RESEARCH CIRCULAR 284

JANUARY 1985

Ornamental Plants — 1985: A Summary of Research

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

CONTENTS

**** ***** ****

ON THE COVER: Dr. T. Davis Sydnor (center), associate professor of horticulture, explains to industry representatives the performance of a tree species in the Shade Tree Evaluation Plot located in the Secrest Arboretum on the campus of the Ohio Agricultural Research and Development Center, Wooster.

The information in this research circular is supplied with the understanding that no discrimination is intended and no endorsement by the Ohio Agricultural Research and Development Center and Ohio Cooperative Extension Service is implied. Due to constantly changing laws and regulations, no liability for the recommendations can be assumed.

AGDEX 272-275-276-282/16-24-28

1-85-3M

Field Transplant Survival of *Amelanchier* Liners Produced by Tissue Culture[1]

DANIEL K. STRUVE and R. DANIEL LINEBERGER[2]

ABSTRACT

Tissue cultured *Amelanchier laevis* liners were transplanted to the field with almost complete survival. Plants transplanted from Cone-Tainers were slightly shorter but had more lateral breaks 1 year after planting. A period of outdoor acclimation under 60% shade for as little as 5 days reduced transplant shock as indicated by incremental growth at 1, 2, or 3 months, but plant height and number of lateral breaks after 1 year were not affected by outdoor acclimation. Tissue cultured liners could be outplanted as late as early October and still overwinter without damage.

INTRODUCTION

Propagation of nursery crops through tissue culture is gaining increasing acceptance from the nursery industry. Micropropagation systems from initial explanting to acclimation of microcuttings have been developed for many species [see Lineberger (3) for an example of such a system].

Physiological and morphological changes which occur in micropropagated plants during acclimation from aseptic conditions to the greenhouse environment have focused on two areas. The structure and amount of epicuticular wax on the leaves increases upon exposure of microcuttings to lowered relative humidity, a change deemed necessary to lower rates of water loss from the delicate microcuttings (5). Concomitantly, the stomata increase in rate of response to water stress after 5 days of acclimation. This change is believed to be significant to the survival of tissue cultured woody plants (1).

Relatively little research has been conducted to determine factors necessary to acclimation of tissue cultured liners to the field environment. Smith (4) recommends a minimum size of 10-15 cm top growth and an 8-10 cm root ball for field transplanting of tissue cultured liners. Dunstan (2) reported that tissue cultured apple rootstocks transplanted to the field directly from the greenhouse in early spring were susceptible to frost damage and were defoliated but regrew after about 2 months of quiescence. Dunstan's transplanting procedure for summer transplanting now involves preconditioning plants under 50% shade to achieve a "partially exposed environment into which plants are placed before full exposure." Losses of tissue cultured liners were no greater than those for seedlings using this procedure.

This research was undertaken to determine the effect of certain factors (container type, planting date, days of outdoor acclimation) on the transplant survival of tissue cultured plants of *Amelanchier laevis*.

MATERIALS AND METHODS

Microcuttings of *Amelanchier laevis* were produced *in vitro* according to the method described for 'Hally Jolivette' cherry (3). The growth regulator concentration in the shoot proliferation stage was 0.1 mg/l naphthaleneacetic acid and 2.5 mg/l benzyladenine. These microcuttings were rooted in plastic-covered foil containers containing a moistened peatmoss-perlite medium (1:1 by volume). Rooting was done in the tissue culture laboratory where the temperature was 24-27° C and lighting was provided for 16 hr per day at 40μ Einsteins/m^2/sec by cool white fluorescent lamps.

Transplanted microcuttings were immediately placed on a shaded intermittent mist bench for 3 days (6 sec mist every 6 min; light intensity, 360μ Einsteins/m^2/sec). After an additional 7 to 10 days of acclimation on a shaded greenhouse bench (light intensity, 270μ Einsteins/m^2/sec), plants were grown under standard greenhouse cultural conditions including fertilization at every watering with 200 ppm of 20-20-20 soluble fertilizer. Plants which received an outdoor acclimation treatment were held for various time intervals under 60% shade (light intensity, 810μ Einsteins/m^2/sec) prior to planting.

Field transplanting studies were conducted on the Dept. of Horticulture's Lane Avenue Farm. The plot used was a Brookston silty clay loam with a previous record of heavy fertilization. The plot was irrigated as needed.

In experiment 1, plantlets approximately 15 cm tall were acclimated for 0, 5, 10, or 15 days under 60% shade outdoors. Two types of containers were used, 5.7 x 5.7 cm peatmoss pots or 4 x 20 cm Cone-Tainers (Ray Leach Cone-Tainer Nursery, Canby, OR 97013). A 1:1 (by volume) peatmoss-perlite medium was used. Field planting was done June 28, 1981. A randomized complete block design with six six-plant replications was used.

Experiment 2 was a replication of experiment 1 except only peatmoss pots were used. Field planting was done August 6, 1981. A randomized complete block design was used with six six-plant replications.

Experiment 3 was conducted to determine how late in the year plants could be transplanted without suffering significant winter damage. At approximately 3-day intervals beginning Sept. 6 and ending Oct. 4, 1981, ten 15 cm tall plants growing in peatmoss pots were transplanted directly from the greenhouse to the field.

---

[1] Partial support for this project was provided by grants from the Horticultural Research Institute and the Western Region of the International Plant Propagators Society. The authors thank Joe Takayama for his excellent technical support.

[2] Assistant Professor and Associate Professor, Dept. of Horticulture.

TABLE 1.—Comparison of the Transplant Survival, Shoot Growth, and Basal Branching of Tissue Cultured *Amelanchier laevis* Transplanted to the Field from Peatmoss Pots or Cone-Tainers.

Container Type	Percentage Survival*	Increase in Shoot Length (cm)†	Number of Basal Lateral Branches‡
Cone-Tainer	99%	59.3a**	2.9a
Peatmoss Pot	98%	64.4b	1.8b

Planting date: June 28, 1981.

*Percentage of 144 plants which survived; survival was the same 3 or 12 months after transplanting.

†Increase in shoot length from June 28, 1981, to June 24, 1982.

‡Average number of basal lateral branches observed 4 months after field planting.

**Means within columns followed by different letters are significantly different at the 0.05 level by Duncan's multiple range test.

TABLE 2.—Height Increase and Number of Basal Lateral Shoots of Tissue Cultured *Amelanchier laevis* Transplanted to the Field Following Various Time Intervals of Holding Outdoors Under 60% Shade Prior to Planting.

Days of Outdoor Acclimation	Initial Height	Incremental Height Increase (cm)				Height at 12 months (cm)	Number of Basal Lateral Branches
		1 month	2 months	3 months	12 months		
0	24.6	5.5a*	13.4b	14.8a	59.3ab	83.9	2.3a
5	19.7	7.5c	16.9c	18.8b	62.7b	82.4	2.2a
10	19.6	7.1c	14.4b	16.7ab	66.1b	85.7	2.6a
15	18.5	6.0b	11.7a	14.3a	59.0a	77.5	2.6a

Planting date: June 28, 1981.

*Means within columns followed by the same letter are not significantly different at the 0.05 level by Duncan's mean separation.

TABLE 3.—Height Increase and Basal Branching of Tissue Cultured *Amelanchier laevis* Subjected to Various Periods of Outdoor Acclimation Prior to Field Planting.

Days of Outdoor Acclimation	Initial Height (cm)	Height Increase (cm) After 3 months	Number of Basal Lateral Shoots
0	11.7	0.0b*	1.5a
5	10.4	0.2b	1.4a
10	9.7	2.6a	1.9b
15	10.1	4.0a	2.1b

Planting date: August 6, 1981.

*Means within columns followed by the same letter are not significantly different at the 0.05 level by Duncan's mean separation.

In all experiments, plant height, number of leaves, and number of basal lateral branches were recorded. Plants in experiments 1 and 2 were measured monthly until Oct. 4, 1981, and again on June 24, 1982, after the first growth flush ceased elongation. Winter survival was assessed in May and June 1982.

All data were subjected to analysis of variance. Mean separation by Duncan's multiple range test was conducted only for effects significant at the 0.05 level.

RESULTS AND DISCUSSION

Tissue cultured plants of *Amelanchier laevis* survived transplanting in excellent condition. When results are compared by container type across all other treatments, transplant losses were negligible in either container (Table 1). Shoot growth was slightly higher when plants were grown in peat pots, but those transplanted from Cone-Tainers had a higher number of basal lateral branches at the end of the first growing season (Table 1).

Plants exposed to a period of outdoor acclimation under shade prior to field planting appeared to have less transplant shock. Plants acclimated for 5 or 10 days exhibited the greatest incremental increase in height after 1 month (Table 2). During the 1, 2, and 3 month measurement periods, those plants acclimated for 5 days grew more than those acclimated for 10 days, which in turn grew more than those acclimated for 15 days (differences were not all significant, but the trend was evident). By the end of 12 months, the growth rates of all plants tended to one value despite pretransplant acclimation treatment (Table 2). Additionally, the acclimation treatments did not affect the number of basal lateral shoots observed 4 months after planting (Table 2).

When the experiment was repeated with an August rather than a June planting date (experiment 2) and using only plants grown in peat pots, a slight benefit to prior acclimation was observed. Increasing time outdoors under shade increased both growth in height and the number of basal lateral shoots observed after 3 months (Table 3). The experiment was terminated before the long term effects of acclimation on August transplanting were determined. Survival was 100%.

A final study was conducted to determine how late in the season transplanting could be done without affecting overwinter survival (experiment 3). These plants were transplanted to the field directly from the greenhouse as late as Oct. 4, 1982. When survival data were taken on May 12, 1983, it was determined that all transplants had survived the winter and begun active shoot growth.

The number of leaves per plant at transplanting had no effect on transplant or winter survival or on height growth in any of these experiments. It was common for the lower third of the leaves to abscise within 2 weeks of transplanting.

These studies have demonstrated excellent field transplant survival of tissue cultured *Amelanchier laevis*. Survival levels of nearly 100% can be achieved: 1) without outdoor acclimation under shade, 2) when plants are grown either in peatmoss pots or Cone-Tainers, and 3) at planting dates varying from late June to early October. A period of outdoor acclimation appears to lessen transplant shock of either June or August transplanting, but the long term (12 month) benefit to this procedure with regard to shoot growth or basal branching appears negligible.

These results should not be generalized to plants which are succulent at the time of transplanting, however. Even though the *Amelanchier* liners used in this study were greenhouse grown, they did have sturdy, woody stems at transplanting.

LITERATURE CITED

1. Brainerd, K. E. and L. H. Fuchigami. 1981. Acclimatization of aseptically cultured apple plants to low relative humidity. J. Amer. Soc. Hort. Sci., 106:515-518.
2. Dunstan, D. I. 1981. Transplantation and post-transplantation of micropropagated tree fruit rootstocks. Proc. Int. Plant Prop. Soc., 31:39-45.
3. Lineberger, R. D. 1983. Shoot proliferation, rooting, and transplant survival of tissue-cultured 'Hally Jolivette' cherry. HortScience, 18:182-185.
4. Smith, W. A. 1981. The aftermath of the test tube in tissue culture. Proc. Int. Plant Prop. Soc., 31:47-49.
5. Sutter, E. and R. W. Langhans. 1979. Epicuticular wax formation on carnation plantlets regenerated from shoot tip culture. J. Amer. Soc. Hort. Sci., 104:493-496.

An Evaluation of Strawdust — an Alternative Growing Media

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

ABSTRACT

Wheat straw processed with heat, pressure, and urea formaldehyde is used as an amendment to media for the production of container grown nursery crops. Marketed as "Strawdust", this material is available to combine with other ingredients or as a pre-mixed media with peat moss and perlite. In a series of comparisons with hardbark and pinebark, plant growth was evaluated following one growing season. The prepared media of Strawdust 6 — Peat Moss 2 — Perlite 2 (with 7 lb starter fertilizer/cu yd) resulted in the best growth of forsythia. The next best treatment was the combination of Strawdust 3.5 — Pinebark 3.5 — Peat Moss 1.5 — Sand 1.5. Plant growth was acceptable in the treatment of Pinebark 7 — Peat Moss 1.5 — Sand 1.5, which could be considered the standard media or control plot.

Foliar magnesium and iron were high in each of these treatments and the soil pH ranged from 5.1 to 5.9. The percent air filled pore space was higher in each of these three treatments. Strawdust decomposed more rapidly than media without this additive, leading to increased media shrinkage.

INTRODUCTION

The trade name "Strawdust" has been given to straw (usually wheat) processed with heat, pressure, and urea formaldehyde to use as an amendment to conventional growing media for nursery crops. The straw has been hammermilled and treated such that the distributor claims it to:

1) Contain slow release nitrogen,
2) Be non-flammable,
3) Have pH adjusted to 5.8 — 6.0,
4) Be sterilized and pest free, and
5) Have a slow breakdown rate and thus minimum shrinkage.

Previous unpublished research conducted by Ticknor in Oregon has indicated that azalea and arborvitae grew well in mixtures amended to 70% with Strawdust.

The objectives of studies conducted at The Ohio State University in 1983 were to compare plant growth from prepared Strawdust media with Strawdust combined in various percentages with pinebark, hardwood bark, and peat moss.

MATERIALS AND METHODS

The treatments in this study were:

1. Strawdust 6 — Peat Moss 2 — Perlite 2 (Tuefel Products Mix)
2. Strawdust 6 — Peat Moss 2 — Perlite 2* (Tuefel Products Mix)
3. Strawdust 7 — Peat Moss 1.5 — Sand 1.5
4. Hardwood Bark 7 — Peat Moss 1.5 — Sand 1.5

---

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

*All treatments were fertilized at the rate of 15 lb of starter fertilizer/cu yd except treatment No. 2, which received 7 lb/cu yd. The starter fertilizer contained 5% N, 4% P_2O_5, and 3% K.

TABLE 1.—Vegetative Growth, Dry Weight, and Color Rating of Forsythia and Cotoneaster Produced in Strawdust Amended Container Media During the 1983 Growing Season.

Treatment	Vegetative Growth* (inches) Forsythia	Cotoneaster	Dry Weight (grams) Forsythia	Cotoneaster	Foliar Color Rating† Forsythia
Strawdust 6—Peat Moss 2—Perlite 2 (15 lb fertilizer)	18.6	15.7	3.3 c‡	2.7 c	2.5
Strawdust 6—Peat Moss 2—Perlite 2 (7 lb fertilizer)	65.6		66.5 a		5.0
Strawdust 7—Peat Moss 1.5—Sand 1.5	24.7	18.5	5.4 de	3.9 bc	2.3
Hardwood Bark 7—Peat Moss 1.5—Sand 1.5	40.6	21.4	12.3 d	5.4 bc	2.0
Pinebark 7—Peat Moss 1.5—Sand 1.5	47.5	30.7	23.9 c	15.3 ab	3.0
Strawdust 3.5—Hardwood Bark 3.5—Peat Moss 1.5—Sand 1.5	28.1	20.5	7.1 de	3.6 bc	2.3
Strawdust 3.5—Pinebark 3.5—Peat Moss 1.5—Sand 1.5	58.8	32.2	36.7 b	17.5 ab	4.0
Hardwood Bark 3.5—Pinebark 3.5—Peat Moss 1.5—Sand 1.5	40.3	23.5	12.8 d	6.4 bc	2.3

*Vegetative Growth = Height + width ÷ 2.

†Color rating 1-5 with 5 = Black Green, 4 = Dark Green, 3 = Medium Green, 2 = Light Green, and 1 = Yellow Green.

‡Letters followed by dissimilar letters within columns are significantly different at the 5% level according to Tukey's studentized range test.

5. Pinebark 7 — Peat Moss 1.5 — Sand 1.5
6. Strawdust 3.5 — Hardwood Bark 3.5 — Peat Moss 1.5 — Sand 1.5
7. Strawdust 3.5 — Pinebark 3.5 — Peat Moss 1.5 — Sand 1.5
8. Hardwood Bark 3.5 — Pinebark 3.5 — Peat Moss 1.5 — Sand 1.5

All plants received an additional application of slow release 14-14-14 Osmocote at recommended rates in early July.

Plants included in the study were *Forsythia intermedia* 'Spring Glory' — Spring Glory Forsythia and *Cotoneaster dammeri* 'Royal Beauty' — Royal Beauty Cotoneaster. All plants were potted May 17, 1983, into 1-gal containers, irrigated, and sprayed for pests as needed according to general nursery practices.

There were three plants/treatment and three replications of each treatment. The limited amount of prepared media available for treatments 1 and 2 restricted the number of plant species selected and numbers of plants/treatment. The height and dry weight were evaluated Sept. 22, 1983, or one growing season following canning.

RESULTS AND DISCUSSION

The results of this preliminary study indicate that vegetative growth and dry weight of forsythia were larger in the Tuefel Products prepared mix of Strawdust 6 — Peat Moss 2 — Perlite 2 fertilized initially with 7 lb of starter fertilizer (Table 1). Sufficient media was not available to fully evaluate growth of cotoneaster in that treatment. The second best treatment for forsythia and best for cotoneaster was the combination of Strawdust 3.5 — Pinebark 3.5 — Peat Moss 1.5 — Sand 1.5. Next best was the treatment of Pinebark 7 — Peat Moss 1.5 — Sand 1.5. Both of the last two treatments were fertilized with 15 lb/cu yd of starter fertilizer at planting. Treatment 3 could be considered a standard treatment for comparison purposes. No other treatments resulted in quality (of either species) sufficient to be considered acceptable by the nursery industry.

The highest foliar color ratings of forsythia with medium, dark or black green color ratings were the same three treatments as indicated above for superior vegetative growth and dry weight (Table 1). Forsythia is a better indicator plant than cotoneaster, so values of forsythia only are shown in Table 1.

The three best treatments were all grown at media pH levels between 5.1 and 5.9 (Table 2), which is considered ideal for nursery crops produced in organic media.

TABLE 2.—Season Ending Media Mineral Element Values of Strawdust Amended Container Grown Forsythia and Cotoneaster.

Treatment	pH		S.S.		NO_3		P		K		Ca		Mg	
	Forsythia	Cotoneaster	Forsythia	Cotoneaster	Forsythia	Cotoneaster	Forsythia	Cotoneaster	Forsythia	Cotoneaster	Forsythia	Cotoneaster	Forsythia	Cotoneaster
Strawdust 6—Peat Moss 2—Perlite 2 (15 lb fertilizer)	5.4	6.1	1.25	0.73	122	64	17	8	71	50	162	80	43	23
Strawdust 6—Peat Moss 2—Perlite 2 (7 lb fertilizer)	5.8	5.3	1.27	1.35	123	127	4	4	39	45	168	184	54	57
Strawdust 7—Peat Moss 1.5—Sand 1.5	5.7	5.5	0.99	0.77	88	81	11	9	44	38	106	92	2	27
Hardwood Bark 7—Peat Moss 1.5—Sand 1.5	6.5	7.0	1.17	0.62	96	48	6	2	67	31	152	88	34	17
Pinebark 7—Peat Moss 1.5—Sand 1.5	5.9	5.1	0.56	0.58	49	53	5	7	24	70	55	63	20	22
Strawdust 3.5—Hardwood Bark 3.5—Peat Moss 1.5—Sand 1.5	6.5	6.1	0.98	0.83	78	85	6	6	47	49	114	115	28	26
Strawdust 3.5—Pinebark 3.5—Peat Moss 1.5—Sand 1.5	5.5	5.2	1.20	0.75	100	74	11	8	58	35	125	91	41	29
Hardwood Bark 3.5—Pinebark 3.5—Peat Moss 1.5—Sand 1.5	6.6	5.6	0.79	1.20	71	100	4	11	42	58	106	125	26	41

TABLE 3.—Season Ending Foliar Mineral Element Values of Strawdust Amended Container Grown Forsythia and Cotoneaster.

