Growth Response and Mineral Uptake of Lettuce and Tomato Transplants Grown in Media Amended with Composted Sewage Sludge[1]

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Abstract

Lettuce, *Lactuca sativa* L. 'Summer Bibb' and tomato, *Lycopersicon esculentum* Mill. 'Westover' were grown 4 weeks in plastic market packs (MP) in 3 experimental media and a commercially available (Maryland Mix) control. The experimental media were prepared by combining equal parts, by volume of: 1) screened composted sewage sludge (CSS) (made from lime dewatered ferric chloride treated sewage sludge and wood chips), peat moss (PM), and perlite (PL) (CSS-PM-PL); 2) CSS, PM, and vermiculite (VL) (CSS-PM-VL); and 3) CSS-PL-VL. A commercially prepared medium, Maryland mix consisting of silt loam, peat, perlite, and vermiculite (1:2:1:1 by vol) was used as a control. The market packs containing 6 transplants each, were arranged in a completely randomized design and replicated 4 times. One set of seedlings were grown in Maryland mix and CSS-PM-PL and fertilized at the end of the 1st, 2nd, and 3rd week after transplanting with a commerical 20N-8.6P-16.6K (20-20-20) fertilizer. Another set of seedlings were grown for 4 weeks in the control mix and 3 experimental media and fertilized at 1st and 3rd week after transplanting with only N fertilizer.

For both lettuce and tomato plants, only 270 mg of N per MP per growing period produced marketable size transplants when grown in the CSS-PM-VL medium. These seedlings had no toxic levels of Zn, Cd, Pb, and Ni and contained adequate N, P, K, Ca, Mg, Mn, Fe, and Cu as compared to plants grown in the control medium.

Index words: compost, peat moss, perlite, sewage sludge, vermiculite, N, P, K, Ca, Mg, Mn, Fe, Cu, Zn, Cd, Pb, and Ni

Introduction

Growing media amended with composted sewage sludge (CSS) have been effective for growing bedding plants and vegetable transplants (3, 4, 5, 6, 7, 8, 9). Elevated levels of trace elements and heavy metals in plant tissues are of major concern when plants are grown in media containing composted sewage sludge. Sterrett, *et al.* (9), however, reported no differences in metal content of edible parts of tomato, muskmelon or cabbage after being grown to transplanting size in a medium amended with composted sewage sludge and grown to maturity in field soils with recommended agricultural practices. The nutrient supplying capacity of composted sewage sludge (6) suggests that modified fertilizer regimes may be appropriate (7). The objective of this study was to evaluate the effect of fertilizer treatments on growth and accumulation of heavy metals and macro and micro-nutrients in tissue of plants grown in high and low organic content media amended with one-third (by volume) of composted sewage sludge.

Materials and Methods

Three different composted sewage sludge amended media and the commercially premixed medium, Maryland mix (W.B. Hofflin Co., Rockville, MD) as a control were used. The CSS-amended media contained equal parts by volume of: 1) CSS, peat moss, and perlite (CSS-PM-PL), 2) CSS, peat moss, and vermiculite (CSS-PM-VL) and 3) CSS-PL-VL. The Maryland mix consisted of soil, peat moss, perlite, and vermiculite (1:2:1:1 by vol) with sufficient dolomitic limestone to adjust the pH to 6.5. The Maryland mix also contained 73.6 g/m^3 (3 oz/yd^3) of fritted trace elements (FTE #503) and 590 g/m^3 (14 oz/yd^3) of Aqua-grow wetting agent. Preparation of media, source of composted sewage sludge and greenhouse facilities were the same as previously reported (6, 7).

Six uniform seedlings of 'Summer Bibb' lettuce and 'Westover' tomato were transplanted at 1st true leaf stage in each market pack, filled with 700 cm^3 (43 in^3) of medium. The market packs were thoroughly irrigated with tap water immediately after transplanting and as necessary during the growing period and were arranged in a completely randomized design with 4 replications.

