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Contents

THE OHIO STATE UNIVERSITY

OARDC

Kirklyn M. Kerr
Director

On the Cover: The flowering crabapple is the most popular small flowering tree in Ohio. It is valued for its flowers, foliage, fruit and varying habits of growth. In addition, the fruits are edible and used in jellies and preserves as well as being a favorite food of birds!

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Physical Facilities and Capital Requirements for Establishing a Three-Acre Perennial Container Nursery in Ohio—1989

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Abstract

Capital requirements for establishing a perennial container nursery in Ohio were about $325,000 for a three-acre facility. This facility had 1.2 acres of growing space while buildings, roads, parking area, and other production facilities accounted for 1.8 acres. Of the total capital requirements, about $37,000 (12 percent) was for bare land, $32,000 (10 percent) for land improvements, $158,000 (49 percent) for buildings, and $98,000 (30 percent) for machinery and equipment.

Introduction

This article presents capital requirements for production of crops representing five categories of container-grown production schemes in Ohio given that all facilities were purchased new. Physical coefficients are included so the information can be readily updated and so individual nurseries can use the model as a standard against which to compare their own operation or planned operation. Information derived should provide a basis for decision-making for those evaluating the necessary physical and capital requirements in either establishing a new container nursery, expanding an existing container nursery, or phasing out of container production.

Comprehensive cost models have been developed for both container-grown and field-grown woody ornamental crops in USDA Plant Hardiness Zones 5, 6, 7 and 8 (1,2,3,4). A study has been completed and is approaching publication for Zone 9. This article presents physical requirements and capital expenditures for establishing a three-acre perennial nursery in Ohio.

Objectives

The objectives of this study were to:

1. Model production systems that would accommodate a majority of the perennial plant species being container grown in Ohio.
2. Analyze the important species of perennial plants commonly grown in containers in Ohio, and assign each of them to one of the designated groups based on similarities of growing and production requirements.
3. Design physical facilities including land areas, land improvements, irrigation systems, buildings, machine and equipment components, for a commercial container nursery based on the model production systems.

Materials and Methods

This article is based on a firm synthesized using the conceptual framework of economic engineering wherein the "best proven practice" was included. The analysis assumed typical soil conditions, expansion capacity, optimal spacing configurations, new buildings, equipment and machinery. It was synthesized based on Ohio conditions. If specific items were required (i.e. depth of the well), coefficients were based on the Columbus, Ohio area. The complete model included developing an appropriate production cycle (Table 1); schematic drawings of the physical layout, including buildings and irrigation system; lists of equipment and other items (Figures 1 & 2); a complete sequence of nursery operational steps beginning with land preparation and ending with loading the finished product for wholesale distribution.

Data for this study were obtained from wholesale nurseries and nursery suppliers in Ohio during the Spring of 1989. The basic goals in synthesizing the production facilities were to minimize labor expenses, flow and movement of plant material and equipment, maximize the number of salable plants and allow future expansion.

The nursery reported in this paper included 1.18 acres of growing space and 1.82 acres of buildings, other production facilities, and roads.

Enterprise Mix

It was assumed that the model nursery would produce a diverse line of nursery stock (Table 1). The length of the production cycle for the different species grown vary. Commonly grown nursery stock were divided into five cultural groups. While not all inclusive, the groups do permit a range of per unit costs to be developed as they relate to input costs and cultural factors. The five groups with some of their cultural characteristics are listed below and on the following pages:

Group	Plant	Cultural Characteristics
I	Seeds	Planted from seed in May.
	(May Propagation)	Propagated in plug trays
	Armeria maritima	(200 TLC's).
	Rudbeckia 'Goldsturm'	Shifted to shaded polyhouse—
	Aguilegia 'McKana's Hybrids'	two weeks before potting.

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Group	Plant	Cultural Characteristics
	Coreopsis 'Baby Sun' Lychnis Chalcedonica	Overwintered in structure- less units.
	(August-October Propagation) Primrose 'Pacific Giant Hybrids' Lupine 'Russels Mix' Delphinium 'Connecticut Yankee' Gaillardia 'Goblin' Iberis sempervirens	Seed planted in October in plug trays (200 TLC). All plants sold the following spring. Grown to salable size in heated polyhouses, then moved to unheated polyhouses in winter to harden off.
II.	Cuttings Monarda 'Cambridge Scarlet' Lythrum 'Morden's Pink' Sedum 'Autumn Joy' Thymus 'Citriodorus' Achillea 'Red Beauty'	Cuttings are taken from mother plants in the spring and other times when needed. Stuck into either #98 #200 plug trays. Commercial media (ProGro 200). Mist system used until cuttings root, then trays are moved out of mist. When well rooted, pot into one-quart containers (about 6-weeks after sticking). Overwintered in structureless system.
III	Plants (Divisions) Subdivided—Large Hosta 'Albo-marginata' Dicentra 'Spectabilis' Artemesia 'Silver Mound' Brunnera macrophylla Astilbe 'Fanal'	Field-grown plants received bare root. Large divisions are planted directly into one gallon containers in June. Placed directly into polyhouses where they are grown and overwintered. Sold the following Spring.
	Subdivided—small Astilbe 'Fanal' Geranium 'Wargrave Pink' Polemonium 'Blue Pearl' Viola Oderata 'Purple Robe'	Placed into #72 plug trays. Put into prop house under mist until they root. After well rooted they are potted into quart containers and placed into heated polyhouses. When plants are salable, they are moved to an unheated polyhouse for overwintering.
IV.	Mums	Rooted cuttings are purchased. Directly planted into 3-quart containers. Placed in mum area where they remain until sold. Media—ProGro 300S. Pinched twice plus corrective pruning. Sold in the fall—No overwintering.

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Group	Plant	Cultural Characteristics
V.	Herbs—Seed w/ transplant Basil Thyme, English Winter savory Catnip Lavender, Munstead	Seed sown by hand into #200 plug trays. Media—ProGro 200. Transplanted into NU-TRAY 16's. Placed into heated polyhouse until they reach salable size. Shifted to unheated polyhouse for hardening off and sales.
	Herbs—Direct Seed Coriander Anise Curled Parsley Chives Dill	Seeded directly into sale-sized containers #16 (they don't transplant well). Placed into heated polyhouse until they reach salable size. Shifted to unheated polyhouse for hardening off and sales.
	Herbs—Cuttings Greek Oregano French Lavender Spearmint 'Kentucky Colonel' French Tarragon Rosemary	Cuttings from mother plants. Fall cuttings are stuck in #98 plug trays. Plants are potted into Nutray 16, and grown in heated polyhouse until they reach salable size, then they are moved to unheated polyhouse to harden off.

Physical Plant and Equipment

Assumptions about physical facilities and equipment can greatly affect a nursery's cost and thereby cost per salable plant. The authors included all items a nursery would typically require. Many of the facilities could be reduced at the expense of convenience and by increasing operating costs. A nursery can easily eliminate or reduce items as required. However, it would require substantial effort to do the analysis on its own if they were not included.

Components Land Improvement.

For full utilization of the production facilities, extensive grading, graveling, surface and underground drainage tiles were provided (Table 2). This area was graded to allow a gradual slope from the central facility to lower points on the edges to utilize a buried 8-inch drain tile. The complete facility was tiled with 4″ plastic tile, 30′ on center, 46″ deep using a herringbone design.

Due to irrigation needs and rainfall, ground erosion may occur. Even with low application rates, the need to allow for base soil saturation and the possibility of heavy natural rainfall necessitates graveling. The total area was graveled 6-inches deep with #8 gravel. In areas where heavy equipment would be used (roadways, shipping area, and parking), a 2-inch deep top dressing of 46D stone was used. Although the cost of this graveling operation is high, it is offset by greater efficiencies and dependability in the handling of plants, ability to reenter the areas after natural or artificial irrigation and reduction of soil erosion.

Central facility.

The nursery was supplied with a permanent 3750 square foot buildings (50′x75′), It includes an office, computer and reception room (20′x20′), two restrooms with showers (each 10′x15′), a lunch room (15′x20′), potting shed with storage (30′x50′), machine shop with storage (25′x40′), a room for the well (8′x10′), a change room with heat and a shower for those using chemicals (10′x10′), and a room with heat and ventilation for chemicals (7′x10′). The office, restrooms and lunch room were heated, air conditioned and finished. All of the building were insulated. The potting shed and machine shop was furnished with overhead heaters. Contiguous to the building is a concrete slab (50′x75′). At the back is an area for bulk and/or other materials. This area is divided into three bins (each with internal dimensions of about 7.5′x24.5′) This (25′x50′) area was covered with a 16′ high roof. The front portion of the concrete slab (50′x50′) is used for unloading,

Table 1. Estimated Planting and Harvesting Requirements for a Three-Acre Perennial Container Nursery, 1989.

Group	Description	Propagation No.	Propagation Container	Propagation % Loss	Transplanted No.	Transplanted Container[1]	Transplanted % Loss	Sales/Annum Season	Sales/Annum Next Spring	Sales/Annum Total	Total
			Cells/flat							Units	Plants
I	Seed	444	200's	10	6,667	flats/12's	10	1000	5000	6000	72000
II	Cuttings	907	98's	10	6,667	flats/12's	10	1000	5000	6000	72000
III	Divisions	617	72's	20	3,333	flats/12's	10	500	2500	3000	36000
IV	Mums	—	—	—	17,778	3-Quart	10	16000	0	16000	16000
V	Herbs	605	98's	10	6,667	flats/16's	10	6000	0	6000	96000
		297	200's	10							

[1]Groups I, II, and III are grown and sold in flats containing 12, 1-quart (4″ x 4″ containers). Group IV plants (mums) are grown and sold in 3-quart containers, and herbs are sold in flats containing 16 cells.

order assembly, and loading. Also provided was a dugout ramp wherein a semi-truck can back in level with the concrete slab so that loading and unloading can be enhanced.

Overwintering (growing facilities).

Overwintering facilities are of three types: (1) Structureless. Eleven (19′x 96′) structureless units were provided (total=20,064 sq. ft.). (2) Unheated polyhouses. Five (20′ x 100′) unheated polyhouses were provided (total=10,000 sq. ft.). (3) Heated polyhouses. Three heated polyhouses (20′x100′) were provided. They are provided with rolling benches. The temperature, during the winter, is maintained at a minimum of 45 degrees fahrenheit. All polyhouses are covered with inflated double polyethylene.

Cold Frames.

Three (5′x100′) cold frames are provided (total 1500 sq. ft). These are used as hardening off areas and as a way-station for plants waiting for room in either a polyhouse or structureless unit.

Propagation house.

One (20′x100′) polyhouse was provided for propagation (total=2000 sq. ft.). It is also used for growing when space is available. The polyhouse is covered by inflated double polyethylene. Plants are propagated on benches and bottom heat is used. The temperature is maintained at a minimum of 55 degrees fahrenheit. A misting system is provided.

Irrigation system.

Irrigation systems were designed to minimize labor efforts and plant loss risk, yet provide sufficient irrigation capabilities to meet present and future water needs even under the most unlikely situations. A basic irrigation system is composed of four parts: water source, pumping equipment, inground irrigation pipe, and above ground irrigation pipe and materials.

The water source must have adequate reserves to meet maximum water needs and sufficient purity to meet cultural requirements. Because municipal water is expensive, especially if the production site is located far from a center of population, a well would be desirable. We did, however, provide for access to municipal water in case of well and/or pump failure. Our model assumed an adequate water source found approximately 60 feet below ground. The well was dug to a depth of 80 feet to ensure adequate recharging capacity. In some areas wells would have to be drilled to much greater depths which would result in higher costs.

Selection of a well pump is crucial to the nursery operation. A 20 HP electric pump was selected to drive the water from an 80 foot-deep well. The well depth depends not only on the depth at which water is found at but also on the amount of water being drawn per minute by the pump. An electric motor was chosen because of reliability of performance, low maintenance cost and close availability of electrical power.

The third part of the irrigation system is the inground irrigation pipe. The advantages of inground water mains are: labor costs for pipe movement is eliminated, breakage due to equipment running over above ground pipe is eliminated, and lower initial cost of P.V.C. pipe compared to portable above ground aluminum.

The fourth part of the irrigation system would be above ground and would include frost-free hydrants. Rotating #30BH rainbird sprinklers were provided for dispersing water in the structureless areas and Nelson Whizhead rotating sprinklers were used in the polyhouses.

Two forms of irrigation "back up" were provided. First, in case of power outage, a right angled gear drive was added to the pump. Using the provided equipment, a tractor can power the pump to provide water into the irrigation system. Also, it was assumed that the nursery would be located near a population center and would be able to utilize municipal water in case of an emergency.

Results and Discussion

Capital Investment Requirements

Capital investment requirements for establishing the nursery were itemized under three broad divisions: land and improvements, buildings, and machinery and equipment (Table 2). Each was further divided into several components. The nursery required $325,755 in investment. Land and land improvements represented 21 percent or $69,183 of the investment, buildings 49 percent or $158,190, and machinery and equipment 30 percent or $98,382.

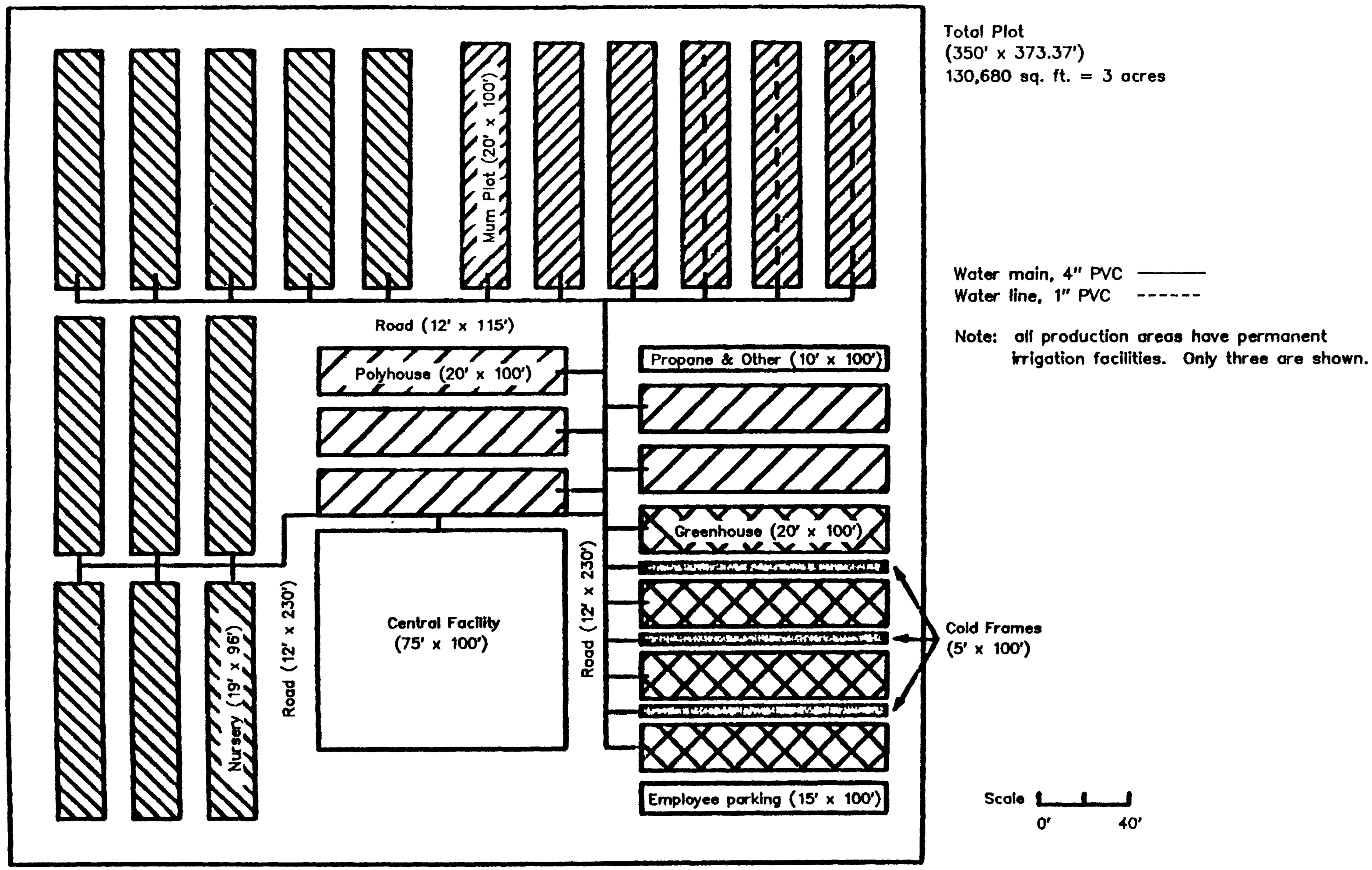

FIG. 1.——Schematic Drawing of a Three-Acre Perennial Container Nursery.

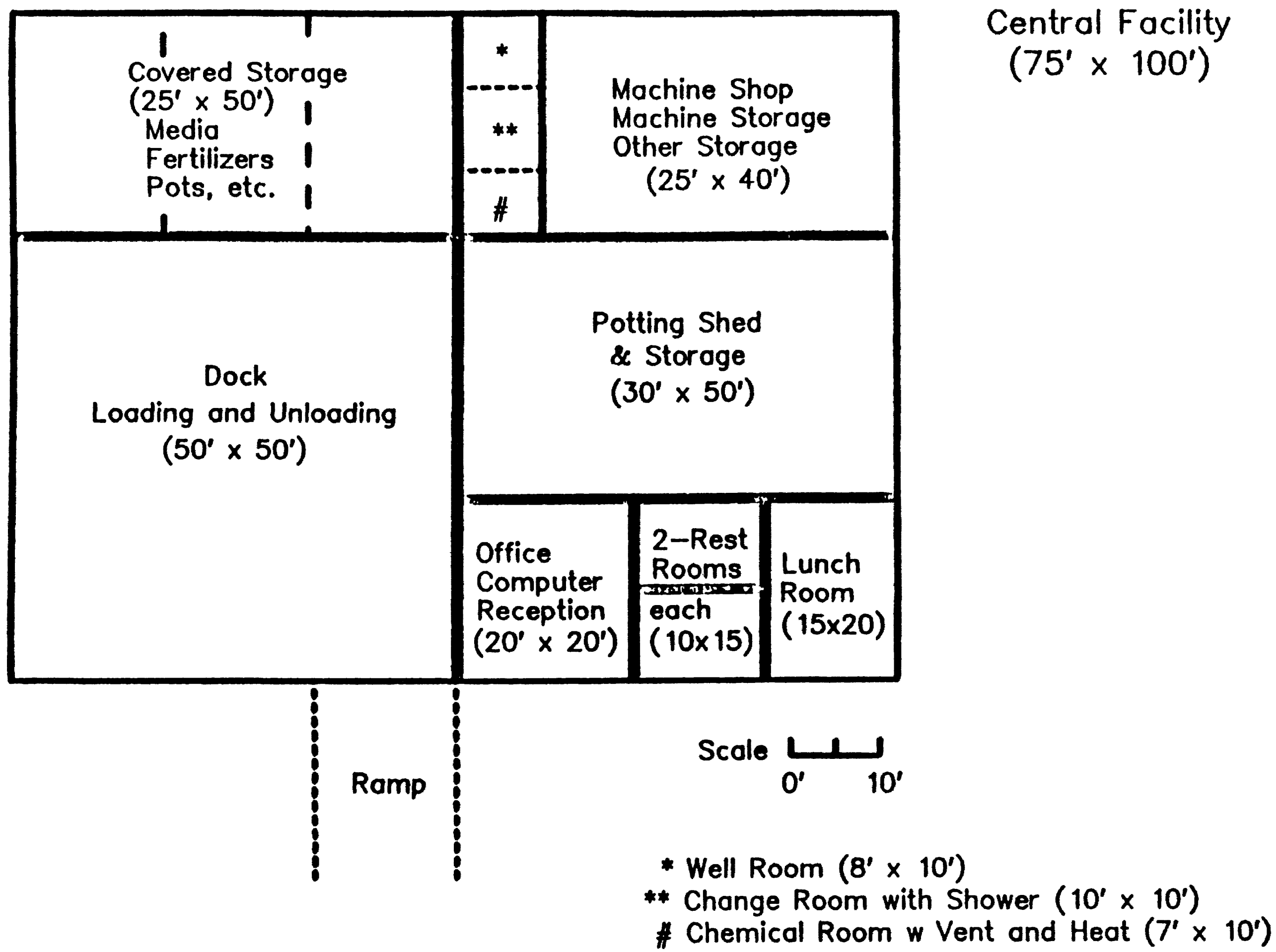

FIG. 2.––Schematic Drawing of a Three-Acre Perennial Container Nursery's Central Facility

Table 2. Capital Requirements for a Three-Acre Perennial Container Nursery, 1989.

Item	Description	Unit	Useful Life (yr)	Quantity	Cost per Unit ($)	Total Cost ($)	Percent of Total Cost
Land							
Unimproved land	Flat, near a metropolitan area	acre	—	3	12,500	37,500	12
Improvements	Clearing, grading, drainage, graveling	acre	20	3	10,561	31,683	10
Subtotal (land)						69,183	21
Buildings							
Building (50'x75')	50'x75'	each	20	1	100,000	100,000	31
Dock (loading & unloading)	50'x75' (includes covered bulk bins, truck ramp	each	20	1	15,450	15,450	5
Polyhouses (unheated)	(20'x100')	each	10	5	1,997	9,985	3
Polyhouses (heated)	(20'x100')	each	10	4	7,852	31,408	10
Cold Frames	(5'x100')	each	10	3	449	1,347	0
Subtotal (buildings)						158,190	49
Machinery and equipment							
Office equipment	Computers, copiers, furniture, etc.	system	5	1	9,000	9,000	3
Water system	Wells and pumps	system	20	1	27,780	27,780	9
Irrigation	Complete (other than misting)	system	20	1	8,752	8,752	3
Propagation house misting system	Mist-a-matic & plumbing	system	2	1	1,050	1,050	0
Municipal water hook-up (backup)	Materials and fees	system	20	1	2,000	2,000	1
Tractor, 23HP	Ford 1600,	each	10	1	9,000	9,000	3
	Front-end loader	each	10	1	2,000	2,000	1
Tractor, 16HP	Ford, lawn type	each	10	1	2,500	2,500	1
	Mower, 48"	each	10	1	300	300	0
Flatbed wagons	Each (8'x16')	each	10	5	600	3,000	1
Sprayer, boom	300-gal.; 10' boom	each	10	1	1,500	1,500	0
Standby generator	7500 watt	each	10	1	2,500	2,500	1
Delivery truck, stretch van	Holds 150 flats	each	10	1	12,000	12,000	4
Delivery truck, 15' parcel van	Holds 400 flats	each	10	1	15,000	15,000	5
Miscellaneous	Fert. injector, pallets, hand tools	system	5	1	2,000	2,000	1
Subtotal (machinery & equipment)						98,382	30
TOTAL						325,755	100

Individual nurseries could, of course, incur somewhat different costs than those presented. Individual costs would depend upon variables such as production cycle chosen, labor productivity and ability to bargain with suppliers. The nurseryman also may choose not to provide for future expansion, choose land that would require minimum drainage modifications, reduce optimal growing/overwintering space requirements, rent land and/or equipment, and/or operate used equipment.

Summary

Production schemes were developed for five categories of ornamental crops which would represent the majority of container grown perennial plants being produced in Ohio. Based on these production schemes, a three-acre model container perennial nursery was synthesized. Total capital requirements for establishing the nursery were $325,755.

Literature Cited

1. Badenhop, M.B., and T.D. Phillips and S-103 Technical Committee. 1985. Costs of Establishing and Operating Field Nurseries Differentiated by Size of Firm and Species of Plant in USDA Climatic Zones 7 and 8. Southern Coop. Ser. Bull. 311.
2. Perry, F.B., M.B. Badenhop, T.D.Phillips, and S-103 Technical Committee. 1987. Costs of Establishing and Operating a Small and Large Size Container Nursery in USDA Climatic Zones 7 and 8. Southern Coop. Ser. Bull. 327.
3. Taylor, Reed D., Harold H. Kneen, David E. Hahn, Elton M. Smith and S-103 Technical Committee. 1983. Costs of Establishing and Operating Container Nurseries Differentiated by Species of Plant in U.S.D.A. Climatic Zone Six. Southern Coop. Ser. Bull. 301.
4. Taylor, Reed D., Harold H. Kneen, Elton M. Smith, David E. Hahn, Stanley Uchida, and S-103 Technical Committee. 1986. Costs of Establishing and Operating Field Nurseries Differentiated by Size of Firm and Species of Plant in USDA Plant Hardiness Zones 5 and 6. Southern Coop Ser. Bull. 315.