	N		P		K		Ca		Mg	
Treatment	Forsythia	Cotoneaster	Forsythia	Cotoneaster	Forsythia	Cotoneaster	Forsythia	Cotoneaster	Forsythia	Cotoneaster
Strawdust 6—Peat Moss 2—Perlite 2 (15 lb fertilizer)	3.03	2.83	0.25	0.28	1.6	1.8	0.9	1.3	0.5	0.3
Strawdust 6—Peat Moss 2—Perlite 2 (7 lb fertilizer)	2.17	2.76	0.15	0.28	0.5	1.5	1.1	1.4	0.6	0.4
Strawdust 7—Peat Moss 1.5—Sand 1.5	2.61	2.64	0.23	0.30	1.7	1.7	0.8	1.6	0.4	0.4
Hardwood Bark 7—Peat Moss 1.5—Sand 1.5	1.75	2.33	0.17	0.23	1.4	1.6	0.7	1.6	0.3	0.3
Pinebark 7—Peat Moss 1.5—Sand 1.5	1.46	1.84	0.13	0.19	0.8	1.4	1.0	1.7	0.5	0.4
Strawdust 3.5—Hardwood Bark 3.5—Peat Moss 1.5—Sand 1.5	2.22	2.88	0.22	0.32	1.6	1.7	0.7	1.6	0.3	0.3
Strawdust 3.5—Pinebark 3.5—Peat Moss 1.5—Sand 1.5	1.59	2.22	0.13	0.20	0.7	1.2	0.9	1.6	0.5	0.4
Hardwood Bark 3.5—Pinebark 3.5—Peat Moss 1.5—Sand 1.5	1.66	2.42	0.19	0.26	1.3	1.7	0.9	1.6	0.4	0.3

	Mn		Fe		B		Cu		Zn	
	Forsythia	Cotoneaster	Forsythia	Cotoneaster	Forsythia	Cotoneaster	Forsythia	Cotoneaster	Forsythia	Cotoneaster
Strawdust 6—Peat Moss 2—Perlite 2 (15 lb fertilizer)	318	72	101	87	33	57	4	3	236	171
Strawdust 6—Peat Moss 2—Perlite 2 (7 lb fertilizer)	249	80	313	109	33	56	5	4	168	148
Strawdust 7—Peat Moss 1.5—Sand 1.5	135	66	68	85	25	64	5	4	166	170
Hardwood Bark 7—Peat Moss 1.5—Sand 1.5	139	56	65	106	25	62	3	3	99	126
Pinebark 7—Peat Moss 1.5—Sand 1.5	262	78	233	94	28	61	6	6	159	142
Strawdust 3.5—Hardwood Bark 3.5—Peat Moss 1.5—Sand 1.5	122	63	64	95	23	64	4	4	95	115
Strawdust 3.5—Pinebark 3.5—Peat Moss 1.5—Sand 1.5	127	55	120	80	29	58	5	4	128	121
Hardwood Bark 3.5—Pinebark 3.5—Peat Moss 1.5—Sand 1.5	119	51	64	92	27	61	5	4	119	117

TABLE 4.—Season Ending Percent Air Filled Pore Space and Media Breakdown of Strawdust Amended Container Media.

Treatment	Percent Air Filled Pore Space	Media Breakdown*
Strawdust 6—Peat Moss 2—Perlite 2 (15 lb fertilizer)	15.9 de†	4.3 cm
Strawdust 6—Peat Moss 2—Perlite 2 (7 lb fertilizer)	31.9 a	2.8 cm
Strawdust 7—Peat Moss 1.5—Sand 1.5	21.1 bc	4.7 cm
Hardwood Bark 7—Peat Moss 1.5—Sand 1.5	12.7 e	2.0 cm
Pinebark 7—Peat Moss 1.5—Sand 1.5	21.7 bc	1.0 cm
Strawdust 3.5—Hardwood Bark 3.5—Peat Moss 1.5—Sand 1.5	23.7 b	3.6 cm
Strawdust 3.5—Pinebark 3.5—Peat Moss 1.5—Sand 1.5	31.9 a	2.3 cm
Hardwood Bark 3.5—Pinebark 3.5—Peat Moss 1.5—Sand 1.5	17.4 cd	1.0 cm

*Measured as shrinkage within the container from a known filling point.

†Means with similar letters not significantly different according to Tukey's studentized range test at the 5 % level.

An examination of the foliar mineral element values in Table 3 indicates for the top three treatments that, in general, nitrogen, phosphorus, and potassium are relatively low in comparison to other treatments. Magnesium was higher for the top three treatments and iron was consistently high in forsythia foliage. Quite possibly the high iron and magnesium levels contributed to the darker green foliage observed in forsythia.

The highest percentage of air-filled pore space occurred in the three media which resulted in the greatest vegetative growth (Table 4). The greatest amount of media decomposed during the season in the treatments containing strawdust. Long term studies are needed to determine the expected life of strawdust as a component of container media.

In conclusion, when strawdust or strawdust containing media become available to the nursery trade in Ohio, the results of this study suggest that it should be evaluated by producers as a growing media or as an amendment to same. Results of this study indicate that the prepared media of Strawdust 6 — Peat Moss 2 — Perlite 2 and the amendment of Strawdust 3.5 with Pinebark 3.5 — Peat Moss 1.5 — Sand 1.5 resulted in forsythia and cotoneaster growth equal to or superior to Pinebark 7 — Peat Moss 1.5 — Sand 1.5, an industry standard.

Growth of Container Grown Nursery Stock Produced in Composted Municipal Sludge Amended Media

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

ABSTRACT

Composted municipal sludge (CMS) from the cities of Akron and Columbus, Ohio, was used as an amendment to pinebark or hardwood bark media for the production of container grown nursery stock. 'Emerald 'N Gold' euonymus grew well in the treatments with Columbus CMS at 50% the first season and in nearly all CMS treatments after 2 years. 'Goldfinger' potentilla grew best with Columbus CMS at 30% and 50%, by volume, of the media with pinebark the first season. Growth of potentilla was very good in all media treatments at the conclusion of the second growing season. Cranberry cotoneaster responded well to Columbus CMS at 50% with either pinebark or hardbark. Columbus CMS at 30% was also a very acceptable treatment for cotoneaster growth.

INTRODUCTION

Composted municipal sludge (CMS) has been available for commercial use by the horticulture industry on the east coast for several years. Numerous studies have shown its value as a media amendment for production of landscape plants (1, 3, 4, 5, 6, 7, 8, 9). Until 1982 no CMS had been available from Ohio sources. At that time the city of Akron provided CMS for experimental use. In 1983 the city of Columbus began to market CMS on a limited basis.

Previous studies have indicated that CMS from different sources such as Beltsville, Md., and Philadelphia, Pa., will vary in pH (2, 3) and require different additives. Recognizing potential differences in sources, a study was undertaken to compare growth of container grown nursery plants produced in CMS from two Ohio sources at two additive levels. Initial studies in 1982 with the Akron CMS source indicated that 30% of the media produced very satisfactory results (5, 6). However, if a greater percent of CMS is used, production costs would be reduced because pinebark and hardwood bark cost between $20 and $30/cu yd while CMS is priced at $9/cu yd. Thus, the two sources of CMS were used at 30% and 50% of the total mix, substituting the CMS for the more expensive bark sources.

MATERIALS AND METHODS

The CMS for this evaluation was prepared from two sources. The Akron source was prepared by the Paygro Co. of South Charleston, Ohio, because the Akron facility was still under construction. The Columbus CMS was prepared by the city at the composting site at South Waverly. Both facilities utilize a polymer-dewatering system.

Media formulations included two controls without CMS and eight mixes incorporating 3 or 5 parts of CMS with pinebark or hardwood bark and sphagnum peat as follows on a volume basis:

Pinebark 8 — Peat 2
Hardbark 8 — Peat 2
Columbus CMS 3 — Pinebark 5 — Peat 2
Columbus CMS 3 — Hardbark 5 — Peat 2
Columbus CMS 5 — Pinebark 3 — Peat 2
Columbus CMS 5 — Hardbark 3 — Peat 2
Akron CMS 3 — Pinebark 5 — Peat 2
Akron CMS 3 — Hardbark 5 — Peat 2
Akron CMS 5 — Pinebark 3 — Peat 2
Akron CMS 5 — Hardbark 3 — Peat 2

Peat was kept constant to study the effect of substituting CMS for bark. The media were mixed and placed in 2-gallon poly bag containers and thoroughly leached of excess soluble salts until all levels were below 2.5 mmhos/cm. Within 2 days the salts levels were all well below 2.5. If leaching is not thorough, plant phytotoxicity is likely to occur.

Elemental sulfur in granular, water degradable form was incorporated at the rate of 1.0 lb/cu yd into all pinebark based media and 3.0 lb/cu yd into all hardwood based media.

Rooted cuttings of *Euonymus fortunei* 'Emerald 'N Gold', *Potentilla fructicosa* 'Goldfinger', and *Cotoneaster apiculata* were planted April 20, 1983. All plants were top dressed with an 18-6-12, 8-9 month formulation of Osmocote at 1 tablespoon/container on June 14 and July 26, 1983, and May 15, 1984.

There were five plants/species/treatment and three replications of each treatment placed in a randomized block design in the container nursery at The Ohio State University.

Plants were watered, sprayed, and weeded, as necessary, for the next two growing seasons. All plants were overwintered under a poly covered quonset shaped hoop house.

Data recorded during the study included vegetative growth ratings, vegetative growth, and dry weight.

RESULTS AND DISCUSSION

Euonymus

The monthly visual evaluation of the vegetative growth of 'Emerald 'N Gold' euonymus during 1983 was superior all summer in the treatment of Columbus CMS 5 — Pinebark 3 — Peat 2 (Table 1). Plant growth in September in the treatment of Columbus CMS 5 —Hardbark 3 — Peat 2 was also greater.

Measurements of vegetative growth (Table 4) in Sep-

---

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

tember 1983 indicated that the greatest growth was in the Columbus CMS 5 — Hardbark 3 — Peat 2 treatment. However, by the end of the second growing season there were no differences among the treatments except that Pinebark 8 — Peat 2 plants were inferior to the others.

The dry weight measurements (Table 5) at the end of the 1983 growing season indicated the best treatment to be Columbus CMS 5 — Pinebark 3 — Peat 2. The greatest dry weight in 1984 occurred in the treatment of Columbus CMS 5 — Hardbark 3 — Peat 2.

Euonymus responded well to the treatments with CMS and in particular to the Columbus source at 50% of the mix in both pinebark and hardbark.

TABLE 1.—Monthly Visual Evaluation of Vegetative Growth of Euonymous During 1983.

Treatment	Visual Evaluation*			
	June 6	July 15	August 12	September 16
Pinebark 8—Peat 2	6.8 b†	7.3 ab	6.3 b	7.1 abc
Hardbark 8—Peat 2	3.4 de	3.7 de	4.1 cd	4.5 d
Columbus CMS 3—Pinebark 5—Peat 2	4.7 cd	5.3 cd	5.5 bc	7.3 ab
Columbus CMS 3—Hardbark 5—Peat 2	4.3 cde	4.7 cde	5.9 b	7.3 ab
Columbus CMS 5—Pinebark 3—Peat 2	8.5 a	8.5 a	8.7 a	8.3 a
Columbus CMS 5—Hardbark 3—Peat 2	5.9 bc	6.3 bc	6.1 b	8.5 a
Akron CMS 3—Pinebark 5—Peat 2	4.0 de	4.5 cde	4.2 cd	6.3 bcd
Akron CMS 3—Hardbark 5—Peat 2	2.9 e	3.3 e	3.4 d	5.2 cd
Akron CMS 5—Pinebark 3—Peat 2	3.8 de	4.1 de	4.2 cd	7.4 ab
Akron CMS 5—Hardbark 3—Peat 2	4.8 cd	5.2 cde	5.1 bc	7.3 abc

*Each value represents means of 15 evaluations, with 1 = dead plant and 10 = largest and most vigorous plant.

†Means with same letters not significantly different at the 5% level according to Tukey's studentized range test.

TABLE 2.—Monthly Visual Evaluation of Vegetative Growth of Potentilla During 1983.

Treatment	Visual Evaluation*			
	June 6	July 15	August 12	September 16
Pinebark 8—Peat 2	4.1 g†	6.9 de	6.3 bc	8.2 ab
Hardbark 8—Peat 2	2.3 i	2.9 f	3.3 e	5.8 c
Columbus CMS 3—Pinebark 5—Peat 2	9.0 b	8.8 b	8.5 a	8.9 a
Columbus CMS 3—Hardbark 5—Peat 2	5.1 f	6.3 e	5.5 cd	7.5 b
Columbus CMS 5—Pinebark 3—Peat 2	9.8 a	9.9 a	7.1 ab	8.8 ab
Columbus CMS 5—Hardbark 3—Peat 2	6.9 d	7.4 cd	6.7 bc	8.5 ab
Akron CMS 3—Pinebark. 5—Peat 2	6.7 d	7.6 c	7.5 ab	8.1 ab
Akron CMS 3—Hardbark 5—Peat 2	3.1 h	6.9 de	4.7 de	7.5 b
Akron CMS 5—Pinebark 3—Peat 2	7.9 c	7.9 c	7.2 ab	8.5 ab
Akron CMS 5—Hardbark 3—Peat 2	5.9 e	7.3 cd	7.3 ab	8.3 ab

*Each value represents means of 15 evaluations, with 1 = dead plant and 10 = largest and most vigorous plant.

†Means with same letters not significantly different at the 5% level according to Tukey's studentized range test.

Potentilla

As rated visually in June and July, the significantly best growth of Goldfinger potentilla was in the treatment of Columbus CMS 5 — Pinebark 3 — Peat 2 (Table 2). Growth was excellent throughout the season but in August and September a number of other treatments resulted in superior plant growth.

Upon actual measurement at the end of the growing season, the largest plants also were observed in the treatment of Columbus CMS 3 — Pinebark 5 — Peat 2 (Table 4). The largest plants in 1984 were in the Columbus CMS 3 — Hardbark 5 — Peat 2 treatment.

The 1983 dry weight data indicated the heaviest plants to be those which initially grew best, *i.e.*, those in Columbus CMS 5 — Pinebark 3 — Peat 2 (Table 5). However, by the end of 1984 the growth of potentilla in all treatments had become nearly equal. Potentilla is rapid growing and the effect of media treatments was not a factor after two growing seasons.

In summary, potentilla appeared to grow equally well with Columbus CMS at either 3 or 5 parts with pinebark as the base in 1983. At the end of the second growing season, almost all other treatments including both sources of CMS and bark resulted in equivalent growth.

Cotoneaster

Cranberry cotoneaster received the highest visual ratings each month during the first growing season in treatments with Columbus CMS at 50% of the media (Table 3). In June and July, the Columbus CMS 5 — Hardbark 3 — Peat 2 treatment resulted in highest plant evaluations. The same CMS source and rate with Pinebark 3 — Peat 2 was the best treatment for cotoneaster growth in August and September.

When measured for growth in width late in 1983, the only treatment not resulting in good growth was the Hardwood Bark 8 — Peat 2 media (Table 4). At the conclusion of 1984, the greatest width was recorded in the treatment of Columbus CMS 5 — Hardbark 3 — Peat 2.

The two best media for cotoneaster growth in 1983 and 1984 were Columbus CMS 3 — Pinebark 5 Peat 2 and Columbus CMS 5 — Hardbark 3 — Peat 2 (Table 5) based on dry weight.

In summary, cotoneaster responded well to Columbus CMS at 50% of the media with hardbark at 30% and/or pinebark at 30%.

Examining the growth of the three species evaluated in this study would indicate that Columbus CMS at 50% of the media assists in promoting early growth. Growth over the course of the 2 years tends to even out some and no one treatment was superior, although Columbus CMS at 30% to 50% of the mix with pinebark or hardbark were usually supporting good growth. The addition of Columbus CMS to the growing media of pinebark or hardbark can be recommended with the species used in this study. Leaching will be necessary to reduce soluble salts and sulfur may be needed to control pH depending on species, source of media, and water.

There was definite winter injury to both cotoneaster and euonymus during the winter of 1983 and 1984. However, there was no correlation with media treatment but correlation with placement in the storage structures, particularly along the sides of the structures where temperatures are normally much lower.

TABLE 3.—Monthly Visual Evaluation of Vegetative Growth of Cotoneaster During 1983.

	Visual Evaluation*			
Treatment	June 6	July 15	August 12	September 16
Pinebark 8—Peat 2	3.8 cd†	4.1 c	3.4 cd	7.0 bc
Hardbark 8—Peat 2	2.2 e	2.3 d	3.3 cd	6.5 c
Columbus CMS 3—Pinebark 5—Peat 2	5.2 bc	5.9 ab	5.6 b	8.7 ab
Columbus CMS 3—Hardbark 5—Peat 2	4.7 bc	5.1 bc	3.6 cd	7.9 abc
Columbus CMS 5—Pinebark 3—Peat 2	6.2 ab	6.6 ab	7.9 a	8.9 a
Columbus CMS 5—Hardbark 3—Peat 2	7.1 a	7.5 a	8.5 a	8.6 ab
Akron CMS 3—Pinebark 5—Peat 2	2.3 de	2.4 d	4.7 bc	7.7 abc
Akron CMS 3—Hardbark 5—Peat 2	2.2 e	2.4 d	2.4 d	6.5 c
Akron CMS 5—Pinebark 3—Peat 2	3.2 de	4.1 c	5.6 b	8.7 ab
Akron CMS 5—Hardbark 3—Peat 2	2.3 de	2.4 d	4.3 bc	8.1 abc

*Each value represents means of 15 evaluations, with 1 = dead plant and 10 = largest and most vigorous plant.

†Means with same letters not significantly different at the 5% level according to Tukey's studentized range test.

TABLE 4.—Vegetative Growth of Euonymus, Potentilla, and Cotoneaster Grown in Composted Municipal Sludge Amended Media.

	Growth (cm)					
	Euonymus 'Emerald 'N Gold' (width)		Potentilla 'Goldfinger' (height)		Cotoneaster apiculata (width)	
Treatment	1983	1984	1983	1984	1983	1984
Pinebark 8—Peat 2	27.4 ab*	31.5 b	49.7 abc	49.4 ab	59.1 a	63.6 bc
Hardbark 8—Peat 2	21.2 b	44.1 ab	42.9 c	49.9 ab	48.0 b	64.8 abc
Columbus CMS 3—Pinebark 5—Peat 2	26.5 ab	48.2 a	54.1 a	52.9 ab	64.2 a	72.6 ab
Columbus CMS 3—Hardbark 5—Peat 2	26.1 ab	38.5 ab	48.3 abc	56.3 a	59.5 a	68.9 abc
Columbus CMS 5—Pinebark 3—Peat 2	24.0 ab	46.3 ab	51.3 ab	52.4 ab	62.1 a	64.8 abc
Columbus CMS 5—Hardbark 3—Peat 2	30.1 a	51.5 a	50.5 ab	51.9 ab	59.5 a	82.8 a
Akron CMS 3—Pinebark 5—Peat 2	24.3 ab	48.5 a	50.7 ab	49.9 ab	59.0 a	52.4 c
Akron CMS 3—Hardbark 5—Peat 2	19.6 b	41.0 ab	45.7 bc	48.5 b	54.0 ab	65.0 bc
Akron CMS 5—Pinebark 3—Peat 2	27.3 ab	46.3 ab	52.2 ab	49.1 b	59.5 a	66.7 abc
Akron CMS 5—Hardbark 3—Peat 2	26.6 ab	52.3 a	52.3 ab	50.3 ab	56.4 ab	67.3 abc

*Means with same letters not significantly different at the 5% level according to Tukey's studentized range test.

TABLE 5.—Dry Weight of Euonymus, Potentilla, and Cotoneaster Grown in Composted Municipal Sludge Amended Media.

	Dry Weight (grams)					
	Euonymus 'Emerald 'N Gold'		Potentilla 'Goldfinger'		Cotoneaster apiculata	
Treatment	1983	1984	1983	1984	1983	1984
Pinebark 8—Peat 2	15.1 bc	41.0 d	71.2 cd	133.5 a	39.8 cd	118.2 abc
Hardbark 8—Peat 2	10.0 c	66.0 bcd	36.0 e	141.0 a	27.4 d	99.2 bc
Columbus CMS 3—Pinebark 5—Peat 2	18.4 b	95.2 ab	84.7 bc	153.5 a	70.2 a	166.7 a
Columbus CMS 3—Hardbark 5—Peat 2	16.4 bc	90.7 ab	76.5 bcd	145.8 a	56.4 abc	158.3 ab
Columbus CMS 5—Pinebark 3—Peat 2	28.4 a	84.0 abc	113.2 a	126.8 a	56.5 abc	121.3 abc
Columbus CMS 5—Hardbark 3—Peat 2	14.6 bc	112.7 a	92.1 abc	143.5 a	64.4 ab	169.3 a
Akron CMS 3—Pinebark 5—Peat 2	19.1 b	66.0 bcd	98.3 ab	152.5 a	43.2 cd	86.0 c
Akron CMS 3—Hardbark 5—Peat 2	9.5 c	53.5 cd	60.9 d	113.7 a	31.1 d	113.0 abc
Akron CMS 5—Pinebark 3—Peat 2	15.2 bc	94.0 ab	82.0 bcd	114.2 a	43.0 cd	129.2 abc
Akron CMS 5—Hardbark 3—Peat 2	15.7 bc	76.7 abcd	82.8 bcd	150.2 a	52.9 bc	110.5 abc

*Means with similar letters not significantly different at the 5% level accordng to Tukey's studentized range test.

