Comparison of Micronutrient Sources for Container Rhododendron

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SUMMARY. Micronutrient supplements were applied to container rhododendron (*Rhododendron* L. x 'Girards Scarlet' [Girard Evergreen Hybrid Group]) in three forms: uncoated micronutrient fertilizer; slow-release, NPK-plus-minors fertilizer; and biosolids compost (15% v/v). Control plants received no supplement. While all micronutrient treatments had significantly higher foliar Mn or Cu concentrations than controls 1 year after potting, they did not increase growth (dry weight) or plant quality. At 1, 3, and 12 months after potting, the compost treatment had significantly higher diethylenetriaminepentaacetic acid (DTPA)-extractable levels of Mn, Fe, and Zn in the medium. Only one micronutrient fertilizer treatment increased extractable micronutrient concentrations (Cu) on all testing dates. Correlations between medium-extractable and foliar micronutrient concentrations were low ($r^2 < 0.30$). Vigorous growth in the control treatment suggested that adequate levels of micronutrients were supplied by the pine bark-hardwood bark-peat-sand medium. September concentrations [ppm (mg L^{-1})] as low as 2.0 Mn, 17.8 Fe, 0.3 Cu, 4.2 Zn, and 0.9 B in DTPA extracts produced acceptable growth in rhododendron through the following June.

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In the late 1960s and 1970s, stand-alone micronutrient fertilizers were developed for use in container media (Whitcomb et al., 1975) and since then have been the most common type of micronutrient supplement used in nursery production. Handrek (1995) found that a single preplant micronutrient charge was as effective as weekly soluble applications in sustaining growth of hebe (*Hebe Comm. ex Juss.* 'Inspiration') over 12 months. Broschat and Donselman (1985) examined preplant micronutrients in sulfate or oxide forms or adsorbed to clay carriers. They found that levels of media-extractable micronutrients decreased during the first month after application but were relatively stable for the following 16 months. Only Fe availability was suboptimal.

Research with biosolids compost (Ticknor et al., 1985) and pine bark (Niemiera, 1992; Wright and Hinesley, 1991) has suggested that micronutrient fertilization may be unnecessary when these materials are used as growing medium components. Even phytotoxic levels of micronutrients may be found in some types of media; for example, hardwood bark may contribute toxic levels of Mn (Bunt, 1988; Svenson and Witte, 1992) and compost may have high levels of B (Lumis and Johnson, 1982; Rosen et al., 1993). Other researchers have found micronutrient supply from media components to be insufficient (pine bark: Handrek, 1995; Whitcomb et al., 1975) and that micronutrient addition may optimize growth (Wright et al., 1997). In addition to media components, other potential sources of micronutrients to be considered include irrigation water and fertilizer impurities (Bunt, 1988).

While previous research does not consistently support the need for micronutrient fertilizer supplements, manufacturers are producing an increasing number of slow-release fertilizers with minors packages (slow-release + minors products). Micronutrients in these products may be bulk-blended with N-P-K prills or may occur within or as part of the prill coating (B. Birrenkott, personal communication). In a preliminary experiment (M.A. Rose, unpublished), micronutrient availability from several of these products and a stand-alone micronutrient fertilizer was examined.

One of the slow-release + minors fertilizers and the stand-alone micronutrient fertilizer increased dry weights relative to controls. However, significant growth effects were observed on only one of four sampling dates and for one cultivar of rhododendron. Foliar micronutrient concentrations were not different among treatments at any date. Overall, preliminary research provided only weak support for micronutrient fertilization.

Our primary objective was to compare medium-extractable and foliar micronutrient concentrations of container plants fertilized with micronutrient sources commonly used in nursery production. Biosolids compost was incorporated into the medium in one treatment because some nursery producers rely on it to supply micronutrients (H. Hoitink, personal communication). We were particularly interested in the long-term potential for supplying micronutrients to a container crop. A second objective was to determine benefits, if any, of micronutrient fertilization.

