Fishwaste Compost Medium Improves Growth and Quality of Container-grown Marigolds and Geraniums Without Leaching[1]

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Abstract

Utilization of fish waste for producing fishwaste compost (FWC) as a value-added product is preferred to disposing of it in ocean dumping or landfills. This study determined: (i) the effectiveness of FWC as a container-growth medium and N source for greenhouse production of marigolds (*Tagetes patula* L. 'Queen Sophia') and geraniums (*Pelargonium* x *hortorum* L.H. Bailey 'Sprinter Scarlet') that were drip-irrigated to prevent leaching; and (ii) if leaching was necessary to sustain plant growth. In a 3 by 3 factorial experiment, plants were grown in 100% FWC, 50% FWC:50% Douglas-fir bark (B), and 100% B at 0, 160, and 320 mg (0, 0.0056, 0.0112 oz) N container^{-1} applied as NH_4NO_3 every 2 weeks. Under drip irrigation, FWC in the 100% FWC growing medium supplied a sufficient amount of available N up to 7 weeks after transplanting to produce plant quality, shoot growth index (SGI), and shoot and root dry weights comparable to those treated with 320 mg N container^{-1}. In the 50% FWC:50% B growing medium fertilization with 320 mg N improved plant growth and quality 7 weeks after transplanting. The concentration of inorganic N (NO_3 plus NH_4) in the 100% FWC declined to very low levels 7 weeks after transplanting. This indicated that FWC used as the sole component of the growing medium was an effective N source for marigolds and geraniums up to 7 weeks after transplant. Compared with no leach plants, irrigation of 100% FWC marigolds with a weekly leaching fraction of about 0.55 did not affect quality, SGI, and shoot dry weight at the time-of-sale, 7 weeks after transplant. The FWC did not have sufficiently high salt content to require minimum leaching to prevent salt injury to the plants.

Index words: bedding plants, nitrogen fertilizer, growing media, leaching fraction.

Significance to the Nursery Industry

By using recycled materials as growing media and reducing the amount of leachate from container-grown plants, producers of containerized crops can help to protect the environment and reduce water and fertilizer inputs. A fishwaste compost (FWC) made from ground fish waste and coarse conifer sawdust was a suitable growing medium for the container production of marigolds and geraniums. When plants were grown without leaching, there was sufficient inorganic N in the 100% FWC growing medium to produce high quality marigolds in 7 weeks and salable quality geraniums in 9 weeks. Market-ready marigolds grown in 100% FWC did not benefit from the addition of N fertilizer. At the time-of-sale for geraniums, 9 weeks after transplanting, N fertilizer increased SGI and quality of plants in 100% FWC but had no influence on dry weight and inflorescence number. Geranium quality and SGI increases, though statistically signifi-

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cant, should not have influenced plant sales. The 100% FWC medium did not require weekly leaching to prevent soluble salt accumulation and damage to plants.

Introduction

Annual production of seafood waste exceeds 12,000 Mg (13,200 tons) in coastal Washington (20). The traditional disposal options, landfill and ocean dumping, are being eliminated to protect water quality. Recycling the seafood waste by co-composting with coarse sawdust provides a viable means of disposal.

Quality seafood waste composts have been produced (4, 9, 11). Composts produced by co-composting ground fishwaste with coarse sawdust from Douglas-fir, alder or western hemlock have no offensive odors, contain relatively high concentrations of inorganic (NH_4-N and NO_3-N) and organic N (15, 10), and can be used to produce high quality plants when used as a growing medium component in container production systems (7, 16).

In the production of rhododendron, irrigation practices influenced the efficient use of inorganic N (NH_4-N and NO_3-N) when FWC was used as a growing medium (16). Under a typical overhead sprinkler irrigation regime, rhododendron growth was enhanced only during the first growth flush by the initially high inorganic N concentration in FWC. Excess irrigation water leached much of the inorganic N from the FWC within 2 to 3 weeks, thus requiring repeated applications of N fertilizer to produce commercially acceptable rhododendrons.

