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The Ohio State University
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CONTENTS

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ON THE COVER: Micropropagation techniques being investigated by Dr. R. Daniel Lineberger, associate professor of horticulture, show real opportunities for the nursery industries of the future. Results of some of his studies are presented on page 19. Here Dr. Lineberger is examining plants from micropropagation procedures.

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Capital Requirements for Establishing Container Nurseries in Ohio—1982

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ABSTRACT

Capital costs of establishing container nurseries in Ohio were about $593,000 in 1982 for a 17-acre facility having 340,000 square feet of growing space, and approximately $965,000 for a 33-acre facility having 680,000 square feet of growing space. Assuming a 2-year growing cycle for producing plants in 2-gallon containers, the capacity for producing salable plants on an annual basis ranged from about 59,000 to 128,000, depending upon optimal space requirements of plants in the smaller nursery, and from about 118,000 to 260,000 in the larger nursery. Capital requirements per salable plant ranged from $10.09 to $4.63, depending upon optimal space requirements of plants in the smaller nursery, and $8.21 to $3.71 in the larger nursery.

INTRODUCTION

Over the past few years the nursery industry in the United States has been gradually shifting from field to container production for many species of plants. New technological developments allow container production for species such as Taxus that were previously economically producible only in the field (2). Containers allow greater flexibility in production and marketing and in most cases are less expensive than field production (1). With these developments, questions concerning cost of production become increasingly important as firms decide whether to enter or expand container production.

Specific objectives of this study were to: 1) determine capital requirements of establishing container nurseries in Ohio, and 2) determine capital requirements per annual salable plant capacity according to plant spacing requirements.

A companion study determined operating costs on an annual basis for the two nurseries synthesized in this study.

MATERIALS AND METHODS

In the study two model firms were synthesized using the conceptual framework of economic engineering wherein the 'best proven practice' was included in each model. They were synthesized based on the Columbus, Ohio, area. The complete synthesis included developing an appropriate production cycle; 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 the purchase of plant liners and ending with loading the finished product for wholesale distribution; and budgets for fixed and variable costs (1). That portion of the synthesis included in establishing the physical production facility is included in this report.

Data for this study were obtained from wholesale nurseries and nursery suppliers in Ohio during 1982. The basic goals in synthesizing the production facilities (see Figures 1 and 2) were to minimize labor expenses, flow and movement of plant material and equipment, water runoff, and initial investment, and to maximize the number of salable plants and keep future expansion possible.

A model facility was synthesized for both a small (340,000 sq ft of growing area, Fig. 1) and a large (680,000 sq ft of growing area, Fig. 2) container nursery. Both models were designed with expansion in mind. For example, the small nursery has a centrally located shipping and "order building area" for four semi-truck loads of plant material surrounded by growing area (Fig. 1). When the need for expansion occurs, the firm can expand with a minimum of disruptions. If it were desired to double growing space, the six polyhouse structures in the larger shipping area and three polyhouses in the pond expansion area would be reconstructed around the firm's perimeter with an additional 51 houses.

Expansion for the large nursery would occur in essentially the same manner (Fig. 2). The same buildings and to a lesser degree machinery and equipment needed for the small nursery also met requirements for the large one. Most of the machinery and equipment, even in the large nursery, is under-used but must be available when needed.

The need for overwintering facilities (polyhouse structures) was a primary concern in the development of the production operation. Individual crop storage spacing needs can be a limiting factor to the number of units a given production acreage is able to produce (Table 1). To minimize physical movement of plants, yet maximize production of salable plants, a three-two plan (three polybouses with two growing spaces between the individual polyhouses) was utilized. Once in containers, only 10% of the newly planted crop has to be moved during the first growing season. At the beginning of the second

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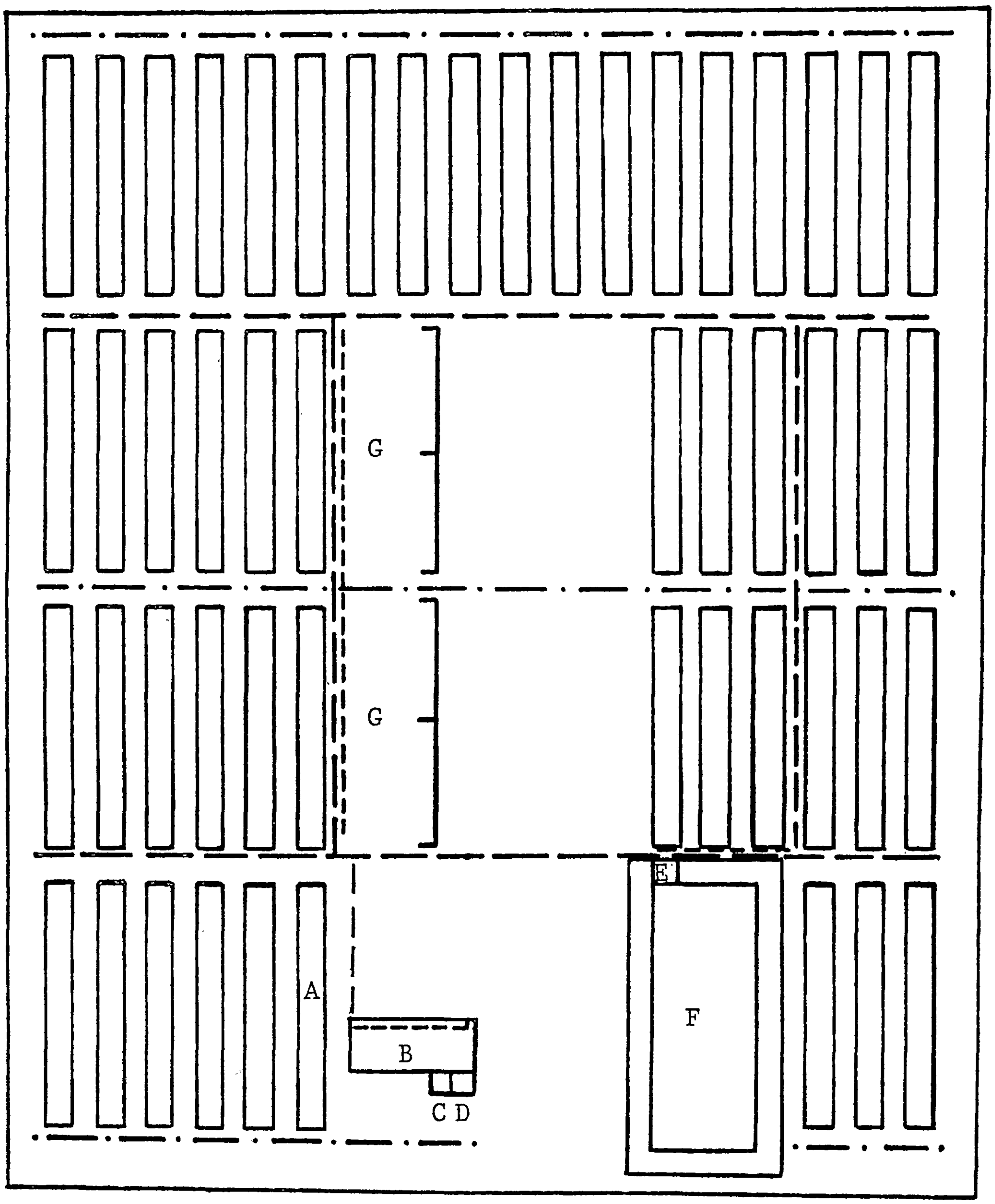
FIG.1.—Schematic drawing of a small commercial container nursery for Ohio.

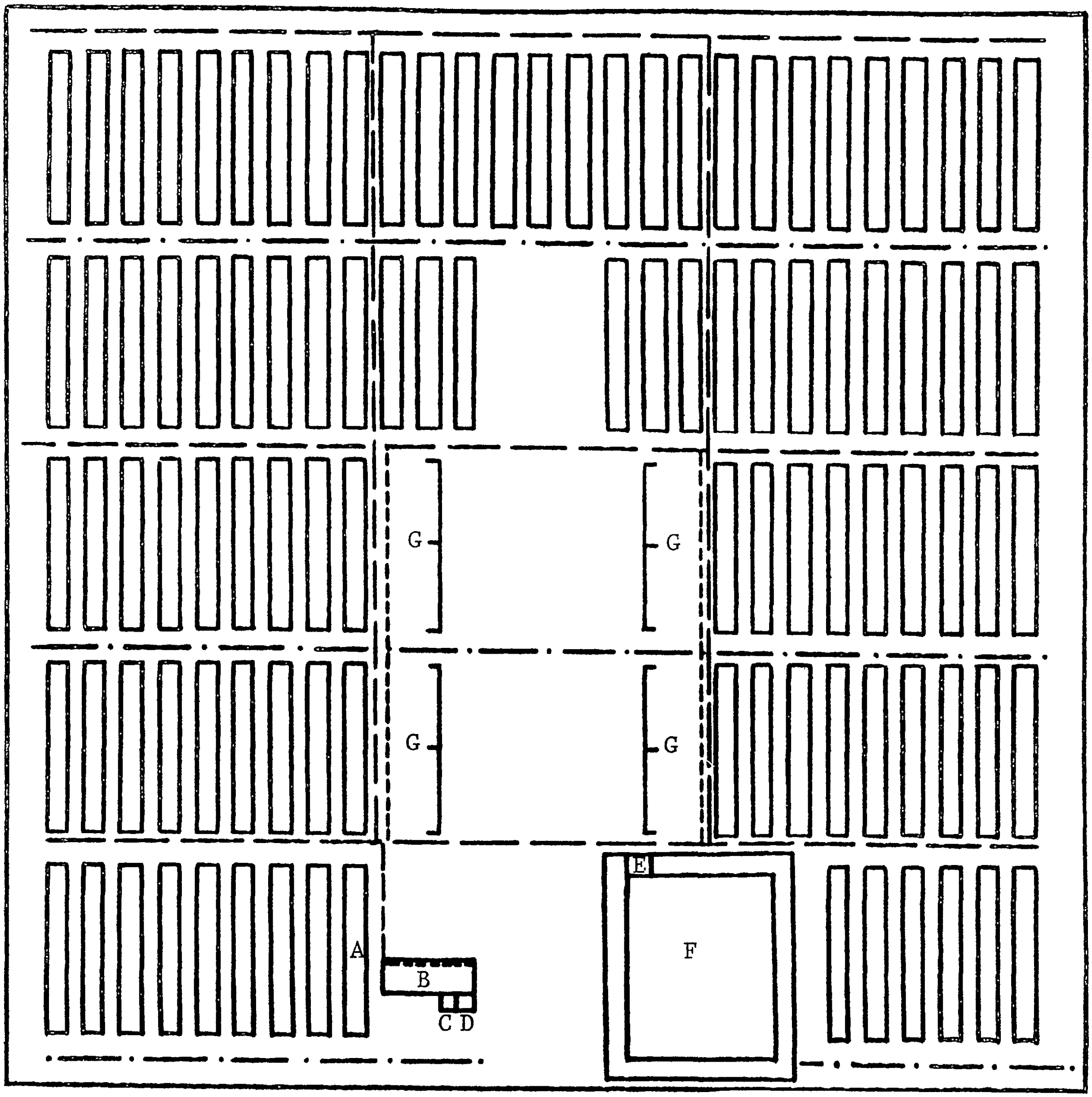


A. Polyhouse structure, 200' x 20'
B. Supply shed, machinery shed, machine shop, 40' x 100'
C. Office, 20' x 20'
D. Restrooms, 20' x 20'
E. Pump house, 10' x 10'
F. Pond, 80' x 120', 14' deep
G. Shipping area, 4 semi truckloads

Drainage Tile, 30" : ·—— · —— ·
Watermain, 8" PVC : —— ——
Watermain, 6" PVC : — — — —
Watermain, 4" PVC : - - - - - - -
Scale : 0' 100' 200'

Total Acreage	= 765' x 970'	= 742,050 sq. ft.	= 17.04 acres
Total Polyhouse Acreage	= 51(20' x 200')	= 204,000 sq. ft.	= 4.68 acres
Total Growing Space	= 85(20' x 200')	= 340,000 sq. ft.	= 7.81 acres

FIG. 2.—Schematic drawing of a large commercial container nursery for Ohio.



A. Polyhouse structure, 200' x 20'
B. Supply shed, machinery storage, machinery shop, 40' x 100'
C. Office, 20' x 20'
D. Restrooms, 20' x 20'
E. Pump house, 10' x 10'
F. Pond, 160' x 220', 14' deep
G. Shipping area, 8 semi truckloads

Drainage Tile, 30":
Watermain, 8" PVC :
Watermain, 6" PVC :
Watermain, 4" PVC :
Scale:
0' 100' 200'

Total Acreage -	1230' x 1170'	= 1,439,100	= 33.04 acres
Total Polyhouse Acreage -	[102(20' x 200')] =	408,000	= 9.37 acres
Total Growing Space -	[170(20' x 200')] =	680,000	= 15.61 acres

TABLE 1.—Capital Requirements for Small and Large Commercial Container Nurseries in Ohio, 1982.

Item	Description	Unit	Useful Life (years)	Small Container Nursery* Quantity	Cost per Unit (dollars)	Total Cost (dollars)	Percent of Total Cost
Land	Unimproved land	Acre		17.04	1,850	31,524	5
+ Improvements	Grading, tiling, graveling, pond		20			171,417	29
Subtotal						202,941	34
Buildings							
Office and restrooms	20' x 40' cement block	sq ft	20	800	28	22,400	4
Potting and packing shed	40' x 50' steel pole insulated	sq ft	20	2000	18	36,000	6
Machinery storage, shop	40' x 50' steel pole insulated	sq ft	20	2000	18	36,000	6
Polyhouse structures	200' x 20' pipe frame	each	10	51	2,193	111,843	19
Subtotal						206,243	35
Machinery and Equipment							
Tractor, 60 HP	60 HP, gas fuel with front end loader	each	10	1	16,000	16,000	3
Tractor, 28 HP	28 HP, gas fuel	each	10	2	6,025	12,050	2
Manure spreader	130 bu capacity	each	10	1	2,135	2,135	‡
Wagon	4 wheel, self steering	each	10	2	2,300	4,600	1
Irrigation pump/well	75 HP electric pump	each	20	1	40,085	40,085	7
Inground irrigation system	PVC pipe/valves		20		38,801	38,801	7
Above ground irrigation system	PVC pipe/sprinklers		5		19,383	19,383	3
Fertilizer injector	200 gal	each	5	1	6,500	6,500	1
Airblast sprayer	300 gal, on trailer	each	7	1	6,955	6,955	1
Cyclone spreader	Hand operated	each		1	40	40	‡
Forklift	3000 lb lift exterior wheels	each	10	1	24,000	24,000	4
Truck	½ ton pick-up	each	5	1	8,000	8,000	1
Pallets	Wooden	each	2	349	12	4,188	1
Handtools	Miscellaneous		5		1,000	1,000	‡
Subtotal						183,737	31
TOTAL						592,921	100

*17.04 total acreage, 340,000 sq ft of growing space, 204,000 sq ft of polyhouse space.
†33.04 total acreage, 680,000 sq ft of growing space, 408,000 sq ft of polyhouse space.
‡Less than half of 1%.

growing season, the close-spaced units and 10% of the newly containerized units will be moved into the opened growing area once occupied by the recently shipped salable units. Thus, for spacing alternative number one, each three-two configuration can support 7,920 first-year plants (can-to-can) and 7,722 second-year plants at 15 inch on center spacing. It can overwinter 7,920 first-year units (can-to-can) and 6,950 second-year units (11.75 inch on center) within the three polyhouses (Table 2). Flanking either side of the three-two growing plan are common access roadways 20 feet in width that are needed for the spray program, plant/polyhouse inspection, and order pulling operations.

To enable fullest utilization of the growing and shipping area, extensive grading, graveling, surface and underground tiles are necessary to provide proper drainage. The growing area must be graded to allow for a gradual sloping of the land from a high point at the shipping area to lower points on the extremes of the growing area. In addition, every two rows of polyhouses must be sloped toward each other to utilize a common buried 30-inch water tile that attaches to the open grassy waterways at the perimeter of the container operation.

A pond is 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 in containers in case of disruptions caused by repairs or electrical failure. In the small operation, for example, a partially above ground pond (80' x 120') was provided as a temporary holding area. This capacity would provide for irrigation needs for approximately 1 week. An auxiliary take-off drive from the pump could be powered by a large 60 HP tractor for temporary irrigation. The pond also functions as a discharge site when operating the pump at higher efficiency levels but not needing the total

TABLE 1 (Continued).—Capital Requirements for Small and Large Commercial Container Nurseries in Ohio, 1982.

				Large Container Nursery†			
Item	Description	Unit	Useful Life (years)	Quantity	Cost per Unit (dollars)	Total Cost (dollars)	Percent of Total Cost
Land	Unimproved land	Acre		33.04	1,850	61,124	6
+ Improvements	Grading, tiling, graveling, pond		20			326,304	34
Subtotal						387,428	40
Buildings							
Office and restrooms	20' x 40' cement block	sq ft	20	800	28	22,400	2
Potting and packing shed	40' x 50' steel pole insulated	sq ft	20	2000	18	36,000	4
Machinery storage, shop	40' x 50' steel pole insulated	sq ft	20	2000	18	36,000	4
Polyhouse structures	200' x 20' pipe frame	each	10	102	2,193	223,708	23
Subtotal						318,108	33
Machinery and Equipment							
Tractor, 60 HP	60 HP, gas fuel with front-end loader	each	10	1	16,000	16,000	2
Tractor, 28 HP	28 HP, gas fuel	each	10	2	6,025	12,050	1
Manure spreader	130 bu capacity	each	10	1	2,135	2,135	‡
Wagon	4 wheel, self steering	each	10	4	2,300	9,200	1
Irrigation pump/well	75 HP electric pump	each	20	1	40,085	40,085	4
Inground irrigation system	PVC pipe/valves		20		77,160	77,160	8
Above ground irrigation system	PVC pipe/sprinklers		5		38,765	38,765	4
Fertilizer injector	200 gal	each	5	1	6,500	6,500	1
Airblast sprayer	300 gal, on trailer	each	7	1	6,955	6,955	1
Cyclone spreader	Hand operated	each		1	40	40	‡
Forklift	3,000 lb lift exterior wheels	each	10	1	24,000	24,000	2
Truck	½ ton pick-up	each	5	2	8,000	16,000	2
Pallets	Wooden	each	2	679	12	8,148	1
Handtools	Miscellaneous		5		2,000	2,000	‡
Subtotal						259,038	27
TOTAL						964,574	100

*17.04 total acreage, 340,000 sq ft of growing space, 204,000 sq ft of of polyhouse space.
†33.04 total acreage, 680,000 sq ft of growing space, 408,000 sq ft of polyhouse space.
‡Less than half of 1%.

water being drawn for present irrigation purposes. The grass perimeter maintains an aesthetically pleasing view and allows for excess water runoff.

Each nursery was assumed to require similar sized permanent buildings for the receiving of nursery stock/storage (50' x 40'), machinery repair/storage (50' x 40'), office space (20' x 20'), and restroom facilities (20' x 20').

The amount of machinery and equipment needed was based on the assumption that each size nursery was an ongoing business. Peak equipment utilization time periods were recognized and appropriate quantities of equipment were provided to carry out necessary daily activities. In particular, the irrigation system was designed to minimize labor efforts yet provide sufficient capacity to meet all anticipated needs.

