Use of Compost Products for Ornamental Crop Production: Research and Grower Experiences

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Composting is believed to be as old as agriculture itself. The earliest known written reference to composting is found in the clay tablets dated to the time of the Akkadian Empire, ≈2700 BC (Rodale et al., 1960). However, the words most commonly used to describe both the process and the product are of relatively recent invention. The noun "compost" first appeared in the English language in 1587 and the verb "to compost" in 1757 (Mish, 1988). Older references describing both the process and the product used words, such as dung and manure, without reference to processing, aging, or stabilization; modern readers must be sensitive to the changing meaning of the various phrases used to describe the controlled decomposition of organic matter to a point where the product can be safely and beneficially used to improve crop productivity (Obeng and Wright, 1987; Poincelot, 1975).

While composting and compost use in plant production are practices that have been employed for thousands of years, two recent developments are especially noteworthy. For most of recorded history, the reported benefits of compost use in crop production were anecdotal rather than the result of controlled scientific study. In the early years of the 20th century, the results of controlled studies on both compost making and compost use in increasing crop productivity were first published (Howard and Wad, 1931). Since these early reports, numerous studies have been published describing the types of compost products made by different kinds of technologies and their effects when used as components in plant production systems. The second recent development is the emergence of organized business enterprises that make, but do not use, compost products. These enterprises earn money by accepting organic waste materials from a variety of customers who pay disposal fees to the composting business; the enterprises also earn money by selling finished compost products to plant growers. There are no complete records indicating the first commercial compost marketers, but one of the earliest ones was Kellogg Supply Inc., in Carson, Calif., which was marketing compost products as early as 1927 and is still in business (Kellogg, 1985). Thus, over the past 60 or so years, there has arisen a new class of compost users who have not been involved in the production of the compost they use. While some of them have developed significant knowledge on issues relating to compost use in horticultural production, others have not. Since compost materials sold by commercial companies are manufactured products, there can be a great deal of variation in the different parameters important to successful plant production. All growers who are interested in using compost products to increase productivity must keep in mind that use patterns associated with naturally occurring organic products, such as peat and related materials, are not necessarily the same as the use patterns associated with manufactured compost products.

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IMPORTANT FACTORS IN A CONTAINER GROWING MEDIUM

While there is no perfect growing medium for all ornamental crops under all growing conditions, numerous authors have described general recommendations. For example, Joiner (1981) recommends for container-grown foliage crops the following general parameters: bulk density—0.30 $g\cdot cm^{-3}$ (dry), 0.60 to 1.20 $g\cdot cm^{-3}$ (wet); pore space—5% to 30%; water-holding capacity—20% to 60%; pH—5.5 to 6.5; soluble salts—400 to 1000 $mg\cdot L^{-1}$; cation exchange capacity—10 to 100 $meq\cdot 100\ cm^{-3}$.

Frequently, commercially made compost products have pH levels higher than those listed above; ranges of pH 6.7 to 7.7 are not uncommon (e.g., Conover and Joiner , 1966; Fitzpatrick, 1989; Fitzpatrick and Verkade, 1991). High pH values can result from the chemical qualities of the substrates from which the composts are made, or from materials added to the substrates. For example, composts made from stabilized sewage sludge frequently have high pH values because of chemical stabilizers, such as lime, added to the sludges prior to composting. Unless milled, (see Fitzpatrick, 1989), pore space and water-holding capacities of commercially made compost products are usually within the acceptable ranges. Soluble salt levels, cation exchange capacity, and bulk density may all be significantly influenced by the composition of the parent material or by preprocessing, so growers of ornamental crops should monitor these parameters regularly.