LITERATURE CITED

1. Chaney, R. L., J. B. Munns, and H. B. Cathey. 1980. Effectiveness of digested sewage sludge compost in supplying nutrients for soilless potting media. J. Am. Soc. Hort. Sci., 105(4):485-492.
2. Delchem Sales, Inc. Earthlife minimum guaranteed analysis. Available from 444 N. 3rd St., 2nd floor, Philadelphia, PA 19123.
3. Gouin, Francis R. Sept. 2, 1977. Screened sludge compost in potting mixes. Southern Florist & Nurseryman, pp. 29-32.
4. Gouin, Francis R. March-April 1982. Composted sewage sludges for potting mixes. Maryland Nurserymen's News, pp. 3-5.
5. Logan, T. J., W. R. Faber, and E. M. Smith. 1984. Use of composted sludge on different crops. OARDC, Ohio Report, 69(3):37-40.
6. Loveless, Jan B. 1983. An evaluation of composted municipal sludge from Akron, Ohio, for container nursery production of *Rhododendron* 'Rosebud' and *Weigela florida* 'Newport Red'. M.S. Thesis, The Ohio State Univ., Columbus.
7. Sanderson, Kenneth C. and Willis C. Martin, Jr. 1974. Performance of woody ornamentals in municipal compost medium under nine fertilizer regimes. Hort. Sci., 9(3):242-243.
8. Sanderson, Kenneth C. 1980. Use of sewage-refuse compost in the production of ornamental plants. HortSci., 15(2):173-178.
9. Stoner, Harold E. 1976. Composting sewage sludge in the nursery. Int. Plant Prop. Soc. Proc., 26:193-194.

Soil Temperature Effects on Root Regeneration of Scarlet Oak Seedlings[1]

DANIEL K. STRUVE[2] and BRUNO C. MOSER[3]

ABSTRACT

As root zone temperature increased from 10° to 26° C, the time to adventitious root initiation decreased, the number of new roots initiated and the root elongation rate increased in root pruned scarlet oak seedlings (*Quercus coccinea* Muenchh). Maximum rates of root regeneration occurred at 26° C, while no root regeneration occurred at 10° C. The critical minimum root zone temperature for root regeneration in scarlet oak seedlings lies between 10° C and 16° C.

INTRODUCTION

Scarlet oak is considered difficult to transplant (4). A characteristically coarse root system and a relatively slow root regeneration rate are responsible for the transplanting difficulty (14). Auxin applications have been shown to result in increased numbers of roots initiated, but auxin delays the rate of root initiation and root elongation (13).

Soil temperature affects all three root regeneration parameters: time to root initiation, number of roots initiated, and root elongation rate (2, 5, 7, 11, 12). The optimum soil temperature for root regeneration varies with species and the root regeneration parameter measured. For instance, the best soil temperature for root elongation was 12-15° C for *Acer rubrum* (8), 28° C for *Tilia americana* (1), 18° C for *Prunus persica* (9), *Picea abies* (8), and *Pinus taeda* (2), and between 15° and 20° C for *Pinus ponderosa*, depending on its source (11). Low temperatures, less than 10° C, retard root regeneration by inhibiting root elongation, but increase root initiation compared to higher temperatures (7, 8, 15).

This study investigated the effects of soil temperature on three root regeneration parameters: time to root initiation, number of roots initiated, and root elongation rate of newly initiated roots of root pruned scarlet oak seedlings.

MATERIALS AND METHODS

Ten scarlet oak acorns, which had been stratified at 3° C for 90 days, were sown in each of eight root observation boxes on March 7 (13). A 1:1 (v:v) peat:vermiculite medium amended with 0.52 kg/m^3 granular wetting agent, 0.68 kg/m^3 trebel superphosphate, and 62 gm/m^3 fritted trace elements was used. The seedlings were watered as needed and fertilized weekly with 250 ppm N from a 20-20-20 water soluble fertilizer.

The acorns germinated and seedlings developed in a 23° C day/18° C night greenhouse under natural photoperiods. By April 22 the seedlings averaged 15 cm in height with 35 cm long taproots. The root observation boxes were then placed in each of four insulated plywood boxes (Fig. 1). The interior walls of these boxes were lined with heating cables calibrated to give root zone temperatures of 10°, 16°, 21°, or 26° C ± 1° C at a 5 cm medium depth. Root zone temperature was monitored hourly (Honeywell Electronic 112 recorder). The four insulated boxes were placed in a Warren-Sherer model CEL-25-7 growth chamber at 10° ± 1° C ambient temperature and a photosynthetic photon flux density at medium level of 20 μE m^{-2}s^{-1} between 400 and 700 nm (as measured with a Lambda LI-185 Quantum/Radiometer/Photometer). The light was supplied by cool-white fluorescent bulbs supplemented with 20% wattage from incandescent bulbs under a 16-hour photoperiod.

After a 5-day acclimation period, the seedlings were thinned to five uniform seedlings in each root observation box and the tap roots were cut to a 15 cm length. The number of initiated roots (defined here as any root greater than 2 mm in length with a white unsuberized root tip) and the amount of root elongation were recorded every third day for (at most) five randomly

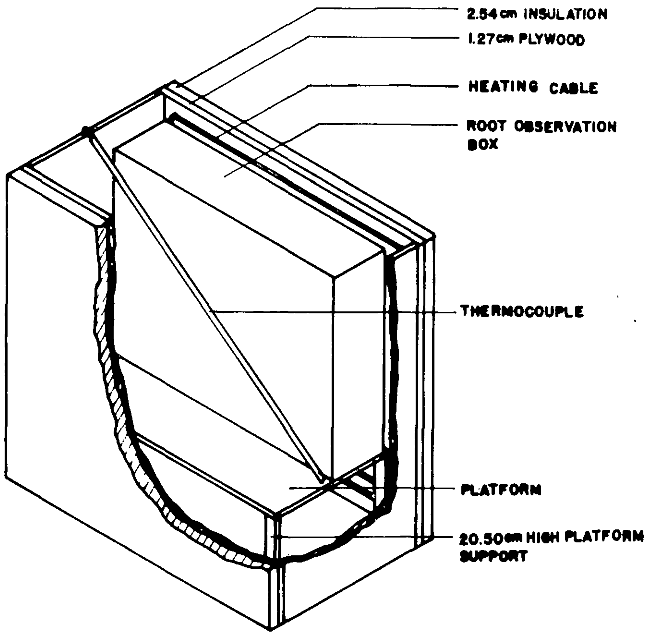

FIG. 1.—Root zone temperature control box. Overall dimensions 40 × 60 × 60 cm including styrofoam insulation.

---

[1] This research was supported in part by a grant from the Horticultural Research Institute, American Association of Nurserymen, and in part by the New Jersey Agricultural Experiment Station.

[2] Assistant Professor, Dept. of Horticulture, The Ohio State University.

[3] Professor and Head, Dept. of Horticulture, Purdue University.

selected roots per seedling. Data were collected from the same five roots for the duration of the experiment. Data were collected over a 21-day period and terminated prior to that when a root reached the bottom of a root observation box or showed no elongation for three consecutive recording periods.

RESULTS AND DISCUSSION

Seedlings grown at root zone temperatures of 26° and 21° C initiated roots 6 days after pruning, while those at 16° C initiated roots after 12 days (Fig. 2). At root zone temperatures of 10° C, no root elongation occurred during the 21-day time span of the experiment, even though there were signs that new root primordia had been initiated. The number of roots initiated per seedling (Fig. 2) and root elongation rate (Fig. 3) increased with increasing root zone temperature, with maximum rates of root regeneration occurring at 26° C.

Adventitious root regeneration has been divided into different phases, with each having different environmental and hormonal requirements (3, 10). In this study, root initiation occurred at all root zone temperatures, but root development and elongation occurred only at temperatures of 16° C or above. Similar results have been found with peach (9), Douglas fir (12) and loblolly pine (15).

The data suggest that soil temperatures below 16° C result in significantly retarded root regeneration and that the critical minimum soil temperature for new root elongation lies between 10° and 16° C when air and shoot temperatures are relatively low (*e.g.*, 10° C). These cool air and soil temperatures are typical of the early spring season when scarlet oak is normally transplanted. Our results indicate that, since greatest root regeneration occurs at soil temperatures of 16° C or above, the transplanting of scarlet oak should be delayed until soil temperatures are warming or steps might be taken to use heat generating organic mulches, backfill materials, or even heating probes to assist in temporary root zone warming. This type of treatment would speed up the root regeneration process and may enhance survival potential and result in more rapid establishment for this relatively difficult to transplant species.

LITERATURE CITED

1. Ashby, W. C. 1960. Seedling growth and water uptake by *Tilia americana* at several root temperatures. Bot. Gaz., 121:228-233.
2. Barney, C. W. 1951. Effects of soil temperature and light intensity in root growth of loblolly pine seedlings. Plant Physiol., 26:146-163.
3. Cameron, R. J. and D. A. Rook. 1974. Rooting stem cuttings of *Radiata* pine: Environmental and physiological aspects. N.Z.J. For. Sci., 4:291-298.
4. Dirr, M. A. 1977. Manual of Woody Landscape Plants. Stipes Publishing Co., Champaign, Ill.
5. Domanski, R., T. T. Kozlowski, and S. Sasaki. 1969. Interactions of applied growth regulators and temperature on root initiation in *Salix* cuttings. J. Amer. Soc. Hort. Sci., 94:39-41.
6. Heide, O. M. 1974. Growth and dormancy in Norway spruce ecotypes (*Picea abies*). I. Interactions of photoperiod and temperature. Physiol. Plant., 30:1-12.
7. Larson, M. M. 1970. Root regeneration and early

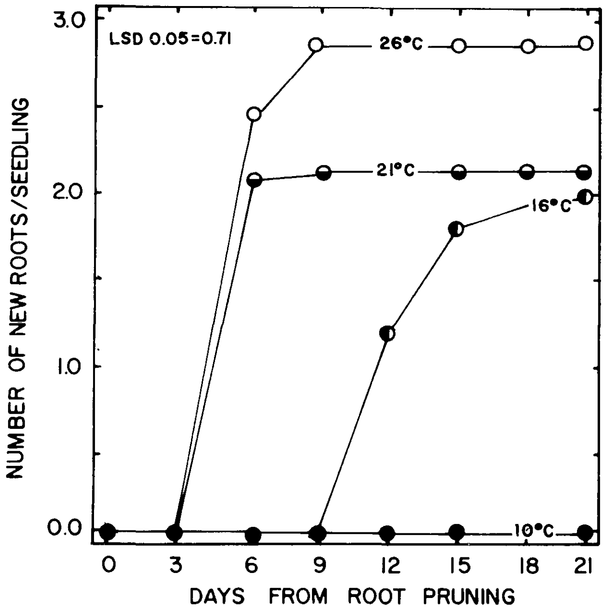

FIG. 2.—The number of newly initiated roots of root pruned scarlet oak seedlings grown at 10° C air temperature and root zone temperature of 10°, 16°, 21°, and 26° C.

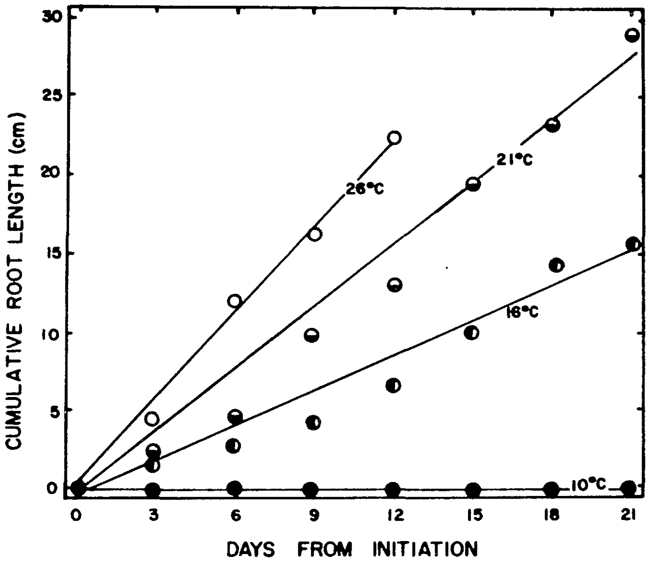

FIG. 3.—Cumulative length of newly initiated roots of root pruned scarlet oak seedlings grown at 10° C air temperature and root zone temperatures of 10°, 16°, 21°, and 26° C.

growth of red oak seedlings: Influence of soil temperature. For. Sci., 16:442-446.

8. Lyford, W. H. and B. F. Wilson. 1966. Controlled growth of forest tree roots: technique and application. Harvard Forest Paper 16.
9. Nightingale, G. T. 1936. Effects of temperature on growth, anatomy and metabolism of apple and peach roots. Bot. Gaz., 96:581-639.
10. Smith, D. R. and T. A. Thorpe. 1975. Root initiation in cuttings of *Pinus radiata* seedlings. I. Development sequence. 26:184-192.
11. Stone, E. C. and G. H. Schubert. 1959. Root regeneration by ponderosa pine seedlings lifted at different times of the year. For. Sci., 5:322-332.
12. Stone, E. C., J. L. Jenkinson, and S. L. Krugman. 1962. Root regeneration potential of Douglas-fir seedlings lifted at different times of the year. For. Sci., 8:288-297.
13. Struve, D. K. and B. C. Moser. 1984. Auxin effects on root regeneration of scarlet oak seedlings. J. Amer. Soc. Hort. Sci., 109:91-95.
14. Struve, D. K. and B. C. Moser. 1984. Root system root regeneration characteristics of pin and scarlet oak. HortScience, 19:123-125.
15. Stupendick, J. T. and K. R. Shepard. 1979. Root regeneration of root-pruned *Pinus radiata* seedlings. Effects of air and soil temperature. Aust. For., 42:142-149.

Lighting *Viburnum opulus* 'Nanum' Cuttings to Increase Winter Survival

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

ABSTRACT

Viburnum species are generally easy to root from softwood cuttings but often very difficult to overwinter successfully. To promote storage survival percentage of *Viburnum opulus* 'Nanum', light duration treatments were initiated following rooting of cuttings July 20, 1983. Some 24% of the control plants, those without light treatments, survived the winter of 1983-84. Those plants under 450 foot-candles from July 20 to Sept. 14, 1983, survived at a rate of 68%. Winter survival of plants was less effective in shorter and longer light interval treatments.

INTRODUCTION

The survival during winter of rooted cuttings of Viburnum has been a problem for many years for commercial plant propagators. Viburnum are relatively easy to root but survival often decreases markedly during winter storage. In some cases the stems split at the soil line, while in other cases the plants do not break bud in spring. Attempts have been made to build overwintering structures to protect against severe low temperature in autumn (2).

Research has indicated that cuttings potted after rooting in summer will not survive the winter nearly as well as those left undisturbed (1) and this is the normal industry practice.

Waxman (3) suggested that normal autumn defoliation, before cuttings have had sufficient time to build up a reserve of carbohydrates, may explain why cuttings die during storage. Long photoperiods very often will delay defoliation and will give the cutting a longer period of time to build up a supply of sugars and develop a more extensive root system. However, Waxman's research did not specifically indicate that lighting cuttings influenced overwintering.

The purpose of this study was to evaluate the effects of extended photoperiods on growth and overwintering survival of *Viburnum opulus* 'Nanum'.

MATERIALS AND METHODS

Viburnum opulus 'Nanum' cuttings were selected for this study because the authors and others have experienced difficulty in overwintering this cultivar. Cuttings taken June 14, 1983, were placed under intermittent mist in a medium of peat and perlite (2:3 by volume).

Plants were placed under lights on July 20, 1983, and 25 plants were removed every 2 weeks and placed outside in an uncovered poly house as follows:

Removed from Lights
Control ——— No lights
2 weeks ——— August 3
4 weeks ——— August 17
6 weeks ——— August 31
8 weeks ——— September 14
10 weeks ——— September 28
12 weeks ——— October 12

The high pressure sodium lamps resulted in 450 foot-candles at plant height operated from 10:00 p.m. to 2:00 a.m. nightly.

All plants were fertilized with 1/2 teaspoon of 18-6-12 Osmocote on July 20, 1983, watered, and sprayed for spider mites as needed. All plants were overwintered in an unheated, quonset shaped, poly covered storage house from mid-November to the first week of May.

RESULTS AND DISCUSSION

The placement of plants under lights resulted in promotion of growth through the 8th week (Table 1) Sept. 14, but not beyond. Plants did not initiate new growth in the first 2 weeks but began to grow in 4 weeks.

In Table 2, the condition of the Viburnums in storage is noted in December, January, and February. In treatments with the longest light exposure, leaf drop was inhibited, leaves remained green, and tissue was injured by low temperature. The longer the time the plants remained under lights, the less normal leaf drop occurred and the greater degree of foliar injury was observed.

On June 13, survival of cuttings was tabulated along with height measurements of living plants (Tables 1 and 3). The control plants which had been transplanted

TABLE 1.—Height of Viburnum in Autumn Following Removal from Lights and Prior to Storage, and in Spring Following Storage in an Unheated Poly House.

Treatment	Average Height Nov. 30, 1983	Average Height June 13, 1984
Control (no light)	6.4 cm	10.2 cm
Light — 2 weeks	6.0 cm	11.4 cm
Light — 4 weeks	8.2 cm	12.4 cm
Light — 6 weeks	10.8 cm	15.4 cm
Light — 8 weeks	13.1 cm	14.5 cm
Light — 10 weeks	13.0 cm	14.4 cm
Light — 12 weeks	13.5 cm	15.0 cm

---

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

TABLE 2.—Condition of Viburnum in Unheated Poly Storage House During December, January, and February of 1983-84.

Date and Treatment	Plant Condition
December 28, 1983	
Control	100% Leaf drop
Light — 2 weeks	90% Leaf drop, remaining green
Light — 4 weeks	40% Leaf drop, dull red-green fall color
Light — 6 weeks	40% Leaf drop, dull red-green fall color
Light — 8 weeks	16% Leaf drop, dull red-green fall color
Light — 10 weeks	0% Leaf drop, freeze damage 92% leaves
Light — 12 weeks	0% Leaf drop, freeze damage 94% leaves
January 27, 1984	
Control	100% Leaf drop
Light — 2 weeks	100% Leaf drop
Light — 4 weeks	44% Leaf drop; remainder brown, frozen, attached
Light — 6 weeks	40% Leaf drop; remainder brown, frozen, attached
Light — 8 weeks	20% Leaf drop; remainder brown, frozen, attached
Light — 10 weeks	4% Leaf drop; most leaves brown, some green
Light — 12 weeks	0% Leaf drop; most leaves brown, some green
February 23, 1984	
Control	100% Leaf drop
Light — 2 weeks	100% Leaf drop
Light — 4 weeks	52% Leaf drop, leaves brown and hanging on
Light — 6 weeks	36% Leaf drop, leaves brown and hanging on
Light — 8 weeks	20% Leaf drop, leaves brown and hanging on
Light — 10 weeks	4% Leaf drop, some leaves still green in part
Light — 12 weeks	0% Leaf drop, some leaves still green in part

TABLE 3.—Survival of Viburnum in Spring Following Light Treatment and Winter Storage.

Treatment	Percent Survival June 13, 1984
Control (no lights)	24
Light — 2 weeks	48
Light — 4 weeks	44
Light — 6 weeks	52
Light — 8 weeks	68
Light — 10 weeks	36
Light — 12 weeks	12

from the flats to quart pots during the previous July survived at the rate of 24%. Plant survival under lights after 8 weeks was 68% and represented the most effective treatment. This treatment represented light duration from July 20 through Sept. 14. Longer duration light periods resulted in 36% survival at 10 weeks and 12% at 12 weeks.

Since this was a 1-year evaluation, growers would be encouraged to attempt, on a trial basis only, a similar light duration evaluation. Certainly other species and cultivars should be evaluated and, where possible, earlier cutting dates attempted. Lighting after mid-September will lead to plant growth which may not properly acclimate to winter conditions depending on the weather.