Materials and methods

Four-inch-square (10-cm^2) potted liners of rhododendron 'Girards Scarlet' were potted 7 June 1996 in 1.6-gal (6.1-L) pots containing 3.0 pine bark : 1.0 hardwood bark : 1.0 peat : 0.2 sand (by volume). The medium was amended with gypsum, dolomitic lime, and granular sulfur at 4, 2, and 1 lb/yard³ (2.4, 1.2, 0.6 kg m^{-3}) respectively. The eight treatments and their corresponding micronutrient sources and manufacturers are listed in Table 1. In one treatment, the stand-alone micronutrient fertilizer STEP HiMag (STEP; Scotts Co., Marysville, Ohio) was topdressed at the manufacturer's standard rate of 0.25 oz (7 g) per pot. In the compost treatment, biosolids compost (Technagro Compost; Kurtz Bros., Cuyahoga Heights, Ohio) was incorporated at 15% by volume. Technagro is an invessel composted, belt-dewatered compost with pH 7.5, electrical conductivity 6.9 mmhos/cm (mS cm^{-1}), containing 1.7N-0.3 K-1.2 P and 63 % organic matter (dry weight). In five of the treatments, micronutrient sources were five different slow-release fertilizers (slow release + minors products). All plants were topdressed with 0.13 oz (3.8 g) of N from either 18-6-12 (18N-2.6P-10K) (no micronutrient

Table 1. Slow-release macronutrient fertilizer source^z and analysis, micronutrient fertilizer source, and micronutrient application rate for each experimental treatment.

Treatment	Slow-release N-P-K source ^x	Micronutrient source	Micronutrient (ppm) ^y				
			Mn	Fe	Cu	Zn	B
Control	Osmocote 18-6-12	No commercial source added	---	---	---	---	---
Compost ^w	Osmocote 18-6-12	Biosolids compost, 15% v/v	37.4	192.1	4.1	22.1	0.9
STEP ^v	Osmocote 18-6-12	STEP HiMag: stand-alone micronutrient product consisting of sulfates & oxides	34.4	91.8	5.7	11.5	---
Customblend ^u	Customblend 19-5-8	Customblend: sulfates, oxides physically blended with fertilizer prills	8.2	29.5	1.6	3.3	---
Sierra ^u	Sierra 17-6-10	Sierra: sulfates in prill coating	3.7	14.7	1.8	1.8	0.7
Osmocote Plus ^u	Osmocote Plus 16-8-12	Osmocote Plus: Fe chelate + sulfates inside prill	2.7	19.5	2.0	---	0.8
High N Plus ^u	High N Plus 22-4-8	Hi N Plus: sulfates in prill coating	2.8	28.4	1.4	1.4	0.6
Nutricote Plus ^u	Nutricote Plus 18-6-8	Nutricote Plus: Fe chelate + sulfates inside prill	2.1	6.9	1.7	0.5	0.7

^zAll fertilizers manufactured by The Scotts Co., Marysville, Ohio except Nutricote Plus (Agrimart Inc., Webster, Tex.).

^yWeight per volume of potting medium.

^xAll slow-release N-P-K fertilizers were applied at rates of 0.13 oz (3.8 g) N per 1.6-gal (6.1-L) pot.

^wMicronutrient application rate calculated by authors from compost elemental analysis.

^vThe stand-alone micronutrient product STEP HiMag was applied at manufacturer's suggested standard rate of 0.25 oz (7 g) per pot.

^uMicronutrient application rates calculated from manufacturer's guaranteed analysis.

package) or the slow-release + minors fertilizers (Table 1). All slow-release fertilizers were eight to nine-month release formulas. Different ratios of micronutrients within the products resulted in different micronutrient application rates among treatments (Table 1).

Treatments were arranged in a randomized complete block design in a container nursery with overhead irrigation. Eighteen single-plant replications of each treatment were divided between three blocks. Minolta SPAD-502 Chlorophyll Meter (SPAD; Minolta Camera Co., Ramsey, N.J.) readings of recently matured leaves were taken 29 Aug. 1996. On all medium and foliage sampling occasions, samples were taken from every pot. Samples from each block-treatment combination were mixed together for a composite sample. Recently matured leaves were sampled 9 Sept. 1996 and 1 June 1997. Leaf tissue was dried, ground, and dry-ashed 4 h at 932 °F (500 °C); ash was dissolved in 2.4 N nitric acid before elemental analysis. The growing medium was sampled three times: 14 July 1996, 12 Sept. 1996, and 27 May 1997. Except for NO₃-N analysis, medium samples were extracted using the 0.005 M DTPA modification of the saturated medium extract procedure (Warncke, 1988). Distilled water was used as the medium extractant for NO₃-N, which was measured with a nitrate-specific electrode (Orion Research, Cambridge, Mass.). Medium extracts and acid digests were analyzed for P, K,

Mn, Fe, Cu, Zn, and B by inductively coupled argon plasma spectrophotometry (Fison Instruments, Dearborn, Mich.) at the Ohio State University Research Extension Analytical Laboratory, Wooster.