ISSUES PERTAINING TO COMPOST USE IN ORNAMENTAL CROP PRODUCTION

Use in media for ornamental crop production is high on the list of priorities of agricultural uses of compost products because of the relatively high value of nursery and greenhouse crops and the need for organic matter for rooting substrates (Slivka et al., 1992; Tyler, 1993, 1996). Every time a container-grown plant is sold, the rooting substrate is sold with it, necessitating the need for more substrate. Many compost products contain significant levels of certain plant nutrients, but rarely in sufficient concentrations to provide all of an ornamental crop's requirement. For example, in one study in which tropical trees were grown in containers (Fig. 1), the compost products used did not provide sufficient nutrients when used without fertilization, especially for rapidly growing trees, such as schefflera (*Brassaia actinophylla* Endl.) and West Indian mahogany [*Swietienia mahagoni* (L.) Jacq.] (Fitzpatrick, 1985). In this same study, the growth rates of slower growing trees, such as pink tabebuia [*Tabebuia pallida* (Lindl.) Miers.] and pigeon-plum (*Coccoloba diversifolia* Jacq.), did not differ whether grown in sewage sludge compost and irrigated with secondary treated sewage effluent or in a peat, pine bark, and sand medium fertilized at normal nursery crop levels. Apparently, the levels of N in the effluent (average 6.8 $mg\cdot L^{-1}$, SD = 5.8) were sufficient to augment nutrients provided by the compost medium for these slower growing trees, but not sufficient for the faster growing species.

The attractiveness of ornamental crops as outlets for compost products does not come without cost. Since the plant's root system is in direct and continual contact with the compost, any concerns regarding compost quality are most acute with container crops and numerous factors can influence quality (Rynk et al., 1992).

Parent material. Compost products are made from a wide variety of materials, including municipal solid waste (commonly known as garbage), biosolids (commonly known as sewage sludge), animal manures, yard trimmings, agricultural residues, waste paper, food processing wastes, and many other materials. The composition of the parent material can have an influence on the quality of the product. For example, a compost made from sewage sludge supported more rapid growth in container-grown *Viburnum suspensum* Lindl. than did composts made from less nitrogen-rich materials, such as garbage, yard trimmings, and stable sweepings (Fitzpatrick and Verkade, 1991).

Preprocessing and postprocessing. Procedures employed before and after the active composting period can sometimes influence compost quality. For example, sludges are frequently stabilized and conditioned prior to being subjected to composting. If a sludge is stabilized by treatment with ferric chloride and lime, a common practice in many wastewater treatment facilities, the level of soluble salts in the finished product may be significantly higher than in compost made from sludge that had been stabilized using a wet-air oxidation process. When composts made from sludges treated with ferric chloride and lime were compared with composts made from sludges not treated with these materials as media for the non-salt-tolerant container crops *Spathiphyllum* 'Mauna Loa' and *Schefflera arboricola* Hayata, plants were significantly smaller when grown in composts with higher soluble salts (Fig. 2). However, plants grown in either of these compost products were significantly larger than those grown in a control medium consisting of 40% peat, 50% pine bark, and 10% sand (Fitzpatrick, 1986). Other processing procedures, such as screening, can influence the physical quality of the compost products by making them more homogenous and, consequently, easier for the grower to mix and apply.

Active composting time and compost product maturity. The earliest references on composting time published in the modern era (e.g., Howard and Wad, 1931) indicate an optimum composting time of ≈6 months for mixtures containing 25% of high nitrogen material, such as animal manure, and 75% high carbon material, such as plant debris. Many current commercial compost producers promise a stabilized end product in a much shorter period. Since many compost producers derive the bulk of their income from fees charged to the waste producers, a strong economic incentive exists to accelerate the active composting. Commercial plant producers who purchase compost products from such sources must be mindful of the negative effects of using immature composts, such as biological blockage of nitrogen, deformity or death of plant parts caused by the ephemeral production of phytotoxic chemicals by the microflora present in immature composts, and increased mobility of certain toxic elements in the soil caused by the reduction of soil redox capacity (Jimenez and Garcia, 1989). Many growers who use compost products store newly delivered material for 6 to 12 months, allowing them to decompose further, as an insurance against any phytotoxic effect that might occur should even a portion of the compost delivered contain immature material.