To maximize plant utilization of inorganic N in FWC, the volume of water delivered to the growing medium must be reduced to minimize leaching. By minimizing leaching, water usage can be reduced and the water supply will be protected from nitrate and phosphate runoff (1). However, without leaching, the accumulation of salts in the growing medium to levels that damage container-grown crops is a potential problem (1, 2, 19). Minimum leaching may be required to reduce excess salt accumulation without depleting the availability of N and other nutrients in the medium. Researchers have successfully grown foliage plants (21), poinsettias (13), cut flower chrysanthemum (18) and New Guinea impatiens (5, 17) using no-leach or minimum-leach irrigation treatments. Ku and Hershey (14) irrigated geraniums with leaching fractions (LF = volume of solution leached from the container/volume of solution applied to the container) of 0, 0.1, 0.2 and 0.4 and found that although leaf area and leaf and stem dry mass decreased with decreasing LF, the inflorescence dry mass and plant appearance were not adversely affected. The objectives of this study were to evaluate FWC as a container-growing medium and N source for the greenhouse production of marigold and geranium crops under drip irrigation with no leaching, and to determine if minimum leaching is necessary for the compost to be an effective growing medium.

Materials and Methods

Experiment 1. Uniform seedlings of 'Queen Sophia' marigold and 'Sprinter Scarlet' geranium grown as plugs were transplanted into 0.7 liter (0.74 qt) square containers 10 cm (4 in) tall with 10 cm (4 in) top diameter filled with the following growing media: 1) 100% FWC; 2) 50% FWC:50% B blended by volume; and 3) 100% B. The FWC was produced by co-composting ground bottom-fish waste with a mixture of western hemlock [*Tsuga heterophylla* (Raf.) Sarg.] and coarse Douglas-fir [*Pseudotsuga menziesii* (Mirbel) Franco] sawdust using the windrow composting method (15). The compost was mixed and rewindrowed as often as twice daily when windrow temperatures exceeded 60C (140F). Composting was completed 15 weeks after initiation. On a dry weight basis, the FWC had 12.5 g total N kg^{-1} (0.2 oz/lb), 1.84 g NH_4-N kg^{-1} (0.029 oz/lb), 1.77 g NO_3-N kg^{-1} (0.028 oz/lb), and a C:N ratio of 34.4 while the B had 500 g C kg^{-1} (8.0 oz/lb), 2.7 g total N kg^{-1} (0.043 oz/lb) and a C:N ratio of 185 (16). The pH values of FWC and B were 4.7 and 4.5, respectively. The particle size distribution (as a percent of weight) for FWC was 50.0%, 29.2%, 16.1%, 0.7% and 4.0% for the particle sizes >1.651 mm, 1.651–1.0 mm, 1.0–0.495 mm, 0.495–0.42 mm, and <0.42 mm, respectively, while the B particle size distribution was 54.5%, 10.4%, 15.7%, 1.1% and 18.3% for the same respective particle size classes. Water-holding capacities (8) for the 100 FWC, 50 FWC:50 B and 100 B media were 57%, 49% and 59%, respectively. The growing medium dry weight in each pot averaged 86 ± 1g (3.03 ± 0.03 oz) for 100 FWC, 102 ± 3g (3.6 ± 0.11 oz) for 50 FWC:50 B, and 118 ± 2g (4.16 ± 0.07) for 100 B. All growing media were amended with Micromax micronutrient mix at the rate of 1038 g/m^3 (1.75 lb/yd^3) and dolomite at 4745 g/m^3 (8 lb/yd^3).

Nitrogen fertilizer solutions as NH_4NO_3 were applied to the containers every 2 weeks at rates of 0, 160 and 320 mg N $container^{-1}$ (0, 0.0056, 0.0112 oz or 0, 300 and 600ppm N, respectively) to produce a factorial treatment combination of 3 growing media by 3 N rates (7, 16). There were 6 replicate containers per treatment with 1 plant per container. Phosphorus [11.7 mg (0.0004 oz) P $container^{-1}$ as triple superphosphate] and K [44.3 mg (0.0016 oz) K $container^{-1}$ as KCl] were applied to all plants every 2 weeks. Plants were arranged in a randomized complete block design with a border row on benches in a glass greenhouse. The study was conducted from January through March and average daily maximum and minimum air temperatures were 25.5 ± 1C (78 ± 2F) and 12.8 ± 2.3C (55 ± 4F), respectively.

