EFFECTS OF CONTAINER SIZE AND FERTILIZER RATE ON GROWTH OF *RHODODENDRON* 'FORMOSA' AND *ILEX* 'NELLIE R. STEVENS' PLANTS

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INTRODUCTION

The production of woody landscape plants in containers began to gain in popularity in the early 1950s. Production has primarily been limited to small containers ranging from 3.8 to 18.9 L. The demand for plants in containers greater than 18.9 L has increased in recent years (1). There is a great volume of literature concerning production practices on smaller container sizes, but little is available concerning production practices in larger containers.

Slow-release fertilizers are applied to container plants by incorporation during blending of growth medium components, top-dressed, or applied in a dibble hole directly beneath the transplanted liner. Rates are determined on a volume (cubic meter) basis (2, 7, 8 10). Methods of incorporation during blending and dibble application may only be used at planting. Subsequent slow release fertilization is accomplished by surface application. Regardless of the method of application, fertilization on a volume basis results in greater amounts of fertilizer per plant as container size increases. Greater per plant amounts of fertilizer may not be justified with increasingly larger containers, especially with containers with capacities greater than 18.9 L.

Laiche (6) found no difference in plant size or foliage color of azalea 'Formosa' grown with 4.2, 5.6 and 7.1 kg of slow-release 18.0 N-2.6P-10.0K/m^3 in 11.4 or 18.9 L containers. Goodale and Whitcomb (3), with four container sizes ranging from 2.2 to 5.8 L, and fertilizer rates of 11.4 to 31.8 grams/container-plant, found that growth varied among the six species tested.

Elaeagnus increased in size as fertilizer rate increased, but not as container size increased. Juniper and pyracantha increased in size as fertilizer rate and as container size increased. No difference, and only slight differences, were obtained with dwarf Burford holly and aucuba, respectively. Barberry did not grow well in the larger containers. Tilt, *et al.* (9) obtained a 2-fold increase in top dry weight of three test plants as container volume increased from 3.8 to 11.4 L.

Amendments, including 3.75 kg/m³ of 18.0 N-2.6 P-10.0 K were added to the growth medium during the blending procedure. Hanson, *et al.* (4) found that container size and shape influenced oak seedling growth. More shoot and root dry weight was obtained in 15.4 x 36 cm containers than in smaller containers but growth was not increased in 15.4 x 110 cm containers.

Seedlings were fertilized in proportion to container sizes and all received the same amount of fertilizer per unit volume of potting medium. Keever, et al. (5) reported increases in plant size due to increased container size with three woody ornamentals fertilized weekly with soluble fertilizer applied to container capacity.

The objective of this study was to determine the effects of container size (5.7 to 45.4 L), and of 17 N-3.0 P-10.0 K slow-release fertilizer rates (0.6 to 9.5 kg/m³ in 1987 and 0.8 to 12.8 kg/m³ in 1988, on the shoot and root growth of two woody landscape plants.

MATERIALS AND METHODS

Liners of *Rhododendron* 'Formosa' and *Ilex* 'Nellie R. Stevens' (*Ilex aquifolium* × *I. cornuta*) growing in 0.33 L containers were transplanted into 5.7, 11.4, 22.7 and 45.4 L containers on April 29 and on May 18, 1987. The growth medium was 100% pine bark. One day after planting an amendment mixture plus complete fertilizers of 20.0 N-2.2 P-8.3 K and 17.0 N-3.0 P-10.0 K, were surface applied and the growth medium cultivated 5 to 8 cm deep.

The amendment mixture consisted of 0.9 kg of dolomitic limestone, 0.2 kg of Micromax (Sierra Chemical Company, Milpitas, CA 95035), and 0.2 kg of simple superphosphate (0 N-8.6 P-0 K) applied at the rate of 1.8 kg/m³. This amendment mixture was reapplied without media cultivation on August 19, 1987, and on April 5 and July 6, 1988.

A complete fertilizer, 20.0 N-2.2 P-8.3 K (Parker Fertilizer Company, Sylacauga, AL 35150), was applied one time in a circular band 13 to 15 cm from the liner ball at 5 g per container plant.

Treatments of 17.0 N-3.0 P-10.0 K slow-release fertilizer (Sierra Chemical Company, Milpitas, CA 95035) were reapplied without medium cultivation at the rates described in Table 1 on April 5, 1988 and at ⅓ this spring rate on July 6, 1988. Plants were grown in full sun and irrigated as required with overhead sprinklers.

