SPECIAL CIRCULAR 115 JANUARY 1988

Ornamental Plants – 1988: A Summary of Research

The Ohio State University
Ohio Agricultural Research and Development Center
Wooster, Ohio

Contents

ON THE COVER: David Chinery (L), M.S. candidate, measuring a 7-month-old red oak whip with Monica Wertz (R), technician. Both are in the Department of Horticulture at The Ohio State University.

AGDEX 272-275-276/16-24-28 1-88-2.5M

Follow-up Evaluation of Cyanazine, Terbacil and Metolachlor Slow-Release Herbicide Tablets on Woody Landscape Crops

Elton M. Smith and Sharon A. Treaster[1]

Abstract

As a follow-up to 1986 studies, slow-release herbicide tablets were evaluated on container-grown *Cotoneaster dammeri* 'Royal Beauty,' *Forsythia intermedia* 'Spring Glory,' and *Rhododendron obtusum* 'Hershey Red.'

Weed control from all treatments through 10 weeks of observations was acceptable. Metolachlor was noninjurious to all test species. Cyanazine at 5 and 10 Kg/ha was severely phytotoxic to cotoneaster and slightly injurious to azalea. Cyanazine caused no damage to forsythia. Terbacil at 2.5 Kg/ha seriously injured cotoneaster and azalea. The 5.0 rate Kg/ha of terbacil was injurious to all three species.

There was definitely a species response to the herbicides. Azalea and forsythia were tolerant of metolachlor and cyanazine, while cotoneaster was resistant to metolachlor.

Overall these results were similar to results from 1986 studies with similar herbicides at lower rates on the same plant species.

Introduction

Previous research has indicated the effectiveness of metolachlor (1,2,3,4) in slow-release herbicide formulations on container-grown nursery stock. Unfortunately, annual broadleaf weeds have not been controlled nearly as effectively as annual grasses.

Cyanazine, sold as Bladex, is labelled for corn. Terbacil, marketed as Sinbar, is labelled for several agronomic and horticultural crops. Both are readily soluble and control a wide spectrum of grasses and broadleaf weeds.

Previous research by the authors in 1986 (4) indicated very good weed control with both cyanazine and terbacil, however, there was some toxicity to all three species from both compounds, especially terbacil.

The specific objective of this study was to compare cyanazine and terbacil with metolachlor (Dual) in slow-release tablet formulation for weed control and phytotoxicity on azalea, forsythia and cotoneaster. The rates of both cyanazine and terbacil were reduced from 1986 to 1987 by one half or more in an attempt to continue with satisfactory weed control without significant injury to the crops.

Materials and Methods

The plant materials in this evaluation were the same species as in the 1986 study, namely, *Forsythia intermedia* 'Spring Glory' - Spring Glory forsythia, *Cotoneaster dammeri* 'Royal Beauty' - Royal Beauty cotoneaster, and *Rhododendron obtusum* 'Hershey Red' - Hershey Red azalea. Rooted cuttings from the previous summer of all three species were planted into one-gallon containers in a pinebark-peat-sand medium (6-3-1 by volume). Plants were potted May 8, 1987, and fertilized with osmocote 18-6-12 slow-release fertilizer. Twelve-gram herbicide tablets were applied at the rate of one tablet per container, on June 17, 1987. Plants were irrigated and maintained as for commercial conditions throughout the remainder of the growing season.

The herbicide tablets were made from technical grade metolachlor (97.0 percent), cyanazine (90.0 percent) and terbacil (95.0 percent). The tablets consisted of dicalcium phosphate and 2 percent magnesium stearate and pressed with a Stokes Model F single punch tablet machine.

There were three plants per species in each treatment with three replications of each treatment. Plants were arranged in a randomized block design. Evaluations were conducted at 2, 4, 6, 8 and 10 week intervals from treatment. Weed control and phytotoxicity were rated on a 1 to 10 scale with 10 best, and 7 or above acceptable.

Results and Discussion

Metolachlor, cyanazine and terbacil all controlled weeds effectively for 10 weeks as indicated in Table 1. Weed control with metolachlor at 10 and 20 Kg/ha was equal to the results of cyanazine at 5 and 10 Kg/ha and terbacil at 2.5 and 5.0 Kg/ha. In 1986, weed control of metolachlor at 10 and 20 Kg/ha was not as effective as cyanazine and terbacil at 10 and 20 Kg/ha. Reducing the rate of cyanazine by one half and terbacil by three fourths in 1987 did reduce weed control effectiveness from the previous year but definitely not below commercially acceptable standards.

Metolachlor, as in 1986, was completely noninjurious to cotoneaster, forsythia and azalea at both the 10 and 20 Kg/ha rates (Table 1).

Cyanazine at both the 5 and 10 Kg/ha rates was noninjurious to forsythia, slightly injurious, yet commercially acceptable to azalea and very phytotoxic to cotoneaster. In 1986, there was some injury to all three species with cotoneaster damaged to the greatest extent.

Terbacil at the 2.5 Kg/ha rate injured all species. Cotoneaster was severely damaged, with moderate yet commercially acceptable damage to forsythia and azalea. At the 5.0 Kg/ha rate damage was too severe on all species to be considered for commercial use. In 1986, terbacil at both the 10 and 20 Kg/ha rate injured all three species.

In summary, lowering the rates of cyanazine from 10 and 20 to 5 and 10 Kg/ha resulted in similar weed control and less injury to the test species than the previous year. As in the past, Terbacil was too phytotoxic on all plants and the rate must be lowered still further in future studies.

[1]Professor and Technician, Department of Horticulture.

Table I. Weed control and phytotoxicity from slow-release herbicides

Herbicide Treatment	Rate Kg/ha	Date	Weed Control[1]	Phytotoxicity[2] Cotoneaster	Forsythia	Azalea
Control	—	July 2	9.0	10.0	10.0	10.0
Control	—	July 30	8.7	10.0	10.0	10.0
Control	—	Aug. 27	6.7	10.0	10.0	10.0
Metolachlor	10	July 2	9.3	10.0	10.0	10.0
Metolachlor	10	July 30	8.7	10.0	10.0	10.0
Metolachlor	10	Aug. 27	8.3	10.0	10.0	10.0
Metolachlor	20	July 2	9.7	10.0	10.0	10.0
Metolachlor	20	July 30	8.7	10.0	10.0	10.0
Metolachlor	20	Aug. 27	7.7	10.0	10.0	10.0
Cyanazine	5	July 2	9.0	9.0	10.0	10.0
Cyanazine	5	July 30	8.7	6.3	10.0	9.0
Cyanazine	5	Aug. 27	7.7	5.3	10.0	9.0
Cyanazine	10	July 2	9.3	10.0	10.0	10.0
Cyanazine	10	July 30	8.7	6.3	10.0	9.7
Cyanazine	10	Aug. 27	7.7	6.0	10.0	9.3
Terbacil	2.5	July 2	10.0	7.0	9.7	10.0
Terbacil	2.5	July 30	9.3	3.7	8.3	8.0
Terbacil	2.5	Aug. 27	7.3	3.3	8.0	7.3
Terbacil	5.0	July 2	9.7	5.7	9.7	9.7
Terbacil	5.0	July 30	9.3	2.7	6.7	5.0
Terbacil	5.0	Aug. 27	8.0	2.3	6.0	5.0

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

Literature Cited

1. Ruizzo, M.A. 1982. Tablets: A Slow Release Herbicide Formulation. M.S. Thesis, The Ohio State University.
2. Ruizzo, M.A., E.M. Smith and S.F. Gorske. 1983. Ohio Agricultural Research and Development Center. Research Circular 274, Ornamental Plants—1983: A Summary of Research. pp. 28-30.
3. Smith, Elton M., Stanley F. Gorske and Melissa Moore. 1986. An evaluation of metribuzin slow release herbicide tablets on woody landscape crops. The Ohio State University, Ohio Agricultural Research and Development Center, Research Circular 289, Ornamental Plants—1986: A Summary of Research, pp. 14-17.
4. Smith, Elton M. and Sharon A. Treaster, 1987. An evaluation of cyanazine, terbacil and metolachlor slow release herbicide tablets on woody landscape crops. The Ohio State University, Ohio Agricultural Research and Development Center. Research Circular 291, Ornamental Plants—1987: A Summary of Research, pp. 15-16.

Tolerance of Daylily and Peony to Surflan, Devrinol and Treflan

Elton M. Smith and Sharon S. Treaster[1]

Abstract

The planting of daylily and peony has increased over the past several years as the use of perennials in the landscape has grown in popularity. Unfortunately, there are a limited number of pre-emergence herbicides registered for use with these two species. The objective of this study was to evaluate Surflan, Devrinol, and Treflan to determine if any of these herbicides could be safely used with daylily and peony.

Results suggest that all three herbicides could be used with both species. Peony is more tolerant of these herbicides than daylily, however, the phytotoxicity of the latter was well above acceptable levels. Weed control was excellent with both compounds.

Introduction

Controlling weeds in daylily and peony plantings presents problems to the commercial landscape firm and homeowner alike because there are relatively few pre-emergence herbicides labelled for these species. Only Eptam is labelled for daylily, and it must be incorporated, while Dacthal, Enide and Chloro IPC are registered for peony (1). Consequently, after planting, there are no materials cleared for daylilies and for the most part only annual grasses can be controlled in peonies.

This study was undertaken in an attempt to determine if additional pre-emergence herbicides could be safely used on daylily and peony. In addition to determining safe herbicides, a second objective was to broaden the spectrum of weeds controlled since Devrinol, Surflan and Treflan all control a wider assortment of weeds than the herbicides currently labelled.

Materials and Methods

The plant materials selected for this study included *Hemerocallis* 'Magnificence' - Magnificence daylily and *Paeonia lactiflora* 'Felix Crousse' - Felix Crousse peony. The dormant plants were potted into one-gallon containers in a pine bark-peat-sand (6-3-1 by volume) medium on April 4, 1987. Plants were fertilized with Osmocote 18-6-12, treated with herbicides on April 20, 1987, and irrigated immediately following treatment.

The herbicide treatments included napropamide (Devrinol) W.P. at 4.0 and 8.0 lbs aia, oryzalin (Surflan) W.P. at 2.0 and 4.0 lbs aia, and trifluralin (Treflan) G at 4.0 and 8.0 lbs aia.

Each treatment was replicated four times with three plants per replication arranged in a randomized complete block design.

Plants were evaluated for weed control using a visual scale of 1 - 10 with 1=no weed control, 7=acceptable weed control and 10=perfect weed control. Phytotoxicity was evaluated in a similar fashion with 1=death of plants, 7=acceptable commercial injury and 10=no injury. Evaluations were conducted at two-week intervals for 12 weeks.

Results and Discussion

Daylily is a plant sensitive to pre-emergence herbicides. Some injury occurred with all three herbicides (Table 1). The overall injury ratings, however, are all above 9.0, indicating very slight damage. Devrinol W.P. at the 4.0 lb aia rate did not cause any phytotoxicity symptoms of daylily. When the rate was doubled, there was slight injury to some plants. Treflan and Surflan, chemically similar compounds, caused slight damage to the foliage of daylily but never at a level considered unacceptable to the commercial grower. All three herbicides could be used on daylily without concern of significant phytotoxicity.

Peony is a more tolerant species to pre-emergent herbicides than daylily. Both Surflan and Devrinol were completely non-phytotoxic to peony at either rate. Treflan caused slight damage only at the 2X or 8.0 lb aia rate. Based on this study, Surflan, Devrinol and Treflan could be used on peony.

All herbicides controlled weeds at well above acceptable levels for the duration of the 12 weeks of the project (Table 1).

Table 1. Weed control and phytotoxicity of daylily and peony to selected pre-emergence herbicides.

Herbicide	Rate	Weed Control[1]	Phytotoxicity[2] Daylily	Peony
Surflan w.p.	2.0	9.4[3]	9.1	10.0
Surflan w.p.	4.0	9.8	9.9	10.0
Devrinol w.p.	4.0	9.8	10.0	10.0
Devrinol w.p.	8.0	9.8	9.5	10.0
Treflan G	4.0	9.1	9.8	10.0
Treflan G	8.0	9.6	9.3	9.7
Control	—	8.9	10.0	10.0

[1] Visual Scale. 1-10 with 1=no weed control, 7=acceptable weed control, 10=complete weed control.
[2] Visual Scale. 1-10 with 1=plant death, 7=acceptable injury, 10=no plant injury.
[3] Each figure represents an average reading of 18 evaluations over 12 weeks.

Literature Cited

1. Smith, Elton M. 1987. Chemical weed control in commercial nursery and landscape plantings. MM-297. Ohio Coop. Ext. Serv., The Ohio State University.

[1]Professor and Technician, Department of Horticulture.

Growth Response of Euonymus, Juniper and Azalea Treated with Differing Rates of Osmocote 18-6-12

Elton M. Smith and Sharon A. Treaster[1]

Abstract

The objective of this study was to determine the optimum rate of Osmocote 18-6-12 for new and established plantings of container grown landscape plants. New plantings or rooted cuttings of euonymus grew best at 2.0 and 2.5 lbs/cu yd, azalea and juniper responded equally well at 1.0, 1.5, 2.0 and 2.5 and juniper grew well in all treatments. Established plants responded in a similar manner to new plantings. Euonymus growth was greatest at rates from 1.0 to 2.5, while azalea and juniper grew equally well at rates from 0.5 to 2.5 according to statistical analysis. In general, euonymus required higher rates of Osmocote for optimum growth than azalea or juniper. There was very little difference in response to fertilizer between rooted cuttings and one-year-old plants.

Introduction

In Ohio, one of the most popular slow release fertilizers in commercial nursery production is the 8-9 month formulation of Osmocote 18-6-12. A question often posed by growers pertains to the most effective rate. Several factors influence the rate of fertilizer, including pH, media, micro-organisms, temperature and plant species (2,3). Within the same season, in any nursery, it is common to experience both under fertilization in the form of inadequate growth and over fertilization in the form of soluble salts damage. With these concerns it became appropriate to try to determine the optimum rate of 18-6-12 on 1) euonymus, highly responsive to fertilizer, 2) azalea, a fertilizer sensitive species, and 3) juniper, a low response species to fertilizer.

