Root and Shoot Growth Response of Three Container-Grown *Kalmia latifolia* L. Cultivars at Two Locations to Growing Medium and Nitrogen Form[1]

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Abstract

Rooted liners of *Kalmia latifolia* L. 'Elf', 'Freckles' and 'Goodrich' were shipped to Griffin, Georgia, and Puyallup, Washington and were potted into 3.8 liter (#1) containers. Factorial combinations of growing media (1 bark:1 peat, 4 bark:1 peat), NO_3/NH_4 ratios (100% NO_3/0% NH_4, 60% NO_3/40% NH_4, 20% NO_3/80% NH_4), and rates of N (40, 80, and 120 mg N/pot; 0.0014, 0.0028, and 0.0042 oz N/pot, resp.) were applied at both locations. Results indicated that a combination of the nitrate/ammonium forms of nitrogen (60/40 NO_3/NH_4) and the 80 mg/pot N rate produced the best overall shoot and root growth on all 3 cultivars at both locations. Root and shoot growth was not affected by growing media at either location. With the exception of lower pH readings for the Georgia media, results for the two locations were remarkably consistent.

Index words: Nitrate-ammonium nutrition, mountain laurel, pine bark, fir bark, fertility, nursery production

Significance to the Nursery Industry

Recent introduction of horticulturally-superior mountain laurel (*Kalmia latifolia* L.) cultivars has increased interest in the commercial potential of this attractive flowering shrub. However, lack of knowledge of mountain laurel's cultural requirements hampers its successful production. Results of this research on 3 mountain laurel cultivars ('Elf', 'Freckles', and 'Goodrich') at 2 locations (Griffin, Georgia, and Puyallup, Washington) indicated that a combination of the nitrate/ammonium forms of nitrogen (60/40 NO_3/NH_4) produced the best overall shoot and root growth. The medium rate of nitrogen, 80 mg N/pot (0.0028 oz N/pot) applied as a liquid once every two weeks, produced the best overall shoot and root growth on all 3 cultivars at both locations. Root and shoot growth was not affected by growing media (1 bark:1 peat vs 4 bark:1 peat) at either location. With the exception of lower pH readings for the Georgia pinebark media, results for the two locations were remarkably consistent.

Introduction

Kalmia latifolia L., mountain laurel, is a broadleaved evergreeen shrub or small tree native to the eastern United States. A member of the *Ericaceae* noted for its showy flowers, *K. latifolia* was first used by the early colonists in their gardens but did not gain popularity as a cultivated landscape plant until recent times (6). During the past 30 years, breeding and selection efforts have led to the introduction of horticulturally superior *K. latifolia* cultivars. Twenty-six valid cultivars were recognized in 1983 and more than a dozen cultivars were named from 1983 to 1986 (5). Concomitant with the improved cultivars came advances in propagation technology, most importantly the development of micropropagation techniques for *K. latifolia*, that make *K. latifolia* propagules readily available to growers. However, a lack of knowledge concerning the cultural requirements of *K. latifolia* has limited the commercial availability of these plants for landscape use. In general, *K. latifolia* is considered to have the same cultural requirements as other ericaceous plants with special importance being attached to the need for low fertility, proper drainage and aeration (5). The shortage of knowledge is particularly acute in the area of container production. Jaynes (5) indicated that an optimal container medium and fertilizer regime for *K. latifolia* production is not known.

The pupose of this study was to determine the effect of growing medium, nitrogen form and rate on shoot and root growth of *K. latifolia* in container production at two different locations.

Materials and Methods

Three *K. latifolia* cultivars, 'Elf', considered easy to grow, 'Freckles' also easy to grow in containers and 'Goodrich', considered difficult to grow (1, 5), were commercially micropropagated, rooted and shipped as liners in 5.7 cm (2 ¼ in) pots to Puyallup, Washington, and Griffin, Georgia. On May 1, 1987, liners were transplanted into 3.8 l (#1) containers filled with either a 1:1 or a 4:1 by volume bark:sphagnum peat moss mixture amended with micromax (micronutrient mix, Sierra Chemical Co.) at the rate of 1038 gm/m^3 (1.75 lb/yd^3).