Content of inert material. Certain types of parent materials may contain noncompostable substances, such as particles of glass or plastic, and metal objects. These materials may be unsightly and can cause hazards, particularly if they have sharp edges. If a compost is made exclusively from materials such as yard trimmings, leaves, or plant debris, then inert material is usually not a problem. If, however, a compost is made from municipal solid waste, inert materials may be a problem, particularly if the parent materials have not been subjected to sufficient preprocessing. Some states have passed environmental regulations limiting the amount of inert materials in compost products. For example, in Florida, state regulations mandate that inert materials may not exceed 2%, by mass, in compost products marketed for unrestricted horticultural uses (Florida Dept. of Environmental Protection, 1989). In other areas, compost producers and brokers have developed self-regulation programs. For example, compost producers in Ohio will not sell a compost product for nursery use if the level of inert material exceeds 0.5%, by mass (Tyler, 1993). The issue of inert material presence in composts is particularly important in container production of ornamental crops for retail markets. Any dangerous, sharp objects in the growing medium can have dire consequences.

Regulated elements. One of the almost universal concerns related to compost use is the question of regulated elements. The U.S. Environmental Protection Agency has issued recommendations for the maximum permissible levels in compost products of 10 heavy

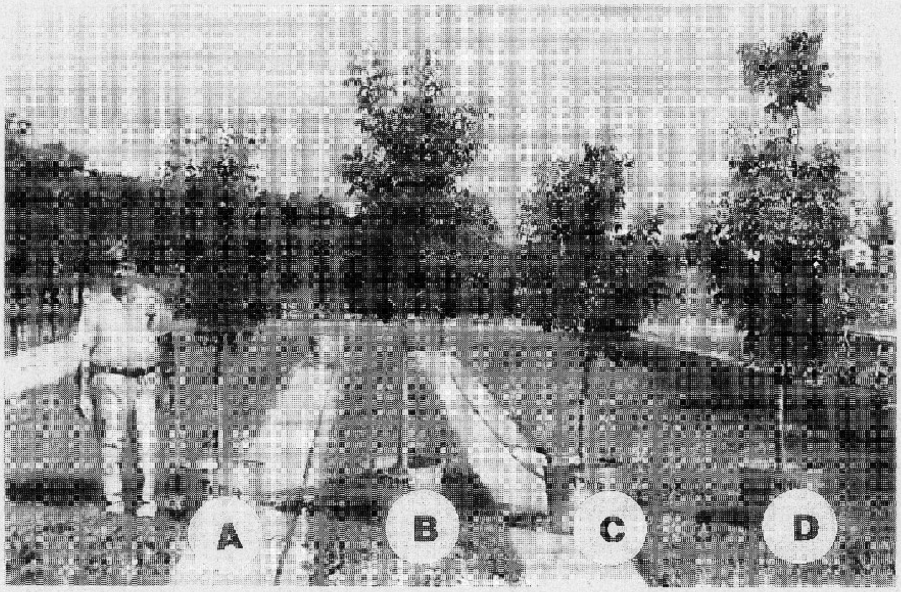

Fig. 1. Effects of medium and irrigation with sewage effluent on growth of West Indian mahogany (*Swietenia mahagoni*). Trees were grown in (**A** and **D**) peat, pine bark, and sand, or in a (**B** and **C**) compost medium. Treatments applied were: (**A**, **B**) irrigated with secondary sewage effluent without fertilization; (**C**) irrigated with well water alone; (**D** = control) irrigated with well water and fertilized at normal nursery crop rates (Fitzpatrick, 1985).

