The data indicated that repellents are not very effective for reducing deer browse to highly desirable food materials under very high deer pressure. However, a test system of this nature can quickly determine statistically the relative effectiveness of repellents.

Since the unscented soap was as effective as the perfumed soap in these tests, we have concluded that the soap perfume was not necessary for activity; however, the perfume had some repellency when sprayed on apple shoots or when apples were dipped in 100% perfume. Dilution of all of the repellents reduced their effectiveness.

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# Plant Response to Container Planting Method and Media[1]

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## Abstract

Shoot dry weight and relative root density of *Ilex crenata* Thunb. 'Compacta' and *Rhododendron obtusum* (Lindl.) Planch. 'Hino Crimson' were greater when liners were transplanted into holes with a core removed (excavated) compared to holes formed by compression (dibbled). Growth index, relative root density, and shoot dry weight increased as the percent pine bark in the growth media increased from 50% to 80 or 90% pine bark with holly and from 50% to 90% pine bark with azalea. Bulk density decreased and air porosity and irrigation frequency increased as the percent pine bark in pine bark:sandy loam container media increased from 50% to 100%. In a second experiment, root density and shoot dry weight of *Ilex crenata* Thunb. 'Helleri', but not *Rhododendron* × 'Trouper', were greater in pine bark and pine bark-sandy loam media when the planting hole was excavated rather than dibbled. Plant growth of the 2 species in peat-based media was not influenced by planting method.

**Index words:** nursery crops, container production, container culture

**Species used in this study:** 'Compacta' and 'Helleri' hollies (*Ilex crenata* Thunb. 'Compacta' and 'Helleri'); 'Hino Crimson' azalea (*Rhododendron obtusum* (Lindl.) Planch. 'Hino Crimson'); 'Trouper' azalea (*Rhododendron* × 'Trouper').

### Significance to the Nursery Industry

Placement of controlled-release fertilizer directly under the liner at transplanting is an effective method of fertilization that avoids media storage and mixing problems. However, plant growth may be adversely affected if the planting hole is formed by compression (dibbling) rather than removal of a core (excavating). This effect is more likely to occur in pine bark-based media that do not contain peat than in peat-based media.

### Introduction

Controlled-release granular fertilizers are typically applied either uniformly incorporated into growth media or surface-applied as a topdressing (6, 7). Incorporation has proven successful in a wide range of applications, but uniform blending is essential and subsequent storage for more than a week is not recommended due to the potential release of fertilizer salts. Longer storage necessitates leaching prior to planting to avoid phytotoxicity, but wastes fertilizer and could result in undesirable pollution of the surrounding area. Intermittent drying of surface-applied fertilizer slows release due to a lack of continuous moisture (1, 8), and fertilizer may be lost if the container is overturned or rapidly flooded.

Placement of the fertilizer directly under the liner at transplanting (dibbling) is a third method that presents no storage,

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mixing, drying or spilling problems. In some cases, dibbling has resulted in more growth or superior-quality plants compared to incorporation (3, 4). In other studies, either no benefit or a negative response (2, 9) to dibbling was observed. A possible explanation for the poor results with dibbling is that compaction of the growth medium at planting restricts root growth. The objective of this research was to compare dibbling to an alternative method of planting, removal of a core to form the planting hole (excavating), without compaction of the growth medium.

## Materials and Methods

Aged pine bark from *Pinus taeda* and *P. elliotti*, milled through a 25.4-mm (1.0 in) screen, was obtained from a local supplier, hammermilled through a 19-mm (0.75 in) screen, and mixed with a sandy loam soil in 4 ratios (1 pine bark:1 soil, 4:1, 9:1, 1:0, by vol). Media were amended by preplant incorporation of 3.6 kg/m$^3$ (6 lb/yd$^3$) dolomitic limestone, 1.2 kg/m$^3$ (2 lb/yd$^3$) gypsum, and 0.9 kg/m$^3$ (1.5 lb/yd$^3$) Micromax. Osmocote 17N-3P-10K (17-7-12) at 18 g (.63 oz)/3.8 l (#1) container was placed under each liner at planting.