RESULTS AND DISCUSSION

Capital investment requirements for establishing container nurseries were itemized under three broad divisions: land and improvements, buildings, and machinery and equipment (Table 1). Each was further subdivided into several components. The small nursery required $592,921 in investment. Land and land improvements represented 34% or $202,941 of the investment, buildings 35% or $206,243, and machinery and equipment 31% or $183,737. The large nursery had an initial investment requirement of $964,574. Land and land improvements represented 40% or $387,428 of the investment, buildings 33% or $318,108, and machinery and equipment 27% or $259,038. The difference in the percent of total investment between the various components of the two nurseries was primarily caused by the larger

TABLE 2.—Capacity in Number of Plants and Capital Required per Salable Plant Capacity by Spacing and Size of Nursery for Commercial Nurseries in Ohio, 1982.

	Growing Cycle Spacing				Small Container Nursery*		
Alternative	First Growing Season On-center (inch)	First Year Over-wintering (inch)	Second Growing Season On-Center (inch)	Second Year Over-wintering (inch)	Total Plants in Production (units)	Salable Plants per Year (units)	Capital Requirements per Salable Plant Capacity (dollars)
One	8.5	8.5	15	11.75	265,930	128,000	4.63
Two	8.5	8.5	18	15	193,909	93,334	6.35
Three	12	12	18	15	152,999	73,643	8.05
Four	12	12	24	18	122,089	58,765	10.09
	Growing Cycle Spacing				**Large Container Nursery†**		
Alternative	First Growing Season On-center (inch)	First Year Over-wintering (inch)	Second Growing Season On-Center (inch)	Second Year Over-wintering (inch)	Total Plants in Production (units)	Salable Plants per Year (units)	Capital Requirements per Salable Plant Capacity (dollars)
One	8.5	8.5	15	11.75	540,170	260,000	3.71
Two	8.5	8.5	18	15	387,817	186,668	5.17
Three	12	12	18	15	305,999	147,286	6.55
Four	12	12	24	18	244,178	117,530	8.21

*17.04 total acreage, 340,000 sq ft of growing space, 204,000 sq ft of polyhouse space.
†33.04 total acreage, 680,000 sq ft of growing space, 408,000 sq ft of polyhouse space.

nursery being able to make more efficient use of buildings, machinery, and equipment than the smaller nursery. Both nurseries were about equally efficient in the use of growing space.

Production capacity in number of salable plants per year is determined by both the size of plant being produced and its growing cycle (Table 2). Capacity for the small nursery ranged from 58,765 to 128,000 salable plants per year while capacity for the large nursery ranged from 117,530 to 260,000.

An important consideration for managers in most industries is determination of investment per unit of production capacity. For container nurseries, the associated indicator would be the capital requirement per-salable-plant capacity. This indicator was determined for four alternatives in the two nurseries (Table 2). The figure ranged from $4.63 to $10.09 for the small nursery, depending on size of plant being produced and its growing cycle, while for the large nursery it ranged from $3.71 to $8.21.

Investment requirements of two different container nurseries for Ohio conditions were examined. However, an infinite number of sizes could have been analyzed. While it is impossible to analyze all possibilities, it would be appropriate to reach some additional conclusions. Observations of the data would indicate higher investment costs per unit of salable plant capacity as container nursery size is decreased from the 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 container nurseries larger than those analyzed as the costs of fixed items would be spread over more units.

Individual nurserymen could, of course, experience somewhat different costs than those presented. Individual costs would depend upon things like production cycle chosen and ability to bargain with suppliers. The nurserymen also may choose not to provide for future expansion, choose land that would require minimum drainage modifications, reduce optimal growing/overwintering space requirements, or operate used equipment. This analysis assumed average soil conditions, expansion capacity, optimal spacing configurations, new buildings, equipment, and machinery.

SUMMARY

Large sized commercial container nurseries are able to make more efficient use of buildings, equipment, and machinery than small container nurseries. This results in large nurseries having a lower cost per salable plant. Most commercial container nurseries are similar in efficiency factors relative to growing space.

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Production Costs of Operating Container Nurseries in Ohio—1982

HAROLD H. KNEEN, REED D. TAYLOR, DAVID E. HAHN, and ELTON M. SMITH[1]

ABSTRACT

The objective of this study was to determine annual production costs of operating container nurseries in Ohio. This objective was accomplished by synthesizing two model container nurseries using the conceptual framework of economic engineering. Annual production costs were about $575,000 in 1982 for a 17-acre facility having 340,000 square feet of growing space, and approximately $1,056,000 for a 33-acre facility having 680,000 square feet of growing space. Total annual costs per salable plant were $4.50 in the small nursery and $4.06 in the large. These per plant costs assumed a 2-year growing cycle, production in 2-gallon containers, and an average size of 12-15 inches per salable plant.

INTRODUCTION

Nurserymen throughout the United States have been gradually shifting from field to container production for many species of plants. Containers allow greater flexibility in production and marketing and in most cases are less expensive than field production (7). Consequently, they have encouraged large companies to enter production and marketing. The result has been escalating competition and narrowing profit margins in the Ohio nursery industry. Most nurserymen also lack the necessary expertise to systematically determine production costs.

Cost models have recently been developed for several species of plants in other regional areas (1, 2, 3, 4, 5, 6). An initial cost model for Ohio was developed by Powers (8) which provided excellent information. However, it did not include overhead costs or information on physical coefficients. The lack of physical coefficients makes it very difficult to update the information without resurveying Ohio nurserymen. Development of complete cost models for Ohio nurserymen would provide a standard against which they could compare their own operations. This type of information would allow present or potential Ohio nurserymen to make more informed decisions as to whether to enter, leave, or expand container production.

The specific objective of the study was to determine annual production costs of operating container nurseries in Ohio.

MATERIALS AND METHODS

In the study, two model firms were synthesized using the conceptual framework of economic engineering wherein the 'best proven practice' was sought for each model. They were synthesized based on data obtained from wholesale nurseries and nursery suppliers near Columbus, Ohio, during 1982.

A model nursery was synthesized for both a small (17 acres, 340,000 square feet of growing space, producing 128,000 12-15 inch salable plants per year) and a large (33 acres, 680,000 square feet of growing space, producing 260,000 12-15 inch salable plants per year) container nursery. A basic premise was to provide key facilities (*i.e.*, storage buildings and irrigation mains) with sufficient capacity for future expansion.[2]

For clarity of presentation, only the first of the four spacing alternatives presented in the companion article is presented in this paper. Also for clarity, only one species of plant, *Juniperus chinensis* 'Pfitzeriana', was analyzed in detail. Other species of plants would have somewhat different budgetary requirements, but generally the costs would be similar assuming a 12-15 inch salable size plant or its equivalent.

The production models were based on selling 12-15 inch plants in 2-gallon containers. Cultural practices of weeding, fertilizing, watering, spraying, pruning, and overwintering were determined. After the second growing season, 10% of the salable crop would be harvested to meet fall orders. The balance of the crop would be stored with tight spacing configuration for spring sales. The crop would be sold as follows: 15% between February and March, 50% in April, and 25% in May.

Costs were established for all factors of production including management and invested capital. In economic terms, costs associated with factors of production inputted by owner/operators are often referred to as 'opportunity costs' or the income these factors could have received if they were employed elsewhere. For example, owners could usually be employed as managers at other nurseries, and money invested in land, buildings, irrigation systems, and equipment could have earned interest if it had been placed in financial institutions.

Costs were classified as either fixed or variable. Fixed costs include all costs that remain constant over

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[2]Schematic drawings for the two facilities are provided in the first article in this circular, Capital Requirements for Establishing Container Nurseries in Ohio—1982, p. 3.

certain increases or decreases in quantity of plants produced. They are usually associated with those items that are partially used up in a given production cycle such as buildings, irrigation systems, and equipment. Variable costs include all cost factors that vary with the quantity of plants being grown at one time. They are usually associated with those items that are used up in a given production cycle such as packaging materials and growing media.

Cost analyses were made on the assumption of ongoing fully operational nurseries. Costs per salable plant were determined by taking total annual costs and dividing them by the number of salable plants. Budgets reflected plant losses of 2.5% between the first and second growing season and a 2.5% final 'pitch loss'.

Fixed costs are presented in Table 1. Land and land improvements budgeted for each model provided

TABLE 1.—Annual Fixed Costs (Dollars) for Small and Large Container Nurseries in Ohio, 1982.

		Small Container Nursery*			
Item	Description	Depreciation‡	Interest**	Insurance and Taxes	Total
Land	Unimproved land		4,739	631	5,370
+ Improvements	Grading, tiling, graveling, pond	8,571	25,713	3,428	37,712
Subtotal		8,571	30,452	4,059	43,082
Buildings					
Office and restrooms	20' x 40'	1,120.	3,360	568	5,048
Potting and packing shed	40' x 50'	1,800	5,400	913	8,113
Machinery storage, shop	40' x 50'	1,800	5,400	913	8,113
Polyhouse structures	200' x 20'	10,066	16,777	2,835	29,678
Subtotal		14,786	30,937	5,229	50,952
Machinery and Equipment					
Tractor, 60 HP	60 HP, gas fuel w/front-end loader	1,440	2,400	73	3,913
Tractor, 28 HP	28 HP, gas fuel	1,085	1,808	55	2,948
Manure spreader	130 bu capacity	192	320	10	522
Wagon	4-wheel	414	690	21	1,125
Irrigation pump/well	75 HP, electric pump	1,804	6,013	182	7,999
Inground irrigation system	PVC pipe/valves	1,940	5,820	176	7,936
Above ground irrigation system	PVC pipe/sprinklers	3,489	2,908	88	6,485
Fertilizer injector	28 gal injector	1,170	975	30	2,175
Airblast sprayer	300 gal, on trailer	894	1,043	36	1,973
Forklift	3,000 lb lift, exterior-use wheels	2,160	3,600	109	5,869
Truck	½ ton pickup	1,440	1,200	36	2,676
Pallets	Wooden	1 047	628		1,675
Handtools	Miscellaneous	200	150		350
Subtotal		17,275	27,555	816	45,646
General Overhead					
Utilities	Telephone, electric, gas heat				5,325
Licenses and Bonds					375
General Repairs and Maintenance	Buildings and grounds				6,140
Advertising and Printing					1,050
Insurance, personnel	Workmen's compensation, FICA, health, unemployment				19,060
Travel and other					1,500
Professional fees					75
Administrative and management costs	Clerical, operator supervisory labor, office supplies				60,500
Miscellaneous					1,000
Subtotal					95,025
Interest on General Overhead, Insurance, and Taxes	Computed at 15% per annum for 6 months				7,885
Total Annual Fixed Costs					242,590
Annual Fixed Cost per 12-15 Inch Salable Plant					1.90

*17.04 acres, 340,000 sq ft of growing space, 204,000 sq ft of polyhouse space, 128,000 12-15 inch salable plants per year.
†33.04 acres, 680,000 sq ft of growing space, 408,000 sq ft of polyhouse space, 260,000 12-15 inch salable plants per year.
‡Depreciation was estimated by dividing initial cost adjusted for salvage value by the years of useful life.
**Interest costs were estimated by multiplying the initial value of land, buildings, equipment, machinery by the interest rate, 15% per annum.

sufficient acreage for adequately drained growing areas, roadways, shipping and building facilities, a pond, and grass perimeter. Buildings were divided into office and restrooms, potting and packing shed, machinery storage and shop, and polyhouse structures. Polyhouse structures were dependent upon overwinter needs as determined by age and space requirements of plants. Machinery and equipment were the minimum necessary to sufficiently operate given sized nurseries during peak load periods. General overhead included utilities, licenses, general repairs, advertising, personnel insurance, travel, professional fees, administration and management, and miscellaneous costs. Interest charges on general overhead, insurance, and taxes were computed for a 6-month period.

Annual fixed costs for land and land improvements, buildings, and machinery and equipment were

TABLE 1 (Continued).—Annual Fixed Costs (Dollars) for Small and Large Container Nurseries in Ohio, 1982.

		Large Container Nursery†			
Item	Description	Depreciation‡	Interest**	Insurance and Taxes	Total
Land	Unimproved land		9,169	1,223	10,392
+ Improvements	Grading, tiling, graveling, pond	16,315	48,946	6,526	71,787
Subtotal		16,315	58,115	7,749	82,179
Buildings					
Office and restrooms	20' x 40'	1,120	3,360	568	5,048
Potting and packing shed	40' x 50'	1,800	5,400	913	8,113
Machinery storage, shop	40' x 50'	1,800	5,400	913	8,113
Polyhouse structures	200' x 20'	20,134	33,556	5,671	59,361
Subtotal		24,854	47,716	8,065	80,635
Machinery and Equipment					
Tractor, 60 HP	60 HP, gas fuel w/front-end loader	1,440	2,400	73	3,913
Tractor, 28 HP	28 HP, gas fuel	1,085	1,808	55	2,948
Manure spreader	130 bu capacity	192	320	10	522
Wagon	4-wheel	828	1,380	42	2,250
Irrigation pump/well	75 HP, electric pump	1,804	6,013	182	7,999
Inground irrigation system	PVC pipe/valves	3,858	11,574	350	15,782
Above ground irrigation system	PVC pipe/sprinklers	6,978	5,815	176	12,969
Fertilizer injector	28 gal injector	1,170	975	30	2,175
Airblast sprayer	300 gal, on trailer	894	1,043	36	1,973
Forklift	3,000 lb lift, exterior-use wheels	2,160	3,600	109	5,869
Truck	½ ton pick-up	2,880	2,400	73	5,353
Pallets	Wooden	2,037	1,222		3,259
Handtools	Miscellaneous	400	300		700
Subtotal		25,726	38,850	1,136	65,712
General Overhead					
Utilities	Telephone, electric, gas heat				7,990
Licenses and Bonds					565
General Repairs and Maintenance	Buildings and grounds				10,585
Advertising and Printing					1,575
Insurance, personnel	Workmen's compensation, FICA, health, unemployment				31,420
Travel and other					2,250
Professional fees					115
Administrative and management costs	Clerical, operator supervisory labor, office supplies				93,500
Miscellaneous					2,000
Subtotal					150,000
Interest on General Overhead, Insurance, and Taxes	Computed at 15% per annum for 6 months				12,521
Total Annual Fixed Costs					391,047
Annual Fixed Cost per 12-15 Inch Salable Plant					1.50

*17.04 acres, 340,000 sq ft of growing space, 204,000 sq ft of polyhouse space, 128,000 12-15 inch salable plants per year.
†33.04 acres, 680,000 sq ft of growing space, 408,000 sq ft of polyhouse space, 260,000 12-15 inch salable plants per year.
‡Depreciation was estimated by dividing initial cost adjusted for salvage value by the years of useful life.
**Interest costs were estimated by multiplying the initial value of land, buildings, equipment, machinery by the interest rate, 15% per annum.

composed of depreciation, interest, insurance, and taxes. Depreciation was calculated by dividing initial cost adjusted for salvage value by the years of useful life. Interest costs were estimated by multiplying the initial value of land and land improvements, buildings, machinery, and equipment by 15% per annum. Taxes and insurance costs were based on rates prevailing in the rural areas adjacent to Columbus, Ohio. Land, land improvements, and buildings were assessed taxes at the rate of $20 per $1,000 of market value. Insurance was set at $5.35 per $1,000 of market value for buildings and $4.54 per $1,000 of initial value for equipment. Costs for general overhead were determined on a current basis. Interest charges for general overhead, insurance, and taxes were computed for a 6-month average use period at a rate of 15% per annum.

Variable costs were subdivided into materials, machinery and equipment, labor, and interest charges on operating capital (Table 2). Materials were subdivided into containers, liners, polyethylene film, strip tags, and chemicals. Machinery and equipment variable costs included repairs, maintenance, fuel, oil, and lubrication. Labor hours were budgeted for both direct production and related items. Related items included down time between nursery

TABLE 2.—Annual Variable Costs (Dollars) for Small and Large Container Nurseries in Ohio, 1982.

				Small Container Nursery*	
Item	Description	Unit	Cost per Unit	Quantity	Total Variable Cost
Materials					
Container	#2, 8½" x 8" copolymer propylene	each	0.29	134,480	38,999
Soil mixture	Hardwood bark, sand, nutrients	cu yd	31.00	1,076	33,356
Liners	2-year 6-7" liner	each	0.95	134,480	127,756
Polyethylene film	4 mil white, 32' x 225'	each	107.00	51	5,457
Strip tags	⅝" x 7" plastic strip tag	each	0.02	128,000	2,560
Chemicals	Oxadiazon 4G (herbicide)	pound	0.90	1,460	1,314
	Benomyl 50 WP (fungicide)	pound	10.00	15‡	152
	Demetron 6 (insecticide)	ounces	0.71	130	92
	Cyhexatin 50WP (miticide)	pound	22.25	4	89
	Chlorothalonil 10M cu ft (fungicide)	canister	1.90	301	572
	Osmocote 8-9 mo (18-6-12)	pound	0.86	18,158	15,616
	Urea 45-0-0 (fertilizer)	pound	0.13	13,142	1,708
	Glyphosate (herbicide)	quart	16.60	14	232
Subtotal					227,903
Machinery and Equipment					
	Tractor, 60 HP	hour	15.85	133	2,108
	Tractor, 28 HP	hour	4.92	517	2,544
	Manure spreader, 130 bu	hour	1.58	43	68
	Wagon, 4-wheel	hour	0.53	778	412
	Irrigation/well, pump 75 HP	hour	6.65	735	4,888
	Inground irrigation system	hour	1.54	735	1,132
	Above ground irrigation system	hour	3.09	735	2,271
	Fertilizer injector	hour	4.33	120	520
	Airblast sprayer	hour	23.98	16	384
	Forklift	hour	6.59	130	857
	½ ton pick-up truck	hour	8.51	375	3,191
Subtotal					18,375
Labor					
	Labor hours	hour	5.15**	10,221	52,638
	Related labor hours	hour	5.15	2,044	10,527
Subtotal					63,165
Interest Charge on Operating Capital	Computed at 15% on an annual basis for 6 months	percent	7.5 (0.75)	309,443	23,208
Total Annual Variable Costs					332,651
Annual Variable Cost per 12-15 Inch Salable Plant					2.60

*17.04 acres, 340,000 sq ft of growing space, 204,000 sq ft of polyhouse space, 128,000 12-15 inch salable plants per year.
†33.04 acres, 680,000 sq ft of growing space, 408,000 sq ft of polyhouse space, 260,000 12-15 inch salable plants per year.
‡Rounded to the nearest whole number.
**Average basic wage before withholding taxes and fringes $4.30, taxes and fringes add 19.84% or $0.85 for a total of $5.15.

activities, inclement weather conditions, minor repair and maintenance work, and odd jobs. An interest charge was assessed on operating capital for a 6-month period.

RESULTS AND DISCUSSION

Annual fixed, variable, and total production costs of operating container nurseries in Ohio for 1982 are summarized in Table 3. In the small nursery, total production costs were $575,240 or $4.50 per salable 12-15 inch plant. Fixed costs totaled $242,540 or $1.90 per plant and made up 42% of total costs. Based on a percentage of total costs, land and improvements made up 8%, buildings 9%, machinery and equipment 8%, general overhead 16%, and interest on general overhead, insurance, and taxes 1%. Variable costs totaled $332,651 or $2.60 per plant and made up 58% of total costs. Based on a percentage of total costs, materials made up 40%, machinery and equipment 3%, labor 11%, and interest on operating capital 4%.

In the large nursery, total production costs were $1,056,440 or $4.06 per salable 12-15 inch plant. Fixed costs totaled $391,047 or $1.50 per plant and made up 37% of total costs. Based on a percentage of total costs, land and improvements made up 8%, buildings 8%, machinery and equipment 6%, gen-

TABLE 2 (Continued).—Annual Variable Costs (Dollars) for Small and Large Container Nurseries in Ohio, 1982.

