Root regeneration potentials usually show a peak and then decline with increased time in storage or in the nursery (6, 11). The highest levels of root regeneration in white ash were obtained in April and May. Whether root regeneration potentials will decrease or be maintained at these levels with increased storage at 5°C remains to be determined. The present work demonstrates that increased periods of cold storage enhanced the rate at which growth of white ash seedlings was resumed after transfer to environmental conditions adequate for growth and that seedlings can be stored at 5° at least until May, a time when most sites are available for planting, without any apparent detrimental effects on root regeneration potential and seedling condition.

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Growth of Chrysanthemums Fertilized with Liquid Sewage Sludge[1]

M. B. Kirkham and E. R. Emino[2]

Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01002

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Abstract. **Chrysanthemum plants (*Chrysanthemum morifolium* Ramat. cv. Bright Golden Anne) were grown for 84 days in plastic pots containing 6 different media treated with inorganic fertilizers or liquid digested sewage sludge at 50, 100, and 200 ml/week. Plants grown in 1 soil:1 sand:1 peat, 1 soil:1 sand, and 1 soil:1 peat were similar to each other in size, and larger than plants grown in 1 sand:1 peat, all sand, or all peat. Peat-grown plants were smallest. Plant size and flower diameter decreased with increasing rates of sludge application. Plants fertilized with inorganic sources of fertilizer looked the same as those grown with 50 ml/week sludge (6 mm), except the sludge-treated plants were shorter and had a smaller dry weight. Plants treated with 50 ml/week sludge had flowers with a diameter and dry weight equal to those of flowers grown with liquid or pelletized inorganic fertilizer.**

Liquid digested domestic sewage sludge has been used to fertilize field crops for decades. It is an inexpensive fertilizer, often available free from sewage treatment plants. In 1965 sewage sludge was suggested as a good fertilizer not only for field plants, but also for horticultural and greenhouse crops (1). But no experiments had been done to prove this. A few years ago, Kiplinger[3] found that various greenhouse potted plants could be grown with sludge. However, because the problem of waste disposal was not urgent then, the research was not published.

Composted municipal refuse, which sometimes is treated with sludge, has been used to grow ornamentals (3, 5). Only 2 reports (2, 6) appear to have been published on the use of sludge, without municipal refuse, in greenhouse media to grow ornamental plants. In these studies, dried sludge was incorporated into the media before planting. Sludge was not applied in the liquid form to the growing potted plants.

Chrysanthemum plants (rooted cuttings) with 10 cm top growth were planted in 10 cm diam plastic pots, 1 plant per pot, on Dec. 10, 1974 (Day 1). Six different media, mixed on a volume basis, were tested: 1 soil:1 sand:1 peat; 1 sand:1 peat; 1 soil:1 sand; 1 soil:1 peat; all sand; and all peat. A Hadley very fine sandy loam (4), sphagnum peat moss from New Brunswick, Canada, and coarse, builder's sand were used to formulate the media.

Six fertilizer treatments were used during a 12-wk period (Table 1). Digested secondary liquid sewage sludge was obtained from the Amherst, Massachusetts, Sewage Treatment Plant. (Secondary treatment of wastewater involves the screening and settling processes of primary treatment plus biological activities designed to reduce the quantity of suspended and dissolved organic solids. Digestion is the process in which organic or volatile matter in sludge is gasified, liquefied, mineralized, or converted into more stable organic matter, through the activities of living organisms.) Fifty ml (or about 6 mm) of sludge added weekly to each pot for 12 wk at 2% solids corresponded to a yearly application rate of 15.5 metric tons/ha. Weekly additions of water,

Table 1. Fertilizer treatment of 'Bright Golden Anne' chrysanthemums.

Treatment	Application rate
No sludge or inorganic fertilizer	100 ml tap water per week
A 2600-ppm solution of an inorganic fertilizer (20% N, 9% P, 17% K)	100 ml per week (standard amount added by commercial greenhouse growers)
Plastic-encapsulated and pelletized inorganic fertilizer (trade name: Osmocote; 14% N, 6% P, 12% K)	5 grams per pot, mixed in media before planting (standard amount added by growers); pots then received 100 ml tap water per week
Liquid sewage sludge	50 ml per week
Liquid sewage sludge	100 ml per week
Liquid sewage sludge	200 ml per week

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[2]Second author's present address: Horticulture Section, Soil and Crop Sciences Department, Texas A&M University, College Station, Texas 77843. The authors are indebted to Yoder Brothers, Inc., Barberton, Ohio, for the plants used in this study.

[3]Ohio State University, personal communication.

liquid inorganic fertilizer, and sludge were made for 12 weeks starting on day 4. In addition to the weekly additions of water, liquid inorganic fertilizer, and sludge, the pots were watered as needed to prevent wilting. The pots had drainage holes which allowed free water drainage.

The experiment was carried out under greenhouse conditions. Temp varied from 14 to 25°C (average daily temp = 21°; night temp = 15°C). The relative humidity varied from 45 to 95%. The average pan evaporation rate during the 84-day experiment was 0.20 cm/day. During the first 16 days of the experiment, incandescent lights were used for 4 hr during the night (22:00 to 02:00) to prevent flower bud initiation. From day 17 to 84, no artificial lights were used.

At harvest (day 84) flower diam was measured, plants were cut off at the sludge or media surface, and divided into stems, leaves, and flowers. The plant parts were dried at 80°C and weighed. The experiment was a randomized complete-block design. All combinations of media and treatments were replicated 5 times.