Production Costs of Operating a Three-Acre Perennial Container Nursery in Ohio—1989

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Abstract

The objective of this research was to determine annual production costs of operating a three-acre perennial container nursery in Ohio. This was accomplished by synthesizing a model perennial container nursery using the conceptual framework of economic engineering. Annual production costs were about $354,000 for the three-acre facility. Of the total, approximately $172,000 (49 percent) were fixed costs and $182,000 (51 percent) variable.

The model nursery had capacity for annually producing approximately 180,000 (15,000 flats) salable perennial plants in quart containers, 16,000 salable mums in three-quart containers, and 96,000 (6,000 flats) salable herbs in #16 flats.

Introduction

To make more informed decisions as to whether to enter, leave, or expand perennial container production, nurseries require production, marketing, and financial information. Comprehensive cost models have been developed for both container- and field-grown woody ornamental crops in USDA Plant Hardiness Zones 5, 6, 7, and 8 (1,2,3,4). A study has been completed and nearing publication for Zone 9. The objective of this paper is to present annual costs of production for a three-acre perennial container nursery producing a diverse combination of perennials, mums, and herbs.

Materials and Methods

A model firm was synthesized using the conceptual framework of economic engineering wherein the "best proven practice" was included for the model. The complete model included developing an appropriate production cycle; schematic drawings of the physical layout, including buildings and irrigation system; list of equipment and other items; a complete sequence by month and year of nursery operational steps beginning with land preparation and ending with loading the finished product for wholesale distribution, and budgets for fixed and variable costs. Details on the capital requirements of establishing the nursery are included in a companion article in this publication entitled "Physical Facilities and Capital Requirements for Establishing a Three-Acre Perennial Container in Ohio—1989."

Commonly grown perennial container nursery stock was divided into five cultural groups: propagated from seed, propagated from cuttings, propagated from crown divisions, mums, and herbs. While not all inclusive, the groups do permit a range of per unit costs to be developed as they relate to input costs and cultural factors.

Data for this study were obtained from wholesale nurseries and nursery suppliers in Ohio during late Spring 1989. The basic goals in synthesizing the production facilities were to minimize labor expenses, flow, and movement of plant material and equipment; maximize the number of salable plants; and allow future expansion. The nursery reported on consisted of three acres, with 1.18 acres of growing space and 1.82 acres of buildings, other production facilities, and roads.

Costs were established for all factors of production including management and invested capital. Capital requirements for establishing the nursery were first determined. Second, physical factors associated with the nursery and annual shipment requirements were established. Third, production systems for the enterprises budgeted were described. Fourth, annual fixed costs were calculated (Table 1). Fifth, estimated variable costs for each of the five groupings of plants were determined. Sixth, each item contributing to variable costs for the five groups was totaled for physical quantities and costs (Table 2).

Table 1. Annual Fixed Costs ($) for a Three-Acre[1] Perennial Container Nursery, 1989.

Item	Description	Depreciation[2]	Interest[3]	Insurance and Taxes[4]	Total
Land					
Unimproved land	Flat, near a metropolitan area		4,500	750	5,250
Improvements	Clearing, grading, drainage, graveling	1,426	1,901	634	3,960
Subtotal (land)		1,426	6,401	1,384	9,210
Buildings					
Building (50'x75')	50'x75'	4,500	6,600	2,446	13,546

(Continued)

Table 1. (Continued)

Item	Description	Depreciation[2]	Interest[3]	Insurance and Taxes[4]	Total
Dock (loading & unloading)	50′x75′ (includes covered bulk bins, truck ramp	695	1,020	378	2,093
Polyhouses (unheated)	(20′x100′)	899	659	244	1802
Polyhouses (heated)	(20′x100′)	2,827	2,073	768	5,668
Cold Frames	(5′x100′)	121	89	33	243
Subtotal (buildings)		9,042	10,441	3,869	23,352
Machinery and equipment					
Office equipment	Computers, copiers, furniture, etc.	1,620	594	34	2,248
Water system	Wells and pumps	1,250	1,833	105	3,189
Irrigation system	Complete	394	578	33	1,005
Propagation house misting system	Misting systems (Mist-a-matic)	473	69	4	546
Municipal water hookup	Hookup (materials and fees)	90	132	8	230
Tractor, 23HP	Ford 1600	810	594	34	1,438
	Front-end loader	180	132	8	320
Tractor, 16HP	Ford, lawn type	225	165	9	399
	Mower, 48″	27	20	1	48
Flatbed wagons	Each (8′x16′)	270	198	11	479
Sprayer, boom	300-gal.; 10′ boom	135	99	6	240
Standby generator	7500 watt	225	165	9	399
Delivery truck, stretch van	Holds 150 flats	1,080	792	45	1,917
Delivery truck, 15′ parcel van	Holds 400 flats	1,350	990	57	2,397
Miscellaneous	Fert. injector, pallets, hand tools	360	132	8	500
Subtotal (machinery & equipment)		8,488	6,493	372	15,354
Total for Depreciation, Interest, Insurance and Taxes		18,956	23,335	5,625	47,916
General Overhead					
Utilities	Telephone, electric, gas heat				2,000
Licenses and bonds					400
General repairs and maintenance	Buildings, grounds, roads				1,000
Advertising and printing	Trade shows, catalogs, etc.				1,000
Insurance, personnel[5]	Workmen's compensation, FICA, health, unemployment				24,980
Travel and professional fees					1,000
Administrative and management[6]	Owner/operator, Propagator, Supervisor Clerical, office supplies				85,870
Miscellaneous					1,000
Subtotal					117,250
Interest on General Overhead, Insurance and Taxes	12% per annum for 6 months on a total of $122,875				7,372
Total Annual Fixed Costs					172,538

[1]Total nursery 3 acres (130,620 sq. ft.), with 1.2 acres growing space (51,560 sq. ft.) and 1.8 acres (79,060 sq. ft.) in production facilities, roads, etc.
[2]Depreciation was estimated by dividing initial cost (adjusted for a 10% salvage value) by the years of useful life.
[3]Interest costs for land was estimated by taking 12% of the initial value. For land improvements it was estimated by taking 12% of the average value based on initial value. Interest on buildings, machinery and equipment was estimated by taking 12% of the average value based on initial cost and salvage value. It was calculated as (((initial value plus salvage value)/2)x.12).
[4]Insurance and taxes.
Land and improvements-only taxes are assessed, at a rate of $20 per $1,000 of market value.
Buildings-taxes are assessed at a rate of $20 per $1,000 of market value. Insurance, $500 deductible, at $4.46 per $1,000 of market value. Total for category=$24.46 per $1,000.
Machinery and equipment-taxes are not assessed in Ohio on personal property. Insurance, $500 deductible, at $3.78 per $1,000 of initial value.
[5]Insurance and other fringe benefits were estimated at 32% for owner/operator, propagator, supervisor, and clerical.
[6]Owner operator=$30,000, propagator=$20,000, supervisor=$20,000, clerical-part time (February thru October=1,536 hrs.@ $5.25=$8,064). Total for salaries $78,064. Supplies=10% of salaries or $7,806. Total for category=$85,870.

Table 2. Total Variable Costs (Dollars) for a Three-Acre[1] Perennial Container Nursery, 1989.

Item	Description	Unit	Cost per Unit ($)	Quantity	Total Variable Cost ($)	Percent of Variable Cost
Propagation						
Containers	Plug trays—72's	each	0.66	617.0	407	0
	Plug trays—98's	each	0.66	1,512.0	998	1
	Plug trays—200's (TLC's)	each	0.66	741.0	489	0
Rooting media	Prepackaged (ProGro 200) 3 cu ft	bag	8.50	116.0	986	1
Seed	Various varieties	oz.	44.83	80.0	3,586	2
Cuttings	From stock plants (non-herbs)	plant	0.07	88,886.0	6,222	3
Plants	For crown divisions	divisions	0.25	50,000.0	12,500	7
Plants	Rooted cuttings (mums)	plants	0.22	17,778.0	3,911	2
Hormone power	Rootone-F #1	lb	15.00	2.0	30	0
Subtotal (propagation)	Does not include labor				29,130	16
Materials						
Containers						
Mums	3-quart	each	0.14	17,778.0	2,542	1
Seed, Cuttings, Divisions	Nupot/Nutray 12	set	1.18	16,667.0	19,667	11
Herbs	Nupot/Nutray 16	set	1.18	6,667.0	7,867	4
Soil mixture	Pro-Grow 300 (3 cu ft)	bag	5.49	3,121.0	17,134	9
Polyethylene film (clear) (4-mil, 1-yr.)	5 (1-sheet ea—5 unheated houses)	ea	65.00	5.0	325	0
Polyethylene film (clear) (6-mil, 3-year material) $226 (32′x125′) roll	8 (2-sheets ea—4 heated houses) (Replaced every 3rd year)	ea	226.00	2.7	610	0
Polyethylene film (white)	5 (32′x125′)—unheated polyhouses	ea	102.90	5.0	515	0
(1-year material)	11 (24′x100′)—Structure-less	ea	61.74	11.0	679	0
Weed barrier (5-year material)	6 mum plots (20′x100′) (Replaced every 5th year	ea	124.00	1.2	149	0
Shade cloth—(5-year)	9—48% (32′ x 100′)=1.8/yr. (Replaced every 5th year)	ea	278.00	1.8	500	0
Thermal blanket (3-year material) $180 (80″x225′) roll	11 (20′x100′) structureless areas 5 (20′x100′) unheated polyhouses Total=16x1.33=22.61/3 yrs.=7.54 (Replaced every 3rd year)	ea	180.00	7.5	1,350,	1
Plant name tags	Stik-stakes (John Henry Co.)	each	0.02	324,450.0	6,489	4
Propane	Heating	gallons	0.65	10,000.0	6,500	4
Electricity	Does not include 7,400 KWH used with the water system pump	KWH	0.06	28,000.0	1,680	1
Chemicals	Plant marvel 20-20-20 (fert)	lb	0.84	215.0	181	0
	Osmocote 14-14-14 (fertilizer)	lb	1.00	3,345.0	3,345	2
	Peter's Liq. 15-16-17 (Herbs)	lb	1.00	40.0	40	0
	Sevin (insecticide)	lb	2.80	12.0	34	0
	Safer's (insect. soap-Herbs)	gal	25.00	7.0	175	0
	Daconil (fungicide)	gal	35.00	2.5	88	0
	Benlate (fungicide)	lb	13.00	19.6	255	0
	Resmethryn (aerosol)	lb	6.25	16.0	100	0
	Havoc (rodent bait)	pkg	0.75	175.0	131	0
Subtotal (materials)					70,355	39

(Continued)

Table 2. (Continued)

Item	Description	Unit	Cost per Unit ($)	Quantity	Total Variable Cost ($)	Percent of Variable Cost
Machinery and equipment						
	Office equipment	hr	0.72	1,000.0	720	0
	Water system and irrigation					
	Water system, well & pump	hr	2.35	270.0	635	0
	Inground (mainline)	hr	0.23	270.0	62	0
	Structure-less areas	hr	0.34	270.0	92	0
	Polyhouse structures	hr	0.08	270.0	22	0
	Propagation house (extra)	hr	1.14	180.0	205	0
	Tractor 23HP	hr	3.55	800.0	2,840	2
	front end loader	hr	0.60	200.0	120	0
	Tractor 16HP (Lawn Type)	hr	2.39	400.0	956	1
	48″ mower	hr	0.18	100.0	18	0
	Flatbed wagons	hr	0.04	3,000.0	120	0
	Sprayer, boom 10′	hr	2.00	60.0	120	0
	Del. vehicle—Rental	hr	15.50	300.0	4,650	3
	Del. vehicle—stretch van	hr	9.11	375.0	3,416	2
	Del. vehicle—15′ van	hr	11.99	375.0	4,496	2
	Standby electric generator	hr				
Subtotal (mach. & Eq.)					18,472	10
Labor (non-permanent)[2]						
	Labor hours	hr	6.93	6,125.0	42,446	23
	Related labor hours, 20%	hr	6.93	1,531.0	10,610	6
Subtotal (labor)					53,056	29
Operating capital	Computed at 12% on an annual basis for 6 months	%	6.00 (0.06)		10,261	6
Total Variable Costs					181,274	100

[1]Total nursery 3 acres (130,620 sq. ft.), with 1.2 acres growing space (51,560 sq. ft.).
[2]Average basic wage before withholding taxes and fringe benefits=$5.25, taxes and fringe benefits add 32% or $1.68 for a total of $6.93.

Results and Discussion

Annual fixed, variable, and total production costs of operating a three-acre perennial container nursery in Ohio for 1989 are summarized in Table 3. Total production costs were $353,812. Fixed costs totaled $172,538 and made up 49 percent of total annual costs. Based on a percentage of total costs land and land improvements made up 3 percent, buildings 7 percent, machinery and equipment 4 percent, general overhead 33 percent, and interest on general overhead, insurance, and taxes 2 percent. Variable costs totaled $181,274 and made up 51 percent of total costs. Based on a percentage of total costs, propagation made up 8 percent, materials 20 percent, machinery and equipment 5 percent, labor 15 percent, and interest on operating capital 3 percent.

Individual nurseries might well experience costs different than those depicted here. Most cost differences would probably be reflected in fixed rather than variable costs because budgets presented assumed new facilities, machinery and equipment. Also most nurseries have owned their land for many years and have used machinery and equipment. For the established nursery, budgeted fixed costs presented here would reflect replacement rather than "book values" of depreciated items.

Interest on investment items was determined using the approximate rate charged by banks. Another method of computing interest charges would be to use the "real" rate which is the difference between what a bank charges and the rate of inflation (i.e., 12 percent bank rate of interest—5 percent rate of inflation=7 percent real interest rate). While fixed costs are viewed uniquely by almost every nursery, variable costs, on the other hand, should be rather consistent regardless of age and size of nursery.

Summary

Total annual production costs of operating a three-acre perennial container nursery were $353,812 for 1989. Fixed costs were $172,538 or 49 percent of the total. Variable costs were $181,274 or 51 percent of the total.

TABLE 3. Summary of Annual Fixed, Variable and Total Costs (Dollars) of Operating a Three-Acre Perennial Container Nursery in Ohio, 1989.

Description	Total	Percent of Total Cost
Fixed Costs		
Land and improvements	9,210	3
Buildings	23,352	7
Machinery and equipment	15,354	4
General overhead	117,250	33
Interest on general overhead, insurance, and taxes	7,372	2
Subtotal	172,538	49
Variable Costs		
Propagation	29,130	8
Materials	70,355	20
Machinery and equipment	18,471	5
Labor	53,057	15
Interest on operating capital	10,261	3
Subtotal	181,274	51
Total	353,812	100

Literature Cited

1. Badenhop, M.B., and T.D. Phillips and S-103 Technical Committee. 1985. Costs of Establishing and Operating Field Nurseries Differentiated by Size of Firm and species of Plant in USDA Climatic Zones 7 and 8. Southern Coop. Ser. Bull. 311.
2. Perry, F.B., M.B. Badenhop, T.D.Phillips, and S-103 Technical Committee. 1987. Costs of Establishing and Operating a Small and Large Size Container Nursery in USDA Climatic Zones 7 and 8. Southern Coop. Ser. Bull. 327.
3. Taylor, Reed D., Harold H. Kneen, David E. Hahn, Elton M. Smith and S-103 Technical Committee. 1983. Costs of Establishing and Operating Container Nurseries Differentiated by Species of Plant in U.S.D.A. Climatic Zone Six. Southern Coop. Ser. Bull. 301.
4. Taylor, Reed D., Harold H. Kneen, Elton M. Smith, David E. Hahn, Stanley Uchida, and S-103 Technical Committee. 1986. Costs of Establishing and Operating Field Nurseries Differentiated by Size of Firm and Species of Plant in USDA Plant Hardiness Zones 5 and 6. Southern Coop Ser. Bull. 315.

Comparative Costs of Producing Alternative Plants in a Three-Acre Perennial Container Nursery in Ohio—1989

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Abstract

The objective of this article is to compare the costs of producing container grown perennial plants in Ohio differentiated by plant group (Table 1). Total annual costs per salable plant in a three-acre perennial container nursery by plant group were $1.17 per quart container (4″ x 4″ x 4 3/4″) for perennials propagated from seed, $1.24 per quart container for perennials propagated from cuttings, $1.49 per quart container for perennials propagated from crown divisions, $1.95 per three-quart container for mums, and $0.99 per cell (16 cells/flat) for herbs, and averaged $1.21 for all species. Fixed costs averaged 49 percent and variable costs 51 percent of the total.

Introduction

To make more informed decisions as to whether to enter, leave, or expand perennial container production, nurseries require production, marketing, and financial information. Comprehensive cost models have been developed for both container- and field-grown woody ornamental crops in USDA Plant Hardiness Zones 5, 6, 7, and 8 (1,2,3,4). A study has been completed and nearing publication for Zone 9. This article summarized per-salable-plant costs of producing container-grown perennial plants in a three-acre nursery in Ohio.

Materials and Methods

A model firm was synthesized using the conceptual framework of economic engineering wherein the "best proven practice" was included for the model. The complete model included developing an appropriate production cycle; schematic drawings of the physical layout, including buildings and irrigation system; list of equipment and other items; a complete sequence by month and year of nursery operational steps beginning with land preparation and ending with loading the finished product for wholesale distribution; and budgets for fixed and variable costs.

Commonly grown perennial container nursery stock was divided into five cultural groups: propagated from seed, propagated from cuttings, propagated from crown divisions, mums, and herbs. While not all inclusive, the groups do permit a range of per unit costs to be developed as they relate to input costs and cultural factors.

Data for this study were obtained from wholesale nurseries and nursery suppliers in Ohio during late Spring 1989. The basic goals in synthesizing the production facilities were to minimize labor expenses, flow, and movement of plant material and equipment; maximize the number of salable plants; and allow future expansion. The nursery reported on consisted of three acres, with 1.18 acres of growing space and 1.82 acres of buildings, other production facilities, and roads.

Costs were established for all factors of production including management and invested capital. Since most nurseries use cash rather than accrual procedures, the analyses were completed on a "cash" basis. Capital requirements for establishing the nursery were first determined. Second, physical factors associated with the nursery and annual shipment requirements were established. Third, production systems for the enterprises budgeted were described. Fourth, annual fixed costs were calculated. Fifth, estimated variable costs for each of the five groupings of plants were determined. Sixth, summaries were made of fixed and variable costs for each cultural group (Tables 2 and 3).

Table 1. Estimated Planting and Harvesting Requirements for a Three-Acre Perennial Container Nursery, 1989.

		Propagation			Transplanted			Sales/Annum			
Group	Description	No.	Container	% Loss	No.	Container[1]	%Loss	Season	Next Spring	Total	Total
			Cells/flat							Units	Plants
I	Seed	444	200's	10	6,667	flats/12's	10	1000	5000	6000	72000
II	Cuttings	907	98's	10	6,667	flats/12's	10	1000	5000	6000	72000
III	Divisions	617	72's	20	3,333	flats/12's	10	500	2500	3000	36000
IV	Mums	—	—	—	17,778	3-Quart	10	16000	0	16000	16000
V	Herbs	605	98's	10	6,667	flats/16's	10	6000	0	6000	96000
		297	200's	10							

[1]Groups I, II, and III are grown and sold in flats containing 12, 1-quart (4″ x 4″ containers). Group IV plants (mums) are grown and sold in 3-quart containers, and herbs are sold in flats containing 16 cells.

Results and Discussion

Annual fixed costs associated with capital investment (depreciation, interest, insurance, and taxes) were $47,916. An additional $117,250 was allocated for general overhead and $7,372 for interest on general overhead, insurance, and taxes, making a total of $172,538 for annual fixed costs. These were allocated to each plant group based on the proportion of nursery resources used by the plant group: plants propagated from seed (25 percent), plants propagated from cuttings (25 percent), plans propagated from crown divisions (12 percent), mums (8 percent), and herbs (30 percent) (Table 2).

On a per-salable-plant basis, there was a considerable difference in fixed costs when they were differentiated by plant group (Table 3). They were: $0.60 for group I (plants propagated from seed), $0.60 for group II (plants propagated from cuttings), $0.58 for group III (plants propagated from crown divisions), $0.86 for group IV (mums), and $0.54 for group V (herbs), and averaged $0.59 for all groups (Table 3).

Nurserymen having established facilities might well consider fixed costs to be lower than those reported here. This is especially true if they calculate depreciation and repairs on the original value of land improvements, buildings, machinery, and equipment and if they place a low value on their own management input. Good management for planning purposes, however, dictates computing depreciation and repairs on replacement value rather than on original cost. It also dictates placing a value on managerial time which would be comparable to salaries paid in competitive firms.

Total variable costs by plant group were $40,974 for group I (plants propagated from seed), $46,240 for group II (plants propagated from cuttings), $32,939 for group III (plants propagated from crown divisions), $17,413 for group IV (mums), and $43,749 for group V (herbs). Total for all groups was $181,315 (Table 2). On a per-salable-plant basis, variable costs were $0.57 for group I, $0.64 for group II, $0.91 for group III, $1.09 for group IV, $0.46 for group V, and averaged $0.62 for all groups (Table 3). Variable costs ranged from 46 percent to 61 percent of total costs and averaged 51 percent for all groups.

Total annual costs are the summation of fixed and variable costs. They were $84,109 for group I (plants propagated from seed), $89,375 for group II (plants propagated from cuttings), $53,644 for group III (plants propagated from crown divisions), $31,216 for group IV (mums), $95,510 for group V (herbs). They totaled $353,853 for all groups (Table 2). On a per-salable-plant basis, total costs were $1.17 for group I, $1.24 for group II, $1.49 for group III, $1.95 for group IV, $0.99 for group V, and averaged $1.21 for all groups (Table 3).

Table 2. Summary of Fixed, Variable and Total Costs (Dollars) of Operating a Three-Acre[1] Perennial Container Nursery, 1989.

Description	Group I (Seed)	Group II (Cuttings)	Group III (Divisions)	Group IV (Mums)	Group V (Herbs)	Total
Fixed Costs[2]						
Land and improvements	2,303	2,303	1,105	737	2,763	9,210
Buildings	5,838	5,838	2,802	1,868	7,006	23,352
Machinery and equipment	3,839	3,839	1,842	1,228	4,606	15,354
General overhead	29,313	29,313	14,070	9,380	35,175	117,250
Interest on general overhead, insurance, and taxes	1,843	1,843	885	590	2,212	7,372
Subtotal	43,135	43,135	20,705	13,803	51,761	172,538
Variable Costs						
Propagation	2,180	7,148	13,239	3,911	2,652	29,130
Materials	18,564	18,564	9,240	6,805	17,217	70,390
Machinery and equipment	4,646	4,646	2,229	1,466	5,487	18,474
Labor	13,265	13,265	6,367	4,245	15,917	53,059
Interest on operating capital	2,319	2,617	1,864	986	2,476	10,262
Subtotal	40,974	46,240	32,939	17,413	43,749	181,315
Total	84,109	89,375	53,644	31,216	95,510	353,853
Salable Plants Per Year	72,000	72,000	36,000	16,000	96,000	292,000
Total Cost per Salable Plant	1.17	1.24	1.49	1.95	0.99	1.21

[1]Total nursery 3 acres (130,620 sq. ft.) with 1.2 acres growing space (51,560 sq. ft.) and 1.8 acres (79,060 sq. ft.) in production facilities, roads, etc.

[2]Fixed costs were allocated based on the number of hours spent with each group of plants. Twenty-three percent of fixed costs allocated to Group I Plants, 23% to Group II Plants, 12% to Group III Plants, 12% to Group IV Plants, and 30% to Group V Plants.

[3]Individual figures do not always add to the total due to rounding.

Table 3. Summary of Fixed, Variable and Total Costs (Dollars) per Salable Plant of Operating a Three-Acre[1] Perennial Container Nursery, 1989.

