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Ornamental Plants — 1986: A Summary of Research

The Ohio State University
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CONTENTS

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ON THE COVER: Dr. Daniel Struve (standing), assistant professor of horticulture, and Dr. R. Daniel Lineberger, associate professor of horticulture, examine birch trees out-planted from the tissue culture laboratory.

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Effects of BAY RSW 0411 Growth Regulator on Cotoneaster and Forsythia

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ABSTRACT

A new growth regulator, BAY RSW 0411, has been introduced for experimental use on nursery crops. Vegetative growth of Royal Beauty cotoneaster and Spring Glory forsythia after one growing season was significantly reduced from control plants. There was unacceptable growth reduction at the 1,000 and 2,000 ppm rates on cotoneaster. Foliage color was considerably darker at all treatment rates with both plant species. Nitrogen levels in the foliage were higher in the 2,000 ppm rate with both species. N, P, and K were generally higher in cotoneaster foliage.

Following the second growing season from the one original treatment, there were no vegetative growth differences in forsythia, indicating that the plants resumed normal growth. The 2,000 ppm treatment on cotoneaster was still significantly reducing growth but the cotoneaster in the 500 and 1,000 ppm treatments resumed normal growth.

The commercial objective of growth regulator treatments is to reduce vegetative growth temporarily, to decrease the number of times pruning is required. The 500 ppm treatment was the most effective treatment with cotoneaster, the more sensitive species, while the 500 and 1,000 ppm rates were effective on forsythia.

INTRODUCTION

Chemical growth regulating compounds are used extensively in the fruit industry for a variety of purposes but very few are used in the nursery-landscape industry (3). The principal objective of growth regulator use is to reduce vegetative growth, particularly of rapidly growing deciduous and evergreen shrubs. Thus the number of required pruning treatments would be eliminated or reduced.

Pruning reductions are desirable in commercial production and in landscape maintenance with larger plant materials. In commercial production, fatty acid chemical pinching agents (Emgard) similar to but with not exactly the same mode of action have been used in azaleas (1). There has been limited commercial use of dikegulac sodium (Atrinal), ancymidol (A-Rest), and phosphonic acid (Florel) on selected crops (2, 4, 5). A major problem has been achieving non-uniform effects from treatment. Typically, the growth following hand pruning is not uniform and timing of spray treatments to achieve uniform growth reduction is difficult.

The objectives of this study were to evaluate the effects of a new growth regulator, BAY RSW 0411, over a 2-year period on cotoneaster and forsythia, both rapid growing shrubs.

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MATERIALS AND METHODS

The growth regulator evaluated in this study was BAY RSW 0411 from Mobay Chemical Corp. The chemical name of this compound has not been released for publication. The material was mixed with water and treated as a foliar spray at 500, 1,000, and 2,000 ppm. Treatments were applied on June 15, 1984, with new shoots actively growing. No additional treatments were applied for the next two growing seasons.

The plant materials selected for container study included *Cotoneaster dammeri* 'Royal Beauty' —Royal Beauty cotoneaster, a rapid growing evergreen, and *Forsythia intermedia* 'Spring Glory' — Spring Glory forsythia, a fast growing deciduous species. Plants from cuttings in the summer of 1983 were potted into 3.78 liter (1 gallon) containers on May 5, 1984. The media consisted of pinebark-peat in a 7:3 ratio by volume. Plants were fertilized, irrigated, and sprayed for pest control according to commercial practices.

There were three plants per treatment and three replications of each treatment located in a completely random plot design.

Plants were measured for vegetative growth and leaf color Sept. 26, 1984. Three plants were selected per replication for dry weight analysis. Following the second growing season, vegetative growth was measured August 29, 1985, and all remaining plants were harvested the same day for dry weight analysis.

All remaining plants after the first growing season were overwintered during the 1984-85 storage season under a 4-mil white copolymer plastic covered storage hut. There was no appreciable injury to any plants the following spring.

RESULTS AND DISCUSSION

One month following treatment, there was no effect from treatment either in the form of vegetative growth reduction or phytotoxicity to foliage or growing tips. However, by Sept. 26 or 3-1/2 months later, very striking results were evident in growth reductions and foliage color. As shown in Table 1, the vegetative growth of both cotoneaster and forsythia was significantly less than the untreated control. However, there was some foliage disfigurement and unacceptable growth reduction of cotoneaster at the 1,000 and 2,000 ppm treatments. The dry weights of both species were less than controls, with significant differences for all treatment rates on cotoneaster and the 2,000 ppm treatment on forsythia (Table 1).

The leaf color of both species in all treatment rates was a darker green (Table 1). An analysis of the foliage for mineral element values indicated that the 2,000 ppm rate resulted in higher nitrogen rates for both species.

TABLE 1.—Vegetative Growth, Dry Weight, and Leaf Color of Cotoneaster and Forsythia One Season Following Treatment with RSW 0411.

RSW 0411	Vegetative Growth (cm)		Dry Weight (g)		Leaf Color*	
Rate ppm	Cotoneaster	Forsythia	Cotoneaster	Forsythia	Cotoneaster	Forsythia
500	16.7†b‡	56.8b	24.2b	38.9ab	8.3b	8.3b
1000	13.2 b	49.1 bc	14.9b	33.6ab	9.3a	9.0a
2000	12.9 b	40.0c	11.5b	21.9b	9.7a	9.7a
Control	34.8 a	74.1 a	63.3a	45.1 a	5.0c	5.3c

*Visual scale 1-10, with 10 = dark green and 1 = yellow.
†Vegetative growth = 9 sample mean, dry wt = 3 sample mean, leaf color = a sample mean.
‡Tukey's studentized range test at the 5% level.

TABLE 2.—Mineral Element Values of Cotoneaster and Forsythia One Season Following Treatment with RSW 0411.

RSW 0411	Percent					ppm				
Rate ppm	N	P	K	Ca	Mg	Mn	Fe	B	Cu	Zn
Cotoneaster										
500	2.28*bc†	0.26bc	1.5a	1.4ab	0.24a	90ab	74a	34b	2.8a	117b
1000	2.76 ab	0.37ab	1.5a	1.6a	0.21a	105a	84a	43a	2.0a	143a
2000	3.12 a	0.46a	1.2a	1.5a	0.27a	125a	89a	49a	2.2a	155a
Check	1.82 c	0.16c	1.1b	1.2b	0.25a	54b	76a	27b	1.5a	116b
Forsythia										
500	1.75 b	0.18a	0.70a	0.95a	0.39a	211a	57a	25a	1.2a	188a
1000	1.90 b	0.18a	0.52a	1.1a	0.41a	290a	61a	30a	1.3a	197a
2000	2.12 a	0.21a	0.54a	1.1a	0.40a	285a	62a	35a	1.3a	206a
Check	1.74 b	0.14a	0.63a	0.95a	0.42a	185a	57a	35a	1.1a	204a

*Each figure represents the means of three plant samples.
†Tukey's studentized range test at the 5% level.

TABLE 3.—Vegetative Growth and Dry Weight of Cotoneaster and Forsythia Two Seasons Following Treatment with RSW 0411.

RSW 0411	Vegetative Growth (cm)		Dry Weight (g)	
Rate ppm	Cotoneaster	Forsythia	Cotoneaster	Forsythia
500	102.8*a†	113.5a	188.5a	143.0ab
1000	102.7 a	101.7a	191.0a	144.5ab
2000	59.8 b	103.3a	85.2	119.5b
Control	111.3 a	122.8a	257.7a	170.0a

*Each figure represents the mean of six samples.
†Tukey's studentized range test at the 5% level.

The 500 and 1,000 ppm rates resulted in increased nitrogen levels of cotoneaster. There were higher phosphorus and potassium levels in the foliage of cotoneaster with most treatment rates (Table 2).

After two growing seasons from treatment, the vegetative growth of cotoneaster was still reduced in the 2,000 ppm treatment. No other treatment with either plant reflected a decrease in height or width. The dry weight was less than control plants in the 2,000 ppm treatment of both species (Table 3). Foliage color was not recorded after the second season because color differences were no longer evident. For the same reason, no leaf analysis data were recorded the second year.

The results from this initial study with BAY RSW 0411 suggest that growth regulation does occur at least with cotoneaster and forsythia. It is not desirable to have significant carry-over effects into the second growing season in a production nursery, although this may be desirable in a landscape setting.

Sufficient regrowth following treatment is desired in the season of application to develop a salable plant without the need for pruning or more than one pruning. From this study there will most likely be species differences. Cotoneaster responded most positively to the 500 ppm rate where growth was slowed the first season, but sufficient regrowth occurred such that the plant was salable the first season. The 500 and 1,000 ppm rates were acceptable treatments for forsythia for the same reasons. The 2,000 ppm rate was too high and growth of both species was affected throughout the second season.

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Evaluation of Flowering Crabapple Susceptibility to Apple Scab in Ohio—1985

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ABSTRACT

The incidence of apple scab on flowering crabapples in Ohio in 1985 was relatively light compared with 1984 and some previous seasons. There were 127 selections found to be highly resistant or resistant and 79 selections observed to be susceptible or highly susceptible to apple scab in 1985. This compares to 89 highly resistant or resistant and 114 susceptible or highly susceptible in 1984 when the spring season was relatively moist.

INTRODUCTION

More than 200 selections of flowering crabapples can be located in Ohio nurseries and arboretums. Many of these are susceptible to some degree to apple scab (*Venturia inequalis*), a serious disease. When the disease is present, olive gray spots can be observed on the foliage which can lead to yellowing and defoliation of certain species and cultivars. Repeated defoliation weakens trees which leads to winter injury and reduced bloom in succeeding years.

Apple scab can be prevented through fungicide treatments but this is a costly and unnecessary procedure if resistant species are selected for planting initially. A sizable number of flowering crabappple selections are resistant or highly resistant to apple scab and these should be the types selected for future production by wholesale growers.

The purpose of this survey was to continue annual evaluations of flowering crabapple selections produced in Ohio for tolerance to apple scab.

MATERIALS AND METHODS

The survey of flowering crabapples located in nurseries and arboretums in Ohio was conducted in August 1985. Apple scab severity was rated and the presence of other diseases such as cedar apple rust, fireblight, and frog eye leaf spot were noted. Ratings were not given to the latter three diseases because they are rarely serious enough in Ohio to discontinue the planting of a species, hybrid, or cultivar.

Apple scab infestation 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; and HS = highly susceptible — heavy infection often accompanied by considerable defoliation. More than one notation may appear in the table for a given selection because severity of infection varied from location to location. This variation was most likely due to differences in time and amount of rainfall and average relative humidity.

RESULTS AND DISCUSSION

The severity of apple scab in Ohio in 1985 was much lower than in previous years because rainfall was generally below normal in April and May (2, 3).

There were 127 selections rated highly resistant or resistant to apple scab while 79 types were susceptible or highly susceptible (Table 1). In 1984, 89 selections were resistant or highly resistant and 114 susceptible or highly susceptible (3), indicating the variability which exists in the *Malus* genera.

Included among the most disease resistant (apple scab, cedar apple rust, fireblight, and frog eye leaf spot) selections in 1985 were *Malus* 'Beverly', 'Brandywine', 'Centennial', 'Christmas Holly', 'David', 'Dolgo', 'Donald Wyman', 'Golden Gem', 'Golden Hornet', 'Indian Summer', 'Jewelberry', and 'Liset'. Also, 'Madonna', 'Makamik', 'Mary Potter', *micromalus*, 'Molton Lava', 'Ormiston Roy', 'Prairie Rose', 'Red Jade', 'Red Jewel', *sargenti*, 'Sentinel', 'Fugi', 'Silver Moon', 'Snowcap', 'Snowmagic', 'Sugartyme', 'Strawberry Parfait', 'White Angel', and *zumi* 'Calocarpa'. These selections should be among those given highest priority for production, retail sales, and landscape use by the nursery industry.

The most disease susceptible selections included *Malus arnoldiana*, 'Dorothea', 'Ellen Gerhart', 'Evelyn', 'Flame', 'Hopa', 'Pink Perfection', 'Pink Spires', 'Pink Weeper', 'Aldenhamensis', 'Eleyi', 'Lemoinei', 'Radiant', 'Red Silver', 'Strathmore', and 'Tanner'. With few exceptions, the latter group should be discontinued from commercial production and sale in order to provide the gardening public with the best selections available.

Additional information on horticultural qualities such as flower, foliage, fruit, and growth habit can be obtained from publications such as The Flowering Crabapple — A Tree For All Seasons (1) or by visiting arboretums in late April through early May. In Ohio, the Secrest Arboretum in Wooster, the Holden Arboretum in Kirtland Hills, and the Dawes Arboretum in Newark all have excellent collections of flowering crabapples.

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TABLE 1.—Susceptibility of Flowering Crabapples to Apple Scab—1985.

Species, Hybrid, or Cultivar	Apple Scab Rating*				Other Diseases Noted
	HR	R	S	HS	
'Adams'		X			
M. x *adstringens*				X	
'Almey'			X		
'American Beauty'		X			
'Amisk'				X	
'Amur'	X				
M. x *arnoldiana*			X	X	
'Arrow'				X	
M. x *atrosanguinea*		X			
M. baccata	X				
M. baccata columnaris	X	X			
M. baccata 'Jackii'	X				Fireblight
M. baccata var. Mandshurica		X	X		
M. baccata 'Midwest'	X				
'Barbara Ann'			X		
'Beverly'	X				
'Bob White'	X				Frog Eye Leaf Spot
'Brandywine'	X				
M. brevipes				X	Fireblight
'Burgundy'		X			
'Calloway'	X				Frog Eye Leaf Spot
'Candied Apple'		X			
'Cashmere'			X		Fireblight
'Centennial'	X				
'Centurion'		X			
'Cheal's Crimson'				X	
'Chestnut'	X				
'Chilko'	X				
'Christmas Holly'	X				
'Coralburst'		X			Frog Eye Leaf Spot
M. coronaria 'Charlottae'			X		
M. coronaria 'Dasycalyx'				X	
M. coronaria 'Nieuwlandiana'			X	X	Frog Eye Leaf Spot
'Cowichan'			X		
'Crimson Brilliant'				X	
'Dainty'			X		
'David'	X				
'Dawsoniana'	X				
'Dolgo'	X				
'Donald Wyman'	X				
'Dorothea'				X	
'Dorothy Rowe'	X				
'Ellen Gerhart'				X	
'Evelyn'				X	
'Exzellenz Theil'				X	
'Flame'			X	X	
'Flexilis'	X				
M. floribunda	X	X			Cedar Apple Rust, Fireblight
'Fusca'	X				
'Geneva'	X				Frog Eye Leaf Spot

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

TABLE 1 (continued).—Susceptibility of Flowering Crabapples to Apple Scab—1985.

Species, Hybrid, or Cultivar	Apple Scab Rating* HR	R	S	HS	Other Diseases Noted
'Goldfinch'				X	
M. glaucescens		X			
M. gloriosa		X			
'Golden Gem'	X				
'Golden Hornet'	X				
'Gwendolyn'	X				
M. halliana	X				
M. halliana 'Parkmanii'	X				Fireblight
M. halliana 'Spontanea'	X				
M. x *hartwigii*	X				
'Harvest Gold'		X			
'Henningi'	X				
'Henrietta Crosby'				X	
'Henry Dupont'		X			Fireblight
'Hopa'			X	X	
'Hopa Austrian'			X		
'Hopa Dwarf'	X				
'Hopa Rosea'			X		
M. hupehensis	X				Fireblight
'Indian Magic'	X	X			
'Indian Summer'	X				
M. ioensis		X	X		
M. ioensis 'Klehms'		X			Cedar Apple Rust
'Klehms Improved'	X				
'Irene'				X	
'Jay Darling'				X	
'Joan'	X				
'Jewelberry'	X				
'Katherine'			X		
'Kibele'		X			
'Kirghisorum'	X				
M. lancifolia			X		Frog Eye Leaf Spot
'Leslie'	X				
'Liset'	X				
'Madonna'	X				
M. x *magdeburgensis*		X			Frog Eye Leaf Spot
'Makamik'	X				
'Marshall Oyama'	X				
'Mary Potter'	X				
'Masek'				X	Fireblight
M. x *micromalus*	X				
'Molton Lava'	X				
M. 'Neville Copeman'			X		
'Oakes'	X				
'Oekonomierat Echtermeyer'				X	
'Ormiston Roy'	X				
'Patricia'	X				
'Pink Beauty'	X	X			
'Pink Cascade'		X	X		
'Pink Flame'				X	
'Pink Perfection'				X	
'Pink Spires'				X	
'Pink Weeper'				X	
'Prairie Rose'	X				Frog Eye Leaf Spot
'Prairifire'	X				
'Pretty Marjorie'			X		
'Prince Georges'	X	X			
'Profusion'		X			
'Prof. Springer'	X				
M. prunifolia				X	

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

TABLE 1 (continued).—Susceptibility of Flowering Crabapples to Apple Scab—1985.

