Proc. Fla. State Hort. Soc. 121:326–330. 2008.

Evaluation of Cow and Swine Manures to Grow Impatiens (*Impatiens wallerana* Hook. f.) in Container Production

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Additional index words. *Impatiens wallerana,* bedding plant, controlled-release fertilizer, soil fertilization

Two experiments were conducted to compare the growth of impatiens plants (*Impatiens wallerana* Hook. f.) in substrates amended with swine manure or dairy manure. In Experiment 1, impatiens plants were grown in substrates amended with 0.88, 1.77, 3.54, or 5.30 g of N per pot incorporated as Nutricote 13N–5.7P–10.8K plus minors type 100, swine manure, or dairy manure. Impatiens plants grown with Nutricote had greater shoot dry weights and final plant quality ratings than plants grown with equivalent N rates of swine or dairy manure. Impatiens plants grown with 3.54 g and 5.30 g of N from swine manure were considered saleable while none of the plants grown in dairy manure were considered saleable. In Experiment 2, impatiens plants were transplanted into Pro-mix BX, or Pro-mix amended with 10% swine manure or 10% dairy manure. All plants were top-dressed with 0.33, 0.65, or 1.30 g of N from Nutricote 13N–5.7P–10.8K plus minors type 100. Highest impatiens quality and greatest shoot dry weights were observed for plants grown in Pro-mix with 0.65 and 1.30 g of N from Nutricote. The combination of 10% swine manure with 0.33 and 0.65 g of N and 10% dairy manure with 0.33 g of N also produced saleable quality plants. It appears from this work that a combination of 10% or less swine or dairy manure with commercial controlled-release products will produce saleable quality impatiens plants.

Traditionally, bedding plants are grown using high inputs of water and fertilizer to produce high quality plants in a relatively short time period. However, these methods are not always cost effective or environmentally friendly. There are numerous organic waste products, like manures and composts, that can be incorporated into the growing substrate to provide some of the nutrients required for plant growth, thus reducing fertilizer inputs. Manures tend to have high cation exchange capacities (CEC) and can serve as a good source of nutrients because many contain low levels of nitrogen (N), phosphorus (P), and potassium (K) that are released slowly as the manure decomposes (Maynard and Lopez, 1979; Nelson, 2003).

Other organic waste products (sewage sludge, biosolids, yard waste, etc.) have been examined as components of the growing substrate for bedding plants (Chaney et al., 1980; Klock, 1997a, 1997b; Klock-Moore, 1999; Sanderson, 1980; Wootton et al., 1981). For example, Altland et al. (2002, 2003) reported on the use of chicken, beef cattle, and dairy cow manures on the growth of bedding plants in the landscape. However, there is a limited amount of published research on the use of dairy or swine manures in container production for bedding plants. Kadota and Niimi (2004) reported that the use of 10% to 30% (by volume) charcoal/barnyard manure in peat-based container substrates improved French marigold (*Tagetes patula* L.), melampodium (*Melampodium paludosum* Kunth), scarlet sage (*Salvia splendens* F. Sellow ex Roem. & Schult.), and zinnia (*Zinnia linearis* Benth.) quality. The first objective of this project was to compare the growth of impatiens (*Impatiens wallerana* Hook. f.) in substrates amended with equivalent N rates of swine manure, dairy manure, and a controlled-release fertilizer product incorporated into a commercial bedding plant substrate. The second objective of this project was to compare impatiens growth in a commercial bedding plant substrate to growth in the commercial substrate amended with 10% swine manure or 10% dairy manure, with all plants top-dressed with three rates of a commercial controlled-release fertilizer.