	Group I (Seed)		Group II (Cuttings)		Group III (Divisions)		Group IV (Mums)		Group V (Herbs)		Total	
Item	Cost per Salable Plant	Percent of Total Cost	Cost per Salable Plant	Percent of Total Cost	Cost per Salable Plant	Percent of Total Cost	Cost per Salable Plant	Percent of Total Cost	Cost per Salable Plant	Percent of Total Cost	Cost per Salable Plant	Percent of Total Cost
Fixed Costs												
Land and improvements	0.03	(3)	0.03	(3)	0.03	(2)	0.05	(2)	0.03	(3)	0.03	(3)
Buildings	0.08	(7)	0.08	(7)	0.08	(5)	0.12	(6)	0.07	(7)	0.08	(7)
Machinery and equipment	0.05	(5)	0.05	(4)	0.05	(3)	0.08	(4)	0.05	(5)	0.05	(4)
General overhead	0.41	(35)	0.41	(33)	0.39	(26)	0.59	(30)	0.37	(37)	0.40	(33)
Interest on general overhead, insurance and taxes	0.03	(2)	0.03	(2)	0.02	(2)	0.04	(2)	0.02	(2)	0.03	(2)
Subtotal	0.60	(51)	0.60	(48)	0.58	(39)	0.86	(44)	0.54	(54)	0.59	(49)
Variable Costs												
Propagation	0.03	(3)	0.10	(8)	0.37	(25)	0.24	(13)	0.03	(3)	0.10	(8)
Materials	0.26	(22)	0.26	(21)	0.26	(17)	0.43	(22)	0.18	(18)	0.24	(20)
Machinery and equipment	0.06	(6)	0.06	(5)	0.06	(4)	0.09	(5)	0.06	(6)	0.06	(5)
Labor	0.18	(16)	0.18	(15)	0.18	(12)	0.27	(14)	0.17	(17)	0.18	(15)
Interest on operating capital	0.03	(3)	0.04	(3)	0.05	(3)	0.06	(3)	0.03	(3)	0.04	(3)
Subtotal	0.57	(49)	0.64	(52)	0.91	(61)	1.09	(56)	0.46	(46)	0.62	(51)
Total Costs per Salable Plant	1.17	(100)	1.24	(100)	1.49	(100)	1.95	(100)	0.99	(100)	1.21	(100)

[1]Total nursery 3 acres (130,620 sq. ft.) with 1.2 acres growing space (51,560 sq. ft.) and 1.8 acres (79,060 sq. ft.) in production facilities, roads, etc.
[2]Individual figures do not always add to the total due to rounding.

Summary

Total costs per salable plant, differentiated by group, ranged from $0.99 to $1.95 and averaged $1.21 for all groups. Fixed costs per salable plant ranged from $0.54 to $0.86 and averaged $0.59. Fixed costs as a percentage of total costs ranged from 39 percent to 54 percent and averaged 49 percent for all groups. Variable costs per salable plant ranged from $0.46 to $1.09 and averaged $0.62 for all groups. Variable costs as a percentage of total costs ranged from 46 percent to 61 percent and averaged 51 percent for all groups. Differences in costs were primarily due to size of container. Plants propagated from seeds, cuttings, and crown divisions were sold in quart containers, mums in three-quart containers, and herbs in cells (16 cells/flat)

Literature Cited

1. Badenhop, M.B., and T.D. Phillips and S-103 Technical Committee. 1985. Costs of Establishing and Operating Field Nurseries Differentiated by Size of Firm and Species of Plant in USDA Climatic Zones 7 and 8. Southern Coop. Ser. Bull. 311.
2. Perry, F.B., M.B. Badenhop, T.D.Phillips, and S-103 Technical Committee. 1987. Costs of Establishing and Operating a Small and Large Size Container Nursery in USDA Climatic Zones 7 and 8. Southern Coop. Ser. Bull. 327.
3. Taylor, Reed D., Harold H. Keen, David E. Kahn, Elton M. Smith and S-103 Technical Committee, 1983. Costs of Establishing and Operating Nurseries Differentiated by Species of Plant in U.S.D.A. Climatic Zone Six. Southern Coop. Ser. Bull. 301
4. Taylor, Reed D., Harold H. Kneen, Elton M. Smith, David E. Hahn, Stanley Uchida, and S-103 Technical Committee. 1986. Costs of Establishing and Operating Field Nurseries Differentiated by size of Firm and Species of Plant in USDA Plant Hardiness Zones 5 and 6. Southern Coop Ser. Bull. 315

Marketing and Sales Strategies Practiced by Ohio Nurseries

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Abstract

The objective of this article is to present marketing and sales strategies practiced by Ohio nurseries. The Ohio nursery industry is characterized by small- to medium-sized firms. Thirty-six percent of firms reported sales of less than $100,000 and 81 percent had sales of less than $1 million. Only 12 percent of firms reported foreign sales. These sales made up less than 1 percent of total Ohio nursery sales. Eighty-eight percent of nurseries did not hire salespersons and only 16 percent used sales brokers. Eighty-three percent of Ohio nurseries reported advertising. Those who advertise spend 2.4 percent of their gross sales for advertising.

Introduction

Information presented in this article is part of the results obtained for Ohio from a comprehensive national survey conducted by the S-103 Technical Regional Research Committee. The S-103 committee is charged with conducting regional and national research on the "Technical and Economical Efficiencies of Producing and Marketing Landscape Plants." The Committee consists of about 37 researchers with an almost equal representation of agricultural economists and horticulturists. States represented are: Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Illinois, Kentucky, Louisiana, Mississippi, New Jersey, New Mexico, New York, North Carolina, Ohio, Oregon, Pennsylvania, South Carolina, and Tennessee. Also represented are the United States Department of Agriculture and the Tennessee Valley Authority. Ohio researchers, both agricultural economists and horticulturists, have been key members of the committee for the past 10 years. During late Winter and early Spring 1989, the S-103 Committee surveyed nursery producers throughout the United States. General results of the survey will be published in a regional bulletin and other media. Researchers from each state were reserved the right to publish "state" information for their own nursery industries.

In Ohio, 130 questionnaires were sent to nurseries and 108 were returned (83 percent). This return was the highest experienced for any state and is exceptionally good for a mail survey. We would like to thank Ohio nurseries for their excellent response. A portion of the Ohio results was previously published in the Educational Update section of the September 1989 issue of the Buckeye Nurseryman. That article was entitled "Selected Characteristics and Practices of Ohio Nurseries." It handled the topics of when nurseries were established, forms of business organization, gross sales, computerization, types of transportation used for shipping, source of trucks, labor, factors limiting expansion, factors limiting expanding geographic scope of trading, and ornamental plant sales by plant category. This article presents results of the survey dealing with sales and marketing.

Results

Gross Sales.

Most Ohio Nurseries are fairly small with 36 percent having gross sales of less than $100,000 and 81 percent with gross sales less than $1,000,000 (Table 1).

Table 1. Gross Sales of Ohio Nurseries in 1988.

Gross Sales Category	Percent of Firms
Less than $100,000	36
$100,000—$499,999	29
$500,000—$999,999	16
$1,000,000—$1,999,999	8
$2,000,000—$2,999,999	3
$3,000,000—3,999,999	2
$4,000,000—$5,000,000	2
Greater than $5,000,000	4
Total	100

Sales by Plant Category.

Sixty-nine percent of Ohio nurseries reported selling deciduous shade and flowering trees (Table 2). Of these nurseries, this category represented 37 percent of their total sales. Closely following deciduous shade and flowering trees was deciduous shrubs with 68 percent of Ohio nurseries selling in this category. While 68 percent of nurseries sold in this category, only 18 percent of their sales were represented by these plants. The least important categories of plants were propagating materials (1 percent reported sales, representing 19 percent of their sales), tree fruits (7 percent reported sales, representing 3 percent of their sales), and small fruits (7 percent reported sales, representing 3 percent of their sales).

Root Holding Media.

Seventy-eight percent of respondents used balling and burlapping to hold root media (Table 3). This method represented 68 percent of their sales. The next most popular root holding media was containers with 69 percent of Ohio nurseries growing plants in containers. Of those growing plants in containers, the method represented 49 percent of their sales. Twenty-one percent of Ohio nurseries sold plants bare root. This method represented 20 percent of their sales. The next most important category was balled and potted with 15 percent of Ohio nurseries reporting sales in this category. While only 15 percent reported sales in this category, it represented 40 percent of their sales. Currently less than 5 percent of producers sold plants in either of the categories of processed balled or field grown bag.

Sales by Month.

March through May is the most important sales season for Sales by Month. Ohio nurseries, with April being the top sales month (Table 4). Those selling in April (89 percent), experienced 24 percent of their total sales during the month. The other high sales season was September through November. Again, most nurseries experienced sales in each of the three months.

Method of Sales Transaction.

Ohio nurseries use a multitude of methods to effect sales (Table 5). The survey obtained information on both negotiated and nonnegotiated sales. In nonnegotiated sales, the customer accepts the terms presented by the producer. In negotiated sales, terms are determined by bargaining. In the case of both trade show orders and telephone, nonnegotiated sales were most important, but in the case of in-person orders, negotiated sales were the most prevalent. In both cases, negotiated and nonnegotiated sales, the telephone was the most important method of sales transaction. Seventy percent of firms used the telephone on nonnegotiated sales and reported 45 percent of their product sold by this method. Thirty-seven percent of firms used the telephone for negotiated sales and sold 30 percent of their product by this method. In-person negotiations were the next most important method of sales transactions. Forty-six percent used this method for negotiated sales selling 36 percent of their product by this method. Thirty-four percent used the method for nonnegotiated orders and sold 37 percent of their product. Twenty-six percent of producers experienced nonnegotiated trade show orders and sold 15 percent their material. Fourteen percent had negotiated trade show orders selling 8 percent of their plants by this method. Twenty-seven percent of producers had mail order sales selling 26 percent of their product through mail orders.

Price Determination.

Eighty-three percent of Ohio producers listed "cost of production" as an important factor in determining price (Table 6). Of those listing cost of production, 52 percent said it was the most important factor. Eighty-eight percent listed "comparison to other growers" as an important factor, but only 25 percent of this group listed it as the most important factor. Other factors listed by over 50 percent of producers were "market demand" (77 percent) with 14 percent listing it as the most important factor, "last year's price" (68 percent) with 14 percent listing it as the most important factor, "by grade of plants" (63 percent) with 12 percent listing it as the most important factor, "based on inventory" (60 percent) with 4 percent listing it as the most important factor. Factors listed by less than 50 percent of the firms were "inflation" 44 percent, "time of year" 7 percent, and "other" 5 percent.

Repeat Sales.

Eighty-two percent of respondents reported having repeat sales which made up 78 percent of their total sales volume.

Printed Price.

Ninety-four percent of Ohio firms reported selling plants at their printed price. This group reported over 88 percent of total sales volume being sold at the printed price and less than 21 percent at a negotiated price.

Table 2. Ornamental Plant Sales by Ohio Nurseries by Plant Category.

Category of Plant	Percent of Firms Selling Plants in This Category	Average Percent of Total Plant Sales by Firms Selling Plants in This Category
Deciduous shade and flowering trees	69	37
Deciduous shrubs	68	18
Broad-leaved evergreen shrubs	51	17
Narrow-leaved evergreen shrubs	57	26
Evergreen trees	60	35
Vines and ground covers	33	15
Roses	15	2
Herbaceous perennials	31	24
Tree fruits	7	3
Small fruits	7	3
Propagating materials (liners, cuttings, etc.)	1	19
Other	3	2

Table 3. Ornamental Plant Sales by Ohio Nurseries by Plant Root Holding Media.

Category of Plant Holding Media	Percent of Firms Selling Plants in This Category	Average Percent of Total Plant Sales by Firms Selling Plants in This Category
Bare root	21	20
Balling and burlapping	78	68
Container	69	49
Balled and potted	15	40
Processed balled	4	15
Field grown bag	3	40
Other	3	48

Export Sales.

Only 12 percent of Ohio producers reported export sales. Those exporting reported that 3.53 percent of their total sales were exported. This would represent less than ½ of 1 percent of total Ohio sales volume.

Salespersons and Sales Brokers.

Only 12 percent of firms hired salespersons. Of those hiring, 23 percent had one salesperson, 61 percent two, and only 16 percent (1 percent of all Ohio nursery firms) had over two. Sixteen percent of Ohio Nurseries used the services of sales brokers.

Advertising.

Eighty-three percent of Ohio nurseries reported doing some forms of advertising spending 2.4 percent of gross sales for advertising. The majority (56 percent) of nurseries used catalogs for advertising. Firms having catalogs spent 47 percent of their advertising budget this way. Thirty-one percent of the firms went to trade shows and used 35 percent of their advertising budgets on trade shows. Thirty-five percent advertised in trade journals spending 23 percent of their advertising budgets on this method. Thirty-two percent used the yellow pages spending 34 percent of for their advertising budget. Thirty-two percent used newspapers/flyers and spent 31 percent of their advertising budget on this method. Twenty-four percent spent 28 percent of their advertising budget on newspapers. Of lesser importance was radio with 8 percent using it and billboards with 3 percent. Nineteen percent of nurseries spent 31 percent of their budgets on yet other methods.

Table 4. Sales of Ohio Nursery Plants by Month.

Month	Percent of Firms Reporting Sales of Plants in This Month	Average Percent of Total Plant Sales in This Month by Firms Reporting Sales in This Month
January	26	4
February	32	4
March	80	13
April	89	24
May	87	20
June	69	10
July	57	6
August	62	7
September	81	10
October	84	11
November	73	11
December	55	8

Table 5. Ornamental Plant Sales by Ohio Nurseries by Method of Sales Transaction.

Category of Sales Transaction	Percent of Firms Selling by This Type of Transaction	Average Percent of Total Plant Sales Using This Type of Transaction
Trade show orders (Negotiated)	14	8
Trade show orders (nonnegotiated)	26	15
Telephone orders (negotiated)	37	30
Telephone orders (nonnegotiated)	70	45
In-person orders (negotiated)	46	36
In-person orders (nonnegoiated)	34	37
Mail orders	27	26

Table 6. Factors Used by Ohio Nurserymen to Determine Price Charged.

Price Determination Factor	Percent of Firms Listing This Factor	Ranking of Importance of This Factor by Those Firms Who Answered Positive to the Question				
		1st	2nd	3rd	4th	5th
		Percent				
Cost of production	83	52	9	20	15	4
Inflation	44	6	14	17	21	42
Comparison to other growers	88	25	31	19	18	7
By grade of plants	63	12	28	25	25	10
Market demand regulations	77	14	28	19	17	22
Time of year	7	0	0	0	13	87
Based on inventory	60	4	11	29	25	31
Based on last year's price	68	14	18	15	24	29
Other	5	0	20	20	0	60

Table 7. Methods Used by Ohio Nurseries for Advertising.

Advertising Method	Percent of Firms Reporting This Method of Advertising	Average Percent of Total Advertising Budget Spent for This Method by Firms Reporting This Method
Yellow pages	32	34
Billboards	3	5
Radio	8	18
Trade shows	31	35
Newspaper	24	28
Trade journals	35	23
Catalogs	56	47
Newspapers/flyers	32	31
Other	19	31

Evaluation of Flowering Crabapple Susceptibility to Apple Scab in Ohio—1989

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Abstract

The wet weather conditions that prevailed in Ohio during the growing season of 1989 resulted in 87 selections of flowering crabapples (*Malus* species and cultivars) found to be resistant or highly resistant to apple scab while 106 selections were susceptible or highly susceptible in a survey of Ohio arboretums. These figures compare to 1988 findings of 128 resistant and 82 susceptible selections in an extremely dry spring season.

Introduction

Apple scab caused by *Venturia inequalis* is a fungus disease which infects *Malus* species and cultivars. The disease is first manifested by olive gray spots on the foliage followed by yellowing and defoliation of susceptible selections of flowering crabapple. Continued defoliation will most likely weaken trees, reduce bloom in succeeding years and contribute towards greater winter injury.

Apple scab can be reduced or eliminated by planting resistant selections. The disease can be controlled by fungicides but this is a continual process requiring application every two weeks from late April until autumn.

This study evaluated flowering crabapples in Ohio arboretums for tolerance to apple scab. A statewide evaluation allows growers, retailers and landscapers to know which selections have proven to be resistant and which are susceptible to this disease of flowering crabapple in Ohio.

Materials and Methods

In August 1989, a survey of flowering crabapples was conducted in Ohio arboretums. Apple scab severity was rated and the presence of other diseases such as fireblight, cedar apple rust and frog eye leaf spot were also noted. Since the severity of the latter three diseases are usually not serious enough in Ohio to discontinue planting, ratings were not given.

The infestation of apple scab was rated as follows:

HR=highly resistant—no indication of disease;

R=resistant—mild infection with no defoliation;

S=susceptible—medium infection with only slight defoliation;

HS=highly susceptible—heavy infection often accompanied by considerable defoliation.

More than one rating may appear in the table for a given selection as severity of infection varied among locations. The variation was most likely due to differences in time and amount of rainfall as well as average relative humidity.

Results and Discussion

Some degree of variability in apple scab exists from year to year based on previous observations by the authors (2, 3, 4, 5). Rainfall between April and mid-July was well above normal in 1989.

In the survey there were 87 selections rated highly resistant or resistant while 106 were susceptible or highly susceptible. Comparing similar seasons there were 127 selections resistant and 79 susceptible in 1985 (4). In 1984, the most recent prolonged wet spring and summer, there were 89 selections resistant and 114 susceptible (3).

In 1989, among the most disease resistant selections to apple scab, fireblight, cedar apple rust and frog eye leaf spot were: *Malus* 'Beverly', 'Bob White', 'Centennial', 'Christmas Holly', 'Coralburst', 'David', 'Dolgo', 'Donald Wyman', *floribunda*, 'Golden Hornet', 'Golden Gem', 'Klehm's Improved', 'Jewelberry', 'Liset', 'Makamik', 'Mary Potter', *micromalus*, 'Mollie Ann', 'Molton Lava', 'Ormiston Roy', 'Prairiefire', 'Prince Georges', 'Prof Sprenger', *prunifolia* 'Pendula', 'Red Jade', 'Red Jewel', *robusta* selections, *sargenti*, 'Selkirk', 'Sentinel', 'Silver Moon', 'Strawberry Parfait', 'Sugartyme', *tschonoksi*, 'White Angel', *yunnanensis* selections and *zumi* 'Calocarpa.'

Flowering crabapples rated highly susceptible to apple scab in 1989 were: 'Almey', 'Amisk', *arnoldiana*, 'Arrow', 'Barbara Ann', 'Dorothea', 'Evelyn', 'Hopa', 'Katherine', 'Pink Flame', 'Pink Spires', 'Pink Weeper', 'Purple Wave', 'Eleyi', 'Radiant', 'Red Silver', and 'Tanner'. Due to the severity of apple scab this and in previous years (2, 3, 4, 5) these selections should be discontinued from planting in Ohio.

To obtain information relative to cultural requirements and descriptions of recommended flowering crabapples consult the publication titled, "The Flowering Crabapple—A Tree For All Seasons" (1) available from county Extension Service offices. Additional information can be obtained by visiting one of several arboretums in Ohio in late April—early May. Outstanding collections of flowering crabapples can be located in the Dawes Arboretum in Newark, Holden Arboretum in Kirkland Hills, and the Secrest Arboretum in Wooster.

Table 1. Susceptibility of Flowering Crabapples to Apple Scab—1989

	Apple Scab Rating				
Species, Hybrid or Cultivar	HR	R	S	HS	Other Diseases Noted
'Adams'		x	x		
M. x adstringens				x	
'Almey'				x	
'Amberina'			x		
'Amisk'				x	
'Amur'				x	
'Anne E'	x				
'Arnold Arboretum'				x	
M. x arnoldiana				x	
'Arrow'				x	
M. baccata	x				
M. baccata columnaris		x			
M. baccata 'Jacki'	x				
M. baccata 'Mandshurica'		x	x		
M. baccata 'Midwest'	x				
baccata 'Serbian'				x	
'Barbara Ann'				x	
'Beverly'	x				
'Blanche Ames'	x				
'Bob White'	x				
'Brandywine'	x				
M. brevipes				x	
'Burgundy'				x	
'Candied Apple'			x		
'Centennial'	x				
'Centurion'			x	x	
'Cheal's Crimson'				x	
'Chestnut'		x			
'Chilko'	x	x			
'Christmas Holly'	x				
'Coralburst '	x				Frog Eye Leaf Spot
M. coronaria 'Charlottae'				x	
M. coronaria 'Nieuwlandiana'			x	x	
'Cowichan'				x	
'Crimson Brilliant'				x	
'Dainty'				x	
'David'	x	x			
'Dawsoniana'	x				
'Dolgo'	x				
'Donald Wyman'		x			
'Dorothea'				x	
'Dorothy Rowe'	x				
'Ellen Gerhart'				x	
'Evelyn'				x	
'Exzellenz Thiel'				x	
'Flame'				x	
'Flexilis'	x				
M. floribunda	x				
'Fusca'	x				
'Girard's Dwarf Weeping'		x			
'Girard's Pendula Nana'	x				

HR=Highly Resistant, R=Resistant, S=Susceptible, and HS=Highly Susceptible. (Continued)

Table 1. (Continued)

Species, Hybrid or Cultivar	HR	R	S	HS	Other Diseases Noted
'Geneva'		x	x		
'Goldfinch'				x	
M. glaucescens	x				Cedar Apple Rust
M. gloriosa				x	
'Golden Gem'	x				
'Golden Hornet'	x				
'Gorgeous'	x				
'Gwendolyn'	x				
M. halliana	x				
M. halliana 'Parkmanii'	x				
'Harvest Gold'			x	x	
'Henningi'			x		
'Henrietta Crosby'			x		
'Henry Dupont'			x	x	
'Hopa'				x	
'Hopa Austrian'				x	
'Hopa Dwarf'			x		
'Hopa Rosea'			x		
M. hupehensis	x				
'Indian Magic'				x	
'Indian Summer'			x		
M. ioensis	x				
'Irene'				x	
'Klehms Improved'	x				Cedar Apple Rust
'Jay Darling'				x	
'Joan'	x				
'Jewelberry'	x	x			
'Katherine'				x	
'Kibele'				x	
'Kirghisorum'	x				
M. lancifolia			x	x	
'Leslie'				x	
'Liset'	x				
'Madonna'			x		
M. x magdeburgensis		x			
'Makamik'	x				
'Marshall Oyama'	x	x			
'Mary Potter'	x				
'Masek'				x	
M. x micromalus	x				
'Milton Barron'				x	
'Mollie Ann'	x				
'Molton Lava'	x	x			
'Neville Copeman'				x	
'Oakes'				x	
'Oekonomierat Echtermeyer'				x	
'Ohio'			x		
'Oporto'				x	
'Ormiston Roy'	x				
Park Centre	x				
'Patricia'				x	
'Pink Beauty'			x	x	

HR=Highly Resistant, R=Resistant, S=Susceptible, HS=Highly Susceptible. (Continued)

Table 1. (Continued)

Species, Hybrid or Cultivar	HR	R	S	HS	Other Diseases Noted
'Pink Cascade'		x	x		
'Pink Dawn'			x		
'Pink Flame'				x	
'Pink Perfection'				x	
'Pink Spires'				x	
'Pink Weeper'				x	
'Prairie Rose'	x				
'Prairiefire'	x				
'Pretty Marjorie'	x				
'Prince Georges'		x			
'Profusion'			x	x	
'Prof. Sprenger'	x				Frog Eye Leaf Spot
M. prunifolia				x	
M. prunifolia 'Fastigiata'		x	x		
M. prunifolia 'Pendula'	x				
M. pumila Elise 'Rathke'				x	
M. pumila 'Niedzwetzkyana'				x	
M. pumila 'Paradise Foleus Aureus'				x	
'Purple Wave'				x	
M. purpurea				x	
M. purpurea 'Aldenhamensis'				x	
M. purpurea 'Eleyi'				x	
M. purpurea 'Lemoinei'				x	
M. Pygmy				x	Frog Eye Leaf Spot
'Radiant'				x	
'Ralph Shay'		x	x		
'Red Baron'			x		
'Red Edinburgh'				x	
'Red Flesh'				x	
'Red Jade'		x			
'Red Jewel'	x				
'Red Swan'		x			
'Red Silver'				x	
'Red Splendor'			x		
'Ringo'				x	
'Robinson'				x	
M. x robusta	x				
M. x robusta 'Erecta'				x	
robusta 'Leucocarpa'	x				
M. robusta 'Persicifolia'	x				
'Rosseau'	x				
'Royal Ruby'			x		
'Royalty'			x	x	
'Ruby Luster'				x	
M. sargentii	x				
M. sargentii 'Candymint'		x	x		
M. sargentii 'Rosea'	x				
M. sargentii 'Rose Low'	x				
M. x scheideckeri			x	x	
M. x scheideckeri 'Hilleri'			x		
'Scugog'		x	x		

HR=Highly Resistant, R=Resistant, S=Susceptible, and HS=Highly Susceptible.