Item	Description	Unit	Cost per Unit	Large Container Nursery† Quantity	Large Container Nursery† Total Variable Cost
Materials					
Container	#2, 8½" x 8" copolymer propylene	each	0.29	273,165	79,218
Soil mixture	Hardwood bark, sand, nutrients	cu yd	31.00	2,185	67,735
Liners	2-year 6-7" liner	each	0.95	273,165	259,507
Polyethylene film	4 mil white, 32' x 225'	each	107.00	102	10,914
Strip tags	⅝" x 7" plastic strip tag	each	0.02	260,000	5,200
Chemicals	Oxadiazon 4G (herbicide)	pound	0.90	2,985	2,686
	Benomyl 50 WP (fungicide)	pound	10.00	31‡	312
	Demetron 6 (insecticide)	ounces	0.71	265	188
	Cyhexatin 50WP (miticide)	pound	22.25	8‡	185
	Chlorothalonil 10M cu ft (fungicide)	canister	1.90	610	1,159
	Osmocote 8-9 mo (18-6-12)	pound	0.86	36,883	31,719
	Urea 45-0-0 (fertilizer)	pound	0.13	25,217	3,278
	Glyphosate (herbicide)	quart	16.60	28	465
Subtotal					462,566
Machinery and Equipment					
	Tractor, 60 HP	hour	15.85	270	4,280
	Tractor, 28 HP	hour	4.92	1,050	5,166
	Manure spreader, 130 bu	hour	1.58	87	137
	Wagon, 4-wheel	hour	0.53	1,580	837
	Irrigation/well, pump 75 HP	hour	6.65	1,002	6,663
	Inground irrigation system	hour	1.54	1,002	1,543
	Above ground irrigation system	hour	3.09	1,002	3,096
	Fertilizer injector	hour	4.33	180	779
	Airblast sprayer	hour	23.98	33	791
	Forklift	hour	6.59	264	1,740
	½ ton pick-up truck	hour	8.51	750	6,382
Subtotal					31,414
Labor					
	Labor hours	hour	5.15**	20,224	104,154
	Related labor hours	hour	5.15	4,045	20,832
Subtotal					124,986
Interest Charge on Operating Capital	Computed at 15% on an annual basis for 6 months	percent	7.5 (.075)	618,966	46,422
Total Annual Variable Costs					665,388
Annual Variable Cost per 12-15 Inch Salable Plant					2.56

*17.04 acres, 340,000 sq ft of growing space, 204,000 sq ft of polyhouse space, 128,000 12-15 inch salable plants per year.
†33.04 acres, 680,000 sq ft of growing space, 408,000 sq ft of polyhouse space, 260,000 12-15 inch salable plants per year.
‡Rounded to the nearest whole number.
**Average basic wage before withholding taxes and fringes $4.30, taxes and fringes add 19.84% or $0.85 for a total of $5.15.

TABLE 3.—Summary of Annual Fixed, Variable, and Total Costs (Dollars) of Operating Container Nurseries in Ohio, 1982.

	Small Container Nursery*			Large Container Nursery†		
Item	Cost	Cost per Salable Plant	Percent of Total Cost	Cost	Cost per Salable Plant	Percent of Total Cost
Fixed Cost Items						
Land and Improvements	43,082	0.34	8	82,179	0.32	8
Buildings	50,952	0.40	9	80,635	0.31	8
Machinery and Equipment	45,646	0.36	8	65,712	0.25	6
General Overhead	95,025	0.74	16	150,000	0.58	14
Interest on General Overhead, Insurance, and Taxes	7,885	0.06	1	12,521	0.05	1
Subtotal	242,540	1.90	42	391,047	1.50	37
Variable Cost Items						
Materials	227,903	1.78	40	462,566	1.78	44
Machinery and Equipment	18,375	0.15	3	31,414	0.12	3
Labor	63,165	0.49	11	124,986	0.48	12
Interest on Operating Capital	23,208	0.18	4	46,422	0.18	4
Subtotal	332,651	2.60	58	665,388	2.56	63
Total Annual Costs	575,240	4.50	100	1,056,440	4.06	100

*17.04 acres, 340,000 sq ft of growing space, 204,000 sq ft of polyhouse space, 128,000 12-15 inch salable plants per year.
†33.04 acres. 680.000 sq ft of growing space, 408,000 sq ft of polyhouse space, 260,000 12-15 inch salable plants per year.

eral overhead 14%, and interest on general overhead, insurance, and taxes 1%. Variable costs totaled $665,388 or $2.56 per plant and made up 63% of total costs. Based on a percentage of total costs, materials made up 44%, machinery and equipment 3%, labor 12%, and interest on operating capital 4%.

Total costs were 44 cents per plant more in the small nursery than in the large. Of this 44 cents, 40 cents or 91% were made up of fixed costs. On a per item basis, the large nursery's advantages were 2 cents on land and improvements, 9 cents on buildings, 11 cents on machinery and equipment, 16 cents on general overhead, and 1 cent on interest for general overhead, insurance, and taxes. The 4 cents accounted for by variable costs were 3 cents on machinery and equipment and 1 cent on labor. Variable costs per plant for materials and interest on operating capital were the same for the two sized nurseries.

In the nurseries analyzed, it cost 11% less to produce a 12-15 inch salable plant in the large nursery than in the small. While the overall reduction was 11%, it was 27% for fixed costs and only 2% for variable. Large-sized commercial container nurseries are able to make more efficient use of buildings, equipment, and machinery than small container nurseries.

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. Variable cost items, on the other hand, should be rather consistent regardless of age and size of the nursery.

Determination of annual production costs on a salable plant basis according to spacing requirements would vary significantly between fixed and variable costs. Fixed costs per plant could be determined simply by dividing the number of salable plants per year into total annual fixed costs. Adjusting variable costs would be more difficult. If a container nursery were growing substantial numbers of larger plants, for example, total annual variable costs would be reduced as a result of lower requirements for containers, soil mixture, liners, strip tags, and labor. On the other hand, annual variable costs per salable plant would increase due to spreading costs for polyethylene film, chemicals, machinery, and equipment over fewer units.

SUMMARY

Total annual costs per salable plant were $4.50 in the small nursery and $4.06 in the large. Fixed costs were $1.90 in the small nursery and $1.50 in the large for a differential of $0.40 per salable plant. Variable costs, on the other hand, were $2.60 in the small and $2.56 in the large for a differential of only 4 cents. These per plant costs assumed a 2-year growing cycle, production in 2-gallon containers, and an average size of 12-15 inches per salable plant.

These figures demonstrated that variable costs on a salable plant basis, at least over the size range of nurseries analyzed, remain reasonably constant. The small nursery could purchase materials and other variable items almost as cheaply as could the large. Fixed costs in contrast changed significantly as size of nursery increased. This occurred because most of the fixed factors required to operate the small nursery such as management, buildings, and most machinery and equipment were also adequate to operate the large. As the size of nursery increased, costs for fixed items of production were spread over more salable units, thereby reducing the fixed cost per plant.

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Pigmented Polyethylene Films for Nursery Crop Storage

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ABSTRACT

Pigmented white films of 50%, 70%, and 80% opacity and white double layer inflated film were evaluated. Shoot quality was highest in structures covered by double layer inflated films. Shoot quality among the single layer pigmented films was generally highest in structures covered with the films of highest opacities, 70% and 80%, and lowest in structures covered with 50% opacity film. Although the 70% and 80% opacity film resulted in better shoot quality than the 50% opacity control, these higher opacity films did not result in quality as high as the double layer inflated film. Maximum air temperature and average soil temperature were lowest in double layer inflated film covered structures. Inside the single layer pigmented film covered structures, maximum air temperature and average soil temperature decreased with increasing opacity. It may be inferred from these results in Ohio that increasing the opacity of the standard white overwintering film to 70% to 80% would give optimum shoot quality with selected plants. However, additional research in geographical areas outside Ohio is desirable before film extruders consider pigmenting to increase opacity.

INTRODUCTION

The use of poly covered quonset houses has been the major method to protect container stock from winter injury. To provide optimum protection from winter injury, a poly covered house should protect against low night temperatures which may cause root damage and high day temperatures which may cause desiccation injury (1, 2, 5, 6, 12, 13).

A major problem with poly covered houses is that the standard white single layer poly covered house of 50 to 60% opacity doesn't provide adequate protection of all woody landscape species grown in Ohio (3, 6, 15). Due to this, nurserymen have used double layer inflated film and other methods of additional protection which have raised their production costs (7, 8, 9, 10).

Due to the above problems, a great need has developed for a single layer film which will be more effective in overwintering a wider range of landscape plant species. The purpose of this study was to determine if a film with greater pigmentation would be more effective in wintering plants than those currently available. In addition, the overwintering effectiveness of these higher opacity films and a double layer inflated film were compared.

MATERIALS AND METHODS

On Nov. 7 and 8, 1979, 11 quonset houses located in a commercial nursery in central Ohio were covered with poly pigmented at higher opacities. Each house was 30.48 m long, 4.57 m wide, and 2.50 m high.

The treatments consisted of three replications of three white films pigmented at opacities of 50%, 70%, and 80%, and two replications of a double layer inflated film. The 50% film was approximately the same pigmentation as the standard white film used in the nursery industry and was therefore considered a control film. The single layer pigmented white films were produced by Canadian Industries Ltd., (CIL) Inc., Willowdale, Ontario. The double layer film was produced by General Films, Inc., Sidney, Ohio. Reference to film type in the tables is C for CIL Inc., and DL for the General Films double layer inflated covering.

The plant materials included were *Cotoneaster dammeri* 'Royal Beauty', *Pyracantha coccinea* 'Kasan', and *Ligustrum* X 'Vicary'. Ten plants of each cultivar were evenly distributed in three locations within each house.

The plants were evaluated March 21, 1980, using a visual scale of 1 to 5 with 1 = dead and 5 = no injury. Soil temperature data were collected from selected houses representing each of the films. Air temperature was recorded daily from Dec. 10, 1979, to March 16, 1980, with Taylor Hi-Lo thermometers placed at plant height.

RESULTS AND DISCUSSION

Plant Quality

The film covered structures resulting in the highest quality shoots following 4 months of storage varied according to the plant species.

Privet, firethorn, and cotoneaster shoot quality was significantly higher under double layer inflated film than for any other film (Table 1). These results agree with previous studies which have shown double layer inflated film to be an excellent overwintering method (4, 6, 8, 11).

The comparison of shoot quality under pigmented CIL films revealed that the shoots of fire-

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TABLE 1.—Effects of Polyethylene Films on Shoot Quality Following 1979-80 Winter Storage.

Treatment	Quality* Privet	Firethorn	Royal Beauty Cotoneaster
C50	4.0b†	3.0e	3.7c
C70	4.1b	3.6cd	4.4b
C80	4.1a	3.6cd	4.4b
DL	4.6a	4.2ab	4.9a

*Visual rating scale: 1 to 5 with 5 best.
†Similar letters in a column are not significantly different at the 5% level according to Duncan's Multiple Range Test.

thorn and cotoneaster had significantly lower quality under 50% opacity than under opacities of 70% and 80% (Table 1). These results are in agreement with previous work by Rizzo, Smith, and Tinga which suggest that opacities of less than 80% to 90% result in inferior plant quality (6, 12, 14). Growers will have to determine the merits of the additional protection and higher costs of double layer film vs. the lesser protection and lower costs of pigmented film. Species of plant certainly will influence this decision.

Temperature

Average soil temperatures of containers in structures covered with the white film treatments were compared. The averages were calculated from the sum of the soil temperatures recorded during the entire season. The difference between the coolest average soil temperature of 1.3° C (double layer inflated) and the warmest average temperature of 6.6° C (50%) was 5.3° C. Average soil temperatures recorded under single layer pigmented film treatments decreased with increasing opacity (Table 2) which concurs with previous work (12).

Maximum temperatures in film covered structures were compared with the average outside maximum temperature (2.7° C). The difference between the coldest maximum temperature of 4.9° C (double layer inflated) and the warmest maximum temperature of 10.2° C (50%) was 5.3° C. The maximum temperatures of film covered structures were warmer than the average outside maximum temperature (Table 3). The desired cooler maximum temperatures under double layer inflated film were in agreement with previous work done by Smith (11).

TABLE 2.—Effects of Polyethylene Films on Average Soil Temperatures During Winter Storage, 1979-80.

Treatments	Temperature °C
C50	6.6
C70	4.4
C80	3.0
DL	1.3

TABLE 3.—Effects of Polyethylene Films on Average Maximum Temperatures During Winter Storage, 1979-80.

Treatments	Temperature °C Dec. 10-16	Dec. 17-23	Dec. 24-30	Dec. 31-Jan. 6	Jan. 7-13	Jan. 14-20	Jan. 21-27	Jan. 28-Feb. 3	Feb. 4-10	Feb. 11-17	Feb. 18-24	Feb. 25-March 2	March 3-9	Av.
C50	14.1ab*	11.0a	13.7ab	6.6a	7.1ab	14.2a	7.7ab	6.4ab	7.9ab	9.6ab	9.3ab	8.5ab	15.3ab	10.2
C70	13.2ab	8.9b	13.0ab	6.0a	5.7bc	11.9b	6.1bc	4.4bc	6.3bc	8.3bc	8.5ab	6.1bc	12.5bc	8.5
C80	11.5ab	8.7b	10.7b	5.3a	5.1cd	10.8b	5.3bc	3.0cd	5.5bcd	7.3bc	7.8bc	4.6cd	11.6c	7.5
DL	10.0b	5.4c	9.4b	4.8a	3.3d	7.1c	3.8c	0.2e	2.4d	3.6d	5.1d	2.2d	6.7d	4.9
Outside	8.9	6.3	5.0	—0.9	3.7	10	1.8	—2.8	—2.1	—1.7	4.1	—1.6	4.4	2.7

*Similar letters in a column are not significantly different at the 5% level according to Duncan's Multiple Range Test.

TABLE 4.—Effects of Polyethylene Films on Average Minimum Temperatures During Winter Storage, 1979-80.

Treatments	Temperature °C Dec. 10-16	Dec. 17-23	Dec. 24-30	Dec. 31-Jan. 6	Jan. 7-13	Jan. 14-20	Jan. 21-27	Jan. 28-Feb. 3	Feb. 4-10	Feb. 11-17	Feb. 18-24	Feb. 25-March 2	March 3-9	Av.
50	—0.8a	—4.0a	—1.5a	—1.8a	—3.6a	0.4a	—3.4a	— 6.3a	— 7.2a	— 5.4a	—2.4a	— 7.0a	—3.5a	—3.6
70	—2.0a	—4.8a	—2.6a	—2.3ab	—4.3a	—0.6a	—3.9a	— 8.2b	— 9.0a	— 7.1a	—3.1a	— 8.0a	—4.9a	—4.7
80	—2.6a	—5.3a	—3.3a	—2.9b	—4.6a	—0.6a	—4.5a	— 9.0b	— 9.1a	— 7.5a	—2.6a	— 8.2a	—5.1a	—5.0
DL	—1.4a	—4.3a	—2.2a	—2.5ab	—3.4a	—1.4a	—4.1a	— 7.3ab	— 8.1a	— 6.7a	—2.7a	— 6.8a	—5.0a	—4.3
Outside	—2.3	—2.8	—1.4	—4.1	—6.4	—0.4	—6.1	—13.7	—11.9	—11.6	—4.5	—11.3	—7.9	—6.5

*Similar letters in a column are not significantly different at the 5% level according to Duncan's Multiple Range Test.

Previous studies have found that structures covered with films with comparatively cooler maximum storage temperatures have resulted in higher quality plants (2, 6, 11) and results of this study support these findings. The structures with the lowest average maximum temperature, double layer inflated and 80% opacity, resulted in firethorn and cotoneaster with significantly higher shoot quality than the same species in film covered structures with the highest average maximum temperatures, 50% opacity (Tables 1 and 2).

There was little variation of minimum temperatures among the film covered structures (Table 4), which agrees with previous work (12).

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Micropropagation of *Ajuga reptans* 'Burgundy Glow'

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ABSTRACT

Excised shoot tips of *Ajuga reptans* L. 'Burgundy Glow' proliferate rapidly *in vitro* on a Murashige-Skoog medium containing either 1.0 mg/liter benzyladenine (BA) or 0.1 mg/liter naphthaleneacetic acid (NAA) and 2.5 mg/liter BA. Shoot proliferation was more rapid on the medium containing 0.1 mg/liter NAA and 2.5 mg/liter BA. Multiple shoots arise from axillary buds, leaf, and root tissues. Cultured shoots vary considerably in size and relative stage of development, with some producing adventitious roots without transferral to a separate rooting medium. Multiplication and subsequent growth of cultured shoots is rapid with as many as 30 salable plants produced per explant in 20 weeks.

INTRODUCTION

Ajuga reptans L. 'Burgundy Glow' is an ornamental ground cover typified by brightly colored foliage which is an irregularly mottled combination of white, green, and pink. The plant is stoloniferous, with the plantlets produced remaining true to type.

Ajuga reptans L. 'Burgundy Glow' was introduced into tissue culture to assess the feasibility of *in vitro* propagation as an alternative to the maintenance of the large stock plantings which are required for traditional methods of propagation. In addition, this article describes the differentiation of plants from nonmeristematic tissue and evaluates the time required to produce salable plants from plantlets established from tissue culture.

MATERIALS AND METHODS

Rapidly growing shoot tips from greenhouse grown plants of *Ajuga reptans* L. 'Burgundy Glow' were stripped of all leaves larger than 1 cm, washed 10 min in 0.2% Alconox, stirred 15 min in 10% Clorox, and rinsed twice in sterilized distilled water. Sterilized shoot tips were trimmed to 1 cm in length and were placed tip up in a modified Murashige-Skoog medium containing either 1.0 mg/liter benzyladenine (BA) or 0.1 mg/liter naphthaleneacetic acid (NAA) and 2.5 mg/liter BA. The medium also contained 100 mg/liter casein hydrolysate and 7 g/liter agar (pH 5.7) (1).

Cultures were initiated in 25 x 150 mm test tubes and were subsequently transferred to 125, then to 500 ml glass jars as shoot proliferation increased. Cultures were held at 26° C, and photosynthetically active radiation at 40μ Einsteins M^{-2} sec^{-1} was provided by Grolux fluorescent lamps for 16 hr per day.

Following 15 weeks in culture, plantlets were transplanted into Redi-Earth, held for 5 days under intermittent mist with the light intensity at 360μ Einsteins M^{-2} sec^{-1}, transferred to a greenhouse bench under shade (270μ Einsteins M^{-2} sec^{-1}) for an additional 5 days, and finally grown in a greenhouse under standard cultural practices (600μ Einsteins M^{-2} sec^{-1}).

RESULTS AND DISCUSSION

Multiplication of *Ajuga reptans* L. 'Burgundy Glow' occurred in culture along three separate paths. Initial proliferation resulted from axillary bud growth. Shoots also differentiated directly from leaf tissue where the leaves contacted the medium (Fig. 1). When detached leaves were placed in culture, however, roots first formed at the cut surface of the petiole, and plants subsequently developed directly on this root tissue (Fig. 2). Upon closer inspection, plants were seen to have originated from the internal tissues within the root and presumably not from the epidermal tissues (Fig. 3).

To quantify the rate of multiplication which occurred in culture, whole cultures were harvested at one time. These cultures contained shoots of a wide range of sizes (Fig. 4). Shoots were graded into three groups based on size and degree of adventitious root development. A No. 1 shoot was smallest and did not possess roots at the time of grading, while a No. 3 shoot was actually a small plant with a well developed root system (Fig. 5). Larger shoots produced abundant adventitious roots without transferral to a separate root inducing medium.