In summary, *Viburnum opulus* 'Nanum' rooted cuttings, potted July 20 and immediately put under an 8-week extended photoperiod at 450 foot-candles, grew approximately 7 additional centimeters during summer than unlighted plants and 68% survived the winter compared to 24% of plants without lights.

LITERATURE CITED

1. Fordham, Alfred J. 1962. Winter survival of some difficult cuttings. Comb. Proc. Plant Prop. Soc., 12:124-125.
2. Templeton, Harvey M. 1957. Overwintering rooted cuttings of viburnum. Comb. Proc. Plant Prop. Soc., 7:79-81.
3. Waxman, Sidney. 1965. Photoperiodic treatment and its influence on rooting and survival of cuttings. Comb. Proc. Int. Plant Prop. Soc., 15:94-97.

Treatments of Etiolated Dormant Rose Shoots[1]

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

ABSTRACT

Packaged or bare-root, hardy garden roses often sprout prior to the normal sales season in April in Ohio if not stored under refrigeration. Pinching sprouts 6-9 inches long by one-half resulted in the highest survival of Rosa x 'Lowell Thomas', 'Queen Elizabeth', and 'Vogue'. The pinch treatment, in general, resulted in better growth and quality of flowers compared to roses which were unpruned or severely pruned when evaluated over a 2-year evaluation period.

INTRODUCTION

Hardware store, garden center, and mass merchandise managers occasionally experience excessive sprouting of dormant packaged or bare-root, hardy garden roses. Sprouting will occur during periods of extended warm temperature prior to the normal sales season. When dormant roses have excessive sprout growth, three options could be exercised: 1) remove the shoots at the point of attachment to the cane, 2) pinch the shoots back to one-half their original length, or 3) allow the shoots to remain without pruning or removal. Long term research has not been conducted to support any of these options.

The inspectors of the Plant Industry Division of the Ohio Dept. of Agriculture charged with determining if nursery stock is pest free and healthy are faced with the dilemma of how to fairly determine the effect of shoot removal, pinching, or neither on overall quality of roses following planting. For these concerns, a study was undertaken to determine the effect of etiolated shoot removal and pinching on plant survival, growth, and flowering over a 2-year period.

MATERIALS AND METHODS

The cultivars selected for this study were *Rosa* x 'Lowell Thomas', a yellow flowered hybrid tea; *Rosa* x 'Queen Elizabeth', a pink blooming grandiflora; and *Rosa* x 'Vogue', a cherry-coral flowered floribunda. All roses were graded No. 1-1/2 when purchased as packaged plants from a nursery in Tyler, Texas, on April 1, 1983.

Roses were received April 1 without sprouts. The plants were placed in a dark cooler maintained at 55° F. On April 18 the etiolated white shoots were pruned to one-half their original length or removed and placed in a greenhouse at 70° F to develop green coloration. On May 2 the plants in their original packages with green shoots were located in a cool greenhouse (without heat) to acclimate to field conditions. On May 13 the plants were planted as bare-root plants in the OSU nursery. The plants were evaluated for condition and bloom quantity every 2 weeks during the growing seasons of 1983 and 1984.

The pruning treatments consisted of: 1) no pruning —etiolated shoots 6-9 inches in length; 2) shoots pinched in half; 3) complete shoot removal from cane. There were three treatments, four plants per treatment per cultivar, and three replications of each treatment.

All plants were watered as necessary, fertilized twice per season, and sprayed once a week for insect and disease control. Plants were overwintered with 12-15 inches of utility wood chips as a mulch around the base.

RESULTS AND DISCUSSION

The average number and length of etiolated shoots per treatment are shown in Table 1. The average numbers of shoots per plant following each growing season are indicated for comparison. There does not appear to be a pattern which would indicate superior shoot quantity as a function of treatment following either growing season. In September 1983 there was an increase in shoot number of 'Queen Elizabeth' and 'Vogue' when compared to April. The cultivar 'Lowell Thomas' had about the same total number of shoots. The winter of 1983-84 was one of the coldest on record in Ohio and roses were severely damaged. Consequently, the quantity of shoots in September 1984 was lower than 1983 in all treatments and with all cultivars.

A better indication of effect of treatments can be noted under plant survival in Table 2. With all three cultivars in 1983 and 1984, the pinch treatment resulted in the highest percent survival. The survival evaluation is significant, especially the season of planting, because roses which do not survive will be expensive to the retailer and supplier to replace or refund in addition to creating unhappy consumers.

At the conclusion of each growing season, plant growth was measured by adding plant height to width and dividing by two. These figures are shown in Table 2 and they suggest that the pinch treatment resulted in slightly larger 'Lowell Thomas' and 'Queen Elizabeth' plants both years. The control or no pinch treatment resulted in slightly larger plants of the cultivar 'Vogue'.

The quantity of flowers per plant of 'Lowell Thomas' was highest in 1983 with the pinch treatment and with the removal treatment in 1984. 'Queen Elizabeth' yielded the highest bloom count per plant both seasons with the pinch treatment. The control treatment of 'Vogue' resulted in the highest bloom count per plant both years.

From the cultivar viewpoint, it appears that the hybrid tea 'Lowell Thomas' and the grandiflora 'Queen Elizabeth', in general, responded most favorably in survival, vegetative growth, and flowering to the pinch treatment. The floribunda Vogue responded most fa-

---

[1] Research conducted in cooperation with the Plant Industry Division, Ohio Dept. of Agriculture.

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

TABLE 1.—Quantity of Rose Shoots at Beginning (April 1983) and Ending of Each Growing Season (September 1983 and September 1984).

Rose Cultivar	Treatment	Average Length of Etiolated Shoots per Plant 4-18-83 Prior to Treatment	Average No. of Etiolated Shoots per Plant 4-18-83	Average No. of Shoots/Live Plant 9-27-83	Average No. of Shoots/Live Plant 9-7-84
'Lowell Thomas'	Control	9.4 inches	4.6	3.4 b*	2.2
(Hybrid Tea)	Pinch	7.7 inches	5.6	5.4 ab	4.4
	Removal	8.2 inches	4.6	6.8 a	4.3
'Queen Elizabeth'	Control	6.1 inches	6.4	8.7 a	5.8
(Grandiflora)	Pinch	6.4 inches	5.6	8.0 a	7.0
	Removal	5.7 inches	6.7	7.0 a	4.7
'Vogue'	Control	5.6 inches	5.6	11.0 a	3.2
(Floribunda)	Pinch	5.9 inches	6.7	9.4 a	3.0
	Removal	6.1 inches	6.7	8.6 a	3.7

*Letters followed by dissimilar letters are significant at the 5% level according to Tukey's studentized range test.

vorably in vegetative growth and flowering to the control or no pinch treatment. However, 50% of the plants died by the end of the first growing season with this cultivar and treatment and for this reason could hardly be recommended. Survival the first season with 'Vogue' was 100% in the pinch treatment, the highest of any treatment or cultivar. Growth and flowering of 'Vogue' in the pinch treatment was slightly but consistently better than the shoot removal treatment. Therefore, the authors conclude that the pinch treatment should be considered the best treatment for all three cultivars.

Accepting that the pinch treatment was generally superior in this evaluation, can we assume that leaving six or seven shoots 6-9 inches long on the plant is an unsatisfactory recommendation for a retailer? Is complete removal of the white shoots also an unsatisfactory treatment? The answer to both questions should be "no".

Leaving entire shoots on the plants could be detrimental, particularly if they attained greater length than the 6-9 inches in this study. The most critical aspect in survival of these roses would be proper acclimation to light and temperature to change shoot color from white to green. Some retailers have these facilities, others do not.

Theoretically, complete shoot removal should weaken the plants through depletion of the carbohydrate supply. Removal of more or longer shoots than those in this study could negatively affect plant survival and growth. Timing could also be a factor here. Strong plants with several canes from the base should survive this treatment better than smaller grades.

In summary, dormant packaged roses with etiolated white shoot growth averaging five to seven shoots per plant approximately 6-9 inches long were evaluated for shoot pruning effect. Shoots pruned in half leaving 3 to 4-1/2 inches on the plant with the plants acclimated to outdoor conditions prior to planting resulted in the highest percent survival, greatest vegetative growth, and greatest quantity of bloom over a 2-year period.

TABLE 2.—Survival, Plant Growth, and Quantity of Rose Blooms Following Each Growing Season.

Rose Cultivar	Treatment	Percent Plant Survival Sept. 1983	Percent Plant Survival Sept. 1984	Plant Growth Sept. 1983	Plant Growth Sept. 1984	Average No. Flowers per Live Plant 1983	Average No. Flowers per Live Plant 1984
'Lowell Thomas'	Control	75 a*	41	15"	18"	13	17
(Hybrid Tea)	Pinch	92 a	66	22"	23"	34	23
	Removal	67 a	58	21"	22"	26	33
'Queen Elizabeth'	Control	83 a	75	25"	29"	68	71
(Grandiflora)	Pinch	83 a	83	26"	30"	77	91
	Removal	75 a	75	21"	27"	53	55
'Vogue	Control	50 b	41	28"	26"	68	141
(Floribunda)	Pinch	100 a	75	26"	21"	64	91
	Removal	67 ab	58	24"	18"	60	65

*Letters followed by dissimilar letters are significant at the 5% level according to Tukey's studentized range test.

Evaluation of Flowering Crabapple Susceptibility to Apple Scab in Ohio — 1984

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

ABSTRACT

The spring season of 1984 in Ohio was fairly wet and cool and consequently the incidence of apple scab was severe. A total of 203 flowering crabapple selections were evaluated in Ohio arboretums and nurseries in 1984. The number found to be susceptible or highly susceptible amounted to 114 selections, and 89 selections were rated as resistant or highly resistant to apple scab.

INTRODUCTION

Apple scab caused by the fungus *Venturia inequalis* is the most serious disease of flowering crabapple in Ohio. The first symptoms of this disease are olive gray spots on the foliage which lead to yellowing and defoliation of certain selections. Extensive defoliation destroys the landscape value of trees, leaves the trees in a weakened condition entering winter, and bloom the following season can be reduced.

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

The purpose of this study was to evaluate flowering crabapple selections for tolerance to apple scab and susceptibility to other diseases.

MATERIALS AND METHODS

Flowering crabapples located in arboretums and nurseries were surveyed in August 1984 for the severity of apple scab infection and for the presence of other diseases such as cedar apple rust and fireblight (Table 1). The latter diseases were not rated because they are usually not serious enough in Ohio to discontinue the planting of a species, hybrid, or cultivar.

The scale used for apple scab evaluations was 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. In some instances more than one notation appears in the table for a given selection because the severity of infection varied from location to location. This variation was most likely due to differences in frequency of rainfall and differences in the average relative humidity in the various locations in Ohio.

RESULTS AND DISCUSSION

Rainfall was above normal in much of Ohio during the April-May period of 1984 and the severity of apple scab was higher than in previous years (2, 3).

The number of flowering crabapple selections rated as susceptible or highly susceptible to apple scab totaled 114, while 89 selections were rated as resistant or highly resistant.

Among the most disease-resistant selections in 1984 were *Malus*: 'Adams', *baccata* 'Jackii', 'Beverly', 'Bob White', 'David', 'Dolgo', 'Donald Wyman', *floribunda*, 'Golden Gem', 'Golden Hornet', *halliana* 'Parkmanii', *hupehensis*, 'Indian Summer', 'Liset', 'Makamik', 'Mary Potter', *micromalus*, 'Ormiston Roy', 'Prairie Rose', 'Profusion', 'Red Jewel', *sargenti*, *sieboldi* 'Fuji', 'Silver Moon', 'White Angel', and *zumi* 'Calocarpa'. These selections should be given highest priorty for production by the nursery industry.

Included among the most disease susceptible selections were *Malus*: 'Almey', 'American Beauty', *arnoldiana*, 'Flame', 'Gorgeous', 'Henry Dupont', 'Hopa', 'Pink Flame', 'Pink Perfection', 'Pink Weeper', 'Purple Wave', 'Aldenhamensis', 'Eleyi', 'Lemoinei', 'Radiant', 'Tanner', and 'White Cascade'. Each of these latter selections should be discontinued from commercial production unless their ornamental value justifies continued production.

For additional information relative to horticultural qualities such as flower, foliage, fruit, and habit of growth, consult the literature (1) or visit an arboretum in early May. In Ohio, the Secrest Arboretum in Wooster, Dawes Arboretum in Newark, and the Holden Arboretum near Mentor all have excellent collections of flowering crabapples.

LITERATURE CITED

1. Brewer, J. E., L. P. Nichols, C. C. Powell, and E. M. Smith. 1979. The flowering crabapple — a tree for all seasons. Coop. Ext. Serv. of Northeast States, NE223, NCR78.
2. Smith, Elton M. 1979. A 10-year evaluation of flowering crabapple susceptibility to apple scab in Ohio. Ohio Agri. Res. and Dev. Ctr., Res. Circ. 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 — 1983. Ohio Agri. Res. and Dev. Ctr., Res. Circ. 279, Ornamental Plants — 1983: A Summary of Research, pp. 22-30.

---

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

TABLE 1.—Susceptibility of Flowering Crabapples to Apple Scab — 1984.

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

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

TABLE 1 (continued).—Susceptibility of Flowering Crabapples to Apple Scab — 1984.

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

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

TABLE 1 (continued).—Susceptibility of Flowering Crabapples to Apple Scab — 1984.

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

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

Tolerance of Azalea, Cotoneaster, and Euonymus to Devrinol, Goal, and Goal Combinations[1]

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

ABSTRACT

The objective of this experiment was to evaluate Devrinol, Goal, and Goal combinations on azalea, cotoneaster, and euonymus. Devrinol 50W and 10G effectively controlled weeds for 2 months with no appreciable injury to azalea or cotoneaster and only slight injury to euonymus. Goal effectively controlled weeds for 3 months but was far too phytotoxic to all three species. Goal at 2.0 lb ai/A and Prowl at 1.0 lb ai/A marketed as Ornamental Herbicide II controlled weeds for 3 months without significant phytotoxicity to azalea or cotoneaster but with slight injury to euonymus in the first month of treatment. Goal at the rate of 2.0 lb ai/A and Surflan at 1.0 lb ai/A sold as Rout controlled weeds for 3 months with slight injury to azalea and cotoneaster early in the season. However, injury was too severe with euonymus to be considered acceptable within the first month of treatment.

INTRODUCTION

The application of pre-emergence herbicides by commercial nurserymen has increased significantly in recent years as the compounds have become increasingly effective in controlling specific, difficult to control weeds. In addition, one application per growing season has often proven effective for most weed species.

A recent introduction, representing the first combination of pre-emergence herbicides registered for nursery crops, has proven quite effective in commercial nurseries. This compound, Ornamental Herbicide II, is a combination of Goal (oxyfluorfen) and Prowl (pendimethalin). A second combination product of Goal and Surflan (oryzalin) was approved by the Environmental Protection Agency for release to the nursery industry during September 1984. This product has the trade name of Rout.

Previous research has shown that Goal can be somewhat phytotoxic to landscape crops (3, 4, 6); however, Goal in combinations is a much safer product. Devrinol, which is used extensively in the commercial nursery industry, is non-phytotoxic but not as long-lasting in respect to effective weed control (1, 2, 5, 7).

The objective of this study was to compare the two Goal combinations with Goal alone and two formulations of Devrinol (Napropamide), a standard product in the industry.

MATERIALS AND METHODS

Crops selected for this evaluation included: *Rhododendron kurume* 'Hershey Red', *Cotoneaster apiculata*, and *Euonymus fortunei* 'Emerald 'N Gold', all commonly grown nursery species. All plants grown from cuttings the previous summer were produced in 1-gallon containers in a media of pinebark-peat (7:3). The plants were potted May 11, 1984, fertilized with Osmocote 18-6-12 at 1 teaspoon/container May 25, and irrigated as needed. The plants were treated with herbicides May 27.

The herbicides and rates used in the study included: Devrinol 50W at 5.0 and 20.0 lb ai/A, Devrinol 10G at 5.0 and 20.0 lb ai/A, Goal 1.6 E at 1.0 and 4.0 lb ai/A, Ornamental Herbicide II at 2.0 and 8.0 lb ai/A Goal and 1.0 and 4.0 lb ai/A Prowl, and Rout at 2.0 and 8.0 lb ai/A Goal and 1.0 and 4.0 lb ai/A Surflan. All herbicide treatments were irrigated in the day of application.

There were three plants/treatment and three replications of each treatment in a randomized block design.

Weed species in the study included foxtail, crabgrass, lambsquarters, purslane, spotted spurge, lesser bittercress, and oxalis.

All evaluations for weed control were on a 1 to 10 scale, with 1 equalling no weed control, 10 equal to perfect weed control, with 7 or above acceptable. Evaluations for phytotoxicity were also on a 1 to 10 scale, with 1 equalling complete crop kill and 10 no crop injury, with 7 or above acceptable.

RESULTS AND DISCUSSION

One desired objective by the user would be to control weeds for the entire growing season with one application. In this evaluation, Devrinol 50W and 10G controlled weeds for 2 months while all Goal compounds were effective for 3 months.

Devrinol 50W and 10G at 1X or recommended rates were completely non-phytotoxic to azalea and cotoneaster and only slightly injurious to euonymus during June and July. The euonymus outgrew the injury and were as large and healthy as the control plants by the end of the growing season.

Goal 1.6E at 1.0 lb ai/A alone was too injurious to all three species to be considered acceptable. The 4X or high rate of Goal killed many of the azalea plants and some other species soon after treatment. Previous research by the authors has shown that the emulsifiable concentrate is extremely phytotoxic to landscape plants (3, 4, 6).

Ornamental Herbicide II at the 1X rate of 2.0 lb ai/A Goal and 1.0 lb ai/A of Prowl slightly injured all three species during the first month but the plants recovered to the point where no injury was observed on any plants on the second evaluation in July or afterwards. Ornamental Herbicide II at the 4X rate was too injurious early in the season on all species evaluated. This injury observation would suggest that the recommended rate

---

[1] The authors acknowledge assistance for this study from Stauffer and Rohm and Haas chemical companies.

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

TABLE 1.—Tolerance of Azalea, Cotoneaster, and Euonymus to Devrinol, Goal, and Goal Combinations.

Treatment	Rate lb ai/A	Weed Control*				Phytotoxicity†											
						Azalea				Cotoneaster				Euonymus			
		June	July	Aug.	Sept.	June	July	Aug.	Sept.	June	July	Aug.	Sept.	June	July	Aug.	Sept.
Check	—	—‡	6	6	5	10	10	10	10	10	10	10	10	10	10	10	10
Devrinol 50W	5.0	—	9	8	7	10	10	10	10	10	10	10	10	8	9	10	10
Devrinol 50W	20.0	—	10	8	6	10	10	10	10	10	10	10	10	7	8	10	10
Devrinol 10G	5.0	—	8	8	6	10	10	10	10	10	10	10	10	8	9	10	10
Devrinol 10G	20.0	—	9	8	6	10	10	10	10	10	9	9	10	7	9	10	10
Goal 1.6E	1.0	—	10	9	8	3	4	6	6	3	4	5	6	2	4	6	7
Goal 1.6E	4.0	—	10	10	10	2	2	2	2	3	3	4	5	2	3	4	6
Ornamental Herbicide II	2.0 and 1.0	—	9	9	9	9	10	10	10	9	10	10	10	7	10	10	10
Ornamental Herbicide II	8.0 and 4.0	—	10	10	10	6	6	7	8	6	6	6	7	6	7	10	10
Rout	2.0 and 1.0	—	10	9	9	7	7	8	8	7	9	10	10	6	9	10	10
Rout	8.0 and 4.0	—	10	10	10	6	7	8	9	7	8	9	10	6	7	10	10

*Visual scale 1-10, with 1 = no weed control, 10 = complete weed control, and 7 = acceptable.
†Visual scale 1-10, with 1 = complete crop kill and 7 or above acceptable.
‡No weed growth extensive enough to evaluate.

of Ornamental Herbicide II is satisfactory for the species in this study, but the level of tolerance of these plants to higher rates is relatively low when compared to a compound such as Devrinol at 4X rates.

Rout applied at the 1X rate of Goal at 2.0 lb ai/A and Surflan at 1.0 lb ai/A was slightly injurious throughout the season on azalea and for 2 months on cotoneaster. Injury was determined to be unacceptable on euonymus early in the season and cannot be recommended for further use. The 4X rate of Rout caused unacceptable injury to both azalea and euonymus, indicating (as with Ornamental Herbicide II) a low level of tolerance for high rates.