(Continued)

Table 1. (Continued)

Species, Hybrid or Cultivar	HR	R	S	HS	Other Diseases Noted
'Selkirk'	x	x			Fireblight
'Sentinel'	x	x			
'Shakespeare'				x	
M. sieboldi	x				
M. sieboldi 'Arborescens'		x			
sieboldi 'Fuji'	x				
M. sikkimensis	x				
'Silver Moon'	x				Fireblight
'Simcoe'	x				
'Sissipuk'	x				
'Snowcloud'				x	
'Snowdrift'			x	x	
'Snowmagic'			x		
M. x soulardii	x				
'Sparkler'				x	
M. spectabilis				x	
M. spectabilis 'Albi-Plena'				x	
M. spectabilis 'Van Eseltine'				x	
'Spring Snow'				x	
'Strathmore'				x	
'Strawberry Parfait'	x				
M. x sublobata			x		
'Sugartyme'	x				
'Sundog'			x		
M. sylvestris 'Plena'	x				
'Tanner'				x	
M. toringoides				x	
M. toringoides 'Macrocarpa'				x	
'Trail'	x				
M. tschonoski	x				
'Turesi'				x	
'Valley City #4'*			x		
'Vanguard'	x				
'Velvet Pillar'				x	
'Wabiskaw'				x	
'White Angel'	x				
'White Candle'				x	
'White Cascade'			x		
'Wilson'				x	
'Winter Gold'				x	
'Wooster No. 1'	x				
M. yunnanensis 'Veitchi'	x				
M. zumi	x	x			
M. zumi 'Calocarpa'	x				

HR=Highly Resistant, R=Resistant, S=Susceptible, and HS=Highly Susceptible.

Literature Cited

1. Brewer, J.E., L.P. Nichols, C.C. Powell and E.M. Smith, 1979. The Flowering Crabapple—a tree for all seasons. Coop. Ext. Serv. of Northeast States. NE 223, NCR 78.
2. Smith, Elton M. 1979. A 10 year evaluation of flowering crabapple susceptibility to apple scab in Ohio. Ohio Agr. Res. and Dev. Ctr., Res. Cir. 246. Ornamental Plants—1979: A Sum of Res. pp 36-39.
3. Smith, Elton M. 1984. Evaluation of flowering crabapple susceptibility to apple scab in Ohio—1984. Ohio Agr. Res. and Dev. Ctr., Res. Cir. 284, Ornamental Plants 1984: A Sum. of Res. pp 19-22.
4. Smith, Elton M. and Sharon A. Treaster, 1985. Evaluation of flowering crabapple susceptibility to apple scab in Ohio—1985. Ohio Agr. Res. and Dev. Ctr., Res. Cir. 289, Ornamental Plants—1985: A Sum. of Res. pp 4-8.
5. Smith, Elton M. and Sharon A. Treaster, 1986. Evaluation of flowering crabapple susceptibility to apple scab in Ohio—1986. Ohio Agr. Res. and Dev. Ctr., Res. Cir. 291, Ornamental Plants—1987: A Sum. of Res. pp 3-7.

Fertilizing Trees in the Landscape: An 18-Year Evaluation

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Abstract

Growth of *Tilia cordata* 'Select,' *Malus* 'Snowdrift' and *Acer saccharum* 'Monumentale' was not affected by nitrogen (N) fertilizer placement after 18 years of evaluation. Most N fertilizer treatments of Tilia resulted in trunk caliper increases compared to controls but there were no differences among rates of N application. Although treatment differences were observed in Malus and Acer through 12 years, there were no trunk caliper, height or branch diameter differences between control and treated trees after 18 years.

Introduction

Trees planted around newly constructed residences and commercial buildings are often located in soils that are less than desirable for plant growth. These sites are often composed of subsoils which are typically low in organic matter, heavily compacted and poorly drained. For these reasons, trees in the landscape must be fertilized regularly to survive when planted in poor soils. A well-fertilized tree will generally be more resistant to insect and disease problems and more tolerant of winter conditions (8).

Fertilizer recommendations for trees historically have been based on trunk caliper. In recent literature, however, the basis has changed to soil surface area (1,3,4). Nutrition research and subsequent recommendations indicate that optimum tree growth will result from the application of from 2-3 lb. N/1000 sq.ft./yr to 6 lb. N/1000 sq.ft. (5,6,9,10,11,12). Tree growth appears to be more directly related to fertilizer rate than to differences in fertilizer placement (2,7).

The objectives of this 18-year study were to evaluate tree growth of three species, in sites similar to many home landscapes, as a function of four nitrogen levels and two placement methods.

Materials and Methods

Branched whips of *Tilia cordata* 'Select'—Improved Littleleaf Linden, *Malus* 'Snowdrift'— Snowdrift Flowering Crabapple, and *Acer saccharum* 'Monumentale'—Sentry Sugar Maple were planted in April 1969. The trees were grown in sod culture and the turf mowed as needed. There were 12 trees per fertilizer treatment/species.

All trees received 6 lb. of actual phosphorus and potassium per 1000 sq.ft. in May 1971 and in April of 1974, 1977, 1980, 1983, and 1986. The nitrogen, in the form of ammonium nitrate, was applied at the same time at either 0, 3, 6, or 9 lb. actual N/1000 sq.ft. One-half of the treated trees received nitrogen as a surface application while the remainder were treated via drill hole application. The 20 holes per tree, drilled with a 2-inch power auger to a 12-inch depth, were spaced in two concentric rings in a 100 sq.ft. area around each tree. In the drill hole treatments, the fertilizer was mixed with calcined clay marketed as Sta-red-bits. One treatment consisted of a drill hole treatment filled with calcined clay without fertilizer to evaluate the effects from aeration alone.

This investigation was conducted utilizing a randomized block design with three trees per treatment and four replications. The data were analyzed by ANOVA using Duncan's Multiple Range Test at the 5 percent level of significance for mean separation.

Results and Discussion

Four fertilizer treatments resulted in significantly increased trunk caliper growth of Tilia when compared to untreated trees after 18 years (Table 1). Average caliper growth of Tilia was larger than Malus or Acer (Tables 2 & 3). The trunk splitting of control trees observed in 1974 (8) as a result of nitrogen stress was still evident in 1988. The control trees of Tilia were approximately the same caliper size as the Malus and Acer control trees.

With the exception of the drill hole only and 6 lb. surface all other fertilizer treatments of Tilia resulted in significantly larger branch diameter spread than control trees (Table 4). There were no height differences in Linden as a function of treatment.

Increases in caliper growth of Malus from fertilizer treatment was evident through 12 but not after 18 years. There were no differences among treatments after 18 years in Malus height or branch spread diameter. This is not surprising in that branch spread diameter measurements after 12 years (11) were approximately the same (16.1-19.0') as those after 15 years (16.6-19.4') (12). With the trees reaching mature size one might not expect significant growth differences in future evaluations.

Fertilizer treatments resulted in differences in caliper growth of Acer through 12 years of research (11) but not after 18 years as shown in Table 3. There were no treatment differences in height or diameter branch spread of Acer after 18 years (Table 4).

There were no growth differences in any plant species between drill hole and surface treatments. This represents a change from earlier evaluations (9,10) when rates and placement did influence growth. Apparently, as trees approach or reach mature size, fertilizer placement and rates of fertilizer used in this study may not be reflected in growth differences as in early years after planting. This does not suggest that regular fertilization is not important for tree health but that significant increases in growth may not occur when a large tree is fertilized.

Table 1. Average Caliper Growth in Inches of Improved Littleleaf Linden after 3, 6, 9, 12, 15 and 18 Years of Nitrogen Fertilizer Treatment.

	Years						
Treatment	3	6	9	12	15	18	Ave./Yr.
Control, No holes,No N	2.0[1]	3.03d[2]	4.84b	7.10b	8.0b	10.6b	0.59
Holes Only plus Calcined Clay	2.9	4.33c	6.38a	8.73a	11.3a	12.7ab	0.71
3 lb N Drill Hole	3.0	4.58bc	6.71a	8.73a	11.3a	12.5ab	0.70
6 lb N Drill Hole	3.0	4.55bc	6.83a	9.14a	11.3a	12.8a	0.71
9 lb N Drill Hole	3.0	4.80ab	7.03a	8.98a	11.9a	13.1a	0.73
3 lb N Surface	3.0	4.78ab	6.90a	9.33a	11.9a	13.3a	0.74
6 lb N Surface	3.2	4.90ab	6.88a	9.09a	11.3a	12.5ab	0.69
9 lb N Surface	3.1	5.08ab	7.49a	9.93a	12.1a	13.5a	0.75

[1]Each figure represents the average of 12 trees measured 1 foot from the soil line.
[2]Letters followed by dissimilar letters within columns are significantly different at the 5 percent level.

Table 2. Average Caliper Growth in Inches of Snowdrift Flowering Crabapple after 3, 6, 9, 12, 15, and 18 Years of Nitrogen Fertilizer Treatment

	Years						
Treatment	3	6	9	12	15	18	Ave./Yr.
Control, No holes, No N	2.7[1]	3.40d[2]	5.19c	6.35cd	7.4a	8.3a	0.46
Holes Only plus Calcined Clay	3.0	4.30c	5.53abc	6.21d	8.0a	8.7a	0.48
3 lb N Drill Hole	2.8	4.35c	5.28bc	6.68bcd	7.7a	8.4a	0.47
6 lb N Drill Hole	3.1	4.83ab	6.23ab	6.88abcd	8.3a	9.3a	0.52
9 lb N Drill Hole	3.1	4.85ab	6.23ab	7.90a	8.6a	9.3a	0.52
3 lb N Surface	2.8	4.50bc	5.40abc	6.78bcd	7.9a	8.8a	0.49
6 lb N Surface	3.3	5.13a	6.39a	7.7ab	8.5a	9.5a	0.53
9 lb N Surface	3.1	4.85ab	6.17ab	7.43abc	8.6a	9.5a	0.53

[1]Each figure represents the average of 12 trees measured 1 foot from the soil line.
[2]Letters followed by dissimilar letters within columns are significantly different at the 5 percent level.

Table 3. Average Caliper Growth in Inches of Sentry Maple After 3, 6, 9, 12, 15 and 18 Years of Nitrogen Fertilizer Treatment.

	Years						
Treatment	3	6	9	12	15	18	Ave./Yr.
Control, No holes, No N	2.5[1]	3.38e[2]	4.7lbc	5.87c	7.9a	9.4a	0.52
Holes Only plus Calcined Clay	2.8	3.50de	4.56c	5.90c	8.1a	9.1a	0.51
3 lb N Drill Hole	2.9	4.00bc	5.45abc	7.15ab	8.9a	10.1a	0.56
6 lb N Drill Hole	3.2	4.50a	6.11a	7.64a	9.8a	10.8a	0.60
9 lb N Drill Hole	2.9	3.95bcd	5.50ab	6.99abc	8.7a	9.6a	0.53
3 lb N Surface	2.8	3.53de	4.93bcc	6.23bc	8.7a	9.9a	0.55
6 lb N Surface	2.9	3.88bc	5.36abc	6.88abc	8.4a	9.5a	0.53
9 lb N Surface	3.1	4.35bc	5.98a	7.50a	9.2a	9.9a	0.55

[1]Each figure represents the average of 12 trees measured 1 foot from the soil line.
[2]Letters followed by dissimilar letters within columns are significantly different at the 5 percent level.

Table 4. Tree Height and Diameter of Branch Spread of Three Species Following 18 Years of Nitrogen Fertilizer Treatment.

Treatment	Littleleaf Linden		Snowdrift Crabapple		Sentry Sugar Maple	
	Height	Branch Dia.	Height	Branch Dia.	Height	Branch Dia.
Control, No holes, No N	32.5[1]a	19.3[2]b	19.2[1]a	18.8[1]a	41.4[1]a	20.5[1]a
Holes Only plus Calcined Clay	35.5a	22.0ab	19.7a	19.7a	38.7a	18.3a
3 lb N Drill Hole	34.6a	21.5a	19.3a	18.7a	40.1a	19.6a
6 lb N Drill Hole	36.4a	21.9a	18.3a	19.9a	39.1a	21.0a
9 lb N Drill Hole	34.6a	21.7a	20.0a	20.7a	37.7a	20.2a
3 lb N Surface	36.9a	22.7a	19.1a	19.9a	38.4a	20.9a
6 lb N Surface	34.7a	21.4ab	18.8a	20.6a	36.4a	20.6a
9 lb N Surface	36.0a	23.2a	18.1a	20.2a	36.7a	20.5a

[1]Feet
[2]Letters followed by dissimilar letters within columns are significantly different at the 5 percent level.

Literature Cited

1. Bettes, Russell, M. 1972. Feeding shade and ornamental trees. Amer. Nur. Oct. 1, pp. 14,100-102.
2. Himelick, E. B. and Dan Neely. 1966. Tree Fertilization. Amer. Nur. 154(21):11.
3. Janne, Everett E. 1971. Under the spreading shade tree. Texas Agri. Prog. 17(1):21-23.
4. Koelling, Melvin R. and J. James Kielbaso. 1974. Fertilizing shade and ornamental trees. Mich. St. Univ. Coop. Ext. Serv., Bull. E-786.
5. Smith, Elton M. and Kenneth W. Reisch. 1974. Fertilizing trees in the landscape—progress report. Ohio Agri. Res. and Dev. Ctr., Res. Sum. 79, pp. 61-62.
6. Smith, Elton M. 1974. A study of the economics of fertilizing trees in the nursery. Ohio Agri. Res. and Dev. Ctr., Res. Sum. 79, pp. 59-60.
7. Smith, Elton M. 1973. Effects of fertilizer placement on tree growth. Ohio Agri. Res. and Dev. Ctr., Res. Sum. 71,pp. 39-40.
8. Smith, Elton M. 1974. Fertilization reduces trunk splitting of Tilia cordata. Ohio Coop. Ext. Serv., Nursery Notes 7(6):1.
9. Smith, Elton M. 1978. Fertilizing trees in the landscape. A 6-year evaluation. Ohio Agri. Res. and Dev. Ctr., Res. Circ. 236, Ornamental Plants-1978: A Summary of Research, pp. 38-40.
10. Smith, Elton M. 1982. Fertilizing trees in the landscape: A 9-year evaluation. Ohio Agri. Res. and Dev. Ctr., Res. Circ. 263, Ornamental Plants-1981: A Summary of Research, pp. 11-13.
11. Smith, Elton M. and Sharon A. Treaster. 1984. Fertilizing trees in the landscape. A 12-year evaluation. Ohio Agr. Res. and Dev. Ctr. Circ. 279, Ornamental Plants-1984: A Summary of Research, pp. 1-4.
12. Smith, Elton M. and Sharon A. Treaster. 1987. Fertilizing trees in the landscape. A 15 year evaluation. Res. Circ. 291, Ornamental Plants-1987: A Summary of Research, pp. 8-10.

The Influence of Irrigation Water Temperature Upon Leaf Abscision in *Ficus benjamina* and *Dracaena marginata*

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Introduction

Plants are comprised of two distinctly different interactive components, the shoots and the roots. Both components are affected by environmental factors, such as temperature, light quality and quantity, and available moisture and nutrients (16, 19,20). Environmental conditions which exist in the regions surrounding each of these two components may not be similar. Temperatures associated with the root-zone may not be indicative of the aerial temperatures and vice versa (10). Thus, it is useful to characterize and understand the plant-environmental interactions in both plant regions and the stresses associated with changes in these microclimates.

Biologically, a system under stress often has the capability to undergo adjustments to minimize the impact of that stress (9,16). The adjustments of plants to the stress of interior environments is evident with many tropical foliage plants. Tropical plants can acclimate low-light levels, and warmer or cooler than optimal temperatures, by exposure to a gradual change of these conditions (4,11). Many tropical plants will undergo morphological and/or physiological changes, as a means of adapting to or compensating for stressful conditions of an interior environment (4,13).

Temperature is a primary environmental factor that determines whether a plant can survive in a given environment (20). A plant generally responds to temperature in two different ways due to the extensive and intensive influences of temperature. An extensive response to temperature would include the energy status associated with thermal processes, such as vaporization of water which had been absorbed by a plant's roots and transferred from plant surfaces to the surrounding air (12). An intensive response involves many chemical and physiological processes that govern plant life processes (12). In general, adverse temperatures associated with the root-zone may effect the biological processes of plants and ultimately decrease plant growth and longevity.

In tropical regions of the world root-zone temperatures generally undergo minimal variations (15). However, in interior environments there may be significant fluctuations in root-zone temperatures. Application of tap water may expose the root systems to lower or higher than optimal temperatures. Exposure to less than optimal root-zone temperatures may affect absorption, translocation, and the use of nutrients by the plant, ultimately inhibiting physiological processes and plant growth (3,7,8,19,21). Under greenhouse conditions application of irrigation water having a temperature of 5°C was found to have no effect on the growth of three tropical foliage plants: *Epipremnum*, *Dieffenbachia*, and *Nephrolepis* (14). It is apparent that root-zone temperature influences that plant's ability to absorb water and nutrients which in turn may influence physiological processes and plant growth. Since interior plants may be exposed to a wide range of root-zone temperatures, resulting from the application of tap water, it is important to gain some perspective about the quality and longevity of tropical foliage plants.

The objectives of this research were to characterize the influence of irrigation water upon plant growth, quality and longevity uptake.

Materials and Methods

Experiment 1 was conducted under interior conditions. A 12-hour photoperiod of 25.8 $\mu Es^{-1}m^{-2}$ (200 ft-c), supplied by cool white fluorescent lamps was used. Air temperature was maintained at 23±2°C and relative humidity at 30±20 percent. Plants included in this study were *Ficus benjamina* L. and *Dracaena marginata* L.. Plants were watered weekly. One liter of water containing 50 mg N $liter^{-1}$ (Peters Tropical Foliage Special 24 N-18.3 P-19.2 K) was supplied at each irrigation. Application of this volume brought medium moisture level to container capacity and allowed for approximately 30 ml at leaching. Leachate was removed after each irrigation. Irrigation water temperatures of 2°, 10°, 20° and 30°C were established using warm and cold tap water and, if necessary, the addition of crushed ice.

Plant material arrived April 10, 1987, from Southern Florida and was maintained for seven weeks in a polyhouse under 60 percent light excluding saran screen. Each plant species was established in a 25.4 cm nursery container. The growing medium was primarily comprised of 2 peat moss:1 coarse sand for each species. Medium was tested using the Saturated Paste Method (1) for soluble salts two weeks prior to installation in the interior environment, and leached if conduction values exceeded 3.50 mmhos cm^{-1}. Plants were double potted into a 36 cm decorative container with a 5 cm layer of styrofoam as the insulating material between the nursery pot and the decorative container. Protoast (a decorative hardwood mulch) was used to cover the soil surface at a thickness of 2.54 cm.

Each species was treated as a separate experiment, occupying a specific region within the interior testing facility. Sixteen plants per species (four plants per irrigation water temperature) were completely randomized in each region. The overall quality of the plant (1=poor, unacceptable aesthetic value; 2=fair, marginally acceptable aesthetic value; 3=good, acceptable aesthetic value; 4=very good, very acceptable aesthetic value; 5=excellent, highly acceptable aesthetic value) (2) and foliage quality (percent foliar necrosis, 1=0 percent, 2=less than 20 percent, 3=21-49 percent, 4=50-100 percent) was visually evaluated on days 0, 60, 132, and 180. Five plants of each species were harvested at the onset of the experiment (day 0) and all remaining plants (16 of each species) were harvested on day 180. Leaf area was recorded using a LiCOr Model LI-3000 Portable Leaf Area Meter. Fresh weights of shoots were recorded using a Sartorius Balance Type 1507 (Sartorius Filters, Inc., Hayward, CA). Plant material was oven dried at 65°C for five to nine days then dry weights recorded. A weekly collection and count of abscised leaves was performed for each plant. The number of leaves abscised and dry weights were recorded. Square root transformation of quality and foliar necrosis data was conducted before data was analyzed (5). Analysis of variance and multiple regression procedures were used to analyze the effects of irrigation water temperature on the seven different plant species studied (17).

Results and Discussion

The data, while not being statistically significant indicates a trend in total leaf abscision. Plants irrigated with the cooler water tended to abscise a greater number of leaves relative to those irrigated with the warmer temperatures (Table 1). This increase in number of leaves abscised when irrigated with cold water may be the result of changes in the root system: cell wall permeability, hormonal transport, and nutrient uptake (6,18).

Irrigation water temperature had a marked effect on leaf abscision in *F. benjamina* at week one (Figure 1). Only the lowest irrigation water temperature increased leaf abscision. This could indicate a problem with initial acclimation of the plant. Analysis of data for *D. marginata* did not show similar results.

The data also indicated that the pattern of leaf abscision was cyclic. It appears that every other week there was a marked increase in the number of leaves abscised when compared to the previous week. Plants irrigated with these water temperatures exhibited a peak number of abscised leaves at different times during the course of the experiment (Figure 2). These phenomena have not been explained, however, they may indicate that there is a lag period between the time water was applied and the time symptoms were observed.

This study has established the ground work for continued avenues of research concerning the effect of irrigation water temperature on plant growth and maintenance in an interior environment. Future studies should focus on the effect of root-zone temperatures on transport of water, nutrients and hormones from the root system to the whole plant system.

Table 1. The Effect of Irrigation Water Temperature on Total Number of Leaves Abscised by *Ficus benjamina* and *Dracaena marginata*.

	Number of leaves abscised			
	Irrigation Water Temperature (C)			
Plant Species	2	10	20	30
F. benjamina	404[1]	282[1]	305[1]	320[1]
D. marginata	132[1]	134[1]	96[1]	67[1]

[1] Mean comparison within rows by Scheffe's multiple-comparison procedure, 5% level. Means not significantly different.

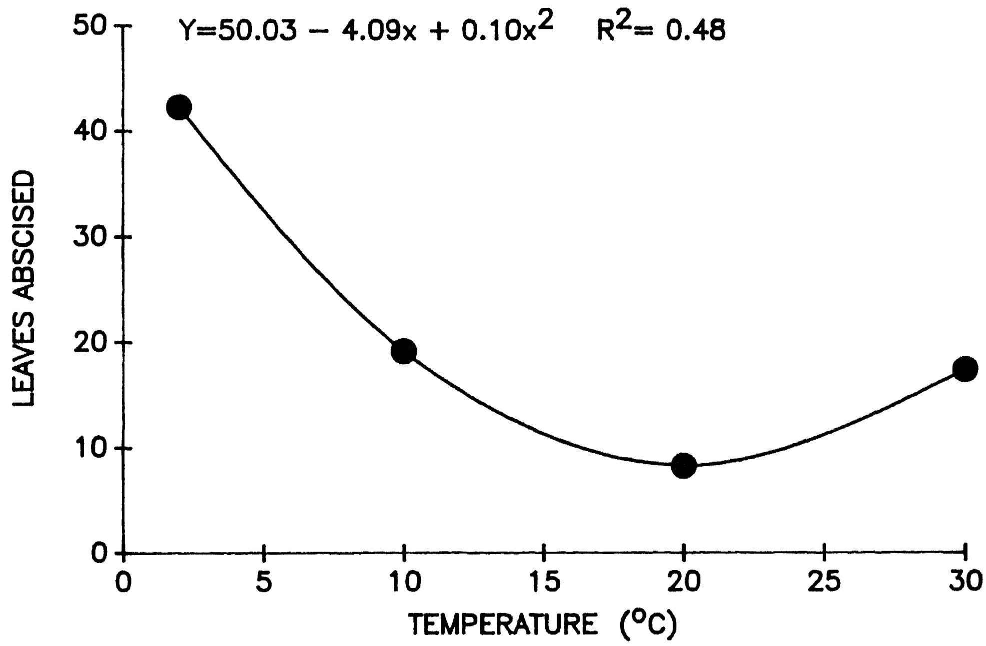

Figure 1. The effect of irrigation water temperature on leaf abscision in *Ficus benjamina* grown in 25 cm containers in a simulated interior environment.