More shoots were produced at the end of 15 weeks on the medium containing 0.1 mg/liter NAA and 2.5 mg/liter BA than on the medium containing 1.0 mg/liter BA (Table 1). The considerable variation noted in the response of individual shoot tips is reflected in the rather large standard deviations about the means of the two treatments. A large percentage of the shoots produced on the medium containing 0.1 mg/liter NAA and 2.5 mg/liter BA were grade 1 (smallest), while relatively few shoots were of grade 3 size (largest). Distribution of shoot sizes from cultures grown on the medium containing 1.0 mg/liter BA was similar for all three grades.

Transplant survival of the cultured shoots was unaffected by the growth regulator content of the tis-

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FIG. 1.—Differentiation of multiple shoots directly on cultured leaves of *Ajuga reptans* **'Burgundy Glow'.**

FIG. 2.—Shoots were produced from root tissue which developed at the base of the petiole of a cultured leaf of *Ajuga reptans* **'Burgundy Glow'.**

FIG. 3.—Shoots were observed to develop directly on the roots of cultured *Ajuga reptans* **'Burgundy Glow'. Note that shoots appeared to develop from internal tissues and arise through splits in the epidermal tissues.**

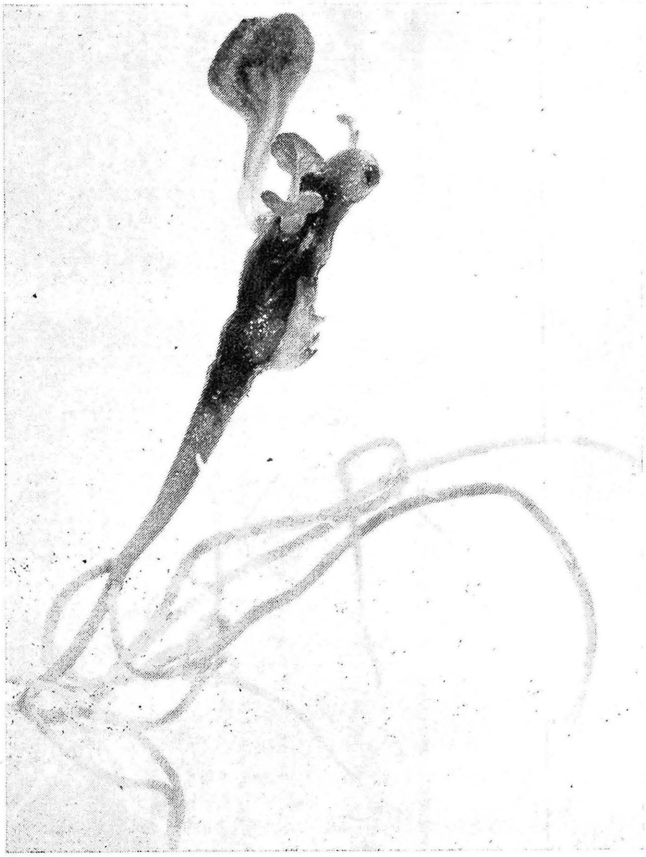

FIG. 4.—An individual culture of *Ajuga reptans* **'Burgundy Glow' contained a wide range of shoot sizes, some possessing adventitious roots.**

FIG. 5.—Individual cultured shoots were graded by size and presence or absence of roots as either No. 1, 2, or 3 (left to right).

sue culture medium (Table 2). However, plants grown from cultures containing 1.0 mg/liter BA were judged to be of salable size and quality earlier than those grown from cultures containing 0.1 mg/liter NAA and 2.5 mg/liter BA (Table 2). The fact that more of the plants grown from cultures containing the

TABLE 1.—Comparative Yield of Ajuga **Cultures Following 15 Weeks' Growth on Murashige and Skoog Media Supplemented with 1.0 mg/liter BA or 0.1 mg/liter NAA and 2.5 mg/liter BA.**

Medium	Shoots per Shoot Tip Explant	Percent of Shoots per Grade 1	2	3
1.0 mg/liter BA	19.6 ± 13.9*	28.9 ± 20.3†	30 ± 13	40.5 ± 26
0.1 mg/liter NAA +2.5 mg/liter BA	47.6 ± 19.4	70.3 ± 11.4	26.5 ± 9.8	3.1 ± 2.9

*Mean ± standard deviation of shoots per original shoot tip explant. Value for 1.0 mg/liter BA is the mean of 13 cultures and the mean for 0.1 mg/liter NAA + 2.5 mg/liter BA is the average of 8 cultures.

†Percentage of total shoots (± standard deviation) which were assigned to the stated grade (see text for explanation of the grading system).

TABLE 2.—Transplant Survival, Occurrence of Altered Phenotypes, and Yield of Salable Plants from Ajuga **Cultures Grown for 15 Weeks on Indicated Media.**

Medium	Percent Transplant Survival	Percent Phenotypic Variants	Percentage of Surviving Plants Salable: 3 Weeks Post Transplant	5 Weeks Post Transplant
1.0 mg/liter BA	83.1 ± 16.7*	26.3 ± 21.3†	55.4 ± 28.5	85.3 ± 17.6
0.1 mg/liter NAA +2.5 mg/liter BA	82.9 ± 11.4	32.1 ± 33.6	19.7 ± 21.5	63.1 ± 13

*Percentage of shoots per culture vessel (± standard deviation) which were alive 3 weeks after transplanting.

†Percentage of shoots per culture vessel which were not the Burgundy Glow' phenotype (± standard deviation).

lower concentration of cytokinin were salable at both 3 and 5 weeks is a reflection of the observation that a fewer number of larger plants was produced on the lower cytokinin containing medium (Table 1). In terms of the yield of salable plants, more plants were produced by the 0.1 mg/liter NAA-2.5 mg/liter BA treatment ($0.63 \times 47.6 = 30$) than the 1.0 mg/liter BA treatment ($0.85 \times 19.6 = 16.7$).

Not all of the plants produced through tissue culture were the 'Burgundy Glow' phenotype. This observation has been reported previously (2), and we have also noted that the "pink over green" or "bronze" sport is the most frequently observed phenotypic variation. Entirely pink plants were also produced in these cultures, but these did not survive transplanting since they lack the capacity for autotrophic growth. Results of this study do not agree with the conclusion of Zilis *et al.* that lowering the cytokinin concentration in the medium reduced the occurrence of chimeral separation. The percentage of phenotypic variants was very similar in both media tested (Table 2). Since shoots are produced from adventitious meristems from root and leaf tissue as well as lateral buds, only conditions which do not allow adventitious shoot proliferation would give cultures with all true to type plants.

Ajuga reptans 'Burgundy Glow' undergoes rapid proliferation in tissue culture, producing shoots from lateral bud, leaf, and root tissue. Adventitious roots form *in vitro* on larger shoots without transferral to a separate root inducing medium, and small shoots root successfully following transplanting to a soilless medium under mist. Plants produced through tissue culture grow vigorously in the greenhouse to salable size in as little as 3 weeks. Even though chimeral variation does occur, 68% to 74% of the plants produced are the 'Burgundy Glow' phenotype, and the remainder of the plants could be marketed as a "bronze" selection.

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Effects of Fertilizer in the Propagation Medium and Extended Photoperiod on Growth of *Acer rubrum* 'Red Sunset' Cuttings

STEVEN M. STILL[1] and BRYCE H. LANE[2]

ABSTRACT

Terminal unbranched *Acer rubrum* 'Red Sunset' cuttings were taken on June 16 and July 23, 1980. Plants were treated with either a natural daylength or a 4-hour extended photoperiod. Fertilizer treatments consisted of a slow release fertilizer (18-6-12, 5.4 kg/m^3) amended medium, a 20-20-20 (200 ppm N) liquid fertilizer applied to the medium, or a control medium containing no fertilizer. Shoot growth was significantly greater on plants grown under an extended photoperiod. Plants propagated on June 16 and grown to Oct. 20 under extended photoperiod were 3 to 42 times as tall as plants propagated on July 23 and grown to Oct. 20 under natural daylength. The effect of photoperiod on shoot growth was greater than the effect of fertilizer incorporated into the propagation medium on subsequent shoot growth.

INTRODUCTION

Cultivars of red maple *(Acer rubrum)* have historically been produced by budding selected cultivars onto seedling understock. Losses due to graft incompatibility have necessitated the development of an alternative method.

Acer rubrum softwood cuttings have been successfully rooted and various cutting dates have been attempted (2, 9). Although several nurseries in Oregon are propagating red maples from cuttings, the cost of these liners to Ohio nurserymen is still high. A propagation production program needs to be developed for *Acer rubrum* in the Midwest.

Fertilizer amended propagation media are possible means for increasing rooting and subsequent growth of red maple (3, 5, 11). The extension of the photoperiod during propagation and after transplanting also may increase subsequent growth of red maples (1, 6, 7, 10). Downs and Borthwick (4) reported rooted cuttings of *Weigela* grown in 14 and 16-hour photoperiods grew significantly larger after 2 months. Nitch (8) has reported that rooted cuttings of *Acer palmatum* were significantly taller when placed under 5.5 additional hours of incandescent light.

The optimum date for taking cuttings will also influence maximum growth. *Acer rubrum* cuttings will successfully root at various times (2, 9). However, maximum growth would probably be obtained at an earlier cutting date.

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The objectives of this study were to determine the effects of: 1) two cutting dates, 2) fertilizers applied to the medium during rooting, and 3) supplemental light on the growth of *Acer rubrum* cuttings.

MATERIALS AND METHODS

Fifteen cm (6 in) softwood terminal cuttings were taken from 6 cm (2.5 in) caliper nursery-grown trees on June 16 and July 23, 1980. The terminal bud and distal node of each cutting were removed and the basal 2.5 cm (1 in) of each cutting was wounded and then dipped into a 6000 ppm indolebutyric acid (IBA) solution [50% water/50% ethyl alcohol (95)] for 5 seconds. The base of each cutting was inserted 5 cm deep into an individual 0.3 liter pot containing a 3 perlite:1 peat rooting medium (vol./vol.) and the pots were placed under intermittent mist. The mist was operational 6 seconds every 3 minutes from 0800 to 1930 hours daily. No bottom heat was used.

There were two light treatments. Cuttings under one treatment received natural daylength (ND) while cuttings under the second treatment received natural daylength plus 4 hours' night interruption (NI) from 2200 to 0200 hours daily. Light was supplied by 75 watt incandescent lamps spaced 1 m apart and 1 m above the tops of the containers, providing an illumination of approximately 215 lux at cutting height. Light treatments were assigned at random to six benches. Photoperiod treatments were accomplished by covering the benches with black cloth and a timer was used to turn on the lamps on the benches receiving night interruption.

Within a photoperiod treatment, cuttings were rooted in the basic medium described above amended with: 1) slow release fertilizer [Osmocote 18.0N-2.6P-10.0K (9-month formulation)] at a rate of 5.4 kg/m^3 incorporated in the medium 1 week before cuttings were inserted; 2) 200 ml liquid fertilizer [Peter's 20N-8.6P-16.6K (200 ppmN)] applied to the medium after 25% of the cuttings had commenced rooting and applied at 3-day intervals; or 3) no fertilizer.

After a 5-week rooting period, 18 plants (3 replications of 6) were transplanted into 3.8 liter plaster pots containing a 4 pine bark:1 sand medium (vol./vol.). Each container received 15 grams of Osmocote 18-6-12 (9-month formulation) and 3.4 grams of Esmigran micronutrient fertilizer. Plants were placed in a glass covered greenhouse and received the same photoperiodic treatment as provided in the propagation area.

TABLE 1.—Effects of Fertility and Photoperiod Treatments on Mean Final Shoot Length of Acer rubrum **'Red Sunset' Cuttings Propagated on June 16 or July 23 and Harvested on Oct. 20, 1980.**

Treatment	Final Shoot Length (mm)	
	Natural Daylength	
	June 16	July 23
Slow release fertilizer	519.2b*	57.7c
Liquid fertilizer	507.2b	11.9c
Control	407.5b	11.3c
	Natural Daylength and Night Interruption	
	June 16	July 23
Slow release fertilizer	984.4a	377.5b
Liquid fertilizer	929.7a	149.9b
Control	878.9a	120.0b

*Mean separation in columns for a photoperiod treatment by Duncan's multiple range test, 5 % level.

RESULTS AND DISCUSSION

For each propagation date, fertility alone did not have a significant effect on shoot growth when photoperiod treatments were compared. However, shoot growth of plants grown at all fertility treatments, including the control, was significantly greater when plants were treated with natural daylength and night interruption (NI) instead of natural daylength (ND) (Table 1). This difference between ND and NI photoperiod was consistent on both cutting dates.

The photoperiod effect agrees with other researchers who reported increased shoot growth of various woody plants grown under extended photoperiods (1, 4, 6). However, the lack of enhanced growth from fertility alone differs from previous work by Ward and Whitcomb (11) who reported increased subsequent growth of *Ilex* after rooting in a medium amended with Osmocote 18-6-12. Maximum growth after rooting appears to be more of a function of photoperiod than fertility.

Shoot growth of plants propagated on July 23 (Table 1) was significantly less than the shoot growth of plants propagated on June 16. This marked difference between propagation dates is obviously due to length of the growth period. Cuttings rooted on July 23 only had an 8-week growing period before the October harvest date, while cuttings of June 16 had a 12-week growing period. This has practical implications for the nurseryman. Cuttings propagated in late July would have only 2-3 weeks under lights before they would be removed from the lights for hardening before winter. If cuttings were propagated in mid-June, a grower could feasibly grow the cuttings for 6 weeks under lights. Data in Table 1 indicate this to be desirable. Shoot growth of plants propagated on June 16 and grown with NI had an average length of 984 mm (39 inches) compared to the shoot growth of plants propagated July 23 and grown with NI of 378 mm (15 inches). The growth advantages of this system are apparent.

SUMMARY

From this study, it is evident that shoot growth of rooted cuttings of *Acer rubrum* 'Red Sunset' is affected most positively when cuttings are taken in mid-June, rooted, and grown under a night interrupted photoperiod of 4 hours.

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Area of Weed Control from a Single Herbicide Tablet

M. A. RUIZZO, E. M. SMITH, and S. F. GORSKE[1]

ABSTRACT

A 35.6 lb ai/A rate of Dual (metolachlor) was incorporated into two slow release tablet formulations and evaluated for specific area of weed control in nursery containers. Dual tablet treatments sigficantly reduced weed density in the area (5.5 to 7.0 inch diameter circles) surrounding a single herbicide tablet. The plaster of paris or dicalcium phosphate tablet formulations did not significantly differ in the suppression of weed germination in nursery containers.

INTRODUCTION

Lack of precise control of chemical application rate (9) and possible contamination of the environment through container media leachate are two serious problems associated with present day application of herbicides to container nursery stock. New methods of herbicide application have been investigated (1, 2, 4, 5, 6, 7, 9). Precise chemical rates can now be applied to each container using the newly developed slow release herbicide tablets (2, 3, 8, 9).

In this study, two slow release herbicide tablet formulations were evaluated to determine the area of weed control that could be obtained from a single tablet. Once a sustained area of control is resolved using one herbicide tablet, the number of tablets per various sized containers can be established for complete coverage.

MATERIALS AND METHODS

Dicalcium phosphate herbicide tablets were prepared by mixing technical grade Dual with dicalcium phosphate (Ca_2HOP_4) and magnesium stearate ($MgC_{18}H_{35}O_2$) and dry pressing the mixture in a Stokes Single Punch Tablet Machine. Rate was calculated on a weight-to-weight basis to deliver 35.6 lb/A of active ingredient when using one 0.47 inch diameter x 0.27 inch herbicide tablet per container. Plaster of paris herbicide tablets of the same dimensions were prepared using the technique developed by Verma and Smith (8, 9), by mixing plaster of paris with technical grade Dual. A 35.6 lb/A rate was calculated on a weight-to-weight basis using one tablet per container. The mixture was uniformly wetted with water, cast in a mold, and air dried.

Plastic nursery pots (7.5 inch x 7.0 inch) and wooden flats (22.5 inch x 15.0 inch x 4.0 inch) were filled with a medium consisting of one part perlite and one part silt loam soil (1:1, v/v) and placed in a greenhouse. On Feb. 2, 1982, containers were seeded with 20 to 24 seeds each of annual bluegrass (*Poa annual* L.), common purslane (*Portulaca oleracea* L.), giant foxtail (*Setaria faberi* (Herrm.)), Pennsylvania smartweed (*Polygonum pensylvanicum* L.). and yellow foxtail (*Setaria lutescens* [Wiegel] Hubb.).

Irrigation was provided daily using a hand-held misting nozzle to prevent surface flooding and random herbicide dissipation. Treatments consisted of containers receiving one Dual tablet formulation placed in their center or left untreated. The experimental design was a randomized complete block with three containers per replication and three replications per treatment.

Weed control measurements, based on the number of weeds located within concentric circles emanating from each placed tablet, were conducted 57 days following initial weed seeding. There were four areas of measurement in the plastic nursery pots and six areas in the wooden flats. Each area was represented by a concentric ring with a 1.0 inch radius. Area 1 was represented by a 1 inch radius from the placed tablet. Area 2 was represented by a 1 to 2 inch radius from area 1, area 3 represented a 2.0 to 3.0 inch radius from area 2, and area 4 represented a 3.0 to 4.0 inch radius from area 3. Two additional measurement areas were evaluated in the wooden flats; area 5 represented a 4.0 to 6.0 inch radius from area 4 and area 6 represented a 6.0 to 8.0 inch radius from area 5.

RESULTS AND DISCUSSION

Containers: Dual tablet treatments in areas 1, 2, and 3 exhibited significantly lower weed densities than the check (untreated) treatment. Area 4 contained the highest density of weeds in Dual tablet treated pots and was not significantly different from the check. Weed density in the Dual tablet treated pots increased with increasing distance from the herbicide tablets. An area with a radius of 2.7 to 3.5 inches from the Dual tablets of both dicalcium phosphate and plaster of paris was primarily weed free in the nursery pots. There were no significant differences between dicalcium phosphate and plaster of paris Dual tablets in reducing weed density in any area within the pots (Fig. 1). Both Dual tablet formulations essentially provided the same level of weed control in all areas of measurement.

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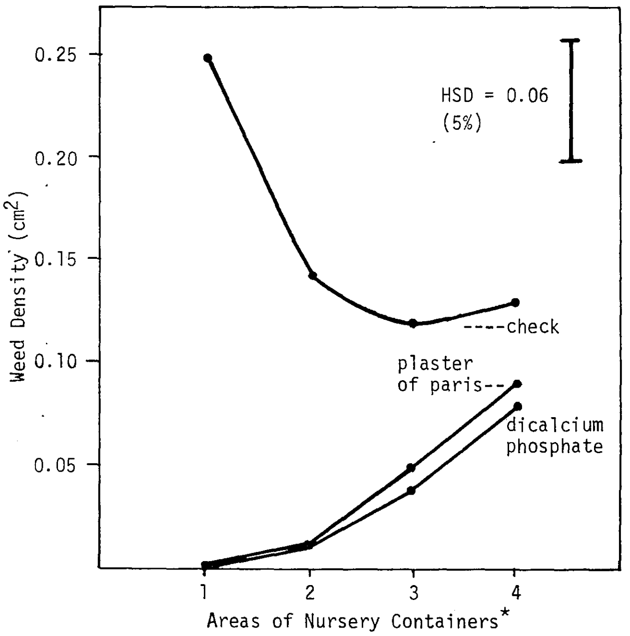
FIG. 1.—Effects of slow release metolachlor tablets on the density of germinating weeds in selected areas of nursery containers.



*Area 1 represented by 2.5 cm radius (1.0 inch) from tablet.
Area 2 represented by 2.5-5.0 cm radius (1.0-2.0 inches) from area 1.
Area 3 represented by 5.0-7.5 cm radius (2.0-3.0 inches) from area 2.
Area 4 represented by 7.5-10.0 cm radius (3.0-4.0 inches) from area 3.

