Rooting Cuttings Hydroponically in Compost Tea and Wastewater©

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Cuttings of sage, currant, euonymus, and weigela were rooted in aerated compost tea, anaerobic digestion process wastewater, and a control nutrient solution, each diluted to various electrical conductivity (salt) levels between 0 and 0.5 dS·m^{-1}. For sage, the highest percent rooting, root number, and root length occurred at 0.34, 0.38, and 0.30 dS·m^{-1}, respectively. Values for the other species varied from 0.25 to 0.5 dS·m^{-1} depending on rooting criterion. Despite these differences, trends in rooting tended to be similar with the three solution sources. The results indicate that, with proper dilution to reduce salts, compost tea and wastewater can be recycled as irrigation water or nutrient source for cuttings during propagation.

INTRODUCTION

Fertilizer and water usage and run-off from farms and nurseries have emerged into issues of primary concern to the nursery industry. Since 1984, the environmentally friendly ornamental research program at the former Horticultural Research Station of Ontario (now part of the University of Guelph) has focused research on how to effectively reutilize and recycle organic waste by-products and garbage-derived composts in container and rooting substrates (Chong, 2005). In the 1990s, the program expanded to include closed system recirculation of nutrients and wastewater recycling for container growing (Chong et al., 2004; Gils et al., 2004), and began to examine wastewater from another perspective — use of leachates and runoff water from compost operations as irrigation and supplemental fertilizer source. We successfully grew nursery trees and grasses irrigated with pond-collected compost leachates (Jarecki, 2002); tomato and marigold seedlings with compost leachates in hydroponic culture (Jarecki et al., 2005); and nursery liners and turfgrasses in hydroponic culture using various compost teas and process wastewater from anaerobic digestion (Michitsch et al., 2005).

The objective of this study was to examine and compare rooting of four species in solutions amended with compost tea and anaerobic digestion wastewater.

MATERIALS AND METHODS

Compost tea [initial electrical conductivity (EC, a measure of soluble salts concentration) 2.3 dS·m^{-1} and pH 7.8] was obtained by pouring 21 L of deionized water over 4 L of municipal solid waste compost (Guelph Waste Resource Innovation Center, Guelph, ON) and filtering through a 1.5 mm screen. Process wastewater (initial EC 19 dS·m^{-1} and pH 8.7) was obtained from an anaerobic digestion pilot facility [Super Blue Box Recycling (SUBBOR) Corporation, Guelph, Ontario], which uses the same source of municipal solid waste as a feedstock to produce biogas for electricity generation. Both tea and wastewater were stored at 4 °C until required for use. Table 1 shows the chemical composition of the tea and wastewater, both at EC of 0.5 dS·m^{-1}.

Table 1. Chemical composition[z] of three sources of nutrient solution at EC 0.5 dS·m^{-1}.

Nutrient (ppm)	Desirable values for irrigation of greenhouse substrates	Hoagland's solution	Compost tea	Process wastewater
NO_3-N	<5	43	7	4
NH_4-N	-	3	3	35
P	<5	6	0.7	0.4
K	<10	51	27	20
Ca	<60	34	3	0.3
Mg	<25	10	0.2	<1
Na	<60	4	33	45
Cl	<100	1	39	42
SO_4	<200	47	12	3
Zn	<0.5	0.03	0.04	0.01
Mn	<1.0	0.09	0.03	<0.01
Cu	<0.2	0.08	0.02	0.01
Fe	<5	1.08	0.68	0.14
B	<0.5	0.10	0.03	0.11
Mo	<0.1	0.01	0.1	0.02

[z]Mean of duplicate samples.

Cuttings of sage (*Salvia officinalis* 'Tricolor'), currant [*Ribes odoratum* (syn. *aureum*)], euonymus (*Euonymus fortunei* var. *vegetus*), and weigela (*Weigela* 'Nana Variegata') were prepared 4–5 cm tall with a node at the base. Leaves were removed from the lower half, and the remaining ones cut in half to reduce surface area. Cuttings were then inserted through 2.5 cm thick × 22 cm × 22 cm Styrofoam platforms and rooted hydroponically under greenhouse conditions (40% shade, daylight misting, 25 °/20 °C day/night temperature, and 16-h photoperiod) in 3-L pots (17.5 cm diam. × 18 cm deep, no drainage holes) with their bases immersed in continuously aerated treatment solutions: deionized water (0 dS·m^{-1}), or compost tea, process wastewater, and