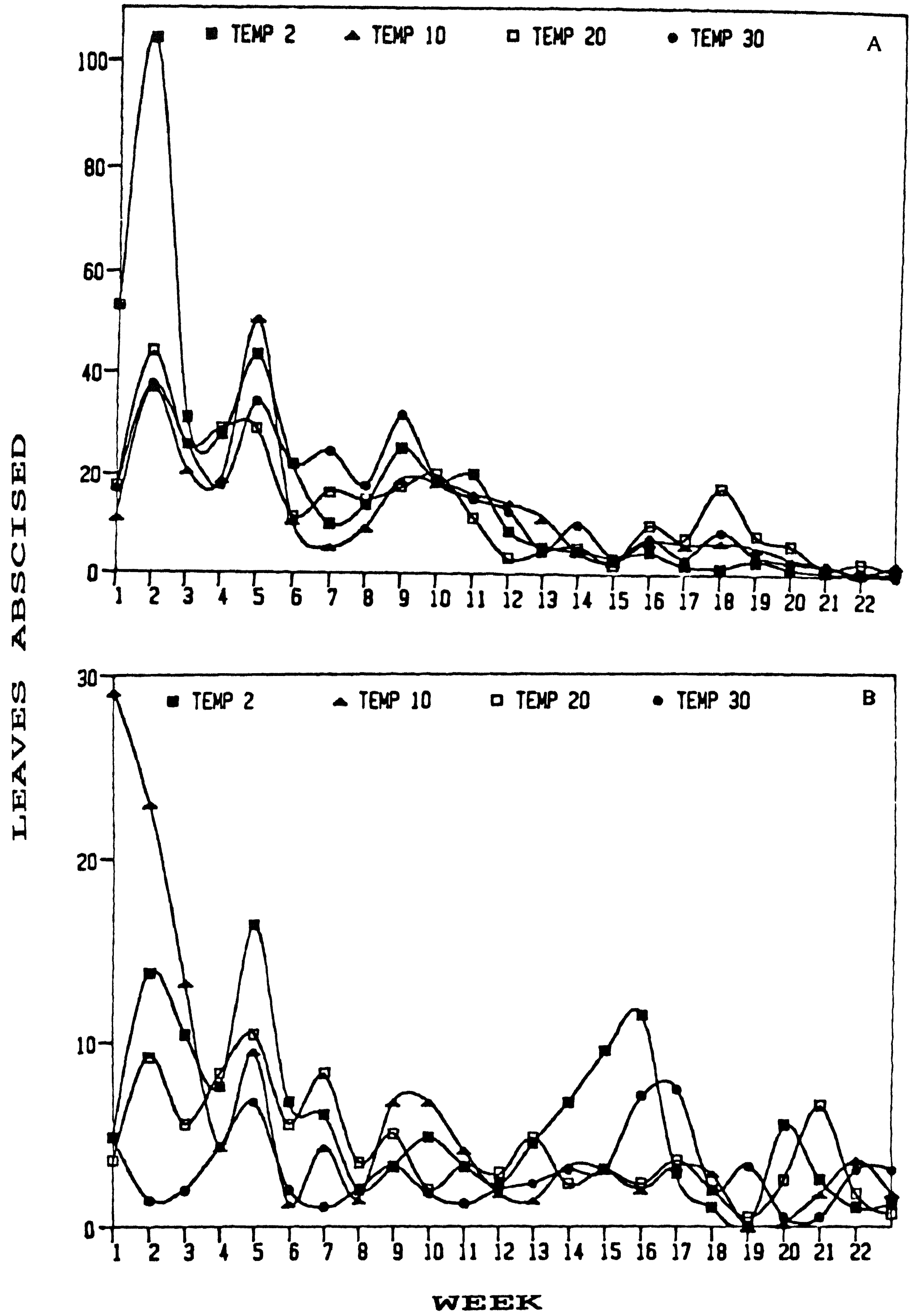

Figure 2. The average number of leaves abscised per week as influenced by irrigation water temperature for *Ficus benjamina* (A) and *Dracaena marginata* (B).

Literature Cited

1. Bunk, A.C. 1976. *Modern Potting Compositions*. The Pennsylvania State University Press, University Park, PA.
2. Conover, C.A. and R.T. Poole. 1977. Effects of cultural practices on Acclimation of *Ficus benjamina* L. J. Amer. Soc. Hort. Sci. 102(5):529-531.
3. Cumbus, I.P. and P.H. Nye. 1982. Root zone temperature effects on growth and nitrate absorption in rape (*Brassica napus* cv. Emerald). J. Exp. Bot. 33(137):1138-1146.
4. Fonteno, W.C. and E.L. McWilliams. 1978. Light compensation points and acclimatization of four tropical foliage plants. J. Amer. Soc. Hort. Sci. 103(1):52-56.
5. Gomez, K.A. and A.A. Gomez. 1984. Statistical Procedures for Agricultural Research. John Wiley and Sons, New York, NY.
6. Gosselin, A. and M.J. Trudel. 1984. Interactions between root-zone temperature and light levels on growth, development and photosynthesis of *Lycopersicon esculentum* Mill. cv 'Vendor'. Scientia Horticulturae 23:313-321.
7. Gosselin, A. and M.J. Trudel. 1986. Root-zone temperature effects on pepper. J. Amer. Soc. Hort. Sci. 111(2):220-224.
8. Ibrahim, S.A., M.Y. Tayel and A. Shehata. 1981. Irrigation water temperature: II. Its effect on macronutrient uptake. Egypt. J. Soi. Sci. 21(1):53-60.
9. Kramer, Paul J. 1983. *Water Relations of Plants*. Academic Press, NY.
10. Leopold, C.A., and P.E. Kriedeman. 1975. *Plant Growth and Development*. McGraw-Hill Book Company, New York, NY.
11. Manaker, George H. 1981. *Interior Plantscaping: Installation, Maintenance and Management*. Prentice-Hall, Inc., Englewood, Cliffs, NJ.
12. Namken, L.N., L. Wiegand, and W.O. Willis. 1974. Soil and air-temperatures as limitations to more efficient water use. Agricultural Meteorology 14:169-181.
13. Peterson, J.C., D.J. Durkin, and J.N. Sacalis. Effects of light level upon leaf area, anatomy and stomatal frequency of *Ficus benjamina* L. 1980: A summary research. The Ohio State University, Agricultural Research and Development Center, Wooster, Ohio.
14. Poole, R.T., and C.A. Conover. 1981. Growth Response of foliage plants to night and water temperatures. Hort Science 16(1):81-82.
15. Russel, S.R. 1977. *Plant Root Systems: Their Function and Interactions with the Soil*. McGraw Hill Book Company Limited. New York, NY.
16. Salisbury, F.B. and C. W. Ross. 1985. *Plant Physiology*. 3rd Edition. Wadsworth Publishing Company, Belmont, CA.
17. *SAS series in Statistical Applications*. 1982 and 1985. SAS Institutes, Inc., Cry, NC.
18. Tayel, M.Y., S.A. Ibrahim and A. Shehata. 1980. Irrigation water temperature: I. Its effect on plant growth and water use efficiency. Egypt. J. Soil Sci. 20(1):75-82.
19. Thomas, M.D. 1965. Photosynthesis (carbon assimilation): Environmental and metabolic relationships. In: F.C. Steward (ed), *Plant Physiology, Vol IVA. Metabolism: Organic Nutrition and Nitrogen Metabolism*. Academic Press, New York, NY, pp, 9-13.
20. Went, F.W. and L. O. Sheps. 1969. Environmental factors in regulation of growth and development: Ecological factors. In: F.C. Steward (Ed.), *Plant Physiology, Vol VA. Analysis of Growth: Behavior of Plants and Their Organs*. Academic Press, New York, NY, pp. 315-332.
21. White, J.W. and J.A. Biernbaum. 1984. Effects of Root-zone heating on elemental composition of calceolaria. J. Amer. Soc. Hort. Sci. 109(3):350-355.

A Two-Year Tolerance Study of Narcissus Cultivars to Selected Pre-emergence Herbicides

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Abstract

Very few pre-emergent herbicides are labelled for use with Narcissus. The objectives of this study were to evaluate Narcissus cultivar tolerance to Devrinol (napropamide) and Surflan (oryzalin) over a two-year period and Endurance (prodiamine) and Snapshot (oryzalin and isoxaben) for one year. *Narcissus* cultivars 'February Gold', 'Golden Perfection', 'Barrett Browning' and 'Geranium' were uninjured by Devrinol at 5.0 lb aia, Surflan at 3.0 lbs aia, Endurance at 2.0 lbs aia and Snapshot at 1.0 lb aia.

Weed control from an October 19, 1987 treatment was effective for eight months in Devrinol and Surflan plots and for seven months with Endurance whereas treatment on November 29, 1988 was effective for approximately seven months with the same two materials. Snapshot was effective for more than seven months in the 1988-89 study. These four herbicides effectively control weeds without phytotoxicity for an extended time period.

Introduction

Research in 1984 (2) had shown the pre-emergence herbicides Devrinol and Surflan to be non-phytotoxic to narcissus. Since that date Devrinol, Betasan and Chloro IPC have been labelled for use with narcissus. However, Chloro IPC was removed from the market, so only two herbicides are currently registered for narcissus.

The specific objectives of this study were to compare weed control and phytotoxicity on Narcissus from Devrinol with Surflan, commonly used in the landscape maintenance trade on woody and herbaceous plants. New herbicides Endurance and Snapshot were also incorporated into the trials.

Materials and Methods

Narcissus cultivars selected for this evaluation included: 'February Gold' [Division 6 with yellow petals and yellow cup], 'Golden Perfection' [Division 7 with yellow petals and yellow cup], 'Barrett Browning' [Division 3 with white petals and white, red, red cup] and 'Geranium' [Division 8 with white petals and orange cup].

By selecting cultivars that had different characteristics, it was believed that more knowledge might be gained if there were cultivar differences in tolerance to the herbicides. All bulbs were planted October 12, 1987 at a depth of 6 inches.

Herbicides used in the 1987-88 study included: napropamide (Devrinol), oryzalin (Surflan) and prodiamine (Endurance), a new unregistered herbicide. Formulations and rates were: Devrinol 50 WP—5.0 lbs aia, Surflan 75 WP—3.0 lbs aia, Endurance 2G—2.0 lbs aia and a control (no herbicide) treatment. Herbicides were applied to the soil October 19, 1987, seven days following planting. Beds were mulched with 1½-2″ of utility wood chips in early November.

Herbicides in the 1988-89 study included both Devrinol and Surflan as above at the same rates. Endurance was withheld from further trial work for 1988-89, so another unlabelled new product, Snapshot 80 percent DF (1.0) was substituted for Endurance. Snapshot is a combination product of oryzalin (20 percent) and isoxaben (60 percent).

Each treatment was applied in an area 6′ wide and 5′ long, with a minimum of 10 bulbs per cultivar in each treatment. Plots were arranged in a randomized block design.

All evaluations for phytotoxicity were on a 1 to 10 visual scale, with 1=plant death, 10=no crop injury and 7 or above being acceptable. Weed control was rated on a 1 to 10 scale with 1=no weed control, 10=excellent weed control and 7 or above acceptable.

Phytotoxicity evaluations were conducted in April, when the plants were in bloom. Weed control was evaluated in May and June.

Results and Discussion

In 1987-88 study, neither flowers nor foliage of Narcissus cultivars 'February Gold', 'Golden Perfection', 'Barrett Browning' and 'Geranium' were injured by the pre-emergence herbicides (Table 1). Devrinol had been previously labelled for use with narcissus and within the year the Surflan label was expanded to include narcissus. Endurance, a new herbicide, may be safe to use on narcissus based on results of this study but is no longer in the research program by the manufacturer.

The narcissus planting was mulched in November with utility wood chips and weed growth was suppressed through the April flowering period. Weeds began to become a problem in May, and by mid-June the control plots were heavily infested (Table 3). Weed control from Endurance was still acceptable in May, but superior weed control was noted with Devrinol and Surflan.

Results of the 1988-89 evaluation the results were very similar to the previous year. There was no phytotoxicity to the foliage or blooms from Snapshot (1.0 lb aia), Devrinol (5.0 lbs aia) or Surflan (3.0 lbs aia) (Table 2) throughout the evaluation period. Weed control during 1988-89 was excellent with Snapshot throughout the month of June by which time the narcissus foliage had turned almost completely brown. Surflan was an acceptable treatment through June 24. Devrinol was an acceptable treatment through June 2 but was below acceptable levels on June 24 (Table 4).

Weeds controlled both years included yellow sweetclover, wild lettuce, oxalis and wild sweet potato which can be difficult to suppress with pre-emergence herbicides.

In summary, Devrinol at 5.0 lbs aia and Surflan at 3.0 lbs aia can be recommended for use on narcissus with confidence that weed control will be acceptable and phytotoxicity will be minimum. Endurance may no longer be available for research purposes while Snapshot could be an excellent herbicide for use with narcissus if and when it receives registration for this species.

Table 1. Tolerance of Narcissus Cultivars to Pre-emergence Herbicides Applied October 19, 1987. Evaluations April 8, 16, and 25, 1988.

		Phytotoxicity[1]											
Treatment	Rate lbs aia	'February Gold'			'Golden Perfection'			'Barrett Browning'			'Geranium'		
		4/8	4/16	4/25	4/8	4/16	4/25	4/8	4/16	4/25	4/8	4/16	4/25
Control	—	10	10	10	—	10	10	10	10	10	—	10	10
Endurance 2G	2.0	10	10	10	—	10	10	10	10	10	—	9.8	10
Devrinol 50 WP	5.0	10	10	10	—	9.0	10	10	10	10	—	10	10
Surflan 75 WP	3.0	10	10	10	—	9.3	10	10	10	10	—	10	10

[1]Visual Scale of 1-10 with 1=plant death, 7=acceptable injury, 10=no plant injury.

Table 2. Tolerance of Narcissus Cultivars to Pre-emergence Herbicides Applied November 29, 1988. Evaluations April 3, 10, 17, 24, 1989.

Treatment	Rate	Phytotoxicity															
		'February Gold'				'Golden Perfection'				'Barrett Browning'				'Geranium'			
	lbs. aia	4/3	4/10	4/17	4/24	4/3	4/10	4/17	4/24	4/3	4/10	4/17	4/24	4/3	4/10	4/17	4/24
Control	—	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Snapshot DF	1.0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Devrinol 50 W	5.0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Surflan 75 WP	3.0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

[1]Visual Scale 1-10 with 1=plant death, 7= acceptable injury, 10=no injury.

Table 3. Spring Weed Control in Narcissus from Autumn Applied Pre-emergence Herbicides. Herbicides Applied October 19, 1987.

Treatment	Rate lbs. aia	Weed Control[1] May 20, 1988	June 16, 1988
Control	—	7.8	5.5
Endurance 2 G	2.0	9.0	7.3
Devrinol 50 W	5.0	9.3	8.3
Surflan 75 WP	3.0	9.3	8.3

[1]Visual Scale of 1-10 with 1=no weed control, 7=acceptable weed control and 10=perfect weed control.

Table 4. Spring Weed Control in Narcissus from Herbicides Applied November 29, 1988.

Treatment	Lbs. aia	May 2, 1989	Weed Control[1] June 2, 1989	June 24, 1989
Control	—	6.0	5.0	3.0
Snapshot DF	1.0	9.7	9.7	8.0
Devrinol 50 W	5.0	8.0	7.0	5.7
Surflan 75 WP	3.0	8.7	8.0	7.0

[1]Visual Scale of 1-10 with 1=no weed control, 7=acceptable weed control and 10=perfect weed control.

Literature Cited

1. Smith, Elton M. and Sharon A. Treaster. 1982. An evaluation of pre-emergence herbicides on tulip and narcissus. Ohio Agr. Res. and Dev. Ctr. Res. Circ. 268, Ornamental Plants—1982: A Sum. of Res. pp. 20-21.
2. Smith, Elton M. and Sharon A. Treaster. 1984. Tolerance of Tulip, Daffodil, and Crocus to selected pre-emergence herbicides. Ohio Agr. Res. and Dev. Ctr. Res. Circ. 268, Ornamental Plants 1984: A Sum. of Res. pp. 14-15.
3. Smith, Elton M. and Sharon A. Treaster. 1989. Chemical Weed Control in Commercial and Nursery and Landscape Plantings. Ohio Coop. Ext. Serv. Bull. MM-297.
4. Smith, Elton M. and Sharon A. Treaster. 1989. Tolerance of Narcissus cultivars to selected pre-emergence herbicides. Special Circular 123, OSU and OARDC. Ornamental Plants: A Sum. of Res.—1989 pp. 1-2.

Tolerance of Clematis and Wisteria to Ronstar and Devrinol

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Abstract

The objectives of this study were to determine the phytotoxicity and weed control of Ronstar (oxadizon) and Devrinol (napropamide) on clematis and wisteria.

Ronstar at 4.0 lbs. aia was relatively nonphytotoxic to clematis and competely nonphytotoxic to wisteria. Ronstar at 8.0 lbs. aia was phytotoxic to the point of being commercially unacceptable on clematis at the two-week evaluation period, however, the plants all survived and recovered to the point of complete saleability after eight weeks. The 8.0 lbs. aia rate of Ronstar was non-injurious to wisteria.

Devrinol W and G at 4.0 and 8.0 lbs. aia was relatively nonphytotoxic to clematis and completely nonphytotoxic to wisteria.

Through 10 weeks all three herbicides were highly effective, yielding better than acceptable weed control.

Introduction

At the present time, there are no pre-emergence herbicides registered by the U.S. E.P.A. for use on woody landscape vines including clematis and wisteria. Previous research by the authors has indicated that while some herbicides are highly phytotoxic to vines (1), Ronstar is only slightly phytotoxic to clematis and wisteria early in the growing season while Devrinol is nontoxic to both species of vines (2).

The specific objective of this study was to ascertain the phytotoxicity and weed control of Ronstar and Devrinol on clematis and wisteria. With sufficient research data available, it is anticipated that registration of herbicides will soon be available for woody vines.

Materials and Methods

The vines included in this study were *Clematis* 'Ernest Markham'—Ernest Markham Clematis and *Wisteria sinensis*—Chinese Wisteria.

Pre-emergence herbicides evaluated were Ronstar (oxadiazon) granular and Devrinol (napropamide) wettable power and granular all at 4.0 and 8.0 lbs. aia.

The clematis were planted into 2 gal and wisteria into 3 gal containers filled with a medium of pinebark-peat-sand (6-3-1) by volume. Plants were fertilized with Osmocote (8-6-12) at recommended rates for the container size utilized. All plants were irrigated as needed with overhead sprinklers. Herbicides were applied April 27, 1989 and plants irrigated the same day.

There were three plants per treatment with four replications placed in a randomized block design. Phytotoxicity evaluations were on a 1 to 10 scale with 1 equal to death, 7 as acceptable and 10 equal to no phytotoxicity. Plants were evaluated May 11 (2 weeks), May 25 (4 weeks), June 10 (6 weeks), June 27 (8 weeks), and July 6 (10 weeks) from treatment date.

Results and Discussion

Phytotoxicity

Ronstar G at 4.0 lbs. aia was only slightly phytotoxic to clematis throughout the 10 week evaluation period (Table 1).

Table 1. Phytotoxicity of Devrinol and Ronstar on Clematis and Wisteria.

		Phytotoxicity					
Weeks From	Check	Ronstar G		Devrinol WP		Devrinol G	
Treatment	—	4.0#	8.0#	4.0#	8.0#	4.0#	8.0#
		Ernest Markham Clematis					
2	10[1]	10	6.0	10	10	10	10
4	10	9.8	8.0	10	10	10	9.5
6	10	10	8.8	9.5	8.3	9.8	9.3
8	10	9.8	9.5	9.5	9.0	9.8	9.0
10	10	9.5	9.8	9.8	9.5	9.8	9.0
		Chinese Wisteria					
2	10	10	10	10	10	10	10
4	10	10	10	10	10	10	10
6	10	10	10	10	10	10	10
8	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10

[1] Visual Scale 1-10 with 1=complete death, 7=acceptable injury and 10=no injury.

Table 2. Weed control with Devrinol and Ronstar in Clematis and Wisteria.

Time From Treatment	Weed Control						
	Ronstar		Devrinol WP		Devrinol G		
	4.0#	8.0#	4.0#	8.0#	4.0#	8.0#	Check
4 weeks	10[1]	10	10	10	10	10	10
6 weeks	9.8	10	10	10	9.5	9.5	9.3
8 weeks	9.8	9.8	10	10	9.5	9.5	9.0
10 weeks	9.5	9.5	9.5	9.5	8.5	8.0	7.3

[1]Visual Scale 1-10 with 1=no weed control, 7=acceptable weed control, and 10=perfect weed control.

At the 8.0 lbs. aia rate considerable plant injury was noted two weeks following application. This injury was considered below commercial standards, thus, this rate could not be recommended to users even though plants eventually recovered and bloomed.

Ronstar at 4.0 and 8.0 lbs. aia was completely nonphytotoxic to wisteria.

Devrinol WP and G were only slightly phytotoxic to clematis at both 4.0 and 8.0 lbs. aia suggesting a greater tolerance than Ronstar especially at the 8.0 lbs. aia rate.

Wisteria was not injured by Devrinol WP or G at either rate.

Weed control through eight weeks was excellent with all herbicides at the two rates evaluated. In the 10th week, weed control had begun to decline slightly even though very acceptable control was observed.

In summary, based on this study and previous work by the authors Ronstar G at 4.0 lbs. aia could be considered safe to use on clematis and wisteria. Devrinol at 4.0 and 8.0 lbs. aia could also be used on both clematis and wisteria. Hopefully, the U.S. E.P.A. will soon label a pre-emergence herbicide for woody vines, notably clematis and wisteria.

Literature Cited

1. Smith, Elton M. and Sharon A. Treaster. 1980. Tolerance of woody landscape vines to Goal combinations. Ohio Agri. Res. and Dev. Ctr. Res. Circ. 289, Ornamental Plants-1986: A Summary of Research, pp. 9-11.
2. Smith, Elton M. and Sharon A. Treaster. 1987. Tolerance of landscape vines to selected pre-emergence herbicides. Ohio Agri. Res. and Dev. Ctr. Res. Circ. 291, Ornamental Plants-1987: A Summary of Research, pp. 17-18.

Increasing Efficiency of Slow-Release Herbicide Tablets

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Abstract

A series of greenhouse studies were conducted to study the release of relatively insoluble herbicides from slow-release herbicide tablets. The most effective of nine surfactants was Triton X-100 at 1 percent. Highly soluble Dual at 530 ppm was selected to combine with nearly insoluble Goal at 0.1 ppm from 9 herbicide or herbicide combinations. These tablets containing Triton X-100, Dual at 0.5 lb. aia and Goal at 0.5 lb. aia were then applied to 10 container grown landscape species and cultivars. There was no indication of phytotoxicity on eight of 10 plant selections for eight weeks. Weed control was acceptable for 2 tablets/container for eight weeks, 3 and 4 tablets for eight-plus weeks.

Introduction

The use of slow-release herbicide tablets have several advantages in the production of container grown nursery stock. Advantages include greater accuracy of herbicide application, greater safety to humans and plants, and reduction of possible environmental pollution. To be commercially acceptable, however, the tablets must also provide long-lasting, wide-spectrum weed control without phytotoxicity to landscape species.

Tablets have been formulated with water soluble herbicides such as alachlor and metolachlor and although they are effective, they do not control a broad range of weed species (2,3,4,5,6,7,8). Most preemergence herbicides currently in nursery use have a low water solubility and have not been successfully utilized in slow release technology.

In recent work by Horowitz et al (1), the area of weed control surrounding a slow-release herbicide tablet was markedly increased by adding a surfactant to the tablet. As a follow-up to this work the authors conducted studies to: screen a number of surfactants, screen various herbicides and herbicide combinations, and field test the final product for weed control and phytotoxicity in container nursery stock grown under commercial conditions.

Materials and Methods

Slow-release herbicide tablets were produced by dry compression of dicalcium phosphate (as a filler), magnesium stearate (as a binder) and commercial formulations of herbicides and surfactants. The tablet making process involved the use of a Stokes single-punch tablet machine. Finished tablets measured 12 mm in diameter and weighed on the average 1.25 g/tablet.

Experiments were conducted in one gallon containers (18 centimeter top diameter) filled with Metro Mix 350 a peat, bark, vermiculite medium. Containers were seeded with Seaside Bentgrass (Agrostis stolonifera 'Seaside'). After seeding a tablet was placed on the soil surface in the center of the pot or equidistance apart if more than one tablet was applied.

A series of four experiments were conducted to evaluate surfactants and herbicides in greenhouse trials prior to the final tablet formulation under outdoor conditions on 10 species and cultivars of landscape plants.

Study No. 1—Preliminary Surfactant Evaluation

Nine surfactants were evaluated as ingredients in the tablets to ascertain their effect on the release of Goal 1.6E (oxyfluorfen). Surfactants included Buffer X, Dash, Regulaid, Triton AG 98, Triton B 1956, Triton X-100, Tween 20, Tween 80, X-77 along with Goal only and check (no surfactant and no herbicide). Each surfactant was incorporated at a rate of 1.0 percent and 2.5 percent by volume of product formulation. Goal was incorporated into all but the control tablets at 0.5 lb. aia of product formulation. All trials were conducted in the greenhouse using 1 gal. containers with 1 tablet/container. Containers were seeded and treated Feb. 17 and evaluated March 6, 1989.

Study No. 2—Final Surfactant Evaluation

The most effective results in study No. 1 were achieved with Goal plus Triton X-100, Tween 80, and X-77 and these were again compared at 1.0 percent and 2.5 percent along with Goal only at .5 aia and control tablets. Trials were conducted with one-gallon seeded containers with either 1, 2 or 3 tablets/container in the greenhouse. Containers were seeded and treated March 11 and evaluated March 27, 1989.