Methods and timing of this experiment were coordinated so that all phases of the experiment were done in the same manner at the same time in both locations. The differences between the two locations other than those imposed by climate were as follows: in Washington plants were grown in full sun and fir bark (pH 4.3) was used in the media, while in Georgia, pine bark (pH 4.2) was used as a media component, and plants were grown in a lath shade structure at

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50% light reduction, and a midseason application of STEM (Soluble Trace Element Mix, W. R. Grace Co.) at 0.60 gm (0.02 oz) per pot was made.

Particle size characteristics of the 2 barks are presented in Table 1. All plants were watered as needed by overhead sprinkler irrigation. Treatments with complete fertilizers in a 3:1:3 N:P:K ratio commenced 3 weeks after transplanting and consisted of one of three NO_3/NH_4 ratios, 100/0, 60/40 or 20/80 NO_3/NH_4, which were applied once a fortnight as 260 ml (7.8 oz) solutions at the rates of 40, 80 or 120 mg N/pot (0.0014, 0.0028 or 0.0042 oz N/pot, respectively).

Six months after experiment initiation, the Virginia Tech Extraction Method (VTEM, also known as the pour through method) was used to collect extracts of the growing medium for specific conductivity (soluble salts) and pH measurements (11, 12). Growth index (height + width/2), visual evaluation of leaf color (1 = brown, dead leaves to 5 = deep green colored leaves), visual evaluation of root length (1 = roots only in upper half of container to 4 = roots circling container bottom) and root ball density (1 = no roots visible at periphery of the root ball to 4 = solid root ball with little soil visible) were recorded 7 months after potting.

This experiment was designed as a randomized complete block with a factorial arrangement of treatments and 8 replicate plants per treatment. Visual evaluation ratings of leaf color, root growth and root ball density were subject to square root transformation before analysis of variance (ANOVA) but the actual values are reported in the tables for ease of comparison (8). ANOVA was performed for each cultivar on data combined over location. When a two factor interaction was significant, ANOVA was done by location and location comparisons were made using Student's t test (8).

Results and Discussion

Shoot Growth and Color. Cultivars were analyzed separately because of their very different growth habits and performance in containers. 'Elf' has a narrow, upright growth habit while 'Freckles' and 'Goodrich' tend to spread. 'Goodrich' was difficult to grow; at both locations there were plants in all treatments that failed to thrive. 'Freckles' and 'Elf' grew readily at both locations.

Table 1. Particle size distribution of Georgia pine bark and Washington fir bark.

U.S. Std. sieve no.	Particle[z] size (mm)	Particle size distribution (% wt) Georgia pine bark	Washington fir bark
8	> 2.38	54.8	26.5
10	2.38–2.00	5.4	4.2
18	2.00–1.00	15.3	15.0
20	1.00-0.84	2.9	3.3
30	0.84–0.60	5.4	6.8
40	0.60–0.42	4.6	8.0
Pan	< 0.42	11.6	36.2

[z]Particle size distribution determined on three 50 ml random samples obtained by use of mechanical sample splitter. Shaking time 20 min. for screen analysis.

There were no significant interactions between location, growing medium, nitrogen form or rate for shoot growth and leaf color. Results from the combined locations indicated shoot growth of 'Freckles' was not influenced by location (Table 2). The average shoot growth of 'Elf' was 9% greater in Washington while average 'Goodrich' shoot growth was 10% greater in Georgia. Leaf color was slightly better for the plants grown in Washington.