As expected, the species of plants revealed various levels of tolerance to the pre-emergence herbicides. Euonymus was injured to some degree by all herbicide or herbicide combinations. Azalea and cotoneaster were tolerant of Devrinol treatments but injured to some degree by Goal and its combination products.

In summary, Devrinol 50W and 10G can be safely used on *Rhododendron* 'Hershey Red', *Cotoneaster apiculata*, and *Euonymus fortunei* 'Emerald 'N Gold'. Satisfactory weed control can be expected for up to 2 months. Goal 1.6E should not be used on these plant species at the rates applied in this evaluation. Ornamental Herbicide II at recommended label rates can be safely used on all three species, with slight injury to be expected early in the season especially on euonymus. Weed control should last for 3 months. Rout at recommended label rates will also slightly injure azalea and cotoneaster early in the season. Rout should not be used on *Euonymus fortunei* 'Emerald 'N Gold'. Season-long control of annual weeds can be expected from Rout.

LITERATURE CITED

1. Smith, Elton M. 1978. An evaluation of prodiamine, oxadiazon and oxyfluorfen in nursery lining-out stock. Research Report, North Central Weed Control Conf., pp. 81-82.
2. Smith, Elton M. 1981. Effects of wettable and granular napropamide on container grown landscape crops. Research Report, North Central Weed Control Conf., 38:11-13.
3. Smith, Elton M. 1981. Oxyfluorfen rate studies on container grown landscape crops. Research Report, North Central Weed Control Conf., 38:9-10.
4. Smith, Elton M. 1982. Rate studies of oxyfluorfen 1G on container grown landscape crops. Research Report, North Central Weed Control Conf., 39:2-3.
5. Smith, Elton M. 1983. Tolerance of canna to pre-emergence herbicides. Research Report, North Central Weed Control Conf., 40:2.
6. Smith, Elton M. 1980. Tolerance of summer flowering bulbs to pre-emergence herbicides. Research Report, North Central Weed Control Conf., 37:8-9.
7. Smith, Elton M. and Sharon A.Treaster. 1984. Tolerance of tulip, daffodil, and crocus to selected pre-emergence herbicides. Ohio Agri. Res. and Dev. Ctr., Res. Circ. 279, Ornamental Plants — 1984: A Summary of Research, pp. 14-15.

Micropropagation of Chimeral African Violets[1]

R. DANIEL LINEBERGER and MARK DRUCKENBROD[2]

ABSTRACT

The pinwheel flowering African violets are periclinal chimeras. Plantlets produced from tissue cultured leaf explants do not flower true-to-type. When intact inflorescences were cultured *in vitro*, plantlets arose in the axils of small bracts on the peduncles. These plantlets flowered between 80% and 95% true-to-type depending on the cultivar under consideration. It is hypothesized that these plantlets result from the growth of dormant axillary buds in the inflorescence. This hypothesis would account for the ability to propagate the periclinal chimeras in a true-to-type fashion since the apical organization of axillary buds is identical to that of the apical meristem.

INTRODUCTION

African violets which have bicolor flowers with a banded arrangement of the colors are termed "pinwheel flowering". The lateral edge of each corolla segment is a different color than the central portion, giving the whole flower a "spoked" appearance, with the "spokes" being one color and the "spaces between the spokes" a different color (Fig. 1A). This patterned arrangement of the flower is not maintained by plants propagated by leaf cuttings, but can be maintained if the terminal portion of the crown is removed and the resulting "suckers" are separated and rooted (1). This technique of propagation gives rise to few propagules per plant, necessitates using large, well-established plants for crown removal, and exposes the stock plants to potential disease problems. The cost of these chimeral plants is therefore very high compared to other African violet types which can be propagated by leaf cuttings.

During the course of experiments designed to separate the component genotypes of several cultivars of pinwheel flowering African violets, it was noted that some plants produced from inflorescence explants produced pinwheeling flowering plants (2). The procedure reported herein is a refinement of this technique suitable for the high fidelity production of chimeral African violets through tissue culture.

MATERIALS AND METHODS

Whole inflorescences of the African violet cultivars 'Valencia', 'Dardevil', 'Desert Dawn', and 'Mauna Loa' served as tissue explants for these studies. Inflorescences were harvested several days prior to the opening of the first flower. Explants were washed in 0.1% Alconox for 5 to 10 min, disinfested in 0.5% sodium hypochlorite for 15 min, and rinsed twice in sterile distilled water. The peduncle was cut 5 to 10 mm below the attachment of the lowest flower buds and the whole inflorescence was placed in 25 x 150 mm test tubes containing 12.5 ml of tissue culture medium. The medium used contained the Murashige and Skoog salt formulation and organics (3), with 100 mg/l myo-inositol, 200 mg/l casein hydrolysate, 3% sucrose, 1 mg/l naphthaleneacetic acid, 1 mg/l benzyladenine, and 0.6% Difco Bacto agar (pH 5.7). Cultures were grown in a culture room providing 16 hr per day of cool white fluorescent light (40μ Einsteins/m^2/sec).

The small plantlets which had formed by 5 weeks were removed from the peduncle and placed in plastic covered foil tins containing moistened Reddi Earth soilless medium (W. R. Grace Co., Cambridge, MA 02140) for rooting. Plantlets were well rooted within 3 to 4 weeks, at which time the plastic lids were loosened to allow the plants to acclimate to lower relative humidities. After approximately 2 to 3 weeks of acclimation, plants were potted into 8 cm plastic pots containing Metromix 350 soilless medium (W. R. Grace Co., Cambridge, MA 02140), placed on a capillary mat watering system in a shaded greenhouse (70% shade), and grown to flowering according to standard African violet culture. Plants were observed through at least one full flowering cycle to ascertain trueness-to-type.

RESULTS AND DISCUSSION

Plants produced through *in vitro* culture of leaf tissue displayed a wide variety of flowering patterns, none of which was the characteristic pinwheel flower (Fig. 1A, compare to Figs. 1B-1L). Similar variation was observed in plants produced from 'Dardevil' leaf tissue (Table 1). Only one type of variant was produced by leaf culture of 'Desert Dawn' (Table 1). In general the plants produced through culture of leaf tissue most often displayed monochromatic (solid color) flowers of the same color as the margin of the corolla segments. Some bicolor, irregular combinations of both colors were produced, but in these studies pinwheel flowering plants were never obtained from leaf tissue (Table 1).

When whole inflorescences were placed in culture, plantlets grew from the axils of the bracts in a short time period (Fig. 2). These plantlets were large enough to be removed for rooting at the end of 5 weeks. Adventitious shoots which differentiated on leaf or peduncle tissue were just barely visible to the naked eye by 5 weeks, suggesting that these shoots arose from dormant vegetative buds in the inflorescence structure. Further evidence in support of this hypothesis was obtained when small plantlets were observed growing in the inflorescence of an intact 'Valencia' plant in the greenhouse. The occa-

---

[1] Partial funding for this project provided by grants from the African Violet Society of America and the Honors Program of the College of Agriculture. The authors thank Joe Takayama for excellent technical assistance. This manuscript is dedicated to the memory of Dale Eyerdom, Grainger Gardens, Medina, Ohio. Mr. Eyerdom, whose encouragement and support were vital to this research, died before the completion of this project.

[2] Associate Professor and Research Associate, Dept. of Horticulture.

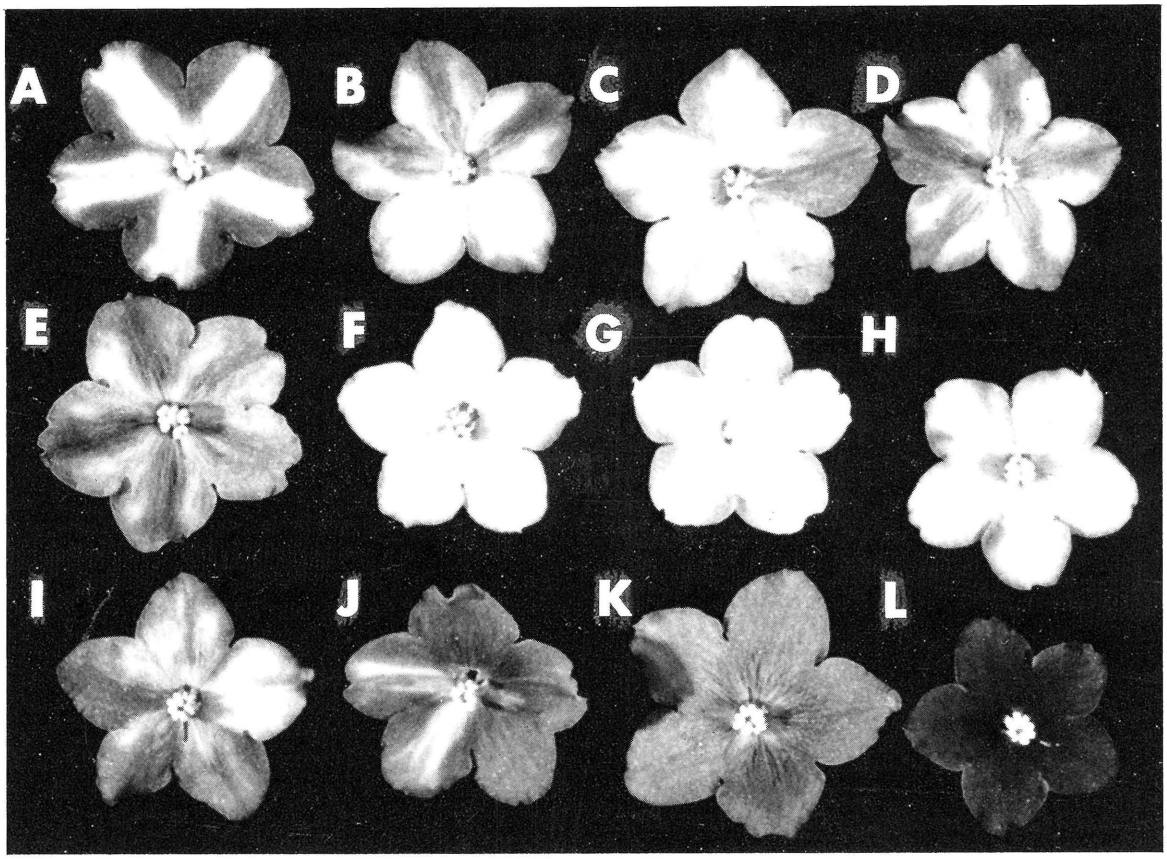

FIG. 1.—Various flowering patterns produced on tissue cultured 'Valencia' African violets. A. 'Valencia', true flower type. B-J. Various unstable off-type flower patterns. K, L. Monochromatic (solid color) flowers of the same color as the segment margin.

TABLE 1.—Flowering Pattern of Plants Produced by *In Vitro* Culture of Leaf Explants of Three Cultivars of Pinwheel Flowering African Violets.

		Plants with Stated Flowering Pattern			
Cultivar	Number of Plants Observed	Margin Color	Center Stripe Color	Bicolor	Pinwheel
'Valencia'	82	67%	0	33%	0
'Dardevil'	49	43%	35%	22%	0
'Desert Dawn'	36	100%	0	0	0

TABLE 2.—Flowering Pattern of Plants Produced by Short Term Culture of Inflorescence Tissue.

			Plants with Stated Flowering Pattern		
Cultivar	Average No. of Plants per Explant After 5 Weeks	No. of Plants Observed	Same Color as Segment Margin	Bicolor	Pinwheel
'Valencia'	9.0	236	1.5%	3%	95.5%
'Dardevil'	3.2	62	8%	0	82%
'Desert Dawn'	3.7	65	20%	0	79%
'Mauna Loa'	2.3	42	0	0	100%

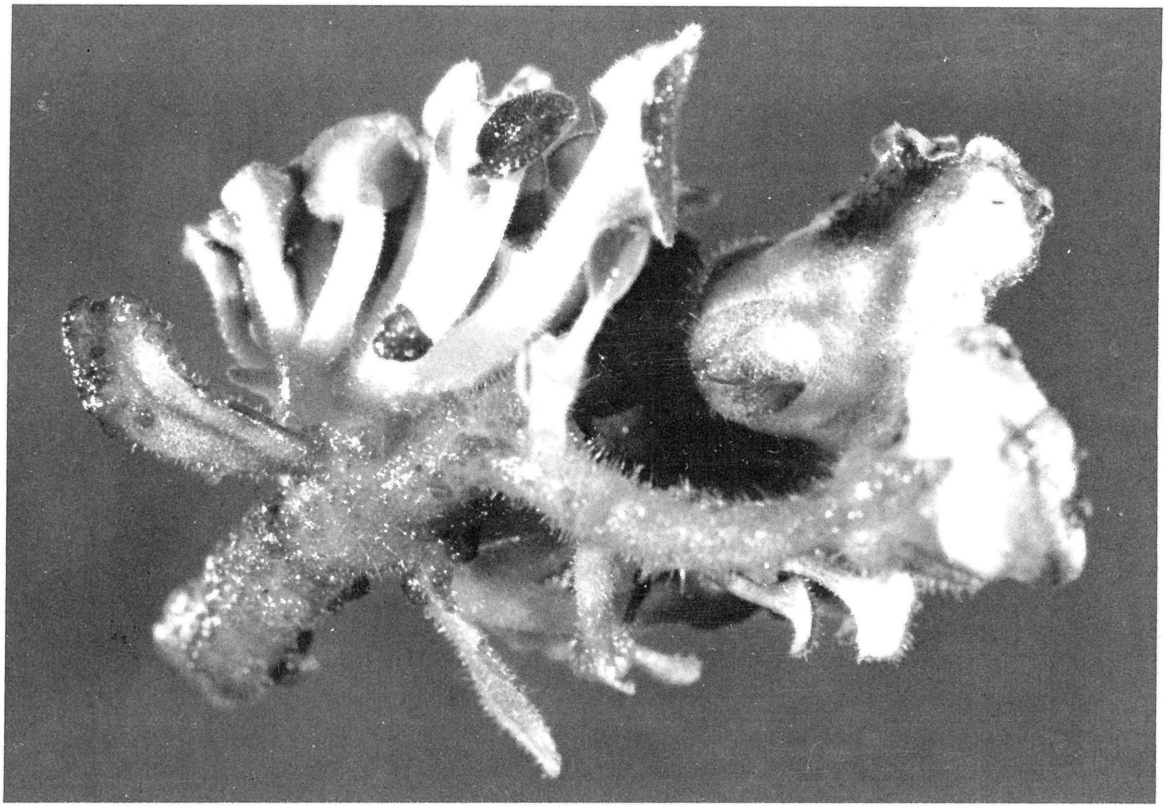

FIG. 2.—Plantlets produced in the bract axil of ‘Valencia’ after 5 weeks *in vitro*.

FIG. 3.—Expanded vegetative plantlets produced on a flowering plant of ‘Valencia’ in the greenhouse.

sional production of true-to-type flowering plants from rooted inflorescences also has been reported (1).

Plants produced through short term culture of inflorescence tissue exhibit a high frequency of true-to-type flowering (Table 2). All of the 'Mauna Loa' plants regenerated through tissue culture were pinwheel flowering, while about 80% of the 'Dardevil' and 'Desert Dawn' plants flowered true-to-type. The multiplication rate varied with cultivar, with 'Valencia' achieving the highest multiplication rate (Table 2). These rates of multiplication appear low for a tissue culture system, but they are quite acceptable since: 1) the system has high fidelity, 2) the explant source (*i.e.*, inflorescence) is produced in abundance on a mature plant, and 3) the taking of explants does not reduce the vigor of the stock plant.

It should be emphasized that the period of *in vitro* culture should not extend beyond 5 or 6 weeks. Adventitious shoots are produced on the peduncle in the vicinity of the plants believed to be produced from the axillary buds and these adventitious shoots would not be pinwheel flowering types. This phenomenon likely accounts for the observed variation in fidelity of the plants produced by the different cultivars. For example, the 'Desert Dawn' cultures may have been "contaminated" by adventitious shoots to a greater degree than the cultures of 'Valencia'.

The inflorescence culture technique should allow true-to-type propagation of other African violet cultivars which are periclinal chimeras. Plants are produced rapidly on the explants and these plants show excellent rooting and survival. Care must be taken, however, to determine the extent of variation in the tissue cultured plants, since trueness-to-type was cultivar dependent and varied between 80% and 100%.

LITERATURE CITED

1. Eyerdom, H. Sept. 1981. Flower color sports and variations in *Saintpaulia* hybrids. Afr. Viol. Mag., pp.33-37.
2. Lineberger, R. D. and M. Druckenbrod. Chimeral nature of the pinwheel flowering African violets. (Manuscript submitted for publication.)
3. Murashige, T. and F. Skoog. 1962. A revised medium for rapid growth and bioassays with tobacco tissue cultures. Physiol. Plant., 15:473-497.

Capital Requirements of Overwintering Structures for Nurseries in Ohio—1984

REED D. TAYLOR, DARYL T. GILLETTE, and ELTON M. SMITH[1]

ABSTRACT

The objective of this study was to develop the resources and costs associated with four model structures used by Ohio nurseries for overwintering nursery products. The four structures were: a simple polyhut, a polyhouse constructed to support a single polyethylene film, a polyhouse equipped with an inflation kit so it would support a double polyethylene film with air being blown between the films, and a polyhouse equipped with both an inflation kit plus heating capacity. The latter house would normally be used for overwintering very temperature-sensitive plants. Costs of constructing the overwintering structures were $120.24 or $0.20 per sq ft for a 6′ x 96′ polyhut, $1,131.58 or $0.84 per sq ft for a 14′ x 96′ polyhouse without inflation or heating capability, $1,201.08 or $0.89 per sq ft for a 14′ x 96′ polyhouse with inflation but not heating capability, and $1,882.18 or, $1.40 per sq ft for a 14′ x 96′ polyhouse with both inflation and heating capability.

INTRODUCTION

Costs of overwintering plant material contribute significantly to the expense of producing nursery products in Northern USDA climatic zones. This is especially true of production in containers where practically all material not previously sold and shipped must be overwintered. A recent study (1) showed polyhouse structures for overwintering accounted for about 20% of the total capital requirements for establishing an 8-acre (growing space) container nursery. The study was based on a 20′ x 200′ structure without inflation or heat. Adding inflation would have only increased costs slightly, while adding inflation and heat would have increased the costs to about 33% of total capital requirements.

The specific objective of this study was to determine construction costs of alternative overwintering structures.

MATERIALS AND METHODS

In the study, four overwintering structures were synthesized using the conceptual framework of economic engineering wherein the 'best proven practice' was included in each model. They were synthesized based on the Columbus, Ohio, area, but would be representative of USDA climatic zones 5 and 6. Each structure measured 14′ x 96′ in the case of polyhouses and 6′ x 96′ in the case of the polyhut. These sizes were suggested by horticulturists as being typical for the two climatic zones.

Data for this study were obtained from wholesale nurseries and nursery suppliers in Ohio during 1984. Prices reflect quantities of materials based on a nursery containing 17 total acres, 350,000 sq ft of growing space, and 210,000 sq ft of polyhouse/hut space. The polyhouse/hut space would be made up of either 156 polyhouses, 365 polyhuts, or some combination of the two.

Construction costs did not include ground preparation, irrigation fixtures, or the cost of poly covers. It was determined that ground preparation and irrigation fixtures should be charged to "grow out" rather than overwintering. Poly covers are variable rather than capital costs. The polyhouse synthesized to contain heating facilities would be constructed with plywood ends, while those without heat would have plastic ends.

RESULTS AND DISCUSSION

Capital investment requirements for constructing a simple 14′ x 96′ polyhouse were itemized under five broad divisions: galvanized steel pipe, wood, hardware, miscellaneous, and labor (Table 1). Construction costs were $1,131.58 or $0.84 per sq ft. Galvanized steel pipe represented 48% or $543.33 of the investment, wood 11% or $115.54, hardware 3% or $42.60, miscellaneous 9% or $100, and labor 29% or $330. Adding a shaded pole blower kit (for where double poly covering would be used) increased construction costs by $69.50 to $1,201.08 or $0.89 per sq ft (Table 2).

Capital investment requirements for constructing a 14′ x 96′ polyhouse with inflation capability and heat were itemized under seven broad divisions: galvanized steel pipe, wood, hardware, heating system, inflation, miscellaneous, and labor (Table 3). Construction costs were $1,882.18 or $1.40 per sq ft. Galvanized steel pipe represented 29% or $543.44 of the investment, wood 10% or $180.30, hardware 2% or $44.04, heating system 29% or $548.90, inflation 4% or $69.50, miscellaneous 5% or $100, and labor 21% or $396.