Study No. 3—Preliminary Herbicide Evaluation

Five pre-emergence herbicides and four herbicide combinations were compared to control (no herbicide, no surfactant) tablets. The rates for each product were 1.0 lb. aia and 0.5+ 0.5 lb. aia in the combination treatments. Triton X-100 was incorporated into all but the control tablets at 1.0 percent. Herbicide treatments included Dual (metolachlor), Gallery (isoxaben), Goal (oxyfluorfen), Ronstar (oxadiazon) and Surflan (oryzalin). The combination treatments were Dual plus Gallery, Dual plus Goal, Dual plus Ronstar and Dual plus Surflan. All containers were seeded with bentgrass and treated April 3 and evaluated April 17, 1989.

Study No. 4—Final Herbicide Evaluation

The least effective herbicide in study No. 3 was Gallery alone and in combinations with Dual and was dropped from further evaluation. Otherwise all herbicides used in study No. 3 were repeated, with some adjustment in rates. Each herbicide treatment was further evaluated with either 1, 2 or 3 tablets/container spaced equidistance apart. The surfactant added was again Triton X-100. Containers were seeded and treated April 24, and evaluated May 10, 1989.

Study No. 5—Nursery Evaluation

Tablets were prepared with Triton X-100 at 1.0 percent and the combination of Goal at 0.5 lb. aia and Dual at 2.0 aia lb. aia. The plant species and cultivars evaluated for phytotoxicity and weed control included:

Chamaecyparis pisifera 'Boulevard'
Cotoneaster dammeri 'Royal Beauty'
Euonymus fortunei 'Emerald Cushion'
Euonymus fortunei 'Emerald 'N Gold'
Forsythia intermedia 'Spring Glory'
Pachysandra terminalis
Rhododendron 'PJM'
Rhododendron 'Hino Pink'
Spiraea 'Gold Flame'
Spiraea nipponica 'Snowmound'

Plants were maintained as under commercial nursery conditions. The medium consisted of pine bark-peat-sand, 6-3-1 by volume. Plants were potted in 2 gal. containers placed outdoors and treated on June 14 and evaluated June 29, July 13, July 27 and Aug. 10, 1989. Each container was treated with either 2, 3 or 4 tablets. Phytotoxicity was evaluated using a visual scale of 1 to 10 with 1=death, 10=no injury and 7=acceptable injury. Likewise weed control was evaluated similarly with 10=excellent control, 7=acceptable control and 1=no control.

Results and Discussion

Study No. 1—Preliminary Surfactant Evaluation

The objective of this study was to screen a number of surfactants using Goal 1.6E at 1.0 lb. aia as the test herbicide. Goal was selected as the test herbicide due to its low solubility of 0.1 ppm and its wide spectrum of weed control. The most effective weed control was achieved by the surfactants Triton X-100, Tween 80 and X-77 (Table 1) and these were selected for further evaluation. The 2.5 percent formulation of Triton X-100 and X-77 were superior rates to 1.0 percent.

Study No. 2—Final Surfactant Evaluation

Triton X-100, Tween 80 and X-77 were further evaluated at 1.0 percent and 2.5 percent in combination with Goal 1.6E at 0.5 lb. aia. The most effective surfactant treatments were Triton X-100 at the 3 tablet rate at both 1.0 percent and 2.5 percent surfactant levels (Table 2). Since the area of weed control was similar, Triton X-100 at 1.0 percent was selected for further evaluation. With all treatments there were significant increases in weed control, as expected when the number of tablets were increased. However, the best treatments only yielded approximately 50 percent weed control in a one-gallon container which is not good enough from a commercial standpoint.

Study No. 3—Preliminary Herbicide Evaluation

Among the most effective herbicides for container grown landscape crops are Goal, Ronstar, Surflan and a relatively new material Gallery. All are relatively insoluble materials for example: Goal—0.1 ppm, Ronstar—0.7 ppm, Surflan—2.4 ppm, and Gallery—ppm. Dual, however, is very soluble at 530 ppm. The idea was to evaluate each herbicide separately with Triton X-100 and in combination with Dual and Triton X-100.

The preliminary results were not strikingly different with one tablet in one-gallon containers although Gallery and Gallery plus Dual were the least effective (Table 3). Thus, these two treatments were dropped from further evaluation.

Table 1. Preliminary Evaluation of Tablets Containing Surfactants Plus Goal. One Tablet per One-Gallon Container.

Treatment	Rate	Area weed control Cm²		Percent weed control
Triton X-100	1.0%	57.3	b	22.5
Triton X-100	2.5%	73.6	a	28.9
Triton AG 98	1.0	14.0	ghi	5.5
Triton AG 98	2.5%	22.5	fgh	8.8
Triton B 1956	1.0%	11.2	hij	4.4
Triton B 1956	2.5%	22.4	fgh	8.8
Tween 80	1.0%	37.6	cde	14.6
Tween 80	2.5%	41.3	cd	16.2
Tween 20	l.0%	31.6	def	12.4
Tween 20	2.5%	34.4	def	l3.5
X 77	1.0%	35.1	def	13.8
X 77	2.5%	49.0	bc	19.3
Buffer X	1.0%	15.9	ghi	6.2
Buffer X	2.5%	25.5	efg	10.0
Regulaid	1.0%	22.4	fgh	8.8
Regulaid	2.5%	25.3	efg	9.9
Dash	1.0%	8.3	ji	3.3
Dash	2.5%	16.1	ghi	6.3
Goal	0.5 lb aia	8.0	ij	3.2
Check	—	0.0	i	0

Tukey's Studentized Range Test at 5% level. Letters followed by dissimilar letters within columns are significantly different.

Study No. 4—Final Herbicide Evaluation

With the exception of Gallery the herbicide treatments in study 4 were a repeat of study No. 3. However, 1, 2 and 3 tablets per one-gallon container were evaluated. As with study 2, as the number of tablets increased the weed control increased.

Over 80 percent weed control was achieved with three tablets of Goal at 0.5 lbs. aia and 90 percent with Goal at 1.0 lbs. aia (Table 4). Furthermore, Dual at three tablets yielded 100 percent weed control of Seaside Bentgrass. The combination of Goal (0.5 lbs. aia) and Dual (2.0 lbs. aia) resulted in 98 percent weed control. Recognizing that Dual as an herbicide is most effective against grasses and Goal most effective against broadleaf weeds it was decided to continue research with the combination product of Triton X-100 at 1.0 percent, Goal at 0.5 lbs. aia and Dual at 2.0 lbs. aia.

Study No. 5—Nursery Evaluation

Ten species of woody nursery stock were planted into two-gallon containers and treated with either 2, 3 or 4 tablets/container. As shown in Table 5 there was no evidence of phytotoxicity six weeks from treatment. Acceptable weed control for two tablets was eight weeks, three and four tablets eight-plus weeks (Table 6). These containers were not sown to Seaside Bentgrass but native weeds were evaluated and the following weed species were controlled: lesser bittercress, spotted spurge and oxalis all weeds which cause significant labor problems in container nurseries. Dual alone will not control these weed species.

Summary

A series of four studies were conducted to determine the most effective surfactant and herbicide to incorporate into slow release tablets for the most effective control of weeds without plant phytotoxicity. The most effective surfactant was Triton X-100 and most effective herbicide was a combination of Dual and Goal which results in broad spectrum weed control. These tablets were then field tested on 10 species and cultivars of woody landscape plants. There was no observable phytotoxicity for eight weeks on eight of 10 plant selections and acceptable weed control was achieved with two tablets for eight weeks, three and four tablets for eight-plus weeks.

Continued research is needed to evaluate more crops, varying rates, and economic analysis.

Table 2. Final Evaluation of Tablets Containing Surfactants Plus Goal. One, Two and Three Tablets/Container.

Treatment	Rate	No. Tablets	Area weed control Cm²	Percent Weed control
Triton X-100	1.0%	1	40.6 ijk	16.0
Triton X-100	1.0%	2	71.3 efg	28.0
Triton X-100	1.0%	3	127.4 ab	50.0
Triton X-100	2.5%	1	48.2 hij	19.0
Triton X-100	2.5%	2	84.6 de	33.0
Triton X-100	2.5%	3	139.1 a	54.7
Tween 80	1.0%	1	18.7 1mno	7.3
Tween 80	1.0%	2	50.6 ghij	20.0
Tween 80	1.0%	3	70.3 efg	27.7
Tween 80	2.5%	1	24.9 k1mn	9.8
Tween 80	2.5%	2	50.8 ghij	20.0
Tween 80	2.5%	3	82.7 ef	32.5
X-77	1.0%	1	34.7 jk1m	13.6
X-77	1.0%	2	56.2 hij	22.1
X-77	1.0%	3	100.1 cd	39.3
X-77	2.5%	1	37.7 ijk1	14.8
X-77	2.5%	2	63.3 fgh	24.8
X-77	2.5%	3	107.2 bc	42.2
Goal (on1y)	0.5 aia	1	8.2 no	3.2
Goal (on1y)	0.5 aia	2	15.8 mno	6.2
Goal (on1y)	0.5 aia	3	21.6 k1mno	8.5
Control	—	1	— 0	0
(No surfactant	—	2	— 0	0
or herbicide)	—	3	— 0	0

Tukey's Studentized Range Test at 5% 1evel. Letters followed by dissimilar letters within columns are significantly different.

Table 3. Preliminary Evaluation of Tablets Containing Herbicides Plus Triton X-100. One Tablet/Container.

Treatment	Rate lb aia	Area weed control Cm^2	Percent weed control
Control	—	0	0
Goal	1.0	74.3 a	29
Dual	1.0	47.6 bcd	19
Ronstar	1.0	44.1 cde	17
Gallery	1.0	26.9 ef	11
Surflan	1.0	36.6 de	14
Goal plus Dual	.5+2.0	63.8 ab	25
Ronstar plus Dual	.5+2.0	48.0 bcd	19
Gallery plus Dual	.5+2.0	39.8 de	16
Surflan plus Dual	.5+2.0	46.9 bcd	18

Tukey's Studentized Range Test at 5% level. Letters followed by dissimilar letters within columns are significantly different.

Table 4. Final Evaluation of Tablets Containing Herbicides Plus Triton X-100. One, Two and Three Tablets/Container.

Treatment	Rate	No. Tablets	Area weed control Cm^2	Percent Weed control
Goal	0.5 lb aia	1	67.8 gh	27
Goal	0.5 lb aia	2	162.8 de	64
Goal	0.5 lb aia	3	217.8 abc	86
Goal	1.0 lb aia	1	76.9 gh	30
Goal	1.0 lb aia	2	134.9 ef	53
Goal	1.0 lb aia	3	229.3 ab	90
Dual	4.0 lb aia	1	70.8 gh	28
Dual	4.0 lb aia	2	148.5 def	58
Dual	4.0 lb aia	3	265.2 a	100
Ronstar	2.0 lb aia	1	71.9 gh	28
Ronstar	2.0 lb aia	2	121.3 efg	48
Ronstar	2.0 lb aia	3	168.6 cde	66
Surflan	1.0 lb aia	1	58.0 h	23
Surflan	1.0 lb aia	2	137.2 def	54
Surflan	1.0 lb aia	3	165.2 cde	65
Goal+Dual	0.5+2.0	1	65.8 h	26
Goal+Dual	0.5+2.0	2	177.5 bcd	70
Goal+Dual	0.5+2.0	3	250.3 a	98
Ronstar+Dual	1.0+2.0	1	71.0 gh	28
Ronstar+Dual	1.0+2.0	2	106.5 fgh	42
Ronstar+Dual	1.0+2.0	3	178.0 bcd	70
Surflan+Dual	0.5+2.0 lb aia	1	64.1 h	25
Surflan+Dual	0.5+2.0 lb aia	2	140.9 def	55
Surflan+Dual	0.5+2.0 lb aia	3	144.5 def	57
Check	—	1	0 I	0
		2	0 I	0
		3	0 I	0

Tukey's Studentized Range Test at 5% level. Letters followed by dissimilar letters within columns are significantly different.

Table 5. Phytotoxicity of Dual-Goal-Triton X-100 Slow Release Herbicide Tablets on Selected Container-Grown Nursery Stock.

Plant Materials	No. Tablets	Phytotoxicity 2 wks	4 wks	6 wks	8 wks
Boulevard Chamaecyparis	2	10[1]	10	10	10
.. ..	3	10	10	10	10
.. ..	4	10	10	10	10
Royal Beauty Cotoneaster	2	10	10	10	10
.. ..	3	10	10	10	10
.. ..	4	10	10	10	10
Emerald Cushion Euonymus	2	10	10	10	10
.. ..	3	10	10	10	10
.. ..	4	10	10	10	10
Emerald 'N Gold Euonymus	2	10	10	10	10
.. ..	3	10	10	10	10
.. ..	4	10	10	10	10
Spring Glory Forsythia	2	10	10	10	10
.. ..	3	10	10	10	10
.. ..	4	10	10	10	10
Pachysandra	2	10	10	10	10
..	3	10	10	10	10
..	4	10	10	10	10
PJM Rhododendron	2	10	10	10	10
.. ..	3	10	10	10	10
.. ..	4	10	10	10	10
Hino Pink Azalea	2	10	10	10	10
.. ..	3	10	10	10	10
.. ..	4	10	10	10	10
Gold Flame Spirea	2	10	10	10	10
.. ..	3	10	10	10	9.0
.. ..	4	10	10	10	8.7
Snowmound Spirea	2	10	10	10	9.3
.. ..	3	10	10	10	9.0
.. ..	4	10	10	10	9.0

[1]Visual Scale 1-10 with 1=death, 10=no injury and 7=acceptable injury.

Table 6. Weed Control with Dual-Goal-Triton X-100 Slow Release Herbicide Tablets on Selected Container-Grown Nursery Stock.

Treatments	Weed Control From Treatment 2 wks	4 wks	6 wks	8 wks
Control—No Tablets	8.0[1]	7.0	7.0	5.7
2 Tablets/Container	9.3	9.7	8.7	7.7
3 Tablets/Container	10	10	9.7	9.0
4 Tablets/Container	9.7	9.7	10	9.7

[1]Visual Scale 1-10 with 1=no control, 10=excellent control and 7=acceptable control.

Literature Cited

1. Horowitz, Menashe, Elton M. Smith, Stanley F. Gorski and Sharon A. Treaster. 1989. Potential of slow-release tablets as carriers of herbicides and growth regulators for containerized ornamentals. Ornamental Plants: A Sum. of Research 1989. Ohio State Univ., Spec. Circ. 123:36-39.

2. Koncal, J. J., S. F. Gorski and T. A. Fretz. 1981. Slow release herbicide formulation for weed control in container-grown plants. Hort Science 16:83-84.

3. Koncal, J. J., S. F. Gorski and T. A. Fretz. 1981. Leaching of EPTC, alachlor and metolachlor through a nursery medium as influenced by herbicide formulation. Hort Science 16:757-758.

4. Ruizzo, M. A., E. M. Smith and S. F. Gorski. 1983. Evaluations of herbicides in slow-release formulations for container grown landscape crops. J. Amer. Soc. Hort. Sci. 108:551-553.

5. Smith, A. E. and B. P. Verma. 1977. Weed control in nursery stock by controlled release of alachlor. Weed Sci. 25:175-178.

6. Smith, E. M. and S. A. Treaster. 1987. An evaluation of cyanazide, terbacil and metolachlor slow release herbicide tablets on woody landscape crops. Ornamental Plants—1987: A Summary of Research. OARDC Res. Circ. 291:15-16.

7. Verma, B. P. and A. E. Smith. 1987. Slow release herbicide tablets for container nursery. Transactions of Amer. Soc. Agr. Eng., 21:1054-1059.

8. Verma, B. P. and A. E. Smith. 1981. Dry pressed slow release herbicide tablets. Transactions of Amer. Soc. Agr. Eng., 24:1400-1407.

Developing Biorational Pesticides for the Landscape Industry

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Introduction

Urban forest pest management is undergoing rapid change in Canada and the United States of America in response to demands for better landscape quality and issues of pesticide exposure/risk. Many consumers and some arborists are no longer willing to use scheduled cover sprays on a preventive basis in an effort to keep landscape plants free of pest organisms. Furthermore, there is growing realization that pesticide management, including spraying only when and where necessary, eliminates the need for scheduled, preventive spraying. Integrated pest management (IPM), as part of plant health care, provides a framework whereby practitioners monitor landscapes, use pesticides only where and when they are needed, and actually improve pest control while dramatically reducing the amount of pesticides used. This process is proving successful for those willing to learn new technology.

Another aspect of IPM that is receiving increased interest, both in terms of research and use by arborists, is the group of pest control products known as biorationals, or biologically rational pest control materials. This article presents information on selected biorational insect and mite control products, provides data on their relative effectiveness against selected pests in our research program, and suggests opportunities for increasing their usage in urban forest pest management.

Materials and Methods

Candidate products, including BT-Pyrenone, a preparation of *Bacillus thuringiensis* Burlinger (Bt) plus Pyrenone (natural pyrethrum), insecticidal soaps (salts of fatty acids), superior horticulutral oil (Scalecide and Sunspray 6E), and Margosan-O (extract of the Neem tree), were evaluated under field or greenhouse conditions against selected arthropod pests of landscape trees and shrubs. Methods varied with the target pest.

Pine Needle Scale.

Scots pine (*Pinus sylvestris* L.) (1.5-3 m tall) growing in Christmas tree plantations infested with a pine needle scale (*Chionaspis pinifoliae* (Cooley)) were used for evaluating efficacy of products against scale crawlers and settled first stage nymphs. Treatments were applied May 6, 1986, July 21, 1987, or May 18, 1988 to coincide with the end of crawler hatch. A KWH backpack mistblower operating at half-throttle on aperature setting 3 was used to deliver enough finished spray to thoroughly wet the foliage. Conditions on spray days were 24°C with 16-32 kph winds ('86), 34°C with a 6-16 kph breeze ('87), and 13°C with 16-25 kph winds ('88). Sky conditions varied from cloudy in 1986 to sunny in 1987 and overcast with threat of rain in 1988. In all years, treatments were applied to four single-tree replicates. No rainfall occurred for at least 24 h in 1986 and 1987; light rain (less than 0.25 cm) fell 2 h after sprays had dried in 1988. Treatment effectiveness was evaluated ca. two weeks after application by removing five needle fascicles from at least three locations within each sprayed tree. Needles were placed in coin envelopes and transported in a cooler to the laboratory where percent mortality was assessed with the aid of a dissecting scope. Viability of the first 20 nymphs encountered on each of five fascicles was determined.

Pine Tortoise Scale.

Scots pine (1-2 m tall) growing in Christmas tree plantations infested with pine tortoise scale (*Toumeyella parvicornis* (Cockerell)) were used for evaluating efficacy of insecticides against mature scales. In 1985, sprays were applied March 26 when only mature female scales were present. A CO_2 compression sprayer at 40 psi with a single TeeJet SS8004 flat-fan nozzle was used to deliver sprays to run-off on four single-tree replicates. Temperature was 7-10°C with winds of 16-23 kph. Treatment effectiveness was evaluated April 9 by removing three infested twigs from each tree and evaluating mortality using a dissecting scope. In 1986, a similar, infested plantation of Scots pine was sprayed, this time with a KWH backpack mistblower operating at aperature setting 4 and spraying to runoff. Sprays were applied to three single-tree replicates per treatment. Conditions while spraying were sunny, 23-25°C, with winds of 16-23 kph. Treatment effectiveness against mature female scales was evaluated May 9 in the aforementioned manner. In 1986, residual impact of treatments on crawler establishment was evaluated June 23 by removing five needle fascicles near the twigs infested with mature scales from each tree and counting the number of settled first nymphs with the aid of a dissecting scope.

Birch Aphid.

Japanese white birch (*Betula platyphylla japonica* Hara) (5.5 m tall) growing in an experimental birch plantation at The Ohio State University, Ohio Agricultural Research and Development Center near Wooster, were chosen for evaluating efficacy of dormant sprays against newly hatched nymphs of the birch aphid (*Euceraphis betulae* (Koch)). A CO_2 compression sprayer at 40 psi with a single TeeJet SS8004 flat-fan nozzle was used to apply ca. 300 ml of finished spray to an infested branch of four, single-tree replicates per treatment. Application was made April 12 under sunny skies at 18°C and a breeze of 8-16 kph. Treatment effectiveness was evaluated April 15 by counting the number of live nymphs on 12.5 cm sections of three terminal twigs for each replicate.

Spruce Spider Mite.

Fraser fir (*Abies fraseri* Poir.) (0.5-1.5 m tall), growing in Christmas tree plantations, were used to evaluate pesticides against spruce spider mite (*Oligonychus ununguis* (Jacobi)) in 1987 and 1988. Four heavily infested single-tree replicates were sprayed to runoff with each treatment, using a KWH backpack mistblower at half-throttle and aperature setting 3. The first application in 1987 was made July 14 under partly cloudy skies at 21ºC with a 16-25 kph breeze. Trees receiving two applications were sprayed again on July 24 under sunny skies at 26ºC with a 0-10 kph breeze. Treatment effectiveness was evaluated one week after the second application by removing four, 10-15 cm long lateral branch tips from each of the trees. Plant material was placed in plastic bags and transported in an ice chest to the laboratory. Samples were then processed immediately by passing twigs through a mite brush six times to dislodge mites to a rotating glass plate coated with Tween-20. Living mites were counted with the aid of a dissecting scope. In 1988, the first application was made to all treatments, except Margosan-O, on June 6 under sunny skies at 29ºC with a breeze of 8-16 kph. Margosan-O was applied June 15 when second applications were made for other treatments. Conditions were sunny at 31ºC and no breeze. Treatment effects were evaluated two, four, and six weeks after the second application by removing five twigs from each tree and processing them as above.

Eastern Tent Caterpillar and Fall Webworm.

Flowering fruit and shade trees growing at OARDC and infested with fall webworm (*Hyphantria cunea* (Drury)) were used to evaluate efficacy of selected insecticides against caterpillars up to 25 mm (1 inch) long. A KWH backpack mistblower operating at half-throttle and aperature setting three was used to spray the web and surrounding foliage in each of 3 single-tree replicates per treatment. Application was made August 19, 1987 under sunny skies at 22ºC and no breeze. Treatment effectiveness was evaluated five, eight, and 14 days post-treatment by visually examining nests and assessing larval mortality. The same procedures were used to evaluate candidate insecticides against eastern tent caterpillar (*Malacosoma americana* (F.) infesting chokecherry (*Prunus virginiana* L.) growing along roadsides in Wayne County, Ohio, in 1988. Application was made May 11 under sunny skies at 16ºC with a 24-32 kph wind. Efficacy was determined as above.

Gypsy Moth.

Containerized northern red oak (*Quercus rubra* L.) seedlings (1-0) growing in a greenhouse were sprayed to run-off with a CO_2 compression sprayer with a SS-8004 flat-fan nozzle at 20 psi. In 1986, plants were sprayed before 4th instars were placed on seedlings. In 1987, five 4th instars were placed on plants prior to application. Forty-eight hours later, an additonal five larvae were placed on each treated plant. Following application, larvae were constrained by securing a one-gallon Fonda carton around the seedling in each container. The top of the carton was replaced with nylon organdy for ventilation. Larvae and foliage were observed daily until final mortality counts were made 72 (1986) or 96 h after application or placing larvae on treated foliage.

Japanese Beetle.

Pyracantha (*Pyracantha angustifolia* 'Gnome' (0.2 m tall) growing in containers were used to evaluate efficacy of insecticides against Japanese beetle (*Popillia japonica* Newman) adults. A CO_2 compression sprayer with a TeeJet SS-8004 flat-fan nozzle was used to apply foliar and topical sprays to runoff. Foliar applications were made at 40 psi on July 25 under sunny skies at 29ºC and a 16-24 kph breeze. Treatments received ca. 0.8 cm of rainfall four hours after sprays were applied and 2.0 cm additional rainfall throughout the test period, along with 3.8 cm of weekly overhead irrigation after first samples were removed. Foliar sprays were evaluated by removing two 10-15 cm twigs from each plant at specified intervals. They and five field-collected beetles were placed in one-liter Fonda cups with mesh tops. Residual efficacy of insecticides was evaluated 1, 3, 7, 14, and 21 days after foliar sprays were applied by allowing adults to feed on sprayed foliage for 48 h. After 48 h, moribund adults were placed on unsprayed foliage, and final percent mortality was assessed 48 h later. Topical applications were made at 15 psi on July 27 under sunny skies at 27ºC and an 8-16 kph breeze. In topical tests, three 10-15 cm twigs were placed upright in culture tubes with the cut end in water. Five adults were placed on each twig, and sprays were applied to runoff in the aforementioned manner. Adults and twigs were immediately transferred to one-liter Fonda cups fitted with mesh tops. Treatment effectiveness was evaluated as above. All treatments were replicated three times.