Immediately after transplanting but prior to N–P–K application, 0.3 liter (0.32 qt) water was applied to each plant. After this initial watering, all plants were drip irrigated to container capacity. Water applied was measured daily with applications to marigolds ranging from 15–20 ml (0.45 to 0.6 oz) at the beginning of the experiment to 40–45 ml (1.2 to 1.35 oz) at the termination of the experiment after 7 weeks when plants were flowering. The amount of water applied to geraniums via drip irrigation varied from a minimum of 20–25 ml (0.6–0.75 oz) initially to 75–80 ml (2.25–2.4 oz) prior to harvest at 9 weeks after transplanting when plants were flowering. Approximately 1.41 liters (1.49 qt) of water was used to produce each marigold plant while the geraniums were produced with approximately 2.50 liters (2.64 qt) of water per plant.

Three weeks after transplanting, height and width of all plants were measured. Plant height and width measurements were repeated at 2-week intervals. The marigold and geranium experiments were terminated at 7 and 9 weeks, respectively, after transplant when plants flowered and were considered ready for sale. Shoot height, width, quality, fresh and dry weights of all plants were measured. Shoot growth index (SGI) where SGI = (height + width) / 2 was calculated. Shoot quality was rated visually on a scale of 1 to 5 with 1 = dead plant to 5 = superior quality plant. Marigold root systems were rated on the following scale: 1) no roots visible at the periphery of the root ball; 2) few roots visible; 3) many roots visible but growing medium still obvious; 4) solid root mass with little or no growing medium visible at the periphery (6). Geranium flower production was measured by recording the number of inflorescences per plant.

In order to determine the effect of weekly leaching on marigold growth, 18 additional marigold plugs were transplanted, 6 replications in each of the three growing media. These plants were given no supplemental N (0 mg N treatment) but P and K were applied as described. In addition to the daily no-leach drip irrigation, 0.3 liter (0.32 qt) of deionized (DI) water was added to each pot at transplant and at weekly intervals thereafter. Leachate resulting from the weekly applications of 0.3 liter DI water was collected (22) and the leachate volume, electrical conductivity (EC) (CDM 80 Conductivity Meter; Radiometer A/S, Copenhagen, Denmark), and pH (Hach One Laboratory pH/ISE Meter, Hach Company, Loveland, CO) were determined. Leachates collected each week were analyzed by steam distillation (12) for total inorganic N. Marigold growth and quality were measured as described.

Experiment 2. Experiment 2 was conducted simultaneously with Experiment 1 to determine the availability of N in the FWC media. No-leach drip irrigation, growing conditions, treatments and replication were the same with the following exceptions: only marigold 'Queen Sophia' and the 0 mg N container^{-1} fertilizer treatment were used. At weeks 3, 5, and 7 after transplanting, SGI and quality of 6 randomly selected plants from each growing medium was measured. Then plants were harvested and shoot and root dry weights, shoot N accumulation, and inorganic N in the growing medium of these plants were determined.

After roots were gently washed from the growing media, plants were dried at 65C (149F) for 96 h then shoots and roots were severed at the stem base and weighed separately. Shoots were ground to pass through a 1-mm (0.04 in) sieve. Sub-samples of the ground plant materials were digested in concentrated H_2SO_4 and H_2O_2 at 400C (752F) and analyzed for total N by steam distillation (12). After removing the roots, inorganic N was extracted from each growing medium with 2M HCl and the concentration was determined as described by Keeney and Nelson (12).

Analysis of variance (ANOVA) was performed on all data (SAS 6.12, SAS Institute Inc. Cary, NC). When the two-factor interaction was significant, data were analyzed by one-way ANOVA with mean separation using a protected Tukey's studentized range test (HSD).

Results and Discussion

Experiment 1. The shoot growth response of drip-irrigated geraniums and marigolds to N fertilizer application varied depending on growing medium (Table 1). Three weeks after transplanting, SGI response to added N fertilizer occurred only in the 100 B medium for geraniums and marigolds. Marigolds in the 50 FWC:50 B medium did not respond to added N until week 7, when plants in the 320 mg N treatment were larger than those in the 0 mg N treatment. After 7 weeks of growth in 100 FWC, marigolds were flowering and ready for sale and SGI had not responded to added N fertilizer. Supplemental N improved geranium SGI 5 weeks after transplanting in both the 100 B and 50 FWC:50 B media. It was not until 9 weeks after transplanting, when geraniums were ready for sale, that SGI of plants in the 100 FWC/320 mg N treatment was larger than in the 100 FWC/0 mg N treatment.