Materials and Methods

Experiment 1

Plugs of impatiens 'Dazzler Punch' from a #392 square plug tray were transplanted into 9.5 cm tall × 10.2 cm diameter (400 mL) round pots filled with Pro-mix BX (Premier Horticulture, Red Hill, PA) that had swine manure (Bion Environmental Technologies Inc., Clayton, NC), dairy manure (Bion Environmental Technologies Inc.), or Nutricote 13N–5.7P–10.8K plus minors type 100 (Florikan Inc., Sarasota, FL) incorporated at equivalent N rates of 0.88, 1.77, 3.54, and 5.30 g N per pot (the standard incorporation rate of Nutricote for bedding plant growth is 1.77 g of N per pot). The manure products were manufactured by Bion Environmental Technologies, which uses a patented nutrient management system in which the dairy or swine waste flows into an aerated bioreactor where the bioconversion process begins (www.biontech.com). The mixture of solids, water, and microbes flow into a solids ecoreactor where the biomass settles to the bottom for further bioconversion. The settled biomass is periodically harvested and sold as BionSoil® (fertilizer swine or soil dairy). Four samples of the swine and dairy products were

Acknowledgment. I wish to thank Ms. Luci Fisher for her technical assistance, Bion Environmental Technologies for supplying the swine and dairy manure products, and Hines Nursery (Miami, FL) for supplying the plant material.
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Table 1. Chemical analysis of swine manure and dairy manure determined by A&L Southern Agricultural Laboratories (Pompano Beach, FL) averaged for four samples. The nutrient analysis of Nutricote13N–5.7P–10.8K plus minors type 100, (Florikan, Sarasota FL) is reproduced as reported on the fertilizer label. Type 100 means the fertilizer will release 80% of its nitrogen evenly over a 100-d period at a constant temperature of 25 °C.

Parameter	Swine manure	Dairy manure	Nutricote
Moisture (%)	23.96	39.99	---
C:N	13.75	20.49	---
Solids (%)	76.04	60.01	---
Nitrogen total (%)	3.52	1.51	13
Phosphorus (%)	3.26	0.67	5.7
Potassium (%)	0.14	0.08	10.8
Sulfur (%)	1.13	0.49	2.9
Magnesium (%)	1.13	0.17	1.2
Calcium (%)	5.21	2.05	0.5
Sodium (%)	0.03	0.02	---
Aluminum (mg/L)	3081	689	---
Boron (mg/L)	17	21	200
Copper (mg/L)	397	456	500
Iron (mg/L)	7296	1210	2000
Manganese (mg/L)	765	269	600
Zinc (mg/L)	3270	441	150

independently analyzed by A&L Southern Laboratories (Pompano Beach, FL) to determine initial nutrient concentrations prior to being incorporated into Pro-mix (Table 1). After incorporating swine manure, dairy manure, and Nutricote into Pro-mix, four replicate samples of each treatment were collected for initial chemical analysis by A&L Southern Laboratories, which used a Morgan extract (Soil and Plant Analysis Council, Inc., Athens, GA) to determine pH, soluble salt (EC), N, P, K, calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), and sulfur (S).

Plants were arranged in a completely randomized design with 10 replicates per treatment combination (3 products × 4 N rates). Plants were grown in an open-sided greenhouse at the University of Florida Fort Lauderdale Research and Education Center. Greenhouse temperatures during the experiment were 30/27 °C day/night. Plants were watered daily with Roberts No. 435 sprinkler head overhead irrigation (Hummert International, Earth City, MO) for 10 min delivering approximately 100 mL (1 cm) of water per pot.

Plants were harvested 30 d after transplanting when control plants (Pro-mix with 1.77 g of N per pot as Nutricote) reached a saleable size. Plant quality was rated on a scale of 1 to 5 with 1 = poor, no flowers, foliage not extending to edge of pots; 2 = fair, minimal flowers, foliage not extending to edge of pots; 3 = "OK", some flowers, foliage extends to edge of pot, saleable; 4 = very good, moderate number of flowers, foliage extends to edge of pot and beyond; and 5 = excellent, many flowers, foliage extends beyond edge of pot. Any plant rated a 3 or better was considered saleable. At this time, shoots were cut at the soil surface and dried to determine dry weights. Substrate samples were collected at this time and extracted with distilled water to determine final pH and EC concentrations using the saturated media extraction method (SME) (Warncke, 1986). Final pH and EC were determined on the extracted solution using a pH/conductivity meter (Acumet model 20; Fisher Scientific, Pittsburgh, PA).