Results and Discussion

Pine Needle Scale.

Safer insecticidal soap caused high mortality of settled nymphs in all three years of evaluation, and was consistently more effective than standard, conventional products. Murphy's insecticidal soap at the 1 percent rate was more effective than carbaryl in 1987 and provided relatively good control at the standard rate of 2 percent (Table 1).

Results from three years of testing indicate that insecticidal soaps are excellent products for controlling crawlers and settled first stage nymphs of pine needle scale. Results suggest that their timing may be less important than with conventional products. However, applicators should always apply these and other pesticidal substances when target insects are in their most vulnerable stage. Sprays for armored scale insects, like pine needle scale, Euonymus scale (*Unaspis euonymi* (Comstock)), and oystershell scale (*Lepidosaphes ulmi* (L.)), should always be applied soon after crawler hatch has ended but before they molt to the second stage. If crawler hatch extends beyond about five days in the South or seven to eight days in the North, two applications at five to 10 day intervals may be required to achieve an acceptable level of control.

Horticultural oils, sometimes in combination with a conventional insecticide like Ethion, have been used for control of scale insects for decades. In our 1986 trial, 2 percent horticultural oil (Sunspray 6E) was as effective as

Table 1. Efficacy of Insecticides Against Pine Needle Scale Crawlers and Settled Nymphs in Central Ohio.

Pesticide and lb or % AI/100 gal ( )=g AI/1		Mean percent mortality Days post-treatment 7 1986	14 1987	14 1989
Dursban 4 E	1.0 (1.2)	40 b	—	87 b
Orthene 75 SP	0.5 (0.6)	21 cd	31 d	—
Sevin 80 S	1.0 (1.2)	34 bc	—	91 b
Safer Soap	2%	97 a	95 a	99 a
Murphy Soap	1%	—	52 c	—
Murphy Soap	2%	—	84 b	—
Sunspray 6 E	2%	92 a	—	—
Pestroy 8 E	1.0 (1.2)	—	98 a	—
Water Check	—	25 bcd	16 e	14 c

Means in a column followed by the same letter are not significantly different, Duncan's New Multiple Range Test (DNMRT) (P=0.05). Data were transformed to arcsin $\sqrt{x}$ before ANOVA.

Table 2. Efficacy of Insecticides Against Pine Tortoise Scale in Ohio.

Pesticide and lb or % AI/100 gal ( )=g AI/1	Mean percent mortality[a] 1985	1986	Mean no. live crawlers[b] 1986
Safer Soap 4%	0	—	—
Scalecide 2 & 4%	0	—	—
Safer+Scalecide 2+2%	0	—	—
Safer Soap 2%	0	39 b	5 ab
Sunspray 6 E 2%	—	37 b	4 b
Orthene 75 SP 0.75 (0.9)	—	41 b	7 ab
Supracide 2 E 1.0 (1.2)	0	—	—
Trimethacarb 3.3 F	—	100 a	0 c
Water check	0	8 b	18 a

Means in a column followed by the same letter are not significantly different, DNMRT (P=0.05).
[a]Data were transformed to arcsin $\sqrt{x}$ before ANOVA.
[b]Data were transformed to $\log_{10}$ (X+1) before ANOVA.

insecticidal soap and better than the standards Dursban, Orthene, and Sevin (Table 1). Baxendale and Johnson (1) used Sunspray 6E at 3 percent against soft and armored scales, both after crawler hatch was advanced and just as or before hatching commenced. In all trials, the treatment caused excellent control of crawlers and settled first stage nymphs; unhatched eggs were killed as the oil penetrated beneath the protective covering secreted by the female scale. Since insect metabolism is extremely high during the late stages of incubation and early crawler activity, oils can be expected to be most effective at that time, if indeed their mode of action is to interfere with gas exchange. More tests are needed to evaluate effectiveness of lower concentrations of horticultural oils to determine their minimum dosage and the window of opportunity against both armored and soft scales.

Pine Tortoise Scale.

None of the insecticides evaluated against overwintered females in early spring 1985 was effective, as measured by our evaluation procedures (Table 2). Application of soap and oil in early May, 1986, again failed to cause obvious mortality of overwintered females. However, later foliage sampling indicated that Sunspray 6E significantly reduced the number of first stage nymphs on adjoining branches after hatch was complete. This result indicates that oils may cause sublethal effects that eventually provide population reduction through means other than direct toxicity to sprayed life stages. Tests by Baxendale and Johnson (1) would seem to substantiate this speculation.

Birch Aphid.

Even high concentrations of insecticidal soap and horticultural oil, used alone, failed to significantly reduce aphid numbers on branches of white birch soon after overwintered eggs had hatched in 1985 (Table 3). However, a combination of Safer soap and Scalecide caused a significant reduction in aphid numbers. Since this test was performed on branches, rather than entire trees, it is possible that within-tree migration of wingless aphids during the three days from application to sampling resulted in a conservative estimate of treatment effects. This work needs to be repeated by spraying entire, isolated trees with each product. Furthermore, it apppears that combinations of soaps and oils deserve further evaluation as aphicides. Since aphids and resultant honeydew are common problems in environmentally sensitive areas, including patios, swimming pools, and ponds, these biorational products need to be tested in novel ways to maximize their utility in landscape management.

Table 3. Efficacy of Insecticides Against a Birch Aphid in Ohio.

Pesticide and lb or % AI/100 gal ( )=g AI/1	Mean number live nymphs
Safer Soap 4%	42 ab
Safer Soap 10%	27 ab
Scalecide 2%	41 ab
Scalecide 4%	22 abc
Safer+Scalecide 4+2%	18 bc
Turcam 76 WP 1.0 (1.2)	0.2c
Water Check	46 a

Means in a column followed by the same letter are not significantly different, DNMRT (P=0.05). Data were transformed to $\log_{10}$ (X+1) before ANOVA.

Spruce Spider Mite.

The mite population crashed soon after the second application in 1987, even on the unsprayed check plants, precluding critical evaluation of treatment effects. However, the limited data obtained indicated that pesticidal soaps can not be expected to provide control of spruce spider mite unless at least two applications are used (Table 4). Although a single application of Plictran was effective, it has been removed from the market and is no longer available to landscape managers or producers of nursery crops or Christmas trees. Other conventional miticides like Kelthane also require two applications at a six to 10 day interval, depending upon local temperatures.

Even two applications of Safer insecticidal soap were ineffective by themselves in 1988, but the soap showed promise as an acaricide when combined with cotton seed oil (Table 4). Again, mite populations diminished soon after the two-week sampling, precluding further evaluation of residual effectiveness of treatments. Sunspray 6E was ineffective against spruce spider mite, but should be evaluated at higher concentrations and in combination with soap and other products before it is discarded as a miticide. In a small-scale test with spruce spider mite on Hemlock (*Tsuga canadensis* (L.)), Baxendale and Johnson (1) achieved excellent mite control with a single application of three percent Sunspray 6E. They had similar results against spider mites on deciduous landscape plants.

Table 4. Efficacy of Insecticides Against Spruce Spidermite in Ohio.

Pesticide and lb or % AI/100 gal ( )=g AI/1	Number applications	Mean no. mites 1987	Mean no. mites 1988
Safer Soap 2%	1	2 ab	—
Safer Soap 2%	2	0 b	5.3 abc
Safer Soap+SSI	2	—	11.3 a
Safer Soap+CSO	2	—	0.8 bc
SS+SSI+CSO	2	—	0.8 bc
SSI .05%	2	—	9.8 a
CSO .25%	2	—	10 a
Murphy Soap 1%	2	0 b	—
Murphy Soap 2%	1	6 a	—
Murphy Soap 2%	2	0 b	—
Margosan-O .66%	1	—	9 a
Sunspray 6 E 2%	2	—	4.5 abc
Kelthane 35 WP 0.33 (.42)	2	—	0 c
Plictran 50 WP 0.125	1	0	—
Water check (1988)	2	—	3.8 abc
Unsprayed check (1988)	—	—	12.8 a
Water check (1987)	2	2.3 ab	—

Means in a column followed by the same letter are not significantly different, DNMRT (P=0.05). Data were transformed to $\log_{10}(X+1)$ before ANOVA.
SS=Safer insecticidal soap; SSI=water conditioner (0.48 ml/l); CSO=cotton seed oil (2.5 ml/l).

Defoliators.

Soaps and oil sprayed on webs (tents) and surrounding foliage of infested trees in the field were ineffective against eastern tent caterpillar and fall webworm (Table 5). However, when soaps were applied topically to fourth instar gypsy moth on containerized oaks in the greenhouse, they provided acceptable larval mortality (Table 6). In the same test, when larvae were placed on foliage previously treated with soap, the treatment was ineffective. This indicates that if soaps are to be effective against lepidopterous defoliators, application should be made when larvae are small and before webs provide significant protection from contact sprays. Since there is no residual effectiveness, even when larvae eat treated foliage (see Table 6), thorough coverage of all plant surfaces is critical to efficacy.

Similar results were obtained with soaps against Japanese beetle adults. When foliage was sprayed before beetles were placed on plants, soaps were ineffective. However, in 1988 and 1989, when the beetles were contacted with Safer insecticidal soap, all of them died within 24 hours. If thorough coverage can be achieved and repeated applications are feasible, it appears that insecticidal soap is a viable treatment for controlling Japanese beetle adults in landscape management. This usage is probably more amenable to use by homeowners than arborists, since repeat applications are costly and sometimes impossible to provide to a large number of customers on a timely basis.

Sunspray 6E was ineffective against Japanese beetles, whether applied to foliage or when sprayed directly on the adults. Margosan-O was ineffective as a foliar spray against this important pest.

The combination of natural pyrethrum and B.t. provided excellent control of second instar gypsy moth within three days and fourth instars within five days (Table 6). This combination product may have utility in urban forest pest management. Natural pyrethrum, singly and in combination with biorational and conventional pesticides, deserves further attention as efforts are made to reduce usage of conventional pesticides in urban and community forests.

Conclusion

Horticultural oils and soaps have broad labels for use against insect and mite pests of woody landscape plants. None of them caused obvious phytotoxicity in tests reported here or in studies reported elsewhere (1,2,3). McClure (4) had good success with horticultural oil against Fletcher scale (*Parthenolecanium fletcheri* (Cockerell)) on yews (*Taxus cuspidata* Siebold and Zuccarini 'Densiformis' and 'Hicksii,') in the fall without causing phytotoxicity. However, when Scalecide was applied during winter, followed by subfreezing temperatures, phytotoxicity was evident on both cultivars (5).

Oils and soaps are proving effective against a number of important pests that lead to widespread, annual pesticide application in the urban forest. Although definitive recommendations for their use cannot all be based on research results at this time, arborists and other landscape managers are encouraged to try them on a limited basis in comparison

Table 5. Efficacy of Insecticides Against Defoliators in Ohio.

Pesticide and lb or % AI/100 gal ( )=g AI/l	Mean Percent Mortality		
	Fall Webworm	Eastern Tent Caterpillar	Japanese Beetle Adults
Murphy Soap 2%	5 b	—	—
Safer Soap 2%	5 b	8 d	0 b
Safer Soap 2% (Topical=contact)	—	—	100 a
Sunspray 6E 2%	—	27 c	0 b
Sunspray 6E 2% (Topical=contact)	—	—	7 b
Margosan-O 0.66%	—	—	0 b
Sevin SL 1.0 (1.2)	98 a	80 b	100 a
Tempo 2 0.02 (.028)	—	100 a	100 a
Water check	5 b	8 d	7 b

Means in a column followed by the same letter are not significantly different, DNMRT (P=0.05). Data were transformed to arcsin $\sqrt{x}$ before ANOVA.

Table 6. Efficacy of Insecticides Against Gypsy Moth Larvae Under Greenhouse Conditions.

Pesticide and lb AI/100 gal or %	Mean Percent Mortality — Days after treatment 1		3		5		On 48 h residues
	2nd	4th	2nd	4th	2nd	4th	
Bt-Pyrenone WP (.5 f.)	0	0	53	27	100	87	—
Bt-Pyrenone WP (1.0 f.)	20	0	93	40	100	100	—
Sevin 80 S 1.0	100	100	—	—	—	—	—
Water check	0	0	0	0	0	0	—
Murphy Soap 2%	—	27 a	—	—	—	67 b	0
Safer Soap 2%	—	13 a	—	—	—	87 ab	0
Orthene 75 SP .0.25	—	27 a	—	—	—	100 a	100
Water check	—	0 a	—	—	—	0 c	0

Means within a column below the line followed by the same letter are not significantly different (P=0.05), DNMRT. Data were transformed to arcsin $\sqrt{x}$ before ANOVA.
f.=formulation

to standard products. If they prove effective, then biorational products can be used on a larger scale to reduce non-target impacts of landscape pest control.

Arboriculture, by definition, concerns environmental enhancement through professional management of our tree and shrub resources. Surely, arborists agree that this must be done without degrading other components of the environment. Biorational pesticides can help us achieve these goals and are worthy of increased usage by arborists. Their development deserves major effort by agricultural pesticide companies and renewed research efforts by scientists at Land Grant institutions.

Literature Cited

1. Baxendale, R. W. & W. T. Johnson. 1988. Evaluation of summer oil spray on amenity plants. J. Arboriculture 14:220-225.
2. Nielsen, D. G. & M. J. Dunlap. 1988. Phytotoxicity test on selected woody plants. Insecticide & Acaricide Tests 13:380-381.
3. Nielsen, D. G. & M. J. Dunlap. 1989. Phytotoxicity test on selected woody plants. Insecticide & Acaricide Tests 14:325-326.
4. McClure, M. S. 1988a. Fletcher scale control on taxus using foliar sprays in autumn. Insecticide & Acaricide Tests 13:365-366.
5. McClure, M. S. 1988b. Winter oil spray to control fletcher scale on taxus. Insecticide & Acaricide Tests 13: 366.

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Interactions Between Subdue and Slow-Release Fertilizers at High Temperatures

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Abstract

During the 1988 growing season, phytotoxicity problems developed on azaleas and rhododendrons within days after planting of liners in containers. Fungicide drenches and/or slow release fertilizer treatments were thought to be the cause of the problem. This article reports results of experiments designed to test those hypothesis.

Under very high temperature conditions, azalea and rhododendron liners, treated with Osmocote 18-6-12 and Subdue 2E at recommended rates during May or July, did not develop root or leaf injury symptoms. In one of two tests with rhododendrons, root injury did develop after several days of high temperature, but only on plants treated with twice the recommended rate of Osmocote and drenched with a high rate of Subdue (4 oz/100 gal).

Ammonia, nitrate and soluble salt concentrations, in addition to the effects of the various treatments on pH, suggested that high salinity caused the damage and that it was due to high release rates by Osmocote 18-6-12 at high temperatures. Subdue 2E, even at a high application rate, did not affect the rate of release of nutrients by Osmocote 18-6-12 slow release fertilizer.

Introduction

During the past decade, Ohio nurserymen occasionally have suffered losses of azaleas and rhododendrons within days after potting. These losses occurred after abnormally high temperatures. Symptoms observed on azalea were yellowing of new growth in leaves within three to five days after potting, followed by necrosis (dry, brown dead leaves) within 24 hours. High ammonia concentrations were found in the necrotic leaf tissue suggesting that death was due to high salinity (ammonium nitrate) or ammonia toxicity (H. A. J. Hoitink and M. E. Watson, *unpublished information*). Rhododendron foliage did not show symptoms but root browning and death was observed on plants three to five days after potting. A few weeks later, roots of affected plants recovered.

The cause of the phytotoxicity has not been determined. However, slow-release fertilizer and fungicide drenches typically are applied at potting. Since some fungicides inhibit the conversion of ammonium to nitrate nitrogen, it has been speculated, that the damage possibly was due to fungicide side effects.

This article reports results of three tests with rhododendrons and azaleas and of a controlled high temperature test, in which the interactions between fungicides and slow release fertilizers were examined.

Materials and Methods

Rhododendron Greenhouse Tests.

Rooted cuttings of Roseum Elegans rhododendron, with one fully expanded flush of new growth, were received from Willoway Nursery, Avon, OH and planted into a container medium consisting of 15 percent composted hardwood bark, 50 percent pine bark, 20 percent Canadian sphagnum peat and 15 percent expanded shale (Haydite B'Grade), on a volume basis. This medium (pH 5.5) was amended with 0.6 kg gypsum and epsom salts each per m^3 (1 lb/cubic yard), and Micro max trace elements at the recommended rate. The liners were potted in one-gallon containers in mid-May in a greenhouse set to provide 35°C (95°F) day and 24°C (75°F) night temperatures. Under these conditions, the temperature on the surface of the medium at 12:00 noon on the south side of the plant reached 51°C (123°F) on bright, sunny days.

Osmocote 18-6-12 (8-9 mo) slow-release fertilizer was applied at rates of 0, 21 and 42 grams per 3.78 L (1 gal) container (0, 1X and 2X recommended rates, respectively). The Osmocote granules were applied in a small pile on a layer of cheesecloth on the south side of plants, 5 cm (2") from the stem, just above where roots were growing into the new medium. This procedure is the worst method that would possibly be used by growers resulting in the highest chance of phytotoxicity.

A Subdue 2E, 25.1 percent E.C. drench (0, 1 or 4 fl oz/100 gal), was applied (1 pt. sq. ft.) immediately after the Osmocote. Plants were irrigated daily to maintain adequate moisture levels for plant growth, but not enough to leach the medium.

Immediately after all treatments were applied and at three and five days thereafter, the slow release fertilizer on the layer of cheesecloth was removed from the surface of the container medium and discarded. A 200 ml volume of container medium was removed from the surface 7.5 cm (3") layer in each pot just underneath the pile of Osmocote. Samples from three plants were pooled, blended and analyzed at the Research Extension and Analytical Laboratory for ammonia, water extractable ammonia, nitrate, electrical conductivity and pH. In addition, roots were rated for symptoms of phytotoxicity and new growth. Each treatment was replicated three times. The experiment was a completely randomized design. In addition to this test, a second rhododendron test was performed, using a 2X Osmocote and a Subdue drench at 1 and 4 oz/100 gal rates.

Azalea Field Test.

Quart-size Herbert azalea liners, also received from Willoway Nursery, were potted in one-gallon containers, as described above but in mid-July when temperatures in excess of 33°C (90°F) were predicted. In this test, slow release fertilizers used were Osmocote 18-6-12 (8-9 mo), Nutricote 16-10-10 (blend 140/40) and Sref II 20-4-10 (9-10 mo). Recommended rates for these Osmocote, Nutricote and Sref formulations are 21, 14 and 19 grams per one-gallon container, respectively. All were applied at 0, 1X and 2X rates.

Fungicide drenches used were Truban 80 percent WP at 8 oz/100 gal, 1 pt/sq. ft. and Subdue 2E at 1 oz/100 gal, 1 pt/sq. ft. Control treatments were drenched with water. Three replicates of three plants were used per treatment. All treatments and replicates were randomized. In addition to a full sun exposure, this azalea test was also set up under 50 percent shade cloth. Plants were irrigated as needed. At 0, 3, 5, and 9 days after treatment, roots and foliage of plants were examined for phytotoxicity symptoms.

Controlled High Temperature Test.

Canadian sphagnum peat, blended with coarse perlite (7:3, v/v), was amended with lime to adjust the pH to 6.3. Water was added to moisten the medium and then an equal weight of medium was placed in 400 ml pots. The container medium then was saturated with water overnight and allowed to drain. The average volume of the mixture in the containers was 362 ± 5 mL. The dry weight was 37.3 ± 0.5 g. The bulk density was 100 ± 1 g/L and the total pore volume was 94 percent. Water capacity and air capacity immediately after drainage (2 hrs) were 63 ± 1 percent (volume) and 31 ± 1.5 percent (volume), respectively.

A moist piece of cheesecloth was placed on each container in direct contact with the mixture. Osmocote 18-6-12 (8 g/container) was then evenly distributed on top of the cheesecloth and covered with 50 ml of fine perlite. The perlite was finally covered with Whatman No. 1 filter paper. Each container was placed in a 400-ml styrofoam cup to collect any leachate that might drain out. They were irrigated with 40 ml of either Subdue 2E or deionized water, covered with polyethylene to avoid evaporation and placed in the oven at 50°C for 3, 24, 48, 72 and 96 hrs.

Treatments used were a water control, the recommended rate of Subdue 2E (1 oz/100 gal, 1 pt/sq. ft.) and a 4X rate of Subdue (4 oz/100 gal, 1 pt/sq. ft.). Each treatment consisted of three replicates per sampling time. At the end of each sampling period, containers were leached with 40 ml of deionized water. After 30 min the cheesecloth was removed (including the Osmocote and perlite), and a "saturated paste" was made from the whole substrate in the container by the addition of the solution that had accumulated in the polystyrene cup. After an hour of equilibration, subsamples were taken for measurement of moisture content and the mixture was then extracted by vacuum. Total soluble salts, as well as NO_3^- nitrogen and pH were measured at 3, 24, 48, 72 and 96 hrs. From the moisture content and bulk density, all final calculations were made on a container medium volume basis.

Results

Rhododendron Tests.

Control plants not treated with slow-release fertilizer developed nutrient deficiency symptoms after nine days. Extracted ammonium, nitrate and soluble salts level concentrations from media samples increased with increased Osmocote rates but did not exceed E.C. values of 5.5 mmhos/cm. The ammonium to nitrate ratio and the pH of the medium was not affected by the Subdue treatment. In one of the two rhododendron tests root injury was evident, but only on the one side of the plant just below where a 2X Osmocote rate had been applied (E.C. >9.0 mmhos/cm). Root injury, typical of high salinity (brown root tips on new growth), was not observed in any of the recommended (1X) Osmocote treatments (21 g/gallon container), regardless of Subdue treatment.

Azalea Test.

Temperatures on the surface of containers in full sun reached 50°C (120°F) during one day only (fifth day after treatments). Excessively high temperatures, such as those that prevailed in 1988, occurred during that one day only. Control plants not treated with slow release fertilizer, whether in the shade or full sun, showed nutrient deficiency symptoms after nine days. Root and shoot growth of plants treated with either the 1X or 2X rate of any of the three slow-release fertilizers did not differ, regardless of fungicide treatment.

Controlled High Temperature Tests.

Concentrations of nitrate nitrogen (Figure 1) and soluble salts (Figure 2) in the container medium extracts, regardless of Subdue treatment, increased linearly with time. Medium pH (Figure 3) decreased slightly from 6.3 at the beginning of the experiment to 5.7 after 72 hrs. It may be concluded that Subdue 2E drenched at 0, 1 or 4 oz/100 gal did not affect the nutrient release rate from the Osmocote slow-release fertilizer. Regression equations and other statistical data are presented in Table 1.

Discussion

Harbaugh and Wilfret (1982) have shown that the release rate of soluble salts from Osmocote 18-6-12 during the first 96 days is linear, and that rates of release are more than doubled if temperatures increase from 15° to 30°C (60-86°F). Our work shows that the release rate is much higher at 50°C (122°F). The Osmocote label indicates that the application rate is based on an average container medium temperature of 21°C (70°F). Excessively high temperatures, therefore, easily can result in salinity problems. This is even more likely to occur if the granules are applied on the surface of a pot in full sun and in a small pile, since temperatures as high as 50°C (123°F) have been detected in nurseries on pot surfaces. Today growers recognize that slow release fertilizer granules should be spread over the entire surface of the pot to avoid high and toxic concentrations of nutrients on one side of a plant.

The active ingredient metalaxyl in Subdue 2E may affect nitrification if applied at high enough rates. The active ingredient in Truban, etridiazole, is an inhibitor of nitrification. Therefore, it has been speculated that the toxicity problem observed in some nurseries when Subdue and slow release fertilizers were applied at the same time, was due to inhibition of the conversion of ammonia in the container medium to nitrite and finally, to nitrate. Elliott (1989), who examined the effects of a number of fungicides, including Benlate, Subdue and Truban, on these nitrogen transformations in soilless potting media, concluded that no direct evidence was found that suggested that either ammonium or nitrite toxicity occurred as a result of fungicide applications. In our work we found that the ratio of ammonium to nitrate nitrogen released was not affected by Subdue. Also, medium pH did not increase after Subdue treatment, suggesting that Subdue 2E did not have inhibitory effects on nitrification.

Temperature affects nitrification (Alexander, 1977). At temperatures above 37-40°C (96-104°F) nitrification does not occur because the microflora involved in the process is inhibited. Since temperatures on the surface of containers may be as high as 50°C (123°F), when the problem occurs in nurseries, inhibition of nitrification probably does not play a significant role. It would be best if these temperature sensitive fertilizers could be mixed into the surface layer of container media or covered with a mulch to avoid high temperature exposure.