Treatments were applied to rooted cuttings and one-year-old plants to try and separate response between young and established plants of the same species.

Recommended rates of 18-6-12 Osmocote per cubic yard are: low—6 lbs, medium—9 lbs, and high—12 lbs (1), depending on plant species and other factors. These rates equate to 1.0, 1.6, and 2.2 pounds of actual nitrogen/cu yd.

Materials and Methods

Plant materials selected for this evaluation included *Euonymus fortunei* 'Emerald 'N Gaiety' - Emerald 'N Gaiety euonymus, *Rhododendron obtusum 'Hershey Red'* - Hershey Red azalea, and *Juniperus horizontalis* 'Wiltoni' - Blue Rug juniper. Plants selected were rooted cuttings from the previous summer and potted plants one year older in order to compare differences in growth and/or sensitivity to the fertilizer.

All plants were planted in one-gallon containers, containing pine bark-peat-sand (6-3-1 by volume). Plants were potted and fertilized April 24, 1987. The fertilizer was thoroughly incorporated into the media prior to planting. The fertilizer was 8-9 month Osmocote 18-6-12.

The fertilizer rates used were as follows:

Pounds nitrogen/cu yd	Osmocote 18-6-12/cu yd
0.0	0.0
0.5	3.0
1.0	6.0
1.5	8.5
2.0	11.0
2.5	14.0

The rates selected are both lower and higher than those recommended by the manufacturer. Sierra Chemical Co. recommends 6, 9 and 12 lbs of Osmocote per cubic yard, which is equal to 1, 1.6 and 2.2 pounds actual nitrogen.

There were three replications of each three plant treatment arranged in a randomized block design in the container research nursery of The Ohio State University.

On September 4, 1987, plants were evaluated for growth by measuring height and width. These values were added together and divided by two to determine total vegetative growth.

Results and Discussion

The growth of rooted cuttings of euonymus was superior in the 2.0 and 2.5 lbs N/cu yd rate (Table 1). Established plants grew best in the 1.0 to 2.5 lb N/cu yd treatments (Table 2). Higher rates of nitrogen were required for euonymus growth than the other species.

Rooted cuttings of azalea grew equally well at rates between 1.0 and 2.5 lbs N/cu yd and juniper grew well in all fertilized treatments. Growth of established azalea and juniper was similar at rates of 0.5 to 2.5 lbs N/cu yd according to statistical analysis.

There was no indication of plant damage from soluble salts on any plant which might be expected on azalea at the higher rates of fertilizer.

Rates should be higher in future studies to create a toxic or high salts situation or at least reach a point at which fertilizer is no longer beneficial to the growth response of the plant.

In summary, the optimum rate of 18-6-12 Osmocote for euonymus rooted cuttings and established plants was 1.0—2.5 lbs N/cu yd or 6—14 lbs of fertilizer. Established plants of azalea and juniper appeared to grow equally well at rates of 0.5—2.5 lbs N/cu yd or 3.0—14.0 lbs Osmocote/cu yd.

[1] Professor and Technician, Department of Horticuluture.

Table 1. Growth of rooted cuttings of selected container-grown woody landscape plants.

	Fertilizer Rate lbs N/cu yd	Euonymus	Juniper	Azalea
		Plant type		
		Growth Index[1]		
Osmocote	2.5	22.8 ab[2]	11.4 a	46.3 a
Osmocote	2.0	24.7 a	11.3 a	48.1 a
Osmocote	1.5	19.4 bc	9.8 ab	49.1 a
Osmocote	1.0	18.6 bc	9.6 ab	46.4 a
Osmocote	0.5	15.6 c	8.9 bc	41.4 b
Control	0	7.1 d	7.3 c	22.1 c

[1] Height plus width ÷ 2,expressed in inches.
[2] Numbers followed by dissimilar letters significantly different at the 5% level.

Table 2. Growth of established one year selected container-grown woody landscape plants.

	Fertilizer Rate lbs N/cu yd	Euonymus	Juniper	Azalea
		Plant Type		
		Growth Index[1]		
Osmocote	2.5	36.0 a[2]	16.1 a	54.2 a
Osmocote	2.0	34.1 ab	17.2 a	54.9 a
Osmocote	1.5	32.3 ab	14.2 a	48.6 a
Osmocote	1.0	31.0 bc	15.3 a	50.2 a
Osmocote	0.5	27.7 c	13.4 ab	48.7 a
Control	0	21.0 d	9.0 b	38.9 b

[1] Height plus width ÷ 2, expressed in inches.
[2] Numbers followed by dissimilar letters significantly different at the 5% level.

Literature Cited

1. Gilliam, Charles H. and Elton M. Smith. 1980. Fertilization of container-grown nursery stock. Ohio Cooperative Extension Service Bulletin 658. The Ohio State University.
2. Johnson, Charles R. 1979. How to fertilize plants in containers. American Nurseryman. Aug. 15, 1979, pp. 12-13, 105-108.
3. Williams, David J. 1980. How slow-release fertilizers work. American Nurseryman. March 15, 1980, pp. 90-97.

Evaluation of Ronstar Wettable Powder on Woody Landscape Crops

Elton M. Smith and Sharon A. Treaster[1]

Abstract

Ronstar (oxadiazon) was just recently made available in a wettable powder (W.P.) formulation. In general, W.P. formulations of herbicides are often more phytotoxic than granular formulations. The objective of this study was to determine the efficacy and phytotoxicity of Ronstar on Hino Pink azalea, Gold Flame spirea, Emerald 'N Gaiety euonymus and Boulevard chamaecyparis. For comparative purposes Ronstar wettable was compared to commercial standards including Ronstar granular, Devrinol granular and Surflan W.P.

The results of studies conducted between late May and late July 1987 indicated that weed control was acceptable after 10 weeks in all treatments. There was some phytotoxicity to all four plant species from Ronstar W.P. However, Ronstar W.P. at 1.5 and 2.0 lbs aia did not injure euonymus or chamaecyparis and only slight injury occurred at the 3.0 lb rate. Ronstar W.P. did cause unacceptable injury to the foliage of azalea and spirea.

Introduction

Oxadiazon, marketed as Ronstar, has been registered for nursery crops for several years in the granular form. It is widely used in landscape maintenance and in both field and container production nurseries. In 1986 this herbicide became available to the landscape horticulture industry as a W.P. formulation (2).

Research conducted during the growing season of 1986 at The Ohio State University indicated that new growth of Hershey Red azalea would be injured with the Ronstar W.P. formulation but not the granular form (1). Species not injured by either formulation included Blue Rug juniper, Emerald 'N Gold euonymus and Cranberry cotoneaster.

As a follow-up to this work and to include additional plant species this research was continued in 1987. The specific objective was to compare Ronstar W.P. with other pre-emergence herbicides on additional species and cultivars of container grown woody landscape plants.

Materials and Methods

The landscape plants selected for this evaluation included: *Rhododendron* 'Hino Pink' - Hino Pink azalea, *Chamaecyparis* 'Boulevard' - Boulevard Falsecypress, *Euonymus fortunei* 'Emerald 'N Gaiety' - Emerald 'N Gaiety euonymus and *Spiraea bumalda* 'Gold Flame' - Gold Flame spirea.

The rooted cuttings from the previous season's propagation were potted April 18, 1987 into one-gallon containers. The media consisted of pinebark-peat-sand (6-3-1 by volume). Plants were fertilized with Osmocote 18-6-12 at planting and the plants irrigated as needed with overhead sprinklers. The plants were treated with herbicides on May 18, 1987.

Herbicides utilized included Ronstar W.P. at 1.5, 2.0 and 3.0 lbs aia, Ronstar G at 3.0 lbs aia, Devrinol 10G at 5.0 lbs aia and Surflan 75 W.P. at 3.0 lbs aia. All herbicide treatments were irrigated the day of application.

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

All evaluations for weed control were on a 1-10 scale with 1 equaling no weed control, 10 equal to perfect weed control, and a rating of 7 or above acceptable weed control. Evaluations for phytotoxicity were on a similar scale with 1 equal to death, 10 equal to no phytotoxicity and 7 or above acceptable. Evaluations were recorded June 1, 15, 29, and July 13 and 27.

Results and Discussion

Weed populations were not exceedingly high and all treatments controlled weeds for a period of about 10 weeks. The Ronstar W.P. and G. formulations were slightly more effective than Devrinol and Surflan in controlling weeds throughout the study.

Within two weeks phytotoxicity was evident from Ronstar W.P. on azalea and spirea (Table 1). Ronstar W.P. resulted in unacceptable injury to spirea at all rates and unacceptable injury to azalea at the 2.0 and 3.0 lb aia rates. There was no injury to these two species from Ronstar G at the 3.0 lb aia rate or Devrinol 10G at the 50 lb aia rate. Surflan 75 W.P. at 3.0 lb aia injured both azalea and spirea but not to an unacceptable level for commercial production.

Ronstar W.P. at 3.0 lbs aia was the only treatment to cause foliar injury to Emerald 'N Gaiety euonymus and Boulevard chamaecyparis. In neither case was the damage from Ronstar W.P. considered unacceptable.

In summary, Ronstar W.P. is equally as effective in controlling weeds as Ronstar G, Devrinol G, and Surflan W.P. However, Ronstar W.P. at 1.5, 2.0 and 3.0 injured azalea and spirea to unacceptable levels, while Ronstar G., Devrinol G and Surflan W.P. were relatively noninjurious. All herbicides were nonphytotoxic on Emerald 'N Gaiety euonymus and Boulevard chamaecyparis except Ronstar W.P. at 3.0 lb aia which was slightly phytotoxic.

[1] Professor and Technician, Department of Horticulture.

Table 1. Weed control and phytotoxicity of Ronstar wettable powder.

Herbicide	Rate aia	Weed Control	Phytotoxicity[1] Azalea	Spirea	Euonymus	Chamaecyparis
Ronstar W.P.	1.5	9.5[2]	8.1	7.0	10.0	10.0
Ronstar W.P.	2.0	9.7	6.8	7.3	10.0	10.0
Ronstar W.P.	3.0	9.8	7.0	6.3	9.4	9.8
Ronstar 2G	3.0	9.7	9.9	10.0	10.0	10.0
Devrinol 10G	5.0	9.2	10.0	10.0	10.0	10.0
Surflan 75W.P.	3.0	9.3	9.5	8.0	10.0	10.0
Control	—	8.4	10.0	10.0	10.0	10.0

[1] Visual Scale: 1-10 with 1 = complete crop kill and 7 or above acceptable.
[2] Each figure represents an average of 15 evaluations.

Literature Cited

1. Smith, Elton M. and Sharon A. Treaster. 1986. An evaluation of oxadiazon wettable powder and granular formulations on woody landscape plants. Research Report North Central Weed Control Conference 43:5.
2. Smith, Elton M. 1987. Chemical weed control in commercial nursery and landscape plantings. MM-297. Ohio Cooperative Extension Service, The Ohio State University.

An Evaluation of Ronstar Plus Diflufenican on Container-Grown Landscape Crops

Elton M. Smith and Sharon A. Treaster[1]

Abstract

For purposes of greater spectrum of weed control, Ronstar has been combined with Diflufenican (DFF), the latter an experimental pre-emergence herbicide. This granular combination was compared with Ronstar alone, OH-2 and Rout, all commonly used pre-emergence herbicides in the container plant industry.

The results of a 12-week evaluation indicated excellent weed control throughout the study with Ronstar+DFF at 200 and 400 lbs. per acre and equivalent to results with Ronstar, OH-2 and Rout. Ronstar+DFF was noninjurious to juniper and azalea but damaged the foliage of viburnum and euonymus. Conversely, Ronstar alone was noninjurious to all four species in the study.

Introduction

In Ohio, Ronstar (Rhone Poulenc) is an effective (2,3) and popular pre-emergence herbicide used in container-grown landscape crops during summer months. During the cooler period of spring and autumn other pre-emergent herbicides are utilized to a greater extent because Ronstar is somewhat weak in controlling spurges, bittercress, chickweed and other weeds (1). To overcome this deficiency during the cool season Ronstar was combined with Diflufenican, a new pre-emergent herbicide not available for commercial use.

[1]Professor and Technician, Department of Horticulture.

The objective of this study was to evaluate weed control and phytotoxicity of a granular formulation of Ronstar and Diflufenican (DFF) on container-grown woody landscape crops. For comparison purposes the Ronstar-DFF combination was evaluated against Ronstar alone, OH-2 and Rout, the latter two used more frequently in the cooler autumn and early spring months.

Materials and Methods

The herbicides in this study were: Ronstar (2 percent) plus Diflufenican (0.2 percent) at 100, 200 and 400 lbs per acre, Scotts Ornamental Herbicide 2 at 100 lbs per acre, Rout (3G) at 100 lbs per acre and Ronstar (2G) at 150 lbs/per acre.

Plant materials were: *Juniperous horizontalis* 'Wiltoni' - Blue Rug Juniper; *Rhododendron obtusum* 'Hershey Red' - Hershey Red azalea; *Viburnum opulus* 'Nanum' - Dwarf European Cranberrybush viburnum; *Euonymus fortunei* 'Emerald 'N Gold' - Emerald 'N Gold euonymus.

The plants were one year liners planted into two-gallon containers in a media of pine bark-peat-sand (6-3-1 by volume). Plants were potted April 23, and the herbicides applied with a granular applicator on May 7, 1987. The treatments were irrigated with 1/2 inch of water following treatment.

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

Table I. Weed control and phytotoxicity of Ronstar plus Diflufenican on container-grown landscape crops.

Treatments	Rate/Acre	Weed[1] Control	Phytotoxicity[2]			
			Juniper	Azalea	Viburnum	Euonymus
Ronstar + DFF	100 lbs	8.7[3]	10.0	10.0	9.0	9.0
Ronstar + DFF	200 lbs	9.2	10.0	10.0	8.7	9.4
Ronstar + DFF	400 lbs	9.5	10.0	10.0	6.3	7.8
OH-2	100 lbs	9.8	10.0	10.0	8.4	10.0
Rout	100 lbs	9.1	10.0	10.0	8.1	10.0
Ronstar	150 lbs	9.1	10.0	10.0	10.0	10.0
Control	—	7.5	10.0	10.0	10.0	10.0

[1]Visual Scale: 1-10 with 1=no control, 7=acceptable control, 10=complete control.
[2]Visual Scale: 1-10 with 1=death, 7=acceptable injury, 10=no injury.
[3]Each figure an average of 15 evaluations over 12 weeks.