At the time plants were ready to sell, dry weights (fresh weight data not shown because results were similar) of marigolds and geraniums in the 50 FWC:50 B and 100 B media

Table 1. Effect of nitrogen fertilization rates on shoot growth index [SGI:(height + width)/2] of geraniums and marigolds growing in 100% fishwaste compost (FWC), 100% Douglas-fir bark (B) and 50% FWC:50% B growing media. Plants were measured at 3, 5, and 7 weeks after transplanting for marigolds and weeks 3, 5, 7, and 9 for geraniums.

Weeks after transplant	N (mg/pot)	Growing medium: Geranium 100 FWC	Geranium 50 FWC:50 B	Geranium 100 B	Marigold 100 FWC	Marigold 50 FWC:50 B	Marigold 100 B
	0	8.2a[z]A[y]	8.2aA	6.6aB	11.3aA	12.5aA	3.9aB
3	160	8.4aA	8.7aA	7.9bA	11.7aA	12.5aB	8.5bC
	320	8.6aA	8.4aA	8.2bA	11.3aA	12.2aA	9.1bB
	0	10.8aA	10.6aA	7.2aB	14.3aA	14.1aA	4.5aB
5	160	11.0aA	11.1abA	9.4bB	14.3aA	14.6aA	11.4bB
	320	10.9aAB	11.4bA	10.4bB	14.0aAB	14.8aA	12.8cB
	0	13.2abA	12.7aA	7.5aB	18.0aA	15.7aB	5.4aC
7	160	12.9aA	13.0aA	10.6bB	18.6aA	17.2abB	14.1bC
	320	13.8bA	13.7bA	12.4cB	17.5aA	17.7bA	16.4cB
	0	15.2aA	14.3aA	7.5aB			
9	160	16.0aA	15.0aA	12.2bB			
	320	17.5bA	16.5bA	14.5cB			

[z]Lower case letters compare N rates within a species, date and growing medium treatment; the means followed by the same letter are not significantly different at the 5% level using Tukey's Studentized Range Test (HSD).

[y]Upper case letters compare growing media within a species, date and N rate treatment; the means followed by the same letter are not significantly different at the 5% level using Tukey's Studentized Range Test (HSD).

Table 2. Effect of nitrogen fertilization rates on shoot growth and quality of marigolds and geraniums growing in 100% fishwaste compost (FWC), 100% Douglas-fir bark (B), and 50% FWC:50% B growing media. Growth and quality were measured at the time plants were ready to sell, weeks 7 and 9 after transplanting for marigolds and geraniums, respectively.

	Marigold dry weight (gm)			Geranium dry weight (gm)		
	Growing medium			Growing medium		
N (mg/pot)	100 FWC	50 FWC:50 B	100 B	100 FWC	50 FWC:50 B	100 B
0	5.53a[z]A[y]	4.29aB	0.19aC	9.99aA	8.60aB	1.88aC
160	5.70aA	5.27bA	2.16bB	10.11aA	10.29bA	5.83bB
320	5.61aA	5.59bA	3.22cB	10.74aA	10.96bA	8.66cB

	Marigold quality[x]			Geranium quality		
	Growing medium			Growing medium		
N (mg/pot)	100 FWC	50 FWC:50 B	100 B	100 FWC	50FWC:50B	100 B
0	5.0aA	3.8aB	2.0aC	4.5aA	3.2aB	2.0aC
160	5.0aA	4.5bB	3.0bC	5.0bA	4.0bB	3.0bC
320	5.0aA	5.0bA	3.8cB	5.0bA	5.0cA	4.0cB

[z]Lower case letters compare N rates within a species and growing medium treatment; the means followed by the same letter are not significantly different at the 5% level using Tukey's Studentized Range Test (HSD).

[y]Upper case letters compare growing media within a species and N rate treatment; the means followed by the same letter are not significantly different at the 5% level using Tukey's Studentized Range Test (HSD).

