils were more winter hardy than seedlings grown in the 0 treatment and in adjoining nursery beds. Seedlings in the compost-treated soils retained their foliage after several frosts while seedlings growing in the 0 treatment and in fertilized beds were

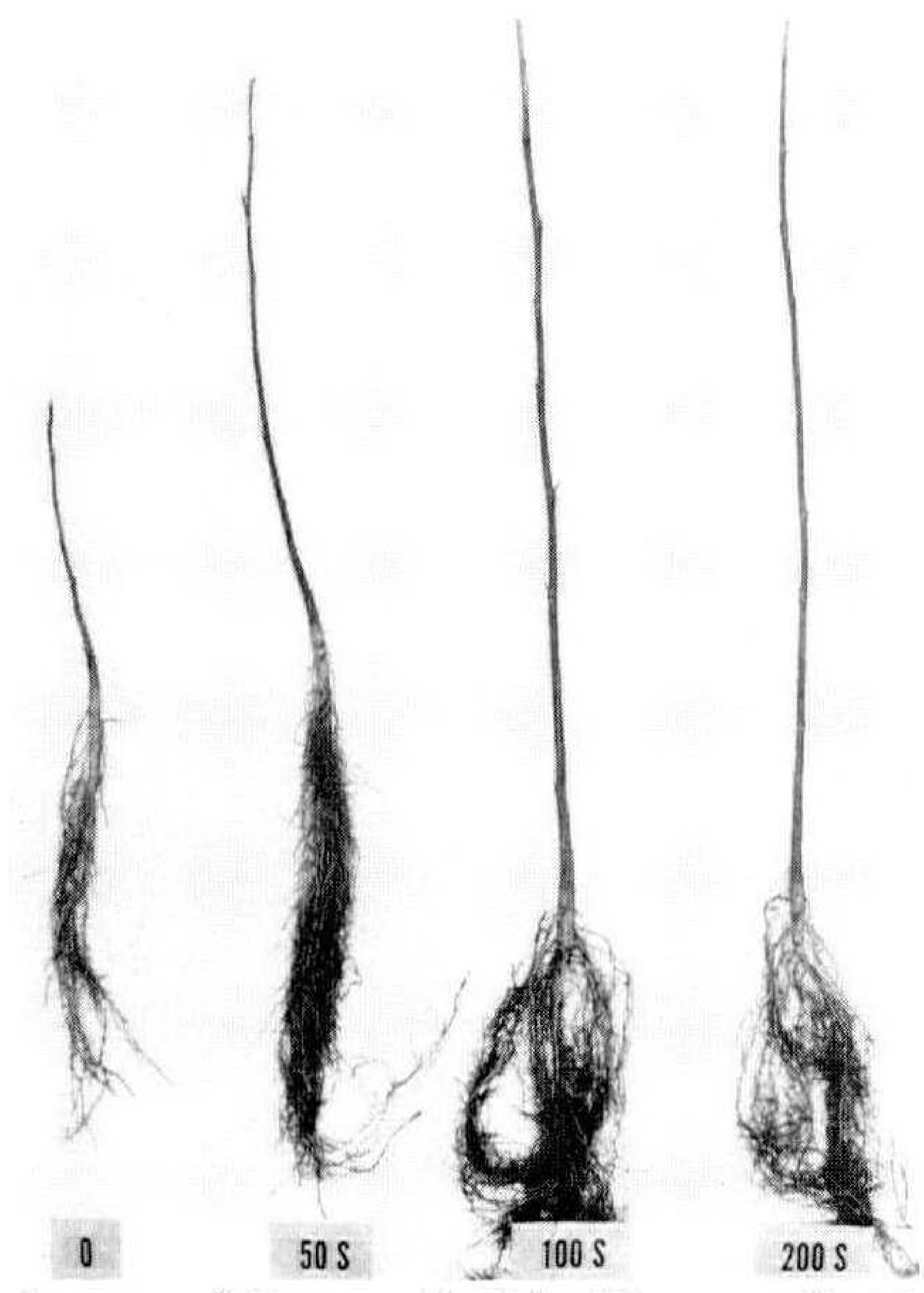

Figure 1. Stems and roots of *Cornus florida* (Dogwood), 16 months after seedings in compost-treated soils. *Soil treatment:* (0) Unfertilized control, (50S), (100S) and (200S), respectively, 112, 224, and 448 T/ha screened composted sludge amendments.