Flats: Generally, weed density increased with increasing distance (areas 1 through 6, excluding 5) from the Dual tablets placed in the center of each wooden flat (Fig. 2). A relatively weed-free radius of 2.7 to 3.5 inches encompassing the herbicide tablet was observed, indicating no effect of difference between containers of varying depths. There were no significant differences in weed control between dicalcium phosphate and plaster of paris Dual tablets in any areas of the herbicide treated wooden flats. Significantly lower weed densities were observed when Dual tablet formulations were compared with areas 1, 2, and 3 of the check (untreated) treatments (Fig. 2).

These results suggest that one 0.47 inch diameter tablet containing Dual at 35.6 lb/A with dicalcium phosphate or plaster of paris as the carrier will satisfactorily control selected weeds in 1-gallon containers which generally measure 5.5 to 6.5 inches in diameter. More than one tablet will be required for 2-gallon containers which generally measure 8.5 inches in diameter.

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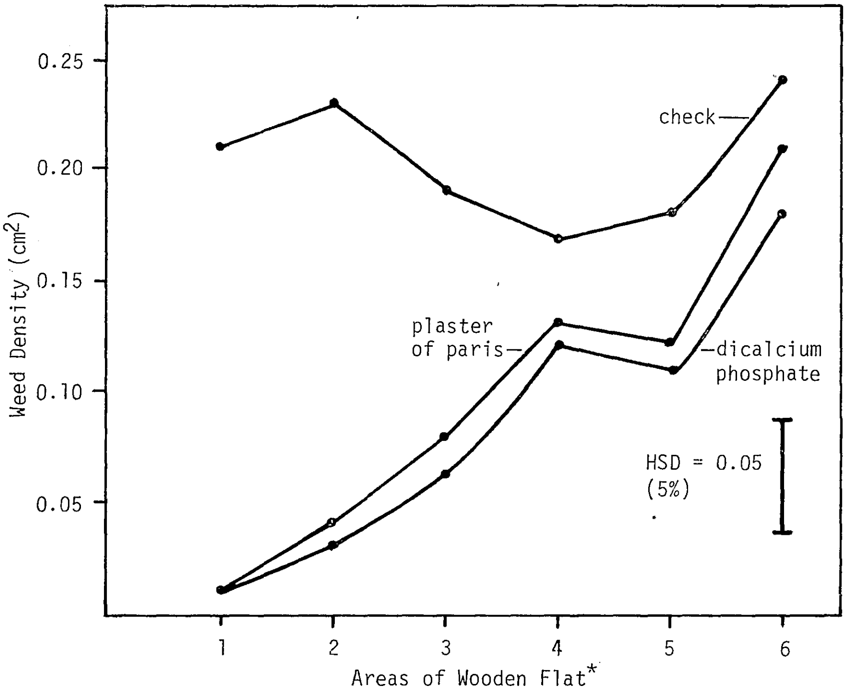
FIG. 2.—Effects of slow release metolachlor tablets on the density of germinating weeds in selected areas of wooden flats.



*Area 1 represented by 2.5 cm radius (1.0 inch) from tablet.
Area 2 represented by 2.5-5.0 cm radius (1.0-2.0 inches) from area 1.
Area 3 represented by 5.0-7.5 cm radius (2.0-3.0 inches) from area 2.
Area 4 represented by 7.5-10.0 cm radius (3.0-4.0 inches) from area 3.
Area 5 represented by 10.0-15.0 cm radius (4.0-6.0 inches) from area 4.
Area 6 represented by 15.0-20.0 cm radius (6.0-8.0 inches) from area 5.

Slow Release Herbicide Formulations for Container Grown Landscape Crops[1]

M. A. RUIZZO, E. M. SMITH, and S. F. GORSKE[2]

ABSTRACT

Dicalcium phosphate and plaster of paris slow release tablet formulations containing Lasso (alachlor), Ornamental Weeder (chloramben), Alanap (naptalam), and Ramrod (propachlor) controlled weeds successfully for 16 weeks with no significant injury to Royal Beauty cotoneaster (*Cotoneaster dammeri* C. Schneid. 'Royal Beauty'), Emerald 'N Gold euonymus (*Euonymus fortunei* [Tarxz.] Hand Mazz. Emerald 'N Gold), Spring Glory forsythia (*Forsythia* x *intermedia* Zab. 'Spring Glory'), and Vicary privet (*Ligustrum* x *vicaryi*). One tablet per container was applied, delivering 17.8 and 35.6 lb/A active ingredient.

INTRODUCTION

In an attempt to improve the efficacy of selected herbicides, formulations have been altered in a manner that will control the rate of herbicide release. Changing the formulation of the same herbicide can modify the efficacy of the herbicide (3). A weed control program using herbicides, singly or in multiple combinations, currently must be applied several times during the growing season to achieve season-long weed control (1, 2). The concept and development of slow or controlled-release technology is a step towards more efficient, safe, and suitable herbicide applications.

This study was designed to evaluate selected preemergent herbicides, in two slow release tablet formulations, for weed control and phytotoxicity in container grown ornamentals.

MATERIALS AND METHODS

Dicalcium phosphate herbicide tablets were prepared by mixing each technical grade herbicide with dicalcium phosphate (Ca_2HPO_4) and magnesium stearate ($MgC_{18}H_{35}O_2$) and dry pressing the mixture in a Stokes Single Punch Tablet Machine. Plaster of paris herbicide tablets were prepared using a technique developed by Verma and Smith (5, 6) by mixing plaster of paris with each technical grade herbicide. The herbicides selected for incorporation included Lasso (alachlor), Ornamental Weeder (chloramben), Alanap (naptalam), and Ramrod (propachlor). The mixtures were uniformly wetted with water, cast in a mold 0.5 inch by 0.3 inch, and air dried. Rates were calculated on a weight-to-weight basis to deliver 0, 17.8, and 35.6 lb/A active ingredient with one tablet per container.

Uniform rooted cuttings of Royal Beauty cotoneaster (*Cotoneaster dammeri* 'Royal Beauty'), Emerald 'N Gold euonymus (*Euonymus fortunei* 'Emerald 'N Gold'), Spring Glory forsythia (*Forsythia* x *intermedia* 'Spring Glory'), and Vicary privet (*Ligustrum* x *vicaryi*) were established in 1-gallon plastic nursery containers on June 10, 1981. The medium consisted of four parts hardwood bark and one part sand (4:1, v/v). Containers were overseeded with annual bluegrass (*Poa annua* L.), common purslane (*Portulaca oleracea* L.), Pennsylvania smartweed (*Polygonum pensylvanicum* L.), and yellow foxtail (*Setaria lutescens* [Wiegel] Hubb.), and irrigated.

Herbicide impregnated dicalcium phosphate tablets, at 2% and 4% magnesium stearate levels, and plaster of paris tablets were applied to the container media surface on June 16, 1981, and the containers were then irrigated. Treatments consisted of one tablet per container. A randomized complete block design was used with one plant per container, two containers per replication, and four replications per treatment.

Weed control and phytotoxicity evaluations were performed at 2-week intervals spanning 16 weeks. At the conclusion of the study, green vegetative tissue was harvested, oven dried at 100° C for 48 hours, and dry weights recorded. Weed control and crop phytotoxicity evaluations were based on a 1 to 10 scale. One represented no weed control or complete stock kill, 10 represented complete weed control or no stock damage, 8 was considered an acceptable rating for both phytotoxicity and weed control.

RESULTS AND DISCUSSION

All four herbicides investigated in both the dicalcium phosphate and plaster of paris slow release tablet formulations successfully controlled weeds for the 16-week period (Table 1). Weed control for this duration would not be expected from commercially available formulations.

The partial liberation of herbicide from the tablet with subsequent waterings permits an effective concentration of herbicide to be maintained in the zone of weed seed germination. This successive release of herbicide from its tablet carrier provided season-long weed control with a single herbicide appli-

[1]This research was supported in part by a grant from the Ohio Nurserymen's Association.

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cation. Variability between rate and additive level effects on weed control occurred in both tablet formulations; however, weed control ratings for each herbicide were acceptable and therefore combined. Generally, weed control values in the control treatments decreased with time (Table 1). The long efficacy of Lasso in the plaster of paris tablet formulation was satisfactory, as suggested by Koncal (4) and Verma and Smith (6).

Herbicide rate had no consistent significant effect on plant dry weight (Table 2). Visual foliar evaluations showed no visual damage and ranged from 9.06 to 10. This suggests that the herbicide was released at a rate that did not cause phytotoxicity.

Results of this study indicate that acceptable weed control can be achieved with slow release herbicides in container grown ornamentals for more than 16 weeks. This length of control can be achieved without phytotoxicity to the crops evaluated. All four herbicides tested in both the dicalcium phosphate

TABLE 1.—Evaluation of Slow Release Dicalcium Phosphate and Plaster of Paris Herbicide Tablets for Weed Control in Container Grown Ornamentals Over 16 Weeks. Values Represent an Average of All Rates and Additives.

	Weed Control Rating* (Weeks)							
Herbicide	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**
Dicalcium Phosphate								
Ramrod	10.00a	9.35b	9.10bc	8.73d	8.71d	8.69d	8.97cd	9.22bc
Alanap	10.00a	9.39b	8.82c	8.48cd	8.27d	8.59cd	8.78c	9.25b
Lasso	10.00a	9.26b	8.94cde	9.02bcd	8.72e	8.75de	9.05bc	9.30b
Onamental Weeder	10.00a	9.48b	9.19bc	9.03cd	8.88de	8.68e	8.80de	9.25bc
Control	10.00a	8.49b	7.91c	7.44cd	7.31d	6.47e	6.52e	7.31d
Plaster of Paris								
Ramrod	10.00a	9.33b	8.91bc	8.20e	8.27de	8.74dc	9.22bc	9.33b
Alanap	10.00a	8.59bc	7.92d	7.48e	7.42e	8.36c	8.83b	9.00b
Lasso	10.00a	9.13bc	8.70cd	8.70cd	8.42d	8.95bc	9.05bc	9.22b
Ornamental Weeder	10.00a	9.25ab	8.69bc	8.06e	7.56f	8.34de	8.94bc	8.86bc
Control	10.00a	8.80b	8.38bc	7.72cd	7.03de	6.69e	6.31e	6.41e

*Visual rating scale: 1 = no control, 8 = acceptable control, 10 = complete control. Means within chemical, followed by the same letter, are not significantly different at the 5% level according to Duncan's new multiple range test.

TABLE 2.—Effects of Slow Release Herbicide Tablets on Crop Dry Weight for 16 Weeks.

			Plant Dry Weight (g)*			
Herbicide	**Formulation**	**Rate (lb/A)**	**Euonymus**	**Cotoneaster**	**Privet**	**Forsythia**
Ramrod	Dicalcium Phosphate	17.8	23.31a-g	54.75abc	18.69bcd	31.44a-e
		35.6	29.63a-d	64.38abc	13.88c-f	33.56a-e
	Plaster of Paris	17.8	24.38a-g	65.89abc	25.75bc	35.75a-e
		35.6	19.88c-g	53.63abc	43.50a	42.13ab
Alanap	Dicalcium Phosphate	17.8	20.06c-g	71.00ab	23.69bc	32.06a-e
		35.6	24.75a-f	39.69b-f	25.60bc	27.56c-f
	Plaster of Paris	17.8	26.75a-f	49.25b-e	20.63bcd	37.63a-d
		35.6	31.00ab	60.38abc	31.00b	36.50a-d
Lasso	Dicalcium Phosphate	17.8	29.86abc	82.50a	25.63bc	40.25abc
		35.6	18.23a-h	61.13abc	16.94b-e	35.69a-e
	Plaster of Paris	17.8	27.75a-e	50.38b-e	27.00bc	31.88a-e
		35.6	27.25a-f	66.89ab	23.13bc	44.00a
Ornamental Weeder	Dicalcium Phosphate	17.8	18.36e-h	61.88abc	21.88bcd	23.81def
		35.6	19.25d-g	63.44abc	21.38bcd	22.13ef
	Plaster of Paris	17.8	14.13gh	47.50b-e	23.50bc	27.00c-f
		35.6	9.25hi	48.00b-e	20.50bcd	24.75def
Control (Blank)	Dicalcium Phosphate	0	20.79b-g	48.41b-e	19.00bcd	28.54b-f
	Plaster of Paris	0	31.00ab	61.88abc	23.13bc	30.63a-e

*Means within species, followed by the same letter, are not significantly different at the 5% level according to Duncan's new multiple range test.

and plaster of paris tablet formulations provided acceptable results.

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Effects of Pre-emergence Herbicides on Selected Herbaceous Perennials[1]

ELTON M. SMITH[2], GARY GIBSON[3], and SHARON A. TREASTER[4]

ABSTRACT

Napropamide (Devrinol), Oryzalin (Surflan), oxyfluorfen (Goal), and trifluralin (Treflan) were evaluated for weed control and phytotoxicity on seven species of commonly grown herbaceous perennials. All of the herbicides resulted in satisfactory weed control and were all phytotoxic to some degree. Napropamide 5G at 4.0 lb ai/A was observed as non-injurious on five of the seven species, trifluralin 5G at 4.0 lb ai/A on four species, and oryzalin 75W at 2.0 lb ai/A on four species. No herbicides were considered safe to use on oriental poppy and garden phlox.

INTRODUCTION

The production and sale of herbaceous perennials has increased significantly in the past several years. This increased production has resulted in a need for more effective herbicides for both the producer and consumer.

Currently, there are only six herbicides with a Federal label for use on herbaceous perennials (3), even though other workers have indicated crop safety with additional herbicides (1, 2). The purpose of this study was to compare napropamide (Devrinol), oryzalin (Surflan), and oxyfluorfen (Goal), all relatively new herbicides not labeled for herbaceous plants, to trifluralin which is labeled. An effective herbicide with a relatively long residual effect but without phytotoxicity is an objective desired by all who raise herbaceous plant materials. The newer herbicides have longer residual control than the labeled product.

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, trifluralin (Treflan) 5G at 4.0 and 16.0 lb ai/A, oryzalin (Surflan) 75W at 2.0 and 8.0 lb ai/A, and oxyfluorfen (Goal) at 0.5 and 2.0 lb ai/A. Each herbicide was applied at the recommended and 4X rates. A control and a hand weeded control treatment were included for phytotoxicity comparison purposes.

There were three plants per replication and three replications of each herbicide treatment. Granular herbicides were applied with a hand held rotary spreader and the wettable powders were applied with a 3-gallon pump-type compression sprayer.

The plant materials included *Achillea filipendula* 'Parkers Variety', Parkers Yarrow; *Aquilegia* 'McKana's Giants', McKana's Giants Columbine; *Aster novi-belgi,* New England Aster; *Chrysanthemum maximum* 'Alaska', Alaska Shasta Daisy; *Delphinium* 'Blue Fountains', Blue Fountains Delphinium; *Papaver* 'Princess Victoria Louise', Princess Victoria Louise Oriental Poppy; and *Phlox decussata,* Garden Phlox. All perennials were potted in 1 gallon containers on May 15, 1982, in a medium of hardwood bark-sand (4:1 by volume). The herbicide treatments were applied June 2, 1982.

All evaluations were on a 1 to 10 scale with a value of 7 acceptable and 10 best. Plants were evaluated 1, 3, 5, 9, and 13 weeks from date of treatment.

RESULTS AND DISCUSSION

Weed Control: Since the plants were potted late in the season and the hardwood bark medium was composted, the weed population was relatively light most of the summer. All of the herbicide treatments satisfactorily controlled weeds for the length of the study (13 weeks), although Napropamide 50W at 4.0 lb ai/A and oxyfluorfen 1G at 0.5 lb ai/A were at the borderline of yielding acceptable control at the conclusion of the study (Table 1). The most consistent weed control during the 13 weeks of the evaluation was noted with trifluralin at 4.0 lb ai/A, with the 16.0 lb ai/A only slightly more effective in August and September.

Phytotoxicity: Although all herbicides were effective in controlling weeds, none of the herbicides were non-phytotoxic to all plant species studied. Napropamide 5G at 4.0 lb ai/A was the least phytotoxic to the greatest number of plant species (Columbine, Yarrow, Aster, Daisy, and Delphinium), followed by trifluralin 5G at 4.0 lb ai/A (Columbine, Yarrow, Aster, and Daisy), and oryzalin 75W at 2.0 lb ai/A (Columbine, Yarrow, Aster, and Daisy) (Table 2).

Poppy: All treatments injured this species and none of the herbicides in this study can be safely applied to Oriental poppy. Oryzalin at both recommended X and 4X rates killed the poppies, while only the higher rates of napropamide, trifluralin, and oxyfluorfen were particularly injurious.

[1]The authors express sincere thanks to the Rohm and Haas Chemical Co. for financial assistance for this study.

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TABLE 1.—Weed Control in Herbaceous Perennials with Pre-emergence Herbicides from June 2 Treatment.

Treatment	Rate lb ai/A	Evaluation Dates June 22	July 6	Aug. 6	Sept. 3
Hand Weeded		8.3*	6.3	5.7	7.7
Check		8.7	6.3	6.0	5.0
Napropamide 50W	4.0	9.3	9.3	9.3	7.0
Napropamide 50W	16.0	10.0	10.0	9.0	8.7
Napropamide 50W	4.0	9.7	9.0	9.0	8.7
Napropamide 50W	16.0	9.7	9.3	9.0	9.0
Trifluralin 5G	4.0	9.7	10.0	9.0	9.0
Trifluralin 5G	16.0	9.3	9.7	9.7	9.3
Oryzalin 75W	2.0	9.3	9.3	9.0	8.7
Oryzalin 75W	8.0	10.0	9.7	9.7	9.3
Oxyfluorfen 1G	0.5	9.3	9.0	8.3	7.3
Oxyfluorfen 1G	2.0	10.0	10.0	10.0	9.3

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

Phlox: In 1 week from treatment, every herbicide had caused unacceptable injury to phlox. However, as the growing season progressed, the phlox "out-grew" the injury in napropamide and oxyfluorfen treatments. Trifluralin and oryzalin caused severe injury in the meristematic area of the plants and they did not satisfactorily recover from this early injury.

Columbine: This plant is very tolerant of herbicides and was injured only by oxyfluorfen early in the summer (plants later recovered); oryzalin at the 4X rate caused injury late in the season. Napropamide (both granular and wettable) and trifluralin were non-injurious to Columbine.

Yarrow: An unacceptable degree of injury was observed with napropamide 50W at 16.0 lb ai/A, oryzalin late in the season, and oxyfluorfen early in the season. Napropamide at the recommended rate, trifluralin at both rates, and oryzalin at the recommended rate were all non-phytotoxic throughout the season.

Aster: This species was the most tolerant of all species tested and was seriously injured only by oxyfluorfen at both rates early in the season. No injury was observed with trifluralin or oryzalin and only slight injury with napropamide at the high rates in September.

Daisy: Shasta Daisy is fairly susceptible to herbicide injury, particularly at higher herbicide rates. Non-injurious treatments were napropamide 5G at 4.0 lb ai/A, followed by trifluralin 5G at 4.0 lb ai/A and oryzalin 75W at 2.0 lb ai/A. All other treatments were too phytotoxic.

Delphinium: Only napropamide 5G at 4.0 lb ai/A was observed to be non-injurious to Blue Fountains delphinium. All other treatments injured this species, especially the 4X rate of each herbicide.

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TABLE 2.—Phytotoxicity of Herbaceous Perennials from June 2 Treatments of Pre-emergence Herbicides.