The experimental design for each cultivar was a split plot with 12 replications. Main plots were four container sizes. Subplots were six fertilizer rates. Experimental units were one container plant, with the exception of the 5.7 L container size, which consisted of two container plants. Three replications selected at random were sacrificed on August 18 and December 3, 1987 to obtain root and shoot growth data. The study was terminated on November 21, 1988.

Data collected included visual foliage color ratings on November 6, 1987, and on October 19, 1988; visual root ratings on August 19 and December 3, 1987 and November 21, 1988; and shoot fresh weight on August 18 and December 3, 1987, and November 21, 1988. Foliage color ratings were 4 = excellent, and 0 = very poor. Visual root ratings were 10 = roots completely surrounding the rootball bottom to top, and 0 = no root growth evident on the surface of the rootball. Plants were severed at the growth medium surface to obtain shoot fresh weight.

RESULTS AND DISCUSSION

Fertilizer rates used in this study were on a volume basis. Therefore, the amount of fertilizer applied per container plant increased as container size increased. Compared to 5.7 L containers, fertilizer applied per plant in the 11.4, 22.7, and 45.4 L containers was 2, 4, and 8-fold, respectively. Comparisons in Table 1 of fertilizer rates were made on a volume basis and comparisons in Table 2 between container sizes were made between only those plants with identical fertilizer rates per unit plant and not per unit volume. For brevity, only fresh-weight data from both species collected 19 months after transplanting is included in tabular form.

Table 1. Effects of container size and slow-release fertilizer rate (volume basis) on plant fresh weight (grams) of *Rhododendron* 'Formosa' and *Ilex* 'Nellie R Stevens' 19 months after transplanting.

Species	Fertilizer Rate	Container size (liters)			
		5 7	11 4	22 7	45 4
	kg/m³	grams			
R 'Formosa'	0 8	83	150	387	757
	1 6	168	348	789	1503
	3 2	309	691	1898	2713
	6.4	572	1062	2642	3893
	9.6	624	1392	2808	2417
	12 8	908	1680	2756	2849
	Linear	**	**	**	**
	Quadratic	NS	**	**	**
	R^2	0 89	0 90	0.84	0 43
I 'Nellie R. Stevens'	0 8	185	279	442	761
	1.6	263	444	749	1357
	3.2	364	628	1260	2062
	6.4	515	783	1472	2031
	9.6	599	928	1487	2228
	12 8	570	956	1607	1798
	Linear	**	**	**	**
	Quadratic	**	**	**	**
	R	0 80	0.86	0 66	0.61

NS, *, ** Nonsignificant or significant at the 5% or 1% level, respectively

Comparisons—Fertilizer rates per unit volume. Fresh weight of *R.* 'Formosa' plants at 4 months increased quadratically by both fertilizer rate and container size. An interaction occurred at 7 months in which maximum fresh weight for plants fertilized at 0.6 kg/m^3 was observed for plants in the 22.7 L containers and in the 45 L containers for all other fertilizer rates. At 19 months after transplanting, fresh weight increased either linearly (5.7 L containers) or quadratically by increased fertilizer rate (Table 1). A linear increase was obtained with container size.

Root quality of *R.* 'Formosa' plants at 4 months increased quadratically by fertilizer rate only in 5.7 L containers and decreased quadratically by increasing container size. Root quality was not affected at 7 months by increasing fertilizer rates, and decreased quadratically by container size. At 19 months root quality increased quadratically by fertilizer rate and was similar for all container sizes.

Foliage-color rating of *R.* 'Formosa' plants increased with increasingly higher fertilizer rates and container sizes at 7 and 19 months.

Fresh weight of *I.* 'Nellie R. Stevens' plants was not affected by either fertilizer rate or container size at 4 or 7 months after transplanting, with the exception of a linear increase after 4 months by fertilizer rate in 5.7 L containers. Fresh weight increased quadratically by fertilizer rate in all container sizes (Table 1) and linearly by container size 19 months after transplanting.

Root quality of *I.* 'Nellie R. Stevens' plants was only affected linearly 4 months after planting and quadratically 7 months after planting in 5.7 L containers, and linearly in 45.4 L containers 7 months after planting by fertilizer rate. Root quality was reduced quadratically by increasing container sizes 4 and 7 months after planting. Root quality was similar after 19 months for all container sizes and fertilizer rates.

Foliage color of *I.* 'Nellie R. Stevens' plants 7 and 19 months after planting improved with higher fertilizer rates and larger container sizes.