Species, Hybrid, or Cultivar	Apple Scab Rating* HR	R	S	HS	Other Diseases Noted
M. prunifolia 'Pendula'	X				
M. prunifolia var. *rinkii*				X	
M. pumila 'Elise Rathke'				X	
M. pumila 'Niedzwetzkyana'				X	
M. pumila 'Paradise Foleus Aureus'		X			Frog Eye Leaf Spot
'Purple Wave'			X		
M. purpurea			X	X	
M. x *purpurea* 'Aldenhamensis'			X	X	Frog Eye Leaf Spot
M. x *purpurea* 'Eleyi'				X	
M. purpurea 'Lemoinei'				X	
M. 'Pygmy'			X		
'Radiant'				X	
'Ralph Shay'		X	X		Frog Eye Leaf Spot
'Red Baron'		X			
'Red Bud'				X	Fireblight
'Red Edinburgh'		X			
'Red Jade'	X				
'Red Jewel'	X				
'Red Flesh'		X			
'Red Silver'			X	X	
'Red Splendor'		X	X		
'Ringo'				X	
'Robinson'			X		
M. x *robusta*	X				
M. x *robusta* 'Erecta'		X			
M. robusta 'Persicifolia'	X				
'Rose Tea'	X				
'Rosseau'	X				
'Rosybloom'	X				
'Royal Ruby'			X		
'Royalty'		X	X		
'Ruby Luster'	X	X			
'Rudolf'				X	
M. sargentii	X				
M. sargentii 'Rosea'	X				
M. sargentii 'Rose Low'	X				
M. sargentii 'Tina'	X				
M. x *scheideckeri*			X	X	
M. x *scheideckeri* 'Hillieri'			X	X	
'Scugog'	X				
'Selkirk'	X	X			
'Sentinel'	X				
'Shakespeare'			X		
M. sieboldi	X	X			
M. sieboldi 'Fuji'	X				
M. sikkimensis	X	X			
'Silver Moon'	X				
'Simcoe'	X				
'Sissipuk'		X	X		Frog Eye Leaf Spot
'Snowcap'	X				
'Snowcloud'	X	X			
'Snowdrift'		X	X		
'Snowmagic'	X				
M. x *soulardii*		X			
'Sparkler'		X	X		
M. spectabilis			X		
M. spectabilis 'Albi-Plena'			X	X	Frog Eye Leaf Spot
M. spectabilis 'Riversii'		X			
M. spectabilis 'Van Eseltine'		X			
'Spring Snow'		X			
'Strathmore'				X	

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

TABLE 1 (continued).—Susceptibility of Flowering Crabapples to Apple Scab—1985.

Species, Hybrid, or Cultivar	Apple Scab Rating* HR	R	S	HS	Other Diseases Noted
'Strawberry Parfait'	X				
M. x *sublobata*			X		
'Sugartyme'	X				
'Sundog'	X				
M. sylvestris 'Plena'	X				
'Tanner'				X	
M. toringoides			X		
M. toringoides 'Macrocarpa'			X		Frog Eye Leaf Spot
'Trail'	X				
M. tschonoski	X				Fireblight
'Turesi'				X	
'Valley City #4'			X		
'Vanguard'		X			
'Velvet Pillar'			X		
'Wabiskaw'				X	
'White Angel'	X				
'White Candle'		X			
'White Cascade'	X	X			
'Wickson'	X				
'Wilson'			X		
'Winter Gold'			X		
'Wooster No. 1'	X				
M. yunnanensis 'Veitchi'	X				
M. yunnanensis 'Veitch's Scarlet'	X				
M. zumi	X	X			
M. zumi 'Calocarpa'	X				

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

Tolerance of Woody Landscape Vines to Goal Combinations

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ABSTRACT

The specific objective of this study was to evaluate Goal combinations on container grown clematis, wisteria, silver lace vine, and trumpetcreeper. Goal at 2.0 lb ai/A in combination with Prowl at 1.0 lb ai/A marketed as Ornamental Herbicide-2 (OH-2) controlled weeds very successfully for 3 months, as did Goal at 2.0 lb ai/A in combination with Surflan at 1.0 lb ai/A marketed as Rout.

Both pre-emergence herbicides were too phytotoxic within a week of application on clematis, wisteria, and silver lace vine. At recommended rates, trumpetcreeper was slightly injured by both compounds, although not below acceptable levels. Due to the extensive nature of this injury, neither OH-2 nor Rout should be used with clematis, wisteria, or silver lace vine.

INTRODUCTION

Several woody species of vines are commercially grown in Ohio. There are no U.S. Environmental Protection Agency (EPA) approved herbicides for use on these crops. There has been a recent significant expansion of vine production in Ohio and this has brought producer concerns relative to the use of herbicides.

The combination of Goal (oxyfluorfen) and Prowl (pendimethalin) has proven quite effective in container nurseries against a variety of weeds. A relatively new herbicide, a combination of Goal and Surflan (oryzalin), is also effective against a wide spectrum of weeds. Previous research has shown that Goal can be somewhat phytotoxic to landscape crops (1, 2, 3, 4); however combinations of Goal are much safer products.

The objective of this evaluation was to determine if either of the Goal combination products presently available could be safely used in container production of several common vine crops.

MATERIALS AND METHODS

Vine crops selected for this study included: *Clematis paniculata*—Sweetautumn Clematis, *Campsis radicans* — Trumpetcreeper, *Polygonum aubertii*—Silver Lace Vine, and *Wisteria sinensis*—Chinese Wisteria. The dormant plants were potted May 21, 1985, in either 2-or 3-gallon containers filled with a media of pinebark-peat-sand medium (7-2-1) by volume. Plants were fertilized with Osmocote 18-6-12 at 1 tablespoon per 2-gallon container and 1.5 tablespoons per 3-gallon container June 1 and irrigated as needed with overhead sprinklers. The plants were treated with herbicides on May 20.

The herbicides used in this study included Ornamental Herbicide-2 (Goal and Prowl) at 2.0 lb ai/A + 1.0 lb ai/A or 8.0 lb ai/A + 4.0 lb ai/A, respectively, and Rout (Goal and Surflan) at the same rates. All herbicide treatments were irrigated the day of application.

There were three plants per treatment and four replications placed in a randomized block design.

Weed species present included foxtail, lambsquarters, purslane, spotted spurge, lesser bittercress, and oxalis.

All evaluations for weed control were on a 1 to 10 scale, with 1 equaling no weed control, 10 equal to perfect weed control, and a rating of 7 or above acceptable weed control. Evaluations for phytotoxicity were also on a 1 to 10 scale, with 1 equaling no weed control, 10 equal to perfect weed control, and 7 or above acceptable. Evaluations were recorded May 28, June 10, July 1, and August 25.

RESULTS AND DISCUSSION

Both Goal combination products controlled annual weeds for 3 months. There were few weeds in the Goal and Prowl plots and essentially none in the Goal and Surflan treatments at the conclusion of the study (Table 1).

Sweetautumn clematis was severely injured 1 week following application and did not appreciably recover from the initial foliage discoloration and stunting during the 3-month evaluation period (Table 2). Neither Ornamental Herbicide 2 nor Rout should be used to treat sweetautumn clematis.

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TABLE 1.—Weed Control in Woody Landscape Vines with Goal Combinations.

Treatment	Rate lb ai/A	Weed Control* May 28	June 10	July 1	August 25
Control	--	8	7	5	5
Goal and Prowl	2.0 and 1.0	10	9	9	9
Goal and Prowl	8.0 and 4.0	10	10	10	9
Goal and Surflan	2.0 and 1.0	10	10	10	10
Goal and Surflan	8.0 and 4.0	10	10	10	10

*Visual scale 1-10, with 1 = no weed control, 10 = complete weed control, and 7 = acceptable.

Clematis paniculata — Sweetautumn Clematis. Note height difference between treated and check plants.

Chinese wisteria foliage was also severely discolored and stunted within 1 week of application with both herbicides at the recommended and four times recommended rates (Table 2). However, some plant recovery was observed in June and by late August recovery was almost complete. Even though all the plants survived the herbicide treatments and eventually recovered, use of these two Goal compounds cannot be recommended for use on wisteria.

Silver lace vine was also very sensitive to the Goal compounds at both rates and Goal should be avoided on this species. The initial damage was large brown tan spots on lower leaves only with some defoliation.

Trumpetcreeper was injured initially to some degree by all treatments (Table 2). The four times recommended rate of both compounds resulted in injury too severe to be commercially acceptable; however, the plants in the 1X treatment were commercially acceptable throughout the 3 months. The injury that did occur was in the form of brown leaf spotting. At the end of the study, all trumpetcreeper plants were given low injury ratings of 9 and 10, indicating almost complete recovery. Ornamental Herbicide 2 and Rout if given EPA approval could be used at 1X rates on trumpetcreeper if the grower accepts slight injury.

In summary, neither Ornamental Herbicide 2 containing Goal and Prowl nor Rout containing Goal and Surflan can be used without excessive phytotoxicity on sweetautumn clematis, Chinese wisteria, and silver lace vine. The herbicides were less phytotoxic to trumpetcreeper at recommended rates.

TABLE 2.—Tolerance of Woody Landscape Vines to Goal Combinations.

Treatment	lb ai/A	Clematis				Wisteria				Silver Lace Vine				Trumpetcreeper			
		May	June	July	August	May	June	July	August	May	June	July	August	May	June	July	August
Control	--	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Goal and Prowl	2.0 and 1.0	5	5	5	6	5	7	9	9	6	7	9	8	7	8	9	9
Goal and Prowl	8.0 and 4.0	3	3	3	4	5	6	6	8	4	5	8	7	5	5	6	9
Goal and Surflan	2.0 and 1.0	4	5	6	7	5	6	9	9	6	6	8	8	7	8	10	10
Goal and Surflan	8.0 and 4.0	4	4	4	5	5	6	8	9	5	6	7	8	5	6	9	10

*Visual scale 1-10, with 1 = complete crop kill and 7 or above acceptable.

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Tolerance of *Hosta albomarginata* to Napropamide and Oryzalin

ELTON M. SMITH and SHARON A. TREASTER[1]

ABSTRACT

No pre-emergence herbicides are labeled for use with hosta, one of the most popular herbaceous landscape plants. This study was designed to determine weed control and the level of tolerance of *Hosta albomarginata* to napropamide (Devrinol) and oryzalin (Surflan). Weed control was acceptable with all herbicides throughout the evaluation period. Oryzalin was almost completely non-injurious to hosta throughout the study. Napropamide 5%G was somewhat less phytotoxic than the 50% formulation, especially at the 4X rate. The greatest amount of foliar injury occurred on May 6, 3 weeks following treatment.

INTRODUCTION

One of the more popular herbaceous ornamental plants in the marketplace today is hosta, especially the variegated selections. Unfortunately, there are no pre-emergence herbicides which can be recommended to producers, landscapers, or grounds maintenance personnel for weed control in this crop (3).

Previous research (1, 2, 4) with herbaceous perennials indicated that oryzalin is an effective herbicide with relatively little phytotoxicity. In 1984, oryzalin was registered by the U.S. Environmental Protection Agency (EPA) for use with herbaceous annual plants; however, hosta and other perennials were not included on the label.

Napropamide, registered for woody landscape crops but not herbaceous species, has been shown (4) to be relatively non-phytotoxic with some perennial crops.

The specific objectives of this evaluation were to determine the efficacy and phytotoxicity of oryzalin 75W and napropamide 5G and 50W on *Hosta albomarginata*, a variegated selection.

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MATERIALS AND METHODS

The herbicides evaluated in this study were: napropamide (Devrinol) 5G at 4.0 and 16.0 lb ai/A, napropamide (Devrinol) 50W at 4.0 and 16.0 lb ai/A, and oryzalin (Surflan) 75W at 2.0 and 8.0 lb ai/A. Each herbicide was applied at recommended and 4X rates.

The plant selected for this evaluation is one of many variegated hosta selections, *Hosta albomarginata*. The plants were canned March 20, 1985, into 3.78 liter (1 gallon) pots containing pinebark and peat in a 7:3 ratio by volume. Plants were fertilized with 18-6-12 osmocote, treated with slug bait, placed in shade, and irrigated as needed.

Granular napropamide was applied on April 17 with a hand held rotary spreader and the wettable powders were applied with a pump-type compression sprayer on the same date.

There were three plants per treatment and four replications of each treatment. Plants were evaluated using a 1-10 visual scale, with 7 acceptable and 10 best. Plants were evaluated 3, 6, and 9 weeks from treatment, after which the plants covered the containers and herbicides were no longer necessary.

RESULTS AND DISCUSSION

Weed Control: Weed control was effectively achieved throughout the duration of the experiment, although by mid-June weed control was not as satisfactory as earlier in the study (Table 1). As expected, weed control was more effective at the 4X rate but that treatment was incorporated principally to determine the degree of phytotoxicity of a given herbicide.

Phytotoxicity: Oryzalin 75W at the 2.0 lb ai/A rate was completely non-phytotoxic in this evaluation on all evaluation dates (Table 2). The 8.0 lb ai/A rate was also an extremely safe treatment. Based on this success-

TABLE 1.—Weed Control in *Hosta albomarginata* with Pre-emergence Herbicides.

Treatment	Rate lb ai/A	Evaluation Date May 6	May 22	July 14
Oryzalin 75W	2.0	8.3*	8.3	7.3
Oryzalin 75W	8.0	9.5	9.5	8.5
Napropamide 5G	4.0	8.0	8.0	7.7
Napropamide 5G	16.0	9.5	9.3	9.5
Napropamide 50W	4.0	9.0	9.5	8.8
Napropamide 50W	16.0	9.8	9.3	8.8
Control	--	7.3	6.3	5.3

*Visual weed control rating 1-10, with values of 7 or above acceptable and 10 best.

TABLE 2.—Phytotoxicity of *Hosta albomarginata* with Pre-emergence Herbicides.

Treatment	Rate lb ai/A	Phytotoxicity Ratings May 6	May 22	July 14
Oryzalin 75W	2.0	10.0*	10.0	10.0
Oryzalin 75W	8.0	9.8	10.0	10.0
Napropamide 5G	4.0	9.8	9.5	9.8
Napropamide 5G	16.0	9.5	9.8	9.5
Napropamide 50W	4.0	8.8	9.3	9.5
Napropamide 50W	16.0	6.5	7.3	7.5
Control	--	10.0	10.0	10.0

*Visual phytotoxicity rating 1-10, with values of 7 or above acceptable and 10 best.

ful evaluation, additional trials should be conducted with other cultivars in various media and soil types.

Napropamide 5G appeared to be slightly less phytotoxic than 50W, especially at the 4X rate. The 4X rate of 50W was initially too phytotoxic for commercial application, even though there was some plant recovery at later evaluation dates. Additional trials should also be conducted with napropamide, particularly the 5G formulation, since there was very slight phytotoxocity and reasonably good weed control.

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An Evaluation of Metribuzin Slow-release Herbicide Tablets on Woody Landscape Crops

ELTON M. SMITH, STANLEY F. GORSKI, and MELISSA MOORE[1]

ABSTRACT

Slow-release herbicide tablets containing metribuzin alone and in combination with Monsanto 097 and metolachlor were evaluated on container grown *Euonymus fortunei* 'Emerald 'N Gold', *Cotoneaster apiculata*, and *Juniperus horizontalis* 'Wiltoni'. Juniper was most tolerant to herbicide treatments, followed by cotoneaster and euonymus. The most effective weed control treatment with the minimum plant injury was achieved with the combination of metribuzin and Monsanto 097. The most effective tablet size was 6 mm diameter with two tablets per container.

INTRODUCTION

Slow-release fertilizers have been an effective means of providing mineral elements to nursery and other horticultural crops for many years. Slow-release fertilizers in a tablet form have also been on the market for some years. However, successful slow-release pesticides and, in particular, herbicides have not been important in the nursery industry. In fact, slow-release herbicides are not on the market.

Previous studies in Georgia (4, 5) and Ohio (1, 2, 3) have indicated the possibility of utilizing certain herbicides in a slow-release form. Although there has been some degree of success in obtaining season-long control (3, 4, 5), there has not been outstanding control of both narrow and broadleaved weeds, especially the latter. Broadleaf weed herbicides such as simazine (Princep), oxadiazon (Ronstar), and diclobenil (Casoron) do not have sufficient solubility to leach out of the tablets quickly enough and are not satisfactory ingredients.

Metribuzin (Sencor and Lexone), labeled for soybeans and selected vegetable crops but not landscape crops, controls broadleaf weeds and is soluble enough for incorporation into the tablets. Early trials with this material were rather phytotoxic to several ornamentals at the rates selected (2). To attempt to offset the plant injury in earlier studies, lower rates of metribuzin were utilized in this evaluation. Also, metribuzin was combined with Monsanto 097 and metolachlor (Dual) in an attempt to increase the spectrum of weed control.