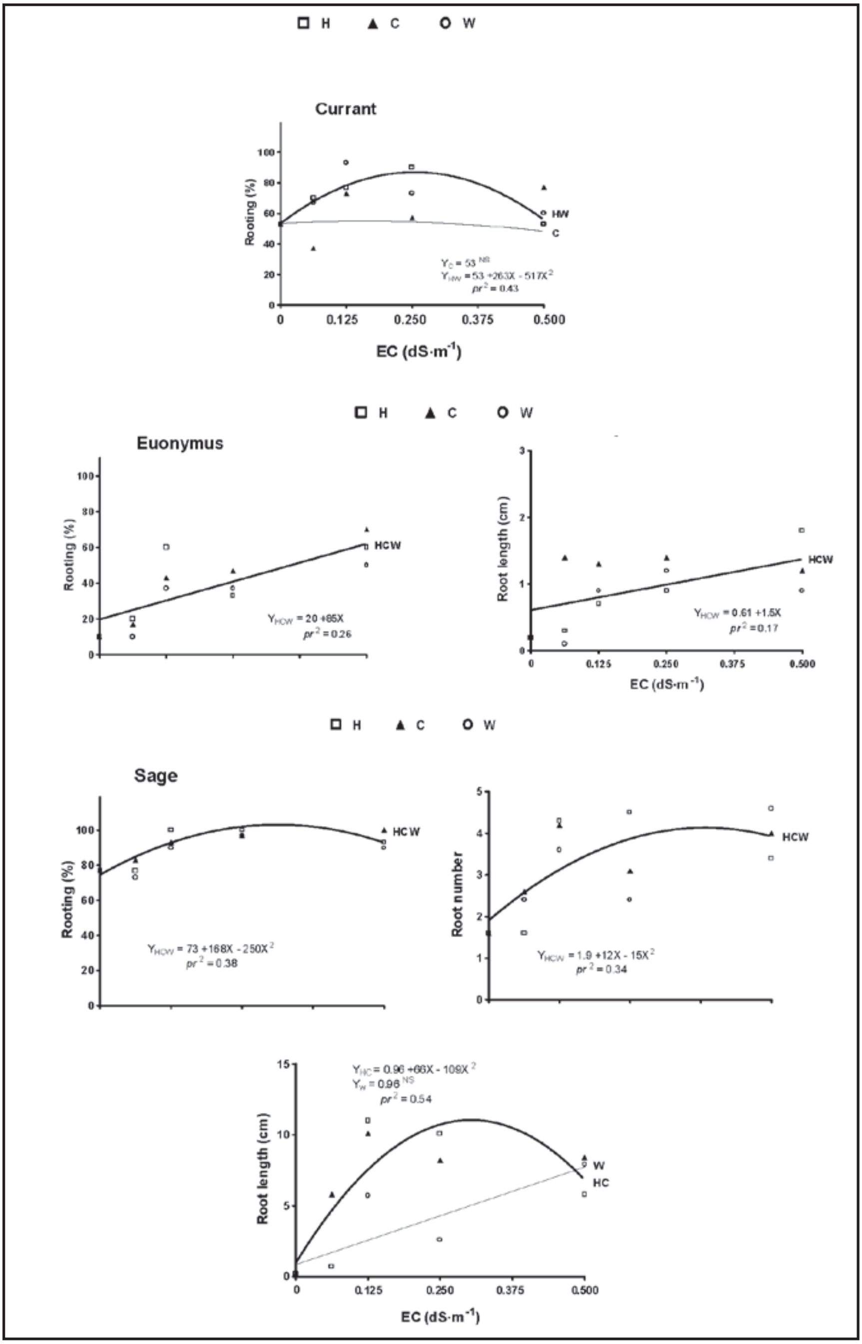

Figure 1. Rooting performance of currant, sage, and euonymus cuttings in response to various EC levels in Hoagland's control nutrient solution (H), compost tea (C), and anaerobic digestion wastewater (W).

Hoagland's (control) nutrient solution (Hoagland and Arnon, 1938), each diluted with deionized water to EC of 0.0625, 0.125, 0.25, and 0.5 $dS{\cdot}m^{-1}$.