[x]Quality was rated on a scale of 1 to 5 with 1 = dead plant to 5 = superior quality plant.

were increased by supplemental N fertilizer (Table 2). However, N fertilizer addition did not increase marigold and geranium dry weights or marigold quality in 100 FWC. In the 50 FWC:50 B medium, fertilizing with 160 mg N improved marigold and geranium dry weight and quality but increasing the fertilizer rate to 320 mg N only increased geranium quality.

Table 3. Effect of nitrogen fertilization rates on root rating of marigolds and infloresence production of geraniums growing in 100% fishwaste compost (FWC), 100% Douglas-fir bark (B), and 50% FWC:50% B growing media. Data were collected at the time of sale, weeks 7 and 9 after transplanting for marigolds and geraniums, respectively.

	Geranium inflorescence number		
N (mg/pot)	100 FWC	50 FWC:50 B	100B
0	2.5a[z]A[y]	2.0aA	0.0aB
160	2.5aA	2.0aB	1.8bB
320	2.5aA	2.2aA	2.2bA
	Marigold root rating[x]		
N (mg/pot)	**100 FWC**	**50 FWC:50 B**	**100 B**
0	4.0aA	4.0aA	2.0aB
160	4.0aA	4.0aA	3.0bB
320	3.8aAB	4.0aA	3.3bB

[z]Lower case letters compare N rates within a growing medium treatment; the means followed by the same letter are not significantly different at the 5% level using Tukey's Studentized Range Test (HSD).

[y]Upper case letters compare growing media within a N rate treatment; the means followed by the same letter are not significantly different at the 5% level using Tukey's Studentized Range Test (HSD).

[x]Growth of root systems was rated according to the following scale: 1) no roots visible at the periphery of the root ball; 2) few roots visible; 3) many roots visible but growing medium still obvious; 4) solid root mass with little or no growing medium visible at the periphery.

Marigolds produced excellent roots in the 100 FWC and 50 FWC:50 B media with no additional N fertilizer (Table 3). However, fertilizing with 160 mg N enhanced marigold root rating in 100 B. Geraniums growing in 100 B produced more inflorescences when fertilized with N (Table 3). In general, geraniums in the 100 FWC medium had the greatest number of inflorescences.

FWC enhanced marigold and geranium growth and quality at all rates of N fertilization (Tables 1 and 2). Marigolds in the 100 FWC/0 mg N treatment were as large and of as high a quality as plants in any of the N fertilized treatments. Although geraniums in the 100 FWC/0 mg N treatment were rated somewhat lower in quality than those with added N, they were attractive, marketable plants at the time-of-sale.

Results of SGI measurements during the production cycle indicate N availability in the 100 B and 50 FWC:50 B growing media was the primary growth limiting factor (Table 1). With a very low (< 2 mg kg^{-1} (<0.00003 oz/lb)) inorganic N content in the 100 B medium, a positive growth response of marigolds and geraniums would be expected. In the 50 FWC:50 B medium, the FWC added approximately 152 mg kg^{-1} (0.0024 oz/lb) of inorganic N to each pot. In 100 FWC medium the amount of inorganic N added to each pot from FWC was doubled (304 mg kg^{-1} (0.0049 oz/lb)). SGI response to supplemental N did not occur until 7 weeks after transplanting for marigolds in the 50 FWC:50 B medium and 9 weeks for geraniums in the 100 FWC medium. Growers often use too much fertilizer when producing greenhouse container-grown crops (1). Over fertilization has lead to excess water application and leaching in order to prevent soluble salt accumulation in the growing medium. With reduced fertilizer concentrations, less leaching is needed. By minimizing leaching, the nutrients in the medium can be more efficiently used by the plant, instead of being flushed out of the pot. In 100 FWC adequate N was supplied for the growth of marigolds and geraniums up to week 7 when there was no leaching (Tables 1 and 2). Although there was a SGI reduc-

Table 4. **Effect of 100% fishwaste compost (FWC), 100% Douglas-fir bark (B), and 50% FWC:50% B growing media on the electrical conductivity and the amount of inorganic nitrogen in leachates collected at transplant (week 0) and at one week intervals from marigold plants in the 0 mg N fertilizer treatment.**