Bulk densities were calculated from weights of oven-dried (105°C (221°F) for 24 hours) volumes of unamended media (Table 1). Particle size distributions for the 4 media were obtained by drawing 10, 50 cc (3.1 in$^3$) samples of each growth medium using a mechanical sample splitter. Each air-dried sample was placed, 50 cc (3.1 in$^3$) at a time, on a Ro-tap shaker (W.S. Tyler, Inc., Mentor, OH) and sieved for 20 minutes using U.S. standard sieves with openings of 4.76 (.19 in), 2.38 (.09 in), 2.00 (.08 in), 1.00 (.04 in), 0.84 (.03 in), 0.60 (.02 in), and 0.42 mm (.016 in) (NBS screen numbers 4, 8, 10, 18, 20, 30, and 40, resp.). Fractions retained on each screen and in the receiver pan were collected after each shaking period and weighed. Water holding capacities and air porosities of the 4 growth media were determined by modifying a method reported by Gessert (5). Air porosities and water holding capacities were calculated using 5 samples of each growth medium in 3.8 l (#1) containers.

Uniform 10 cm (4 in) liners of 'Compacta' holly and 'Hino Crimson' azalea were transplanted 1 to a 3.8 l (#1 gal) container of the 4 growth media on March 28, 1984. Two planting methods were compared: 1) compression to form the planting hole (dibbling) and 2) removal of a core to form the planting hole (excavating). Compressed hole and core were similar in size to liner rootball, 8.3 cm top × 7.0 cm depth × 6.4 cm bottom (3¼ × 2¾ × 2½ in). Plants were grown in full sun. Plants within media treatments were irrigated as needed by overhead impact sprinklers. After 7 months, growth index ((height + width$_1$ + width$_2$)/3), shoot dry weight, and relative root density were determined. There were 6 blocks with 4 replicate plants for each species. A factorial arrangement of media and fertilizer placement was used.

In a second experiment, uniform 10 cm (4 in) liners of 'Helleri' holly and 'Trouper' azalea were transplanted April 12, 1985, into 2.8 l (#1) and 3.8 l (#1 gal) containers, resp., by either dibbling or excavating. Growth media included 4 commonly used media in the southeastern United States: 100% milled pine bark; pine bark: sandy loam soil (4:1 by vol); pine bark:peat moss (3:1 by vol); and peat moss:softwood shavings (1:1 by vol). Media were amended as in the first experiment, and 19 g (0.67 oz) and 27 g (0.95 oz) of Osmocote 17N-3P-10K (17-7-12) were placed under each holly and azalea liner, resp., prior to transplanting. Plants were grown in full sun and watered as needed by overhead irrigation. After 7 months, growth index, shoot dry weight and relative root density were determined. There were 15 blocks with 1 replicate plant per treatment completely randomized within each species. A factorial arrangement of media and fertilizer placement was used.

## Results and Discussion

*Experiment 1.* Physical properties varied greatly among the 4 media (Table 1). For example, the higher the percent bark in the pine bark:soil media the higher the percentage retained by N.B.S. screen no. 4, from 3.9% (1:1) to 31.6% (1:0), and the higher the air porosity, from 9.2% (1:1) to 31.3% (1:0). Conversely, the higher the percent soil in the media the greater the fraction retained in the pan, from 61.3% (1:1) to 9.5% (1:0), and the greater the bulk density, from 0.84 g/cc (1:1) to 0.20 g/cc (1:0). Water-holding capacity was not greatly influenced by media (data not shown); however, irrigation frequency was increased 23.4, 29.8, and

**Table 1. Particle size distribution (retained by screen), bulk density, and air porosity of 4 growth media.**

| N.B.S.[z] screen no. | Opening (mm) | Particle size distribution (% by wt) | | | |
|---|---|---|---|---|---|
| | | Pine bark:sandy loam media | | | |
| | | 1:1 | 4:1 | 9:1 | 1:0 |
| 4 | 4.76 | 3.9[y] | 16.1 | 18.2 | 31.6 |
| 8 | 2.38 | 5.0 | 13.5 | 14.0 | 24.7 |
| 10 | 2.00 | 1.3 | 2.9 | 3.3 | 5.2 |
| 18 | 1.00 | 8.4 | 10.0 | 16.6 | 16.7 |
| 20 | 0.84 | 2.2 | 2.1 | 2.6 | 3.2 |
| 30 | 0.60 | 6.2 | 4.7 | 5.4 | 5.1 |
| 40 | 0.42 | 11.7 | 8.1 | 6.9 | 4.0 |
| Pan | — | 61.3 | 42.6 | 33.0 | 9.5 |
| Bulk density (g/cc) | | 0.84 (.10[x]) | 0.43 (0.1) | 0.34 (0.2) | 0.20 (.01) |
| Air porosity (%) | | 9.2 (2.6) | 19.1 (3.4) | 31.0 (6.5) | 31.3 (2.1) |

[z]National Bureau of Standards; values are the means of 5 replicates.
[y]Particle size distribution values are the means of 10 replicates, other values are the means of 5 replicates.
[x]Standard deviation.