Experiment 2

Plugs of impatiens 'Super Elfin Blue Pearl' from a #392 square plug tray were transplanted into 9.5 cm tall × 10.2 cm diameter (400 mL) round pots filled with Pro-mix BX, Pro-mix with 10% swine manure (v/v), or 10% dairy manure (v/v) incorporated into the substrate. The same manure products used in Experiment 1 were used in this experiment. All pots were top-dressed with 0.33, 0.65, or 1.30 g of N per pot as Nutricote 13N–5.7P–10.8K plus minors type 100 (the standard top-dress application rate is 0.65 g of N per pot). Four initial substrate samples were collected and extracted with distilled water to determine pH and EC concentrations using the saturated media extraction method (SME).

Plants were arranged in a completely randomized design with 10 replicates per treatment combination and grown in the same greenhouse under similar conditions as Experiment 1. When control plants (Pro-mix with 0.65 g N) reached a saleable size, 30 d after transplanting, plant quality was rated on the same 1 to 5 scale. At this time shoots were harvested and dried to determine dry weights. Substrate samples were collected after harvesting the shoots and extracted with distilled water (SME) to determine final pH and EC. Both initial and final pH and EC were determined on the extracted solution using an Acumet model 20 pH/conductivity meter.

Data from both experiments were analyzed separately using analysis of variance procedures to investigate the effects of amendment type, substrate, application rate, and any interactions (SAS Systems, SAS Institute, Cary, NC). For each experiment, differences in plant quality and shoot dry weight treatment means was calculated using Duncan's multiple range test at the 5% level.

Results and Discussion

Experiment 1

All of the plants grown in substrates containing Nutricote were considered saleable and had greater shoot dry weights than plants grown in substrates containing swine manure (Table 2; Fig. 1). Impatiens plants grown in substrates with 3.54 and 5.30 g of swine manure also were considered saleable (Fig. 1). Furthermore, impatiens shoot dry weight and quality increased as the amount of Nutricote and swine manure increased which coincided with an increase in substrate EC and N concentrations as the amount of Nutricote and swine manure increased (Tables 2 and 3). Although initial EC and N concentrations were similar between substrates with Nutricote and swine manure, substrates containing Nutricote had higher initial P and K concentrations (Table 3). There was no difference in initial Ca, Mg, Fe, Mn, Zn, Cu, B, or S concentrations among the three products or application rates (data not reported). Kadota and Niimi (2004) reported greater melampodium plant height with 30% charcoal/barnyard manure incorporated into the control substrate than in substrates with no charcoal/barnyard manure but heights of French marigold and scarlet sage with 10% and 30% charcoal/barnyard manure were similar to control plants. Kadota and Niimi (2004) speculated that the effect of the fertilizer component from the cattle manure was slow to break down and release nutrients.

The release rate of nutrients from manure products is variable and requires microbial decomposition to release them. Chae and Tabatabai (1986) reported that there was little or no N mineralization in animal manure-treated field soils during the first 4 weeks of incubation. However, the label for Nutricote Type 100 specifies that the fertilizer will release 80% of its N evenly over a 100-d

Table 2. Final impatiens 'Dazzler Punch' quality and shoot dry weight of plants fertilized with 0.88, 1.77, 3.54, or 5.30 g N per pot incorporated as Nutricote13N–5.7P–10.8K plus minors type 100, swine manure, or dairy manure (Experiment 1). Means are averages of 10 replicates. Mean separation within each column by Duncan's multiple range test, 5% level. Means followed by the same letter were not significantly different.