The specific objectives of this slow-release herbicide study were to: 1) evaluate metribuzin alone and in combination for weed control and phytotoxicity on three container grown nursery species, and 2) evaluate tablet size and number in a 1-gallon container for weed control and plant phytotoxicity.

MATERIALS AND METHODS

The herbicides evaluated were technical grade metribuzin (99.4%), Monsanto 097 (86.0%), and metolachlor (97.0%). Metribuzin and metolachlor are federally registered for use with various agronomic and horticultural crops. Monsanto 097 is an experimental compound with no registrations at this time.

Metribuzin was incorporated into each tablet at the rate of 1.875 kg/ha (2,418 ppm), Monsanto 097 at 7.5 kg/ha (9,740 ppm), and metolachlor at 7.5 kg/ha (9,740 ppm).

The tablets consisted of dicalcium phosphate and 2% magnesium stearate and were pressed with a Stokes Model F single-punch tablet machine.

Plant materials in the study were *Euonymus fortunei* 'Emerald 'N Gold'—Emerald 'N Gold Euonymus, *Cotoneaster apiculata*—Cranberry Cotoneaster, and *Juniperus horizontalis* 'Wiltoni'—Blue Rug Juniper. The liners were potted into 3.78 liter (1 gallon) containers in a hardwood bark and peat medium (7:3 by volume). Plants were potted on July 22 and treated with tablets on July 23, 1984. Following treatment the plants were mulched with hardwood bark to prevent birds from removing the tablets.

Plants were fertilized with 20-20-20 at 200 ppm N twice a week. Irrigation and insecticides were applied as needed.

There were two plants per species in each treatment with three replications of each treatment. Plants were arranged in a randomized block design. Evaluations were conducted at 4, 6, 10, and 14 weeks from treatment. Data were analyzed using Tukey's studentized range test at the 5% level.

RESULTS AND DISCUSSION

Annual weed control was generally very satisfactory through 10 weeks in most treatments (Table 1). Statistically, the most effective treatments were the combination of metribuzin and Monsanto 097 at the 6 mm, 2-tablet per container rate and the 12 mm, 1-tablet rate.

Blue Rug Juniper was not injured with any treatment at any combination of tablet size or number per container. Since there was no injury, the data are not presented in tabular form.

Emerald 'N Gold Euonymus after 10 weeks was injured to some degree by most treatments (Table 2). Minimum to no injury was observed in metribuzin alone at 6 mm with 1 tablet, metribuzin + Monsanto 097 at 6 mm with 1 and 2 tablets, and metribuzin + metolachlor at 6 mm with 1 and 2 tablets.

Cranberry Cotoneaster was damaged to a lesser extent than Euonymus. After 10 weeks only one treatment was judged unacceptable and that was metribuzin alone at 12 mm with 1 tablet per container (Table 3). All other treatments were acceptable to producers.

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In an attempt to select the best treatments with all plant species included, the combination of metribuzin and Monsanto 097 at 6 mm, 2 tablets per container gave the most satisfactory weed control without appreciable injury to euonymus, cotoneaster, or juniper. Since cotoneaster and juniper were more tolerant of the herbicides than euonymus, a wider choice of treatments could be selected for these species.

Further research is needed to evaluate many more nursery species for tolerance to metribuzin and/or its combinations. Studies need to be conducted to determine the lowest possible rate of metribuzin which can be used and still result in acceptable weed control for the season.

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TABLE 1.—Weed Control from Slow Release Herbicide Tablets.

Herbicide Treatment	Tablet Size (mm)	Tablets/ Container	Weed Control		
			Sept. 4	Oct. 3	Nov. 7
Metribuzin	6	1	7.7*abcd†	7.3ab	7.3a
Metribuzin	6	2	7.7abcd	8.0ab	5.0a
Metribuzin	6	3	9.0abc	8.7ab	8.3a
Metribuzin	9	1	7.0bcd	8.0ab	5.3a
Metribuzin	9	2	9.3abc	9.0ab	6.7a
Metribuzin	12	1	8.7abcd	8.0ab	4.7a
Metribuzin+ Monsanto 097	6	1	8.3abcd	8.0ab	7.3a
Metribuzin+ Monsanto 097	6	2	9.67ab	9.7a	8.3a
Metribuzin+ Monsanto 097	6	3	9.7ab	9.3ab	8.7a
Metribuzin+ Monsanto 097	9	1	9.3abc	8.0ab	6.3a
Metribuzin+ Monsanto 097	9	2	10.0a	8.7ab	8.3a
Metribuzin+ Monsanto 097	12	1	9.3abc	9.7a	8.7a
Metribuzin+ Metolachlor	6	1	6.7cd	6.0b	5.0a
Metribuzin+ Metolachlor	6	2	8.7abcd	8.3ab	6.7a
Metribuzin+ Metolachlor	6	3	9.0abc	8.7ab	7.0a
Metribuzin+ Metolachlor	9	1	8.0abcd	6.7ab	5.7a
Metribuzin+ Metolachlor	9	2	9.0abc	9.0ab	8.3a
Metribuzin+ Metolachlor	12	1	7.3abcd	7.7ab	7.0a
Control	--	-	6.0d	6.0b	4.7a

*Visual scale 1-10, with 1=no weed control, 10=excellent weed control, and 7 or above acceptable.
†Data analyzed by Tukey's studentized range test at the 5% level.

TABLE 2.—Tolerance of Emerald N' Gold Euonymus to Slow Release Herbicide Tablets.

Herbicide Treatment	Tablet Size (mm)	Tablets/ Container	Phytotoxicity Euonymus		
			Sept. 4	Oct. 3	Nov. 7
Metribuzin	6	1	10.0*a†	10.0a	10.0a
Metribuzin	6	2	9.7a	9.0ab	8.7ab
Metribuzin	6	3	9.3a	9.3ab	8.0abc
Metribuzin	9	1	8.3a	8.0ab	8.0abc
Metribuzin	9	2	6.0a	5.0bc	3.3cd
Metribuzin	12	1	7.0a	6.3ab	4.7bcd
Metribuzin+ Monsanto 097	6	1	10.0a	10.0a	10.0a
Metribuzin+ Monsanto 097	6	2	10.0a	10.0a	9.7a
Metribuzin+ Monsanto 097	6	3	8.7a	8.0a	8.3ab
Metribuzin+ Monsanto 097	9	1	6.3a	8.3ab	7.0abc
Metribuzin+ Monsanto 097	9	2	8.0a	7.0ab	6.0abcd
Metribuzin+ Monsanto 097	12	1	8.0a	7.3ab	7.7abc
Metribuzin+ Metolachlor	6	1	9.0a	9.7a	10.0a
Metribuzin+ Metolachlor	6	2	9.7a	9.7a	10.0a
Metribuzin+ Metolachlor	6	3	8.7a	8.3ab	7.7abc
Metribuzin+ Metolachlor	9	1	8.3a	8.0ab	7.0abc
Metribuzin+ Metolachlor	9	2	5.7a	1.7c	1.3d
Metribuzin+ Metolachlor	12	1	8.7a	7.3ab	5.7abcd
Control	--	-	10.0a	10.0a	10.0a

*Visual scale 1-10, with 1=complete crop kill, 10=no crop injury, and 7 or above acceptable.
†Data analyzed by Tukey's studentized range test at the 5% level.

TABLE 3.—Tolerance of Royal Beauty Cotoneaster to Slow Release Herbicide Tablets.

Herbicide Treatment	Tablet Size (mm)	Tablets/ Container	Phytotoxicity Cotoneaster Sept. 4	Oct. 3	Nov. 7
Metribuzin	6	1	9.7*a†	10.0a	9.3ab
Metribuzin	6	2	9.3a	9.7a	9.3ab
Metribuzin	6	3	9.3a	9.3a	9.7a
Metribuzin	9	1	8.3ab	9.7a	10.0a
Metribuzin	9	2	6.7ab	7.0ab	7.0bc
Metribuzin	12	1	5.3b	5.0b	5.3b
Metribuzin+ Monsanto 097	6	1	9.7a	10.0a	10.0a
Metribuzin+ Monsanto 097	6	2	10.0a	10.0a	10.0a
Metribuzin+ Monsanto 097	6	3	9.7a	10.0a	9.7ab
Metribuzin+ Monsanto 097	9	1	9.7a	10.0a	9.3ab
Metribuzin+ Monsanto 097	9	2	8.0ab	8.7a	10.0a
Metribuzin+ Monsanto 097	12	1	8.3ab	9.3a	9.3ab
Metribuzin+ Metolachlor	6	1	10.0a	10.0a	9.7ab
Metribuzin+ Metolachlor	6	2	9.7a	10.0a	10.0a
Metribuzin+ Metolachlor	6	3	10.0a	9.3a	9.3ab
Metribuzin+ Metolachlor	9	1	7.3ab	7.7ab	7.3abc
Metribuzin+ Metolachlor	9	2	8.0ab	9.0a	9.7ab
Metribuzin+ Metolachlor	12	1	7.0ab	7.0ab	5.3c
Control	--	-	10.0a	10.0a	10.0a

*Visual scale 1-10, with 1=complete crop kill, 10=no crop injury, and 7 or above acceptable.
†Data analyzed by Tukey's studentized range test at the 5% level.

A Comparison of Armin and Ethyl Visqueen White Copolymers for Overwintering Landscape Plants

ELTON M. SMITH and SHARON A. TREASTER[1]

ABSTRACT

Following 4 months of winter storage, the quality of plants stored in walk-in houses covered with Armin and Ethyl Visqueen white copolymer was essentially similar. There were no differences in average minimum temperatures. The average maximum temperature was warmer under the Armin film in March but not significantly warmer in December, January, or February. Light transmission was significantly greater through Armin film when measured in March and April. There were no differences in thickness or bursting strength between the film sources. In general, except for greater light transmission with the Armin film, the two white co-polymers were essentially equal in comparison and very satisfactory for winter storage of landscape plants.

INTRODUCTION

In Ohio, nearly all container grown and a high percentage of autumn harvested field grown B & B evergreens are overwintered under white poly covered structures (3). Within the past several years, Armin Plastics (the formulator of Tufflite Clear film used for covering production greenhouses) has introduced a white copolymer for nursery storage. This white film was compared to a white copolymer film extruded by the Ethyl Visqueen Corp., one of the standard nursery storage films available in the nursery industry for many years. Previous research with Ethyl Visqueen white copolymer has shown it to be a very satisfactory film (1, 2).

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The specific objectives of this study were to: 1) evaluate plant condition following 4 months of storage under two white copolymer sources, 2) monitor minimum and maximum temperatures daily during the storage season, 3) evaluate light transmission through each poly covering, and 4) determine film thickness and bursting strength of both copolymer films.

MATERIALS AND METHODS

The study was conducted in winter storage houses measuring 97′ x 14′ x 7′ located in The Ohio State University container research nursery in Columbus. The houses were covered in November 1984 following a fungicide treatment and thorough watering of the plants.

The plants evaluated for winter injury included: *Berberis thunbergi* 'Crimson Pygmy' — Crimson Pygmy Barberry, *Chamaecyparis obtusa* 'Boulevard' — Boulevard Falsecypress, *Cotoneaster apiculata* — Cranberry Cotoneaster, *Potentilla fructicosa* 'Sutters Gold' — Sutters Gold Potentilla, *Spiraea bumalda* 'Gold Flame' — Gold Flame Spirea, and *Viburnum macrocephalum* — Chinese Snowball Viburnum. All plants were in 3.78 liter (1 gallon) containers. Evaluations of foliage and roots were on a visual scale of 1 to 10, with 7 and above acceptable.

The films evaluated were 4 mil white copolymer nursery storage coverings from Armin Plastics and Ethyl Visqueen Corp.

Temperatures were recorded with Taylor Hi-Lo thermometers. Minimum and maximum temperatures were recorded daily from Dec. 1 through March 30.

TABLE 1.—Condition of Plants Following Winter Storage During 1984-1985. Evaluation May 6, 1985.

Treatment and Plant Material	Replicate No. 1	Replicate No. 2	Replicate No. 3	Average
Visqueen Covered Poly House				
Potentilla 'Sutters Gold'	10*	10	10	10
Cotoneaster apiculata	7	7	1	5
Viburnum macrocephalum	4	1	1	2
Spiraea 'Gold Flame'	10	10	10	10
Chamaecyparis 'Boulevard'	10	10	9	10
Berberis 'Crimson Pygmy'	7	6	6	6
Armin Covered Poly House				
Potentilla 'Sutters Gold'	10	10	10	10
Cotoneaster apiculata	9	5	1	5
Viburnum macrocephalum	1	1	1	1
Spiraea 'Gold Flame'	10	10	10	10
Chamaecyparis 'Boulevard'	10	10	10	10
Berberis 'Crimson Pygmy'	10	3	3	5

*Figures represent visual evaluation of three plants using a 1-10 scale, with 7 acceptable and 10 best.

TABLE 2.—Monthly Maximum and Minimum Temperatures During Winter Storage 1984-1985. Each figure represents an average of 30 readings.

Treatment	Dec.	Jan.	Feb.	March
Maximum Winter Temperatures				
Visqueen Covered House	52.1ab*	42.0a	48.9ab	64.1b
Armin Covered House	57.5a	47.0a	55.6a	75.1a
Outside	49.9c	35.6b	43.4b	75.8c
Minimum Winter Temperature				
Visqueen Covered House	36.8a	23.0ab	25.2a	34.3a
Armin Covered House	36.7a	27.2a	27.6a	35.4a
Outside	33.4a	19.0b	21.6a	33.7a

*Tukey's studentized range test at the 5% level.

Light intensity was recorded within the nursery storage structures with a footcandle meter.

Film thickness was measured with a micrometer and bursting strength with a Model A Mullen tester. Film samples were stored at 70° F and 50% relative humidity for a minimum of 40 hours as a pre-conditioning procedure.

RESULTS AND DISCUSSION

Winter survival of Sutters Gold Potentilla, Gold Flame Spirea, and Boulevard Chamaecyparis under both film types was rated as excellent with no appreciable injury (Table 1). There was injury below acceptable levels with *Cotoneaster apiculata* (roots) and Crimson Pygmy Barberry (roots) under both films. All the *Viburnum macrocephalum* died under the Armin film and the majority died under the Visqueen film. Therefore, neither film provided adequate protection for Cranberry Cotoneaster, Crimson Pygmy Barberry, or Chinese Snowball Viburnum. To adequately protect the latter three species during the winter season in central Ohio, additional protection with poly liners, thermal blankets, or both placed directly over the plants will be necessary.

The average monthly minimum temperatures did not vary significantly between the two films (Table 2). The monthly maximum temperature averaged about 5° F warmer in the Armin-covered house during December, January, and February. There was a significant difference of 11° F warmer temperature in the Armin house in March. Warm temperature can be disadvantageous to plant survival, especially if followed immediately by very low temperatures.

TABLE 3.—Foot Candles of Light Intensity Under White Copolymer Covered Storage Houses.

Date	Outside	Armin Covered Structure	Visqueen Covered Structure
March 14	8,000	3,800	2,000
March 18	5,750	2,500	1,200
March 19	7,750	3,000	1,500
April 1	8,750	3,750	1,600
April 2	8,700	3,500	1,550
April 3	8,750	3,750	1,800
April 4	8,000	3,700	1,500
April 5	9,000	4,000	2,200
Av.	8,087a*	3,500b	1,669c

*Tukey's studentized range test at the 5% level.

The somewhat warmer air temperature under the Armin film can be explained by the fact that light transmission was significantly greater under this film (Table 3). By comparison to the outside light conditions during the eight sampling dates in March and April, the Armin film yielded approximately 56% shade and the Visqueen film 80% shade.

TABLE 4.—Thickness and Bursting Strength of Armin and Visqueen White Copolymer Films.

	Film Thickness (mils)		Bursting Strength (lb/sq in)	
	Armin	Visqueen	Armin	Visqueen
Rep. No. 1	3.8*	3.9	41.2	40.0
Rep. No. 2	3.9	4.0	42.7	37.7
Rep. No. 3	3.4	4.0	43.0	44.4
Rep. No. 4	3.9	3.9	42.7	39.6
Rep. No. 5	3.5	3.9	41.1	42.6
Av.	3.7a†	3.9a	42.1a	40.9a

*Each figure represents an average of nine samples.
†Tukey's studentized range test at the 5% level.

The thickness of the Armin film averaged 3.7 mils and the Visqueen 3.9 mils (Table 4). The bursting strength of the Armin film measured 42.1 lb/sq in and Visqueen film measured 40.9 lb/sq in, almost identical pressures. These physical parameters would suggest that no differences would be expected between films relative to puncturing during the storage season.

In summary, except for light transmission, the relatively new Armin white copolymer film compares favorably to the standard white Ethyl Visqueen copolymer film.

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Effects of Light Level Upon Leaf Area, Anatomy, and Stomatal Frequency of *Ficus benjamina* L.