'Elf' and 'Freckles' showed the best overall top growth in response to a combination of NO_3/NH_4 nitrogen (Table 2). 'Goodrich' also grew better in response to combined NO_3/NH_4 nutrition although the growth response to the 20/80 NO_3/NH_4 ratio was not significantly better than the 100/0 ratio, plants in the 60/40 treatment were larger than the 100/0 plants (Table 2). Foliage color of all cultivars was best in the combined NO_3/NH_4 treatments. Our findings of improved *K. latifolia* growth and leaf color when fertilized with a combination of NO_3/NH_4 nitrogen are in agreement with the results of other work showing improved growth of ericaceous plants in response to NH_4 nitrogen nutrition (2, 3, 4, 7, 9, 10).

The 120 and 80 mg N/pot rates produced the best shoot growth of 'Elf' and 'Freckles' (Table 2). 'Goodrich' plants were larger at the 120 and 80 mg N/pot rates but the 120 mg N/pot plants were not significantly larger than the 40 mg N/pot plants (Table 2). Leaf color was better at the 120 and 80 mg N/pot rates (Table 2). *K. latifolia* is not a "heavy feeder" and requires considerably less fertilizer than fast-growing plants (5). In this experiment, quality top growth was produced on *K. latifolia* in both Washington and Georgia at the 80 mg/pot rate of nitrogen.

Shoot growth and leaf color of 'Elf', 'Freckles' and 'Goodrich' was not significantly different in the 4 bark:1 peat and the 1 bark:1 peat growing media (data not shown). Studies by DeRoo (cited in 5) showed that addition of bark to a peat-sand-perlite or a peat-sand media improved *K. latifolia* growth and leaf color. DeRoo obtained the best results with a container medium of 2 parts Canadian peat:1 part sand:1 part bark. The addition of bark improved the drainage of these mixes. Results of our study indicated that increasing the amount of bark in the growing medium did not alter *K. latifolia* shoot growth and leaf color.

Root Growth. Root growth showed significant interactions between location and nitrogen form for root length of all cultivars and root density of 'Elf' and 'Goodrich' at the 0.05 level of significance and 'Freckles' at the 0.10 level of significance. In general, root systems tended to be larger in the Washington plants although not all of the differences were significant (Table 3).

Nitrogen form had no effect on root length of Washington grown 'Elf,' 'Freckles' and 'Goodrich' (Table 3). Root density of 'Elf' in Washington was increased by the 20/80 NO_3/NH_4 treatment but the root densities of 'Freckles' and 'Goodrich' were not affected. Root length and density of all cultivars grown in Georgia was reduced when the proportion of NH_4 was increased to 80%.

Root length and density of 'Elf' and root density of 'Freckles' was not influenced by nitrogen rate (Table 4). The 120 mg/pot N rate decreased root length and density of 'Goodrich' and root length of 'Freckles' (Table 4). Root length but not root density of 'Goodrich', the most difficult-to-grow cultivar, was also reduced at the 80 mg/pot N rate. When both shoot and root growth results for all 3 *K. latifolia*

Table 2. Influence of location, NO_3/NH_4 ratio and N rate on shoot growth index (SGI) and leaf color rating (LCR) of the *Kalmia latifolia* cultivars 'Elf', 'Freckles' and 'Goodrich'.

	'Elf'		'Freckles'		'Goodrich'	
	SGI[z]	LCR[y]	SGI	LCR	SGI	LCR
Location						
GA	25.2 b	3.6 b	28.0 a	3.8 b	26.2 a	3.3 b
WASH	27.8 a	4.1 a	28.8 a	4.1 a	23.5 b	3.9 a
NO_3/NH_4						
100/0	25.2 b	3.7 b	26.6 b	3.8 b	24.2 b	3.4 b
60/40	26.9 a	4.0 a	29.3 a	4.0 a	25.7 a	3.7 a
20/80	27.4 a	3.9 a	29.4 a	4.1 a	24.8 ab	3.8 a
N Rate/pot						
120 mg	27.8 a	4.1 a	30.2 a	4.2 a	25.0 ab	3.8 a
80 mg	27.4 a	3.8 b	29.9 a	4.0 a	26.0 a	3.7 ab
40 mg	24.3 b	3.7 b	25.3 b	3.7 b	23.6 b	3.4 b

[z]SGI = (height + width) ÷ 2.