Plants were over-wintered between first and second seasons in a single-layer polyhouse. Shoots from all 144 plants were harvested to measure dry weights one year after potting (1 June 1997). SAS statistical procedures were used for analysis of variance and mean separation (SAS Institute, Cary, N.C.). Dunnett's two-tailed *t* test was used to determine statistically significant differences from the control treatment; the protected LSD test was used to compare all means ($p \leq 0.05$).

Results and discussion

PLANT APPEARANCE, GROWTH RESPONSE, AND MACRONUTRIENT CONCENTRATIONS IN THE MEDIUM. All plants reached salable size by September and flowered the following May. The plants in the control and compost treatments had excellent color. Plant quality in these treatments was at least as good as others. Shoot dry weights (Table 2) were not significantly different among treatments, although some color differences were noted. By late August, plants in the Sierra and Customblend treatments had lighter green leaves than controls; visual observations were confirmed by significantly lower SPAD readings (data not shown). Visual color observations and SPAD readings in other treatments were not different from controls.

Macronutrient concentrations in the medium (Table 3) were measured in July, ≈ 1 month before the color differences were noted, and also in Sept. Even though plants were of good quality in most treatments, the NO₃-N and K concentrations were below the adequate range (Table 3) in most and some of the treatments, respectively. Macronutrient concentrations did not suggest why the Sierra and Customblend treatments had poor foliage color by late August. The Sierra treatment actually had higher, but not excessive medium concentrations of N, P, and K than controls in July. Perhaps the rate of nutrient release from these fertilizers was insufficient in August. By September, medium N, P, and K concentrations in the Sierra and Customblend treatments were not different from controls.

Table 2. Effect of micronutrient source on shoot dry weight of rhododendron 'Girards Scarlet' one year after potting.

Treatment	Dry wt (g ^z)
Control	65 a ^y
Compost	73 a
STEP	73 a
Customblend	69 a
Sierra	75 a
Osmocote Plus	66 a
High N Plus	59 a
Nutricote Plus	78 a

^z10 g = 0.35 oz.

^yMeans followed by the same letter are not significantly different using a protected LSD ($p \leq 0.05$); $n = 3$.

Table 3. Effect of micronutrient source on growing medium macronutrient concentrations of rhododendron 'Girards Scarlet' on two dates during the first growing season.

Treatment	Macronutrient (ppm)		
	NO ₃ -N	P	K
14 July 1996			
Control	29.1 b ^z	10.6 bcd	56.7 b
Compost	17.1 bc	23.0 a	58.4 b
STEP	27.3 b	11.4 bc	61.0 b
Customblend	23.3 bc	9.2 bcd	38.3 c
Sierra	51.7 a	18.3 a	107.5 a
Osmocote Plus	19.6 bc	11.9 b	65.5 b
High N Plus	12.7 bc	6.9 bcd	24.5 cd
Nutricote Plus	13.9 bc	5.4 d	32.5 cd
12 Sept. 1996			
Control	28.2 a	14.8 bc	91.7 ab
Compost	8.8 a	25.6 a	51.2 c
STEP	26.8 a	18.7 ab	92.5 ab
Customblend	17.5 a	12.5 bcd	57.9 bc
Sierra	12.6 a	10.1 bcd	56.8 bc
Osmocote Plus	12.1 a	13.4 bcd	95.0 a
High N Plus	26.9 a	5.9 cd	28.0 c
Nutricote Plus	3.3 a	3.6 d	25.6 c
Adequate ranges ^y	40–99	3–5	60–149

^zMean separation within columns and dates by protected LSD ($p \leq 0.05$).