Polyhut investment requirements for a 6′ x 96′ structure were itemized under polyhut framework, concrete blocks for weighting plastic, and labor (Table 4). Construction costs were $120.24 or $0.21 per sq ft. Polyhut framework represented 35% or $42, concrete blocks 10% or $12.24, and labor 55% or $66.

SUMMARY

Costs of constructing overwintering structures were $0.20 per sq ft for a polyhut, $0.84 per sq ft for a polyhouse without inflation or heat capability, $0.89 per sq ft for a polyhouse with inflation capability but not heat, and $1.40 per sq ft for a polyhouse with both inflation and heat capability. The polyhut, while being inexpensive, is also difficult to work with. A polyhut is nor-

---

[1] Associate Professor and Graduate Student, Dept. of Agricultural Economics and Rural Sociology, and Professor, Dept. of Horticulture, respectively.

mally covered with poly in late autumn and generally it is not opened until spring. Of the various structures analyzed, a nurseryman can normally expect the maximum amount of plant damage from plants stored in polyhuts. The more expensive structures protect plants more effectively, with the degree of protection directly correlated with costs of construction.

LITERATURE CITED

1. Taylor, Reed D., Harold H. Kneen, David E. Hahn, and Elton M. Smith. 1983. Costs of Establishing and Operating Container Nurseries Differentiated by Size of Firm and Species of Plant in USDA Climatic Zone Six. Southern Coop. Ser. Bull. 301.

TABLE 1.—Cost of Construction for Container Nursery Overwintering System, 14' x 96' Polyhouse, USDA Climatic Zones 5 and 6, 1984.*

Item	Description	Unit	Useful Life (years)	Quantity	Cost per Unit (dollars)	Total Cost (dollars)	Percent of Total Cost
Galvanized steel pipe							
Arches — 26	¾" x 21'	ft	10	546	0.57	311.22	28
Ground inserts — 52	¾" x 4.2'	ft	10	218.4	0.57	124.49	11
Threaded ridge line — 5 including couplings	¾" x 21'	ft	10	105	0.57	59.85	5
End braces — 4	¾" x 21'	ft	10	84	0.57	47.88	4
Subtotal				953.4		543.44	48
Wood — treated white pine							
Baseboards	2" x 4" x 220'	ft	10	220	0.27	59.40	5
Door frame — Uprights — 4	4" x 4" x 8'	ft	10	32	0.54	17.28	2
Door frame brace — 4	1" x 4" x 6'	ft	10	24	0.27	6.48	1
Door sill plate — 4	2" x 4" x 3'	ft	10	12	0.27	3.24	†
Doors (3' x 6') — 2	4' x 8' plywood	each	10	2	14.57	29.14	3
Subtotal						115.54	11
Hardware							
Pins for connecting arches and ground inserts — 52	½" x 6"	ft	10	52	0.65	33.80	3
Hinges	3" rustproof	each	10	4	1.20	4.80	†
Door latch	hasp	each	10	2	2.00	4.00	†
Subtotal						42.60	3
Miscellaneous	welding rod, nails, connectors, etc.					100.00	9
Labor requirements		hours	10	50	6.60‡	330.00	29
TOTAL						1131.58	100

*Based on a nursery containing 17 total acres, 350,000 sq ft of growing space, 210,000 sq ft of polyhouse space, 156 (14' x 96') polyhouses.

†Less than 0.5%.

‡Average basic wage before withholding taxes and fringes $5.00, taxes and fringes add 32% or $1.60 for a total of $6.60.

TABLE 2.—Cost of Construction for Container Nursery Overwintering System, 14' x 96' Polyhouse with Inflation, USDA Climatic Zones 5 and 6, 1984.*

Item	Description	Unit	Useful Life (years)	Quantity	Cost per Unit (dollars)	Total Cost (dollars)	Percent of Total Cost
Galvanized steel pipe							
Arches — 26	¾" x 21'	ft	10	546	0.57	311.22	26
Ground inserts — 52	¾" x 4.2'	ft	10	218.4	0.57	124.49	10
Threaded ridge line — 5 including couplings	¾" x 21'	ft	10	105	0.57	59.85	5
End braces — 4	¾" x 21'	ft	10	84	0.57	47.88	4
Subtotal				953.4		543.44	45
Wood — treated white pine							
Baseboards	2" x 4" x 220'	ft	10	220	0.27	59.40	5
Door frame — Uprights — 4	4" x 4" x 8'	ft	10	32	0.54	17.28	1
Door frame brace — 4	1" x 4" x 6'	ft	10	24	0.27	6.48	1
Door sill plate — 4	2" x 4" x 3'	ft	10	12	0.27	3.24	†
Doors (3' x 6') — 2	4' x 8' plywood	each	10	2	14.57	29.14	3
Subtotal						115.54	10
Hardware							
Pins for connecting arches and ground inserts — 52	½" x 6"	ft	10	52	0.65	33.80	3
Hinges	3" rustproof	each	10	4	1.20	4.80	†
Door latch	hasp	each	10	2	2.00	4.00	†
Subtotal						42.60	3
Inflation							
Shaded pole blower kit	complete	each	10	1	69.50	69.50	6
Miscellaneous	welding rod, nails, connectors, etc.					100.00	8
Labor requirements		hours	10	50	6.60‡	330.00	28
TOTAL						1201.08	100

*Based on a nursery containing 17 total acres, 350,000 sq ft of growing space, 210,000 sq ft of polyhouse space, 156 (14' x 96') polyhouses.

†Less than 0.5%.

‡Average basic wage before withholding taxes and fringes $5.00, taxes and fringes add 32% or $1.60 for a total of $6.60.

TABLE 3.—Cost of Construction for Container Nursery Overwintering System, 14' x 96' Polyhouse with Inflation and Heat, USDA Climatic Zones 5 and 6, 1984.*

Item	Description	Unit	Useful Life (years)	Quantity	Cost per Unit (dollars)	Total Cost (dollars)	Percent of Total Cost
Galvanized steel pipe							
Arches — 26	¾" x 21'	ft	10	546	0.57	311.22	17
Ground inserts 52	¾" x 4.2'	ft	10	218.4	0.57	124.49	7
Threaded ridge line — 5 including couplings	¾" x 21'	ft	10	105	0.57	59.85	3
End braces — 4	¾" x 21'	ft	10	84	0.57	47.88	2
Subtotal				953.4		543.44	29
Wood — treated white pine							
Baseboards	2" x 4" x 192'	ft	10	196	0.27	52.92	3
Door frame — Uprights — 4	4" x 4" x 8'	ft	10	32	0.54	17.28	1
Door sill plate — 4	2" x 4" x 3'	ft	10	12	0.27	3.24	†
Ends — including doors	4' x 8' plywood	each	10	6	14.57	87.42	5
Ends — wall studs — 4	2" x 4" x 12'	ft	10	48	0.27	12.96	1
Ends — vertical stud base — 2	2" x 4" x 12'	ft	10	24	0.27	6.48	†
Subtotal						180.30	10
Hardware							
Pins for connecting arches and ground inserts — 52	½" x 6"	ft	10	52	0.65	33.80	2
Bolts, washers, and nuts	¼" x 2" (oval hd)	each	10	12	0.12	1.44	†
Hinges	3" rustproof	each	10	4	1.20	4.80	†
Door latch		each	10	2	2.00	4.00	†
Subtotal						44.04	2
Heating System							
Gas fired unit heater — Empire	125,000 BTU	each	10	1	408.90	408.90	22
Thermostat		each	10	1	40.00	40.00	2
Set-up for propane‡	vent., reg., etc.					100.00	5
Subtotal						548.90	29
Inflation							
Shaded pole blower kit	complete	each	10	1	69.50	69.50	4
Miscellaneous	welding rod, nails, connectors, etc.					100.0	5
Labor requirements		hours	10	60	6.60**	396.00	21
TOTAL						1882.18	100

*Based on a nursery containing 17 total acres, 350,000 sq ft of growing space, 210,000 sq ft of polyhouse space, 156 (14' x 96') polyhouses.

†Less than 0.5%.

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

**Average basic wage before withholding taxes and fringes $5.00, taxes and fringes add 32% or $1.60 for a total of $6.60.

TABLE 4.—Cost of Construction for Container Nursery Overwintering System, 6' x 96' Polyhut, USDA Climatic Zones 5 and 6, 1984.*

Item	Description	Unit	Useful Life (years)	Quantity	Cost per Unit (dollars)	Total Cost (dollars)	Percent of Total Cost
Polyhut framework — 6' x 96' concrete reinforcement mesh 6" x 6" — 10 gauge wire†	5' x 10' sections	each	10	14	3.00	42.00	35
Concrete blocks for weighting plastic	2" x 4" x 8" — 6 lb weight	each	10	102	0.12	12.24	10
Labor requirements		hours	10	10	6.60‡	66.00	55
TOTAL						120.24	100

*Based on a nursery containing 17 total acres, 350,000 sq ft of growing space, 210,000 sq ft of polyhut space, 365 (6' x 96') polyhuts.

†Purchased in rolls 5' x 150'. Rolls would be cut into 10' sections to make the 6' wide hoops. Each section would therefore be 5' long. Approximately 2' of space would be left between sections to facilitate service.

‡Average basic wage before withholding taxes and fringes $5.00, taxes and fringes add 32% or $1.60 for a total of $6.60.

Annual Fixed Costs of Overwintering Plants in Nurseries Differentiated by Type of Structure for Ohio—1984

DARYL T. GILLETTE, REED D. TAYLOR, and ELTON M. SMITH[1]

ABSTRACT

The objective of this study was to estimate annual fixed costs of systems used by Ohio nurseries for overwintering nursery products. Most systems use one of the four structures analyzed in this report. The four structures were: a simple polyhut, a polyhouse constructed to support a single polyethylene film, a polyhouse equipped with an inflation kit so it can support a double polyethylene film with air being blown between the films, and a polyhouse equipped with both an inflation kit plus heating capability. Annual fixed costs for the four structures were $109.61 or $0.19 per sq ft for a 6′ by 96′ polyhut, $487.28 or $0.36 per sq ft for a 14′ x 96′ polyhouse without inflation or heating capability, $506.15 or $0.38 per sq ft for a 14′ x 96′ polyhouse with inflation but not heating capability, and $691.08 or $0.51 per sq ft for a 14′ x 96′ polyhouse with both inflation and heating capability. For a 14′ x 96′ area in a system which did not require a structure, annual fixed costs would be $180.07 or $0.13 per sq ft. Annual fixed costs per sq ft of the overwintering structures varied directly with the amount of protection offered. The systems without structures would offer the least protection, while the polyhouse with double polyethylene film and heat offers the most.

INTRODUCTION

Practically all plants grown in containers as well as field-grown plants harvested in the autumn for spring sales will suffer damage or death if not protected. Costs of overwintering plant material contribute significantly to the expense of producing nursery products in Northern USDA climatic zones. A recent study (1) showed polyhouse structures for overwintering account for about 20% of the total capital requirement for establishing an 8-acre (growing space) container nursery. The study was based on a 20′ by 200′ structure without inflation or heat. Adding inflation would have increased costs slightly, while adding inflation and heat would have increased the cost to about 33% of total capital requirements.

The specific objective of this study was to estimate annual fixed costs of alternative overwintering systems.

MATERIALS AND METHODS

In the study, four overwintering structures were synthesized using the conceptual framework of economic engineering wherein the 'best proven practice' was included in each model. They were synthesized based on the Columbus, Ohio, area, but would be representative of USDA climatic zones 5 and 6. Each structure synthesized measured 14′ x 96′ in the case of polyhouses and 6′ x 96′ in the case of the polyhut.

Data for this study were obtained from wholesale nurseries and nursery suppliers in Ohio during 1984. Prices reflect quantities of materials based on a nursery containing 17 total acres, 350,000 sq ft of growing space, and 210,000 sq ft of overwintering space. The overwintering space would be made up of either 156 polyhouses, 156 spaces where structures were not used, 365 polyhuts, or some combination of the three. Details on capital requirements for constructing the structures are contained in a companion article in this publication (page 29).

Costs were established for all factors of overwintering contributing to fixed costs, including management and invested capital. In economic terms, costs associated with factors of production provided 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 overwintering structures could have earned interest if it had been placed in financial institutions.

Most fixed costs are derived from costs of constructing structures. These costs were grouped into a total of nine categories for polyhouses: galvanized steel pipe, wood, hardware, heating system, inflation, miscellaneous, labor, general overhead, and interest on general overhead, insurance, and taxes.

Not all categories were included for every structure. For polyhuts, costs were grouped into five categories: polyhut framework, concrete blocks for weighting plastic, labor, general overhead, and interest on general overhead, insurance, and taxes. Annual fixed costs, with the exception of general overhead and interest on general overhead, insurance, and taxes, were composed of depreciation, interest, insurance, and taxes. Depreciation was calculated by dividing initial cost by years of useful life. Interest costs were estimated by multiplying the initial value of materials and labor by 15% per annum. Taxes and insurance costs were based on rates prevailing in the rural areas adjacent to Columbus, Ohio. They were assessed at the rate of $20 per $1,000 of market value. General overhead was assessed by taking the figure $95,025 developed in an earlier study (1) using 1982 figures for the appropriate sized nursery and inflating it by 10% to $104,527. This figure was divided by 156 for polyhouses and spaces not requiring struc-

---

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

TABLE 1.—Annual Fixed Costs (Dollars) for a Container Nursery Overwintering System, 14' x 96' Polyhouse, USDA Climatic Zones 5 and 6, 1984.*

Item	Description	Depreciation†	Interest‡	Insurance and Taxes**	Total
Galvanized Steel Pine					
Arches — 26	¾" x 21'	31.12	46.68	6.22	84.02
Ground inserts — 52	¾" x 4.2'	12.45	18.67	2.49	33.61
Threaded ridge line — 5 including couplings	¾" x 21'	5.98	8.98	1.20	16.16
End braces — 4	¾" x 21'	4.79	7.18	0.96	12.93
Subtotal		54.34	81.51	10.87	146.72
Wood — treated white pine					
Baseboards	2" x 4" x 220'	5.94	8.91	1.19	16.04
Door frame — Uprights — 4	4" x 4" x 8'	1.73	2.59	0.35	4.67
Door frame brace — 4	1" x 4" x 6'	0.65	0.97	0.13	1.75
Door sill plate — 4	2" x 4" x 3'	0.32	0.49	0.06	0.87
Doors (3' x 6') — 2	4' x 8' plywood	2.91	4.37	0.58	7.86
Subtotal		11.55	17.33	2.31	31.19
Hardware					
Pins for connecting arches and ground inserts — 52	½" x 6"	3.38	5.07	0.68	9.13
Hinges	3" rustproof	0.48	0.72	0.09	1.29
Door latch	hasp	0.40	0.60	0.08	1.08
Subtotal		4.26	6.39	0.85	11.50
Miscellaneous	welding rod, nails, connectors, etc.	10.00	15.00	2.00	27.00
Labor requirements	construction	33.00	49.50	6.60	89.10
General overhead††					167.51
Interest on general overhead, insurance and taxes	Compounded at 15% per annum for 6 months				14.26
TOTAL		113.15	169.73	22.63	487.28

---

*Based on a nursery containing 17 total acres, 350,000 sq ft of growing space, 210,000 sq ft of polyhouse space, 156 (14' x 96') polyhouses.

†Depreciation was estimated by dividing initial cost by the years of useful life.

‡Interest costs were estimated by multiplying the initial value of construction costs by the interest rate, 15% per annum.

**Insurance and taxes were estimated by multiplying the initial value of construction by 2%.

††General overhead was estimated by taking the figure $95,025 developed in an earlier study using 1982 figures for the appropriate sized nursery and inflating it by 10% to $104,527. This figure was divided by 156 polyhouses to yield a value of $670.04 per polyhouse. One-fourth of the general overhead costs were assigned to overwintering.

tures or 365 polyhuts to yield values for this study. One-fourth of the general overhead costs were assigned to overwintering. Interest charges for general overhead, insurance, and taxes were computed for a 6-month average use period at a rate of 15% per annum.

RESULTS AND DISCUSSION

Annual fixed costs for a 14′ x 96′ house constructed to support one layer of polyethylene film were $487.28 (Table 1). By category, they were $146.72 for galvanized steel pipe, $31.19 for wood, $11.50 for hardware, $27.00 for miscellaneous, $89.10 for labor, $167.51 for general overhead, and $14.26 for interest on general overhead, insurance, and taxes. Of the total costs for materials and labor, $113.15 was for depreciation, $169.73 for interest, and $22.63 for insurance and taxes. Total interest was $183.99 and exceeded depreciation.

Providing a kit to the above house to blow air between a double polyethylene film cover would have increased annual fixed costs by $18.87 to $506.15 (Table 2). Further addition of a heating system increases these costs to $691.08 (Table 3).

Annual fixed costs for a 6′ x 96′ polyhut were $109.61 (Table 4). By category, they were $11.34 for the polyhut framework, $3.30 for concrete blocks for weighting plastic, $17.82 for labor, $71.60 for general overhead, and $5.55 for interest on general overhead, insurance, and taxes. Of the total costs for materials and labor, $12.02 was for depreciation, $18.04 for interest, and $2.40 for insurance and taxes. Total interest was $23.59 and, as in the case of the polyhouses, exceeded depreciation. The largest expense was for general overhead, accounting for 65% of the total. General overhead is assessed based on square footage of the structure. While costs of constructing a polyhut are considerably less than for the various polyhouses, they nevertheless carry the same general overhead cost on a per square foot basis.

TABLE 2.—Annual Fixed Costs (Dollars) for a Container Nursery Overwintering System, 14' x 96' Polyhouse with Inflation, USDA Climatic Zones 5 and 6, 1984.*

Item	Description	Depreciation†	Interest‡	Insurance and Taxes**	Total
Galvanized Steel Pipe					
Arches — 26	¾" x 21'	31.12	46.68	6.22	84.02
Ground inserts — 52	¾" x 4.2'	12.45	18.67	2.49	33.61
Threaded ridge line — 5 including couplings	¾" x 21'	5.98	8.98	1.20	16.16
End braces — 4	¾" x 21'	4.79	7.18	0.96	12.93
Subtotal		54.34	81.51	10.87	146.72
Wood — treated white pine					
Baseboards	2" x 4" x 220'	5.94	8.91	1.19	16.04
Door frame — Uprights — 4	4" x 4" x 8'	1.73	2.59	0.35	4.67
Door frame brace — 4	1" x 4" x 6'	0.65	0.97	0.13	1.75
Door sill plate — 4	2" x 4" x 3'	0.32	0.49	0.06	0.87
Doors (3' x 6') — 2	4' x 8' plywood	2.91	4.37	0.58	7.86
Subtotal		11.55	17.33	2.31	31.19
Hardware					
Pins for connecting arches and ground inserts — 52	½" x 6"	3.38	5.07	0.68	9.13
Hinges	3" rustproof	0.48	0.72	0.09	1.29
Door latch	hasp	0.40	0.60	0.08	1.08
Subtotal		4.26	6.39	0.85	11.50
Inflation					
Shaded pole blower kit	complete	6.95	10.43	1.39	18.77
Miscellaneous	welding rod, nails, connectors, etc.	10.00	15.00	2.00	27.00
Labor requirements	construction	33.00	49.50	6.60	89.10
General overhead††					167.51
Interest on general overhead, insurance, and taxes	Compounded at 15% per annum for 6 months				14.36
TOTAL		120.10	180.16	24.02	506.15

*Based on a nursery containing 17 total acres, 350,000 sq ft of growing space, 210,000 sq ft of polyhouse space, 156 (14' x 96') polyhouses.

†Depreciation was estimated by dividing initial cost by the years of useful life.

‡Interest costs were estimated by multiplying the initial value of construction costs by the interest rate, 15% per annum.

**Insurance and taxes were estimated by multiplying the initial value of construction by 2%.

††General overhead was estimated by taking the figure $95,025 developed in an earlier study using 1982 figures for the appropriate sized nursery and inflating it by 10% to $104,527. This figure was divided by 156 polyhouses to yield a value of $670.04 per polyhouse. One-fourth of the general overhead costs were assigned to overwintering.