Plants were evaluated 3, 6, 8, 10, and 12 weeks from treatment. Ratings were visual using a scale of 1-10 for weed control with 1=no weed control, 7=acceptable weed control, and 10=complete weed control. A similar scale was used for phytotoxicity with 1=plant death, 7=acceptable injury, and 10=no phytotoxicity.

Results and Discussion

The overall result of the weed control evaluation was highly successful with all herbicides over the 12 weeks. As expected, Ronstar+DFF was more effective as the rate increased from 100 to 400 lbs per acre. Weed control of OH-2, Rout and Ronstar G was equal to the Ronstar+DFF at 200 and 400 lbs per acre. Weeds controlled with Ronstar plus DFF included summer annuals such as foxtail, crabgrass, and lambsquarters, and until late in the season, bittercress, groundsel and spurge.

There was no phytotoxicity from any herbicide at any evaluation date on Blue Rug juniper and Hershey Red azalea. All three rates of Ronstar plus DFF injured to some degree, Dwarf Cranberrybush viburnum and Emerald 'N Gold euonymus. The 400 lbs per acre rate was too injurious to viburnum to warrant further trials. Injury to euonymus at the 400 lb rate was borderline of acceptability. OH-2 and Rout also injured viburnum but not euonymus. Ronstar 2G did not injure any plant species in this trial.

In summary, Ronstar+DFF was very effective in controlling weeds including bittercress, groundsel and spurge, and was more injurious than Ronstar alone. However, some plants appear to be fairly tolerant to this combination of herbicides. More research is needed to more fully develop the range of woody landscape crops that can be treated with this combination.

Literature Cited

1. Smith, Elton M. 1987. Chemical weed control in nursery and landscape plantings. MM-297. Ohio Cooperative Extension Service. The Ohio State University.
2. Smith, Elton M. and Sharon A. Treaster. 1987. Tolerance of landscape vines to selected pre-emergence herbicides. Ornamental Plants - 1987: A summary of Research. Research Circular 291:17-18. The Ohio State University, OARDC.
3. Smith, Elton M. and Sharon A. Treaster. 1988. An evaluation of Ronstar wettable powder on woody landscape crops. Ornamental plants - 1988: A Summary of Research. Special Circular, The Ohio State University.

Prodiamine Evaluation In Container-Grown Landscape Crops

Elton M. Smith and Sharon A. Treaster[1]

Abstract

Prodiamine, a pre-emergence herbicide, was evaluated for weed control and phytotoxicity in container grown woody landscape crops. Weed control was effective for all 10 weeks of the evaluation. The 1 G formulation was non-phytotoxic to all test species. The 2 G formulation was essentially non-phytotoxic to all test species at the 2.0 lb aia rate, while the 4.0 lb aia injured all plants except viburnum. There was some injury to all species with the 65 percent dispersible granule.

Introduction

A new pre-emergence herbicide, prodiamine (trade name Blockade) may soon be marketed for woody landscape crops. As an experimental herbicide, it is available as a 1 percent granular, 2 percent granular and 65 percent dispersible granular. The specific objective of this research was to evaluate each of these three formulations for weed control and phytotoxicity in container-grown woody landscape crops. Prodiamine was compared to oxadiazon, marketed as Ronstar, in both the 2 percent granular and 75 percent wettable powder formulations. Ronstar is a widely used herbicide for container-grown nursery stock in Ohio (2).

Materials and Methods

Plant materials included in this study were: *Rhododendron obtusum* 'Hershey Red' - Hershey Red azalea, *Viburnum plicatum tomentosum* - Doublefile viburnum, *Forsythia intermedia* 'Spring Glory' - Spring Glory forsythia, *Cotoneaster apiculata* - Cranberry cotoneaster and *Euonymus fortunei* 'Emerald 'N Gold' - Emerald 'N Gold euonymus. All plants were grown in one-gallon containers in a pinebark-peat-sand medium (6-3-1 by volume). Plants were fertilized with Osmocote 18-6-12 at planting and irrigated immediately following treatment and as needed during the growing season via overhead sprinklers. Plants were potted May 4, fertilized May 5 and treated with herbicides May 8, 1987. Herbicides were applied with a granular applicater and a tank sprayer.

Herbicides and formulations included: prodiamine (Blockade) 1 percent granular at 2.0 and 4.0 lbs. aia, prodiamine 2 percent granular at 2.0 and 4.0 lbs aia, prodiamine 65 percent dispersible granule at 2.0 and 4.0 lbs aia, oxadiazon (Ronstar) 75 percent wettable powder at 2.0 lbs aia, oxadiazon 2 percent granular at 2.0 lbs aia, and control.

There were three replications of three plants per treatment arranged in a randomized complete block design.

Evaluations for weed control were on a 1-10 scale with 1=no weed control, 10=complete weed control and 7=acceptable weed control. A similar scale was used for phytotoxicity with 1=complete death of the plant, 10=no phytotoxicity and 7 or above=acceptable injury. Evaluations of the plots were conducted May 22, June 5 and 19, and July 2 and 14.

Results and Discussion

Weeds were effectively controlled for 10 weeks with all formulations of prodiamine and oxadiazon (Table 1). There were little differences in general weed control between prodiamine formulations.

[1]Professor and Technician, Department of Horticulture.

Table 1. Weed control and phytotoxicity of container-grown landscape crops

			Phytotoxicity[2]				
Herbicide	Rate lbs.aia	Weed[1] Control	Euonymus	Forsythia	Azalea	Cotoneaster	Viburnum
Prodiamine 1G	2.0	8.9[3]	10.0	10.0	10.0	10.0	10.0
Prodiamine 1G	4.0	9.7	10.0	10.0	10.0	10.0	10.0
Prodiamine 2G	2.0	8.9	9.9	10.0	10.0	10.0	10.0
Prodiamine 2G	4.0	8.5	9.9	9.7	8.5	9.9	10.0
Prodiamine 65DG	2.0	9.2	9.9	9.6	8.6	9.4	10.0
Prodiamine 65DG	4.0	9.2	9.9	10.0	7.5	9.6	9.8
Oxadiazon 75%W	2.0	9.3	10.0	9.7	9.6	10.0	10.0
Oxadiazon 2%G	2.0	9.2	10.0	10.0	9.9	10.0	10.0
Control	—	8.4	10.0	10.0	10.0	10.0	10.0

[1] Visual Scale: 1-10 with 1 = no weed control, 7 = acceptable weed control, and 10 = complete weed control.
[2] Visual Scale: 1-10 with 1 = complete crop death, 7 = acceptable plant injury, 10 = no injury.
[3] Each figure represents an average of 15 evaluations.

Table 2. Prodiamine phytotoxicity of azalea

Herbicide	Rate	Phytotoxicity[1] Date 5/22	6/5	6/19	7/2	7/14
Prodiamine 1G	2.0	10.0[2]	10.0	10.0	10.0	10.0
Prodiamine 1G	4.0	10.0	10.0	10.0	10.0	10.0
Prodiamine 2G	2.0	10.0	10.0	10.0	10.0	10.0
Prodiamine 2G	4.0	10.0	9.0	8.7	8.0	6.7
Prodiamine 65DG	2.0	10.0	9.0	9.0	7.7	7.3
Prodiamine 65DG	4.0	10.0	7.0	7.0	6.3	7.0
Oxadiazon 75%W	2.0	9.0	9.0	10.0	10.0	10.0
Oxadiazon 2%G	2.0	10.0	10.0	9.7	10.0	9.7
Control	—	10.0	10.0	10.0	10.0	10.0

[1] Visual Scale: 1-10 with 1 = complete crop death, 7 = acceptable plant injury, and 10 = no injury.
[2] Each figure represents an average of three evaluations.

Prodiamine 1G at both 2.0 and 4.0 lb aia was completely non-phytotoxic to all five test species. The 2G formulation was essentially non-phytotoxic at the 2.0 lb aia rate. The 4.0 lb aia rate of prodiamine injured, to some degree, all plants except viburnum. There was some injury to all species with the dispersible granular formulation. Azalea was the most susceptible species to this formulation (Table 2).

The 2X or 4.0 lb aia rate of 65 DG caused injury that would be considered unacceptable to the grower by the eighth week of the study. Overall, the injury caused by prodiamine was stunting of growth which became more obvious with time. The granular oxadiazon was safe on all species, however, the wettable powder caused some initial injury on forsythia and azalea as can be expected from previous research (1). The oxadiazon treated plants recovered and outgrew the injury.

Literature Cited

1. Smith, Elton M. and Sharon A. Treaster. 1986. An evaluation of oxadiazon wettable powder and granular formulations on woody landscape plants. Research Report North Central Weed Control Conference 43:5.
2. Smith, Elton M. 1987. Chemical weed control in commercial nursery and landscape plantings. MM-297. Ohio Cooperative Extension Service, The Ohio State University.

Evaluation of Flowering Crabapple Susceptibility to Apple Scab in Ohio—1987

Elton M. Smith and Sharon A. Treaster[1]

Abstract

One hundred twenty-eight selections of flowering crabapple (Malus species) were found to be resistant or highly resistant to apple scab in a 1987 survey of Ohio arboretums and nurseries. There were 95 selections observed to be susceptible or highly susceptible to apple scab. When compared to 1985, a year when apple scab was relatively light, and 127 resistant and 79 susceptible selections were reported, it is clear that apple scab prevalence varies from year to year dependent upon weather conditions. Weather conditions in 1987 were relatively moist in May and June but dry prior to and following those months.

Introduction

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

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

The objective of this study was to evaluate flowering crabapples in nurseries and arboretums in Ohio for tolerance to apple scab. A statewide evaluation is valuable because it allows growers, retailers and landscapers to know which selections have proven to be resistant and which are too susceptible to this most significant disease of flowering crabapple in Ohio.

Materials and Methods

An August 1987 survey of flowering crabapples was conducted in Ohio arboretums and nurseries. Apple scab severity was rated and the presence of other diseases such as fireblight, cedar apple rust and frog eye leaf spot were also noted. Since the severity of the latter three diseases are usually not serious enough in Ohio to discontinue planting, ratings were not given.

The infestation of apple scab was rated as follows: HR=highly resistant - no indication of disease; R=resistant - mild infection with no defoliation; S=susceptible - medium infection with only slight defoliation; and HS=highly susceptible - heavy infection often accompanied by considerable defoliation.

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

Results and Discussion

Some degree of variability in apple scab exists from year to year based on previous observations by the authors (2, 3, 4, 5). Rainfall in May and June in much of Ohio was moderate to high although it was dry in April, July and August.

In the 1987 survey there were 128 selections rated highly resistant or resistant while 95 were susceptible or highly susceptible. Comparing similar seasons there were 127 selections resistant and 79 susceptible in 1985 (4). In 1984, the most recent prolonged wet spring and summer, there were 89 selections resistant and 114 susceptible (3).

In 1987, the most disease resistant selections to apple scab, fireblight, cedar apple rust and frog eye leaf spot were: Malus 'Adams,' baccata selections, 'Beverly,' 'Bob White,' 'Centennial,' 'Christmas Holly,' 'Coralburst,' 'David,' 'Dolgo,' 'Donald Wyman,' floribunda, 'Girard's Dwarf Weeping,' 'Golden Gem,' 'Klehm's Improved,' 'Jewelberry,' 'Liset,' 'Makamik,' 'Mary Potter,' micromalus, 'Molton Lava,' 'Ormiston Roy,' 'Prairifire,' 'Prince Georges,' 'Prof Springer,' prunifolia 'Fastigiata,' prunifolia 'Pendula,' 'Red Jade,' 'Red Jewel,' robusta selections, sargenti, 'Selkirk,' 'Sentinel,' 'Silver Moon,' 'Strawberry Parfait,' 'Sugartyme,' tschonoksi, 'White Angel,' yunnanensis selections and zumi 'Calocarpa.'

Flowering crabapples rated highly susceptible to apple scab in 1987 were: 'Almey,' 'Amisk,' arnoldiana, 'Arrow,' 'Barbara Ann,' 'Cheals Crimson,' 'Dorothea,' 'Ellen Gerhart,' 'Evelyn,' 'Flame,' 'Hopa,' 'Irene,' 'Pink Flame,' 'Pink Perfection,' 'Pink Spires,' 'Pink Weeper,' 'Purple Wave,' 'Eleyi,' 'Radiant,' 'Tanner,' and 'Vanguard.' Due to the severity of apple scab this and in previous years (2, 3, 4, 5) these should be discontinued from planting in Ohio.

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

Literature Cited

1. Brewer, J.E., L.P. Nichols, C.C. Powell and E.M. Smith, 1979. The flowering crabapple—a tree for all seasons. Cooperative Extension Service of Northeast States. NE 223, NCR 78.
2. Smith, Elton M. 1979. A 10 year evaluation of flowering

[1] Professor and Technician, Department of Horticulture.

crabapple susceptibility to apple scab in Ohio. Ohio Agr. Res. and Dev. Ctr., Research Circular 246. Ornamental Plants—1979: A Summary of Research, pp 36-39.

3. Smith, Elton M. 1984. Evaluation of flowering crabapple susceptibility to apple scab in Ohio—1984. Ohio Agr. Res. and Dev. Ctr., Research Circular 284, Ornamental Plants—1984: A Summary of Research, pp 19-22.

4. Smith, Elton M. and Sharon A. Treaster, 1985. Evaluation of flowering crabapple susceptibility to apple scab in Ohio—1985. Ohio Agr. Res. and Dev. Ctr., Research Circular 289, Ornamental Plants—1985: A Summary of Research, pp 4-8.

5. Smith, Elton M. and Sharon A. Treaster, 1986. Evaluation of flowering crabapple susceptibility to apple scab in Ohio—1986. Ohio Agr. Res. and Dev. Ctr., Research Circular 291, Ornamental Plants—1987: A Summary of Research, pp 3-7.