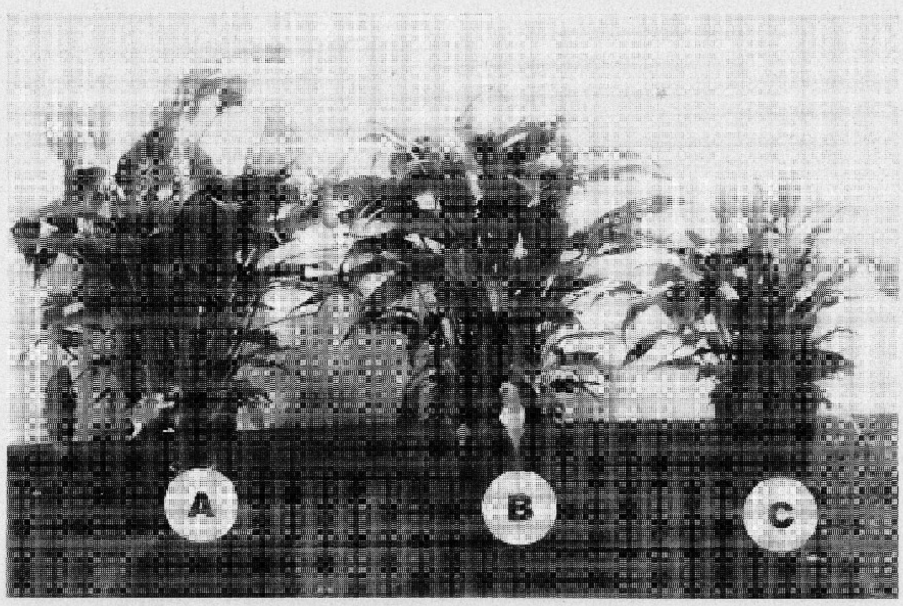

Fig. 2. Effects of electrical conductivity of compost medium on growth of *Spathiphyllum* 'Mauna Loa': (**A**) 3.9 dS·M^{-1}; (**B**) 7.5 dS·M^{-1}; (**C**) 3.5 dS·M^{-1} (Fitzpatrick, 1986).

metals: arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc. Many of the states have passed their own regulations, using the federal recommendations as guidelines. Substantial differences in heavy metal concentrations can exist between different types of compost products that are attributable to the parent material and the relative level of preprocessing (Table 1). However, the overwhelming majority of compost products that are available at the present time fall well within the federal and state guidelines (Chaney and Ryan, 1993; Stilwell, 1993). The safety of compost products has been improved by the reduction of toxic heavy metals in waste streams. Such reduction have been obtained by the implementation of industrial pretreatment programs as well as by quality control programs practiced by commercial compost producers and monitored by governmental regulatory authorities.

Microbiological status. A common concern relative to compost use is the possible presence of pathogenic organisms. The heat generated during active composting reduces the levels of any pathogens that might have been present in the parent material to insignificant levels (Burge, 1983; Haug, 1993). However, since commercial composting is frequently conducted on a large scale, involving hundreds of tons per day, the question of the existence of cool spots within active compost piles and the possibility of reinoculation after composting are normally addressed by examining representative samples of the product and conducting microbiological screening. Usually, the pathogens themselves are not cultured, but the compost samples are tested for the presence of indicator organisms, such as fecal coliform bacteria. Indicator organism tests are simple, reliable, and are required by both federal and state regulations. They serve as an additional safeguard to insure the maintenance of compost quality and safety.

Another microbiological issue of concern is the presence of the ubiquitous thermotolerant fungus *Aspergillus fumigatus* Fres., a saprophyte frequently found in decaying organic materials. *A. fumigatus* is one of the relatively few fungi that can be pathogenic to humans, since the temperature of the human body, 37 °C, is optimum for its growth (Oliver, 1994). However, the relatively small number of confirmed cases of aspergillosis, coupled with the ubiquity of *A. fumigatus* in the environment, suggests that the susceptibility of humans is rather low. A recent review of the literature indicates that humans that are immunocompromised may become ill after only a minimal exposure to *A. fumigatus*, but that healthy individuals appear to show no significant health impacts from exposure to this fungus (Maritato et al., 1992). Moreover, the average horticultural worker is exposed to many substrates that contain *A. fumigatus*, such as soil, peat, sawdust, wood chips, and other products. If horticultural workers do not experience any aspergillosis symptoms from contact with these products, they probably will not do so as a result of exposure to compost products.