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ABSTRACT

Leaves of *Ficus benjamina* L. exposed to full sun during production in a northern U.S. (New Jersey) greenhouse and outdoors in a subtropical southern (Florida) location were significantly smaller and had a higher stomatal frequency but had similar numbers of stomata per leaf as compared to plants grown under reduced light levels. Observations of transverse leaf sections and examination of stomata and leaf area data indicate anatomical differences are primarily the result of differences in cell development and expansion. Production of leaves under reduced light levels may result in development of leaves which may optimize light absorption under low light indoor conditions.

INTRODUCTION

The light levels to which certain tropical foliage plants, including *Ficus benjamina* L., are exposed during production can influence plant survival in indoor plantings (3, 4, 5, 7). For many plants the light level to which they are exposed can alter the development and anatomy of leaves (2, 8, 9, 10, 11, 12, 16, 18).

F. benjamina leaves produced under high light conditions are reported to be smaller, thicker, more glossy, and lighter green than those which develop on plants exposed to reduced light (7). The following study identifies leaf area and stomatal frequency differences between sun-grown and shade-grown *F. benjamina* leaves and visual observations of transverse leaf sections are reported.

MATERIALS AND METHODS

Northern U.S. (New Jersey) Greenhouse Grown Plants: Fifteen rooted cuttings of *F. benjamina* were planted in 3.79 liter plastic pots containing a 1:1:1 Canadian peat, soil (clay loam), perlite soil mix. Five plants each were grown in an unshaded northern United States greenhouse (New Jersey, latitude 40° N) starting March 18 for 14 weeks under: 1) 60% shade polypropylene screening, 2) 30% shade polypropylene screening, and 3) full sun. Light levels at plant tops on 3 clear days for each light regime are shown in Fig. 1. All plants were supplied with 300 ppm (nitrogen) 20-20-20 soluble fertilizer with every irrigation.

Southern U.S. (Florida) Outdoor Grown Plants: Twenty rooted cuttings were planted in 3.79 liter plastic pots containing a 2:2:1 Florida peat, cypress bark, sand soil mix. Ten plants were grown outdoors in a southern United States location (Florida, latitude 27° N) exposed to full sun and under 60% shade polypropylene screening. All plants were top dressed with 1 tablespoon per pot of 17-17-17 encapsulated slow release fertilizer and received 200 ppm (nitrogen) 20-20-20 fertilizer with every irrigation.

After 8 weeks, plants were shipped to the northern greenhouse and placed under 60% shade polypropylene screening. A string was tied loosely around shoot terminals between the terminal bud and the first leaf to allow identification of southern outdoor produced leaves and subsequent greenhouse growth. Three hundred ppm (nitrogen) 20-20-20 fertilizer was supplied to each plant when irrigated.

The day after the southern outdoor plants arrived at the northern site, the fourth, fifth, and sixth leaves from the terminal of the longest shoot were collected from five plants grown under each of the three greenhouse and two outdoor light regimes. Leaf area was determined by tracing the perimeter of each leaf, cutting out the tracing, weighing the leaf, and calculating the area from the weight to area ratio of the paper.

Revlon[2] nail enamel was applied to a median portion of the leaf on the abaxial side to acquire an epidermal impression. Each impression was peeled off and applied to a glass slide for microscopic examination. Ten

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[2]Trade mark registered.

TABLE 1.—Light Intensities Recorded on Three Clear Days Outside and Within a Northern U.S. Greenhouse (New Jersey, Latitude 40° N) at Plant Tops Under the Three Production Light Regimes.

	Light Intensity Measurement (klx)			
		Greenhouse		
Date	Full Sun Outdoors	Full Sun	30% Shade	60% Shade
April 14	84.24	72.36	49.68	29.16
May 19	99.63	85.32	59.94	34.02
June 17	105.53	91.26	63.72	36.18

random counts were made of the number of stomata in a circular field, which magnified an 8.55 x 10^{-4} cm^2 area. Total stomata per leaf were determined by multiplying the calculated number of stomata/cm^2 by the area (cm^2) of each leaf.

Thirty-five days later, the first, second, and third new but mature leaves above the string on the remaining five full sun and 60% shade outdoor grown plants were collected. Leaf area, stomatal frequency, and total number of stomata per leaf were determined as previously described.

Microscopic observations of transverse sections were made using the fifth leaf from the terminal on plants grown under three greenhouse and two outdoor light regimes. One centimeter wide sections from a median portion of the leaves were excised and infiltrated with one part Tissue-Tek II O.C.T. plus five parts of deionized water under a vacuum for 3 hours. The tissue was then freeze mounted using Tissue-Tek II O.C.T., and 20 micron thick transverse sections were cut using an American Optical Model 345 Cryo-Cut microtone. Sections were stained with safranine, then viewed and photographed using a Leitz Ortholux microscope equipped with a 35 mm Leica camera.

RESULTS

Thirty and 60% shade greenhouse grown leaves were 31% larger, respectively, than full sun greenhouse grown leaves (Table 1). Sixty percent shade outdoor grown leaves were 16% larger in area than produced outdoors under full sun. Additional leaves which developed on full sun outdoor southern grown plants after transfer to low light conditions within the northern greenhouse were significantly larger than leaves which developed outdoors under full sun on the same plant. Results showed a clear inverse relationship between light levels during production and leaf area in *F. benjamina* and support prior findings (1, 9, 12, 15, 16).

Stomatal frequency was found to be directly associated with light level during production, with high light resulting in high frequency (Table 1). Similar results have been reported elsewhere (13, 14). Stomatal frequency was low on the additional leaves which developed on outdoor grown plants after transfer to low light greenhouse conditions as compared to leaves produced on the same plants under full sun outdoor conditions.

Total stomata per leaf (Tables 2 and 3) appeared to increase slightly with a lower light level during development, but the differences were not statistically significant at the 5% level.

Direct observation and comparisons of micrographs of transverse leaf sections revealed that full sun greenhouse (Fig. 1) and outdoor grown (Figs. 3 and 5) leaves were thicker than shade-grown leaves (Figs. 2, 4, and 5). Thickness differences seemed to result from greater anticlinal elongation and perhaps some additional periclinal divisions of subepidermal cells, greater de-

TABLE 2.—Area Stomatal Density, and Total Number of Stomata per Leaf for *Ficus benjamina* Leaves Developed Under Three Light Regimes in a Northern U.S. Greenhouse (New Jersey, Latitude 40° N).

Light Regime	Leaf Area (cm^2)	X 10 Stomata/cm^2	X 10 Stomata/Leaf
Full Sun (14 wk)	12.89	274	3488
30% Shade (14 wk)	16.90	241	3974
30% Shade (14 wk)	20.93	202	4215
LSD (5%)	2.96	23	NS

TABLE 3.—Area, Stomatal Density, and Total Number of Stomata per Leaf for *Ficus benjamina* Leaves Developing Under Two Outdoor Light Regimes in the Southern U.S. (Florida, Latitude 27° N) and Leaves Developing on Same Plants After Transfer to Low Light Conditions in a Northern U.S. Greenhouse (New Jersey, Latitude 40° N).

Light Regime	Leaf Area (cm^2)	X 10 Stomata/cm^2	X 10 Stomata/Leaf
Southern Full Sun (8 wk)	15.47	262	4051
Southern 60% Shade (8 wk)	17.99	215	3872
Southern Full Sun (8 wk), then Northern 66% Shade (5 wk)	20.22	223	4408
Southern 60% Shade (8 wk), then Northern 66% Shade (5 wk)	18.23	225	4089
Southern: Southern LSD (5%)	1.18	16	NS
Southern: Northern LSD (5%)	1.53	19	NS
Northern: Northern LSD (5%)	1.37	21	NS

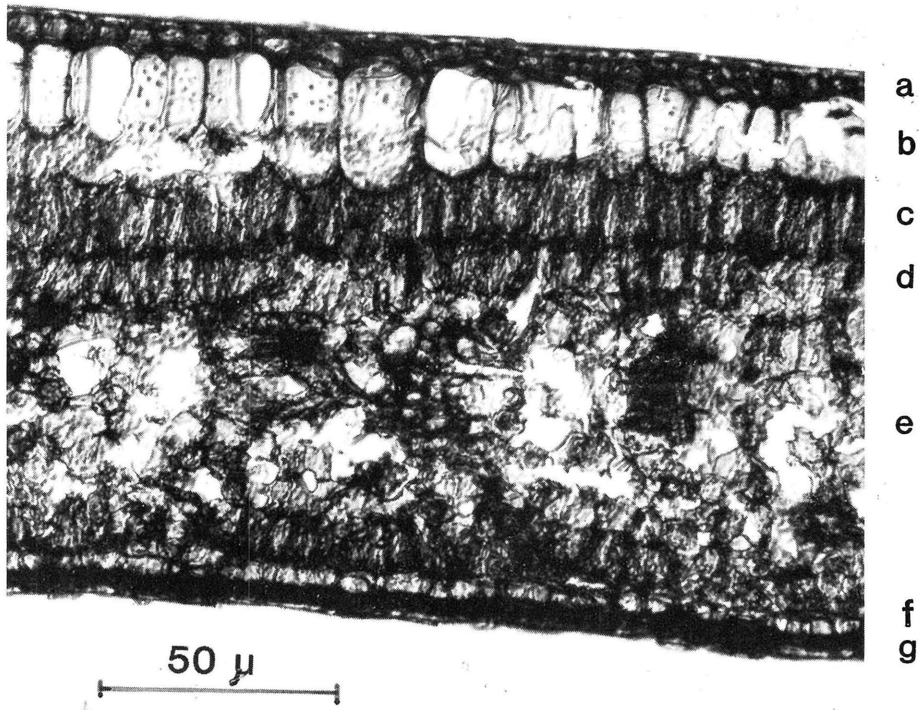

FIG. 1.—Transverse section of a typical *F. benjamina* leaf from a plant grown under full sun within an unshaded northern U.S. greenhouse (New Jersey, latitude 40° N). Upper epidermis (a) 6 ± 3 microns, upper subepidermis (b) 25 ± 6 microns, upper layer palisades (c) 17 ± 5 microns, lower layer palisades (d) 10 ± 3 microns, spongy mesophyll (e) 56 ± 9 microns, lower subepidermis (f) 3 ± 2 microns, lower epidermis (g) 5 ± 4 microns.

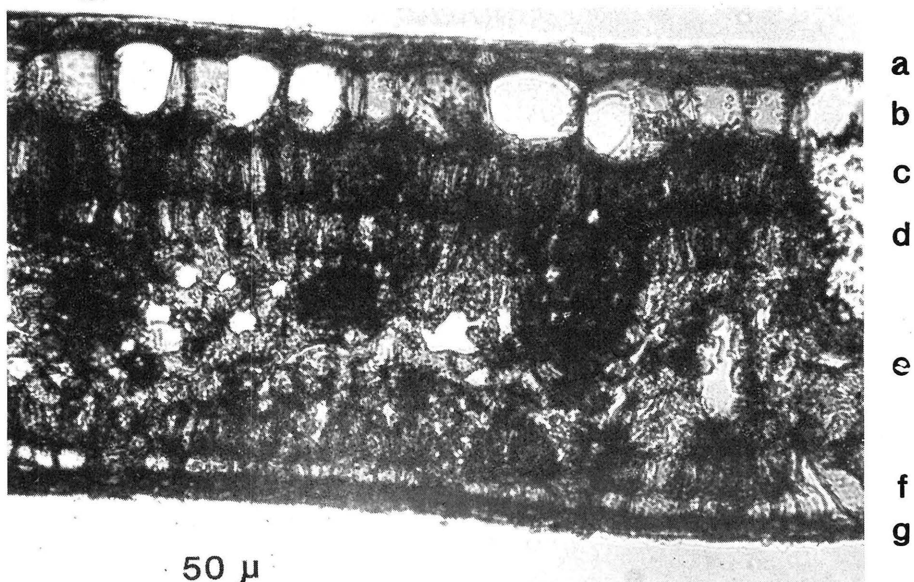

FIG. 2.—Transverse section of a typical *F. benjamina* leaf from a plant grown under 60% light excluding polypropylene screening within an unshaded northern U.S. greenhouse (New Jersey, latitude 40° N). Upper epidermis (a) 5 ± 2 microns, upper subepidermis (b) 15 ± 4 microns, upper layer palisades (c) 15 ± 2 microns, lower layer palisades (d) 5 ± 2 microns, spongy mesophyll (e) 42 ± 5 microns, lower subepidermis (f) 2 ± 2 microns, lower epidermis (g) 5 ± 2 microns.

velopment of two layers of palisades cells, and larger cells and intracellular spaces in the spongy mesophyll region of sun-grown leaves. Greenhouse and outdoor 60% shade-grown leaves (Figs. 2 and 4) had one layer of isodiametric subepidermal cells, only one layer of fully developed palisades cells (second layer present but not as fully developed), and smaller spongy mesophyll cells and intercellular spaces. Palisades cells appeared to be darker green in shade-grown leaves, suggesting the presence of more chlorophyll or a greater number of chloroplasts. Greenhouse 30% shade-grown leaves were intermediate in structure to full sun and 60% shade-grown leaves. Dissimilarities of sun and shade-grown leaves seemed to result principally from differences in cell development and expansion.

DISCUSSION

Light levels seem to have a profound effect on cellular development and expansion as evidenced by stomata and leaf area data and visual observation of transverse sections. This researcher believes differences among sun and shade-grown *Ficus benjamina* leaves result primarily from influences upon cell development and expansion rather than cell division and differentiation. This conclusion is supported by previous research (8, 9, 17) and by findings of Insangole (10), who indicated that a certain developmental plasticity exists which allows environmental factors to influence ultimate development, particularly during expansion.

With respect to indoor plant culture, the observed larger leaf area, thinner subepidermal cells, and an apparent greater concentration of chloroplasts or chlorophyll in the upper palisades layer would tend to suggest that these factors may enhance light absorption capabilities of shade leaves exposed to low light interior conditions. This may account for enhanced longevity and quality of shade-grown plants within interior environments. Plants which are going to be maintained in low light levels need to be produced under low light levels so that leaves are adapted for maximum light absorption and photosynthetic efficiency.

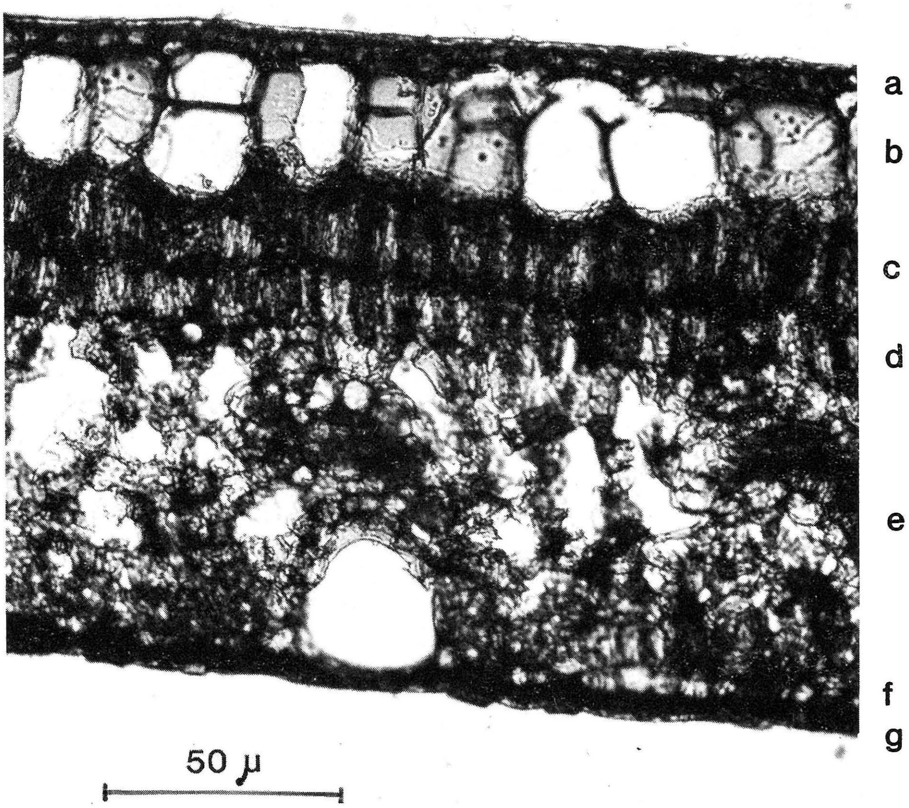

FIG. 3.—Transverse section of a typical *F. benjamina* leaf from a plant grown outdoors in a southern U.S. location (Florida, latitude 27° N) exposed to full sun. Upper epidermis (a) 6 ± 2 microns, upper subepidermis (b) 19 ± 4 microns, upper layer palisades (c) 15 ± 2 microns, lower layer palisades (d) 8 ± 2 microns, spongy mesophyll (e) 56 ± 10 microns, lower subepidermis (f) 2 ± 2 microns, lower epidermis (g) 5 ± 2 microns.