Two different fertilizer formulas and regimes were used. A complete fertilizer 20N-8.6P-16.6K (20-20-20) which provides 106-46-88 mg N-P-K/MP/application was provided three times (at 1st, 2nd & 3rd week after transplanting) to the plants grown in Maryland mix and CSS-PM-PL media. The other fertilizer contained only nitrogen (135 mg N/MP/application) supplied as USP Grade NH_4NO_3 and was applied twice (at 1st and 3rd week after planting) to the plants grown in each of the media containing CSS. The total quantity of elements applied during the growing period to each MP were 318-138-264 mg N-P-K for complete fertilizer and 270 mg N for nitrogen fertilizer.

Both species were grown 4 weeks to reach marketable size. Harvesting, sample preparation, and tissue and soil analysis were as described by Falahi-Ardakani, *et al.* (6, 7).

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The air filled pore space was measured using the procedure described by Bucher *et al.* (2).

Results and Discussion

Tomatoes and lettuce responded similarly to the media fertilizer combinations (Tables 1, 2). Plants grown in CSS-PM-VL with only N fertilizer were of similar size (dry wt) as plants grown in the control. The CSS-PM-PL medium produced plants as large as (lettuce) or larger than (tomato) the control when both were receiving complete fertilizer but not when receiving only N fertilizer. Tomatoes grew as well on CSS-PL-VL medium with N only as the control, but lettuce did not.

There were no differences in tissue N concentration among the media-fertilizer combinations for either species (Tables 1, 2). Phosphorus concentrations were generally lower in plants grown in media amended with CSS than the control although the levels were similar to the control in lettuce grown in CSS-PM-VL receiving complete fertilizer. There was no apparent relationship between P tissue concentration and dry wt, suggesting an adequate supply in the medium for growth. Tissue K levels were significantly increased by media containing VL, being equal to the control (or CSS-PM-PL receiving K fertilization). Higher concentrations of Ca in tissues of plants grown in CSS amended media probably reflects the high levels of Ca in the compost (4). High tissue concentration of Mg in the control may be due to the addition of dolomitic limestone. Competitive effects of K on Ca and Mg is apparent in tissues of both species grown in CSS-PM-PL under complete and N fertilizers. Tomato plants growing in the control treatment had higher levels of Fe and Mn while only Fe was significantly higher in lettuce tissue. The high concentrations of Mn and Fe in tissues may be due to addition of fritted trace elements to the Maryland mix and to its lower pH (Table 3). Tissue concentrations

Table 1. Growth (dry wt) and concentrations of macro- and micro-nutrients, and heavy metals in tissues of lettuce plants as influenced by growing media.

	Total applied fertilizer N-P-K				
	318-138-264 (mg/MP)		270-0-0 (mg/MP)		
	Control	CSS-PM-PL	CSS-PM-PL	CSS-PM-VL	CSS-PL-VL
Dry Wt. (g)	3.91 a[z]	3.72 a	3.17 b	3.98 a	2.43 c
Elements					
N (%) ns[y]	4.20	4.20	4.50	4.50	4.50
P (%)	0.96 a	0.88 a	0.56 b	0.50 b	0.52 b
K (%)	7.30 a	7.70 a	3.20 b	6.70 a	7.30 a
Ca (%)	1.14 c	1.72 b	2.07 a	1.83 b	1.76 b
Mg (%)	0.75 b	0.45 d	0.86 a	0.61 c	0.56 c
Fe (ppm)	168.00 a	127.00 b	98.00 c	106.00 bc	117.00 bc
Mn (ppm) ns	90.00	80.00	84.00	76.00	77.00
Cu (ppm) ns	19.00	16.00	22.00	21.00	23.00
Zn (ppm)	70.00	72.00	63.00	66.00	63.00
Cd (ppm)	0.38 c	0.94 b	0.81 b	1.34 a	1.06 ab
Pb (ppm) ns	6.10	3.50	4.40	4.60	4.80
Ni (ppm) ns	2.10	1.90	1.80	1.80	2.60

[z] = means within rows followed by the same letter or letters are not significantly different using the Duncan Waller MRT at the 5% level.

[y] no significant differences among means due to treatment effects.

Table 2. Growth (dry wt) and concentrations of macro- and micro-nutrients and heavy metals in tissues of tomato plants as influenced by growing media.