^yAdequate range for concentrations in saturated medium extracts from Warncke and Krauskopf, 1983; $n = 3$

DTPA-EXTRACTABLE MICRONUTRIENT LEVELS IN THE GROWING MEDIUM. While the amount of N applied was constant among treatments, the micronutrient application rates varied due to different ratios within the products (Table 1). The stand-alone micronutrient fertilizer, STEP, when used at the manufacturer's recommended rate, provided three to four times the quantity of Mn, Fe, Cu, and Zn supplied by any of the slow release + minors products. However, the STEP treatment only increased media-extractable Mn levels above controls on one date (September 1996, Table 4). The slow-release + minors products did not raise extractable micronutrient levels above controls in any consistent pattern, with the exception of the Customblend treatment, which had higher medium Cu levels on all testing dates. Extractable Fe was not increased by any of the slow-release + minors products.

The compost treatment had higher extractable Mn, Fe, and Zn than con-

Table 4. Effect of micronutrient source on growing medium pH and micronutrient concentrations of rhododendron 'Girards Scarlet' on two dates during the first growing season and 1 year after potting.

Treatment	Micronutrient (ppm)					
	pH	Mn	Fe	Cu	Zn	B
14 July 1996						
Control	4.9	5.4	29.2	0.6	5.1	0.7
Compost	5.2	18.4 ⁺	50.1 ⁺	1.5	22.6 ⁺	0.7
STEP	4.7	8.8	37.4	1.0	9.0	0.8
Customblend	4.7	10.9	35.6	2.9 ⁺	15.9 ⁺	0.9
Sierra	5.0	7.7	29.2	1.2	4.4	1.2
Osmocote Plus	5.5	2.9	23.8	0.9	3.7	0.9
High N Plus	5.0	6.5	33.5	0.5	5.1	0.8
Nutricote Plus	4.9	3.5	25.9	1.0	4.2	1.0
12 Sept. 1996						
Control	4.5	2.1	30.2	0.3	4.2	2.3
Compost	5.6 ⁺	14.1 ⁺	58.5 ⁺	1.6	28.4 ⁺	1.4
STEP	4.8	7.6 ⁺	30.1	1.5	11.1	2.0
Customblend	4.8	7.6 ⁺	30.3	2.4 ⁺	11.5	0.9
Sierra	5.0	4.3	19.0 ⁻	0.7	12.3	1.1
Osmocote Plus	5.3	2.0	20.0 ⁻	1.4	4.2	1.9
High N Plus	4.7	2.9	28.4	0.4	5.2	0.9
Nutricote Plus	5.2	2.3	17.8 ⁻	1.1	4.4	0.9
27 May 1997						
Control	4.7	5.1	23.5	1.6	11.2	0.1
Compost	5.1	16.9 ⁺	77.2 ⁺	1.9	26.8 ⁺	0.3 ⁺
STEP	4.5	4.3	26.3	2.3	10.8	0.1
Customblend	4.6	5.4	32.4	6.6 ⁺	14.9	0.1
Sierra	4.7	2.8	13.6	0.9	7.7	0.1
Osmocote Plus	4.8	2.0	19.5	2.1	5.3	0.3 ⁺
High N Plus	4.8	1.5	33.0	0.8	7.1	0.1
Nutricote Plus	4.8	1.4	12.2	1.9	5.2	0.2
Adequate range ^z		5–30	15–40	0.5–1.5	5–30	0.7–2.5

^zAdequate range for micronutrient concentrations in 0.005 M diethylenetriaminepentaacetic acid (DTPA)-saturated medium extracts, from D. Warncke and R. Berghage, personal communication. The + or - symbols to right of treatment means indicate a statistically significant difference from the control treatment using Dunnett's two-tailed t test at $p \leq 0.05$. Mean comparisons are made within each column and date; $n = 3$.