Comparisons—Fertilizer rates per unit plant. Growth of *R.* 'Formosa' plants 4 months after planting decreased in fresh weight, with larger container sizes at fertilizer rates of 0.055, 0.027 and 0.014 kg/plant. At higher rates with *R.* 'Formosa', and at all rates with *I.* 'Nellie R. Stevens' plants, growth was generally similar with all container sizes. Seven months after planting, fresh weight of *R.* 'Formosa' plants, at 0.027 kg/plant, decreased in 45.4 L and, at 0.109 and 0.218 kg/plant, growth decreased in smaller containers. Fresh weight of *I.* 'Nellie R. Stevens' plants decreased

in 5.7 L containers at 0.055 kg/plant and was similar at all other fertilizer rates and container sizes.

In general, 4 and 7 months after planting, root quality (in relation to container size) decreased with both species as container size increased. At 19 months high root quality ratings were obtained with both species with only slight differences among treatments. A trend of decreased foliage color rating was obtained at low fertilizer rates with larger containers with both species, 7 but not 19 months after planting.

Nineteen months after planting, at fertilizer rates of 0.009 to 0.036 kg/plant of 17.0 N-2.2 P-8.3 K, there were no differences in fresh weight due to container size for either species (Table 2). At higher rates, plant growth was restricted by smaller container sizes with both species. At 0.072 kg/plant, less growth was obtained in 5.7 and 11.4 L containers, compared to 22.7 and 45.4 L containers with both species although the growth obtained with *R.* 'Formosa' plants in 11.4 L containers was not different than growth obtained in 45.4 L containers. At 0.144 kg/plant, less growth was obtained in 11.4 L containers compared to 22.7 L and 45.4 L containers with *R.* 'Formosa' plants. At 0.144 kg/plant growth of *I.* 'Nellie R. Stevens' plants was reduced by container sizes of 11.4 L, compared to 22.7 L, and in 22.7 L compared to 45.4 L. At 0.288 kg/plant, less growth was obtained with both species in 22.7 L containers, compared to 45. 4 L containers (Table 2).

In summary, results on a per plant basis with both species indicated that optimum growth was obtained in larger containers only in the presence of sufficient quantities of fertilizer. At low fertilizer rates/plant, growth in large containers was not increased. At high fertilizer rates/plant, small container size restricted growth. Fertilizer rates applied per plant at which growth reductions occurred have a common rate when given on a volume basis. For example, growth of *R.* 'Formosa' plants in 11.4 L containers and *I.* 'Nellie R. Stevens' plants in 22.7 L containers was reduced at 0.072 and 0.144 kg/plant respectively, rates equivalent to 6.4 kg/m^3. Similarly, growth reductions that were obtained with both species in 5.7, 11.4 and 22.7 L containers at 0.072, 0.144 and 0.288 kg/plant, respectively, are equivalent to 12.8 kg/m^3.

In this study, conducted for two growing seasons with two plant species, growth was restricted by container size in 5.7, 11.4 and 22.7 L containers when 17.0 N-2.2 P-8.3 K fertilizer rates were increased to a range beginning at 6.4 to 12.8 kg/m^3.

Table 2. Effects of container size and fertilizer rate (per plant) on plant fresh weight (grams) of *Rhododendron* 'Formosa' and *Ilex* 'Nellie R Stevens' 19 months after transplanting.

Species	Fertilizer Rate	Container size (liters)			
		5.7	11.4	22.7	45.4
	(kg/plant)	grams			
R					
'Formosa'	0.004	83			
	0.009	168 a[z]	150 a		
	0.018	309 a	348 a	387 a	
	0.036	572 a	691 a	789 a	757 a
	0 054	624			
	0 072	908 c	1062 b	1898 a	1503 ab
	0 108		1392		
	0.144		1680 b	2642 a	2713 a
	0 216			2808	
	0 288			2756 b	3893 a
	0.432				2417
	0 576				2849
I. 'Nellie R Stevens'	0 004	185			
	0.009	263 a	279 a		
	0 018	364 a	444 a	442 a	
	0.036	515 a	628 a	749 a	761 a
	0 054	599			
	0 072	570 b	783 b	1260 a	1351 a
	0 108	928			
	0.144		956 c	1472 b	2062 a
	0 216			1487	
	0 288			1607 b	2031 a
	0.432				2228
	0 576				1798

[z] Mean separation within rows by least significant difference ($P < 0.05$).

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