	Electrical conductivity mS·cm⁻¹							
	Week							
Growing media	0	1	2	3	4	5	6	7
100 FWC	1.98a[z]	1.04a	0.87a	0.95a	0.56a	0.25b	0.20b	0.20b
50 FWC:50 B	2.11a	1.07a	0.68b	0.43b	0.28b	0.20c	0.18b	0.17c
100 B	1.06b	0.53b	0.53c	0.40b	0.35b	0.31a	0.34a	0.25a
	Nitrogen (mg/pot)							
100 FWC	43.70a	17.69a	12.11a	9.53a	2.98a	0.44a	0.17b	0.24a
50 FWC:50 B	31.11b	13.14b	5.30b	1.19b	0.28b	0.18b	0.20b	0.23a
100 B	1.04c	0.34c	0.40c	0.43b	0.33b	0.21b	0.33a	0.30a

[z]Letters compare growing media within a week; the means followed by the same letter are not significantly different at the 5% level using Tukey's Studentized Range Test (HSD).

tion for geraniums at week 9 in 100 FWC the amount of N from FWC was sufficient to produce salable quality plants.

The weekly application of 0.3 liter (0.32 qt) DI water to marigolds in addition to the no-leach drip irrigation, produced LF averages that were slightly higher for 100 B (0.77 ± 0.07SD) than for 100 FWC (0.54 ± 0.11SD) or 50 FWC:50 B (0.55 ± 0.11SD). Marigolds in the 100 B medium receiving no N fertilizer were small (Tables 1 and 2). Limited water uptake by the small plants could account for the higher leaching fraction in the 100 B medium. The pH levels of leachates from marigolds in this 0 mg N treatment were 5.8, 5.4 and 5.3 immediately after transplanting for 100 FWC, 50 FWC:50 B, and 100 B media, respectively, and increased to 7.0, 7.0, and 6.9 for the same media at week 7. Leachate EC from the 100 FWC and 50 FWC:50 B plants was similar until week 2 (Table 4). By week 3 leachate EC from the 50 FWC:50 B medium was similar to the 100 B medium. Leachate EC from the 100 FWC medium remained higher until weeks 5–7 when its ECs were lower than the 100 B medium. Differential nutrient utilization by plants may account for the lower ECs of leachate from 100 FWC and 50 FWC:50 B marigolds (Tables 1 and 2).

The amount of inorganic N initially leached from the 100 B medium without added N fertilizer was low (Table 4). Nitrogen in leachate decreased rapidly with time and by week 3, there was no difference between the 100 B and 50 FWC:50 B media. On week 7, similar amounts of inorganic N leached from all three media. The cumulative amount of inorganic N leached represented 28.6% of the inorganic N from FWC in the 100 FWC medium and 33.2% of the inorganic N from FWC in the 50 FWC:50 B medium.

Growth parameters of the 0 mg N, weekly-leached marigolds growing in the 3 test media were compared to growth parameters of marigolds in the 0 mg N treatment that were not leached. Results of the Student's t-tests comparing 0 mg N leached versus 0 mg N non-leached marigolds in 100 FWC, 50 FWC:50 B and 100 B media indicated SGIs on weeks 3, 5 and 7, and week 7 dry weights were not significantly influenced by weekly leaching (data not shown). The only significant influence of leaching was on the time-of-sale quality of marigolds in the 50 FWC:50 B medium (p-value = 0.0005) where the non-leached plant quality was rated higher, 3.8, than the leached plant quality, 3.0. Depletion of inorganic N in the medium, as reflected in the very low inorganic N level in the leachate on week 3 (Table 4), was the likely cause. Quality of marigolds in the 100 FWC was not influenced by leaching.

Conover and Poole (3) found no difference in plant quality rating or top fresh weight when 'Fluffy Ruffle' ferns were irrigated with either 0.1, 0.2 or 0.3 liters (0.106, 0.21, 0.32 qt) water per 15 cm (6 in) pot twice weekly. EC of leachate from pots in their study varied widely from highs of 9.60 and 2.10 mS×cm⁻¹ for plants given 0.1 and 0.3 liters water, respectively, on week 7; to lows of 4.14 and 0.66 mS×m⁻¹ on week 12. Wright (22) indicated many nursery crops grew rapidly at EC levels of 0.6 to 2.0 mS×m⁻¹ in leachate from a pine bark growing medium. When leached weekly with a leaching fraction up to 0.55, the 100 FWC did not lose its effectiveness as a N source for the production of marigolds. However, weekly leaching was not necessary to prevent soluble salt accumulation in the 100 FWC growing medium.