Table 5. Micronutrient concentrations in irrigation water and in fresh, unused growing medium components used in the production of rhododendron 'Girards Scarlet'.²

Source	Micronutrient (ppm)				
	Mn	Fe	Cu	Zn	B
Irrigation water	0.03	0.03	0.06	0.30	0.06
Biosolids compost	45.4	37.3	2.2	57.5	1.8
Pine bark	81.4	38.7	0.2	2.2	0.6
Composted hardwood bark	93.1	38.7	0.3	2.7	0.5
Peat moss	0.2	21.1	<0.1	0.7	0.1

²Concentrations in 0.005 M diethylenetriaminepentaacetic acid (DTPA) extracts of medium components.

trols on all three testing dates, and higher B on 27 May 1997. This treatment supplied greater absolute amounts of these elements than other treatments (Table 1). The compost treatment was the only treatment that increased medium pH (12 Sept. 1996, Table 4), and also increased extractable P (Table 3). High levels of P in media can reduce extractable levels of Mn, Fe, and Zn (Broschat and Donselman, 1985); however this was not observed in the compost treatment.

In most treatments, extractable Mn and B decreased between the first and last sampling dates, falling below critical ranges developed for the 0.005 M DTPA-saturated medium extract procedure (Table 4). Growing medium concentrations of Fe were relatively stable over the course of the year. Only the Sierra and Nutricote Plus treatments fell below the Fe standard on the last sampling date. All treatments had adequate Zn and Cu on the last sampling date. Throughout the year, medium micronutrient concentrations may have been maintained by slow release from fertilizer sources, or by cation exchange from growing medium components. Given the strong evidence of micronutrient availability from the medium components, the latter seems more probable.

The adequate ranges given in Table 4 were developed at Michigan State University for floral crops, and might need revision for woody ornamentals. By Sept., extractable concentrations [ppm (mg·L⁻¹)] were as low as 2.0 Mn, 17.8 Fe, 0.3 Cu, 4.2 Zn, and 0.9 B. These concentrations fell below the standards for Mn, Cu, and Zn, but nonetheless sustained acceptable growth through final harvest the following June. Although two treatments (Customblend and Sierra) had poor foliage color, availability of micronutrients in the growing medium did not

appear to be a factor since other treatments had comparable concentrations but good foliage color.

MICRONUTRIENT CONTRIBUTIONS OF IRRIGATION WATER AND MEDIA COMPONENTS. The irrigation water analysis (Table 5) suggested that water impurities were not a significant source of micronutrients. The Zn concentration in water was at most 10% of medium concentrations; Mn, Fe, Cu, and B were proportionately much lower. In contrast, extractable micronutrient concentrations in fresh medium components suggested that these were important sources (Table 5). Biosolids compost (Table 5) had Mn, Fe, Cu, Zn, and B concentrations within or exceeding the adequate ranges (Table 4) developed for the 0.005 M DTPA-saturated medium extract procedure. Relative to these standards, peat moss, pine and hardwood bark were also significant sources of Fe, and pine and hardwood bark were sources of Mn.

FOLIAR NUTRIENT CONCENTRATIONS. Foliar micronutrient concentrations were not different among treatments on the first sampling date (9 Sept. 1996, data not shown). One year after

potting, all micronutrient treatments had higher foliar Mn or Cu levels than controls (Table 6). However, elevated foliar Mn and Cu did not appear to enhance growth of micronutrient treatments since controls were equivalent or superior in quality and size. With the exception of Cu, foliar micronutrient concentrations of the controls fell within or close to adequate ranges (Table 5); this was further evidence that growing medium components supplied adequate amounts of micronutrients. Correlations between foliar micronutrient concentrations and DTPA-extractable micronutrients were low (all micronutrients, $r^2 < 0.30$).

Conclusions

The vigorous growth and good color we observed in controls corroborates other research that suggests pine or hardwood bark media may supply sufficient micronutrients to woody plants (Niemiera, 1992; Svenson and Witte, 1992; Wright and Hinesley, 1991). None of the micronutrient-containing fertilizer products increased growth or medium-extractable levels of Fe compared to controls. Only one micronutrient fertilizer increased medium-extractable micronutrients (Customblend-Cu) on all three dates. In contrast, the biosolids compost provided higher medium-extractable Mn, Fe, and Zn on all dates; this treatment also had significantly higher foliar Mn concentrations than controls.

Growers should consider the species, crop duration, growing medium composition, water source, as well as cost when deciding whether to use micronutrient fertilizers. Eliminating micronutrient supplements from a stan-

Table 6. Effect of micronutrient source on foliar micronutrient concentrations of rhododendron 'Girards Scarlet' 1 year after potting.