Appearance of plants. Plants that received water only were small and chlorotic, especially those in pots without soil. Plants grown with 50 ml/week sludge looked similar (green, turgid) to plants grown with liquid fertilizer or pelletized fertilizer, except sludge-treated plants were shorter. In general, plants grown with 100 or 200 ml sludge grew poorly because sludge stayed ponded on the pot surfaces. Roots lacked air for growth and plants often appeared wilted.

Dry weight. Plants grown with liquid fertilizer or pelletized fertilizer had the highest total top dry wt (Table 2). There was no difference in growth between the liquid-fertilized and pelletized-fertilizer-treated plants except in the "all sand" medium. In this medium, plants grew better with liquid fertilizer than with the pellets. Simpson et al. (7) found that chrysanthemums grown in a 1 soil:1 sand:1 peat:1 rice hull medium fertilized with liquid fertilizer grew better than those fertilized with pellets (Osmocote) which they incorporated into the medium.

Dry wt of plants grown in the soil-peat medium that received liquid fertilizer exceeded the dry wt of plants grown in all media-fertilizer combinations except soil-sand with liquid fertilizer, soil-sand with pelletized fertilizer, and soil-peat with pelletized fertilizer. Presence of soil in the media increased plant growth. Chrysanthemums grown in the soil-sand-peat, soil-sand, and soil-peat media grew the best, disregarding treatment effects. The sand-peat, all sand, and all peat media produced poor growth.

Table 2. Dry weight of chrysanthemum plants grown for 84 days in 6 media with inorganic fertilizers or sewage sludge.

Treatment	Plant dry wt (g)					
	Soil-sand-peat	Sand-peat	Soil-sand	Soil-peat	Sand	Peat
			Total top growth			
No sludge, no inorganic fertilizer	3.1d-h[z]	1.6a-e	3.2e-h	3.6f-i	2.1a-f	1.3a-e
Liquid fertilizer	11.5n-p	4.8h-k	12.4p-r	13.9r	6.0k	3.5f-i
Pelletized fertilizer	12.0o-q	5.2i-k	13.1p-r	13.3q-r	4.0g-j	1.8a-f
50 ml sludge weekly	9.01-m	3.0c-h	8.51	10.4m-o	3.6f-i	1.2a-d
100 ml sludge weekly	6.1k	1.4a-e	5.3i-k	10.01-n	1.6a-e	1.3a-d
200 ml sludge weekly	2.4b-g	0.5a	1.1a-c	5.5j-k	0.9a-b	0.2a
			Flowers			
No sludge, no inorganic fertilizer	0.6a-b	0.3a-b	0.5a-b	0.6a-b	0.5a-b	0.4a-b
Liquid fertilizer	2.5f-i	1.1b-e	3.2i-k	3.1i-k	1.8d-g	0.4a-b
Pelletized fertilizer	3.3i-k	1.9e-g	3.7k	3.4j-k	1.7c-f	0.3a-b
50 ml sludge weekly	2.8h-j	0.9a-c	2.6g-j	3.2i-k	1.0b-d	0.2a-b
100 ml sludge weekly	1.9f-h	0.4a-b	2.2f-h	3.3i-k	0.7a-b	0.1a-b
200 ml sludge weekly	0.8a-b	0.2a-b	0.6a-b	1.7c-g	0.2a-b	0.0a

[z]Mean separation by Duncan's new multiple range test, 5% level.

Table 3. Flower diameter of chrysanthemum plants grown for 84 days in 6 media with inorganic fertilizers or sewage sludge.

Treatment	Flower diam (cm)					
	Soil-sand-peat	Sand-peat	Soil-sand	Soil-peat	Sand	Peat
No sludge, no inorganic fertilizer	9.2e-h[z]	6.7b-e	9.6e-h	7.4c-f	1.5a-b	2.5a-b
Liquid fertilizer	11.4f-h	7.7c-g	12.4g-h	11.2f-h	11.7f-h	5.5b-e
Pelletized fertilizer	12.1f-h	10.6f-h	12.1f-h	11.6f-h	11.7f-h	7.2c-f
50 ml sludge weekly	12.4g-h	8.4d-h	12.7h	12.4g-h	9.7e-h	4.4a-d
100 ml sludge weekly	12.7h	5.4b-e	10.9f-h	11.6f-h	8.5d-h	3.1a-c
200 ml sludge weekly	7.8d-h	1.5a-b	4.0a-d	8.2d-h	5.1b-e	0.2a

[z]Mean separation by Duncan's new multiple range test, 5% level.

Total top dry wt generally decreased with increasing sludge application rate. Plants grown with 50 ml/week sludge usually had less top dry wt than plants grown with liquid fertilizer or with pelletized fertilizer. However, plants grown in the soil-peat medium that received 50 ml/week sludge grew as well as plants grown in the soil-sand-peat medium treated with either liquid fertilizer or pelletized fertilizer. In general, flower dry wt of plants grown with 50 ml/week sludge was similar to flower dry wt of plants grown with liquid fertilizer or pelletized fertilizer.

Flower diameter. Generally, plants grown with 50 ml/week sludge produced flower diam similar to those of plants grown with either liquid inorganic fertilizer or pelletized fertilizer (Table 3). Also, as sludge application rate increased, flower diam decreased except in the soil-sand-peat medium.

Conclusion. The results of this experiment suggested that liquid sewage sludge can be used as a fertilizer to grow chrysanthemum flowers. An application rate of 50 ml/week sludge to 10 cm diam pots produced flowers with a diam and dry wt similar to those of flowers grown with liquid fertilizer or pelletized fertilizer.

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