Application rate (g N/pot)	Quality[z]	Shoot dry wt (g)
No fertilizer		
0.00	1.8 g	0.11 f
Nutricote 13N–5.7P–10.8K plus minors type 100		
0.88	4.2 c	0.84 d
1.77	4.4 bc	1.57 b
3.54	4.7 ab	1.61 b
5.30	4.9 a	2.21 a
Swine manure (3.52 % N)		
0.88 (2% of substrate volume)	2.7 ef	0.43 e
1.77 (4% of substrate volume)	2.7 ef	0.71 d
3.54 (8% of substrate volume)	3.0 de	0.85 d
5.30 (12% of substrate volume)	3.2 d	1.09 c
Dairy manure (1.51% N)		
0.88 (4.6% of substrate volume)	2.0 f	0.16 f
1.77 (8.8% of substrate volume)	2.6 f	0.17 f
3.54 (16.2% of substrate volume)	2.8 ef	0.22 f
5.30 (22.6% of substrate volume)	2.8 ef	0.32 e
Significance ($P > F$)		
Amendment type	0.0001	0.0001
Application rate	0.0002	0.0001
Amendment × rate	0.0257	0.0001

[z]Plant quality was rated on a scale of 1 to 5 with 1 = poor, no flowers, foliage not extending to edge of pots; 2 = fair, minimal flowers, foliage not extending to edge of pots; 3 = OK, some flowers, foliage extends to edge of pot, saleable; 4 = very good, moderate number of flowers, foliage extends to edge of pot and beyond; and 5 = excellent, many flowers, foliage extends beyond edge of pot.