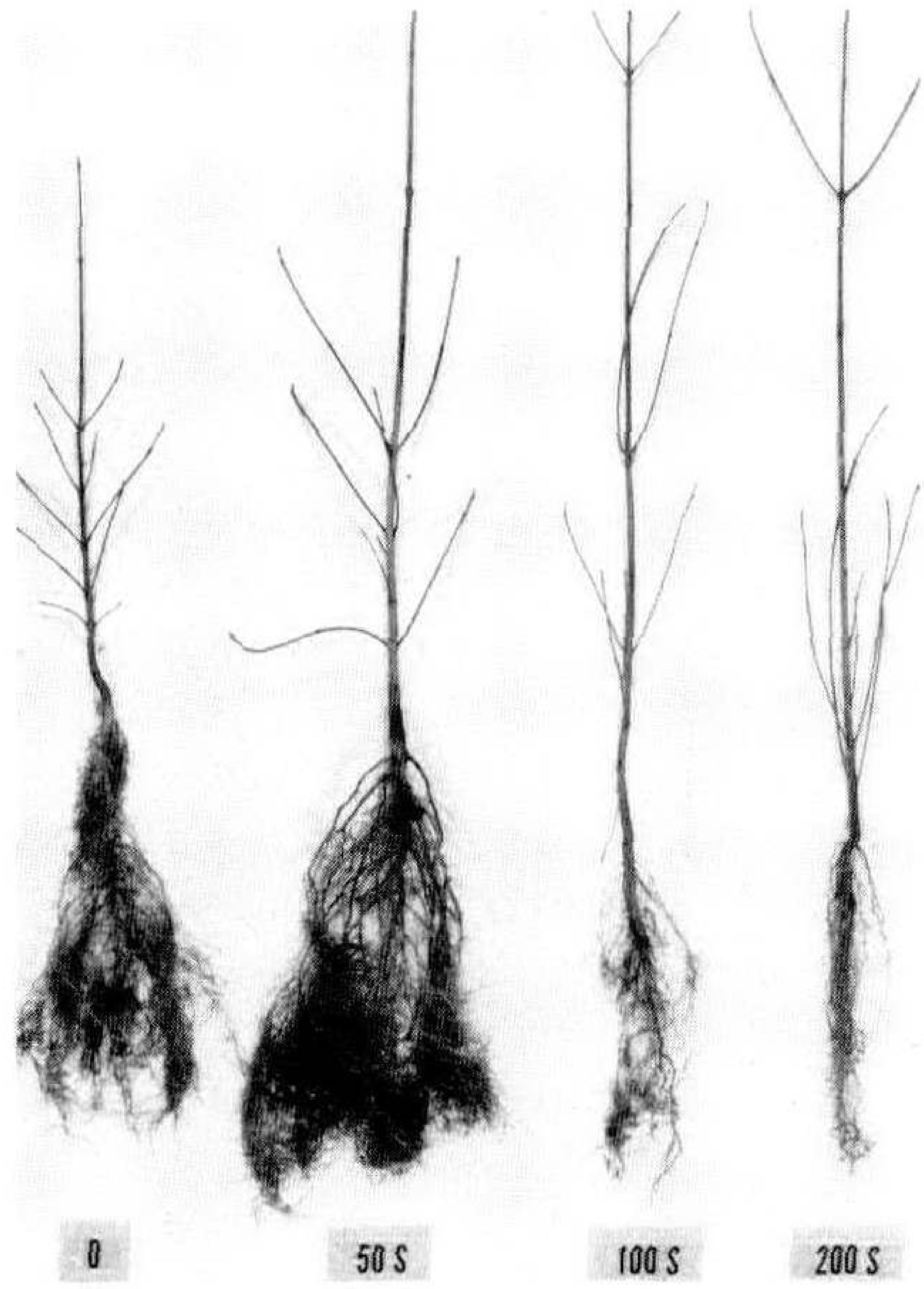

Figure 2. Stems and roots of *Liriodendron tulipifera* (T poplar) 16 months after seeding in composted-treated soils. *Soil treatment:* (0) Unfertilized control, (50S), (100S), and (200S), respectively, 112, 224, 448 T/ha screened composted sludge amendments.

defoliated. In March when the seedlings were harvested and graded, L. *tulipifera* seedlings grown in composted-treated beds exhibited no winter die-back, while seedlings grown in the 0 treatment and in the fertilized beds suffered extensive tip die-back. Increase in the water-holding capacity of the compost and the slow-release of plant nutrients probably accounted for the excellent winter survival observed.