[y]LCR was rated on a 1 to 5 scale with 1 = brown, plant dead; 5 = deep green.

[x]Numbers in the table represent actual ratings, but all statistical analyses were done on square root transformed data. Means within a cultivar followed by the same letter are not significantly different at the 5% level using Waller-Duncan K-ratio t test.

Table 3. Influence of nitrate/ammonium ratio at each location on root length and density of the *Kalmia latifolia* cultivars 'Elf', 'Freckles' and 'Goodrich'.

	'Elf'		'Freckles'		'Goodrich'	
	WASH	GA	WASH	GA	WASH	GA
Root length[z]						
NO_3/NH_4						
100/0	3.7 a[y]	3.2 a NS[x]	3.6 a	3.2 a NS	3.2 a	2.8 a NS
60/40	3.8 a	3.2 a *	3.6 a	3.0 a *	3.3 a	2.4 b *
20/80	3.9 a	2.8 b *	3.6 a	2.8 b *	2.9 a	2.3 b *
Root density[w]						
NO_3/NH_4						
100/0	3.5 a	3.5 a NS	3.7 a	3.6 a NS	2.7 a	3.0 a NS
60/40	3.6 a	3.5 a NS	3.7 a	3.4 a NS	2.8 a	2.4 b NS
20/80	3.9 b	2.6 b *	3.6 a	3.0 b *	2.6 a	2.4 b NS

[z]Root length was rated according to the following scale: 1 = roots ½ way to container bottom; 2 = roots ¾ way to container bottom, 3 = roots to container bottom; 4 = roots circling container bottom.

[y]Numbers in the table represent actual ratings, but all statistical analyses were done on square root transformed data. Means within a location followed by the same letter are not significantly different at the 5% level using the Waller-Duncan K-ratio t test.

[x]NS and * are used to indicate nonsignificance and significance at the 5% level, respectively, as determined by Student's t test, of the location effect within a treatment.

[w]Root density was rated according to the following scale: 1 = no roots visible at periphery of the root ball; 2 = few roots visible; 3 = root density intermediate; 4 = solid root ball with little soil visible.

Table 4. Influence of N rate on root length and density of the *Kalmia latifolia* cultivars 'Elf', 'Freckles' and 'Goodrich'.

	Root length[z]			Root density[y]		
	'Elf'	'Freckles'	'Goodrich'	'Elf'	'Freckles'	'Goodrich'
Nitrogen rate						
120 mg/pot	3.3 a[x]	3.2 b	2.6 b	3.3 a	3.4 a	2.4 b
80 mg/pot	3.4 a	3.3 ab	2.7 b	3.4 a	3.5 a	2.7 a
40 mg/pot	3.5 a	3.4 a	3.1 a	3.4 a	3.6 a	2.9 a

[z]Root length was rated according to the following scale: 1 = roots 1/2 way to container bottom; 2 = roots 3/4 way to container bottom; 3 = roots to container bottom; 4 = roots circling container bottom. Numbers in the figure represent actual ratings, but all statistical analysis was done on square root transformed data.

[y]Root density was rated according to the following scale: 1 = no roots visible at periphery of the root ball; 2 = few roots visible; 3 = root density intermediate; 4 = solid root ball with little soil visible. Numbers in the figure represent actual ratings, but all statistical analysis was done on square root transformed data.

[x]Means within columns followed by the same letter are not significantly different at the 5% level using the Waller-Duncan K-ratio t test.

cultivars are considered, the conclusion that the 80 mg/pot N rate produced the best overall plants seems warranted.