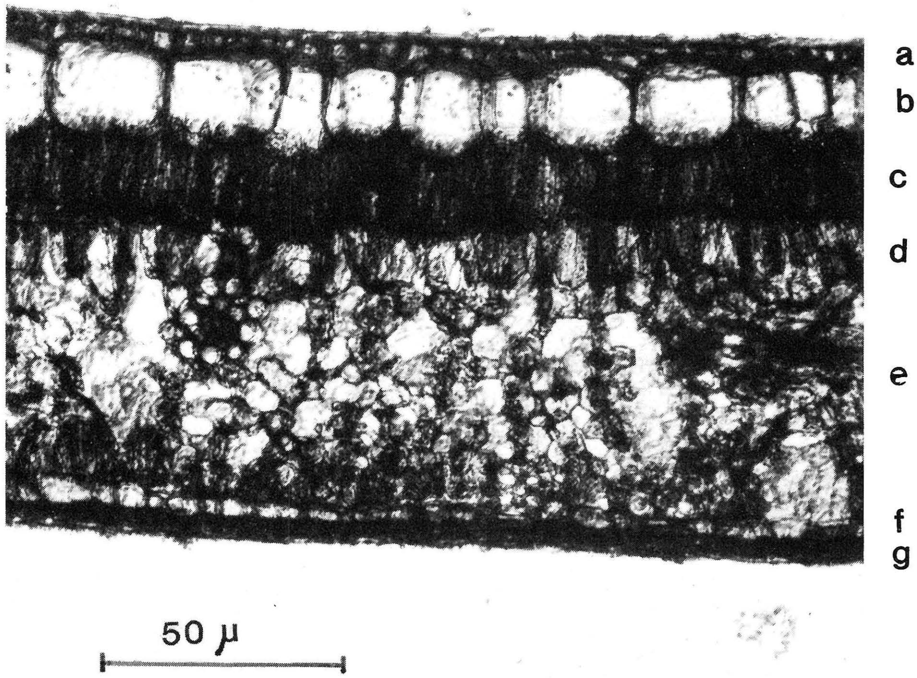

FIG. 4.—Transverse section of a typical *F. benjamina* leaf from a plant grown outdoors in a southern U.S. location (Florida, latitude 27° N) under 60% light excluding polypropylene screening. Upper epidermis (a) 5 ± 3 microns, upper subepidermis (b) 15 ± 3 microns, upper layer palisades (c) 15 ± 3 microns, lower layer palisades (d) 8 ± 2 microns, spongy mesophyll (e) 45 ± 5 microns, lower subepidermis (f) 4 ± 2 microns, lower epidermis (g) 4 ± 1 microns.

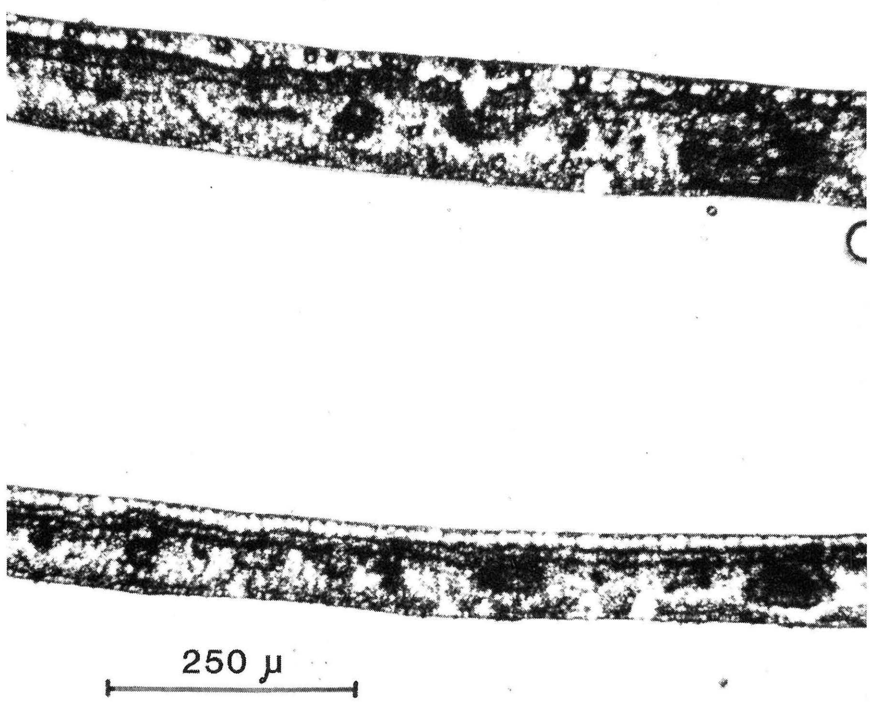

FIG. 5.—Transverse sections of a typical full sun-grown (upper) and 60% shade-grown (lower) *F. benjamina* leaves from plants produced outdoors in a southern U.S. location (Florida, latitude 27° N).

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Micropropagation of *Nyssa sylvatica*

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ABSTRACT

Shoot tip cultures of *Nyssa sylvatica* proliferated rapidly on Woody Plant Medium containing 1.0 mg/l benzyladenine (BA). Shoot tip explants were slow to initiate rapid shoot proliferation, but eventually achieved an average six-fold multiplication per 6 weeks. Microcuttings were rooted under non-sterile conditions in a soilless medium. A combination of 100 ppm naphthaleneacetic acid (NAA) and 200 ppm indolebutyric acid (IBA), used as a basal dip, resulted in superior rooting when compared to 100 ppm NAA alone. Rooted microcuttings were readily acclimated to greenhouse and outdoor conditions and produced high-quality landscape plants.

INTRODUCTION

Once believed to be intractable *in vitro*, woody trees and shrubs are now commonly propagated by tissue culture methods (3). Among the most notable examples are the *Kalmia latifolia* cultivars which were extremely difficult to propagate before the advent of *in vitro* techniques for their culture (10).

One of the primary objectives of most micropropagation systems is maximizing shoot proliferation to obtain numerous microcuttings. In most instances, axillary bud development is enhanced by the addition of growth regulators, usually cytokinins, to the culture medium (8, 11, 14). Shoots which have been produced in culture are usually stimulated to root by removing them from the cytokinin-supplemented medium and providing them with a root-enhancing auxin treatment and high humidity (7, 12, 14). Once rooted, plantlets can be acclimated to greenhouse conditions by gradually increasing light levels and gradually decreasing humidity. Intermittent mist and shading have performed this function well (7, 13).

The research described here represents the application of these basic tissue culture techniques to *Nyssa sylvatica*—black gum. The black gum is a deciduous, medium to large shade tree, native to the eastern one-third of the United States. Its landscape attributes include glossy, dark green summer foliage, brilliant orange-scarlet fall color, attractive, blocky bark, a pyramidal habit resembling that of pin oak, and fruit which is relished by wildlife. Once relatively unknown, the black gum is becoming increasingly popular as a residential shade tree and warrants greater availability and use.

The objectives of this study were to describe a system for rapid *in vitro* propagation of *Nyssa*, determine the rate of multiplication, and devise a system for acceptable rooting of shoots produced *in vitro*.

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MATERIALS AND METHODS

Fifteen shoot tips of *Nyssa sylvatica* were taken from 6-month-old actively growing seedlings. Stock plants were maintained in The Ohio State University greenhouses under high-intensity discharge (HID) lamps, at 50 to 60 μEinsteins/m^2/s, with a 16-hour photoperiod. Expanded leaves were removed from the shoot tips and the resulting shoot tips were surface sterilized in 10% Clorox for 15 minutes. Following rinsing in sterile distilled water, shoot tips were trimmed at the base to 1.5 cm and placed on the culture medium.

The basal medium consisted of Woody Plant Medium (WPM) as described by Lloyd and McCown (10), to which was added 30 g/l sucrose and 6 g/l Difco Bactoagar (pH 5.3). To achieve shoot proliferation, the basal medium was supplemented with 1.0 mg/l BA. Cultures were initially placed in 25 x 150 mm culture tubes containing 12.5 ml of medium and were moved to 125 ml jars containing 25 ml of medium after 12 weeks of growth. An initial transfer was performed 2 days after culture initiation, with subsequent transfers being carried out at 3-week intervals. The culture environment was maintained at 23° C ± 2° C and illumination was provided by cool white fluorescent lamps at 40 μEinsteins/m^2/s with a 16-hour light period.

Rooting experiments were conducted using 1 to 2 cm long microcuttings excised from 8-month-old proliferating cultures. In all rooting experiments, microcuttings were rooted for 5 weeks in a soilless medium (1:1 peat:vermiculite, v/v) under non-sterile conditions and high humidity. Rooting containers were foil trays covered by clear plastic lids. Microcuttings were given a 2-minute basal dip in either 100 mg/l NAA or 100 mg/l NAA plus 200 mg/l IBA. Environmental conditions for rooting were maintained as for shoot proliferation.

Microcuttings were evaluated for rooting percentage and number of roots (>2 mm) per rooted microcutting. Rooted plantlets were then acclimated to greenhouse conditions through placement in intermittent mist (mist for 6 sec every 6 min during daylight hours) and 60% shade for 7 days, followed by 60% shade alone for an additional 7 days. Plantlet survival was evaluated 2 weeks after the acclimation period. Acclimated plants were then grown in the greenhouse under HID lighting and were finally moved to outdoor container growing areas.

RESULTS AND DISCUSSION

Shoot tip explants taken from the greenhouse could be placed in culture without any instance of contamination. However, during the initial placement into culture, a purple-black substance leached from the cut surfaces of the explants into the surrounding medium. A single transfer after 2 days removed the tissue to fresh

FIG. 1.—Rapid multiplication of *Nyssa* occurs due to active growth of axillary shoots. Swelling axillary buds which later developed into shoots are indicated by the arrows.

medium and no further exudate was noted. Of the 15 initial explants, 12 initiated shoot proliferating cultures. Explants were slow to begin rapid proliferation, with approximately 16 weeks of culture elapsing before optimum proliferation was achieved. During the early stages of growth, considerable internal callusing of the stem occurred without erupting through the epidermis. As rapidly proliferating cultures developed, such callusing ceased.

FIG. 2.—Mass of shoots which has proliferated from a clump of 4 to 5 shoots of *Nyssa* in 6 weeks.

Shoot proliferation appears to occur through enhanced axillary branching, although the possibility of adventitious bud formation cannot be ruled out. Axillary buds swelled slowly at first and appeared "beak-like" before expanding (Fig. 1, arrows). Once rapid shoot proliferation had been reached, an approximately six-fold increase in shoots resulted in 6 weeks, with 25 to 30 shoots forming from initial clumps of 4 to 5 shoots (Fig. 2).

Shoot proliferation rates for *Nyssa* compare favorably with those reported for other woody plants. *Prunus* x 'Hally Jolivette', *Spiraea* x *bumalda* 'Froebellii', and *Potentilla fruticosa* cultivars multiply at faster rates than *Nyssa* (9, 12), while others such as some crabapples (14) and *Castanea sativa* (15) have slower proliferation rates. The successful use of BA at concentrations at or near 1.0 mg/l to induce axillary bud development in *Nyssa* is consistent with results reported for a majority of other woody plants (3). With the exception of the use of 2-isopentenyladenine on some ericaceous species (1, 5, 10), BA has produced acceptable shoot proliferation in almost all other woody plants mass propagated *in vitro* (2, 6, 9, 12, 14).

Successful rooting of aseptically produced *Nyssa* shoots was accomplished under non-sterile conditions (Fig. 3). Sixty-eight percent of those microcuttings given a basal dip in 100 mg/l NAA rooted, but on average only 1.3 roots were produced per rooted microcutting. Of the 34 microcuttings which rooted, nearly 75% produced only a single, coarse, stocky root which was oriented perpendicularly to the stem. Plantlets possessing such root systems initially exhibited poor lateral stability and often tipped over when watered from above.

The use of 200 mg/l IBA in combination with 100 mg/l NAA as the basal dip increased the rooting percentage to 82% and induced an average of 2.2 roots to form per rooted microcutting. Under this auxin treatment, less than 20% of those microcuttings which rooted struck only one root. In addition, the roots which were produced were longer, finer and more fibrous than those produced by NAA alone. Consequently, these plants tended to be better anchored and tipped over less frequently. Vieitez and Vieitez, working with *Castanea*, found similar differences in the rooting performance of IBA- and NAA-treated microcuttings (15). IBA was more effective than NAA, both for percentage rooting and number of roots per rooted microcutting. Root morphogenesis also varied according to the auxin. IBA-induced roots were longer and more fibrous than the short, thick roots induced by NAA. It is possible that with *Nyssa* IBA added to the root-inducing dip had similar positive effects on root induction and morphogenesis. The improved rooting may have also resulted from the overall higher effective auxin concentration arising from the combination of both auxin types.

Rooted microcuttings were easily acclimated to greenhouse environmental conditions and began growth without a lag period (Fig. 4). Survival rates near 95% were achieved for acclimated plantlets resulting from both rooting treatments. Once acclimated, plantlets grew rapidly in the greenhouse, attaining heights of 5 to 6 feet in 6 months. Plants were uniform, possessing a single leader with radially arranged lateral branches. Trees were easily acclimated to outdoor growing conditions by providing them with shade for a period of time.

To our knowledge, this is the first report of *in vitro* techniques applied to *Nyssa sylvatica* or any other member of the Nyssaceae. Proliferation rates may be high enough for commercial applications and rooting percentages and plantlet survival are within acceptable levels. Further rooting investigations may result in improved root system quality, although such improvements may not be necessary to assure acceptable plantlet growth. Even those microcuttings which struck only one root grew normally once established. Typically, *Nyssa* has a sparse root system of thick, fleshy roots (4), so root systems of this nature, when produced on microcuttings, may not necessarily be of poor quality.

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FIG. 3.—Microcuttings of *Nyssa* rooting under non-sterile conditions.

FIG. 4.—Young acclimated plantlets of two ages. Plantlets in the foreground are 2 weeks old post-acclimation, while the larger plants behind are 4 weeks old.

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Physical Facilities and Capital Requirements for Establishing a 200-Acre Field Nursery in Ohio—1985

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ABSTRACT

Capital requirements for establishing a field nursery in Ohio were about $1,380,000 for a 200-acre facility having 175 acres of growing space and 25 acres of production facilities, holding and field bed areas, and roads. Assuming a diversified product mix, the capacity for producing salable plants on an annual basis was 18,156 slow-growing evergreens, 25,418 fast-growing evergreens, 27,162 deciduous shrubs, 8,177 shade trees, and 11,954 ornamental trees. Capital requirements per salable plant capacity were $15.19 for slow-growing evergreens, $10.85 for fast-growing evergreens, $10.16 for deciduous shrubs, $22.73 for shade trees, and $23.07 for ornamental trees.

INTRODUCTION

A cost model for production of crops representing five categories of field-grown production schemes in Ohio was developed. Physical coefficients are included so the information can be readily updated and so individual nurserymen 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 field nursery, expanding an existing field nursery, or phasing out of field production.

Comprehensive cost models have recently been developed for container grown crops in USDA plant hardiness zone 6 (3), for field-grown crops in USDA plant hardiness zones 7 and 8 (1), and for field-grown crops in USDA plant hardiness zones 5 and 6 (2). This paper presents physical requirements and capital expenditures for establishing a 200-acre field nursery in Ohio.

OBJECTIVES

The objectives of this study were to:

- Model production systems which would accommodate a majority of the species of plants being field-grown in Ohio.
- Analyze the important species of plants commonly grown in the field in Ohio, and assign each of them to one of the designated groups based on similarities of growing and production requirements.
- Design physical facilities including land areas, land improvements, irrigation systems, and buildings for a commercial field nursery based on the model production system.
- Determine capital costs for the above physical facility.

MATERIALS AND METHODS

This paper is based on a firm synthesized using the conceptual framework of economic engineering wherein the "best proven practice" was included. It was synthesized based on Ohio (Figs. 1 and 2). 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 (Tables 1 and 2); schematic drawings of the physical layout, including buildings and irrigation system; lists 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 (2).

Data for this study were obtained from wholesale nurseries and nursery suppliers in Ohio during the late autumn and winter of 1984 and the spring of 1985. Price quotations obtained were for the 1985 production season. The basic goals in synthesizing the production facilities were to minimize labor expenses, flow and movement of plant material and equipment, and water runoff, and to maximize the number of salable plants and allow future expansion.

The nursery reported in this paper included 175 acres of growing space and 25 acres of production facilities, holding area, field bed area, and roads.

Physical Plant and Equipment

Assumptions

Assumptions about the physical facilities and equipment can greatly affect its cost and thereby the cost per salable plant. The authors included all items a nursery would typically require; thus, the physical plant is probably more elaborate than many nurserymen would require. A nurseryman can easily eliminate or reduce items as required. However, it would require substantial effort to do the analysis on his own if they were not included.