Preliminary studies on the use of screened sewage sludge compost in potting mixes appears promising. Potted rooted cuttings of *Cotoneaster congestus* and *Jasminum nudiflorum* top-dressed with Osmocote 18-6-12 at potting time grew best in a potting mix containing 3 parts screened composted sewage sludge, and 2 parts composted municipal leaves (Table 4) However, by the end of the first growing season only 2/3 of the original potting mix remained in the containers. In the spring, after over-wintering, the containers were only half-full. This loss of the growing medium is primarily attributed to shrinkage due to oxidation. Plants growing in containers filled with 3 parts screened composted sewage sludge and 2 parts sand grew almost equally as well without any noticeable shrinkage in the containers.

To establish Osmocote 18-6-12 fertilizer levels for potting mixes containing screened sewage sludge compost, a replicated trial with *Ilex crenata* 'Buxifolia' was conducted using 3 potting mixes (Table 5). The results indicate that Osmocote levels of 252 g/35.2 liters (9 oz/bu) appear to be near optimum (2). Additional studies are currently being conducted to further evaluate the use of composted sewage sludge for container-growing of ornamental plants.

With increased national emphasis on cleaning up the environment and recycling, it is likely that compost made from sewage sludge will become a readily available material near municipalities, with sludges that are low in heavy metals, within a few years. Several communities are already composting sewage sludge with wood chips, and many more are expressing considerable interest. The possibility of composting sewage sludge with other muncipal waste also looks promising and feasible. The nursery and greenhouse industries appear to be suitable users of this product without the fear of accumulation of heavy metals in soils or in food crops.

Table 4. Growth response of *Cotoneaster congesta* and *Jasminum nudiflorum* growing in 15 cm (6 inch) plastic containers filled with 3 different potting mixes top-dressed with 14 gr (1/2 oz) of Osmocote 18-6-12 per container.

	Total stem length in cm^x		
species	3 compost 2 leaves	3 compost 2 sand	3 leaves 2 sand
C congesta	342	324	309
J. nudiflorum	378	316	310

^{x} Means of 3 replications with 3 plants per replication.

Table 5. Growth response of *Ilex crenata* 'Buxifolia' growing in 15 cm (6 inch plastic containers filled with 3 different potting mixes with 4 levels of Osmocote 18-6-12 fertilizer incorporated in each mix.

Potting mix by volume	18-6-12 Osmocote oz/bu	or g/35.22 L	Mean total stem length^x in cm	
3 composted sewage sludge	0	0	30.9 b^y	
2 sand	3	84	42.7 b	50.4 a
	6	168	56.9 ab	
	9	252	71.1 a	
2 composted sewage sludge	0	0	33.4 b	
1 leaf compost	3	84	46.0 b	55.2 a
2 sand	6	168	59.8 ab	
	9	252	81.6 a	
1 composted sewage sludge	0	0	25.2 b	
2 leaf compost	3	84	33.8 b	43.3 a
2 sand	6	168	43.0 ab	
	9	252	71.4 a	

^{x} Means of 3 replications with 5 plants per replication.
^{y} Mean separation for each column by Duncan's multiple range test, 95% confident level.

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TEMPERATURE RELATIONSHIP IN ROOT INITIATION AND DEVELOPMENT OF CUTTINGS[1]

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Optimum temperatures for rooting of cuttings have long been accepted to be in the range of 20 to 25°C. Many studies have been carried out to support this assumption (2,5). However most studies on rooting temperatures have involved only one evaluation — that of root development after a set time period. Few studies have actually looked at root initiation and root development as two separate plant processes. Likewise, few workers have noted the time required for root initiation at different temperatures and actual root numbers initiated at different temperatures.

Hartmann and Kester (2) state that 21°-27°C day and 15°C night is optimum for most plant species. Below 21°C rooting is reduced and slowed down. At temperatures of 23°-27°C root inhibition often occurs as well as root injury. Howard (4) has shown that easily-rooted plum cuttings root best at 20°C. However, he noted that shy-rooting clones root more readily at 25°C.

A few workers throughout the last 50 years have looked at root initiation and root development as two separate processes in regard to temperature response. Sykes (8) showed that at temperatures of 30°-33°C, hop cuttings showed little delay in callusing and development of small roots, but these roots failed

[1] Michigan Agricultural Experiment Station Journal Article No. 7649.