Treatment	Rate lb ai/A	Evaluation Dates	Poppy	Phlox	Columbine	Yarrow	Aster	Daisy	Delphinium
Control		June 8	10.0*	10.0	10.0	10.0	10.0	10.0	10.0
		July 6	10.0	10.0	10.0	10.0	10.0	10.0	10.0
		Aug. 6	10.0	10.0	10.0	10.0	10.0	10.0	10.0
		Sept. 3	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Hand Weeded		June 8	10.0	10.0	10.0	10.0	10.0	10.0	10.0
		July 6	10.0	10.0	10.0	10.0	10.0	10.0	10.0
		Aug. 6	10.0	10.0	10.0	10.0	10.0	10.0	10.0
		Sept. 3	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Napropamide 50W	4.0	June 8	10.0	6.7	10.0	10.0	10.0	10.0	10.0
		July 6	3.3	7.7	10.0	9.3	10.0	6.7	6.0
		Aug. 6	2.3	8.7	9.3	8.0	10.0	7.3	5.7
		Sept. 3	6.0	9.7	9.7	8.0	10.0	8.3	5.0
Napropamide 50W	16.0	June 8	10.0	6.0	10.0	10.0	10.0	10.0	7.7
		July 6	2.0	4.7	8.7	5.7	10.0	3.7	5.7
		Aug. 6	2.0	6.0	7.7	5.3	10.0	3.7	5.3
		Sept. 3	2.0	7.0	8.7	7.7	9.7	5.7	5.7
Napropamide 50W	4.0	June 8	10.0	6.7	10.0	10.0	10.0	10.0	9.0
		July 6	5.3	9.0	10.0	8.7	10.0	9.0	8.3
		Aug. 6	6.3	9.7	10.0	8.3	10.0	9.7	8.7
		Sept. 3	9.0	10.0	10.0	9.7	10.0	9.7	7.0
Napropamide 50W	16.0	June 8	9.3	6.0	10.0	8.7	10.0	10.0	8.3
		July 6	2.0	7.0	10.0	8.0	10.0	5.7	6.3
		Aug. 6	2.0	8.7	9.7	8.7	10.0	5.7	4.3
		Sept. 3	5.7	7.7	9.7	8.7	9.7	6.7	4.3
Trifluralin 5G	4.0	June 8	10.0	5.7	10.0	9.3	10.0	10.0	9.7
		July 6	4.3	5.3	10.0	9.0	10.0	7.0	6.3
		Aug. 6	2.7	7.0	9.7	8.0	10.0	9.0	7.0
		Sept. 3	3.7	6.3	9.3	8.7	10.0	9.0	6.0
Trifluralin 5G	16.0	June 8	10.0	5.0	10.0	8.7	10.0	10.0	8.7
		July 6	4.0	3.3	9.3	7.7	10.0	6.0	5.3
		Aug. 6	1.7	4.7	10.0	8.0	10.0	7.7	3.7
		Sept. 3	1.3	3.7	10.0	8.7	10.0	8.7	4.0
Oryzalin 75W	2.0	June 8	10.0	5.7	10.0	9.3	10.0	10.0	5.7
		July 6	2.7	4.0	9.7	10.0	10.0	9.3	6.7
		Aug. 6	1.0	4.0	9.3	8.7	10.0	8.3	7.7
		Sept. 3	1.0	3.0	10.0	7.7	10.0	7.0	6.3
Oryzalin 75W	8.0	June 8	10.0	5.0	10.0	8.7	10.0	10.0	8.0
		July 6	1.3	3.0	10.0	7.7	10.0	8.3	6.0
		Aug. 6	1.0	3.0	8.0	7.3	10.0	7.3	4.7
		Sept. 3	1.0	1.7	6.7	5.3	10.0	5.0	3.0
Oxyfluorfen 1G	0.5	June 8	5.0	4.7	7.3	6.7	6.0	5.7	5.3
		July 6	6.0	7.3	9.0	9.3	9.7	7.3	6.1
		Aug. 6	7.0	9.3	9.7	9.0	10.0	9.3	6.0
		Sept. 3	7.0	10.0	10.0	9.3	10.0	9.3	9.0
Oxyfluorfen 1G	2.0	June 8	3.7	4.7	5.7	6.3	5.7	4.7	4.7
		July 6	3.7	6.7	10.0	9.3	10.0	6.0	5.7
		Aug. 6	3.0	7.7	10.0	8.2	9.7	8.7	5.3
		Sept. 3	6.1	8.7	10.0	9.3	10.0	9.3	8.3

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

Controlling Weeds in Garden Lily, Gladiolus, and Dahlia with Pre-emergence Herbicides[1]

ELTON M. SMITH and SHARON A. TREASTER[2]

ABSTRACT

The objective of this evaluation was to determine if oxadiazon (Ronstar), napropamide (Devrinol), or trifluralin (Treflan) would result in satisfactory weed control without causing injury on garden lily, gladiolus, and dahlia. At recommended rates of application, the most effective weed control without appreciable injury was achieved with oxadiazon at 4.0 lb ai/A and napropamide 50W at 5.0 lb ai/A. Garden lily is more susceptible to injury than gladiolus or dahlia.

INTRODUCTION

The control of weeds in summer flowering bulb crops has long been a problem in commercial production and in the landscape. Although in recent years there has been an increase in the number of pre-emergence herbicides available to the nursery-landscape industry, very few are labeled for crops grown from bulbs, corms, rhizomes, or tuberous roots (4). Therefore, a need exists to determine what additional herbicides can be expected to control weeds without injury to the desired crops.

MATERIALS AND METHODS

Crops selected for this study included *Lilium* 'Golden Splendor' — Golden Splendor garden lily, *Gladiolus* 'Friendship' — Friendship gladiolus, and *Dahlia* 'Park Princess' — Park Princess dahlia, all commonly grown landscape plants.

The herbicides included: 1) trifluralin (Treflan) which is labeled for use on gladiolus and dahlia; 2) napropamide (Devrinol) which is not labeled even though previous research by Bing (1, 2, 3) has proven its effectiveness and safety on gladiolus; and 3) oxadiazon (Ronstar) which is not labeled for herbaceous crops. The formulations and rates selected were as follows: Ronstar 2G at 4.0 and 16.0 lb ai/A; Devrinol 10G at 5.0 and 20.0 lb ai/A; Devrinol 50W at 5.0 and 20.0 lb ai/A; and Treflan 5G at 4.0 and 16.0 lb ai/A. The herbicides were applied May 18, 1982, 1 week following planting. Each treatment was 150 sq ft in area and was replicated three times.

The granular herbicides were applied with a hand held rotary spreader and the sprayable materials were applied with a 3-gallon pump-type compression tank sprayer. The soil composition was a Brookston clay loam with a pH of 6.5 and an organic matter content of 2.0%. All evaluations were on a 1 to 10 scale with values 7 or above acceptable.

RESULTS AND DISCUSSION

All treatments resulted in satisfactory weed control for 1 month from treatment. At the 8-week evaluation period, weed control from Devrinol 10G at the 5.0 lb ai/A rate and Treflan 5G at the 5.0 lb ai/A rate were below acceptable standards (Table 1). Generally, the same degree of control as rated in July was observed into September, with only Devrinol 10G at 20.0 lb ai/A losing effectiveness at the later date. At the recommended rates of application, Ronstar 2G at 4.0 lb ai/A and Devrinol 50W at 5.0 lb ai/A yielded the most effective weed control. All herbicides at the 4X concentration successfully controlled weeds into September, although Devrinol 10G at 20.0 lb ai/A had begun to lose effectiveness. Interesting-

[1]The authors express sincere thanks to Rhone Poulenc Chemical Co. for financial assistance for this study.

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TABLE 1.—Weed Control in Garden Lily, Gladiolus, and Dahlia with Pre-emergence Herbicides Applied May 18, 1982.

Treatment	Rate lb ai/A	Evaluation Dates June 15	July 19	Aug. 19	Sept.14
Check		5.4*	2.4	1.8	1.2
Ronstar 2G	4.0	9.3	8.3	8.3	7.3
Ronstar 2G	16.0	10.0	10.0	10.0	10.0
Devrinol 10G	5.0	8.3	5.7	4.7	4.0
Devrinol 10G	20.0	9.0	7.0	7.0	6.7
Devrinol 10G	5.0	9.3	8.3	8.3	7.3
Devrinol 10G	20.0	10.0	9.0	9.0	8.7
Treflan 5G	4.0	7.7	6.7	6.7	5.7
Treflan 5G	16.0	9.3	8.3	8.3	8.3

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

TABLE 2.—Phytotoxicity of Garden Lily, Gladiolus, and Dahlia Following May 18, 1982, Treatment with Pre-emergence Herbicides.

		Phytotoxicity*					
	Rate	Garden Lily		Gladiolus		Dahlia	
Treatment	lb ai/A	June 15	Sept. 14	June 15	Sept. 14	June 15	Sept. 14
Check		10.0	10.0	10.0	10.0	10.0	10.0
Ronstar 2G	4.0	10.0	9.0	9.0	10.0	10.0	10.0
Ronstar 2G	16.0	7.3	5.3	10.0	6.0	6.0	9.3
Devrinol 10G	5.0	9.0	9.7	10.0	10.0	8.3	8.3
Devrinol 10G	20.0	9.3	8.3	10.0	10.0	10.0	10.0
Devrinol 50W	5.0	8.7	7.0	10.0	9.0	9.0	10.0
Devrinol 50W	20.0	8.7	8.7	8.3	10.0	7.3	9.3
Treflan 5G	4.0	9.0	9.7	8.7	8.7	10.0	10.0
Treflan 5G	16.0	9.3	9.7	10.0	10.0	10.0	10.0

*Visual phytotoxicity scale = 1 to 10, with values of 7 or above acceptable and 10 best.

ly, Devrinol applied as a wettable powder formulation was consistently more effective in controlling weeds than the granular formulation at the same rates. This difference may have been due to the very dry summer season of 1982 in which the wettable powder formulation did not require several rains to activate the product, thus controlling the early flush of weeds.

Although there was some phytotoxicity to certain crops with all herbicides at all rates, only Ronstar at 16.0 lb ai/A would be considered totally unacceptable with all three plant species studied (Table 2). Based on this study, Ronstar at 4.0 lb/A, Devrinol 10G and 50W at 5.0 and 20.0 lb/A, and Treflan 5G at 4.0 and 16.0 lb/A could be safely used on garden lily, gladiolus, and dahlia grown in clay loam soil. Garden lily was definitely more sensitive to phytotoxicity than gladiolus or dahlia. Devrinol 50W was somewhat injurious to garden lily at both rates and to gladiolus and dahlia at the 20.0 lb ai/A rate.

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Root Pruning Landscape Plants Produced on Sand Capillary Beds

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

ABSTRACT

Gloquat C was evaluated for root pruning forsythia and weigela produced on a sand bed capillary irrigation system. The recommended rate of 5.25 oz/100 sq ft (147 g/9.0 m^2) treatment pruned the roots of forsythia at an acceptable percentage throughout the summer. Weigela was satisfactorily pruned for 2 months at 5.25 oz and for 3 months at 10.5 oz (294 g/9.0 m^2). A reduction in height growth was observed at the 10.25 oz/100 sq ft rate with forsythia and 15.75 oz/100 sq ft (441 g/9.0 m^2) treatment rates with weigela.

INTRODUCTION

Traditional overhead watering of container nursery stock requires large quantities of irrigation water and results in considerable run-off. One system designed to reduce water requirements and, therefore, run-off is capillary irrigation. In this system, the plants are watered from below rather than above, which eliminates water falling between the plants. Capillary action causes water to move from the sand base into the container. The sand bed is kept moist by water forced under low pressure through twin wall hose which is buried under or laid on the sand (1). The more uniform moisture of the media results in improved plant growth when compared to other irrigation methods (2, 3).

One disadvantage of this system is that the roots of certain vigorous plants such as deciduous shrubs will penetrate the drainage holes of the container and grow vigorously in the sand. Lifting the plants periodically to break these penetrating roots will satisfactorily root prune but is laborious and expensive.

The sand can be treated chemically to prune the roots but until 1982 no chemicals were available in the United States that could be satisfactorily used. A sanitizing agent used in England, marketed as Gloquat C,[2] was imported to evaluate for root pruning. The specific objective was to determine a desirable rate that would satisfactorily control root growth of weigela and forsythia, which are both vigorous rooting species.

MATERIALS AND METHODS

A capillary bed was constructed with 2 x 4's measuring 5 ft wide x 54 ft in length. The base of the bed was crowned slightly in the center and covered with a 4 mil black plastic. Two lines of Chapin twin wall tubing were placed the length of the bed and covered with sand to the top of the 2 x 4's. The bed was then divided into 18 sections by placing a 5-foot 2 x 4 across the bed at 3-foot intervals. The sand was leveled and sprayed with Gloquat C at ¼X = 1.3 oz/100 sq ft (36.4 g/9.0 m^2), ½X = 2.6 oz/100 sq ft (72.8 g/9.0 m^2), 1X = 5.25 oz/100 sq ft (147 g/9.0 m^2), 2X = 10.50 oz/100 sq ft (294 g/9.0 m^2), and 3X = 15.75 oz/100 sq ft (441 g/9.0 m^2) treatments. There were three replications of each treatment.

One-gallon containers of *Weigela hybrida* 'Newport Red' — Newport Red Weigela and *Forsythia intermedia* 'Spring Glory' — Spring Glory forsythia were placed on the sand June 3, 1982. There were six plants per species in each treatment and each replication. The well established plants were potted in 1981 into a medium of hardwood bark-sand 4:1 (v:v) and most pots were slightly root bound at the time of placement on the sand.

The plants were evaluated the first week in July, August, and September to determine the extent of root growth through the container and into the sand.

RESULTS AND DISCUSSION

One month from treatment all the forsythia plants were rooted into the sand, while 89% of the containers at the X rate were completely root pruned and 100% of the 2X and 3X rates were root pruned (Table 1). More than 50% were partially pruned at both ¼ and ½X rates in July. By August, 56% of the forsythia had grown through the ¼X rate and 33% through the ½X rate treatments. Complete prunings of roots in August at the X, 2X, and 3X rates were the same as for July: 89, 100, and 100%. In September, 44% were fully root pruned at the ½X rate, 82% at the X rate, and 94% at both the 2 and 3X rates.

From this study, it would appear that forsythia can be satisfactorily root pruned for the summer growing season at the recommended rate of 5.25 oz of product per 100 sq ft of Gloquat C.

Weigela was 100% root pruned at the X rate in July but declined to 78% in August and 22% in September (Table 2). At the 2X rate in July and August, 100% root pruning of weigela was observed and 78% in September. Root pruning of weigela at the

[1]Professor and Technician, Dept. of Horticulture.

[2]Available from: Aceto Chemical Co., Inc., 126-02 Northern Boulevard, Flushing, N. Y. 11368.

TABLE 1.—Effects of Gloquat C on Root Pruning of Forsythia Produced on Sand Capillary Beds.

	July			August			September		
Treatment	No*	Partial	Full	No	Partial	Full	No	Partial	Full
					Percent				
Control	100	0	0	100	0	0	100	0	0
Gloquat ¼X	0	56	44	56	31	13	67	33	0
Gloquat ½X	0	56	44	33	44	22	33	22	44
Gloquat X	0	11	89	0	11	89	0	18	82
Gloquat 2X	0	0	100	0	0	100	0	6	94
Gloquat 3X	0	0	100	0	0	100	0	6	94

*No = no root pruning; partial = some root pruning; full = complete root pruning.

TABLE 2.—Effects of Gloquat C on Root Pruning of Weigela Produced on Sand Capillary Beds.

	July			August			September		
Treatment	No*	Partial	Full	No	Partial	Full	No	Partial	Full
					Percent				
Control	100	0	0	100	0	0	100	0	0
Gloquat ¼X	0	33	67	11	67	22	100	0	0
Gloquat ½X	0	44	56	0	33	67	89	11	0
Gloquat X	0	0	100	0	22	78	28	50	22
Gloquat 2X	0	0	100	0	0	100	0	22	78
Gloquat 3X	0	0	100	0	0	100	0	18	83

*No = no root pruning; partial = some root pruning; full = complete root pruning.

3X rate in July and August was 100% effective but declined to 83% in September.

Weigela was more vigorous than the forsythia and the Gloquat C was not as effective in pruning roots in September as in July and August.

To determine if the Gloquat C had an effect on vegetative growth, the height of the plants was measured in September (Table 3). The plants were tallest in the control plots because they rooted into the moist sand and these roots were not disturbed throughout the study. There were no significant differences in height between the ¼, ½, and X rates of either species. At the higher rates the height was somewhat reduced.

In addition to root pruning, Gloquat C served as a pre-emergence herbicide and, although no data were taken, it controlled many annual weeds on the surface of the sand, but not in the containers, for approximately 2 months.

TABLE 3.—Height of Weigela and Forsythia Produced on Sand Capillary Beds and Root Pruned with Gloquat C.

	Height - Inches	
Treatment	Weigela	Forsythia
Control	25.0a*	23.4a
Gloquat C ¼X	20.3b	22.2a
Gloquat C ½X	19.2bc	20.3ab
Gloquat C 1X	19.3bc	21.1ab
Gloquat C 2X	16.9cd	17.6c
Gloquat C 3X	14.6d	18.4bc

*Similar letters in a column are not significantly different at the 5% level according to Duncan's multiple range test.

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Genetic Variation in Wound Response Among Cultivars of *Acer platanoides* L.[1,2]

PETER W. GALLAGHER[3] and T. DAVIS SYDNOR[4]

ABSTRACT

Wound closure and growth data were recorded for 11 cultivars of Norway maple (*Acer platanoides*). Branch and trunk wounds were analyzed for extent of an associated discoloration column. A cultivar effect was noted in both closure and compartmentalization.

The cultivars Jade Glen and Globosum had a significantly slower wound closure rate than all other Norway maple cultivars.

The cultivar Globosum possesses very poor branch wound compartmentalization abilities compared to the other cultivars. Trunk wound data indicate the presence of a greater than average volume of discoloration and decay for the three cultivars Globosum, Jade Glen, and Royal Red.

INTRODUCTION

Wound response in trees involves two simultaneously occurring processes: *wound closure* or callusing over of the wound and *internal compartmentalization* of damaged tissue.

The rate of wound closure in *Acer rubrum* is in part a function of genetics (2). In addition, it has been observed that cambial dieback, a component of wound closure, varies according to species (4, 5). Compartmentalization is quite consistent within a clone and independent of closure rate, growth rate, and tree size (3, 6). Gallagher and Sydnor have demonstrated the use of electrical resistance (ER) measurements obtained with a Shigometer and twisted wire probe for selecting trees on the basis of their compartmentalization ability (1).

This study was undertaken in an effort to determine which currently available Norway maple (*Acer platanoides*) cultivars have a superior inherent wound response.

MATERIALS AND METHODS

A total of 48 Norway maple trees located in the shade tree evaluation plots at the Ohio Agricultural Research and Development Center were used for this study. Included were 11 cultivars plus the species, *Acer platanoides*.

Trees varied in age from 10 years to 16 years and had a mean caliper of 18 cm dbh. Four trees of each cultivar were used in most instances. In the case of two cultivars (Greenlace and Olmsted), there were only three trees available and with the cultivar Summershade, there were only two replicates.

Closure

Wounds 10 mm diam x 20 mm deep were inflicted by a rechargeable electric drill in each of four cardinal directions at a height of 1.5 m. Trees were wounded at the time of bud break (April 14, 1981).

Annual twig extension, caliper increase, cambial dieback (Fig. 1), canopy volume (Fig. 2), and electrical resistance (Fig. 3) were recorded for each tree. Closure data were taken every 2 weeks with an inside reading micrometer.

Compartmentalization

Two trunk wounds per tree from the closure study were chosen for Shigometer[5] probe analysis as an index of discoloration. Trees were not cut. Five holes (0.28 cm diam x 5 cm deep) were drilled into each tree (Fig. 4). One probe was situated at least 5 cm to the side of the wound and served as a control. Two probe sites were located above each of the two wounds per tree at a distance of 1 cm and 3 cm above each wound. This was done in the fall after the growing season.