Components

Land Improvement: For full utilization of the production facilities, holding area, and field-bed area, extensive grading, graveling, and surface and underground drainage tiles were provided. Liner bed area and general field production were tiled with 4″ plastic tile,

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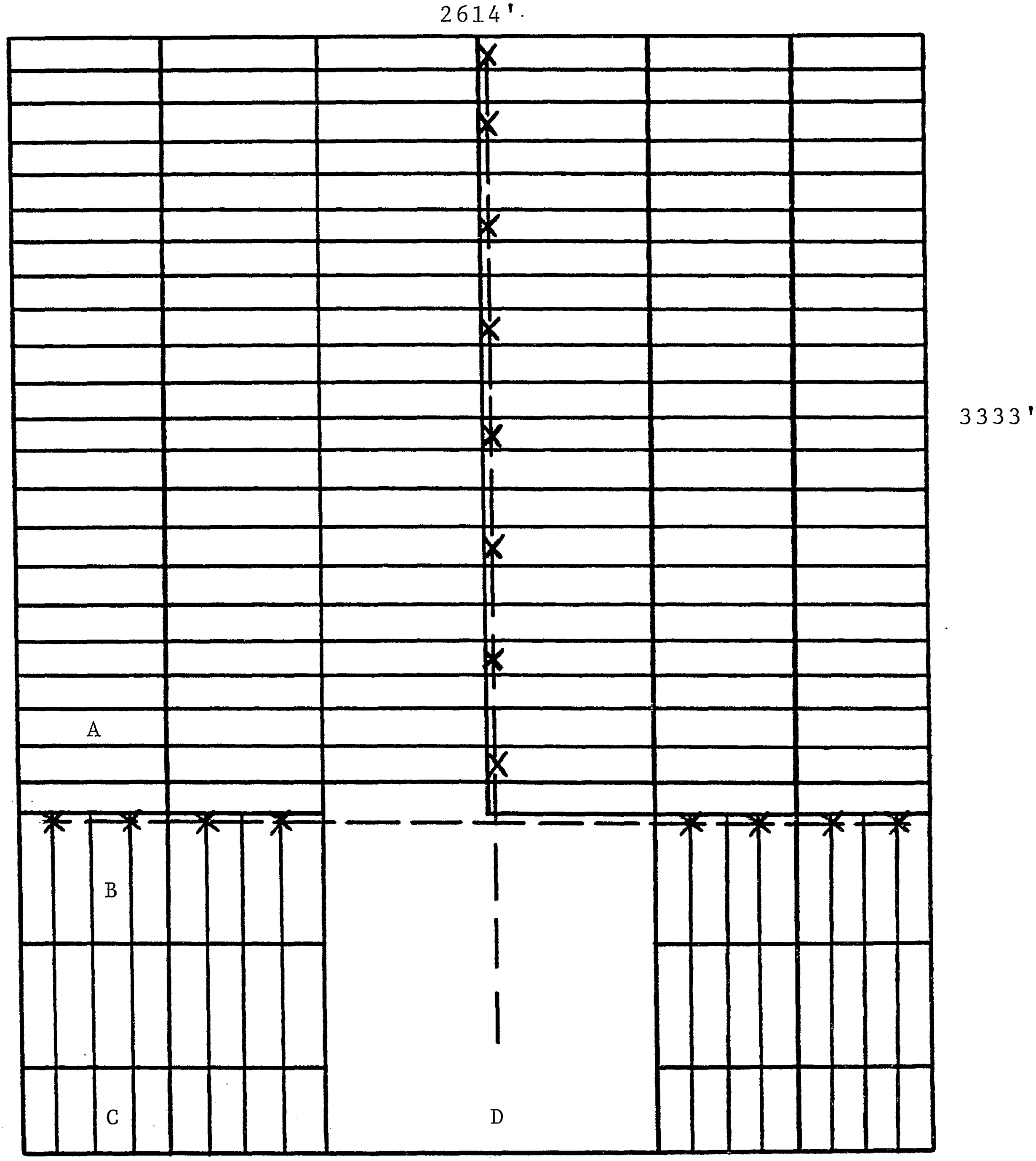
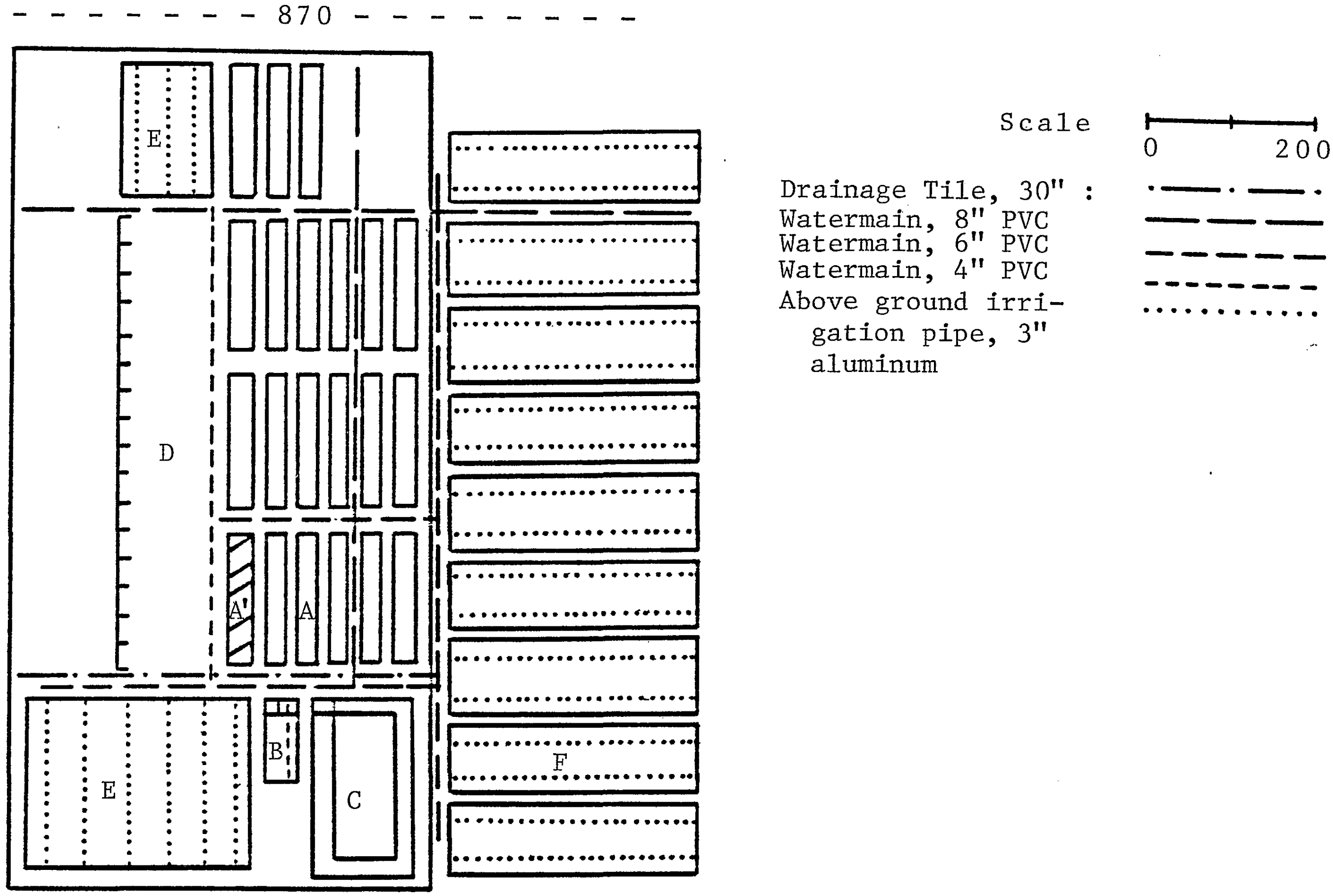
FIG. 1.—Schematic drawing of a 200-acre field nursery for Ohio.



A. Growing plots (131) 100.0' x 435.6' (one acre)
B. Growing plots (32) 108.9' x 400.0' (one acre)
C. Growing plots (16) 108.9' x 300.0' (3/4 acre)
D. Production facilities, holding area, and field-bed area, 870' x 1200' (Note: one acre from this area was used as a growing plot.
X Denotes placement of water hydrants for irrigation.
8" PVC pipe —— —— ——

FIG. 2.—Schematic drawing of a 200-acre field nursery's production facilities, holding area, and field bed area for Ohio.



A. Polyhouse structure, 20 each (20' x 200') = 80,000 sq. ft. = 1.84 acres
A'. Propagation house, 1 each (20' x 200') = 4,000 sq. ft. = .09 acres
B. Supply shed, machinery storage, machine shop (40' x 100')
Office and restrooms (20' x 40')
C. Pond, (80' x 220' x 14' depth), Pump house, (10' x 10')
D. Shipping area, (10 semitruck loads)
E. Holding area, (240' x 280') and
(200' x 64') = 80,000 sq. ft. = 1.84 acres
F. Liner bed area, 9 each (100' x 330') = 297,000 sq. ft. = 6.82 acres

Total Acreage, 870' x 1200' = 1,044,000 sq. ft. = 23.97 acres

TABLE 1.—Plant Densities and Losses for Field Production of Nursery Plants, Ohio, 1985.

Group	Description	Size of Salable Plant	Years in Rotation	Spacing Between Rows (inches)	Spacing in Rows (inches)	Sq Ft per Plant*	Plants per Acre	Estimated Percent Loss†
I	Slow-growing Evergreens—*Taxus*	18-24″	7	44	28	10.2	4,272	15
II	Fast-growing Evergreens—*Juniperus*	18-24″	5	44	28	10.2	4,272	15
III	Deciduous Shrubs—*Viburnum*	3-4′	4	48	30	11.9	3,652	15
IV	Shade Trees—*Acer rubrum*	2″ diameter	5	96	42	33.6	1,298	10
V	Ornamental Trees—*Malus*	5-6′ (1-1/2″)	4	96	36	28.7	1,518	10

*Sq ft per plant includes necessary perimeter roads.

†Assume one-half of loss between first and second year and remainder in last year of production. Losses in the last year of production would be left in the field.

TABLE 2.—Planting and Harvesting Requirements for a 200-Acre* Field Nursery, Ohio, 1985.

		Propagation†	Bedding Area‡	Field Planting			
Plant Group	Description	Units Stuck	Rooted Cuttings Planted	Acres	Acres Planted per Year	Units Planted per Year	Units Harvested per Year**
I	Slow-growing Evergreens—*Taxus*	37,710	26,700	35	5.00	21,360	18,156
II	Fast-growing Evergreens—*Juniperus*	48,594	37,380	35	7.00	29,904	25,418
III	Deciduous Shrubs—*Viburnum*	51,927	39,944	35	8.75	31,955	27,162
IV	Shade Trees—*Acer Rubrum*††	--	--	35	7.00	9,086	8,177
V	Ornamental Trees—*Malus*††	--	--	35	8.75	13,283	11,954
	Total	138,231	104,024	175	36.50	105,588	90,867

*200 total acres with 175 acres in field growing space and 25 acres in production facilities, holding area, field bed area, roads, etc.

†For each plant available for transplanting as a rooted cutting into the bedding area, it is estimated that 1.3 cuttings would need to be stuck in the propagation facility.

‡For each plant available for transplanting into the field, it is estimated that 1.25 root cuttings would need to be planted in the bedding area.

**Assume one-half dug in fall for fall sales and overwintering and one-half dug in the spring.

††Shade and ornamental trees would be purchased as bare-root liners for planting directly into the field.

30′ on center, 46″ deep using a herringbone design. For any area that heavy equipment may run over (shipping area and machine storage shed), #4 gravel was used. In other graveled areas, #8 grade was utilized. Although the cost of this graveling operation is high, it is offset by greater efficiencies and dependability in the handling of plants, ability to re-enter the areas after natural or artificial irrigation, and reduction of soil erosion.

A pond was included even though it was assumed a well could be dug with sufficient regenerative water capacity. This was done to reduce the risk to plants while in holding areas in case of disruptions caused by repairs or electrical failure. An auxiliary take-off drive from the pump could be powered by a large 100 HP tractor for temporary irrigation.

Buildings: Permanent buildings were provided for the receiving of nursery stock/storage (50′x40′), machinery repair/storage (50′x40′), office space (20′x20′), and restroom facilities (20′x20′).

Propagation Facilities: For propagating the three classes of shrubs, a full 20′x200′ polyhouse would be utilized. This propagation area was equipped with a double polyethylene cover and heating equipment.

Overwintering Facilities: Twenty polyhouses (20′x 200′) were provided to overwinter one-fourth of a year's shrub harvest.

Machinery and Equipment: Purchase of new machinery and equipment was assumed for the model nursery to achieve true replacement costs. Many nurserymen may choose to buy used equipment, rent equipment, or time-share some expensive items with other nurseries.

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. The basic irrigation system was composed of four parts: water source, pumping equipment, in-ground 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 in conjunction with a constructed lake or a site situated near an open water source of high quality water would be desirable. This 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 of USDA plant hardiness zones 5 and 6, wells would have to be drilled to much greater depths and this would result in higher costs.

Selection of a well pump is crucial to the nursery operation. An electric motor was chosen because of reliability of performance, low maintenance cost, and close availability of three-phase electrical power.

The third part of the irrigation system is the in-ground irrigation pipe. The advantages of in-ground water mains are: labor costs for pipe movement are eliminated, breakage due to equipment running over above-ground pipe is eliminated, and lower initial costs 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. Three-inch, portable, latchless, aluminum portable pipe was provided for irrigation within the central area. Rotating #30BH rainbird sprinklers were provided for dispersing water in the central area. A traveler gun with a dispersion rate of 450-500 gallons per minute was provided for irrigating the grow-out areas.

Enterprise Mix

It was assumed that the model nursery would produce a diverse line of nursery stock. The length of the production cycle for the different species grown will vary. Five cultural groups were selected. 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 (Table 1). For analytical purposes, it was assumed that each cultural group would occupy 20% of the growing area (35 acres per group). Annual sales capacity would be 90,867 plants (Table 2).

For detailed analysis, one specific plant from each group was chosen as representative of the group. While it is recognized that other plants from each category would have somewhat different requirements, it was felt that the requirements would not vary significantly in cost from the representative plant. The five groups (plant types chosen for detailed analysis are designated with a star) with some of their cultural characteristics are listed on page 36.

Group	Plant	Cultural Characteristics
I	Slow-Growing Evergreens	
	**Taxus* (species) *Buxus* (species)	18-24" salable plant 12" B&B 10.2 sq ft of growing space per plant
II	Rapid-Growing Evergreens	
	**Juniperus* *chinensis* (varieties) *horizontalis* (varieties) *Pinus strobus* *Thuja* (species)	18-24" salable plant 12" B&B 10.2 sq ft of growing space per plant
III	Deciduous Shrubs	
	**Viburnum* (species) *Forsythia* (species) *Weigela* (species) *Ligustrum* (species)	18-24" salable plant 12" B&B 11.9 sq ft of growing space per plant
IV	Shade Trees	
	**Acer rubrum* (varieties) *Acer platanoides* (varieties) *Fraxinus* (species) *Quercus* (species) *Tilia* (species) *Gleditsia* (species)	2" caliper 24" B&B 33.6 sq ft of growing space per plant
V	Ornamental Trees	
	**Malus* (flowering crab) (species) *Prunus* (ornamental plums) (species)	5-6' (1-1/2 to 1-3/4" caliper) 20" B&B 28.7 sq ft per plant

This mixture of plant materials would all be packaged in soil balls (balled and burlapped). Groups I, II, III would be harvested by hand and groups IV and V would require the assistance of a mechanical spade for harvesting.

RESULTS AND DISCUSSION

Capital Investment Requirements

Capital investment requirements for establishing field nurseries were itemized under three broad divisions: land and improvements, buildings, and machinery and equipment (Table 3). Each was further divided into several components. The nursery had an initial investment requirement of $1,379,236. Land and land improvements represented 50% or $684,210 of the investment, buildings 12% or $165,981, and machinery and equipment 38% or $529,045.

An important consideration for managers in most industries is determination of investment per unit of production capacity. For field nurseries this indicator would be the capital requirement per-salable-plant capacity. To determine this figure, it was necessary to determine how many salable plants would be produced annually for each group in its allocated 20% of the growing space. This quantity ranged from a low of 8,177 for group IV (*Acer rubrum*) to 25,418 for group III (*Viburnum*).

The number of plants grown per unit of space directly relates to the capital requirements per-salable-plant. These capital costs differentiated by plant group were: $15.19 for group I (*Taxus*), $10.85 for group II (*Juniperus*), $10.16 for group III (*Viburnum*), $33.73 for group IV (*Acer rubrum*), and $23.07 for group V (*Malus*). The average for all groups was $15.18.