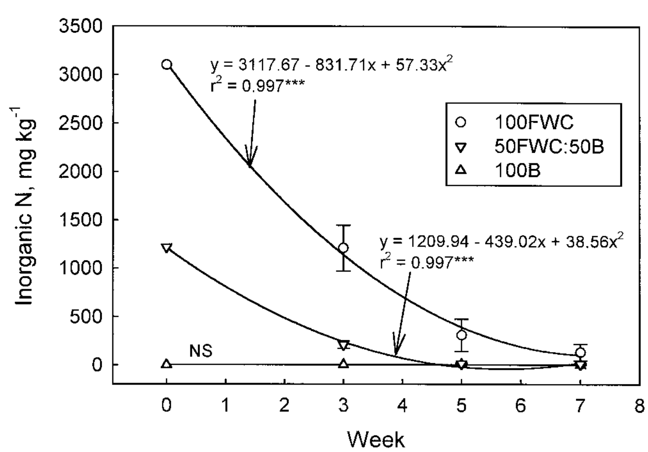

Fig. 1. **Inorganic N concentration in the 100% fishwaste compost (FWC), 100% Douglas-fir bark (B) and 50% FWC:50% B growing media from marigolds in the 0 mg N fertilizer treatment. Media inorganic N was measured at transplant (week 0) and when marigolds were harvested at weeks 3, 5, and 7 after transplant.**

Table 5. Effect of 100% fishwaste compost (FWC), 100% Douglas-fir bark (B), and 50% FWC:50% B growing media on N uptake of marigolds in the 0 mg N fertilization treatment. Plants were harvested at weeks 3, 5, and 7 after transplant.

	Harvest date		
	Week 3	Week 5	Week 7
Growing medium	N uptake (mg/pot)		
100 FWC	35.58b[z]	113.87a	160.55a
50 FWC:50 B	43.44a	70.55b	78.64b
100 B	1.27c	1.59c	1.91c

[z]Letters compare growing media within a measurement date; the means followed by the same letter are not significantly different at the 5% level using Tukey's Studentized Range Test (HSD).

If the amount of FWC used in the growing medium is reduced to 50 FWC:50 B, weekly leaching is not recommended because the quality reduction brought marigolds to the lowest rating considered marketable.

Experiment 2. The effect of growing medium on SGIs of marigolds in Experiment 2 was similar to the effect on 0 mg N marigolds in Experiment 1 at weeks 3, 5, and 7 (data not shown). Shoot dry weight and quality of marigolds harvested from the 50 FWC:50 B and 100 FWC media were improved on weeks 3 and 5; by week 7 marigolds in the 100 FWC medium were of the highest quality and had the largest shoot dry weights (data not shown). Marigold root dry weights at week 7 in Experiment 2 (data not shown) reflected the root system ratings (Table 3) in Experiment 1.

Under no-leach drip irrigation, the concentration of inorganic N in the 100 FWC and 50 FWC:50 B media declined rapidly during the 7 weeks of marigold growth (Fig. 1). The inorganic N was below 20 mg kg^{-1} (0.0003 oz/lb) in 50 FWC:50 B by week 5 and in 100 FWC by week 7. Not all inorganic N lost from the medium was accounted for by N accumulation in shoots (Table 5). The total amount of N accumulated in the shoots at week 7 was 52.8% of the FWC-N in the 100 FWC medium and 51.7% of the FWC-N in the 50 FWC:50 B medium. By week 7, the combined N in the shoots and the remaining inorganic N in the medium totaled 56.6% in the 100 FWC and 53.2% in the 50 FWC:50 B of the total N added from the FWC. Root N concentrations were not analyzed. Some of the inorganic N unaccounted for could be lost due in part to denitrification or conversion to stabilized organic N (16). Additional research is needed to determine the suitability of FWC for production of other species and to evaluate the post-production performance of plants grown in FWC.

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