Table 1. Susceptibility of flowering crabapples to apple scab—1987

	Apple Scab Rating				
Species, Hybrid or Cultivar	HR	R	S	HS	Other Diseases Noted
'Adams'	x				
M. x adstringens				x	
'Almey'			x	x	
'Amberina'			x		
'Amisk'				x	
'Amur'	x				
'Anne E'	x				
'Arnold Arboretum'	x				
M. x arnoldiana				x	
'Arrow'				x	
M. baccata	x				
M. baccata columnaris	x	x			
M. baccata 'Jacki'	x	x			
M. baccata 'Mandshurica'		x			
M. baccata 'Midwest'	x				Fireblight
'Barbara Ann'				x	
'Beverly'	x				
'Bob White'	x				
'Brandywine'	x				Cedar Apple Rust
M. brevipes			x		
'Burgundy'		x			
'Callaway'	x				
'Candied Apple'		x			
'Cashmere'	x				Fireblight
'Centennial'	x				
'Centurion'		x	x		
'Cheal's Crimson'				x	
'Chestnut'	x				
'Chilko'	x	x			
'Christmas Holly'	x				
'Coralburst '	x	x			
M. coronaria 'Charlottae'			x	x	
M. coronaria 'Nieuwlandiana'			x	x	Cedar Apple Rust, Frog Eye Leaf Spot
'Cowichan'			x	x	
'Crimson Brilliant'				x	
'Dainty'				x	
'David'	x				
'Dawsoniana'	x				

(Continued)

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

Table 1. (Continued)

Species, Hybrid or Cultivar	HR	R	S	HS	Other Diseases Noted
'Dolgo'	x				
'Donald Wyman'	x	x			
'Dorothea'			x	x	
'Dorothy Rowe'	x				
'Ellen Gerhart'				x	
'Evelyn'				x	
'Flame'			x	x	
'Flexilis'	x				
M. floribunda	x				
'Fusca'	x				
'Girard's Dwarf Weeping'	x				
'Geneva'		x			
'Goldfinch'				x	
'Gorgeous'	x				
M. glaucescens		x			
M. gloriosa			x	x	
'Golden Gem'	x				
'Golden Hornet'	x				Frog Eye Leaf Spot
'Gwendolyn'		x			
M. halliana	x				
halliana 'Keller'	x				
M. halliana 'Parkmanii'	x				Fireblight
halliana spontanea	x				
'Harvest Gold'				x	
'Henningi'		x			
'Henry Dupont'		x	x		
'Hopa'			x	x	
'Hopa Austrian'				x	
'Hopa Dwarf'			x		
'Hopa Rosea'			x	x	
M. hupehensis	x				Fireblight
'Indian Magic'			x		
'Indian Summer'		x	x		
M. ioensis		x	x		
ioensis 'Kohankie'	x				
M. ioensis 'Klehms'	x				Cedar Apple Rust
M. ioensis 'Plena'		x			
'Klehms Improved'	x	x			
'Irene'				x	
'Jay Darling'				x	
'Joan'	x				
'Jewelberry'	x				
'Katherine'			x		
'Kibele'				x	
'Kingsmere'				x	
'Kirghisorum'		x			
'Kola'	x				
M. lancifolia				x	
'Leslie'		x			
'Liset'	x				

(Continued)

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

Table 1. (Continued)

Species, Hybrid or Cultivar	HR	R	S	HS	Other Diseases Noted
'Madonna'		x			
M. x magdeburgensis		x	x		
'Makamik'	x				
'Marshall Oyama'		x			
'Mary Potter'	x				
'Masek'			x	x	
M. x micromalus	x				
'Milton Barron'			x	x	
'Millie Ann'	x				
'Molton Lava'	x				
'Neville Copeman'				x	
'Oakes'			x		
'Oekonomierat Echtermeyer'				x	
'Oporto'			x		
'Ormiston Roy'	x				
'Patricia'		x	x		
'Pink Beauty'		x	x		
'Pink Cascade'		x	x		
'Pink Dawn'	x	x			
'Pink Flame'				x	
'Pink Perfection'				x	
'Pink Spires'				x	
'Pink Weeper'				x	
'Prairie Rose'	x				Fireblight
'Prairifire'	x				
'Pretty Marjorie'	x				
'Prince Georges'	x				
'Profusion'		x	x		
'Prof. Springer'	x				
M. prunifolia			x	x	
M. prunifolia 'Fastigiata'	x				
M. prunifolia 'Pendula'	x				
M. pumila Elise 'Rathke'			x	x	
M. pumila 'Niedzwetzkayana'				x	
M. pumila 'Paradise Foleus Aureus'	x				
'Purple Wave'				x	
M. purpurea				x	
M. purpurea 'Aldenhamensis'			x		
M. purpurea 'Eleyi'				x	
M. purpurea 'Lemoinei'				x	
M. Pygmy			x		
'Radiant'				x	
'Ralph Shay'		x			
'Red Baron'		x	x		
'Red Bud'			x		
'Red Edinburgh'			x		
'Red Flesh'	x				
'Red Jade'	x	x			
'Red Jewel'	x				

(Continued)

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

Table 1. (Continued)

Species, Hybrid or Cultivar	HR	R	S	HS	Other Diseases Noted
'Red Swan'	x				
'Red Silver'			x		
'Red Splendor'		x	x		
'Ringo'			x		
'Robinson'		x	x		
M. x robusta	x				
M. x robusta 'Erecta'	x				
M. rubusta 'Persicifolia'	x				
'Rose Tea'		x			
'Rosseau'	x				
'Royal Ruby'			x		
'Royalty'			x		
'Ruby Luster'			x	x	
'Rudolf'				x	
M. sargentii	x				
M. sargentii 'Rosea'		x	x		
M. sargentii 'Rose Low'	x				
'Satin Cloud'	x				
M. x scheideckeri			x		
M. x scheideckeri 'Hilleri'			x		
'Scugog'		x	x		
'Seikirk'	x				
'Sentinel'	x	x			
'Shakespeare'				x	
M. sieboldi	x				
M. sieboldi 'Arborescens'	x				
sieboldi 'Fugi'	x				
M. sikkimensis	x				
'Silver Moon'	x				
'Simcoe'		x			
'Sissipuk'	x				
'Snowcap'		x			
'Snowcloud'		x	x		
'Snowdrift'		x	x		
'Snowmagic'				x	Fireblight
M. x soulardii		x			
'Sparkler'			x	x	
M. spectabilis	x				
M. spectabilis 'Albi-Plena'				x	
M. spectabilis 'Van Eseltine'			x	x	
'Spring Song'	x				
'Spring Snow'		x	x		
'Strathmore'				x	
'Strawberry Parfait'	x				
M. x sublobata		x			Fireblight
'Sugartyme'	x				
'Sundog'	x				
M. sylvestris 'Plena'	x	x			
'Tanner'				x	
M. toringoides				x	Fireblight

(Continued)

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

Table 1. (Continued)

Species, Hybrid or Cultivar	HR	R	S	HS	Other Diseases Noted
M. tschonoski	x				
'Turesi'				x	
'Valley City -4'			x		
'Vanguard'				x	
'Velvet Pillar'			x	x	
'Wabiskaw'				x	
'White Angel'	x				
'White Candle'				x	
'White Cascade'		x			
'Wickson'	x				
'Wilson'				x	
'Winter Gold'		x	x		
'Wooster No. 1'		x			
M. yunnanensis 'Veitchi'	x				
M. yunnanensis					
'Veitch's Scarlet'	x				
M. zumi	x	x			
M. zumi 'Calocarpa'	x				

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

Field Study of Root Zone Heating Systems in Greenhouses

Michael F. Brugger and Randall H Zondag[1]

Abstract

While research has shown the benefits of root zone heating and provided some design data, the performance in commercial greenhouses has not been documented. Root zone heating systems in four commercial greenhouses were studied to identify the deficiencies of the systems and the necessary changes.

Introduction

Root zone or soil heating is a concept to produce high quality, uniform plants in a shorter period of time while reducing heating costs. A major advantage of the root zone heating system is better and quicker plant growth due to a warmer root zone temperature. Also a lower top zone temperature reduces energy use because the air temperature in the rest of the greenhouse remains cooler. The plant roots are maintained at an optimum temperature by direct heating of the growing material. Modern systems use hot water flowing in tubes placed in the soil, in a concrete floor, or on the bench to provide the direct heating of plants placed in the soil or in flats or pots on the floors and benches.

Water based root zone heating systems usually have either 0.75 inch diameter plastic tubes (large diameter) or 0.375 inch diameter EPDM (ethylene diene monomer) tubes (small diameter). In addition to the heating tubes, all systems have a boiler or other source of hot water, distribution pipes, headers, and controls. A typical large diameter tube system is shown in Figure 1. Electric resistance heating cable and mats are also available.

The root zone heating system needs to provide uniform, constant soil temperature. Uniform heating is accomplished by the appropriate vertical and horizontal spacing of tubes in the soil or concrete floor and the horizontal spacing of tubes on the bench. The water supply temperature is maintained at about 100° F for the 0.75 in. diameter tube system and 140° F for the smaller tube system. The flow rates in all tubes must be equal to ensure a uniform temperature across the bench or bed. The system can be zoned to meet the temperature needs of different plants.

Root zone heating systems can be purchased commercially or grower designed and installed. Current research and design information is available for the large diameter tube system (Elwell, et al., 1985; Roberts and Mears, 1980; and Brugger, 1983). Completely designed small diameter tube systems are available commercially.

While research results and design information exist, there is a lack of field verification of the performance of root zone heating systems installed in commercial greenhouses. In the spring of 1984, field studies of the two root zone heating systems in four greenhouses were started and continued through 1986.

[1] Associate Professor, Agricultural Engineering Department, and State Extension Specialist; Lake County Extension Agent, Department of Horticulture.

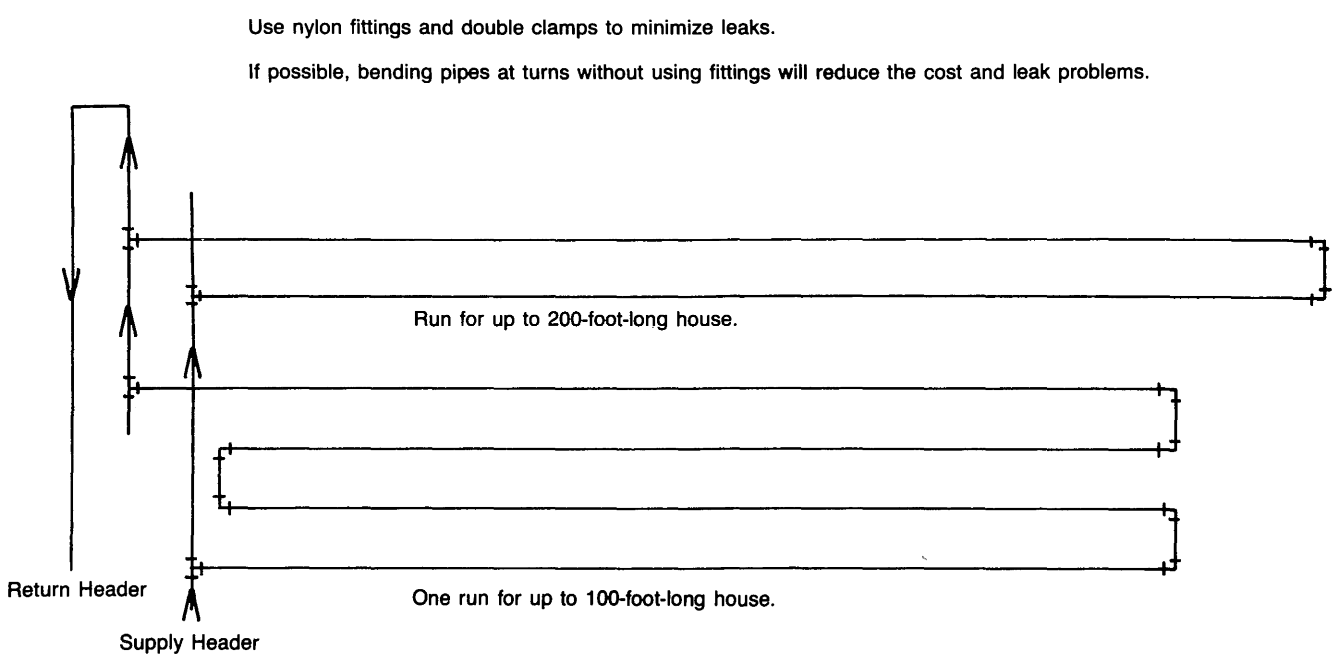

Figure 1. Pipe layout for soil heating showing runs for a short and a long greenhouse.

Test Greenhouses

Greenhouse "A" had EPDM tubes at a two-inch spacing on top of polystyrene (two inches thick) benches holding bedding plants in market packs and Easter lilies in pots. The root zone system was the only heat in the glass greenhouse.

Greenhouse "B" was in a nursery operation that forced Rhododendron into growth in late winter. EPDM tubes spaced two inches apart on raised benches with open bottoms were used to replace a forced hot air system. The plants were placed in pots on the benches.

Greenhouse "C" used EPDM tubes placed two inches apart on the ground and covered with two inches of sand. The system had three separate heating zones. The grower was propagating plants in flats inside a double plastic quonset greenhouse that did not have any perimeter insulation.

Greenhouse "D" used 0.75 inch diameter tubes spaced twelve inches apart and six inches deep in sand. The system used one tube which made several loops down and back in the bench instead of the typical header with multiple parallel tubes.

Experimental Procedures

The field studies were designed to evaluate the uniformity of temperatures in the root area and identify problems in the design system. The field studies were not to be a complete analysis of all aspects of the system, e.g., energy savings. Temperatures in the growing medium, plant canopy, and air were measured using thermocouples and a Kaye Digistrip II Datalogger. The measurement locations varied with the crop being grown but usually consisted of the bottom, middle, and top of the root zone, middle of the plant canopy above the plant and outside air. Also visual observations of the plants were made at the time of recorder installation.

Results and Discussion

In Greenhouse "A", one of several problems identified was hot and cold sections developing along the benches. The likely cause was air locks in the lines. While leaks were identified and repaired, the system needed a periodic bleeding of air to maintain uniform temperature.