Although investment requirements for a cost model field nursery for Ohio conditions were examined, an infinite number of sizes could have been analyzed. Examination of the data indicate higher investment costs per unit of salable plant capacity would incur as field nursery size is decreased from the 200-acre one analyzed. This would be caused by spreading the cost of fixed items such as buildings, equipment, and machinery over fewer units. Conversely, lower costs per unit of salable plant capacity would be realized for field nurseries larger than the 200-acre nursery analyzed as the costs of fixed items would be spread over more units.

TABLE 3.—Capital Requirements for a 200-Acre* Field Nursery, Ohio, 1985.

Item	Description	Unit	Useful Life (yr)	Quantity	Cost per Unit ($)	Total Cost ($)	Percent of Total Cost
Land	Unimproved land	acre	--	200	2,000	400,000	29
+Improvements	Grading, tiling, graveling, pond		20			284,210	21
Subtotal						684,210	50
Buildings							
Office and restrooms	20′ x 40′	sq ft	20	800	35	28,000	2
Plant and supply storage	40′ x 50′	sq ft	20	2000	20	40,000	3
Machinery storage and shop	40′ x 50′	sq ft	20	2000	20	40,000	3
Polyhouse structures	200′ x 20′	each	10	21	2,761	57,981	4
Subtotal						165,981	12
Machinery and Equipment							
Tractor, 100 hp	100 hp, diesel fuel	each	10	1	28,278	28,278	2
Tractor, 60 hp	60 hp, diesel fuel	each	10	1	20,419	20,419	1
Tractor, 34 hp	34 hp, gas fuel	each	10	4	14,504	58,016	4
Articulated 4-wheel drive loader	Swinger 220-lift capacity = 2,000 lb	each	10	2	25,000	50,000	4
Articulated 4-wheel drive loader	Swinger 320-lift capacity = 3,000 lb	each	10	2	38,000	76,000	6
Tree spade	530P handles 20″, 22″, and 24″ + lift pads	each	2	2	8,490	16,980	1
Forks	For front-end loaders	each	10	4	1,100	4,400	†
Plow	3-14 inch plows	each	10	1	2,616	2,616	†
Disk	8′ wide	each	10	1	3,900	3,900	†
Harrow	10′ wide	each	10	1	650	650	†
Cultimulcher—bed area	10′ wide	each	10	1	3,800	3,800	†
Sprayrig (boom sprayer)	100-gallon tank with 7′ and 10′ booms	each	7	1	1,407	1,407	†
Transplanter, 3-row	3-20 inch row bed transplanter	each	10	1	7,500	7,500	1
Transplanter, 1-row	Tree planter	each	10	1	5,000	5,000	†
Permanent irrigation/well pump	100 hp electric pump	each	20	1	36,396	36,396	3
In-ground irrigation/bed area	PVC pipe/valves		20		34,606	34,606	3
Above-ground irrigation/bed area	Aluminum pipe/valves/sprinkler heads		5		4,347	4,347	†
In-ground irrigation storage/holding	PVC pipe/valves		20		17,959	17,959	1
Above-ground irrigation storage/holding	Aluminum pipe/valves/sprinkler heads		5		8,286	8,286	1
Traveler gun—field irrigation	450-500 gallons per minute		10	1	22,000	22,000	2
Portable irrigation pump	40 hp P.T.O. irrigation pump/foot valve	each	10	1	425	425	†
Airblast sprayer	Myer—300 gallon high pressure on trailer	each	7	1	3,600	3,600	†
Fertilizer injector	26-gallon injector	each	5	2	858	1,716	†
Transplanter, 2-row	2-42/48″ row field transplanter	each	10	1	5,600	5,600	†
U Blade—field	18″ for undercutting	each	5	1	240	240	†
Undercutter—bed	Bed undercutter, 50″ blade, lift tines	each	7	1	285	285	†
Fertilizer sidedresser	2-row sidedresser	each	10	1	1,000	1,000	†
Cultivator, 2-row	2-row field cultivator	each	7	2	1,750	3,500	†
Wagon	4-wheel, farm wagon	each	10	8	1,978	15,824	1
Cultivator, 3-row	3-row bed cultivator	each	7	1	2,250	2,250	†
Truck	1/2-ton pickup truck	each	5	2	13,485	26,970	2
Pallets	Wooden	each	2	482	12	5,784	†

*Total nursery = 200 acres, with 175 acres of growing space and 25 acres in production facilities, holding and field bed area, roads, etc.
†Less than one-half of 1%.
‡Propane tanks, connectors, etc. will be leased from the company supplying propane.

TABLE 3 (continued).—Capital Requirements for a 200-Acre* Field Nursery, Ohio, 1985.

Item	Description	Unit	Useful Life (yr)	Quantity	Cost per Unit ($)	Total Cost ($)	Percent of Total Cost
Hand tools	Miscellaneous	sets	5	76	100	7,600	1
Seeder	Broadcast seeder		10	1	175	175	†
Mower	7′-3-blade mower		10	1	2,283	2,283	†
Flatbed truck	24′ flatbed, gas fuel		5	1	42,000	42,000	3
Heating system for progagation							
Gas-fired unit heater—Modine	200,000 BTU (input)	each	10	2	1,104	2,208	†
Fan jet—Acme		each	10	2	103	206	†
Thermostat	Two-stage	each	10	2	44	88	†
Set-up for propane‡	Vent., reg., etc.	each	10	2	100	200	†
Set-up for heating system	Plywood, braces, bolts, etc.	each	10	2	100	200	†
Other propagation materials						1,494	
Misting system	Mist-a-matic	each	2	6	249	494	†
Pipe and nozzles	For misting system		2	2	300	600	†
Treated boards	5/4″ x 8″ x variable length	foot	2	1,320	0.74	977	†
Heating cable	Propagation	foot	2	3,600	0.35	1,260	†
Subtotal						529,045	38
TOTAL						1,379,236	100

*Total nursery = 200 acres, with 175 acres of growing space and 25 acres in production facilities, holding and field bed area, roads, etc.

†Less than one-half of 1%.

‡Propane tanks, connectors, etc. will be leased from the company supplying propane.

Individual nurserymen 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. This analysis assumed average soil conditions, expansion capacity, optimal spacing configurations, new buildings, equipment, and machinery.

SUMMARY

Production schemes were developed for five categories of ornamental crops which would represent the majority of field-grown nursery plants being produced in Ohio. Based on these production schemes, a 200-acre model field nursery was synthesized. Total capital requirements for establishing the nursery were $1,379,236. Investment per annual salable plant capacity was $15.19 for slow-growing evergreens, $10.85 for fast-growing evergreens, $10.16 for deciduous shrubs, $33.73 for shade trees, and $23.07 for ornamental trees.

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Production Costs of Operating a 200-Acre Field Nursery in Ohio—1985

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ABSTRACT

The objective of this paper is to determine annual production costs of operating a 200-acre field nursery in Ohio. This was accomplished by synthesizing a model field nursery using the conceptual framework of economic engineering. Annual production costs were about $1,130,000 for the 200-acre facility. Of the total, approximately $444,600 were fixed costs and $685,400 variable.

INTRODUCTION

To make more informed decisions as to whether to enter, leave, or expand field production, nurserymen require production, marketing, and financial information. Comprehensive cost models have recently been developed for container grown crops in USDA plant hardiness zone 6 (3), for field grown crops in USDA plant hardiness zones 7 and 8 (1), and for field grown crops in USDA plant hardiness zones 5 and 6 (2). The objective of this paper is to present annual costs of production for a 200-acre field nursery producing a diverse combination of shrubs and trees.

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 (2).

Commonly grown nursery stock was divided into five cultural groups: slow-growing evergreens, fast-growing evergreens, deciduous shrubs, shade trees, and ornamental trees. 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. One species of plant was chosen to represent each cultural group. The production system provided for propagating shrubs (*Taxus, Juniperus,* and *Viburnum*) and for purchasing liners for trees (*Acer rubrum* and *Malus*).

Data for this study were obtained from wholesale nurseries and nursery suppliers in Ohio during the late autumn and winter of 1984 and the spring of 1985. Price quotations obtained were for the 1985 production season. 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 200 acres, with 175 acres of growing space and 25 acres of production facilities, holding area, field bed area, and roads. Twenty percent of the growing space was assigned to each of the cultural groups.

Costs were established for all factors of production including management and invested capital (2). 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 (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 species was totaled for physical quantities and costs (Table 2).

RESULTS AND DISCUSSION

Annual fixed, variable, and total production costs of operating a 200-acre field nursery in Ohio for 1985 are summarized in Table 3. Total production costs were $1,129,917. Fixed costs totaled $444,525 and made up 39% of total annual costs. Based on a percentage of total costs, land and improvements made up 10%, buildings 3%, machinery and equipment 11%, general overhead 14%, and interest on general overhead, insurance, and taxes 1%. Variable costs totaled $685,392 and made up 61% of total costs. Based on a percentage of total costs, propagation made up 1%, materials 25%, machinery and equipment 8%, labor 24%, and interest on operating capital 3%.

Individual nurserymen might well experience costs different than those depicted here. Most cost differences would probably be reflected in fixed rather than variable costs. Budgets presented assumed new facilities, machinery, and equipment. Most nurserymen 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

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In addition to research, Drs. Taylor, Smith, and Hahn have appointments in the Ohio Cooperative Extension Service.

TABLE 1.—Annual Fixed Costs (Dollars) for a 200-Acre* Field Nursery, USDA Plant Hardiness Zones 5 and 6, 1985.

Item	Description	Depreciation†	Interest‡	Insurance and Taxes**	Total
Land	Unimproved land	--	48,000	8,000	56,000
+Improvements	Grading, tiling, graveling, pond	12,789	34,105	5,684	52,578
Subtotal	-	12,789	82,105	13,684	108,578
Buildings					
Office and restrooms	20′ x 40′	1,260	3,360	685	5,305
Plant and supply storage	40′ x 50′	1,800	4,800	978	7,578
Machinery storage and shop	40′ x 50′	1,800	4,800	978	7,578
Polyhouse structures (21 ea)	200′ x 20′	5,218	6,958	1,418	13,594
Subtotal		10,078	19,918	4,059	34,055
Machinery and Equipment					
Tractor, 100 hp	100 hp, diesel fuel	2,545	3,393	107	6,045
Tractor, 60 hp	60 hp, diesel fuel	1,838	2,450	77	4,365
Tractors, 34 hp (4 ea)	34 hp, gas fuel	5,221	6,962	219	12,402
Articulated 4-wheel drive loader (2 ea)	Swinger 220-lift capacity = 2,000 lb	4,500	6,000	189	10,689
Articulated 4-wheel drive loader (2 ea)	Swinger 320-lift capacity = 3,000 lb	6,840	9,120	287	16,247
Tree spades (2 ea)	530P handles 20″, 22″, and 24″ + lift pads	7,641	2,038	64	9,743
Forks	For front-end loaders	396	528	17	941
Plow	3-14 inch plows	235	314	10	559
Disk	8′ wide	351	468	15	834
Harrow	10′ wide	59	78	2	139
Cultimulcher—bed area	10′ wide	342	456	14	812
Sprayrig (boom sprayer)	100-gallon tank with 10′ boom	181	169	5	355
Transplanter, 3-row	3-20-inch row bed transplanter	675	900	28	1,603
Transplanter, 1-row	Tree planter	450	600	19	1,069
Permanent irrigation/well pump	100 hp electric pump	1,638	4,367	138	6,143
In-ground irrigation/bed area	PVC pipe/valves	1,557	4,153	131	5,841
Above-ground irrigation/bed area	Aluminum pipe/valves/sprinkler heads	782	522	16	1,320
In-ground irrigation storage/holding	PVC pipe/valves	808	2,155	68	3,031
Above-ground irrigation storage/holding	Aluminum pipe/valves/sprinkler heads	1,491	994	31	2,516
Traveler gun—field irrigation	450-500 gallons per minute	1,980	2,640	83	4,703
Portable irrigation pump	40 hp P.T.O. irrigation pump/foot valve	38	51	2	91
Airblast sprayer	300-gallon high pressure on trailer	463	432	14	909
Fertilizer injectors (2 ea)	26-gallon injectors	307	205	6	518
Transplanter, 2-row	2-42 inch row field transplanters	504	672	21	1,197
U-Blade—field	18″ for undercutting	43	29	1	73
Undercutter—bed	Bed undercutter, 50″ blade, lift tines	37	34	1	72
Fertilizer sidedresser	2-row sidedresser	90	120	4	214

*Total of 200 acres, with 175 acres of growing space and 25 acres in production facilities, holding area, field bed area, roads, etc.
†Depreciation was estimated by dividing the initial cost (adjusted for a 10% salvage value) by the years of useful life.
‡Interest costs were estimated by multiplying the initial value of land, buildings, equipment, and machinery by the interest rate of 12% per annum.
*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.

TABLE 1 (continued).—Annual Fixed Costs (Dollars) for a 200-Acre* Field Nursery, USDA Plant Hardiness Zones 5 and 6, 1985.

Item	Description	Depreciation†	Interest‡	Insurance and Taxes**	Total
Cultivators, 2-row (2 ea)	2-row field cultivator	450	420	13	883
Wagons (8 ea)	4-wheel, farm wagon	1,424	1,899	60	3,383
Cultivator, 3-row	3-row bed cultivator	289	270	9	568
Trucks (2 ea)	1/2-ton pickup truck	4,855	3,236	102	8,193
Pallets (482 ea)	Wooden	2,603	694	22	3,319
Hand tools (76 sets)	Miscellaneous	1,368	912	29	2,309
Seeder	Broadcast seeder	16	21	1	38
Mower	7′-3-blade mower	205	274	9	488
Flatbed truck	24′ flatbed, gas fuel	7,560	5,040	159	12,759
Heating system for progagation					
Gas-fired unit heaters (2 ea)	2,000,000 BTU (input)	199	265	8	472
Fan jet—Acme (2 ea)		19	24	1	44
Thermostat (2 ea)	Two-stage	8	11	††	19
Set-up for propane (2 ea)	Ventilator, regulator, etc.	18	24	1	43
Set-up for heating system (2 ea)	Plywood, braces, bolts, etc.	18	24	1	43
Other propagation materials					
Misting system (6 ea)	Mist-a-matic	672	179	6	857
Pipe and nozzles	For misting system	270	72	2	344
Treated boards	5/4″ x 8″ x variable length	440	117	4	561
Heating cable		567	151	5	723
Subtotal		61,993	63,483	2,001	127,477
Total for Depreciation, Interest Insurance, and Taxes		84,815	165,386	19,740	270,110
General Overhead					
Utilities	Telephone, electric, gas heat				9,200
Licenses and bonds					600
General repairs and maintenance	Buildings, grounds, roads				12,200
Advertising and printing					1,800
Insurance, personnel‡‡	Workmen's compensation, FICA, health, unemployment				30,400
Travel and professional fees					2,725
Administrative and management***	Clerical, operator, supervisory, labor, and office supplies				104,500
Miscellaneous					2,000
Subtotal					163,425
Interest on General Overhead, Insurance, and Taxes	12% per annum for 6 months on a total of $183,169				10,990
Total Annual Fixed Costs					444,525

*Total of 200 acres, with 175 acres of growing space and 25 acres in production facilities, holding area, field bed area, roads, etc.

†Depreciation was estimated by dividing the initial cost (adjusted for a 10% salvage value) by the years of useful life.

‡Interest costs were estimated by multiplying the initial value of land, building, equipment and machinery by the interest rate of 12% per annum.

**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.

††Less than $0.50.

‡‡Insurance for personnel was estimated at 32% of salaries for owner/operator, supervisors, and clerical.

***Owner/operator = $35,000, two supervisors @ $20,000 ea. = $40,000, two clerical @ $10,000 = $20,000, supplies 10% or $9,500. Total = $104,500.

TABLE 2.—Variable Costs (Dollars) for a 200-Acre* Field Nursery, USDA Plant Hardiness Zones 5 and 6, 1985.