Root length and density was not affected by growing media (data not shown). Our results indicate plants produced in 4 bark:1 peat medium produced similar root and shoot growth to plants in the 1 bark:1 peat medium. The use of a higher percentage of bark in mixes for *K. latifolia* production can help to lower the cost of growing this crop. Research is presently underway to determine whether or not *K. latifolia* can be successfully grown in all bark container medium.

pH and Soluble Salts. There were interactions between location and nitrogen form as well as location and nitrogen rate on the pH of leachate from all 3 cultivars (0.05 level of significance except for the 'Elf' location by nitrogen rate interaction which was at the 0.13 level of significance). Results indicate the expected decrease in pH with the addition of NH_4-N occurred at both locations (Table 5). In Washington, where the pH was higher, there was a relatively greater decrease in pH with the addition of NH_4-N than in Georgia (Table 5). The difference in pH of the growing media at the two locations may have caused the micronutrient deficiency symptoms that necessitated a midseason application of S.T.E.M. in Georgia but not in Washington. The location by N rate interaction resulted from a decrease in pH at the 80 and 120 mg/pot N rates in the Washington 'Freckles' and 'Goodrich' treatments but no decrease in pH in the Georgia treatments (Table 5).

Soluble salts were highest at the 20/80 NO_3/NH_4 treatment for all cultivars (Table 6). The 60/40 NO_3/NH_4 treatment also increased salt levels compared to the 100/0 treatment for 'Goodrich'. The location effect was not significant for 'Elf' but 'Freckles' and 'Goodrich' had higher salt levels in Washington (Table 6). As expected, salt levels decreased with decreasing nitrogen application rate. The observed decline in root growth of 'Goodrich', the most difficult to grow cultivar, at the high fertility level may be related to the high soluble salt levels. The growing media tested in this experiment had no effect on pH or soluble salts (data not shown).

Table 5. Influence of nitrate/ammonium ratio and nitrogen rate at each location on pH measurements of the *Kalmia latifolia* cultivars 'Elf', 'Freckles' and 'Goodrich'.

	'Elf'		'Freckles'		'Goodrich'	
	WASH	GA	WASH	GA	WASH	GA
NO_3/NH_4						
100/0	6.0 a[z]	3.9 a **[y]	6.2 a	4.2 a **	5.8 a	4.0 a **
60/40	5.7 b	3.6 b **	5.7 b	3.4 b **	5.4 b	3.8 a **
20/80	4.8 c	3.4 c **	5.1 c	3.5 b **	4.9 c	3.5 b **
N rate/pot						
120 mg	5.4 a	3.7 a **	5.4 c	3.6 b **	5.2 c	3.8 a **
80 mg	5.5 a	3.7 a **	5.7 b	4.0 a **	5.4 b	3.8 a **
40 mg	5.6 a	3.7 a **	5.9 a	3.8 ab **	5.5 a	3.8 a **

[z]Means within a location followed by the same letter are not significantly different at the 5% level using the Waller-Duncan K-ratio t test.

[y]** is used to indicate significance at the 1% level as determined by Student's t test of the location effect within a treatment.

Table 6. Influence of NO_3/NH_4 ratio, N rate and location on conductivity measurements for the *Kalmia latifolia* cultivars 'Elf', Freckles' and 'Goodrich'.

	Conductivity[z] (μS/cm)		
	'Elf'	'Freckles'	'Goodrich'
NO_3/NH_4 Ratio			
100/0	441 b[y]	431 b	454 b
60/40	444 b	418 b	614 a
20/80	636 a	558 a	633 a
Location			
Georgia	510 a	430 b	400 b
Washington	504 a	509 a	734 a
Nitrogen rate			
120 mg/pot	789 a	725 a	770 a
80 mg/pot	461 b	449 b	582 b
40 mg/pot	271 c	234 c	349 c

[z]Soluble salts were extracted from the container by the pour-through method and electrical conductivity of the solution measured with Radiometer, Inc. Model CDM80 conductivity meter. To convert units in the table from μS/cm to mmho/cm, multiply by 0.001.

[y]Means within columns and treatments followed by the same letter are not significantly different at the 5% level using the Waller-Duncan K-ratio t test.

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