In the bedding plant trays, growth was very uneven, even within the same market pack. The medium temperature varied as much as 10° F between cells in a market pack and was related to location of the incoming and outgoing lines. While the average temperature of the incoming and outgoing lines are the same for the entire length of the run, the small cells were not in contact with both lines and could not average the temperature covered with one-half inch of moist sand which was covered with perforated plastic. The sand distributed heat more evenly and maintained temperature differences to less than two degrees as long as the sand was kept moist.

The Easter lilies were behind in growth due to soil temperatures considerably above the desired temperature. Since a supplemental heating system was not installed, the grower was trying to maintain air temperature by running a higher water temperature. The design of the root zone heating system called for a supplemental air heater. By installing the heater the grower was able to maintain both the desired root and air temperature and to save the lily crop.

The grower was using untreated, high iron content water. After a year of operation, fouling of the system started. The system needed to be flushed thoroughly and refilled with treated water to assure good operation over time.

In Greenhouse "B", the open bottom benches and pots gave a more uniform temperature than the polystyrene benches of Greenhouse "A". The grower expressed a desire for a more sensitive thermostat to maintain closer control over the temperature range. Maintaining tube spacing as the tubes expanded during heating was a problem because the tubes were installed in a cold greenhouse. Ideally to maintain proper placement, tubing should be installed under warm weather conditions.

In Greenhouse "C", the system allowed for better control of top growth by controlling the root growth. This is very important in rooting cuttings. One problem the system caused was drying the plants from the bottom up. More frequent watering was needed to overcome this problem.

Plant growth was slower along the walls and the walkways in this greenhouse resulting in lower and widely varied soil temperatures. The installation of two inch thick polystyrene insulation extending two feet into the ground along the perimeter walls reduced the temperature variation there. An alternative was additional heating tubes added along the wall, but this would have not reduced the energy used as the insulation did. Additional heating tubes are needed along the walkways to correct heating problems.

Monitoring of the system showed that zones were not properly installed. Hot water flowed through all zones whenever heat was required in one zone. This was corrected by changing the location of the pumps and adding check valves.

In Greenhouse "D", the temperatures were very uniform as long as the sand was kept damp. Trickle irrigation and a plastic cover with perforations were installed to help ensure proper sand moisture.

Conclusions

There are some things that a grower who is planning to install a root zone heating system should consider. The system should be properly designed to provide the desired uniform root temperature. For either a large or small diameter system, this includes the horizontal and vertical spacing of the tubes, the placement of the containers with respect to the tubes, the flow rate of water in the system, the temperature of the water, the size of the boiler, and the size of the supplemental heating system.

Once properly designed, the system must be properly installed and checked out. A soil temperature probe should be used to check for uniformity throughout the bench. The probe can be left in one location for daily monitoring of the system.

Pots, market packs, and flats placed directly on the tubes had more temperature variation. The use of sand or an air space between the tubes and the containers helped maintain a more uniform temperature. With sand, the moisture level must be maintained to prevent hot spots. Covering the sand with perforated plastic helped maintain sand moisture and reduced the moisture in the greenhouse.

The plumbing of the system is very important. The system must assure that all water flows the same distance to assure a uniform flow to all pipes in the benches. Air locks can result in improper heating which will cause problems, therefore, the system must be airtight and properly bled.

References

1. Brugger, M.F. 1983. Some application of floor heating in commercial Ohio greenhouses. Proc., Third International Symposium on Energy in Protected Cultivation. Acta Horticulturae, 148 pp. 115-118.
2. Elwell, D.L., M.Y. Hamdy, W.L. Roller, A.E. Ahmed, H.M. Shapiro, J.J. Parker, and S.E. Johnson. 1985. Soil heating using subsurface pipes: A decade of research results at OSU/OARDC. Research Bulletin 1175. The Ohio State University, Ohio Agricultural Research and Development Center. 46 pp.
3. Roberts, William J. and David R. Mears. 1980. Floor heating of greenhouses. ASAE Paper No. 80-4027. American Society Agricultural Engineers, St Joseph, MI.

Costs of Producing Field Rapid-Growing Evergreens (*Juniperus*) in Ohio

Reed D. Taylor, Harold H. Kneen, Elton M. Smith, David E. Hahn and Stanley Uchida[1]

Abstract

The objective of this study was to determine annual production costs for field-grown, rapid-growing evergreens in Ohio by size of firm. This objective was accomplished by synthesizing two model field nurseries using an economic engineering approach. Once the nurseries were simulated, growing space was divided into five equal parts with each segment being assigned a plant group. In the 50-acre nursery, rapid-growing evergreens were allocated 8 acres of growing space and in the 200-acre nursery, 35 acres. One specific species of rapid-growing evergreen (*Juniperus*) was chosen for detailed analysis.

In the space allocated, 5,810 salable *Juniperus*, of size 18-24 inches, could be produced annually in the 50-acre nursery and 25,418 in the 200-acre. Based on 1985 figures total costs per salable plant were $12.51 in the 50-acre nursery and $7.09 in the 200-acre nursery.

Introduction

Rapid-growing evergreens, such as the various species of *Juniperus* and *Thuja*, have long been planted for hedges, foundation plantings, and other locations where rapid growth is desirable. These plants have traditionally been grown in the field. However, new technological developments are now making it economically feasible to grow them in containers. Container production allows greater flexibility in production and marketing, and, in most cases, is less expensive than field production. On the other hand, field-grown plants have greater tolerance against variations in moisture, nutrients, and temperature. When subjected to conditions that would kill or severely damage container-grown plants with no overwintering protection, field-grown plants will often survive with little damage. It is also easier to "hold-over" field grown plants when market conditions are not favorable. It is anticipated that the majority of rapid-growing evergreens will continue to be produced in the field for the foreseeable future, especially the largest plants.

Materials and Methods

In the study, two model firms were simulated using the conceptual framework of economic engineering wherein the "best proven practice" was included in each model. The analysis is based on conditions in Central Ohio. The complete synthesis included developing an appropriate production cycle; schematic drawings of the physical layout, including buildings and irrigation systems; lists of equipment and other items; a complete sequence by month and year of nursery operational steps beginning with propagation and ending with loading the finished product for wholesale distribution; and budgets for fixed and variable costs.

Data for this study were obtained in 1985 from wholesale nurseries and nursery suppliers in Ohio. The basic goals in simulating the production facilities were to minimize labor expenses, flow and movement of plant material and equipment, water runoff, and initial investment, as well as to maximize the number of salable plants and keep future expansion possible. See Taylor, et al., (1) for a detailed analysis of the physical plant, production system, and capital production budgets.

The first step in the production cycle consisted of collecting cuttings from field plants that were at least three years old. Cuttings were trimmed and treated with a hormone solution and stuck in a heated sand bed in an "overwintering" house. During March of the second production year, the six-month-old rooted cuttings are pulled from the propagation beds, root pruned by hand, and planted 7 inches apart with 20 inches between rows, in 4-feet-wide beds. After two years in the beds, they are dug, root and top pruned by hand, and planted in the field. Approximately 25 percent of the field-grown crop is harvested and sold during the fall of the fourth field production year and another 25 percent dug, overwintered and sold during late winter and early spring of the fifth field production year. The remaining 50 percent of the crop is harvested and sold during late winter and spring of the fifth field production year. After the harvest is complete, the land is left fallow and disked for weed control four times during summer months. The fields were plowed in the fall of the fifth production year in preparation for spring planting.

A model facility was simulated for both a 50-acre and a 200-acre field nursery. The nursery operations were assumed to produce a diverse line of nursery stock each having its own unique production cycle. Commonly grown nursery stock was divided into five cultural groups. While not all inclusive, the groups do permit developing a range of per unit costs related to input costs and cultural factors. For analytical purposes, it was assumed that each cultural group

[1]Associate Professor and former graduate student, Dept. of Agricultural Economics and Rural Sociology; Professor, Dept. of Horticulutre; Professor and former graduate student, Dept. of Agricultural Economics and Rural Sociology. Mr. Kneen is presently Director of Marketing, Studebaker Nurseries, Inc., New Carlisle, Ohio. Mr. Uchida works for Brancohio, Columbus, Ohio.

Drs. Taylor, Smith, and Hahn also have appointments in the Ohio Cooperative Extension Service.

would occupy 20 percent of the field growing area (i.e., 50-acre nursery=8 acres per group, 200-acre nursery=35 acres per group). In addition to the field growing area, the 50-acre nursery had 10 acres and the 200-acre nursery 25 acres of production facilities including overwintering houses, propagation facilities, shipping area, holding area, liner bed area, pond, supply shed, machinery storage, machine shop, office, and rest rooms.

Costs developed for rapid-growing evergreens (*Juniperus)* therefore were based on the scale of complete nurseries, but were analyzed on the basis of percent of total space occupied. Companion studies were reported in the 1987 issue of "Ornamental Plants" (2). Fixed costs were reported beginning on page 26, costs for slow-growing evergreens (page 37), costs for deciduous shrubs (page 45), and costs for shade trees (page 51). In this publication costs for ornamental trees are reported beginning on page 30.

For detailed analysis on rapid-growing evergreens, one specific plant type (*Juniperus)* was chosen. While it is recognized that other slow-growing evergreens (i.e., *Thuja*) would have somewhat different requirements, it was felt that they would not vary significantly in cost from *Juniperus*.

Costs were established for all factors of production including management and invested capital. In economic terms, costs associated with factors of production supplied 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 in financial institutions.

Capital requirements for establishing the nurseries were first determined (1). Second, capital requirements per salable plant capacity by size of nursery were established (1). Third, annual fixed costs were calculated (1). Fourth, annual variable costs were determined for each of the two different-sized nurseries (Tables 1-3). Fifth, summaries were made for annual fixed and variable costs according to size of nursery (Table 4). This allowed cost comparisons based on size of nursery.

Most nurseries use cash rather than accrual accounting procedures. For this reason, the analyses were completed on a "cash" basis. This approach does not give a true economic picture of the cost of producing a plant as it does not take into account the time value of money from planting until harvest. The analyses do, however, give a reliable estimate of the annual cost per salable plant based upon the study's assumptions.

Total annual production costs consist of both fixed and variable factors. Fixed costs are primarily made up of implicit costs such as depreciation of buildings and equipment, interest charges (both for borrowed and equity capital), and charges for management. Many nurserymen do not adequately consider fixed costs when computing costs of production. Fixed items are often considered as residual claimants on income. For example, management is compensated if all other factors of production have been paid and there is still a residual. As noted previously, annual fixed costs are discussed in greater detail in a companion article.

Variable Costs. Variable costs are comprised of all expenses that vary with the quantity of plants being grown. Variable costs are explicit, obvious, and normally paid out yearly. An example of variable costs is the amount of burlap that would be needed yearly for harvesting *Juniperus* in a ball & burlap operation. Variable costs were subdivided into the following categories: propagation, materials, machinery and equipment, labor, and interest on operating capital (Tables 1 and 2).

Propagation. Propagation costs included rooting media (sand), hormone powder, labor for collecting, stripping, sticking, maintenance, and harvesting.

Burlap and twine. Nails, burlap and twine were provided for "ball and burlapping" each plant produced. The cost of the nails, burlap and twine reflects a delivered cost to the nursery.

Polyethylene film. The cost consists of the white copolymer film delivered to the nursery.

Strip tags. Strip tags were provided for identifying plants by botanical name, common name, the state they were grown in, and nursery producer. Costs include printing and shipping charges.

Chemicals. Chemical costs were organized around three cultural programs. The first is fertilizer. For field operations the price included custom spreading for a custom blend of fertilizer and for lime. Price for urea included delivery to the nursery. The second, herbicide, includes the price of various pre-emergence and post-emergence materials. The third combines insecticides and fungicides. Purchase price reflects total cost for the chemicals quoted by local distributors. A special category of "other" was included under chemicals. Adequate chemicals were budgeted for normal control of insects and diseases. The "other" category budgeted at 50 percent of the cost of the "normal" insecticides and fungicides was to handle special problems.

Machinery and equipment. Variable machinery and equipment costs represent all costs incurred while equipment and machinery are in use. These costs include repair, fuel and lubrication/filters (Table 3). Repair cost per hour was calculated by multiplying initial cost by a stated repair percentage divided by the estimated lifetime use of the machinery in the 200-acre nursery in hours. The same repair cost per hour was used for both sized nurseries. Fuel costs were determined by multiplying units of fuel used per hour by the price per unit. Filter/lubrication cost was estimated at a constant factor of 15 percent of calculated fuel costs. Summation of repair, fuel and filter/lubrication costs result in total variable cost per hour of machinery or equipment usage.

Table 1. Variable costs (dollars) for rapid-growing evergreens (juniperus) for a 50-acre[1] field nursery in Ohio, 1985.