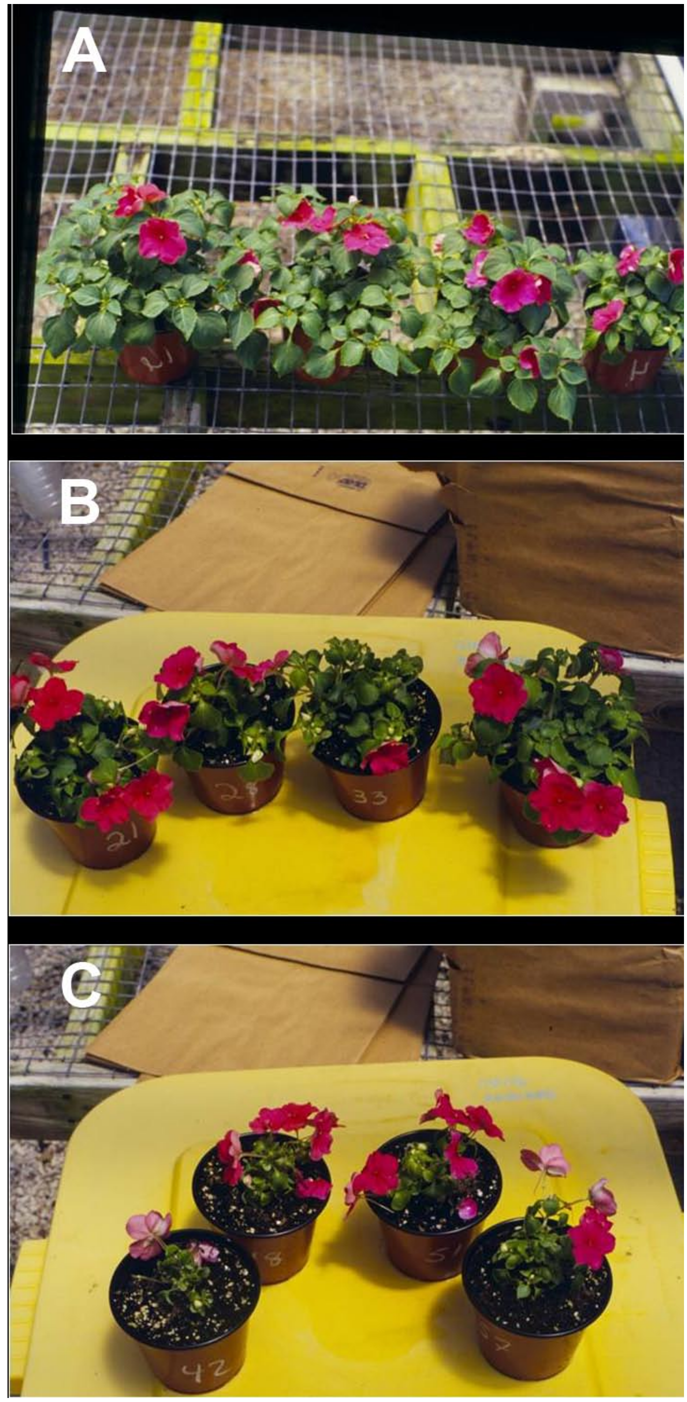

Fig. 1. Experiment 1 impatiens grown in (**A**) Pro-mix with 5.30, 3.54, 1.77, or 0.88 g of N per pot incorporated as Nutricote13N–5.7P–10.8K plus minors type 100; (**B**) Pro-mix with 0.88, 1.77, 3.54, or 5.30 g N per pot from swine manure; or (**C**) Pro-mix with 0.88, 1.77, 3.54, or 5.30 g N per pot from dairy manure.

period at a constant 25 °C but temperatures warmer than 25 °C will shorten release time. Broschat and Moore (2007) reported that Nutricote 13N–5.7P–10.8K Type 180 (180 d or 25 weeks to release 80% of the initial N) released 50% of NO_3-N after 19.3 weeks or 135 d when placed in irrigated sand columns held at 23 °C. It is possible that due to the short crop time (30 d) and average daytime temperatures in the greenhouse of 30 °C, Nutricote released nutrients more readily than the manure products. Final substrate EC concentrations in substrates containing swine manure were higher than concentrations in substrates containing Nutricote, suggesting a potential nutrient reserve in substrates containing swine manure (Table 4). Chae and Tabatabai (1986) did notice a marked increase in mineralization rates of animal manure-treated soils between 4 and 12 weeks.

The smallest and poorest quality impatiens plants were grown in Pro-mix with no fertilizer (Table 2). None of the impatiens plants grown in substrates containing dairy manure were considered saleable and shoot dry weights of plants grown in substrates containing dairy manure were less than in substrates containing equivalent N rates of Nutricote or swine manure (Table 2; Fig. 1). Initial substrate N, P, and K concentrations in substrates with dairy manure were less than in the other substrates (Table 3). Recommendations suggest that cow manure should be incorporated at volume rates no greater than 10% to 15% to avoid ammoniacal nitrogen buildup that could contribute to increased soluble salt concentrations (Nelson, 2003). Due to the lower N content of the dairy manure, a larger percentage of the substrate volume contained dairy manure in order to apply equivalent N rates. For example, approximately 23% of the substrate volume was dairy manure in order to achieve the 5.30 g of N application rate (Table 2). Although initial EC concentrations in substrates

Table 3. Initial substrate chemical analysis of Pro-mix with 0.88, 1.77, 3.54, or 5.30 g N per pot incorporated as Nutricote13N–5.7P–10.8K plus minors type 100, swine manure, or dairy manure as determined by A&L Southern Laboratories (Pompano Beach, FL) who used a Morgan extract. (Means are average of five replicates.)

Application rate (g N/pot)	pH	Electrical conductivity (dS/m)	N[z] (mg/L)	P[z] (mg/L)	K (mg/L)
		No Fertilizer			
0.00	5.4	0.46	80	18	109
		Nutricote 13N–5.7P–10.8K plus minors type 100			
0.88	5.0	0.58	126	45	159
1.77	4.9	0.77	155	71	154
3.54	5.0	1.06	200	80	182
5.30	5.0	1.13	200	80	261
		Swine manure (3.52 % N)			
0.88	5.4	0.47	122	44	121
1.77	5.6	0.62	150	57	138
3.54	5.9	0.82	200	70	185
5.30	6.1	1.15	200	75	146
		Dairy manure (1.51%N)			
0.88	5.0	0.38	100	41	90
1.77	5.0	0.60	114	45	101
3.54	5.1	0.78	158	52	130
5.30	5.6	1.06	160	63	99
Suggested[y]	5.5–6.5	0.2–1.0	25–150	12–60	50–250
Significance ($P > F$)[x]					
Amendment	0.5101	0.0127	0.0202	0.0223	0.0406
App Rate	0.9676	0.0001	0.0013	0.4029	0.3188

[z]The maximum detection limit on the equipment used by A&L Southern Laboratories for N was 200 ppm and for P was 80 ppm.