Treatment	Micronutrient (ppm)				
	Mn	Fe	Cu	Zn	B
Control	46.6	60.4	2.4	44.0	31.8
Compost	83.9 ⁺	60.6	3.0	51.8	28.3
STEP	134.4 ⁺	64.7	2.5	58.0	30.1
Customblend	134.6 ⁺	58.3	3.6 ⁺	53.9	45.7
Sierra	85.3 ⁺	58.2	3.4 ⁺	52.5	38.2
Osmocote Plus	52.8	61.6	3.7 ⁺	47.9	34.8
High N Plus	97.4 ⁺	64.4	4.0 ⁺	54.4	40.8
Nutricote Plus	62.0	56.2	5.1 ⁺	46.1	47.0
Adequate ranges ²	50–200	35–250	6–25	20–200	6–75

²Foliar micronutrient sufficiency ranges from Bailey, D., T. Bilderback, and D. Bir, Container Substrate and Water Management Seminar, 3 Jan. 1996. The + symbols to the right of treatment means indicate a statistically significant difference from the control treatment using Dunnett's two-tailed *t* test at $p \leq 0.05$. Mean comparisons are made within each column; $n = 3$.

dard cultural program may be advisable only if the primary source of these nutrients was identifiable, measurable, and consistent. A final consideration is that this study used a salt-sensitive genus (*Rhododendron*) and hence a moderate rate of N fertilization. Other studies have suggested that micronutrients might become limiting when rapid growth rates are stimulated by high rates of fertilization (Whitcomb et al., 1975) or lime addition (R. Wright, personal communication).

Literature cited

Broschat, T.K. and H.M. Donselman. 1985. Extractable Mg, Fe, Mn, Zn, and Cu from a peat-based container medium amended with various micronutrient fertilizers. J. Amer. Soc. Hort. Sci. 110:196-200.

Bunt, A.C. 1988. Media and mixes for container-grown plants. Unwin Hyman, London.

Handrek, K.A. 1995. Comparison of preplant and fertigated micronutrients on the growth of Hebe 'Inspiration'. Commun. Soil Sci. Plant Anal. 26:3063-3081.

Lumis, G.P. and A.G. Johnson. 1982. Boron toxicity and growth suppression of Forsythia and Thuja grown in mixes amended with municipal waste compost. HortScience 17:821-822.

Niemiera, A.X. 1992. Micronutrient supply from pine bark and micronutrient fertilizers. HortScience 27:272.

Rosen, C.J., T.R. Halbach, and B.T. Swanson. 1993. Horticultural uses of municipal solid waste composts. HortTechnology 3:167-173.

Svenson, S.E. and W.T. Witte. 1992. Ca, Mg, and micronutrient nutrition and growth of *Pelargonium* in pine bark amended with composted hardwood bark. J. Environ. Hort. 10:125-129.

Ticknor, R.L., D.D. Hemphill, Jr., and D.J. Flower. 1985. Growth response of *Photinia* and *Thuja* and nutrient concentration in tissues and potting medium as influenced by composted sewage sludge, peat, bark, and sawdust in potting media. J. Environ. Hort. 3:176-180.

Warncke, D. 1988. Recommended test procedures for greenhouse growth media, p. 34-37. In: Recommended chemical soil test procedures for the North-Central region. North Central Publ. 221 (revised).

Warncke, D and D. Krauskopf. 1983. Greenhouse growth media: Testing and nutrition guidelines. Mich. State Univ. Ext. Bul. E-1736.

Whitcomb, C.E., A. Storjohann, and W.D. Warde. 1975. Micromax-micronutrients for improved plant growth. Proc. Intl. Plant Prop. Soc. 30:462-467.

Wright, R.D. and L.E. Hinesley. 1991. Growth of containerized eastern red cedar amended with dolomitic limestone and micronutrients. HortScience 26:143-145.

Wright, A.N., J.K. Fanelli, A.X. Niemiera, J.R. Harris, and R.D. Wright. 1997. Amending pine bark with lime and micronutrients affects growth of nine landscape tree species. Proc. S. Nursery Assn. 42:71-74.