Table 1. Residues of cadmium, copper, lead, and zinc in two types of compost products.[z]

Element	Average residue (N = 3), mg·kg⁻¹ dry mass		
	Municipal solid waste compost[y]	Sludge-yard trimming compost[x]	Control growing medium[w]
Cadmium	0.87	0.43	<0.09
Copper	96.21	3.84	1.74
Lead	27.30	2.28	0.68
Zinc	127.63	39.61	7.93

[z]Analyses conducted by the students in Principles of Horticultural Compost Technology AGG 4932, Univ. of Florida, Fall semester, 1994, using the DTPA (diethylenetriaminepentaacetic acid) method (Lindsay and Norvell, 1978).

[y]Bagged Agrisoil municipal solid waste compost, made in 1990 by Agripost Co., Miami.

[x]Bulk-delivered compost made in 1989 of 1 dewatered sewage sludge : 3 yard trimmings by the Broward County Public Works Dept., Pompano Beach, Fla.

[w]A commercial growing medium made of 4 peat : 5 pine bark : 1 sand.

EXPERIENCES USING COMPOST PRODUCTS FOR ORNAMENTAL CROP PRODUCTION

Numerous research studies have been published, some of which are described in the preceding sections of this paper, on how compost products can be used to improve production of nursery crops. In addition to these studies, several general reviews report numerous studies in summary form. Sanderson (1980) reviewed many published studies and reported significant increases in productivity across a wide variety of nursery crops. More recently, Shiralipour et al. (1992) reviewed compost use in a wide variety of crops, including nursery crops, and reported significant increases in productivity as a result of using compost products.

Compost materials have been used successfully to grow a wide spectrum of nursery crops, from flowering annuals (Wootton et al., 1981) to container-grown tropical trees (Fitzpatrick, 1985). In a demonstration project conducted in 1979–80 at a commercial nursery in southern Florida, a number of container-grown ornamental species grown in a compost made from sewage sludge and yard trimmings grew to marketable size significantly faster than did plants grown in a medium composed of 6 peat: 4 sawdust: 1 sand (by volume) (Fitzpatrick, 1981). Plants of one of the species tested, dwarf oleander (*Nerium oleander* L.), grown in 25-cm-diameter containers for 5 months, were ≈1.25× as large when grown in the compost mixture than when grown in a control medium (Fig. 3). Moreover, compost products have been successfully used in field nurseries as soil amendments to increase productivity in various tree species (Gouin, 1977; Gouin and Walker, 1977).

Careful attention to the characteristics of the growing medium can allow faster and more economical production of ornamental crops. Since nursery crops need new growing medium as each growing cycle is completed, compost marketers have the opportunity to develop products that can be very attractive to ornamental plant growers. Provided that the compost products are made with emphasis on quality, their use in nursery crop production will probably continue to expand.

Fig. 3. Effect of medium on growth of dwarf oleander (*Nerium oleander*) grown in 25-cm-diameter containers for 5 months in a trial conducted at a commercial nursery: (**A**) compost made from 1 sewage sludge : 3 yard trimmings (by volume); (**B** = control) 6 peat : 4 sawdust : 1 sand (by volume) (Fitzpatrick, 1981).

Literature Cited

Burge, W.D. 1983. Monitoring pathogen destruction. BioCycle 24(2):48–50.

Chaney, R.L. and J.A. Ryan. 1993. Heavy metals and toxic organic pollutants in MSW composts: Research results on phytoavailability, bioavailability and fate, p. 451–506. In: H.A.J. Hoitink and H.M. Keener (eds.). Science and engineering of composting. Renaissance Publ., Worthington, Ohio.

Conover, C.A. and J.N. Joiner. 1966. Garbage compost as a potential soil component in production of *Chrysanthemum morifolium* 'Yellow Delaware' and 'Oregon'. Proc. Florida State Hort. Soc. 79:424–426.

Fitzpatrick, G. 1981. Evaluation of potting mixes derived from urban waste products. Proc. Florida State Hort. Soc. 94:95–97.

Fitzpatrick, G. 1985. Container production of tropical trees using sewage effluent, incinerator ash and sludge compost. J. Environ. Hort. 3:123–125.

Fitzpatrick, G.E. 1986. Sludge processing effects on compost quality. BioCycle 27(9):32–35.

Fitzpatrick, G.E. 1989. Solid waste composts as growing media. BioCycle 30(9):62–64.