TABLE 3.—Annual Fixed Costs (Dollars) for a Container Nursery Overwintering System, 14' x 96' Polyhouse with Inflation and Heat, USDA Climatic Zones 5 and 6, 1984.*

Item	Description	Depreciation†	Interest‡	Insurance and Taxes**	Total
Galvanized Steel Pipe					
Arches — 26	¾" x 21'	31.12	46.68	6.22	84.02
Ground inserts — 52	¾" x 4.2'	12.45	18.67	2.49	33.61
Threaded ridge line — 5 including couplings	¾" x 21'	5.98	8.98	1.20	16.16
End braces — 4	¾" x 21'	4.79	7.18	0.96	12.93
Subtotal		54.34	81.51	10.87	146.72
Wood — treated white pine					
Baseboards	2" x 4" x 192'	5.29	7.94	1.06	14.29
Door frame — Uprights — 4	4" x 4" x 8'	1.73	2.59	0.35	4.67
Door sill plate — 4	2" x 4" x 3'	0.32	0.49	0.06	0.87
Ends — including doors	4' x 8' plywood	8.74	13.11	1.75	23.60
Ends — wall studs — 4	2" x 4" x 12'	1.30	1.94	0.26	3.50
Ends — vertical stud base — 2	2" x 4" x 12'	0.65	0.97	0.13	1.75
Subtotal		18.03	27.04	3.61	48.68
Hardware					
Pins for connecting arches and ground inserts — 52	½" x 6"	3.38	5.07	0.68	9.13
Bolts, washers, and nuts	¼" x 2" (oval hd)	0.14	0.22	0.02	0.38
Hinges	3" rustproof	0.48	0.72	0.09	1.29
Door latch	hasp	0.40	0.60	0.08	1.08
Subtotal		4.40	6.61	0.87	11.88
Heating System					
Gas fired unit heater — Dayton	125,000 BTU	40.89	61.34	8.18	110.41
Thermostat		4.00	6.00	0.80	10.80
Set-up for propane	vent., reg., etc.	10.00	15.00	2.00	27.00
Subtotal		54.89	82.34	10.98	148.21
Inflation					
Shaded pole blower kit	complete	6.95	10.43	1.39	18.77
Miscellaneous	welding rod, nails, connectors, etc.	10.00	15.00	2.00	27.00
Labor requirements		39.60	59.40	7.92	106.92
General overhead††					167.51
Interest on general overhead insurance, and taxes	Compounded at 15% per annum for 6 months				15.39
TOTAL		188.21	282.33	37.64	691.08

*Based on a nursery containing 17 total acres, 350,000 sq ft of growing space, 210,000 sq ft of polyhouse space, 156 (14' x 96') polyhouses.

†Depreciation was estimated by dividing initial cost by the years of useful life.

‡Interest costs were estimated by multiplying the initial value of construction costs by the interest rate, 15% per annum.

**Insurance and taxes were estimated by multiplying the initial value of construction by 2%.

††General overhead was estimated by taking the figure $95,025 developed in an earlier study using 1982 figures for the appropriate sized nursery and inflating it by 10% to $104,527. This figure was divided by 156 polyhouses to yield a value of $670.04 per polyhouse. One-fourth of the general overhead costs were assigned to overwintering.

TABLE 4.—Annual Fixed Costs (Dollars) for a Container Nursery Overwintering System, 6' x 96' Polyhut, USDA Climatic Zones 5 and 6, 1984.*

Item	Description	Depreciation†	Interest‡	Insurance and Taxes**	Total
Polyhut framework — 6' x 96' concrete reinforcement mesh 6" x 6" — 10 gauge wire	5' x 10' sections	4.20	6.30	0.84	11.34
Concrete blocks for weighting plastic	2" x 4" x 8" — 6 lb weight	1.22	1.84	0.24	3.30
Labor requirements		6.60	9.90	1.32	17.82
General overhead††					71.60
Interest on general overhead, insurance, and taxes	Compounded at 15% per annum for 6 months				5.55
TOTAL		12.02	18.04	2.40	109.61

*Based on a nursery containing 17 total acres, 350,000 sq ft of growing space, 210,000 sq ft of polyhut space, 365 (6' x 96') polyhuts.

†Depreciation was estimated by dividing initial cost by the years of useful life.

‡Interest costs were estimated by multiplying the initial value of construction costs by the interest rate, 15% per annum.

**Insurance and taxes were estimated by multiplying the initial value of construction by 2%.

††General overhead was estimated by taking the figure $95,025 developed in an earlier study using 1982 figures for the appropriate sized nursery and inflating it by 10% to $104,527. This figure was divided by 365 polyhuts to yield a value of $286.38 per polyhut. One-fourth of the general overhead costs were assigned to overwintering.

Annual fixed costs for overwintering where structures were not used were made up of general overhead and interest on general overhead. For a 14' x 96' area they totaled $180.07. By category they were $167.51 for general overhead and $12.56 for interest on general overhead.

SUMMARY

Annual fixed costs for overwintering structures were $0.19 per sq ft for a polyhut, $0.36 per sq ft for a polyhouse without inflation or heat capability, $0.38 per sq ft for a polyhouse with inflation capability but not heat, and $0.51 per sq ft for a polyhouse with both inflation and heat capability. Where structures were not used, they were $0.13 per sq ft. Annual fixed costs for the various overwintering structures are positively correlated with the amount of protection offered plants being overwintered. The polyhut would provide the least amount of protection, while a heated house covered with a double polyethylene film would provide the most.

LITERATURE CITED

1. Taylor, Reed D., Harold H. Kneen, David E. Hahn, and Elton M. Smith. 1983. Costs of Establishing and Operating Container Nurseries Differentiated by Size of Firm and Species of Plant in USDA Climatic Zone Six. Southern Coop. Ser. Bull. 301.

Comparative Costs of Overwintering Plants in Nurseries Differentiated by System for Ohio—1984

REED D. TAYLOR, DARYL T. GILLETTE, and ELTON M. SMITH[1]

ABSTRACT

The objective of this study was to develop the resources and costs associated with 11 overwintering systems. Calculations were based on 1984 prices. Annual costs were $0.30 per sq ft for a structure-less system where plants are simply bunched up and covered with a single layer of polyethylene. They were $0.33 per sq ft for the same system with a thermal blanket placed directly on the plants and polyethylene laid on top of the thermal blanket. For a structure-less system where plants are surrounded by bales of straw, annual costs were $0.40 per sq ft. In the case of a 6′ x 96′ polyhut, they were $0.44. For a polyhouse covered with a single layer of polyethylene, they were $0.56 where no additional covering was placed directly on plants, $0.58 where plants were covered by a single layer of polyethylene, and $0.61 where plants were covered by both a thermal blanket and polyethylene. In the case of a polyhouse covered with a double layer of polyethylene, they were $0.61 where no additional covering was placed directly on plants, $0.63 where the plants were covered by a single layer of polyethylene, and $0.66 where plants were covered by both a thermal blanket and polyethylene. For a polyhouse equipped with both a double layer of polyethylene and a heating system, they were $0.93. In a heated house, there would be no need to directly cover plants. In general, annual costs of overwintering systems increased as degree of plant protection increased.

INTRODUCTION

Practically all plants grown in containers as well as field-grown plants harvested in the autumn for spring sales suffer damage or death if not protected. Costs of overwintering plant material contribute significantly to the expense of producing nursery products in Northern USDA climatic zones. A recent study (1) showed that polyhouse structures for overwintering account for about 20% of the total capital requirement for establishing an 8-acre (growing space) container nursery. The study was based on a 20′ by 200′ structure without inflation or heat. Adding inflation would have increased costs slightly, while adding inflation and heat would have increased costs to about 33% of total capital requirements.

The specific objective of this study was to estimate the annual costs of alternative overwintering systems.

MATERIALS AND METHODS

In the study, 11 overwintering systems were synthesized using the conceptual framework of economic engineering wherein the 'best proven practice' was included in each model. They were synthesized based on the Columbus, Ohio, area, but would be representative of USDA climatic zones 5 and 6. Not all practices were analyzed. For example, some nurserymen leave hardy plants (some varieties and/or cultivars of junipers and/or taxus) without any overwintering protection. Others "bunch them up" without additional protection. In this study, systems extending overwintering protection beyond simple "bunching up" were analyzed.

Data for this study were obtained from wholesale nurseries and nursery suppliers in Ohio during 1984. Prices reflect quantities of materials based on a container nursery with 17 total acres, 350,000 sq ft of growing space, and 210,000 sq ft of overwintering space. Overwintering space would be made up of either 156 polyhouses, 156 spaces where structures are not used, 365 polyhuts, or some combination of the three. Two companion articles are in this publication. The first, Capital Requirements of Overwintering Structures for Nurseries in Ohio—1984, estimates the costs of constructing various overwintering facilities (page 29). The second, Annual Fixed Costs of Overwintering Plants in Nurseries Differentiated by System for Ohio—1984, estimates fixed costs associated with various overwintering systems (page 33).

Structures for overwintering come in a great many sizes and configurations. The 14′ x 96′ polyhouse and 6′ x 96′ polyhut have been traditional. In the case of the polyhouse, pipe for making arches normally came in 21-foot lengths (proper size for making hoops) and polyethylene in 100-foot lengths. By putting plywood ends on polyhouses, the 100-foot lengths were just right. The 6′ x 96′ polyhut also used building materials efficiently. Both the polyhouse and polyhut, in the traditional sizes, were sturdy and withstood northern weather with little difficulty. Many nurserymen now prefer larger houses (*i.e.*, 20′ x 200′ or larger) so they can work in the houses with forklifts and other types of equipment. Also, a large nursery can now order polyethylene "cut to specification". Traditional house/hut sizes were chosen for this study upon the recommendation of horticulturists. Previous studies have shown that while the costs of constructing various sized houses vary significantly, the cost per square foot would be similar.

---

[1] Associate Professor and Graduate Student, Dept. of Agricultural Economics and Rural Sociology, and Professor, Dept. of Horticulture, respectively.

Overwintering Systems

Eleven overwintering systems analyzed were: 1) a basic 14′ x 96′ structure-less system wherein plants are bunched up container to container and covered directly with a single layer of polyethylene film; 2) same as the preceding with a thermal blanket placed directly over the plants before polyethylene film is added (the first two systems would usually be restricted to hardy juniper and/or taxus plants where sales are not anticipated for at least one additional growing season); 3) a 14′ x 96′ structure-less system wherein plants are bunched up and surrounded by bales of straw, with the root zones often covered with some type of mulch (usually used with hardy field-grown crops harvested in autumn or early winter for spring sales); 4) a 6′ x 96′ polyhut structure 3-4′ high, covered with a single layer of polyethylene film without additional covering of the plants; 5) a 14′ x 96′ polyhouse covered with a single layer of polyethylene film without additional covering of plants; 6) same as the preceding with the addition of one layer of used polyethylene film placed directly on the plants; 7) same as the preceding with a thermal blanket placed directly on the plants before the used polyethylene film is added; 8) a 14′ x 96′ polyhouse covered with a double layer of polyethylene film, with air being blown between the films, without additional covering of plants; 9) same as the preceding with the addition of one layer of used polyethylene film placed directly on the plants; 10) same as the preceding with a thermal blanket placed directly on the plants before the used polyethylene film is added; 11) a 14′ x 96′ heated polyhouse covered with a double layer of polyethylene film, with air being blown between the films, without additional covering of the plants.

Overwintering Cost Budgets

Costs were established for all factors of production associated with overwintering. Costs for land preparation, irrigation, and the single layer of black or white polyethylene film upon which plants are often placed were not considered. It was felt that they should be charged to "grow-out". One-fourth of the charge for general overhead was charged to overwintering. Fixed costs were discussed in detail in the companion article on fixed costs (page 33); therefore, this article will detail variable costs only.

Polyethylene. Polyethylene film used by Ohio nurseries is normally 4 mil, clear, white, or black. White (opaque) is the choice for the outer cover of polyhouses/huts and to place directly on plants. Clear is often used as the inner layer in a polyhouse with a double covering. Black is usually the choice to place directly on the ground to help control weeds, avoid working in mud, and in the case of field-grown crops, act as a mulch. Polyethylene film, in the amounts required for a nursery of the size budgeted, can be ordered "cut to specification".

Thermal Blankets. Thermal blankets come in various types, shapes, and sizes. The type budgeted works best when covered with a layer of used polyethylene film to protect it from falling ice and other elements. The layer of polyethylene also provides additional overwintering protection. One type of thermal blanket comes with a layer of polyethylene bonded directly to the thermal material and is preferred by many nurserymen. It is easier to handle, but considerably more expensive than the type budgeted for. Standard sizes are either 80″ wide x 225′ long or 5′ wide x 225′ long. It was assumed in the study that a nurseryman would use three 5′ x 100′ long strips in a polyhouse. It was estimated that a thermal blanket would last 3 years. With proper care, a nurseryman may be able to extend its life beyond the 3 years budgeted. Also, new materials are coming on the market which might well have a much longer useful life.

Bait Blocks. Eaton bait blocks are proving effective in controlling mice within overwintering areas. Apple-flavored blocks are the most popular. They are normally placed about 10′ apart and are replaced once during the overwintering season. In addition to bait blocks placed directly within the overwintering areas, poisoned grain is placed between areas.

Chemicals. Chemicals are used for control of fungus. In the case of structure-less areas and polyhuts, plants are sprayed with a mixture of Benlate and Captan after the plants are bunched-up. This treatment is usually the only treatment for fungus for these systems. In the case of polyhouses, Benlate is usually sprayed on at the beginning of the overwintering season. Once houses are covered, a fumigant bomb of Termil is added. A second bomb of Termil would be added at some point during the winter.

Hourly Labor. It was estimated that hourly labor would receive a base wage of $5.00 per hour. An additional 32% was added to take care of social security, workmen's compensation, general health insurance, holiday and vacation pay, and unemployment insurance. This amounted to $1.60 per hour, for a total hourly labor cost of $6.60.

Straw. The charge of $2.00 per bale would include delivery to the nursery.

Propane Heat. Propane was chosen for heating as it is normally available at all locations. A delivered price of $0.85 per gallon was quoted by suppliers as available to large users and included the use of tanks and regulators.

Miscellaneous. This category included tie-down straps, furring strips, and nails to secure plastic coverings, poisoned grain for placement between overwintering areas, electricity for operating fans providing inflation between double polyethylene film covers and for blowing heat in heated houses, mulch in the case of straw enclosures, etc.

RESULTS AND DISCUSSION

Each system is presented separately. Comparisons between systems are then made. For the analysis, it was assumed containers would be stored container to container in the case of the structure-less systems and in the polyhut. For the polyhouses, they would be stored container to container with the exception of a 2-foot aisle

TABLE 1.—Annual Costs (Dollars) for Overwintering Plants in a 14' x 96' Enclosure (Covered with Either Single Poly or Single Poly Plus Thermal Blanket) in USDA Climatic Zones 5 and 6, 1984.*

Item	Description	Unit	Cost per Unit	Quantity	Total Cost Poly Only	Total Cost Poly and Thermal Blanket
Annual Fixed Costs						
General overhead	One-fourth of total nursery overhead was assigned to overwintering				167.51	167.51
Interest on general overhead	Compounded at 15% per annum for 6 months				12.56	12.56
Subtotal (annual fixed)					180.07	180.07
Annual Variable Costs						
Polyethylene	4 mil white, 20' x 100'	1000 sq ft	16.00	2	32.00	32.00
Thermal blanket	1/4" — 15' x 100'	1000 sq ft	65.00	1/3 (1.5)†	0.00	32.50
Labor‡	Hired	hours	6.60	24/25	158.40	165.00
Bait blocks	Eaton	blocks	0.16	20	3.20	3.20
Chemicals	Benlate 50 WP (fungicide) Captan 50 WP (fungicide)	lb lb	13.30 2.15	0.05 0.10	0.67 0.22	0.67 0.22
Miscellaneous	Tie-down materials, treated grain, etc.				15.00	15.00
Interest on operating capital	Computed at 15% on an annual basis for 6 months	percent	7.5 (0.075)	209.49 248.59	15.71	18.64
Subtotal (annual variable)					225.20	267.23
Total Annual Cost					405.27	447.30
Annual Cost	Square foot	sq ft		1344	0.30	0.33
Annual Cost	Gallon container	containers		3926	0.10	0.11
Annual Cost	2-gallon container	containers		2270	0.18	0.20
Annual Cost	3-gallon container	containers		1510	0.27	0.30

*Containers would be placed container to container in the enclosure.

†Thermal blankets would be used for three seasons.

‡It was estimated that it would take 10 hours to put plants within the enclosore, 10 hours to space them after overwintering, 3 hours to place and remove the polyethylene, and 1 hour for spraying and other miscellaneous chores. One additional hour was budgeted for the addition of a thermal blanket. Average basic wage before withholding taxes and fringes $5.00, taxes and fringes add 32% or $1.60 for a total of $6.60.

TABLE 2.—Annual Costs (Dollars) for Overwintering Plants in a 14' x 96' Enclosure (Plants Surrounded by Bales of Straw) in USDA Climatic Zones 5 and 6, 1984.[*]

Item	Description	Unit	Cost per Unit	Quantity	Total Cost
Annual Fixed Costs					
General overhead	One-fourth of total nursery overhead was assigned to overwintering				167.51
Interest on general overhead	Compounded at 15% per annum for 6 months				12.56
Subtotal (annual fixed)					180.07
Annual Variable Costs					
Straw	3' length	each	2.00	73	146.00
Labor[†]	Hired	hours	6.60	25	165.00
Bait blocks	Eaton	blocks	0.16	20	3.20
Chemicals	Benlate 50 WP (fungicide) Captan 50 WP (fungicide)	lb lb	13.30 2.15	0.05 0.10	0.67 0.22
Miscellaneous	Mulch, treated grain, etc.				15.00
Interest on operating capital	Computed at 15% on an annual basis for 6 months	percent	7.5 (0.075)	330.09	24.76
Subtotal (annual variable)					354.85
Total Annual Cost					534.92
Annual Cost	Square foot	sq ft		1344	0.40
Annual Cost	Gallon container	containers		3926	0.14
Annual Cost	2-gallon container	containers		2270	0.24
Annual Cost	3-gallon container	containers		1510	0.35

[*] Containers would be placed container to container in the enclosure.

[†] It was estimated that it would take 10 hours to put plants within the enclosure, 10 hours to space them after overwintering, 4 hours to place and remove the straw, and 1 hour for spraying and other miscellaneous chores. Average basic wage before withholding taxes and fringes $5.00, taxes and fringes add 32% or $1.60 for a total of $6.60.

TABLE 3.—Annual Costs (Dollars) for Overwintering Plants in a 6' x 96' Polyhut Structure in USDA Climatic Zones 5 and 6, 1984.[*]

Item	Description	Unit	Cost per Unit	Quantity	Total Cost
Annual Fixed Costs					
Depreciation	10% of construction cost				12.02
Interest	Compounded at 15% per annum				18.04
Insurance and taxes	2% of construction cost				2.40
General overhead	One-fourth of total nursery overhead was assigned to overwintering				71.60
Interest on general overhead, insurance, and taxes	Compounded at 15% per annum for 6 months				5.55
Subtotal (annual fixed)					109.61
Annual Variable Costs					
Polyethylene	4 mil white, 12' x 105'	1000 sq ft	16.00	1.26	20.16
Labor[†]	Hired	hours	6.60	15.0	99.00
Bait blocks	Eaton	blocks	0.16	10.0	1.60
Chemicals	Benlate 50 WP (fungicide) Captan 50 WP (fungicide)	lb lb	13.30 2.15	0.02 0.04	0.27 0.09
Miscellaneous	Tie-down materials, treated grain, etc.				15.00
Interest on operating capital	Computed at 15% on an annual basis for 6 months	percent	7.5 (0.075)	136.12	10.21
Subtotal (annual variable)					146.33
Total Annual Cost					255.94
Annual Cost	Square foot	sq ft		576	0.44
Annual Cost	Gallon container	containers		1682	0.15
Annual Cost	2-gallon container	containers		972	0.26
Annual Cost	3-gallon container	containers		647	0.40

[*] Containers would be placed container to container in the polyhut.

[†] It was estimated that it would take 5 hours to put plants within the enclosure, 5 hours to space them after overwintering, 4 hours to place and remove the polyethylene, and 1 hour for spraying, fumigating, and other miscellaneous chores. Average basic wage before withholding taxes and fringes $5.00, taxes and fringes add 32% or $1.60 for a total of $6.60.

down the center of the houses. In reality, many plants need greater spacing to avoid damage and to overwinter effectively. Costs per gallon, 2-gallon, and 3-gallon containers as presented in this study would have to be adjusted where greater spacing would be desired.