Item	Description	Unit	Cost per Unit[2]	Quantity	Total Variable Cost
Propagation[3]					
Rooting media	Sand	cu yd	6.50	12.00	78
Collecting, stripping & sticking	11,107 @ 700/hr	hrs	6.93[4]	6.60	46
Maintainance	25% of total prop. maint. hrs	hrs	6.93	182.50	1,265
Harvest	11,107 @ 500/hr	hrs	6.93	22.21	154
Hormone powder	#3, I.B.A.	lbs	11.70	0.32	4
Subtotal					1,547
Materials					
Field pot	32" x 32" squares + twine	each	0.45	5,810.00	2,615
Polyethylene film	4 mil white, 32' x 225'	each	127.50	1.45	185
Strip tags	5/8" X 7" plastic strip tag	each	0.02	5,810.00	116
Chemicals	Custom spread, custom blend: 45-0-0, 0-44-0, 0-0-60 (fertilizer)	ton	176.00	1.02	180
	Custom spread, (lime)	ton	20.00	1.80	36
	Urea, 45-0-0 (fertilizer)	ton	220.00	0.88	194
	Soluble 20-20-20 (fertilizer)	ton	1,411.20	0.12	169
	Trifluralin 4 EC (Treflan) (herbicide)	gallon	33.49	0.45	15
	Simazine 80WP (Princep) (herbicide)	pound	3.75	13.00	49
	DCPA 75WP (Dacthal) (herbicide)	pound	6.37	36.40	232
	Malathion, 57EL, (Cythion) (insecticide)	gallon	18.28	11.70	214
	Benomyl, 50 WP, (Benlate) (fungicide)	pound	14.17	19.50	276
	Carbaryl, 80WP (Sevin) (insecticide)	pound	6.09	7.80	48
	Chlorothalonil 10M cu ft(Termil) (fung.)	canister	1.76	4.55	8
	Other (i.e., Kelthane, Captan, Di-syston, Orthene, etc.)[5]				
Subtotal					4,337
Machinery and Equipment					
	Tractor, 100 HP	hour	17.00	24.29	413
	Tractor, 34 HP	hour	4.99	37.31	186
	Articulated Loader/3,000 lbs	hour	14.81	49.77	737
	Fork	hour	0.01	49.77	1

(Continued)

Table 1. (Continued)

Item	Description	Unit	Cost per Unit[2]	Quantity	Total Variable Cost
	Plow, 3-14"	hour	6.57	1.44	9
	Disk, 8' wide	hour	4.23	3.48	15
	Harrow, 10' wide	hour	8.45	0.21	2
	Cultimulcher, 10' wide	hour	24.74	0.38	10
	Spray rig with 10' boom	hour	2.77	2.14	6
	Transplanter, 3 row	hour	26.79	1.71	46
	Permanent irrigation/well & pump 100HP	hour	7.60	63.20	480
	Inground irrigation—bed area	hour	3.13	48.00	150
	Above ground irrigation—bed area	hour	1.83	48.00	88
	Inground irrigation—storage & holding	hour	5.65	12.00	68
	Above ground irrigation—storage & hold.	hour	11.05	12.00	133
	Traveler gun	hour	12.06	3.20	39
	Portable PTO pump, 40 HP	hour	(no costs budgeted)		
	Airblast sprayer	hour	1.01	15.60	16
	Fertilizer injector	hour	12.39	3.00	37
	Transplanter, 2 row	hour	12.0	2.84	34
	Undercutter, bed	hour	1.16	1.64	2
	Sidedresser, 2 row	hour	0.63	4.80	3
	Cultivator, 2 row	hour	0.95	9.51	9
	Wagon, 4 wheel	hour	0.48	15.12	7
	Cultivator, 3 row	hour	13.93	1.32	18
	Truck, ½ ton pickup	hour	8.42	346.67	2,919
	Flatbed truck, 24' bed	hour	14.87	36.47	542
Subtotal					5,970
Labor					
	Labor hours	hour	6.93[4]	1,491.56	10,337
	Related labor hours, 20%	hour	6.93	298.00	2,065
Subtotal					12,402
Interest Charge on Operating Capital	Computed at 12% on an annual basis for 6 months	percent	6.0 (0.06)	24,256.00	1,456
Total Variable Costs					25,712
Variable Cost per 18-24 Inch Salable Plant	Units available for sale in a given year	each		5,810.00	4.42

[1] Total nursery—50 acres, 40 acres of growing space, 10 acres production facilities, holding & field bed area, roads, etc. Rapid Growing Evergreens—10 acres, 8 acres of growing space, 2 acres production facilities, holding & field bed area, roads, etc., 5,810, 18-24 inch salable plants per year.
[2] Quantity discounts were applied to chemicals and other items.
[3] 11,107 plants would be stuck in the propagation house where about 23% would be lost leaving 8,544 for trans planting into liner beds. About 20% of the plants in the liner beds would be lost leaving 6,835 for transplanting into the field.
[4] Average basic wage before withholding taxes and fringes $5.25, taxes and fringes add 32% or $1.68 for a total of 6.93.
[5] To achieve better pest and disease control, alternative chemical useage is advisable. Alternative chemical costs were estimated at 50% of the cost of Malathion, Benomyl, and Carbaryl.

Table 2. Variable costs (dollars) for rapid-growing evergreens (juniperus) for a 200-acre[1] field nursery in Ohio, 1985.

Item	Description	Unit	Cost per Unit[2]	Quantity	Total Variable Cost
Propagation[3]					
Rooting media	Sand	cu yds	6.50	24.00	156
Collecting, stripping & sticking	48,594 @ 700/hr	hrs	6.93[4]	69.42	481
Maintainance	25% of total prop. maint. hrs	hrs	6.93	200.00	1,386
Harvest	48,594 @ 500/hr	hrs	6.93	97.19	674
Hormone powder	#3, I.B.A.	lbs	11.70	1.39	16
Subtotal					2,713
Materials					
Burlap	32" x 32" squares + twine	each	0.45	25,418.00	11,438
Polyethylene film	4 mil white, 32' x 225'	each	127.50	6.35	810
Strip tags	5/8" X 7" plastic strip tag	each	0.02	25,418.00	508
Chemicals	Custom spread, custom blend: 45-0-0, 0-44-0, 0-0-60 (fertilizer)	ton	176.00	4.44	781
	Custom spread, (lime)	ton	20.00	4.95	99
	Urea, 45-0-0 (fertilizer)	ton	220.00	4.95	1,089
	Soluble 20-20-20 (fertilizer)	ton	1,411.20	0.52	734
	Trifluralin 4 EC (Treflan) (herbicide)	gallon	33.49	1.97	66
	Simazine 80WP (Princep) (herbicide)	pound	3.75	61.10	229
	DCPA 75WP (Decthal) (herbicide)	pound	6.37	159.04	1,013
	Malathion, 57EL, (Cythion) (insecticide)	gallon	18.28	48.59	888
	Benomyl, 50 WP, (Benlate) (fungicide)	pound	14.17	32.36	459
	Carbaryl, 80WP (Sevin) (insecticide)	pound	6.09	80.90	493
	Chlorothalonil 10M cu ft(Termil) (fung.)	canister	1.76	19.05	34
	Other (i.e. Kelthane, Captan, Di-syston, Orthene, etc.)[5]				920
Subtotal					19,561
Machinery and Equipment					
	Tractor, 100 HP	hour	17.00	26.23	446
	Tractor, 60 HP	hour	11.68	79.25	926
	Tractor, 34 HP	hour	4.99	142.18	709
	Articulated Loader/2,000lbs	hour	6.67	49.88	333
	Articulated Loader/3,000lbs	hour	14.81	49.88	739
	Forks	hour	0.01	99.67	1
	Plow, 3-14"	hour	6.57	6.29	41
	Disk, 8' wide	hour	4.23	10.84	46
	Harrow, 10' wide	hour	8.45	0.94	8
	Cultimulcher, 10' wide	hour	24.70	1.65	41
	Spray rig with 10' boom	hour	2.77	9.37	26
	Transplanter, 3 row	hour	26.79	7.48	200

Table 2. (Continued)

Item	Description	Unit	Cost per Unit [2]	Quantity	Total Variable Cost
	Permanent irrigation/ well & pump 100HP	hour	7.60	88.00	669
	Inground irrigation—bed area	hour	3.13	62.00	194
	Above ground irrigation—bed area	hour	1.83	62.00	113
	Inground irrigation—storage & holding	hour	5.65	12.00	68
	Above ground irrigation—storage & hold.	hour	11.05	12.00	133
	Traveler gun	hour	12.06	14.00	169
	Portable PTO pump, 40 HP	hour			
	Airblast sprayer	hour	1.01	68.16	69
	Fertilizer injector	hour	12.39	3.00	37
	Transplanter, 2 row	hour	12.00	12.46	150
	Undercutter, bed	hour	1.16	7.19	8
	Sidedresser, 2 row	hour	0.63	21.00	13
	Cultivator, 2 row	hour	0.95	41.58	40
	Wagon, 4 wheel	hour	0.48	66.20	32
	Cultivator, 3 row	hour	13.93	5.68	79
	Truck, ½ ton pickup	hour	8.42	520.00	4,378
	Flatbed truck, 24' bed	hour	14.87	159.48	2,371
Subtotal					12,039
Labor					
	Labor hours	hour	6.93[4]	6,271.93	43,465
	Related labor hours, 20%	hour	6.93	1,254.38	8,693
Subtotal					52,158
Interest Charge on Operating Capital	Computed at 12% on an annual basis for 6 months	percent	6.0 (0.06)	86,471.00	5,188
Total Variable Costs					91,659
Variable Cost per 18-24 Inch Salable Plant	Units available for sale in a given year	each		25,418.00	3.61

[1] Total nursery—200 acres, 175 acres of growing space, 25 acres production facilities, holding & field bed area, roads, etc. Rapid-Growing Evergreens—40 acres, 34 acres of growing space, 6 acres production facilities, holding & field bed area, roads, etc., 25,418, 18-24 inch salable plants per year.

[2] Quantity discounts were applied to chemicals and other items.

[3] 48,594 plants would be stuck in the propagation house where about 23% would be lost leaving 37,380 for transplanting into liner beds. About 20% of the plants in liner beds would be lost leaving 29,904 for transplanting into the field.

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

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

Table 3. Estimated variable cost per hour of use for machinery and equipment for field nurseries in Ohio, 1985.

				Estimated Annual Use		Estimated Cost per Hour of Use			
Item Number	Item	New Cost (dollars)	Expected Life (years)	50 Acre[1] Nursery (hours)	200 Acre[2] Nursery (hours)	Repairs[3] (dollars)	Fuel[4] (dollars)	Lubrication and Filter (dollars)	Total (dollars)
1	Tractor, 75 HP	28,278	10	217	494	5.15	10.30	1.55	17.00
2	Tractor, 60 HP	20,419	10	—	583 ea	3.15	7.42	1.11	11.68
3	Tractor, 34 HP	14,504	10	169	632	2.07	2.54	0.38	4.99
4	Flatbed truck	42,000	10	383	1,702	2.22	11.00	1.65	14.87
5	Articulated Loader/2,000lbs	25,000	10	—	600	3.75	2.54	0.38	6.67
6	Articulated Loader/3,000lbs	38,000	10	328	600	5.70	7.92	1.19	14.81
7	Tree Spade	8,490	2	181	641	5.30			5.30
8	Forks for loaders	1,100	10	328	1,200	0.01			0.01
9	Plow	2,616	10	8	32	6.57			6.57
10	Disk	3,900	10	15	60	4.23			4.23
11	Harrow	650	10	2	5	8.45			8.45
12	Cultimulcher	3,800	10	3	10	24.70			24.70
13	Spray rig (Boom Sprayer)	1,407	7	13	58	2.77			2.77
14	Transplanter, 3 row	7,500	10	5	21	26.79			26.79
15	Transplanter, one row	5,000	10	93	407	0.92			0.92
16	Permanent irrigation, well + pump	36,396	20	221	323	0.56	6.12	0.92	7.60
17	Inground irr. bed-field[5]	34,606	20	151	221	3.13			3.13
18	Above ground irr. bed-field[5]	4,345	5	144	190	1.83			1.83
19	Inground irr. storage/hold[5]	16,957	20	60	60	5.65			5.65
20	Above ground irr. S. & H.[5]	8,286	5	60	60	11.05			11.05
21	Traveler[5]	22,000	10	17	73	12.06			12.06
22	Portable irr. pump (emergency)	425	10	—	—	—	—	—	—
23	Airblast sprayer	3,600	7	94	406	1.01			1.01
24	Fertilizer injector	858	5	9 ea	9 ea	12.39			12.39
25	Transplanter, 2 row	5,600	10	8	35	12.00			12.00
26	Undercutter—bed	285	7	5	21	1.16			1.16
27	U-Blade—field	240	5	0.38	1.65	17.65			17.65
28	Fertilizer sidedresser	1,000	10	24	103	0.63			0.63
29	Cultivator, 2 row	1,750	7	44	172	0.95			0.95
30	Wagon	1,978	10	57 ea	249 ea	0.48			0.48
31	Cultivator, 3 row	2,250	7	4	15	13.93			13.93
32	Truck—1/2 ton pickup	13,485	5	1,771	2,779	4.37	3.52	0.53	8.42
33	Mower	2,283	10	9	46	2.98			2.98
34	Seeder	175	10	4	10	1.05			1.05

1 50 total acres
2 200 total acres
3 Repairs per hour were based on useage of the large nursery. They were computed on the basis of percent of new cost over the life of the asset. Percent factors used were: 90 for item numbers 1, 2, 3, 4, 5, 6, 32; 80 for items 9, 13, 23; 75 for items 14, 15, 25, 28; 65 for items 10, 11, 12, 24, 29, 31; 60 for items 26, 27, 30, 33, 34; 40 for items 7, 17, 18, 19, 20, 21, 22; and 10 for items 8, 16. The total was then divided by the estimated total number of hours the equipment would be used in the large nursery during the life of the asset.
4 Fuel was estimated at $1.10 per gallon for gasoline driven items, $1.03 for diesel driven items and $0.31 per kilowatt for electrically driven.
5 Cost is for a large nursery on which variable costs per hour were based. Cost for the small nursery was lower.

Hourly labor. The hourly basic wage was estimated at $5.25. An additional 32 percent or $1.68 was allocated for fringe benefits making a total hourly labor cost of $6.93. Each major production activity was allocated necessary labor hours to accomplish assigned tasks.

Cost Summaries. After all cost factors were determined, they were summarized based upon cost per salable plant by size of nursery.

Results and Discussion. Annual fixed, variable, and total production costs of producing slow-growing evergreens (*Juniperus*) in the field in Ohio for 1985 are summarized in Table 4. In the 50-acre nursery, total annual costs were $72,614 or $12.51 per salable 18-24 inch plant. Fixed costs totaled $46,902 or $8.08 per plant and made up 65 percent of total costs. Based on percentage of total costs, land and improvements made up 10 percent, buildings 7 percent, machinery and equipment 18 percent, general overhead 28 percent, and interest on general overhead, insurance, and taxes 2 percent. Variable costs totaled $25,712 or $4.43 per plant and made up 35 percent of total costs. Based on percentage of total costs, propagation made up 2 percent, materials 6 percent, machinery and equipment 8 percent, labor 17 percent, and interest on operating capital 2 percent.