	Total applied fertilizer N-P-K				
	318-138-264 (mg/MP)		270-0-0 (mg/MP)		
	Control	CSS-PM-PL	CSS-PM-PL	CSS-PM-VL	CSS-PL-VL
Dry Wt. (g)	4.64 b[z]	5.87 a	4.03 c	4.58 b	4.28 bc
Elements					
N (%) ns[y]	3.50	3.40	3.70	3.90	3.50
P (%)	1.06 a	0.51 b	0.35 c	0.46 bc	0.38 c
K (%)	5.10 ab	4.30 ab	1.90 c	5.40 a	4.00 b
Ca (%)	1.27 d	2.40 c	3.16 a	2.68 b	2.78 b
Mg (%)	0.75 a	0.37 d	0.60 b	0.50 c	0.52 c
Fe (ppm)	110.00 a	93.00 b	78.00 c	86.00 bc	91.00 b
Mn (ppm)	65.00 a	27.00 b	28.00 b	28.00 b	29.00 b
Cu (ppm)	15.00 c	14.00 c	21.00 ab	16.00 bc	24.00 a
Zn (ppm)	59.00 b	51.00 c	50.00 c	57.00 b	66.00 a
Cd (ppm)	0.88 c	1.31 a	0.94 bc	1.13 ab	1.00 bc
Pb (ppm) ns	2.40	2.10	3.10	1.20	1.60
Ni (ppm) ns	3.90	1.70	3.20	2.80	1.90

[z] = means within rows followed by the same letter or letters are not significantly different using the Duncan-Waller MRT at the 5% level.

[y] no significant differences among means due to treatment effects.

Table 3. **Soluble salts (S.S.), pH, air filled pore space (A.F.P.S.) and CEC of the various media at the end of the experimental period (4 weeks after transplanting).**

Media cm	mmhos/cm S.S.	pH	% A.E.P.S.	Meq/cm^3 CEC
control	0.8	6.5	9.18	17.10
CSS-PM-PL	0.9	7.3	12.18	22.80
CSS-PM-VL	1.0	7.5	11.12	37.55
CSS-PL-VL	0.6	7.6	15.60	16.15
S.D.	±0.2	±0.5	±2.7	±9.9

of Cu and Zn in lettuce were not affected by media-fertilizer combinations and concentration in tomato tissue showed no particular pattern. Media-treatment combinations had no effect on Pb and Ni tissue concentrations for either species. Cadmium concentrations were higher in tissues from all CSS amended media, but below levels considered to cause concern for food chain contamination (3). This supports the results of previous studies (6, 7) that lettuce transplants could be grown satisfactorily in compost amended media with only N-fertilizer, but tomato plants grow larger when K is added to the fertilizer. Vermiculite is capable of supplying some elemental K to the plants; therefore the CSS-PM-VL medium could be considered as a more suitable medium for growing tomato plants than the CSS-PM-PL medium. Another favorable characteristic of VL is its high CEC and water holding capacity which provide suitable characteristics to the CSS-PM-VL medium (Table 3). Media amended with CSS had higher pH at the end of the experiment which probably accounts for lower Fe and Mn concentration in the tissue of plants grown in these media.

Peat moss added to a medium enhanced plant growth, because of increasing CEC water holding capacity, and buffering capacity (Table 3). These characteristics may have contributed to the differences between dry weights of lettuce plants grown in CSS-PM-VL and CSS-PL-VL receiving N-fertilizer (Table 1). Leafy vegetable plants such as lettuce may need more frequent watering and more fertilizer, when grown in media without peat moss because of the high air-filled pore space and lower CEC as evidenced by the lower soluble salts due to more leaching (Table 3).

Significance to the Nursery Industry

The use of composted sewage sludge in growing mixes containing vermiculite may obviate the need for complete fertilizers in that lettuce and tomato seedlings grown with only N fertilization grow as well as control or CSS-PM-PL receiving complete fertilizer. Mixes containing composted sewage sludge but not vermiculite will produce transplants equal to or larger than when grown in prepared mix only if provided with complete fertilizer. No media-fertilizer combination suggested problems associated with minor element nutrition or accumulation of heavy metals. The use of composted sewage sludge and reduced fertilizer requirements may have a beneficial effect on the environment and the profitability of vegetable plant production.

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