Table 2. **Effects of planting method and growth media on growth of 'Compacta' holly 7 months after transplanting.**

| Comparison | Growth index[z] | Shoot dry weight (g) | Relative root density[y] |
|---|---|---|---|
| Method (M) | | | |
| Dibble | 35.7 a | 33.3 b | 3.2 b |
| Excavate | 36.1 a[x] | 38.1 a | 3.5 a |
| Pine bark:sandy loam media (PB:SL) | | | |
| 1:1 | 33.7 | 34.5 | 2.3 |
| 4:1 | 36.6 | 35.5 | 3.7 |
| 9:1 | 37.0 | 38.3 | 3.6 |
| 1:0 | 36.4 | 34.7 | 3.8 |
| Significance[w] | q** | c* | c** |
| M × PB:SL[v] | ns | ns | ns |

[z]Growth index = (height + $width_1$ + $width_2$)/3, in cm.

[y]Relative root density: 1 = few surface roots on rootball; 3 = moderate root density over entire rootball; 5 = dense matting over entire rootball.

[x]Mean separation within columns by Duncan's multiple range test, 5% level.

[w]Quadratic (q) or cubic (c) regression response significant at 5% (*) or 1% (**) level.

[v]Planting method × media interaction not significant (ns).

Table 3. **Effects of planting method and growth media on growth of 'Hino Crimson' azalea 7 months after transplanting.**

| Comparison | Growth index[z] | Shoot dry weight (g) | Relative root density[y] |
|---|---|---|---|
| Method (M) | | | |
| Dibble | 31.1 a | 39.9 b | 3.2 b |
| Excavate | 31.8 a[x] | 43.7 a | 3.4 a |
| Pine bark:sandy loam media (PB:SL) | | | |
| 1:1 | 28.6 | 38.9 | 2.3 |
| 4:1 | 30.9 | 38.9 | 3.2 |
| 9:1 | 33.3 | 44.0 | 3.9 |
| 1:0 | 33.0 | 45.5 | 4.0 |
| Significance[w] | c** | q** | c** |
| M × PB:SL[v] | ns | ns | * |

[z]Growth index = (height + $width_1$ + $width_2$)/3, in cm.

[y]Relative root density: 1 = few surface roots on rootball; 3 = moderate root density over entire rootball; 5 = dense matting over entire rootball.

[x]Mean separation within columns by Duncan's multiple range test, 5% level.

[w]Quadratic (q) or cubic (c) regression response significant at 1% (**) level.

[v]Planting method × media interaction not significant (ns) or significant at 5% (*) level.

44.7% with 4:1, 9:1, and 1:0 pine bark: sandy loam soil media, resp., compared to the 1 bark:1 soil growth medium.

Planting method influenced shoot growth and root density of both holly and azalea (Tables 2 and 3). Shoot dry weight of holly and azalea averaged 4.8 g (0.17 oz) and 3.8 g (0.13 oz), resp., more when media were excavated at transplanting compared to dibbled. Root densities also were greater with excavating. Growth indices of the 2 species were not influenced by planting method.

Growth index and relative root density of holly increased as the percentage of sandy loam soil in the media decreased from 50% (1:1) to 20% (4:1); there were little differences in these measurements among the 3 media with lower percentages of soil. Shoot dry weight was similar among treatments except for more growth of holly in the 9:1 growth medium. Interactions were not significant.

Growth index, shoot dry weight, and root density of azalea increased with increasing percentages of pine bark up to 90%; there was little change in measurements as the percentage of pine bark increased from 90% to 100%. A planting method × media interaction with root density resulted from greater root density with excavation than from dibbling in the 4:1 and 9:1 media but similar root densities of plants in the other 2 media transplanted by the 2 methods.

*Experiment 2*. All planting method × media interactions were significant with holly (Table 4). Excavation resulted in a higher growth index than dibbling in the pine bark-sandy loam growth medium and a greater shoot dry weight and relative root density in 100% pine bark and pine bark-sandy loam media (Table 4). Planting method did not affect measurements of plants grown in other media.

Growth index and shoot dry weight of dibbled hollies were greater when plants were grown in media containing peat moss compared to media without peat moss. Plants of the excavation planting method had the lowest growth index and shoot dry weight when grown in 100% pine bark, possibly because of less water retention compared to the other media. Root density of dibbled hollies was greater in a pine bark medium when peat moss was a component compared to sandy loam soil. Excavation resulted in less root growth in a peat moss-shavings medium than in the pine bark-sandy loam medium.