Item	Description	Unit	Cost per Unit†	Quantity	Total Variable Cost
Propagation‡					
Rooting media	Sand	cubic yd	6.50	66.00	429
Collecting, stripping, and sticking	135,231 units	hr	6.93**	152.78	1,059
Maintenance		hr	6.93	800.00	5,544
Harvest	135,231 units	hr	6.93	289.97	2,010
Hormone powder	#1, I.B.A. (*Viburnum*)	lb	8.00	1.49	12
	#3, I.B.A. (*Juniperus*)	lb	11.70	1.39	16
	#8, I.B.A. (*Taxus*)	lb	15.50	1.08	17
Subtotal					9,087
Materials					
Burlap	32″ x 32″ squares + twine (shrubs)	each	0.45	70,736.00	31,831
	54″ x 54″ squares — 24″ basket (*Acer rubrum*)	each	3.10	8,177.00	25,349
	54″ x 54″ squares — 18″ basket (*Malus*)	each	2.53	11,954.00	30,244
Twine	Nails and twine (trees)	each	0.15	20,131.00	3,020
Liners	*Acer rubrum*, 6-8′ 2 yr branched	each	8.68	9,086.00	78,866
	Malus, 5-6′ 2 yr branched	each	4.86	13,283.00	64,555
Polyethylene film	4 mil white, 32′ x 225′ (shrubs overwinter)	each	127.50	17.68	2,254
Strip tags	5/8″ x 7″ plastic strip tag	each	0.02	90,867.00	1,817
Poultry wire	1″ for rabbit control (trees)	roll	29.00	18.00	522
Seed	Ryegrass (Kentucky 31) (trees)	lb	0.64	3,430.35	2,195
Chemicals	Custom spread, custom blend: 45-0-0, 0-44-0, 0-0-60 (fertilizer)	ton	176.00	21.96	3,865
	Custom spread (lime)	ton	20.00	35.53	711
	Urea, 45-0-0 (fertilizer)	ton	220.00	20.27	4,459
	Soluble 20-20-20 (fertilizer)	ton	1,411.20	1.35	1,905
	Trifluralin 4 EC (Treflan) (herbicide)	gal	33.49	16.29	546
	Simazine 80WP (Princep) (herbicide)	lb	3.75	366.11	1,373
	DCPA 75WP (Dacthal) (herbicide)	lb	6.37	999.30	6,366
	Malathion, 57EL (Cythion) (insecticide)	gal	18.28	323.10	5,906
	Benomyl, 50WP (Benlate) (fungicide)	lb	14.17	271.20	3,843
	Carbaryl, 80WP (Sevin) (insecticide)	lb	6.09	459.65	2,799
	Chlorothalonil 10M cu ft (Termil) (fungicide)	canister	1.76	53.00	93
	Other (*i.e.*, Kelthane, Captan, Di-syston, Orthene, etc.)††				6,308
Subtotal					278,827
Machinery and Equipment					
	Tractor, 100 HP	hr	17.00	493.33	8,387
	Tractor, 60 HP	hr	11.68	583.16	6,811
	Tractor, 34 HP	hr	4.99	631.20	3,150

*Total of 200 acres, with 175 acres of growing space and 25 acres in production facilities, holding area, field bed area, roads, etc.

†Quantity discounts were applied to chemicals and other items.

‡135,231 plants would be stuck in the propagation house where about 23% would be lost, leaving 104,024 for transplanting into liner beds. About 20% of the plants in the liner beds would be lost, leaving 83,219 for transplanting into the field.

*Average basic wage before withholding taxes and fringes = $5.25, taxes and fringes add 32% or $1.68 for a total of $6.93.

†To achieve better pest and disease control, alternative chemical usage is advisable. Alternative chemical costs were estimated at 50% of the cost of Malathion, Benomyl, and Carbaryl.

TABLE 2 (continued).—Variable Costs (Dollars) for a 200-Acre* Field Nursery, USDA Plant Hardiness Zones 5 and 6, 1985.

Item	Description	Unit	Cost per Unit†	Quantity	Total Variable Cost
	Articulated loader/2,000 lb	hr	6.67	524.58	3,499
	Articulated loader/3,000 lb	hr	14.81	525.17	7,778
	Tree spade	hr	5.30	1,018.23	5,397
	Forks	hr	0.01	1,044.01	10
	Plow, 3-14"	hr	6.57	31.12	204
	Disk, 8' wide	hr	4.23	59.23	251
	Harrow, 10' wide	hr	8.45	4.66	39
	Cultimulcher, 10' wide	hr	24.70	8.76	216
	Spray rig with 10' boom	hr	2.77	57.04	158
	Transplanter, 1-row (tree)	hr	0.92	406.71	374
	Transplanter, 3-row	hr	26.79	20.81	557
	Permanent irrigation/well and pump, 100 HP	hr	7.60	323.00	2,455
	In-ground irrigation—bed/field area	hr	3.13	221.50	693
	Above-ground irrigation—bed area	hr	1.83	190.00	348
	In-ground irrigation—storage and holding	hr	5.65	60.00	339
	Above-ground irrigation—storage and holding	hr	11.05	60.00	663
	Traveler gun	hr	12.06	73.00	880
	Portable PTO pump, 40 HP (emergency)	hr	3.75	3.40	13
	Airblast sprayer	hr	1.01	405.15	409
	Fertilizer injector	hr	12.39	9.00	112
	Seeder	hr	1.05	10.72	11
	Mower	hr	2.98	42.84	128
	Transplanter, 2-row	hr	12.00	34.67	416
	Undercutter, bed	hr	1.16	20.00	23
	U-Blade	hr	17.56	1.65	29
	Sidedresser, 2-row	hr	0.63	102.25	64
	Cultivator, 2-row	hr	0.95	171.46	163
	Wagon, 4-wheel	hr	0.48	248.80	119
	Cultivator, 3-row	hr	13.93	14.75	205
	Truck, 1/2-ton pickup	hr	8.42	2,779.10	23,402
	Flatbed truck, 24' bed	hr	14.87	1,701.74	25,305
Subtotal					92,608
Labor					
	Labor hours	hr	6.93**	31,995.24	221,727
	Related labor hours, 20%	hr	6.93	6,399.28	44,347
Subtotal					266,074
Interest Charge on Operating Capital	Computed at 12% on an annual basis for 6 months	percent	6.0 (0.06)	646,596.00	38,796
Total Variable Costs					685,392

*Total of 200 acres, with 175 acres of growing space and 25 acres in production facilities, holding area, field bed area, roads, etc.
†Quantity discounts were applied to chemicals and other items.
‡135,231 plants would be stuck in the propagation house where about 23% would be lost, leaving 104,024 for transplanting into liner beds. About 20% of the plants in the liner beds would be lost, leaving 83,219 for transplanting into the field.
††Average basic wage before withholding taxes and fringes = $5.25, taxes and fringes add 32% or $1.68 for a total of $6.93.
**To achieve better pest and disease control, alternative chemical usage is advisable. Alternative chemical costs were estimated at 50% of the cost of Malathion, Benomyl, and Carbaryl.

TABLE 3.—Summary of Annual Fixed, Variable, and Total Costs (Dollars) of Operating a 200-Acre Field Nursery in Ohio, 1985.

Item	Cost	Percent of Total Cost
Fixed Cost Items		
Land and improvements	$108,578	10
Buildings	34,055	3
Machinery and equipment	127,477	11
General overhead	163,425	14
Interest on general overhead, insurance, and taxes	10,990	1
Subtotal	$444,525	39
Variable Cost Items		
Propagation (shrubs)	$9,087	1
Materials	278,827	25
Machinery and equipment	92,608	8
Labor	266,074	24
Interest on operating capital	38,796	3
Subtotal	$685,392	61
Total	$1,129,917	100

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% bank rate of interest—5% rate of inflation=7% real interest rate). Yet another method of computing interest would be to use the "real" interest rate computed on 50% of the cost of depreciable items. This latter method takes into account the "real" rate of interest and cost recovery of depreciable items. The method selected was believed to be most understandable to the majority of nurserymen. It does, however, overstate the cost of interest in most cases. Variable cost items, on the other hand, should be rather consistent regardless of age and size of nursery.

SUMMARY

Total annual production costs of operating a 200-acre field nursery were $1,129,917. Fixed costs were $444,525 or 39% of the total. Variable costs were $685,392 or 61% of the total.

LITERATURE CITED

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Comparative Costs of Producing Plants in a 200-Acre Field Nursery in Ohio Differentiated by Species of Plant

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ABSTRACT

The objective of this paper is to compare the costs of producing "balled and burlapped" field grown plants in Ohio differentiated by species of plant. Total annual costs per salable plant in a 200-acre nursery by species were $9.39 for 18-24″ slow-growing evergreens (*Taxus*), $7.09 for 18-24″ fast-growing evergreens (*Juniperus*), $7.07 for 3-4′ tall deciduous shrubs (*Viburnum*), $35.61 for 2″ caliper shade trees (*Acer rubrum*), $24.73 for 1-1/2″ caliper ornamental trees (*Malus*), and averaged $12.43 for all species. Fixed costs averaged 39% and variable costs 61% of the total.

INTRODUCTION

To make more informed decisions as to whether to enter, leave, or expand field production, nurserymen require production, marketing, and financial information. Comprehensive cost models have recently been developed for container grown crops in USDA plant hardiness zone 6 (3), for field grown crops in USDA plant hardiness zones 7 and 8 (1), and for field grown crops in USDA plant hardiness zones 5 and 6 (2). This paper summarizes per-salable-plant costs of producing nursery products in a 200-acre field nursery.

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 (Table 1); 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 (2).

Commonly grown nursery stock was divided into five cultural groups: slow-growing evergreens, fast-growing evergreens, deciduous shrubs, shade trees, and ornamental trees. 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. One species of plant was chosen to represent each cultural group. The production system provided for propagating shrubs (*Taxus*, *Juniperus*, and *Viburnum*) and for purchasing liners for trees (*Acer rubrum* and *Malus*).

Data for this study were obtained from wholesale nurseries and nursery suppliers in Ohio during the late autumn and winter of 1984 and the spring of 1985. Price quotations obtained were for the 1985 production season. 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 200 acres, with 175 acres of growing space and 25 acres of production facilities, holding area, field bed area, and roads. Twenty percent of the growing space was assigned to each of the cultural groups.

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).

RESULTS AND DISCUSSION

Annual fixed costs associated with capital investment (depreciation, interest, insurance, and taxes) were $270,110. An additional $163,425 was allocated for general overhead and $10,990 for interest on general overhead, insurance, and taxes, making a total of $444,525 annual fixed costs. These costs were divided equally between the five plant groups, with each group receiving an assessment of $88,905 (Table 2). It was felt that the most reasonable way of assigning fixed costs is by area rather than plant. Once the physical facility is provided, fixed costs are incurred at essentially the same amount regardless of how the nursery facility is used.

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: $4.90 for group I (*Taxus*), $3.48 for group II (*Juniperus*), $3.27 for group III (*Viburnum*), $10.87 for group IV (*Acer rubrum*), and $7.43 for group V (*Malus*), and averaged $4.88 for all groups (Table 3). Fixed costs as a percent of total costs ranged from 30% to 52% and averaged 39% for all groups (Table 3).

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In addition to research, Drs. Taylor, Smith, and Hahn have appointments in the Ohio Cooperative Extension Service.

TABLE 1.—Plant Densities and Losses for Field Production of Nursery Plants, Ohio, 1985.

Group	Description	Size of Salable Plant	Years in Rotation	Spacing Between Rows (inches)	Spacing in Rows (inches)	Sq Ft per Plant*	Plants per Acre	Estimated Percent Loss†
I	Slow-growing Evergreens—*Taxus*	18-24″	7	44	28	10.2	4,272	15
II	Fast-growing Evergreens—*Juniperus*	18-24″	5	44	28	10.2	4,272	15
III	Deciduous Shrubs—*Viburnum*	3-4′	4	48	30	11.9	3,652	15
IV	Shade Trees—*Acer rubrum*	2″ diameter	5	96	42	33.6	1,298	10
V	Ornamental Trees—*Malus*	5-6′ (1-1/2″)	4	96	36	28.7	1,518	10

*Sq ft per plant includes necessary perimeter roads.
†Assume one-half of loss between first and second year and remainder in last year of production. Losses in the last year of production would be left in the field.

TABLE 2.—Summary of Fixed, Variable, and Total Costs (Dollars) of Operating a 200-Acre* Field Nursery, Ohio, 1985.

Item	Group I (*Taxus*)	Group II (*Juniperus*)	Group III (*Viburnum*)	Group IV (*Acer rubrum*)	Group V (*Malus*)	Total
Fixed Cost						
Land and improvements	21,716	21,716	21,716	21,716	21,716	108,578†
Buildings	6,811	6,811	6,811	6,811	6,811	34,055†
Machinery and equipment	25,495	25,495	25,495	25,495	25,495	127,477†
General overhead	32,685	32,685	32,685	32,685	32,685	163,425†
Interest on general overhead, insurance, and taxes	2,198	2,198	2,198	2,198	2,198	10,990†
Subtotal	88,905	88,905	88,905	88,905	88,905	444,525†
Variable Costs						
Propagation	3,560	2,713	2,814	‡	‡	9,087
Materials	17,070	19,561	20,875	113,506	107,815	278,827
Machinery and equipment	11,739	12,039	14,138	24,747	29,945	92,608
Labor	44,540	52,158	59,590	52,558	57,228	266,074
Interest on operating capital	4,615	5,188	5,845	11,449	11,669	38,796
Subtotal	81,524	91,659	103,262	202,260	206,687	685,392
Total	170,429	180,564	192,167	291,165	295,592	1,129,917†
Salable Plants per Year	18,156	25,418	27,162	8,177	11,954	90,867
Annual Cost per Salable Plant	9.39	7.10	7.07	35.61	24.73	12.43

*Total nursery 200 acres, with 175 acres of growing space and 25 acres in production facilities, holding and field bed area, roads, etc.
†Individual figures do not always add to the total due to rounding.
‡Tree liners were purchased rather than propagated. Liner costs were included under materials.

TABLE 3.—Summary of Fixed, Variable, and Total Costs (Dollars) per Salable Plant of Operating a 200-Acre* Field Nursery, Ohio, 1985.

	Group I (*Taxus*)		Group II (*Juniperus*)		Group III (*Viburnum*)		Group IV (*Acer rubrum*)		Group V (*Malus*)		Average	
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 Cost												
Land and improvements	1.20	(13)	0.85	(12)	0.80	(11)	2.66	(7)	1.82	(7)	1.19	(10)
Buildings	0.38	(4)	0.27	(4)	0.25	(4)	0.83	(2)	0.57	(2)	0.37	(3)
Machinery and equipment	1.40	(15)	1.00	(14)	0.94	(13)	3.11	(9)	2.13	(9)	1.40	(11)
General overhead	1.80	(19)	1.28	(18)	1.20	(17)	4.00	(11)	2.73	(11)	1.80	(14)
Interest on general overhead, insurance, and taxes	0.12	(1)	0.08	(1)	0.08	(1)	0.27	(1)	0.18	(1)	0.12	(1)
Subtotal	4.90	(52)	3.48	(49)	3.27	(46)	10.87	(30)	7.43	(30)	4.88	(39)
Variable Cost Items												
Propagation	0.20	(2)	0.11	(1)	0.10	(1)	†		†		0.10	(1)
Materials	0.94	(10)	0.77	(11)	0.77	(11)	13.88	(39)	9.02	(37)	3.07	(25)
Machinery and equipment	0.65	(7)	0.47	(7)	0.52	(8)	3.03	(9)	2.51	(10)	1.02	(8)
Labor	2.45	(26)	2.05	(29)	2.19	(31)	6.43	(18)	4.79	(19)	2.93	(24)
Interest on operating capital	0.25	(3)	0.21	(3)	0.22	(3)	1.40	(4)	0.98	(4)	0.43	(3)
Subtotal	4.49	(48)	3.61	(51)	3.80	(54)	24.74	(70)	17.30	(70)	7.55	(61)
Total Costs per Salable Plant	9.39	(100)	7.09	(100)	7.07	(100)	35.61	(100)	24.73	(100)	12.43	(100)

*Total nursery 200 acres, with 175 acres of growing space and 25 acres in production facilities, holding and field bed area, roads, etc.

†Tree liners were purchased rather than propagated. Liner costs were included under materials.

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 $81,524 for group I (*Taxus*), $91,659 for group II (*Juniperus*), $103,262 for group III (*Viburnum*), $202,260 for group IV (*Acer rubrum*), and $206,687 for group V (*Malus*). Total for all groups was $685,392 (Table 2). On a per-salable-plant basis, variable costs were $4.49 for group I, $3.61 for group II, $3.80 for group III, $24.74 for group IV, $17.30 for group V, and averaged $7.55 for all groups (Table 3). Variable costs ranged from 48% to 70% of total costs and averaged 61% for all groups.

Total annual costs are the summation of fixed and variable costs. They were $170,429 for group I (*Taxus*), $180,564 for group II (*Juniperus*), $192,167 for group III (*Viburnum*), $291,165 for group IV (*Acer rubrum*), and $295,592 for group V (*Malus*). They totaled $1,129,917 for all groups (Table 2). On a per-salable-plant basis, total costs were $9.39 for group I, $7.09 for group II, $7.07 for group III, $35.61 for group IV, $24.73 for group V, and averaged $12.43 for all groups (Table 3).

SUMMARY

Total costs per salable plant differentiated by species ranged from $7.07 to $35.61 and averaged $12.43 for all species. Fixed costs per salable plant ranged from $3.27 to $10.87 and averaged $4.88. Fixed costs as a percentage of total costs ranged from 30% to 52% and averaged 39% for all species. Variable costs per salable plant showed substantial differences between plant species. They ranged from $3.61 to $24.74 and averaged $7.55 for all species. Variable costs as a percentage of total costs ranged from 48% to 70% and averaged 61% for all species.

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