Electrical resistance (ER) was measured with a model OZ167 Shigometer, using a standard twisted wire probe marked off in 5 mm increments. Readings were recorded at 5 mm intervals to a depth of 40 mm. Analysis was performed on "adjusted" readings expressed as a percentage of a mean control reading at a corresponding depth.

An additional wound was applied to a lower branch of each tree in April 1981. A branch wound consisted of a 10 mm diam x 10 mm deep hole drilled into the lower surface of the branch.

Branches were removed during the first week of October 1981. Branches were cut into 1 cm thick discs on a table saw to determine extent of discoloration.

RESULTS

Closure

The cultivars Globosum and Jade Glen are much slower to close wounds and are clearly separated from all other cultivars (Table 1).

[1]Based on a thesis submitted by the senior author in partial fulfillment of the Ph.D. requirements at The Ohio State University.

[2]Significant funding from grant 23504 from the Consortium for Environmental Forestry Studies.

[3]Associate Professor of Horticulture, Louisiana Tech University.
[4]Associate Professor, Dept. of Horticulture.

[5]The authors express appreciation to the USDA, Forest Service, Northeastern Forest Experiment Station, Durham, N. H., for loan of a Shigometer.

FIG. 1.—Cambial dieback revealed below the wound. The vertical extent of discolored tissue below each wound was recorded as cambial dieback.

A partial list of correlation coefficients between closure rate and growth parameters plus the associated probability levels is included in Table 2. Of particular interest is the relatively high correlation between closure and cambial dieback. Also note that electrical resistance (ER) is highly correlated with closure. Ion concentration likewise seems to be strongly correlated to closure rate.

FIG. 3.—Shigometer and "sticker probe" used to measure electrical resistance between the two needle electrodes. Note vertical orientation of the probe.

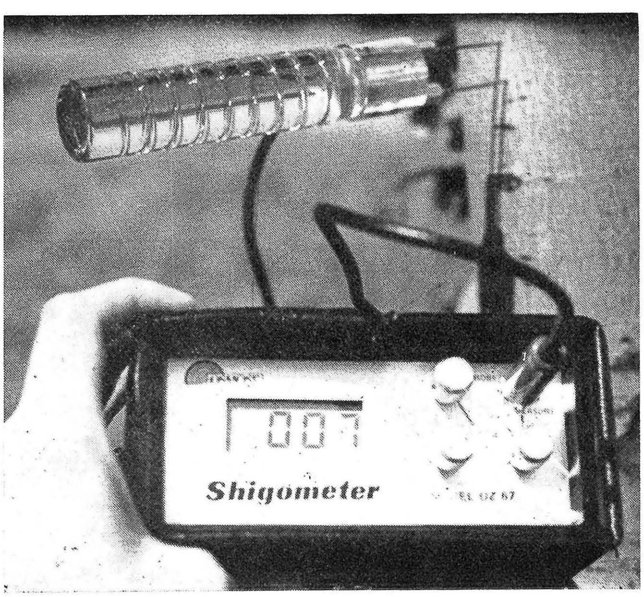
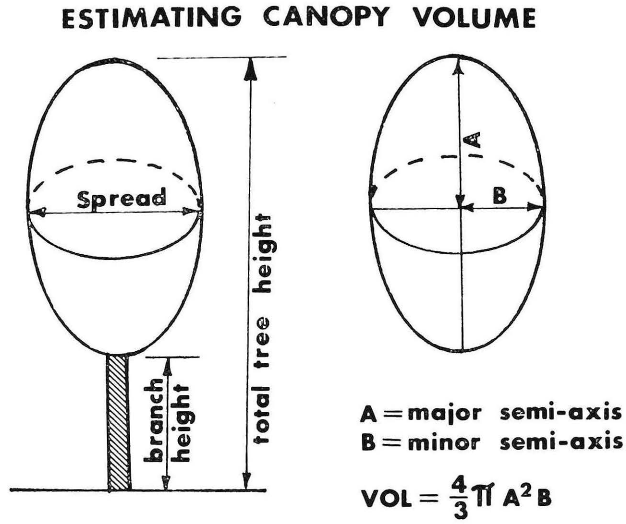


FIG. 2.—Canopy volume is estimated by assuming that the mass of leaves forming the crown is a solid ellipsoid.



Electrical resistance of the cambial zone, as measured with the Shigometer 'sticker probe', appears to be significantly correlated to a number of growth parameters under study. Generally, lower ER readings appear to be indicative of: 1) larger and older trees, 2) faster growing trees, and 3) higher callus nutrient levels (Table 3).

Stepwise regression analysis was performed on the data in an effort to define wound closure as a

FIG. 4.—0.28 cm diameter Shigometer probe holes were drilled to a depth of 5 cm at two sites above each of two wounds per tree. A control probe hole was placed well beyond the wound sites.

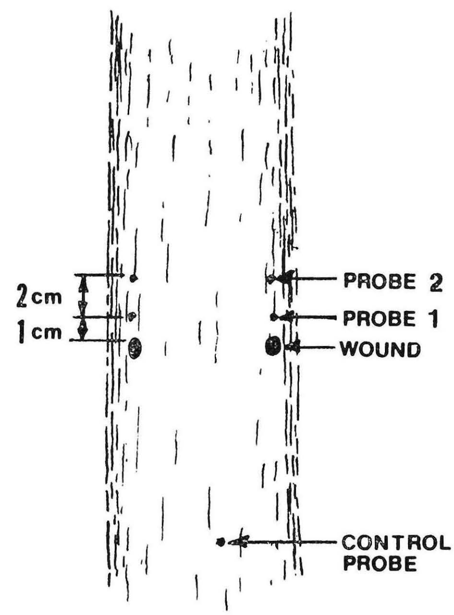


TABLE 1.—Mean Number of Weeks to Closure for 11 Acer platanoides **Cultivars, 1981.**

Cultivar	Weeks to Closure
Olmsted	11.8
Summershade	12.3
Columnare	12.5
Species	12.7
Cleveland	13.0
Superform	13.3
Royal Red	14.5
Crimson King	16.4
Greenlace	16.5
Emerald Queen	17.3
Globosum	27.3
Jade Glen	27.8

$LSD_{.05}$ = 8.2.

TABLE 2.—Pearson Correlation Coefficients (R^2) and Associated Probabilities (p) Between Weeks to Closure and Growth Parameters, Acer platanoides, **1981.**

Factor	R^2	Probability
Cambial dieback	0.55	0.0001
Electrical resistance	0.52	0.0002
Caliper increase	—0.47	0.0011
Canopy volume	—0.45	0.0016
Twig extension '81	—0.34	0.02
Twig extension '80	N.S.	
Phosphorus (P)	—0.49	0.0006
Potassium (K)	—0.57	0.0001
Copper (Cu)	—0.67	0.0001

TABLE 3.—Pearson Correlation Coefficients (R^2) and Associated Probabilities (p) Between Electrical Resistance (Shigometer) and Listed Growth Factors for Acer platanoides.

Factor	R^2	P
Height	—0.76	0.0001
Canopy volume	—0.62	0.0001
Caliper increase	—0.50	0.0004
Spread	—0.39	0.0069
Callus (Cu)	—0.55	0.0001

TABLE 4.—Regression Equations for Acer platanoides **Closure Study, 1981.**

1. Best 2 factor model without tissue analysis data
   (weeks to close) = A_n = 0.23 (twig extension '81) + 1.19 (cambial dieback)
   A_1 = 23.8*
   R_2 = 0.66
   A_2 = 12.1

2. Best 3 factor model with tissue analysis data
   (weeks to close) = B_n + 1.34 (cambial dieback) —0.57 (Cu) + 0.13 (Zn)
   B_1 = 19.0*
   R_2 = 0.85
   B_2 = 12.8

*A_1 and B_1 for cultivars 'Globosum' and 'Jade Glen', A_2 and B_2 for all other cultivars.

function of growth parameters. Two equations were developed: one makes use of tissue analysis data and the other uses only physical growth parameters (Table 4).

Grouping of cultivars proved beneficial for the regression analysis. Among the Norway maple culti-

TABLE 5.—Mean Number of Electrical Resistance Readings Less Than 15% of Mean Control Readings at the Lower Probe Site (1 cm Above the Wound) for 11 Acer platanoides **Cultivars.**

Olmsted	5.7
Columnare	4.5
Royal Red	4.4
Jade Glen	4.3
Globosum	3.0
Crimson King	2.7
Cleveland	2.2
Greenlace	2.0
Summershade	1.5
Superform	1.5
Species	0.4
Emerald Queen	0.0

$LSD_{.05}$ = 2.9.

TABLE 6.—Mean Number of Electrical Resistance Readings Less Than 15% of Mean Control Readings at the Upper Probe Site (3 cm Above the Wound) for 11 Acer platanoides **Cultivars.**

Globosum	2.3
Jade Glen	2.3
Royal Red	2.0
Greenlace	0.7
Olmsted	0.3
Columnare	0.2
Species	0.0
Cleveland	0.0
Crimson King	0.0
Emerald Queen	0.0
Summershade	0.0
Superform	0.0

$LSD_{.05}$ = 2.0.

TABLE 7.—Mean Extent of Discoloration in Branch Wounds of 11 Acer platanoides **Cultivars.**

Globosum	8.0 cm
Summershade	3.7
Cleveland	3.7
Jade Glen	3.7
Royal Red	3.2
Olmsted	2.8
Emerald Queen	2.8
Superform	2.7
Crimson King	2.5
Columnare	2.1
Species	2.0
Greenlace	2.0

$LSD_{.05}$ = 1.5.

vars, Jade Glen and Globosum were placed into one group and all of the remaining cultivars were lumped together into a second group.

Compartmentalization

The cultivar Globosum is statistically indistinguishable from all other Norway maple cultivars on the basis of lower probe data (Table 5). Olmsted is the cultivar with the poorest ER readings and Emerald Queen is the best cultivar according to these data. This suggests that Olmsted has more decay and discoloration than a cultivar such as Emerald Queen (1).

The data for the upper probe site (3 cm above the wound) seem to indicate the presence of greater discoloration with wounds on Globosum, Jade Glen, and Royal Red (Table 6).

Extent of discoloration beyond the branch wounds varied from 8.0 cm for the cultivar Globosum to 2.0 cm for Greenlace (Table 7). From a practical standpoint, Globosum is clearly separated from all other cultivars.

DISCUSSION

In some cases, there appeared to be a continuous actual difference in closure rate for one or more cultivars. Where this occurred, as with *Acer platanoides* 'Jade Glen', there was a concurrent reduction in growth rate. There may also be, in addition to growth factors, a direct inhibition due to pathogens.

Wound closure correlation with ER is likely a result of a growth or vigor relationship. An active and fast growing cultivar is believed to have higher ion concentration in the cambium zone (6).

The Norway maple cultivar 'Globosum' was clearly separated from the other cultivars in the branch study, yet there was no such clarity in the trunk study. Although the ER data may be inconsistent here, it is just as likely that the wound response was somewhat different in the two studies. This is particularly likely in view of the fact that Globosum is budded at 6 feet rather than at ground level. The fact that Globosum, Jade Glen, and Royal Red are grouped (Table 6) indicates that there may well be an overriding vigor related response beyond the purely genetic differences. All three of these cultivars seemed to be in relatively low vigor or even in a declining state.

The branch wound technique is obviously a more direct route, not involving the intermediate step of estimating one parameter (discoloration depth) to in turn estimate another (relative volume of discoloration). The extent of discoloration appeared to be quite stable within a cultivar. It is a simple task to identify those cultivars with very poor branch wound compartmentalization, such as *Acer platanoides* 'Globosum'.

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A Preliminary Host Preference Study for Fall Webworm *(Hyphantria cunea* Drury)[1]

T. DAVIS SYDNOR[2] and DANIEL HERMS[3]

ABSTRACT

Thirty-one of the 57 tree species studied were not affected by fall webworm. Twenty-six species were affected to various extents. Eleven species and cultivars were considered heavily infested during this study conducted in September 1982. Plant selections should be made from trees not affected where this pest is considered a problem.

INTRODUCTION

In late summer and early fall the Ohio landscape is dotted by unsightly, silken limbs. These conditions are caused by fall webworm. This insect is known to attack a number of different tree species and causes a great deal of concern among homeowners. During periods of heavy infestations, a tree can be almost totally defoliated. In most years, however, birds, predators, and internal parasites keep the population of this insect low enough that serious injury is not done to the host plant. A number of plants are not attacked by this pest. Knowing which plants are susceptible and which are not provides another means for selecting trees for use in a landscape situation.

Adult moths first begin to appear in Ohio in early June. These adults deposit eggs in clusters of as many as 900 on the lower leaf surface.

Newly hatched larvae begin to feed on the leaves where the eggs were laid. They also begin to form the webbing which characterizes this pest. The web increases in size as the caterpillars grow. A volume of 2 to 4 cubic feet may eventually be enclosed by the webbing. Larvae vary greatly in color from very pale green to a deeper sepia color. Literature currently suggests that there is a red-headed or lighter colored race and a black-headed or darker colored race. At one time these were considered as separate species. The one characteristic which characterizes fall webworm larvae, and which is useful in identification, is the two rows of black dots along the back of the body. These are normally borne on either side of a dusty stripe which is at the top of the back.

When full grown, larvae weave a web and pupate in the soil or in crevices in bark, buildings, fences, or other objects. The first generation gives rise to a second generation which is usually far more numerous. Fall webworm is named for the second generation which is so obvious during the fall of the year.

[1]Lepidoptera:Arctiidae.

[2]Associate Professor, Dept. of Horticulture.

[3]Graduate Student, Dept. of Entomology.

MATERIALS AND METHODS

This study was conducted at the Shade Tree Evaluation Project on the campus of the Ohio Agricultural Research and Development Center, Wooster. At this 12-acre site, species and cultivars of shade trees are growing in a completely random pattern. Eight trees of each species and cultivar were originally planted. Through natural attrition, caused by a variety of insect, disease, and other problems, the number of plants currently ranges from one to eight. Plants with less than three surviving individuals were eliminated from the table.

In order to check the level of infestation, all infested trees were plotted, and it was noted that infestation was uniform throughout the shade tree evaluation plot. In no case was an uninfested tree more than 100 feet from one or more infested plants. Indeed, the majority of the uninfested plants were adjacent to infested plants.

Trees were evaluated by counting the number of active colonies per tree. Trunk diameter at breast height (caliper) was also measured in order to get a feel for the overall size of the individual trees. Number of colonies per inch of trunk diameter was calculated by dividing the number of colonies by the diameter in inches. By comparing the number of colonies per inch of trunk diameter, one can adjust for differences in plant size, which ranged from 1 to 10 inches in trunk diameter. The percentage of infested plants was calculated by dividing the number of trees with 1 or more colonies by the number of trees observed and then multiplying by 100. A one-way analysis of variance was run for both the number of colonies per tree and number of colonies per inch of trunk diameter. Because of the varying numbers of observations per genus and species, only the standard deviations are reported.

RESULTS AND DISCUSSION

The following plants were classified as heavily infested with at least 66.7% infestation: *Acer platanoides* 'Greenlace', *Betula platyphylla japonica, Corylus colurna, Crataegus prunifolia, Fraxinus excelsior* 'Hessei', *Fraxinus holotrica* 'Moraine'. *Liquidambar styraciflua* 'Festival', *Malus* 'Royalty', *Platanus acerifolia* 'Bloodgood', *Tilia americana* 'Redmond', and *Tilia tomentosa*. The above plants might be avoided in the landscape where the webs are considered objectionable and spraying is not desired. The health of even severely infested plants is normally not seriously affected by this pest, so spraying decisions are dictated by the visual appearance of the plant.

When adjusted for plant size, *Betula platyphylla japonica, Betula platyphylla szechuanica, Corylus colurna, Fraxinus excelsior* 'Hessei', *Liquidambar styraciflua* 'Moraine', *Malus* 'Radiant', *Malus* 'Royal Ruby', *Malus* 'Royalty', and *Tilia americana* 'Redmond' showed infestations of 0.6 colony per inch of trunk diameter or more. In this case, *Betula platyphylla szechuanica* is listed in the heavily infested group because the plants had a disproportionate degree of infestation for their size. A plant such as *Platanus acerifolia* 'Bloodgood' had two or three colonies per plant but the plants were large.

The visual impact of this pest is probably best characterized by considering the number of colonies per inch. Number of colonies per tree or percent of infested trees does not speak well to the aesthetic deterioration. Because this problem is primarily aesthetic, the visual impact of this moth's damage is a major consideration.

Other observed host plants in the central Ohio area, including hosts in the shade tree evaluation plot with less than three replications, include: *Acer negundo, Aesculus hippocastanum, Betula papyrifera, Betula pendula, Carya ovata, Eucommia ulmoides, Fagus sylvatica* 'Atropurpurea', *Fraxinus excelsior* 'Rancho', *Juglans nigra, Maclura pomifera, Malus* 'White Angel', *Morus alba, Platanus occidentalis, Prunus sargenti, Prunus serotina, Quercus bicolor, Q. coccinea, Q. macrocarpa, Q. palustris, Q. prinus, Q. rubra,* and *Ulmus americana.*

Certain genera showed considerable variation in the degree of infestation. *Acer, Betula, Crataegus, Fraxinus, Malus,* and *Tilia* all had some species or cultivars with less damage than others. Selection for resistant species and cultivars appears realistic.

FIG. 1.—A Japanese white birch (Betula platyphylla japonica) **which has been seriously defoliated by fall webworm. The branch on the lower right of the canopy shows the normal foliage density of this tree.**

FIG. 2.—A close-up of a web caused by fall webworm on Betula platyphylla japonica. **Note the abundant excrement found in the webbing.**

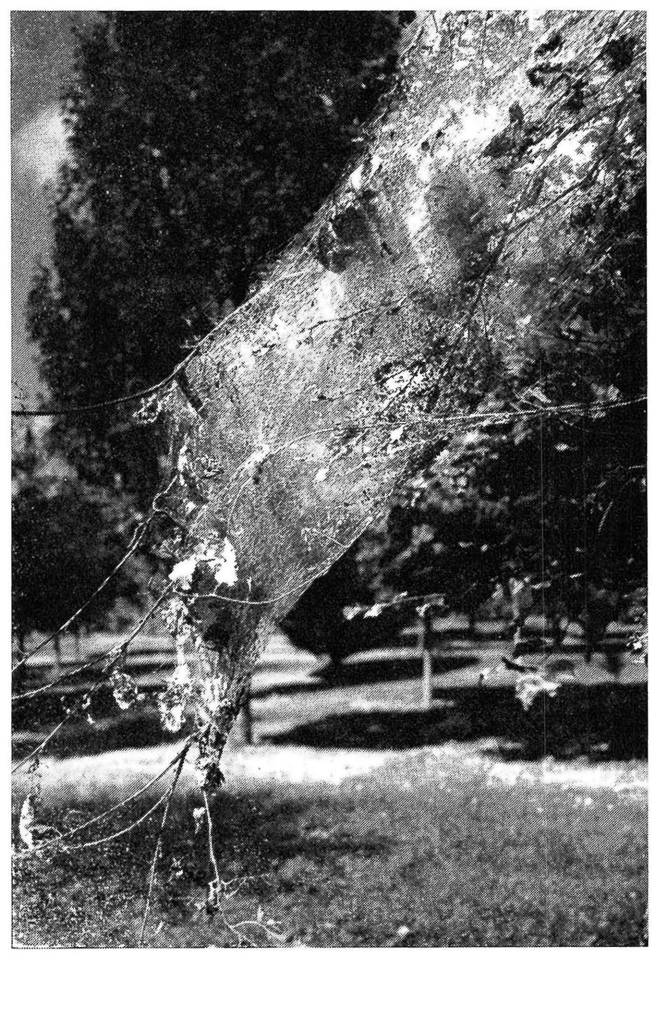

TABLE 1.—Number of Active Fall Webworm Colonies per Tree and Number of Active Colonies per Inch of Caliper for Species and Cultivars of Ornamental Trees, Sept. 9, 1982, Wooster, Ohio.