Neither growth index, shoot dry weight nor relative root

Table 4. **Effects of planting method and growth media on growth of 'Helleri' holly 7 months after transplanting.**

| Growth media | Growth index[z] | | Shoot dry weight (g) | | Relative root density[y] | |
|---|---|---|---|---|---|---|
| | Dibble | Excavate | Dibble | Excavate | Dibble | Excavate |
| Pine bark (100%) | 38.9 a(b)[x] | 39.3 a(b) | 30.4 b(c) | 34.7 a(b) | 2.2 ab(ab) | 2.4 a(ab) |
| Pine bark-sandy loam (4:1) | 35.5 b(c) | 41.5 a(ab) | 25.4 b(c) | 41.0 a(a) | 2.0 b(b) | 2.5 a(a) |
| Pine bark-peat moss (3:1) | 42.5 a(a) | 43.2 a(a) | 39.1 a(b) | 42.3 a(a) | 2.4 a(a) | 2.4 a(ab) |
| Peat moss-shavings (1:1) | 44.6 a(a) | 43.1 a(a) | 49.2 a(a) | 45.5 a(a) | 2.2 a(ab) | 2.2 a(b) |

[z]Growth index = (height + $width_1$ + $width_2$)/3, in cm.

[y]Relative root density: 1 = few surface roots on rootball; 3 = moderate root density over entire rootball; 5 = dense matting over entire rootball.

[x]Mean separation within planting method made using LSD at 5% level; mean separation within growth media ( ) by Duncan's multiple range test, 5% level. All planting method × media interactions were significant.

density of azalea was influenced by planting method. Growth index and shoot dry weight were greater in peat-based media than in media not containing peat moss. Root density of plants grown in pine bark + sandy loam soil or peat moss was greater than root density in 100% pine bark or peat moss-shavings medium (data not shown).

Shoot and root growth of 2 species in 2 experiments were either greater or not influenced when the planting hole was excavated rather than dibbled. This response was media-dependent, occurring in media with a range of pine bark:sandy loam ratios but not in peat-based media. Alterations in the physical properties of the media during formation of the planting hole or differences in moisture holding capacity of excavated and dibbled media may explain growth differences.

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# Growth Analysis of 'Plumosa Compacta' Juniper and 'Coral Beauty' Cotoneaster Subjected to Different Nitrogen Fertilizer Regimes[1]

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## Abstract

'Plumosa Compacta' juniper (*Juniperus horizontalis* Moench.) and 'Coral Beauty' cotoneaster (*Cotoneaster dammeri* C.K. Schneid.) were container grown in a bark:peat:sand medium (2:1:1 by vol.). Plants received either 70, 140, 280 or 420 mg (0.003, 0.005, 0.010 or 0.015 oz) N per week from nutrient solutions. Growth was assessed on plants harvested from each treatment regime on May 22 and then at monthly intervals until September 16. Juniper plants grown with 140 mg (0.005 oz) N per week were larger at the end of the season than those in the other treatments. In cotoneaster, growth increased as weekly N application increased from 70 to 420 mg (0.03 to 0.015 oz) N per week. Path analysis was used to quantify the effect of plant relative growth rate (RGR) during each month on RGR in subsequent months and on total seasonal relative dry weight gain (TRWG). RGR during each month significantly influenced TRWG, with the periods from June 21 to July 20, and from July 21 to August 18 exerting the greatest influence in cotoneaster. In juniper, the influence of RGR in each month on TRWG was equal. For both cotoneaster and juniper, increasing RGR during one month tended to have a negative influence on RGR during subsequent months.

**Index words:** path analysis, containers, nitrogen, Andorra juniper, *Juniperus horizontalis*, *Cotoneaster dammeri*

### Significance to the Nursery Industry

This research provides insights to the patterns of growth of container grown landscape plants. Maximum productivity of 'Plumosa Compacta' juniper and 'Coral Beauty' cotoneaster may be achieved by optimizing growing conditions throughout the season. Suboptimal conditions during any month can significantly diminish growth. Growth optimization, however, does not always mean increasing the rate of fertilizer application. While some plants such as 'Coral Beauty' cotoneaster will develop greater mass as weekly N application is increased, others such as 'Plumosa Compacta' juniper grow best at intermediate rates of N.

### Introduction

Increases in shoot length and new branch formation are important factors influencing the development of size and quality of landscapes shrubs in the nursery. New shoot growth occurs either as periodic flushes, or continuous growth from the shoot tips. Patterns of growth flush, and the influence of environmental conditions on the timing and magnitude

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