In conclusion, evidence presented here suggests that temperature affecting release rate of slow release fertilizer is the chief culprit and that the fungicide effect, if any, is scant. Salinity appears to be the cause of the problems observed in nurseries.

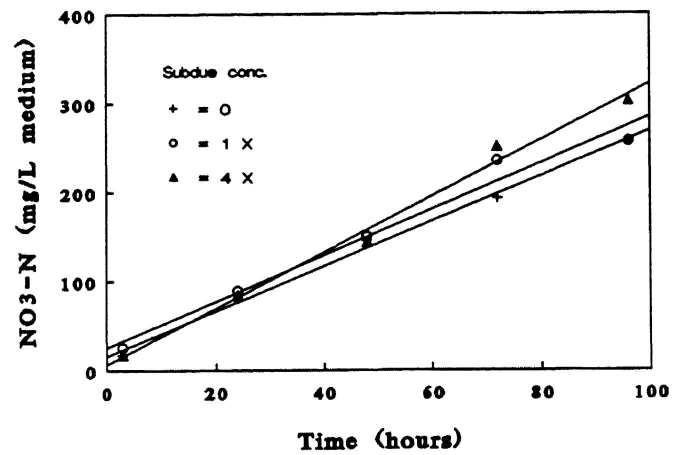

Figure 1. Concentration of nitrate nitrogen with time in a container medium treated with Osmocote 18-6-12 (2.2 g/100 ml), and drenched with Subdue 2E at 0, 1, and 4 oz/100 gal.

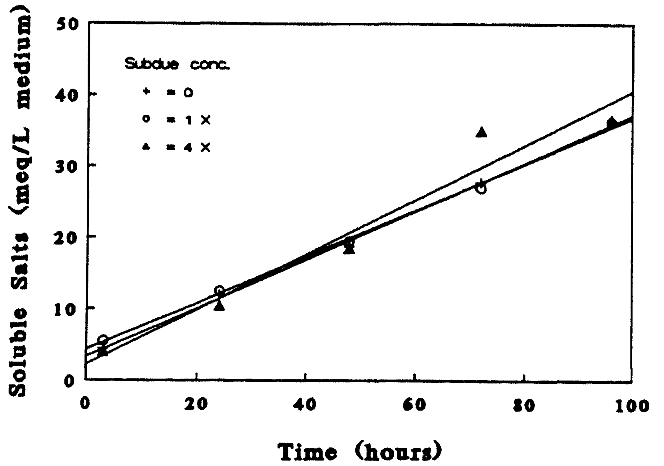

Figure 2. Concentrations of soluble salts with time in a container medium treated with Osmocote 18-6-12 (2.2 g/100 ml), and drenched with Subdue 2E at 0, 1, and 4 oz/100 gal.

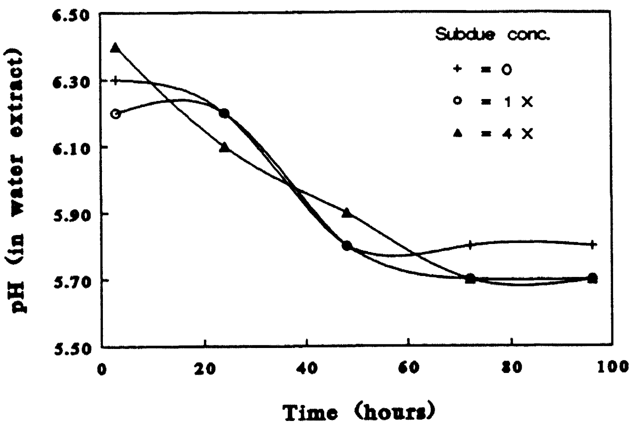

Figure 3. pH with time in a container medium treated with Osmocote 18-6-12 (2.2 g/100 ml), and drenched with Subdue 2E at 0, 1, and 4 oz/100 gal.

Table 1. Regression Equations of the Concentrations of Soluble Salts and Nitrate Nitrogen as a Function of Time for Levels of Subdue[1] and Osmocote[2]

Treatment	Equation	R^2	Degrees of freedom
	Soluble Salts (mg/L medium)		
0 Subdue	Y=3.278+0.340X	0.987	9
1X Subdue	Y=4.290+0.328X	0.957	9
2X Subdue	Y=2.310+0.370X	0.932	
	Nitrate Nitrogen (mg/L medium)		
0 Subdue	Y=15.62+2.530X	0.946	9
1X Subdue	Y=26.62+2.540X	0.905	9
2X Subdue	Y=6.292+3.111X	0.956	7

[1] 1X and 2X Subdue treatment represent rates equivalent to 1 and 4 oz Subdue 2E applied as a drench (1 pt/sq. ft.), respectively.

[2] Osmocote 18-6-12 was applied at a rate equivalent to 2.2 g/100 ml container medium.

Literature Cited

1. Alexander, M. 1977. Introduction to Soil Microbiology. 2nd Edition. John Wiley & Sons, Inc., NY. 201 p.
2. Elliott, G. C. 1989. Effects of fungicides and other inhibitors of microbial activity on nitrogen transformations in soilless potting media. (In press).
3. Harbaugh, B. K., and Wilfret, G. J. 1982. Correct temperature is the key to successful use of Osmocote. Florists' Review 170:21-23.

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Evaluation of Powdery Mildew Severity on Deciduous Azaleas at the Secrest Arboretum—1989

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Abstract

In a 1989 study, deciduous azaleas in the Secrest Arboretum were rated to determine the severity of powdery mildew on foliage. Of the 92 selections studied [*Rhododendron* cultivars (azalea) and two species], 32 displayed no evidence of the disease or only a small amount, while 38 were severely infected. Weather conditions during July and August were relatively dry and hot, contributing to the high incidence and severity of the disease on susceptible selections.

Introduction

The causal fungus, *Microsphaera penicillata* (Wallr. ex Fr.) Lev, is generally recognized as the species causing powdery mildew on deciduous azalea (1). An older name *Microsphaera alni* (Wallr.) Wint., is a synonym and no longer considered as the correct name for the powdery mildew fungus on azalea (1). Taxonomic concepts vary and some authorities consider the azalea fungus distinct enough to be recognized as a different species, *Microsphaera azaleae* (2). A practical diagnosis of the disease is a conspicuous white growth (mycelium) appearing on the surface of host leaves. The obligately parasitic fungus penetrates the epidermal cells of the surface, diverting water and assimilates from the host to the fungus. Microscopic techniques are necessary in identifying the specific fungus species.

In general, infection by the fungus occurs during the summer months under dry conditions in the absence of free water, but high humidities for certain phases of the disease cycle are favorable for disease development. The disease tends to build up most noticeably during dry seasons. It has been observed that if infection occurs early in the growing season, the disease slowly weakens infected leaves and results in premature defoliation, browning of the leaves, depressed flower bud set, and slower-than-normal growth rate.

Mildew colonies first appear on the leaf surface and can remain isolated and scattered or grow to eventually cover the entire upper or lower leaf surfaces, depending on conditions favorable to disease development and host susceptibility. Occurrence and severity of the disease can be rated on host plants from absent to severe.

Since the unsightly fungus reduces the quality (appearance) of the host plant, a study was conducted at the Secrest Arboretum to determine the occurrence of powdery mildew on various selections of deciduous azalea. Ford (4) reported that after two years of observations, 27 selections were found to be free of mildew, and 34 selections were found to be infected (Table 2).

Materials and Methods

During a comparatively long dry period in August 1988, deciduous azaleas in the Secrest Arboretum were observed to evaluate the severity of powdery mildew on the foliage. The occurence of the disease was rated on deciduous azaleas that have been growing in the Arboretum since 1968 as well as on more recently planted selections. Cultivars of deciduous azalea were evaluated as well as two species (Table 1). Emphasis was placed on more recently planted selections to accommodate random and replicated observations.

Evaluation of the occurrence of powdery mildew was rated as follows:

1=no disease
2=slight-highly resistant (less than 25 percent of leaf area infected).
3=moderate occurrence (less than 50 percent of leaf area infected).
4=widespread-susceptible (50 percent or greater of leaf areainfected).
5=severe-highly susceptible (greater than 75 percent of leaf area infected).

Leaves were systematically rated throughout the planting.

Results and Discussion

Ninety-two selections were rated. Of the selections rated 32 selections were observed as being disease free (rating 1) or only a slight occurrence (rating 2), and 38 selections were categorized as rating 4 or 5.

In Wooster, Ohio in 1989, hot and dry conditions began on May 22 and continued through September 13. Maximum daytime temperatures during July and August averaged 28.7°C (83.6°F). Except for three days in July and six in August, maximum daily temperatures were above 26.7°C (80°F). Night temperatures averaged 16.8°C (62.2°F) during July and 14.3°C (57.7°F) during August, resulting in relatively cool night temperatures compared to daytime temperatures. Total rainfall was 4 cm (1.6 inches) and 2.3 cm (.90 inches) for July and August, respectively.

No indication of powdery mildew was present on the following deciduous azaleas: *Rhododendron* 'Antelope', 'Annabelle', 'Chestnut Hill', 'Choptank River', 'Jolie Madame', 'Medford Red', NA#55181, 'Pink Puff', 'Visco', 'Viscosapalum', and *Rhododendron roseum*, *R. vaseyi* and cv. 'White Find' (Table 1).

Browning of the leaf margins and some defoliation were observed on certain infected selections by mid-summer. By September 1, *Rhododendron* 'Orange Beauty' was completely defoliated and the following selections were nearly or completely defoliated during the two weeks that followed: *Rhododendron* 'Buttercup', 'Oxydol', 'Persian Melon', and 'Spicy Lights'. By the end of September, the occurrence of powdery mildew was considered extremely severe on the following selections, but defoliation was minimal: *Rhododendron* 'Coral Queen', 'Gold Flake', 'Hotspur Red', 'Marine', 'Red Sissler', and 'Salmon Joy'.

Lacebug injury was quite apparent on many of the selections in 1989. No lacebug injury was observed on the following selections: *Rhododendron* 'Alice', 'Antelope', 'Chestnut Hill', 'Choptank River', 'Daviesi', 'Hotspur', 'Jolie Madame', 'Medford Red', NA#55181, 'Orient', P.I. #6078, 'Peach Sunset', 'Red Pom Pom', 'Red Sissler', 'Sulphides', 'Verwelda Wendy', 'Visco', 'Viscosapalum', 'Yellow Giant', *R. vaseyi*, *R. vaseyi* 'White Find', and *R. roseum*.

Incidence of mildew observed, in 1989 differed from that reported earlier in the same planting (Table 2). Weather conditions during 1989 were apparently near-optimal conditions for disease occurrence.

Table 1. Severity of Powdery Mildew on Deciduous Azalea.

Species or Cultivar	Rating Index 1	2	3	4	5
'Alice' (Knap Hill; Pride)		x			
'Altair' (Exbury)			x		
'Antelope' (Mollis)	x				
'Annabelle' (Exbury)	x				
'Balls of Fire' (Knap Hill;Bovee)			x		
'Basilisk' (Exbury)					x
'Beaulieu' (Exbury)		x			
'Berryrose' (Exbury)				x	
'BK 37'			x		
'Brazil' (Exbury)			x		
'Bright Forcast' (Exbury)			x		
'Bryon Mayo' (Knap Hill;Bovee)			x		
'Buttercup' (Varnadoe)					x
'Cannon'			x		
'Cathye Mayo' (Knap Hill;Bovee)				x	
'Cecile' (Exbury)				x	
'Chartreuse' (Dr. Yeates)		x			
'Chestnut Hill' (Graefe)	x				
'Choptank River' (Hill)	x				
'Copper Cloud' (Leach)			x		
'Coral Queen' (Knap Hill;Pride)					x
'Corringe' (Exbury)				x	
'Daviesi' (Ghent)		x			
'Exbury White' (Exbury)					x
'Firefly' (Exbury)					x
'George Reynolds' (Knap Hill)				x	
'Gibraltar' (Exbury)				x	
'Ginger' (Exbury)					x
'Girard's Crimson Tide' (Girard)		x			
'Girard's Mount Saint Helen' (Girard)					x
'Gold Dust' (Exbury)					x
'Gold Flake'		x			
'Golden Deciduous'			x		
'Golden Flair' (Metselaar)				x	
'Golden Eagle' (Knap Hill)		x			
'Golden Horn' (Exbury)			x		
'Golden Sunset' (Knap Hill)			x		
'Holden Mystery'			x		
'Hotspur' (Exbury)		x			
'Hotspur A.M.'				x	

1=Absent, 2=Slight-highly resistant, 3=Moderate occurrence, 4=Widespread-susceptible, 5=Severe-highly susceptible.

(Continued)

Table 1. (Continued)

Species or Cultivar	1	2	3	4	5
'Hotspur Red' (Exbury)					x
'Hugh Wormold'(Exbury)				x	
'Jean Allen'			x		
'Jolie Madame' (Boskoop)	x				
'Lila' (Knap Hill;Bovee)			x		
'Maori' (Leach)			x		
'Mariva'					x
'Mary Claire' (Exbury					x
'Mary Holman'			x		
'Medford Red' (Dr. Yeates)	x				
'Mist Maiden'					
'Moonlight Rose' (Girard)			x		
NA#55181	x				
'Nancy Buchanan' (Exbury)					x
'Northern Lights'			x		
'Orange Beauty'					x
'Orient' (Exbury)		x			
'Oxydol'					x
P.I.#6078		x			
Selection #680				x	
'Peach Sunset' (Wells)			x		
'Persian Melon' (Wells)				x	
'Persil' (Slocock)			x		
'Pink Delight' (Exbury)				x	
'Pink Peppermint' (Pride)		x			
'Pink Plush' (Leach)		x			
'Pink Puff'	x				
'Primrose' (Exbury)					x
'Red King'					x
'Red Letter' (Dr. Yeates)		x			
'Red Pom Pom'		x			
'Red Sissler' (knap Hill)					x
'Redder Than' (Knap Hill; Pride)		x			
'Salmon Joy'				x	
'Sandra Marie' (Knap Hill; Bovee)				x	
'Satan' (Slocock)					x
'Silver Slipper' (Exbury)				x	
'Snowdrift' (Mollos)				x	
'Spicy Lights' (Univ. of Minn)				x	
'Sulphides'		x			
'Sunrise' (Wells)				x	
'Sweet Sue' (Knap Hill; Bovee)			x		
'Tintoretto' (Wells)			x		
'Verwelda Wendy'		x			
'Visco'	x				
'Visosalum'	x				
'War Paint'		x			
'White Cap'			x		
'White Find' (la Bar)	x				
'Williams'					x
'Yellow Giant' (Exbury; Pride)		x			
vaseyi	x				
roseum	x				

1=Absent, 2=Slight-highly resistant, 3=Moderate occurrence, 4=Widespread-susceptibile, 5=Severe-highly susceptible.

Table 2. Relative Susceptibility of Deciduous Azaleas to Powdery Mildew as Reported in 1975 (4).

Species or Cultivar	Azaleas Free From Powdery Mildew	Azaleas Susceptible to Powdery Mildew
'Agnes Harvey'	x	
'Altair'		x
'Balls of Fire'	x	
'Bolzae'	x	
'Basilisk'		x
'Berryrose'		x
'BK 37'	x	
'Blight Forecast'		x
'Bryon Mayo'	x	
'Buttercup'		x
'Cathye Mayo'		x
'Chartreuse'	x	
'Copper Cloud'		x
'Desert Pink'		x
'Exbury White'	x	
'Fancy Free'		x
'Firefly'		x
'Gallipoli'	x	
'Geroge Reynolds'		x
'Gibraltor'	x	
'Ginger'		x
'Gold Dust'		x
'Gold Flake'	x	
'Golden Girl'		x
'Golden Horn'		x
'Harvest Moon'		x
'Honeysuckle'		x
'Hotspur A.M.'	x	
'Hotspur Red'	x	
'Hugh Wormald'		x
'J. Jennings'	x	
'Klondyke'		x
'Lila'	x	
'Marina'		x
'Nancy Buchannan'		x
'Old Gold'		x
'Orient'		x
'Oxydol'		x
'Peach Sunset'		x
'Pink Delight'		x
'Red Letter'	x	
'Rennie'		x
'Royal Lodge'	x	
'Sandra Marie		x
'Snow Drift'		x
'Soft Lips'		x
'Strawberry Ice'		x
'Sunrise'	x	
'Sunset Pink'		x
'Sweet Sue'	x	
'W-1'		x
'White Cap'		x

(Continued)

Table 2. (Continued).

Species or Cultivar	Azaleas Free From Powdery Mildew	Azaleas Susceptible to Powdery Mildew
'Williams'		x
calendulaceum	x	
nudiflorum	x	
roseum	x	
vaseyi	x	
vaseyi 'White Find'	x	
vicosum	x	

Literature Cited

1. Coyier, D.L. and M.K. Roane. 1986. *Compendium of Rhododendron and Azalea Diseases.* American Phytopathological Society. APS Press, St. Paul, Minnesota. 65 pp.
2. Sinclair, W.A., H.H. Lyon, and W.T. Johnson. 1976. *Diseases of Trees and Shrubs.* Comstock Publishing Associates, Ithaca, New York and London, England. 574 pp.
3. Galle, F.C. 1985. *Azaleas.* Timber Press, Portland, Oregon. 486 pp.
4. Ford, J.E. 1975. *Performance of Woody Plants in the Secrest Arboretum. II. Health Family: Ericaceae.* OARDC Res. Circular 139 (Revised) 51 pp.

Winter Damage, Regrowth and Vigor of Old Garden Roses

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Introduction

Old garden roses have received increased attention in recent years from gardeners. More people are appreciating their special characteristics including the beautiful flower forms, fragrance, disease resistance and colorful fruit. Fortunately for those interested, the old garden roses are becoming more available from various nurseries and garden stores. Therefore, it is possible for the gardener to obtain and grow many plants which have special historic value, botanical interest or appealing aesthetic qualities.

The Garden of Roses of Legend and Romance, on the campus of the Ohio Agricultural Research and Development Center in Wooster, is a 2.7 acre garden which contains 1500 rose plants. Among these are about 500 different species and cultivars which were in existence prior to 1867. In that year the first hybrid tea rose, "La France," was introduced. The garden was established in 1970 in honor of Michael H. Horvath, one of America's best-known rosarians for more than 50 years. Through the generosity of Mr. Horvath's daughter, Mrs. Samual J. Forbes, and Mentor nurseryman, Joseph J. Kern, the garden became a source of enjoyment and information for many thousands of visitors each year.

Materials and Methods

During the 1989 season, 45 species and cultivars of roses growing in the garden were examined for winter damage, regrowth and vigor. The 45 selected were from a list established by Joseph J. Kern which included those he felt represented the most outstanding old garden roses for growing in Ohio. The list includes plants from each of the major groups represented in the garden.

The plants in the OARDC rose garden are grown in landscaped beds of various geometric configurations. The plants are spaced at 3′ and 5′ centers depending on the growth potential of the plant and according to the original landscape design by William A. Strong and Thomas W. Hill, landscape architects from Cleveland, Ohio. Three plants of a species or cultivar are placed in a triangular grouping with all plants having at least one side toward the outside of the bed.

The rose plants are mulched with decomposed bark for moisture retention and weed control, but no special winter protection is given. Long canes are cut back in the late fall to control the shape of the plant and keep canes from arching over the lawn, growing into adjacent plants or giving an untidy appearance by falling onto the ground. Dead canes or sections of canes are cut out in the late winter or early Spring. Plants that have died during the previous season or those that have winter-killed are replaced with new plants in the early Spring.

During April, 1989 three plants of each of the 45 rose species and cultivars were labeled and examined for winter damage. Each plant was rated none, below average, average, or above average. None meant there was no visible winter damage to the canes, below average meant only the tips were killed, average meant that ¼ - ½ the cane was killed, and above average was recorded when more than ½ of the cane length was killed.

In late June, the vigor and regrowth of each plant was evaluated. A rating of weak, average or strong vigor was assigned to each plant based on observations of the new growth. An average cane length as of June 30, 1989 was also recorded for each individual plant.

Results and Discussion

A listing of 45 species and cultivars of old garden roses growing in the Garden of Roses of Legend and Romance on the campus of the Ohio Agricultural Research and Development Center in Wooster, Ohio is given on the following pages. These were selected at the time the garden was planted in 1969 by nurseryman Joseph J. Kern as outstanding roses from each of the major rose groups to grow in Ohio.

Average observations relative to winter damage, regrowth/vigor and cane length for the plants examined are given in the following table. In a few cases, dead wood had been removed in late winter, therefore meaningful observations could not be made. The hybrid perpetuals had been pruned back to a height of 3′ in December 1988. Due to this cultural practice, the recording of cane length does not reflect the previous season's growth.

The 1988/89 winter was generally considered mild with less than normal winter damage on hybrid tea roses and many other ornamental plants in the Wooster area. The winter damage on the old garden roses was in general below average with vigorous regrowth during the spring growing season.

The average cane length statistics are a combined result of natural plant form, age of the plant and cultural practices. Newly planted roses and those that had been pruned following the previous season's growth are naturally shorter than established plants that were not pruned. The data are established for a matter of reference upon which to compare future observations.

Table 1. Winter Damage, Vigor/Regrowth and Average Cane Length of Old Garden Roses-1989.

Species or Cultivar	Winter Damage AA	Winter Damage A	Winter Damage BA	Winter Damage N	Vigor/Regrowth S	Vigor/Regrowth A	Vigor/Regrowth W	Average Cane Length
Hybrid Perpetuals								(cm)
'Frau Karl Druschki' ('Snow Queen')	X					X		183
'General Jacqueminot' ('General Jack')		X			X			152
'Marchioness of Londonderry'	X					X		122
'Mrs. John Laing'				X	X			97
'Paul Neyron'				X	X			127
'Roger Lambelin'	X					X		213
Bourbons								
'LeReine Victoria'	X					X		168
'Louise Odier'		X			X			168
'Souvenir de la Malmaison'		X			X			107
Chinensis								
'Hermosa'	X					X		91
'Old Blush'	X						X	122
Species Roses								
Rosa foetida bicolor ('Austrian Copper')				X	X			168
Rosa moyessi				X		X		183
Rosa hugonis ('Golden Rose of China')			X				X	76
Hybrid Foetidas								
'Harison's Yellow'				X	X			168
Hybrid Spinosissimas								
'Stanwell Perpetual'		X				X		89
Gallicas								
Rosa gallica officinalis ('Apothecary Rose')				X		X		89
'Camaieux'		X					X	64
'Empress Josephine'			X				X	91
Rosa gallica grandiflora ('Alika')				X	X			140
Rosa gallica versicolor ('Rosa Mundi')				X	X			102
Centifolias								
Rosa centifolia ('Provence Rose', 'Pink Cabbage')				1		X		130
Rosa centifolia bullata				1		X		104
'Red Provence'				1		X		130
'Rose des Peintres' ('Painter's Rose')				1	X			102
Albas								
Rosa alba				1	X			165
'Koenigin von Danemarck'				1		X		117
'Maiden's Blush'				1		X		114
'Mme. Legras de St. Germain'				1	X			89
Eglanterias								
'Lady Penzance'				X	X			203
'Lord Penzance'				X		X		122
Rosa eglanteria ('Sweet Brier Rose')				X	X			183
Rugosa Shrubs and their Hybrids								
Rosa rugosa			X			X		102
Mosses								
'Alfred de Dalmas' ('Mousseline')		X				X		89
'Communis' ('Old Pink Moss')		X					X	140
'Crested Moss' ('Chapeau de Napoleon')			X			X		102
'Mme. Louis Leveque'				X		X		89
'Old Red Moss'			X			X		84
'Salet'			X				X	102

(Continued)

Table 1. (Continued)

Species or Cultivar	Winter Damage				Vigor/Regrowth			Average Cane Length
	AA	A	BA	N	S	A	W	
Damascenas								
'Leda' ('Painted Damask')				X		X		132
'Mme. Hardy'		X				X		122
'Rose of Castile'						X		127
'York and Lancaster'	X						X	122
Old Climber and Ramblers								
'Sombreuil'				X		X		198
Old Hybrid Teas								
'La France'			2		X			91

[1]Dead wood removed prior to data collection
[2]All new plants
Winter Damage: AA=Above average, A=Average, BA=Below average, N=None
Vigor/Regrowth: S=Strong, A=Average, W=Weak

References

1. Austin, David. 1988. A Heritage of the Rose. Antique Collectors Club Ltd., Woodbridge, Suffolk, England.
2. Beales, Peter. 1985. Classic Roses. Holt and Company, New York.
3. LeRougetal, Hazel. 1988. A Heritage of Roses. Stemmer House, Owings Mills, Maryland.