Rooting was assessed by three criteria: percent rooting; number of roots per rooted cutting; and length of the longest root per cutting. For each species [rooting period and days in brackets: sage (20 April–17 May; 27 days); currant (7 July–28 July; 21 days); euonymus (22 July–25 Aug.; 34 days); and weigela (5 Aug.–30 Aug.; 25 days)], pots were arranged in a randomized complete block design. There were 3 replications of the 14 treatment solutions and 10 cuttings per pot (platform). All solutions were adjusted twice daily to pH of 6.5 and changed weekly. Rooting responses were regressed over salt levels. For each species, the model represents graphically three linear or quadratic curves, one for each solution source (tea, wastewater, or Hoagland's), radiating from a common intercept. A common regression was fitted when two or more curves were not significantly different at $P \leq 0.05$. The coefficient of determination for each set of responses was expressed in terms of partial r^2 (pr^2), which measured the strength of the response relationship after removing replication effects.

RESULTS

Despite differences in species response, rooting tended to be similar with the three solution sources. Sage rooting percent and root number (Fig. 1) increased curvilinearly and similarly with nutrient sources (common regression curve, 100% rooting at 0.34 $dS{\cdot}m^{-1}$, and 4.1 roots at 0.38 $dS{\cdot}m^{-1}$, respectively), as did also root length with the compost tea and Hoagland's (common curve for these two nutrient sources, 11.0 cm at 0.30 $dS{\cdot}m^{-1}$), but was unresponsive to wastewater. Currant rooting percent increased curvilinearly and similarly with nutrient sources (87% calculated maximum rooting at 0.25 $dS{\cdot}m^{-1}$) (Fig. 1), but root number and length were unresponsive. Euonymus rooting percent increased linearly with increasing EC and was similar with all three sources (61% rooting at 0.5 $dS{\cdot}m^{-1}$), as did also root length (1.4 cm at 0.5 $dS{\cdot}m^{-1}$), but root number was unresponsive. Weigela was unresponsive to EC or nutrient sources (mean percent rooting, 73; root number, 6.5; and root length, 1.9 cm).

DISCUSSION

While compost teas and wastewaters have been used for growing plants (Michitsch et al., 2005; Riggle, 1996; Scheuerell and Mahaffee, 2003), to our knowledge their use in plant propagation appears to be novel. Major deterrents for considering using these materials in propagation include lack of knowledge about usage and potential phytotoxicity due to excessive individual nutrients or salts.

Cuttings are typically sensitive to salts, although detailed information about species threshold tolerance is sparse. Chong (2002) observed no negative effect when soluble salts concentrations in rooting media are $\leq$ 0.2 $dS{\cdot}m^{-1}$ [as determined by measuring EC in 1 substrate : 2 water (v/v) extracts] were used for rooting stem cuttings during the summer, although greenhouse-rooted hardwood cuttings during winter may be tolerant of higher salt levels (0.7 $dS{\cdot}m^{-1}$).

In this study, maximum rooting response varied with species and rooting criteria at salt levels from 0.25 to at least 0.5 $dS{\cdot}m^{-1}$, the highest level tested. This evidence indicates that, in addition to species, different rooting criteria respond differently to salt level. Unlike sage (a greenhouse-grown herbaceous plant) and currant (softwood cuttings taken in early spring), cuttings of euonymus and weigela were taken later in the season. This observation suggests that higher salt tolerance may also be related to seasonal differences associated with increasing hardness of the cuttings.

The presence of growth regulators observed or speculated to be present in waste by-products and composts (Chong, 2002) was unlikely in the solutions since responses were at most similar to Hoagland's, a balanced nutrient solution. The enhanced rooting responses where observed were due most likely to nutrients present (Table 1). The reduced root length with sage and/or lack of increase in rooting percentage of currant in the wastewater may be indicative of the presence of root inhibiting compounds and/or nutrient imbalance. In hydroponic experiments, the wastewater inhibited growth of nursery liners due likely to a slimy deposit on the roots, although the growth of turfgrasses was little affected (Michitsch et al., 2003).

CONCLUSION

The study shows that, with proper dilutions, compost teas and wastewater can be effectively used in plant propagation, serving as a source of irrigation and supply of small quantities of nutrients for root growth and development. While cuttings are sensitive to salts, small but appropriate amounts and composition can result in enhanced rooting responses.

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