Fitzpatrick, G. and N.S. Carter. 1983. Assessment of sewage sludge compost mixtures as container growing media. Proc. Florida State Hort. Soc. 96:257–259.

Fitzpatrick, G.E. and S.D. Verkade. 1991. Substrate influence on compost efficacy as a nursery growing medium. Proc. Florida State Hort. Soc. 104:308–310.

Florida Dept. of Environmental Protection. 1989. Criteria for the production and use of compost made from solid waste. Florida Administrative Code, Chapter 62–709. Dept. of Environ. Protection, Tallahassee, Fla.

Gouin, F.R. 1977. Conifer tree seedling response to nursery soil amended with composted sewage sludge. HortScience 12:341–342.

Gouin, F.R. and J.M. Walker. 1977. Deciduous tree seedling response to nursery soil amended with composted sewage sludge. HortScience 12:45–47.

Haug, R.T. 1993. Pathogenic organisms, p. 149–159. In: R.T. Haug. The practical handbook of compost engineering. Lewis Publ., Boca Raton, Fla.

Howard, A. and Y.D. Wad. 1931. The waste products of agriculture, their utilization as humus. Oxford Univ. Press, London.

Jimenez, E.I. and V.P. Garcia. 1989. Evaluation of city refuse compost maturity: A review. Biol. Wastes 27:115–142.

Joiner, J.N. (ed.). 1981. Foliage plant production. Prentice-Hall, Englewood Cliffs, N.J.

Kellogg, C. 1985. Marketing to targeted users. BioCycle 26(5):44.

Lindsay, W.L. and W.A. Norvell. 1978. Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil Sci. Soc. Amer. J. 42:421–428.

Maritato, M.C., E.R. Algeo, and R.E. Keenan. 1992. Potential human health concerns from composting. BioCycle 33(12):70–72.

Mish, F.C. (ed.). 1988. Webster's ninth new collegiate dictionary. Merriam-Webster, Springfield, Mass.

Obeng, L.A. and F.W. Wright. 1987. The cocomposting of domestic solid and human wastes. World Bank Technical Report No. 57, The World Bank, Washington, D.C.

Oliver, W.M., Jr. 1994. The *Aspergillus fumigatus* problem. Compost Sci. Util. 2(1):27–31.

Poincelot, R.P. 1975. The biochemistry and methodology of composting. Connecticut Agr. Expt. Sta. Bul. 754.

Rodale, J.I., R. Rodale, J. Olds, M.C. Goldman, M. Franz, and J. Minnich. 1960. The complete book of composting. Rodale Books, Emmaus, Pa.

Rynk, R., M. Van de Kamp, G.B. Willson, M.E. Singley, T.L. Richard, J.J. Kolega, F.R. Gouin, L. Laliberty, Jr., D. Kay, D.W. Murphy, H.A.J. Hoitink, and W.F. Brinton (eds.). 1992. On-farm composting handbook. Northeast Reg. Agr. Eng. Serv., Coop. Ext., Ithaca, N.Y.

Sanderson, K.C. 1980. Use of a sewage-refuse compost in the production of ornamental plants. HortScience 15:173–178.

Shiralipour, A., D.B. McConnell, and W.H. Smith. 1992. Uses and benefits of municipal solid waste composts: A literature review. The Composting Council, Alexandria, Va.

Slivka, D.C., T.A. McClure, A.R. Buhr, and R. Albrecht. 1992. Compost: National supply and demand potential. Biomass Bioenergy 3:281–299.

Stilwell, D.E. 1993. Elemental analysis of composted source separated municipal solid waste. Compost Sci. Util. 1(2):23–33.

Tyler, R.W. 1993. The promise of compost. Amer. Nurseryman 180(14):61–73.

Tyler, R.W. 1996. Winning the organics game. Amer. Soc. Hort. Sci. Press, Alexandria, Va.

Wootton, R.D., F.R. Gouin, and F.C. Stark. 1981. Composted, digested sludge as a medium for growing flowering annuals. J. Amer. Soc. Hort. Sci. 106:46–49.