[y]Suggested standard as reported by A&L Southern Laboratories Inc. Pompano Beach FL.

[x]There were no significant amendment × application rate interactions. There also was no significant difference among the amendments or application rates for Ca, Mg, Fe, Mn, Cu, B, or S concentrations; therefore data was not presented.

containing dairy manure were not significantly higher than other substrates, final EC concentrations of substrates amended with dairy manure were higher than other substrates (Tables 3 and 4). High soluble salt (EC) concentrations will lead to loss of plant vigor and reduced plant growth (Warncke and Krauskopf, 1983). Mixing fertilizer (or manure) into the growing substrate will increase the soluble salt concentrations but fertilizer and manure products will release nutrients into growing substrates at different rates, thus having varied responses on substrate soluble salt concentrations (Warncke and Krauskopf, 1983). Because N mineralization rates vary with the type of manure product, this may explain some of the differences observed between swine and dairy manure. For example, Chae and Tabatabai (1996) reported that the average organic N mineralization rate of cow manure in five different soils over a 26-week period was 35%, but was 53% for chicken manure and 39% for hog manure in the same five soils over the same time period.

Experiment 2

Highest quality and greatest shoot dry weight were observed for impatiens plants grown in Pro-mix with 0.65 and 1.30 g of N top-dressed from Nutricote (Table 5). The addition of top-dress

Table 4. Final substrate pH and soluble salt concentrations (EC) of Pro-mix with 0.88, 1.77, 3.54, or 5.30 g N per pot incorporated as Nutricote13N–5.7P–10.8K plus minors type 100, swine manure, or dairy manure. Samples were extracted with distilled water using the saturated media extraction method (SME). Means are average of 10 replicates.

Application rate (g N/pot)	pH	Electrical conductivity (dS/m)
	Nutricote 13N–5.7P–10.8K plus minors type 100	
0.88	6.91	0.31
1.77	7.17	0.33
3.54	5.69	0.26
5.30	5.54	0.28
	Swine manure (3.52% N)	
0.88	6.88	0.38
1.77	6.85	0.37
3.54	6.50	0.49
5.30	6.14	0.57
	Dairy manure (1.51 %N)	
0.88	5.98	0.39
1.77	6.15	0.49
3.54	6.44	0.64
5.30	5.86	1.38
Suggested standard[z]	5.5–6.5	0.76–2.0
Significance ($P > F$)		
Amendment type	0.5678	0.0458
Application rate	0.2345	0.0567
Amendment × rate	0.4567	0.7895

[z]Suggested standard Warncke and Krauskopf (1983).

applications of Nutricote at all three rates to impatiens plants grown in substrates with 10% swine manure produced saleable quality plants with shoot dry weights comparable to plants grown in Pro-mix with 0.33 g of N. Kraus and Warren (2000) reported that pine bark substrates amended with 8% composted turkey litter required ≥2 g N as Osmocote top-dressed per container to produce cotoneaster (*Cotoneaster dammeri* Schneid. 'Skogholm') growth equivalent to the control plants. Based on data from a previous experiment, they speculated that the N released from the composted turkey litter was lost to leaching; thus, the cotoneaster plants required additional fertilizer in order to obtain growth similar to control plants. Only the lowest top-dress rate of Nutricote applied to plants grown in substrates with 10% dairy manure produced saleable quality plants. Shoot dry weight and plant quality decreased as the top-dress rate increased for plants grown in 10% dairy manure. Initial and final EC concentrations in substrates containing 10% dairy manure were higher than substrates containing 10% swine manure (Table 6). Furthermore, initial and final EC in substrates containing 10% swine manure were higher than in Pro-mix (Table 6). According to Warncke and Krauskopf (1983), soluble salt readings between 3.50 and 5.00 dS/m result in loss of plant vigor and could result in wilting and marginal leaf burn.