In the 200-acre nursery, total annual costs were $180,564 or $7.09 per salable 18-24 inch plant. Fixed costs totaled $88,905 or $3.48 per plant and made up 49 percent of total costs. Based on percentage of total costs, land and improvements made up 12 percent, buildings 4 percent, machinery and equipment 14 percent, general overhead 18 percent, and interest on general overhead, insurance, and taxes 1 percent. Variable costs totaled $91,659 or $3.61 per plant and made up 51 percent of total costs. Based on percentage of total costs, propagation made up 1 percent, materials 11 percent, machinery and equipment 7 percent, labor 29 percent, and interest on operating capital 3 percent.

Total annual costs were $5.42 per plant more in the 50-acre nursery than in the 200-acre. Of this $5.42, $4.60 or 85 percent were comprised of fixed costs. On a per item basis, the 200-acre nursery's advantages were 37 cents on land and im-

Table 4. Summary of annual fixed, variable, and total costs (dollars) of producing rapid-growing evergreens (Juniperus) in the field in Ohio, 1985.

	50 Acre Field Nursery[1]			200 Acre Field Nursery[2]		
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	7,061	1.22	(10)	21,716	0.85	(12)
Buildings	4,740	0.82	(7)	6,811	0.27	(4)
Machinery and Equipment	13,173	2.27	(18)	25,495	1.00	(14)
General Overhead	20,592	3.54	(28)	32,685	1.28	(18)
Interest on General Overhead, Insurance, and Taxes	1,336	0.23	(2)	2,198	0.08	(1)
Subtotal	46,902	8.08	(65)	88,905	3.48	(49)
Variable Cost Items						
Propagation	1,547	0.27	(2)	2,713	0.11	(1)
Materials	4,337	0.75	(6)	19,561	0.77	(11)
Machinery and Equipment	5,970	1.03	(8)	12,039	0.47	(7)
Labor	12,402	2.13	(17)	52,158	2.05	(29)
Interest on Operating Capital	1,456	0.25	(2)	5,188	0.21	(3)
Subtotal	25,712	4.43	(35)	91,659	3.61	(51)
Total Annual Costs	72,614	12.51	(100)	180,564	7.09	(100)

[1] Total nursery—50 acres, 40 acres of growing space, 10 acres production facilities, holding & field bed area, roads, etc. Rapid-growing evergreens—10 acres, 8 acres of growing space, 2 acres production facilities, holding & field bed area, roads, etc.

[2] Total nursery—200 acres, 175 acres of growing space, 25 acres production facilities, holding & field bed area, roads, etc. Rapid growing evergreens—40 acres, 35 acres of growing space, 5 acres production facilities, holding & field bed area, roads, etc.

provements, 55 cents on buildings, $1.27 on machinery and equipment, $2.26 on general overhead, and 15 cents on interest for general overhead, insurance, and taxes. The 82-cent difference for variable costs was 16 cents for propagation, (-2) cents for material, 56 cents for machinery and equipment, 8 cents for labor, and 4 cents for interest on operating capital.

In the nurseries analyzed, it cost 43 percent less to produce a 18-24 inch salable rapid-growing evergreen *(Juniperus)* in the 200-acre nursery than in the 50-acre. While the overall reduction was 43 percent, it was 57 percent for fixed costs and only 19 percent for variable. Large-sized commercial field nurseries are able to make more efficient use of buildings, equipment, machinery, labor, and general overhead than are small field nurseries.

One note of caution should be observed in comparing costs between the two different sized nurseries. Each of the nurseries were analyzed based on the assumption that they would produce a diverse line of plants which included both shrubs and trees. This assumption might be unrealistic for the 50-acre nursery as a considerable amount of specialized equipment was required. It should also be noted that many operators of small nurseries might choose a different line of equipment than that budgeted. While the equipment budgeted is labor saving, smaller nurserymen might have a surplus of family labor and choose less expensive, less labor saving equipment. Also, a small nursery might well operate its office out of a home.

Individual nurserymen might experience different costs or calculate costs differently from those depicted here. Most cost differences would probably be reflected in fixed rather than variable costs. Most fixed costs are implicit and their full impact may not be calculated by established nurserymen. Also, budgets presented in this report assume new facilities, machinery, and equipment, whereas most nurserymen have owned their land for many years and have old machinery and equipment.

For the established nursery, budgeted fixed costs on land improvements, buildings, machinery, and equipment presented here would reflect replacement rather than "book" value of depreciated items. Presented fixed costs also placed a market value on management. Many nurserymen place little if any value on their own management when computing costs. Variable items, on the other hand, are explicit, experienced at least yearly, and easily accounted for. Variable costs presented here would be typical for the industry in Ohio and should be rather consistent regardless of age and size of the nursery.

Implications

Total annual costs per 18-24 inch salable slow-growing evergreen (*Juniperus*) were $12.51 in the 50-acre field nursery and $7.09 in the 200-acre field nursery. Fixed costs were $8.08 in the 50-acre nursery and $3.48 in the 200-acre for a difference of $4.60 per salable plant. Variable costs, were $4.43 in the 50-acre and $3.61 in the 200-acre for a difference of 82 cents. These plant costs assumed propagation in the nursery (6 months), liner production in beds (2 years), and field growing (4 years), ball and burlapped harvesting, and an average size of 18-24 inches per salable plant.

These figures demonstrated that variable costs on a salable plant basis, at least over the size range of nurseries analyzed, were about 19 percent less when going from a 50-acre nursery to a 200-acre nursery. This reduction was primarily accounted for by efficiencies gained in propagation, and machinery and equipment. Fixed costs were reduced significantly as size of nursery was increased. This occurred because most of the fixed factors required to operate the 50-acre nursery, such as management, buildings, and most machinery and equipment, were also adequate to operate the 200-acre. 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.

Literature Cited

1. Taylor, Reed D., Harold H. Kneen, Elton M. Smith, David E. Hahn, and Stanley Uchida. 1986. Costs of establishing and operating field nurseries differentiated by size of firm and species of plant in U.S.D.A. plant hardiness zones five and six. Southern Cooperative Series Bulletin 315.
2. Ornamental Plants—1987: A Summary of Research. Ohio Agr. Res. and Dev. Cntr. Circular 291, Jan. 1987.

Costs of Producing Field Ornamental Trees (*Malus*) in Ohio

Reed D. Taylor, Harold H. Kneen, Elton M. Smith, David E. Hahn and Stanley Uchida[1]

Abstract

The objective of this study was to determine annual production costs for field-grown ornamental trees in Ohio in firms of two sizes. This objective was accomplished by synthesizing two model field nurseries using an economic engineering approach. Once the nurseries were simulated, growing space was divided into five equal parts with each segment being assigned a plant group. In the 50-acre nursery, ornamental trees were allocated 8 acres of growing space and in the 200-acre nursery 35 acres. One species of ornamental tree (*Malus*) was chosen for detailed analysis.

In the space allocated, 2,732 *Malus* of 5-6 foot tall (1-1/2 in. caliper) could be produced annually in the 50-acre nursery and 11,954 in the 200-acre. Based on 1985 figures, total costs per salable plant were $36.82 in the 50-acre nursery and $24.73 in the 200-acre.

Introduction

Ornamental trees, including various species of *Malus* and *Prunus*, are important in Ohio. As a group they encompass a wide range of growing habits, size, foliage, flower, and fruit colors and they can be effectively used in many ways in landscaping.

The specific objective of this study was to determine annual production costs for ornamental trees grown in the field by two sizes of firms. This information should aid Ohio nurserymen in their decisions regarding which plants to grow and in what quantities.

Materials and Methods

Two model firms were synthesized in the study using the conceptual framework of economic engineering wherein the "best proven practice" was included in each model. The analysis is based on conditions in Central Ohio. The complete synthesis included: developing an appropriate production cycle; schematic drawings of the physical layout, including buildings and irrigation systems; lists of equipment and other items; a complete sequence by month and year of nursery operational steps beginning with propagation and ending with loading the finished product for wholesale distribution; and budgets for fixed and variable costs.

Data for this study were obtained from wholesale nurseries and nursery suppliers in Ohio during 1985. The basic goals in simulating the production facilities 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. See Taylor, et al., (1) for a detailed analysis of the physical plant, production system, and capital production budgets.

In the production cycle, two-year-old purchased liners were prepared and planted directly into the field. Approximately 25 percent of the crop will be harvested and sold during the fall of the third field production year and another 25 percent dug, overwintered (heeled in with wood chips), and sold during late winter and early spring of the fourth field production year. The remaining 50 percent of the crop will be harvested and sold during late winter and spring of the fourth field production year. After the harvest is complete, the land is left fallow and disked for weed control four times during summer months. The fields are plowed in the fall of the fourth field production year in preparation for spring planting.

A model facility was synthesized for both a 50-acre and a 200-acre field nursery. The nursery operations were assumed to produce a diverse line of nursery stock, each having its own unique production cycle. Commonly grown nursery stock was divided into five groups. While not all inclusive, the groups do permit developing a range of per unit costs related to input costs and cultural factors. It was assumed that each plant group would occupy 20 percent of the field growing area (i.e., 50-acre nursery=8 acres per group, 200-acre nursery=35 acres per group. In addition to the field growing area, the 50-acre nursery had 10 acres and the 200-acre nursery 25 acres of production facilities including overwintering houses, propagation facilities, shipping area, holding area, liner bed area, pond, supply shed, machinery storage, machine shop, office, and rest rooms.

Costs developed on ornamental trees (*Malus*) therefore were based on the scale of complete nurseries, but were analyzed on the basis of percent of total space occupied. Companion studies were reported in the 1987 issue of "Ornamental Plants" (2). Fixed costs were reported beginning on page 26. These included costs for slow-growing evergreens (page 37), deciduous shrubs (page 45), and shade trees (page 51). In this publication, costs for rapid-growing evergreens are reported beginning on page 21. For a detailed analysis of ornamental trees, one specific plant species, *Malus*, was chosen. While it is recognized that other ornamental trees, such as *Prunus*, would have somewhat different requirements, it was felt that the requirements would not vary significantly in cost from the *Malus* analyzed.

Costs were calculated for all factors of production including management and invested capital. In economic terms, costs associated with factors of production supplied 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

[1]Associate Professor and former Graduate Student, Department of Agricultural Economics and Rural Sociology; Professor, Department of Horticulture; Professor and former Graduate Student, Department of Agricultural Economics and Rural Sociology.

invested in land, buildings, irrigation systems, and equipment could have earned interest if it had been placed in financial institutions.

Capital requirements for establishing the nurseries were first determined (1). Second, capital requirements per salable plant capacity by size of nursery were established (1). Third, annual fixed costs were calculated (1). Fourth, annual variable costs were determined for each of the two sized nurseries (Tables 1 and 2). Fifth, summaries were made for annual fixed and variable costs according to size of nursery (Table 3). This allowed cost comparisons based on size of nursery.

Most nurseries use cash rather than accrual accounting procedures. For this reason, the analyses were completed on a "cash" basis. This approach does not give a true economic picture of the cost of producing a plant as it does not take into account the monetary value of time from planting until harvest. The analyses do, however, give a reliable estimate of the annual cost per salable plant based upon the study's assumptions.

Total annual production costs consist of both fixed and variable factors. Fixed costs are primarily made up of implicit costs such as depreciation on buildings and equipment, interest charges (both for borrowed and equity capital), and charges for management. Many nurserymen do not adequately consider fixed costs when computing costs of production. Fixed items are often considered as residual claimants on income. For example, management is compensated if all other factors of production have been paid and there is still a residual. As noted previously, annual fixed costs are discussed in greater detail in a companion article.

Variable costs include all cost factors that vary with the quantity of plants being grown at one point in time. Variable costs are explicit, obvious, and normally paid out yearly. An example of variable costs would be the liners purchased for tree production. Two costs compose the total for purchased liners. The major cost is the purchase price. While price is somewhat dependent upon quality and quantity, it was assumed that sufficient quantity would be ordered in either sized nursery to obtain them at the lowest possible cost. The second cost was for packing and shipping the liner from producer to purchaser. This was estimated at 10 percent of the purchase price. Variable costs were subdivided into the following categories: propagation, materials, machinery and equipment, labor, and interest on operating capital (Tables

Table 1. Variable costs (dollars) for ornamental trees (malus) for a 50-acre[1] field nursery in Ohio, 1985.

