Interactive Effects of Sewage Effluent Irrigation and Supplemental Fertilization on Container-grown Trees

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Abstract. **Twenty species of ornamental trees were grown for 12–16 months in 50 cm diameter ("20 gallon") containers. Six individuals of each species were irrigated with tap water from a public potable water supply and 6 with secondary treated sewage effluent from a wastewater treatment facility. Three individuals within each irrigation treatment received controlled-release fertilizer applications and 3 received no supplemental fertilization. The effluent irrigation significantly accelerated growth in 4 species: orchid tree (*Bauhinia variegata* L.), baldcypress (*Taxodium distichum* (L.) L. Rich), coconut palm (*Cocos nucifera* L.), and black ironwood (*Krugiodendron ferreum* [Vahl] Urban). The addition of supplemental fertilization accelerated growth in 7 species: orchid tree, ficus (*Ficus benjamina* L.), black olive (*Bucida buceras* L.), satin leaf (*Chrysophyllum oliviforme* L.), royal poinciana (*Delonix regia* [Bojer] Raf.), silver buttonwood (*Conocarpus erectus* var. *sericeus* Fors. ex DC.), and blolly (*Pisonia discolor* Spreng.). A significant interaction occurred between irrigation and fertilization in 3 species: orchid tree, red cedar (*Juniperus silicicola* [Small] L. H. Bailey), and lignum vitae (*Guaicum sanctum* L.). The remaining 8 species grew at rates that were not significantly influenced, one way or another, by either source of irrigation or supplemental fertilization.**

One of the most important aspects of efficient horticultural production is irrigation, both in quantitative and qualitative terms. Adequate water of acceptable quality can be a limiting factor, and in times of water shortages, water rationing has been shown to have a significant and profound effect on plant growth in horticultural crops (9, 10). Water shortages, caused by drought conditions or governmental regulation, have served as an impetus to evaluate irrigation source alternatives.

One promising alternative is the use of treated sewage effluent, available in copious quantities in virtually all urban areas. Under federal law, all sewage wastewater treatment facilities must have a National Pollution Discharge Elimination System (NPDES) permit. This system is regulated and managed by the United States Environmental Protection Agency (EPA), although the EPA has delegated this authority to certain states and certain political subdivisions within states. Due to the NPDES permit requirement, it is possible to achieve broad categorization of wastewater facilities based on the chemical nature of the effluents produced. The parameters can be used to help evaluate potential for horticultural exploitation of the effluents; for example, secondary treated effluents are those with values of N less than 30 mg/L and P less than 10 mg/L, among other factors. Advanced wastewater treatment (AWT) effluent may not have N levels in excess of 5 mg/L, or P levels higher than 1 mg/L. Other parameters, such as total suspended solids or total dissolved solids also may have significance in the evaluation of wastewater reuse potential.

Wastewater effects on plant growth have been the subject of numerous studies, including field and forage crops (5, 6, 7), wetland and forest ecosystems, (4, 13) and, in most instances, beneficial use of effluent either has been demonstrated or has shown potential. There has been relatively little work on effluent use in horticulture apart from citrus and some other fruit crops (1) and pilot project work in hydroponic culture (2). There has been some study of recycled irrigation water to optimize water resource potential (12), and of general guidelines on effluent use in horticulture (3, 8).

Although there is clear potential for increasing exploitation of wastewater for horticultural crops, there remain certain barriers.

Regulatory barriers, for the most part based on health considerations, have eased in recent years due to improved methods of pathogen reduction in wastewater treatment. Modernization of wastewater treatment systems, as mandated by the Clean Water Act, has included regional transmission lines that can allow growers who are not very close to wastewater facilities to arrange more easily for interconnection. One remaining barrier has been lack of information on how specific horticultural crops would respond to effluent irrigation. The objective of this study was to determine if effluent irrigation would yield growth results comparable to those obtained with tap water irrigation among 20 species of container grown ornamental trees.

Seedlings or rooted cuttings of 20 tree species of equal size per species were planted in 50 cm diameter ("20 gallon") containers. The species were: orchid tree, baldcypress, coconut palm, black ironwood, ficus, black olive, satin leaf, royal poinciana, silver buttonwood, blolly, red cedar, lignum vitae, seagrape (*Coccoloba uvifera* [L.] L.), carambola (*Averrhoa carambola* L.), sunshine palm (*Veitchia* 'Sunshine Palm'), silver palm (*Coccothrinax argentata* [Jacq.] L.H. Bailey), carpentaria palm (*Carpentaria acuminata* [H. Wendl. & Drude] Becc.), Geiger tree (*Cordia sebestena* L.), paradise tree (*Simarouba glauca* DC.), and red maple (*Acer rubrum* L.). The growing medium was sewage sludge compost, which has become, over a 10 year period, a commonly used potting medium in several tree nurseries in southern Florida (11). The compost was made from heat-treated dewatered sewage sludge at the Broward County Streets and Highways Division Sludge Composting Facility, using the windrow procedure with wood chips as the bulking agent. After composting, the chips were removed with a Royer® Model 365 shredder-mixer, resulting in a potting mix consisting of about 90 compost: 10 residual wood chips (v/v). Supplemental fertilization, when used, was 18N-3P-10K Osmocote®, applied at 320 g/container at the time of planting and at 6-month intervals thereafter. This rate was determined by extrapolation of the manufacturer's recommended rate for nursery crops grown in 5 gallon containers. Irrigation was provided from 2 sources: secondary treated sewage effluent from a nearby wastewater treatment facility and tap water from the local public utility. Irrigation was applied in a low volume drip system using dribble rings placed around each tree trunk. Analyses of monthly effluent samples by the Broward County Environmental Quality Control Board yielded average values of N = 6.8 mg/L (SD = 5.8), P = 2.5 mg/L (SD = 0.8), Cl = 394.3 mg/L (SD = 47.8), and total suspended solids = 13.3 mg/L (SD = 3.7). Heavy metal analyses were conducted less frequently, one time per year, on effluent composites collected over a 6-hour period on the sampling day. The one effluent composite analyzed during the course of this research yielded a Cd residue of <0.005 mg/L, Pb of <0.10 mg/L, Cr of <0.05 mg/L, Ni of <0.04 mg/L, and Zn of 0.023 mg/L. Trees were evaluated at planting and at 3-month intervals thereafter by means of a growth index whereby tree height and average spread (cm) were summed. The production period for most of the 20 species was