Natural organic products continue to be used as a slow-release source of nutrients in horticulture and represent a large and diverse group of materials (Maynard and Lorenz, 1979). However, organic materials like manures can have variable decomposition, mineralization, and nutrient release rates, making them difficult to use (Maynard and Lorenz, 1979). Furthermore, the release rate of

Table 5. Final impatiens 'Super Elfin Blue Pearl' quality and shoot dry weight of plant grown in Pro-mix, Pro-mix with 10% swine manure, or Pro-mix with 10% dairy manure. All plants were fertilized with top-dress application of 0.33, 0.65, or 1.30 g of N from Nutricote13N–5.7P–10.8K plus minors type 100. Means are averages of 10 replicates. Mean separation within each column by Duncan's multiple range test, 5% level. Means followed by the same letter were not significantly different.

Top-dress fertilizer application rate (g N)	Quality[z]	Shoot dry wt (g)
	Pro-mix BX	
0.33	3.7 b	1.53 b
0.65	4.8 a	2.30 a
1.30	4.8 a	2.23 a
	Pro-mix with 10% swine manure (v/v)	
0.33	4.0 b	1.65 b
0.65	4.0 b	1.61 b
1.30	3.7 b	1.15 c
	Pro-mix with 10% dairy manure (v/v)	
0.33	3.8 b	1.85 b
0.65	2.7 c	1.28 c
1.30	1.5 d	0.35 d
Significance (P > F)		
Substrate	0.0005	0.0051
Application rate of fertilizer	0.0004	0.0002
Substrate × application	0.5689	0.2347

[z]Plant quality was rated on a scale of 1 to 5 with 1 = poor, no flowers, foliage not extending to edge of pots; 2 = fair, minimal flowers, foliage not extending to edge of pots; 3 = OK, some flowers, foliage extends to edge of pot, saleable; 4 = very good, moderate number of flowers, foliage extends to edge of pot and beyond; and 5 = excellent, many flowers, foliage extends beyond edge of pot.

Table 6. Initial and final substrate pH and soluble salt concentrations (EC) determined using the saturated extraction method (SME) on samples of Pro-mix, Pro-mix with 10% swine manure, or Pro-mix with 10% dairy manure. All plants were fertilized with top-dress application of 0.33, 0.65, or 1.30 g of N as Nutricote13N–5.7P–10.8K plus minors type 100. Initial substrate samples were collected prior to fertilization while final substrate samples were collected at termination. (n=10)

Top-dress application rate of fertilizer (g N)	pH	Electrical conductivity (dS/m)
	Initial Substrate Analysis	
	Pro-mix BX	
---	6.2	0.53
	Pro-mix with 10% swine manure (v/v)	
---	5.1	2.74
	Pro-mix with 10% dairy manure (v/v)	
---	5.3	3.90
Significance (P > F)		
Substrate	0.0007	0.0001
	Final Substrate Analysis	
	Pro-mix BX	
0.33	6.3	0.62
0.65	6.3	0.69
1.30	6.3	0.62
	Pro-mix with 10% swine manure (v/v)	
0.33	6.6	0.50
0.65	5.7	1.24
1.30	5.6	1.98
	Pro-mix with 10% dairy manure (v/v)	
0.33	6.2	0.71
0.65	6.1	1.84
1.30	6.2	2.46
Significance (P > F)		
Substrate	0.4878	0.0239
Application rate of fertilizer	0.4066	0.2970
Substrate × application	0.4123	0.2156
Suggested standard[z]	5.5–6.5	0.76–2.0

[z]Suggested standard Warncke and Krauskopf (1983).

nutrients from manures may not be enough for crops with short production periods, requiring supplemental fertilization and thus reducing their potential for effective use.

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