Item	Description	Unit	Cost per Unit[2]	Quantity	Total Variable Cost
Materials					
Burlap	54" x 54" squares + 18" basket	each	2.53	2,732.00	6,912
Twine	Nails + twine	each	0.15	2,732.00	410
Liners	5'-6' 2 yr. branched	each	6.00	3,036.00	18,216
Strip tags	5/8" X 7" plastic strip tag	each	0.02	2,732.00	55
Poultry wire	1" poultry wire for rabbit control	roll	29.00	2.00	58
Seed	Rye grass (Kentucky 31)	pound	0.64	435.60	279
Chemicals	Custom spread, custom blend: 45-0-0 0-44-0, 0-0-60 (fertilizer)	ton	176.00	1.13	199
	Custom spread, (lime)	ton	20.00	2.00	40
	Urea, 45-0-0 (fertilizer)	ton	220.00	0.66	145
	Trifluralin 4 EC (Treflan) (herbicide)	gallon	33.49	0.50	17
	Simazine 80WP (Princep) (herbicide)	pound	3.75	15.00	56
	DCPA 75WP (Dacthal) (herbicide)	pound	6.37	44.10	281
	Malathion, 57EL, (Cythion) (insecticide)	gallon	18.28	13.50	247
	Benomyl, 50WP, (Benlate) (fungicide)	pound	14.17	9.50	135
	Carbaryl, 80WP (Sevin) (insecticide)	pound	6.09	22.50	137
	Other (i.e. Kelthane, Captan, Di-syston, Orthene, etc.)[4]				260
Subtotal					27,447

(Continued)

Table 1. (Continued)

Item	Description	Unit	Cost per Unit[2]	Quantity	Total Variable Cost
Machinery and Equipment					
	Tractor, 100 HP	hour	17.00	68.48	1,164
	Tractor, 60 HP	hour	11.68	17.06	199
	Tractor, 34 HP	hour	4.99	41.78	208
	Articulated Loader/3,000lbs	hour	14.81	92.10	1,364
	Tree spade	hour	5.30	102.57	544
	Forks	hour	0.01	92.10	1
	Plow, 3-14"	hour	6.57	1.60	11
	Disk, 8' wide	hour	4.23	3.24	14
	Harrow, 10' wide	hour	8.45	0.24	2
	Cultimulcher, 10' wide	hour	24.70	0.49	12
	Spray rig with 10' boom	hour	2.77	2.46	7
	Transplanter, one row (tree)	hour	0.92	55.20	51
	Permanent irrigation/ well & pump 100HP	hour	7.60	16.00	122
	Inground irrigation—storage & holding	hour	5.65	12.00	68
	Above ground irrigation—storage & hold.	hour	11.05	12.00	133
	Inground irrigation—bed/field	hour	3.13	4.00	13
	Traveler gun	hour	12.06	4.00	48
	Portable PTO pump, 40 HP	hour		**(no costs budgeted)**	
	Airblast sprayer	hour	1.01	18.00	18
	Seeder	hour	1.05	1.02	1
	Mower	hour	2.98	4.08	12
	Sidedresser, 2 row	hour	0.63	3.60	2
	Cultivator, 2 row	hour	0.95	3.96	4
	Wagon, 4 wheel	hour	0.48	8.16	4
	Truck,½ ton pickup	hour	8.42	346.67	2,919
	Flatbed truck, 24' bed	hour	14.87	157.77	2,346
Subtotal					9,267
Labor	Labor hours	hour	6.93[3]	1,674.91	11,607
	Related labor hours, 20%	hour	6.93	335.00	2,322
Subtotal					13,929
Interest Charge on Operating Capital	Computed at 12% on an annual basis for 6 months	percent	6.0 (0.06)	50,643.00	3,039
Total Variable Costs					53,682
Variable Cost per Salable Plant (1 1/2" caliper)	Units available for sale in a given year	each		2,732.00	19.65

[1] Total Nursery—50 acres, 40 acres of growing space, 10 acres production facilities, holding & field bed area, roads, etc. Ornamental Trees—10 acres, 8 acres of growing space, 2 acres production facilities, holding & field bed area, roads, etc., 2,732, 2 inch caliper salable plants per year.
[2] Quantity discounts were applied to chemicals and other items.
[3] Average basic wage before withholding taxes and fringes $5.25, taxes and fringes add 32% or $1.68 for a total of $6.93.
[4] To achieve better pest and disease control, alternative chemical useage is advisable. Alternative chemical costs were estimated at 50% of the cost of Malathion, Benomyl, and Carbaryl.

Table 2. Variable costs (dollars) for ornamental trees (*Malus*) for a 200 acre[1] field nursery in Ohio, 1985.

Item	Description	Unit	Cost per Unit[2]	Quantity	Total Variable Cost
Materials					
Burlap	54" x 54" squares + 18" baskets	each	2.53	11,954.00	30,244
Twine	Nails & twine	each	.15	11,954.00	1,793
Liners	5-6' 2 yr. branched	each	4.86	13,283.00	64,555
Strip tags	5/8" X 7" plastic strip tag	each	0.02	11,954.00	239
Poultry wire	1" for rabbit control	roll	29.00	9.00	261
Seed	Rye grass (Kentucky 31)	pound	0.64	1,905.75	1,220
Chemicals	Custom spread, custom blend: 45-0-0, 0-44-0, 0-0-60 (fertilizer)	ton	176.00	4.94	869
	Custom spread, (lime)	ton	20.00	8.75	175
	Urea, 45-0-0 (fertilizer)	ton	220.00	3.85	847
	Trifluralin 4 EC (Treflan) (herbicide)	gallon	33.49	8.75	293
	Simazine 80WP (Princep) (herbicide)	pound	3.75	87.50	328
	DCPA 75WP (Dacthal) (herbicide)	pound	6.37	245.00	1,561
	Malathion, 57EL, (Cythion) (insecticide)	gallon	18.28	78.75	1,440
	Benomyl, 50 WP, (Benlate) (fungicide)	pound	14.17	131.25	1,860
	Carbaryl, 80WP (Sevin) (insecticide)	pound	6.09	52.50	320
	Other (i.e. Kelthane, Captan,Di-syston, Orthene, etc.)[4]				1,810
Subtotal					107,815
Machinery and Equipment	Tractor, 100 HP	hour	17.00	248.51	4,225
	Tractor, 60 HP	hour	11.68	252.38	2,948
	Tractor, 34 HP	hour	4.99	102.65	512
	Articulated loader/2,000lbs	hour	6.67	157.26	1,049
	Articulated loader/3,000lbs	hour	14.81	157.87	2,338
	Tree spade	hour	5.30	475.16	2,518
	Forks	hour	0.01	314.52	3
	Plow, 3-14"	hour	6.57	7.00	46
	Disk, 8' wide	hour	4.23	14.18	60
	Harrow, 10' wide	hour	8.45	1.05	9
	Cultimulcher, 10' wide	hour	24.70	2.02	50
	Spray rig with 10' boom	hour	2.77	13.76	38
	Transplanter, one row (tree)	hour	0.92	241.51	222
	Permanent irrigation/ well & pump 100HP	hour	7.60	29.50	224
	Inground irrigation—storage & holding	hour	5.65	12.00	68
	Above ground irrigation—storage & hold.	hour	11.05 (no costs budgeted)	12.00	133
	Inground irrigation—bed/field	hour	3.13	17.50	55
	Traveler gun	hour	12.06	17.50	211
	Portable PTO pump, 40 HP	hour			
	Airblast sprayer	hour	1.01	78.75	80
	Seeder	hour	1.05	5.96	6
	Mower	hour	2.98	23.80	71
	Sidedresser, 2 row	hour	0.63	15.70	10
	Cultivator, 2 row	hour	0.95	17.34	16
	Wagon, 4 wheel	hour	0.48	38.34	18
	Truck,½ ton pickup	hour	8.42	520.00	4,378
	Flatbed truck, 24' bed	hour	14.87	716.67	10,657
Subtotal					29,945

(Continued)

Table 2. (Continued)

Item	Description	Unit	Cost per Unit**	Quantity	Total Variable Cost
Labor					
	Labor hours	hour	6.93[3]	6,881.83	47,691
	Related labor hours, 20%	hour	6.93	1,376.00	9,537
Subtotal					57,228
Interest Charge on Operating Capital	Computed at 12% on an annual basis for 6 months	percent	6.0 (0.06)	194,988.00	11,699
Total Variable Costs					206,687
Variable Cost per Salable Plant (1 1/2" caliper)	Units available for sale in a given year	each		11,954.00	17.29

[1] Total nursery—200 acres, 175 acres of growing space, 25 acres production facilities, holding & field bed area, roads, etc.
Ornamental trees—40 acres, 34 acres of growing space, 6 acres production facilities, holding, & field bed area, roads, etc. 11,954, 5-6' (1 1/2") salable plants per year.
[2] Quantity discounts were applied to chemicals and other items.
[3] Average basic wage before withholding taxes and fringes $5.25, taxes and fringes add 32% or $1.68 for a total of $6.93.
[4] To achieve better pest and disease control, alternative chemical useage is advisable. Alternative chemical costs were estimated at 50% of the cost of Malathion, Benomyl, and Carbaryl.

1 and 2). Details on specific variable costs, other than liners, are included in the companion article on rapid-growing evergreens (page 21).

Results and Discussion

Annual fixed, variable, and total production costs of producing field grown ornamental trees (*Malus*) in Ohio for 1985 are summarized in Table 3. In the 50-acre nursery, total annual costs were $100,584 or $36.82 per salable 5-6 foot tall tree. Fixed costs totaled $46,902 or $17.16 per plant and made up 46 percent of total costs. Based on percentage of total costs, land and improvements made up 7 percent, buildings 5 percent, machinery and equipment 13 percent, general overhead 20 percent, and interest on general overhead, insurance, and taxes 1 percent. Variable costs totaled $53,682 or $19.65 per tree and made up 54 percent of total costs. Based on percentage of total costs, materials made up 28 percent, machinery and equipment 9 percent, labor 14 percent, and interest on operating capital 3 percent.

In the 200-acre nursery, total annual costs were $295,592 or $24.73 per salable 5-6 foot tall tree. Fixed costs totaled $88,905 or $7.43 per plant and made up 30 percent of total costs. Based on percentage of total costs, land and improvements made up 7 percent, buildings 2 percent, machinery and equipment 9 percent, general overhead 11 percent, and interest on general overhead, insurance, and taxes 1 percent. Variable costs totaled $206,687 or $17.30 per tree and made up 70 percent of total costs. Based on percentage of total costs, materials made up 37 percent, machinery and equipment 10 percent, labor 19 percent, and interest on operating capital 4 percent.

Total annual costs were $12.09 per tree more in the 50-acre nursery than in the 200-acre. Of this $12.09, $9.73 or 80 percent were made up of fixed costs. On a per item basis, the 200-acre nursery's advantages were 76 cents on land and improvements, $1.16 on buildings, $2.69 on machinery and equipment, $4.81 on general overhead, and 31 cents on interest for general overhead, insurance, and taxes. The $2.35 difference for variable costs was $1.03 for materials, 88 cents for machinery and equipment, 31 cents for labor, and 13 cents for interest on operating capital. In the nurseries analyzed, it cost 33 percent less to produce a 5-6 foot tall ornamental tree (*Malus*) in the 200-acre nursery than in the 50-acre. While the overall reduction was 33 percent, it was 57 percent for fixed costs and only 12 percent for variable. Large-sized commercial field nurseries are able to make more efficient use of buildings, equipment, machinery, labor, and general overhead than is the case for small field nurseries.

One note of caution should be observed in comparing costs between the two different sized nurseries. Each of the nurseries was analyzed based on the assumption that it would produce a diverse line of plants that included both shrubs and trees. This assumption might be unrealistic for the 50-acre nursery as a considerable amount of specialized equipment was required. It should also be noted that many ooperators of smaller nurseries might choose a different line of equipment than that budgeted. While the euqipment budgeted in labor saving, smaller nurserymen might have a surplus of family labor and thus choose less expensive, less labor-saving equipment. Also, a small nursery might well operate its office out of a home.

Individual nurserymen might experience different costs or calculate costs differently from those depicted here. Most cost differences would probably be reflected in fixed rather than variable costs. Most fixed costs are implicit and their full impact may not be calculated by established nurserymen. Budgets presented assumed new facilities, machinery, and equipment. Most nurserymen have owned their land for many years and have old machinery and equipment. For the established nursery, budgeted fixed costs on land improvements, buildings, machinery, and equipment presented here would reflect replacement rather than "book" value of depreciated items.

Presented fixed costs also assigned a market value to management. Many nurserymen place little if any value on their own management when computing costs. Variable items, on the other hand, are explicit, experienced at least yearly, and easily accounted for. Variable costs presented here would be typical for the industry in Ohio and should be rather consistent regardless of age and size of the nursery.

Implications

Total annual costs per 5-6 foot tall salable ornamental tree (*Malus*) were $36.82 in the 50-acre field nursery and $24.73 in the 200-acre field nursery. Fixed costs were $17.16 in the 50-acre nursery and $7.43 in the 200-acre for a differential of $9.73 per salable plant. Variable costs were $19.65 in the 50-acre and $17.30 in the 200-acre for a differential of $2.35.

Table 3. Summary of annual fixed, variable, and total costs (dollars) of producing ornamental trees (Malus) in the Field in Ohio, 1985.

	50 Acre Field Nursery[1]			200 Acre Field Nursery[2]		
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	7,061	2.58	(7)	21,716	1.82	(7)
Buildings	4,740	1.73	(5)	6,811	0.57	(2)
Machinery and Equipment	13,173	4.82	(13)	25,495	2.13	(9)
General Overhead	20,592	7.54	(20)	32,685	2.73	(11)
Interest on General Overhead, Insurance, and Taxes	1,336	0.49	(1)	2,198	0.18	(1)
Subtotal	46,902	17.16	(46)	88,905	7.43	30
Variable Cost Items						
Propagation	*[3]	*[3]	*[3]	*[3]	*[3]	*[3]
Materials	27,447	10.05	(28)	107,815	9.02	(37)
Machinery and Equipment	9,267	3.39	(9)	29,945	2.51	(10)
Labor	13,929	5.10	(14)	57,228	4.79	(19)
Interest on Operating Capital	3,039	1.11	(3)	11,699	0.98	(4)
Subtotal	53,682	19.65	(54)	206,687	17.30	(70)
Total Annual Costs	100,584	36.82	(100)	295,592	24.73	(100)

[1] Total Nursery—50 acres, 40 acres of growing space, 10 acres production facilities, holding & field bed area, roads, etc. Ornamental Trees—10 acres, 8 acres of growing space, 2 acres production facilities, holding & field bed area, roads, etc.

[2] Total Nursery—200 acres, 175 acres of growing space, 25 acres production facilities, holding & field bed area, roads, etc. Ornamental Trees—40 acres, 35 acres of growing space, 5 acres production facilities, holding & field bed area, roads, etc.

[3] Tree liners were purchased rather than propagated. Liner costs were included under materials.

These plant costs assumed planting purchased liners directly in the field and field growing for three years, ball and burlapped harvesting, and an average size of 5-6 feet high per salable tree.

These figures demonstrated that variable costs on a salable plant basis, over the size range of nurseries analyzed, had a moderate reduction of about 12 percent when going from a 50-acre nursery to a 200-acre. This reduction was primarily accounted for by efficiencies gained in materials, and machinery and equipment. Fixed costs, on the other hand, had a substantial reduction of about 57 percent as size of nursery was increased . This occurred because most of the fixed factors required to operate the 50-acre nursery, such as management, buildings, and most machinery and equipment, were also adequate to operate the 200-acre. 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.

Literature Cited

1. Taylor, Reed D., Harold H. Kneen, Elton M. Smith, David E. Hahn, and Stanley Uchida. 1986. Costs of Establishing and Operating Field Nurseries Differentiated by Size of Firm and Species of Plant in U.S.D.A. Plant Hardiness Zones Five and Six. Southern Cooperative Series Bulletin 315.
2. Ornamental Plants—1987: A Summary of Research. Ohio Agr. Res. and Dev. Ctr. Circular 291, Jan. 1987.

This page intentionally blank.

THE OHIO STATE UNIVERSITY