Species	Colonies	Std. Dev.	Colonies in Caliper	Std. Dev.	Percent Infested
Acer X 'Autumn Blaze'	0	0	0	0	0
Acer campestre	0	0	0	0	0
Acer ginnala	0	0	0	0	0
Acer platanoides	0.3	0.2	0.0	0.1	25.0
Acer p. 'Cleveland'	0	0	0	0	0
Acer p. 'Columnare'	0	0	0	0	0
Acer p. 'Crimson King'	1.2	2.0	0.2	0.3	33.0
Acer p. 'Emerald Queen'	0.3	0.8	0.0	0.1	14.0
Acer p. 'Globosum'	0	0	0	0	0
Acer p. 'Greenlace'	1.0	1.0	0.2	0.2	66.7
Acer p. 'Jade Glen'	0	0	0	0	0
Acer p. 'Olmsted'	0.3	0.6	0.0	0.1	33.0
Acer p. 'Royal Red'	0.5	1.2	0.1	0.2	16.7
Acer p. 'Superform'	0.5	0.5	0.1	0.1	50.0
Acer pseudoplatanus	0.3	0.5	0.0	0.1	25.0
Acer rubrum	0	0	0	0	0
Acer r. 'Armstrong'	0	0	0	0	0
Acer r. 'Autumn Flame'	0	0	0	0	0
Acer r. 'Autumn Glory'	0	0	0	0	0
Acer r. 'Bowhall'	0	0	0	0	0
Acer r. 'Columnare'	0	0	0	0	0
Acer r. 'Doric'	0	0	0	0	0
Acer r. 'Gerling'	0	0	0	0	0
Acer r. 'October Glory'	0	0	0	0	0
Acer r. 'Red Sunset'	0	0	0	0	0
Acer r. 'Scanlon'	0	0	0	0	0
Acer r. 'Schlesinger'	0	0	0	0	0
Acer r. 'Tilford'	0	0	0	0	0
Acer saccharinum	0	0	0	0	0
Acer saccharum	0	0	0	0	0
Acer s. 'Globosum'	0	0	0	0	0
Acer s. 'Sweet Shadow'	0	0	0	0	0
Acer s. 'Temple's Upright'	0	0	0	0	0
Amelanchier grandiflora	0.2	0.4	0.1	0.1	16.7
Betula nigra	0.1	0.4	0.0	0.1	12.5
B. platyphylla japonica	4.7	4.1	2.0	1.1	85.7
B. p. szechuanica	1.3	1.4	0.9	0.4	50.0
Carpinus b. 'Fastigiata'	0	0	0	0	0
Carpinus b. 'Pyramid'	0	0	0	0	0
Celtis occidentalis	0	0	0	0	0
Cercidiphyllum japonicum	1.3	2.6	0.3	0.6	42.9
Corylus colurna	1.3	1.5	0.7	0.8	66.7
Crataegus intricata	0.2	0.5	0.1	0.1	20.0
Crataegus mollis	0	0	0	0	0
Crataegus nitida	0	0	0	0	0
C. 1. 'Crimson Cloud'	0	0	0	0	0
C. p. 'Tree Form'	0	0	0	0	0
Crataegus prunifolia	1.5	1.4	0.3	0.3	66.7
Crataegus punctata	0	0	0	0	0
C. punc. 'Ohio Pioneer'	0	0	0	0	0
C. viridis 'Winter King'	0	0	0	0	0
Euonymus bungeana	0.2	0.4	0.0	0	16.7
F. a. 'Autumn Purple'	0.9	1.6	0.5	0.9	25.0
F. a. 'Hillcrest'	0	0	0	0	0
F. a. 'Skyline'	0.5	0.9	0.5	0.9	25.0
F. excelsior 'Hessei'	6.6	5.6	0.8	0.3	100.0
F. holotrica 'Moraine'	6.1	5.3	0.7	0.6	71.0
F. p. 'Marshall's Seedless'	0	0	0	0	0
F. 'Summit'	0.2	0.4	0.0	0	16.7

TABLE 1 (Continued).—Number of Active Fall Webworm Colonies per Tree and Number of Active Colonies per Inch of Caliper for Species and Cultivars of Ornamental Trees, Sept. 9, 1982, Wooster, Ohio.

Species	Colonies	Std. Dev.	Colonies in Caliper	Std. Dev.	Percent Infested
Fraxinus tomentosa	0	0	0	0	0
Ginkgo b. 'Autumn Gold'	0	0	0	0	0
Ginkgo b. 'Lakeview'	0	0	0	0	0
Ginkgo b. 'Sinclair'	0	0	0	0	0
Gleditsia t. 'Imperial'	0	0	0	0	0
Gleditsia t. 'Moraine'	0	0	0	0	0
Gleditsia t. 'Shademaster'	0	0	0	0	0
Gleditsia t. 'Skyline'	0	0	0	0	0
Gleditsia t. 'Sunburst'	0	0	0	0	0
Gymnocladus dioicus	0	0	0	0	0
Halesia carolina	0	0	0	0	0
Liquidambar s. 'Festival'	3.9	3.3	0.8	0.7	71.0
Liquidambar s. 'Moraine'	6.0	2.7	1.2	0.5	100.0
Malus X 'Radiant'	6.3	5.0	1.4	1.2	87.5
Malus X 'Red Jewel'	1.5	2.5	0.4	0.7	50.0
Malus X 'Royal Ruby'	3.9	4.0	1.3	1.2	85.7
Malus X 'Royalty'	3.3	2.9	0.8	0.7	75.0
Malus X 'Snowdrift'	0.15	0.4	0.0	0	14.0
Malus X 'Van Eseltine'	2.0	4.0	0.4	0.8	25.0
Malus X 'White Candle'	0	0	0	0	0
Malus sieboldi zumi 'Calocarpa'	1.0	1.3	0.3	0.3	42.1
Nyssa sylvatica	0.3	0.8	0.1	0.2	14.3
Platanus acerifolia	1.6	1.6	0.2	0.2	62.5
Platanus a. 'Bloodgood'	1.9	2.7	0.0	0.3	75.0
Prunus s. 'Columnare'	0	0	0	0	0
Prunus serrulata 'Kwanzan'	0	0	0	0	0
Pyrus c. 'Aristocrat'	0.3	0.7	0.1	0.1	12.5
Pyrus c. 'Bradford'	0	0	0	0	0
Pyrus c. 'Chanticleer'	0.2	0.5	0.0	0.1	20.0
Pyrus c. 'Faureri'	0.2	0.4	0	0.1	16.7
Pyrus c. 'Rancho'	0	0	0	0	0
Pyrus c. 'Select'	0.2	0.4	0.0	0.1	16.7
Pyrus c. 'Simpson's #1'	0	0	0	0	0
Pyrus c. 'Simpson's #2'	0	0	0	0	0
Pyrus c. 'Simpson's #4'	0	0	0	0	0
Quercus imbricaria	0	0	0	0	0
Quercus robur	0	0	0	0	0
Quercus r. 'Fastigiata	0	0	0	0	0
Quercus shumardi	0	0	0	0	0
Robinia X ambigua deciasneana	0	0	0	0	0
Sophora japonica 'Regent'	0	0	0	0	0
Sorbus aucuparia 'Cardinal'	2.3	4.5	0.6	1.1	25.0
Sorbus a. 'Wilson'	0	0	0	0	0
Sorbus tianshanica	0	0	0	0	0
Syringa reticulata	0	0	0	0	0
Tilia a. 'Fastigiata'	0.3	0.8	0.0	0.1	16.7
Tilia cordata	0	0	0	0	0
Tilia c. 'Chancellor'	0.2	0.4	0.0	0.1	16.7
Tilia c. 'Greenspire'	0	0	0	0	0
Tilia c. 'Rancho'	0.1	0.4	0.0	0.1	14.3
Tilia c. 'XP110'	0	0	0	0	0
Tilia euchlora	0.4	0.8	0.1	0.2	28.6
Tilia e. 'Redmond'	2.9	2.0	0.6	0.4	87.5
Tilia europaea 'Pallida'	0.1	0.4	0.0	0.1	12.5
Tilia mongolica	0	0	0	0	0
T. playtphyllos 'Orebro'	0.9	1.6	0.2	0.3	25.0
Tilia tomentosa	1.0	0.8	0.1	0.1	75.0
Ulmus X 'Urban Elm'	0	0	0	0	0
Zelkova s. 'Village Green'	0	0	0	0	0

The following species showed no incidence of fall webworm: *Acer campestre, Acer ginnala, Acer rubrum, Acer saccharum, Acer saccharinum, Carpinus betulus, Celtis occidentalis, Crataegus mollis, Crataegus nitida, Crataegus laevigata, Crataegus punctata, Crataegus viridis, Fraxinus tomentosa, Ginkgo biloba, Gleditsia triacanthos, Prunus sargenti* 'Columnaris', *Prunus serrulata, Quercus imbricaria, Quercus robur, Quercus shumardi, Robinia* X *ambigua, Sophora japonica, Sorbus tianshanica, Syringa reticulata, Tilia mongolica, Ulmus* Urban Elm, and *Zelkova serrata.* The plants listed above should be considered first when selecting trees which will be subject to periodic defoliation or attack by the fall webworm, especially if the owner finds spraying to be necessary.

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Evaluation of Flowering Crabapple Susceptibility to Apple Scab in Ohio — 1982

ELTON M. SMITH[1]

ABSTRACT

In 1982, 181 flowering crabapple species, hybrids, and cultivars were evaluated for susceptibility to apple scab. Eighty-nine selections have been found to be highly resistant and 34 selections to be resistant during a relatively dry growing season.

INTRODUCTION

The most serious disease of flowering crabapple in Ohio is apple scab caused by the fungus *Venturia inaequalis*. Infection by this fungus results in the formation of olive gray spots on the foliage which often lead to yellowing and defoliation. Extensive leaf fall not only destroys the landscape value of a tree but may leave the plants in a weakened condition as they enter winter, and flowering the following season is also reduced.

This disease can be controlled by regular spraying with one of several fungicides such as Benlate, Captan, or Cyprex. However, to avoid the disease and subsequent spraying in future plantings, resistant selections should be planted. Many selections are highly resistant or nearly resistant to apple scab and these are the types which should be commercially propagated and produced, assuming their horticultural qualities are acceptable to the consumer and producer. Horticultural qualities have been reviewed in a recent publication titled, "Flowering Crabapple—A Tree for All Seasons" (1).

MATERIALS AND METHODS

Flowering crabapples located in arboretums and nurseries were surveyed in August 1982 for the severity of apple scab infection and for the presence of other diseases such as cedar apple rust, fireblight, and powdery mildew. The latter three diseases were not rated because they are usually not serious enough to discontinue the planting of a species, hybrid, or cultivar.

Rainfall, which influences the severity of certain diseases, was below normal in much of Ohio during the May-August period and the severity of apple scab was lower than in previous years (2).

The scale used for apple scab evaluations was as follows: HR = highly resistant—no indication of diseases; 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. In some instances more than one notation appears in the table for a given selection because the severity of infection varied from location to location. This variation was due to differences in frequency of rainfall and relative humidity in the various locations in Ohio.

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RESULTS AND DISCUSSION

More than half of the 181 flowering crabapple selections have been found to be highly resistant (89) or resistant (34) to apple scab in 1982 (Table 1).

Some of the resistant and highly resistant selections, however, were found to be susceptible to fireblight, cedar apple rust, or powdery mildew, with the former the most serious. Among the most disease-resistant types in Ohio in 1982 were M. 'Adams', 'Barbara Ann', 'Beverly', 'Bob White', 'Centurion', 'Dolgo', 'Donald Wyman', 'Golden Gem', 'Golden Hornet', 'Harvest Gold', 'Henry Kohankie', 'Indian Summer', 'Liset', 'Makamik', 'Mary Potter', 'Ormiston Roy', 'Red Jewel', 'Robinson', sargentii, 'Spring Snow', 'Sugartyme', 'White Angel', and zumi 'Calocarpa'.

Among the most disease susceptible selections were M. arnoldiana, 'Flame', 'Hopa', 'Pink Perfection', 'Pink Weeper', 'Purple Wave', 'Eleyi', 'Lemoinei', and 'Radiant'.

The resistant and highly resistant selections should be given the highest consideration by the nursery industry for commercial production and those most susceptible should be discontinued.

For additional information relative to the horticultural qualities such as flower, fruit, foliage, and habit of growth of flowering crabapples, visit one of the arboretums in early May or early autumn. In Ohio the Secrest Arboretum in Wooster, Dawes Arboretum near Newark, and the Holden Arboretum in Mentor feature outstanding collections of flowering crabapples.

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TABLE 1.—Susceptibility of Flowering Crabapples to Apple Scab—1982.

Species, Hybrid or Cultivar	Apple Scab Rating* HR	R	S	HS	Other Diseases Noted
'Adams'	X				
M. x adstringens			X		
'Almey'			X		
'American Beauty'			X		
'Amisk'				X	
'Amur'	X				
M. x arnoldiana				X	
'Arrow'		X			
M. x atrosanguinea			X		
M. baccata	X	X			Fireblight
M. baccata	X				Fireblight
M. baccata 'Jackii'	X				
M. baccata var. Mandshurica		X			
M. baccata 'Midwest'	X				
'Barbara Ann'	X				
'Beverly'	X				
'Bob White'	X				
'Brandywine'	X	X			Cedar apple rust
M. brevipes		X			
'Burgundy'	X				
'Cashmere'		X	X		
'Centennial'	X				
'Centurion'	X				
'Cheal's Crimson'			X		
'Chestnut'	X				
'Chilko'	X				
'Coralburst'	X	X			
M. coronaria 'Charlottae'			X		Cedar apple rust, Fireblight
M. coronaria 'Dasycalyx		X			Cedar apple rust
M. coronaria 'Nieuwlandiana'	X				Cedar apple rust
'Cowichan'	X				
'Crimson Brilliant'				X	
'Dainty'	X				
'Dauphin'		X			
'David'	X				Fireblight
'Dolgo'	X				
'Donald Wyman'	X				
'Dorothea'			X		
'Ellen Gerhart'		X	X		Fireblight
'Evelyn'		X	X		Fireblight
'Exzellenz Theil'			X		
'Flame'		X	X		Fireblight
'Flexilis'	X				
M. florentina	X				
M. floribunda	X				Fireblight
'Fusca'			X		
'Geneva'	X				
'Gorgeous'	X				
'Girards Dwarf Weeping'	X				
M. glaucescens	X				
M. gloriosa		X			
'Golden Gem'	X				
'Golden Hornet'	X				
'Gwendolyn'	X				
M. halliana	X				
M. halliana 'Parkmanii'	X				
M. x hartwigii	X				
'Harvest Gold'	X				
'Henrietta Crosby'			X	X	
'Henry Dupont'		X			
'Henry Kohankie'	X				

TABLE 1 (Continued).—Susceptibility of Flowering Crabapples to Apple Scab —1982.

Species, Hybrid or Cultivar	Apple Scab Rating* HR	R	S	HS	Other Diseases Noted
'Hopa'			X	X	
'Hopa Rosea'				X	
M. hupehensis	X				
'Indian Magic'	X	X			
'Indian Summer'	X				
M. ioensis 'Klehms'	X				Cedar apple rust
'Klehms Improved'	X				Fireblight
'Irene'				X	Cedar apple rust
'Jay Darling'			X	X	
'Joan'	X				
'Katherine'		X			Fireblight
'Kingsmere'				X	
M. lancifolia		X			
M. lancifolia 'Allegheny'	X				
'Leslie'	X				
'Liset'	X				
M. x magdeburgensis	X				
'Makamik'	X				
'Marshall Oyama'	X	X			Fireblight
'Mary Potter'	X				
'Masek'			X		
M. x micromalus	X				Fireblight
M. 'Neville Copeman'				X	
'Oakes'			X		Powdery mildew
'Oekonomierat Echtermeyer'				X	
'Ormiston Roy'	X				
'Patricia'			X		
'Pink Beauty'	X				
'Pink Cascade'	X	X			
'Pink Flame'			X		
'Pink Perfection'				X	
'Pink Spires'	X	X			Fireblight
'Pink Weeper'				X	
'Prairie Rose'	X				
'Pretty Marjorie'			X		
'Prince Georges'	X				Cedar apple rust
'Profusion'	X				
M. prunifolia				X	
M. prunifolia 'Pendula'	X				
M. prunifolia var. rinkii			X		
M. pumila 'Elise Rathke'			X		
M. pumila 'Niedzwetzkyana'			X		
M. pumila 'Paradise Foleus Aureus'		X			
'Purple Wave'				X	
M. purpurea			X	X	
M. x purpurea 'Aldenhamensis'			X		Fireblight
M. x purpurea 'Eleyi'				X	
M. x purpurea 'Lemoinei'			X	X	
'Radiant'				X	
'Ralph Shay'	X	X			
'Red Baron'	X	X			
'Red Bud'				X	
'Redfield'	X				
'Red Jade'	X				Fireblight
'Red Jewel'	X				
'Red Silver'	X	X			
'Red Splendor'	X	X			
'Robinson'	X				
M. x robusta	X				
M. x robusta 'Erecta'	X	X			

TABLE 1 (Continued).—Susceptibility of Flowering Crabapples to Apple Scab —1982.

Species, Hybrid or Cultivar	Apple Scab Rating* HR	R	S	HS	Other Diseases Noted
M. x robusta 'Leucocarpa'	X				
M. robusta 'Persicifolia'	X				
'Rose Tea'	X				
'Rosseau'	X				
'Rosybloom'	X				
'Royal Ruby'		X	X		
'Royalty'	X	X			
'Rudolf'	X				
M. sargentii	X				
M. sargentii 'Rosea'		X	X		
M. x scheideckeri		X	X		
M. x scheideckeri 'Hillieri'			X		Fireblight
'Scugog'	X				
'Selkirk'	X				
'Sentinel'	X				
'Shakespeare'			X		
M. sieboldi	X				
M. sieboldi var. arborescens	X				Fireblight
M. sieboldi 'Fuji'	X				
M. sikkimensis	X	X			
'Silver Moon'	X				Fireblight
'Simcoe'	X	X			
'Sissipuk'	X				
'Snowbank'	X				
'Snowcap'	X				
'Snowcloud'		X			
'Snowdrift'	X	X			Fireblight
M. x soulardii		X			
'Sparkler'	X	X			
M. spectabilis		X			
M. spectabilis 'Albi-Plena'				X	
M. spectabilis 'Riversii'	X				
M. spectabilis 'Van Eseltine'	X	X			Fireblight
'Spring Snow'	X				
'Strathmore'			X	X	
M. x sublobata	X				
'Sugartyme'	X				
'Sundog'	X				
M. sylvestris 'Plena'	X				
'Tanner'				X	
M. toringoides			X		
M. toringoides 'Macrocarpa'			X		
'Trail'	X				
M. tschonoski	X				Fireblight
'Turesi'			X		
'Valley City #4'				X	
'Vanguard'			X		
'Velvet Pillar'		X			
'Wabiskaw'			X		
'Weeping Candied Apple'		X			
'White Angel'	X				
'White Candle'	X				Fireblight
'Wickson'	X				
'Wilson'		X			
'Winter Gold'		X	X		
'Wooster No. 1'	X				
M. yunnanensis 'Veitchi'	X				Fireblight
M. yunnanensis 'Veitch's Scarlet'	X				
M. zumi		X	X		
M. zumi 'Calocarpa'	X				

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