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Table 1. Growth of 20 species of container grown trees as influenced by secondary treated sewage effluent irrigation and supplemental fertilization.

	Average growth index at end of production period (N = 3)[z]				Significance[y]		
	Effluent irrigation		Tap water irrigation				
Species	Fertilized[x]	Nonfertilized	Fertilized	Nonfertilized	Effluent irrigation	Fertilizer	Water × Fert.
Orchid tree	375	394	384	234	**	*	**
Baldcypress	361	369	310	310	*	NS	NS
Coconut palm	472	515	431	366	*	NS	NS
Black ironwood	M[w]	222	M	126	*	NA	NA
Ficus	338	289	327	267	NS	**	NS
Black olive	415	380	468	324	NS	*	NS
Satin leaf	355	219	317	283	NS	*	NS
Royal poinciana	501	199	424	335	NS	*	NS
Silver buttonwood	378	326	341	269	NS	*	NS
Blolly	396	319	408	334	NS	**	NS
Red cedar	224	313	307	287	NS	NS	*
Lignum vitae	82	116	102	75	NS	NS	**
Seagrape	326	274	286	289	NS	NS	NS
Carambola	256	M	250	M	NS	NA	NA
Sunshine palm	374	319	431	318	NS	NS	NS
Silver palm	118	122	81	92	NS	NS	NS
Carpentaria palm	323	302	352	356	NS	NS	NS
Geiger tree	297	283	335	277	NS	NS	NS
Paradise tree	260	216	343	232	NS	NS	NS
Red maple	187	162	230	115	NS	NS	NS

[z]Growth index determined by summing plant height plus spread (cm); all species had a 16 month production period, except ficus, which had 12 months.

[y]Significant at the 1% level (**), 5% level (*), nonsignificant (NS), not analyzed (NA).

[x]18-3-10 Osmocote top dressed at 320 g/50 cm diameter container at planting and at 6-month intervals thereafter.

[w]All individuals died before end of production period.

16 months, although one of the faster growing species, ficus, had a 12 month production period. The experiment was a 2 × 2 factorial in a completely randomized design, with 3 replications per treatment.

Average growth index at term for the 20 species of trees under the 4 treatment regimes is shown in Table 1. Two species, black ironwood and carambola, did not tolerate certain treatments. The black ironwood trees under both irrigation regimes that received supplemental fertilization had 100% mortality, but those that received no supplemental fertilization survived. Moreover, those irrigated with effluent grew significantly faster than those irrigated with tap water, suggesting a rather narrow nutrient tolerance for this tropical forest species when grown in nursery culture. The carambola trees that received no supplemental fertilization all died before term, suggesting a substantial nutrient requirement for this tropical fruit species.

Of the 20 species tested, 4 had significantly accelerated growth when irrigated with effluent (orchid tree, baldcypress, coconut palm, and black ironwood), and the remaining 16 species exhibited growth that was not influenced by the irrigation water source, one way or another. Seven species (orchid tree, ficus, black olive, satin leaf, royal poinciana, silver buttonwood, and blolly) all grew at significantly faster rates when subjected to supplemental fertilization than when not fertilized. Three species (orchid tree, red cedar and lignum vitae) all showed significant interactions between irrigation and supplemental fertilization effects. The fastest growth occurred among the individuals that received effluent irrigation with no supplemental fertilization or tap water irrigation with supplemental fertilization. The results for these 3 species suggest a relatively narrow tolerance for optimum growth.

Although there were no instances in which effluent irrigation was associated with significantly reduced growth rate, several species revealed nonsignificant treatment effects. These species, including red maple, paradise tree, and Geiger tree, all grew faster when irrigated with tap water compared to effluent, but the differences were not significant ($P = 0.05$).

Sewage effluent contains more nutrient elements, especially N and P, than most irrigation sources; it is readily available in many areas where horticultural applications could be employed; and due to recent advances in the quality of wastewater treatment, it is relatively safe and easy to use. The demonstration of its utility as an irrigation source in the container production of large trees should help to extend the recognition of the value of this resource in horticulture.

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