1. Structure-less System with a Single Cover of Polyethylene Film. Total annual costs of this system for a 14′ x 96′ area were $405.27 (Table 1), with $180.07 being fixed (44%) and $225.20 variable (56%). They totaled $0.30 per sq ft, $0.10 per gallon container, $0.18 per 2-gallon container, and $0.27 per 3-gallon container. This was the least expensive of the 11 systems studied. General overhead and interest on general overhead were the sole contributors to overhead costs. Overhead costs were assessed on a square foot basis and thus remained the same per square foot regardless of system analyzed.

2. Structure-less System with a Thermal Blanket in Addition to a Single Cover of Polyethylene Film. Total annual costs of this system for a 14′ x 96′ area were $447.30 (Table 1), with $180.07 being fixed (40%) and $267.23 variable (60%). They totaled $0.33 per sq ft, $0.11 per gallon container, $0.20 per 2-gallon container, and $0.30 per 3-gallon container. Adding a thermal blanket to the previous system increased total annual costs by $39.10, with $32.50 being for the thermal blanket and $6.60 for an additional hour of labor for placing it.

3. Structure-less System with Overwintering Area Surrounded by Straw. Total annual costs of this system for a 14′ x 96′ area were $534.92 (Table 2), with $180.07 being fixed (34%) and $354.85 variable (66%). They totaled $0.40 per sq ft, $0.14 per gallon container, $0.24 per 2-gallon container, and $0.35 per 3-gallon container. Straw was major expense, contributing $146.00 to the total.

4. Polyhut Structure without Additional Covering of Plants. Total annual costs of this system for a 6′ x 96′ area were $255.94 (Table 3), with $109.61 being fixed (43%) and $146.33 (57%) variable. They totaled $0.44 per sq ft, $0.15 per gallon container, $0.26 per 2-gallon container, and $0.40 per 3-gallon container. Hired labor costing $99.00 was the single most expensive item for this system.

5. Polyhouse Structure with One Polyethylene Film Cover without Additional Covering of Plants. Total annual costs of this system for a 14′ by 96′ area were $751.76 (Table 4), with $487.28 being fixed (65%) and $264.48 (35%) variable. They totaled $0.56 per sq ft, $0.22 per gallon container, $0.38 per 2-gallon container, and $0.57 per 3-gallon container. Fixed costs for the structure, including depreciation ($113.15), interest

TABLE 4.—Annual Costs (Dollars) for Overwintering Plants in a 14' x 96' Polyhouse Structure (Single Polyethylene Cover with No Covering of Plants Within the House) in USDA Climatic Zones 5 and 6, 1984.*

Item	Description	Unit	Cost per Unit	Quantity	Total Cost
Annual Fixed Costs					
Depreciation	10% of construction cost				113.15
Interest	Compounded at 15% per annum				169.73
Insurance and taxes	2% of construction cost				22.63
General overhead	One-fourth of total nursery overhead was assigned to overwintering				167.51
Interest on general overhead, insurance, and taxes	Compounded at 15% per annum for 6 months				14.26
Subtotal (annual fixed)					487.28
Annual Variable Costs					
Polyethylene	4 mil white, 24' x 110'	1000 sq ft	16.00	2.64	42.24
Labor†	Hired	hours	6.60	26.00	171.60
Bait blocks	Eaton	blocks	0.16	20.00	3.20
Chemicals	Termil (fungicide)	canister	1.66	2.00	3.32
	Benlate 50 WP (fungicide)	lb	13.30	0.05	0.67
Miscellaneous	Tie-down materials, furring strips, nails, treated grain, etc.				25.00
Interest on operating capital	Computed at 15% on an annual basis for 6 months	percent	7.5 (0.075)	246.03	18.45
Subtotal (annual variable)					264.48
Total Annual Cost					751.76
Annual Cost	Square foot	sq ft		1344	0.56
Annual Cost	Gallon container	containers		3460	0.22
Annual Cost	2-gallon container	containers		2000	0.38
Annual Cost	3-gallon container	containers		1330	0.57

*Containers would be placed container to container with the exception of a 2-foot aisle down the center.

†It was estimated that it would require 10 hours to place the plants within the polyhouse, 10 hours to space them after overwintering, 5 hours to place and remove the polyethylene, and 1 hour for spraying, fumigating, and other miscellaneous chores. Average basic wage before withholding taxes and fringes $5.00, taxes and fringes add 32% or $1.60 for a total of $6.60.

TABLE 5.—Annual Costs (Dollars) for Overwintering Plants in a 14' x 96' Polyhouse Structure (Single Polyethylene Cover with Plants Covered with Either Single Poly or Single Poly Plus Thermal Blanket) in USDA Climatic Zones 5 and 6, 1984.*

Item	Description	Unit	Cost per Unit	Quantity	Total Cost Poly Only	Total Cost Poly and Thermal Blanket
Annual Fixed Costs						
Depreciation	10% of construction cost				113.15	113.15
Interest	Compounded at 15% per annum				169.73	169.73
Insurance and taxes	2% of construction cost				22.63	22.63
General overhead	One-fourth of total nursery overhead was assigned to overwintering				167.51	167.51
Interest on general overhead, insurance, and taxes	Compounded at 15% per annum for 6 months				14.26	14.26
Subtotal (annual fixed)					487.28	487.28
Annual Variable Costs						
Polyethylene	4 mil white, 24' x 110'	1000 sq ft	16.00	2.64	42.24	42.24
Thermal blanket	¼" — 15' x 100'	1000 sq ft	65.00	1/3 (1.5)†	0.00	32.50
Labor‡	Hired	hours	6.60	29/30	191.40	198.00
Bait blocks	Eaton	blocks	0.16	20.00	3.20	3.20
Chemicals	Termil (fungicide)	canister	1.66	2.00	3.32	3.32
	Benlate 50 WP (fungicide)	lb	13.30	0.05	0.67	0.67
Miscellaneous	Tie-down materials, furring strips, nails, treated grain, etc.				25.00	25.00
Interest on operating capital	Computed at 15% on an annual basis for 6 months	percent	7.5 (0.075)	265.83 304.93	19.94	22.87
Subtotal (annual variable)					285.77	327.80
Total Annual Costs					773.05	815.08
Annual Cost	Square foot	sq ft		1344	0.58	0.61
Annual Cost	Gallon container	containers		3460	0.22	0.24
Annual Cost	2-gallon container	containers		2000	0.39	0.41
Annual Cost	3-gallon container	containers		1330	0.58	0.61

*Containers would be placed container to container with the exception of a 2-foot aisle down the center.

†Thermal blankets would be used for 3 years.

‡It was estimated that it would require 10 hours to place the plants within the polyhouse, 10 hours to space them after overwintering, 5 hours to place and remove the polyethylene cover, 3 hours to place and remove the polyethylene film laid over the plants, and 1 hour for spraying, fumigating, and other miscellaneous chores. One additional hour was budgeted for the addition of a thermal blanket. Average basic wage before withholding taxes and fringes $5.00, taxes and fringes add 32% or $1.60 for a total of $6.60.

($169.73), and insurance and taxes ($22.63), contributed significantly to the total and were additional to structure-less overwintering systems.

6. Polyhouse Structure with One Polyethylene Film Cover Plus a Single Layer of Polyethylene Film Placed Directly on the Plants. Total annual costs of this system for a 14′ x 96′ area were $773.05 (Table 5), with $487.28 being fixed (63%) and $285.77 (37%) variable. They totaled $0.58 per sq ft, $0.22 per gallon container, $0.39 per 2-gallon container, and $0.58 per 3-gallon container.

7. Polyhouse Structure with One Polyethylene Film Cover Plus a Thermal Blanket and a Single Layer of Polyethylene Film Placed Directly on the Plants. Total annual costs of this system for a 14′ x 96′ area were $815.08 (Table 5), with $487.28 being fixed (59%) and $327.80 (41%) variable. They totaled $0.61 per sq ft, $0.24 per gallon container, $0.41 per 2-gallon container, and $0.61 per 3-gallon container.

8. Polyhouse Structure with Two Polyethylene Film Covers with No Additional Covering of Plants. Total annual costs for this system for a 14′ x 96′ area were $823.13 (Table 6), with $506.15 being fixed (61%) and $316.98 (39%) variable. They totaled $0.61 per sq ft, $0.24 per gallon container, $0.41 per 2-gallon container, and $0.62 per 3-gallon container. The annual costs for this system were almost identical to the polyhouse structure with one polyethylene film cover plus thermal blanket and a single layer of polyethylene film placed directly on the plants.

9. Polyhouse Structure with Two Polyethylene Film Covers with a Single Layer of Polyethylene Film Placed Directly on the Plants. Total annual costs of this system for a 14′ x 96′ area were $844.42 (Table 7), with $506.15 being fixed (60%) and $338.27 (40%) variable. They totaled $0.63 per sq ft, $0.24 per gallon container, $0.42 per 2-gallon container, and $0.63 per 3-gallon container.

10. Polyhouse Structure with Two Polyethylene Film Covers Plus a Thermal Blanket and a Single Layer of Polyethylene Film Placed Directly on the Plants. Total annual costs of this system for a 14′ x 96′ area were $886.45 (Table 7), with $506.15 being fixed (57%) and $380.30 (43%) variable. They totaled $0.66 per sq ft, $0.26 per gallon container, $0.44 per 2-gallon container, and $0.67 per 3-gallon container.

TABLE 6.—Annual Costs (Dollars) for Overwintering Plants in a 14' x 96' Polyhouse Structure (Double Polyethylene Cover with No Covering of Plants Within the House) in USDA Climatic Zones 5 and 6, 1984.*

Item	Description	Unit	Cost per Unit	Quantity	Total Cost
Annual Fixed Costs					
Depreciation	10% of construction cost				120.10
Interest	Compounded at 15% per annum				180.16
Insurance and taxes	2% of construction cost				24.02
General overhead	One-fourth of total nursery overhead was assigned to overwintering				167.51
Interest on general overhead, insurance, and taxes	Compounded at 15% per annum for 6 months				14.36
Subtotal (annual fixed)					506.15
Annual Variable Costs					
Polyethylene	4 mil white, 24' x 110'	1000 sq ft	16.00	5.28	84.48
Labor†	Hired	hours	6.60	27.00	178.20
Bait blocks	Eaton	blocks	0.16	20.00	3.20
Chemicals	Termil (fungicide)	canister	1.66	2.00	3.32
	Benlate 50 WP (fungicide)	lb	13.30	0.05	0.67
Miscellaneous	Tie-down materials, furring strips, nails, treated grain, etc.				25.00
Interest on operating apital	Computed at 15% on an annual basis for 6 months	percent	7.5 (0.075)	294.87	22.11
Subtotal (annual variable)					316.98
Total Annual Cost					823.13
Annual Cost	Square foot	sq ft		1344	0.61
Annual Cost	Gallon container	containers		3460	0.24
Annual Cost	2-gallon container	containers		2000	0.41
Annual Cost	3-gallon container	containers		1330	0.62

*Containers would be placed container to container with the exception of a 2-foot aisle down the center.

†It was estimated that it would require 10 hours to place the plants within the polyhouse, 10 hours to space them after overwintering, 6 hours to place and remove the polyethylene, and 1 hour for spraying, fumigating, and other miscellaneous chores. Average basic wage before withholding taxes and fringes $5.00, taxes and fringes add 32% or $1.60 for a total of $6.60.

TABLE 7.—Annual Costs (Dollars) for Overwintering Plants in a 14' x 96' Polyhouse Structure (Double Polyethylene Cover with Plants Covered with Either Single Poly or Single Poly Plus Thermal Blanket) in USDA Climatic Zones 5 and 6, 1984.

Item	Description	Unit	Cost per Unit	Quantity	Total Cost Poly Only	Total Cost Poly and Thermal Blanket
Annual Fixed Costs						
Depreciation	10% of construction cost				120.10	120.10
Interest	Compounded at 15% per annum				180.16	180.16
Insurance and taxes	2% of construction cost				24.02	24.02
General overhead	One-fourth of total nursery overhead was assigned to overwintering				167.51	167.51
Interest on general overhead, insurance, and taxes	Compounded at 15% per annum for 6 montths				14.36	14.36
Subtotal (annual fixed)					506.15	506.15
Annual Variable Costs						
Polyethylene	4 mil white, 24' x 110'	1000 sq ft	16.00	5.28	84.48	84.48
Thermal blanket	¼" — 15' x 100'	1000 sq ft	65.00	1/3 (1.5)†	0.00	32.50
Labor‡	Hired	hours	6.60	30/31	198.00	204.60
Bait blocks	Eaton	blocks	0.16	20.00	3.20	3.20
Chemicals	Termil (fungicide)	canister	1.66	2.00	3.32	3.32
	Benlate 50 WP (fungicide)	lb	13.30	0.05	0.67	0.67
Miscellaneous	Tie-down materials, furring strips, nails, treated grain, etc.				25.00	25.00
Interest on operating capital	Computed at 15% on an annual basis for 6 months	percent	7.5 (0.075)	314.67 353.77	23.60	26.53
Subtotal (annual variable)					338.27	380.30
Total Annual Costs					844.42	886.45
Annual Cost	Square foot	sq ft		1344	0.63	0.66
Annual Cost	Gallon container	containers		3460	0.24	0.26
Annual Cost	2-gallon container	containers		2000	0.42	0.44
Annual Cost	3-gallon container	containers		1330	0.63	0.67

*Containers would be placed container to container with the exception of a 2-foot aisle down the center.

†Thermal blankets would be used for 3 years.

‡It was esetimated that it would require 10 hours to place the plants within the polyhouse, 10 hours to space them after overwintering, 6 hours to place and remove the polyethylene, 3 hours to place and remove the polyethylene film laid over the plants, and 1 hour for spraying, fumigating, and other miscellaneous chores. One additional hour was budgeted for the addition of a thermal blanket. Average basic wage before withholding taxes and fringes $5.00, taxes and fringes add 32% or $1.60 for a total of $6.60.

11. Polyhouse Structure with Two Polyethylene Film Covers Plus Heat with No Additional Covering of Plants. Total annual costs of this system for a 14′ x 96′ area were $1,249.67 (Table 8), with $691.08 being fixed (55%) and $558.59 (45%) variable. They totaled $0.93 per sq ft, $0.36 per gallon container, $0.62 per 2-gallon container, and $0.94 per 3-gallon container. Costs were considerably higher for this system when compared to other systems as it was necessary to provide heating equipment and propane fuel.

Total costs for 14′ x 96′ areas were lowest for the first system (Table 9), structure-less with plants covered with polyethylene film ($405.27), and highest for the last system, polyhouse covered with two layers of polyethylene plus heat ($1,249.67). In general, costs increased with the degree of protection provided plants. Fixed costs as a percent of total costs were the highest for system 5 (65%) and lowest for system 3 (34%). In 7 of the 11 systems, fixed costs were higher than variable. They were only lower than variable costs in the three structure-less systems plus the polyhut. High fixed costs resulted from annual expenses for structures and the assigning of one-fourth of general overhead costs to overwintering.

TABLE 8.—Annual Costs (Dollars) for Overwintering Plants in a 14' x 96' Polyhouse Structure (Double Polyethylene Cover with Heat) in USDA Climatic Zones 5 and 6, 1984.*

Item	Description	Unit	Cost per Unit	Quantity	Total Cost
Annual Fixed Costs					
Depreciation	10% of construction cost				188.21
Interest	Compounded at 15% per annum				282.33
Insurance and taxes	2% of construction cost				37.64
General overhead	One-fourth of total nursery overhead was assigned to overwintering				167.51
Interest on general overhead, insurance, and taxes	Compounded at 15% per annum for 6 months				15.39
Subtotal (annual fixed)					691.08
Annual Variable Costs					
Polyethylene	4 mil white, 24' x 110'	1000 sq ft	16.00	5.28	84.48
Labor†	Hired	hour	6.60	27.00	178.20
Propane heat	Liquid — includes tanks and regulators	gallon	0.85	235.00	199.75
Bait blocks	Eaton	block	0.16	20.00	3.20
Chemicals	Termil (fungicide)	canister	1.66	2.00	3.32
	Benlate 50 WP (fungicide)	lb	13.30	0.05	0.67
Miscellaneous	Tie-down materials, furring strips, nails, treated grain, electricity, etc.				50.00
Interest on operating capital	Computed at 15% on an annual basis for 6 months	percent	7.5 (0.075)	519.62	38.97
Subtotal (annual variable)					558.59
Total Annual Cost					1249.67
Annual Cost	Square foot	sq ft		1344	0.93
Annual Cost	Gallon container	containers		3460	0.36
Annual Cost	2-gallon container	containers		2000	0.62
Annual Cost	3-gallon container	containers		1330	0.94

*Containers would be placed container to container with the exception of a 2-foot aisle down the center.

†It was estimated that it would require 10 hours to place the plants within the polyhouse, 10 hours to space them after overwintering, 6 hours to place and remove the polyethylene, and 1 hour for spraying, fumigating, and other miscellaneous chores. Average basic wage before withholding taxes and fringes $5.00, taxes and fringes add 32% or $1.60 for a total of $6.60.

TABLE 9.—Summary of Annual Fixed, Variable, and Total Costs (Dollars) of Overwintering Nursery Plants Differentiated by System in USDA Climatic Zones 5 and 6, 1984.*

System	Fixed Costs		Variable Costs		
	Amount	Percent of Total	Amount	Percent of Total	Total
Structure-less (14' x 96')					
1. Plants Covered with One Layer of Polyethylene Film	180.07	44	225.20	56	405.27
2. Plants Covered with a Thermal Blanket Plus One Layer of Polyethylene Film	180.27	40	267.23	60	447.30
3. Plants Surrounded by Bales of Straw	180.07	34	354.85	66	534.92
Polyhut Covered with One Layer of Polyethylene Film (6' x 96')					
4. No Direct Covering of Plants	109.61	43	146.33	57	255.94
Polyhouse Covered with One Layer of Polyethylene Film (14' x 96')					
5. No Direct Covering of Plants	487.28	65	264.48	35	751.76
6. Plants Covered with One Layer of Polyethylene Film	487.28	63	285.77	37	773.05
7. Plants Covered with a Thermal Blanket Plus One Layer of Polyethylene Film	487.28	59	327.80	41	815.08
Polyhouse Covered with Two Layers of Polyethylene Film with Air Blown Between the Films (14' x 96')					
8. No Direct Covering of Plants	506.15	61	316.98	39	823.13
9. Plants Covered with One Layer of Polyethylene Film	506.15	60	338.27	40	844.42
10. Plants Covered with a Thermal Blanket Plus One Layer of Polyethylene Film	506.15	57	380.30	43	886.45
Polyhouse Covered with Two Layers of Polyethylene Film with Air Blown Between the Films Plus Heat (14' x 96')					
11. No Direct Covering of Plants	691.08	55	558.59	45	1249.67

Annual costs per square foot of storage space varied from $0.30 to $0.93. They ranged from $0.30 to $0.40 in structure-less systems, were $0.44 in polyhuts, ranged from $0.56 to $0.61 in polyhouses covered with a single layer of polyethylene film, ranged from $0.61 to $0.66 in polyhouses covered with a double layer of polyethylene film, and were $0.93 in polyhouses covered with a double layer of polyethylene film and heated.

One-gallon containers, stored "can tight", had annual costs which varied from $0.10 to $0.36. They ranged from $0.10 to $0.14 in structure-less systems, were $0.15 in polyhuts, ranged from $0.22 to $0.24 in polyhouses covered with a single layer of polyethylene film, ranged from $0.24 to $0.26 in polyhouses covered with a double layer of polyethylene film, and were $0.36 in polyhouses covered with a double layer of polyethylene film and heated.

Two-gallon containers, stored "can tight", had annual costs which varied from $0.18 to $0.62. They ranged from $0.18 to $0.24 in structure-less systems, were $0.26 in polyhuts, ranged from $0.38 to $0.41 in polyhouses covered with a single layer of polyethylene film, ranged from $0.41 to $0.44 in polyhouses covered with a double layer of polyethylene film, and were $0.62 in polyhouses covered with a double layer of polyethylene film and heated.

Three-gallon containers, stored "can tight", had annual costs which varied from $0.27 to $0.94. They ranged from $0.27 to $0.35 in structure-less systems, were $0.40 in polyhuts, ranged from $0.57 to $0.61 in polyhouses covered with a single layer of polyethylene film, ranged from $0.62 to $0.67 in polyhouses covered with a double layer of polyethylene film, and were $0.94 in polyhouses covered with a double layer of polyethylene film and heated.

Covering plants in a polyhouse with a single layer of used polyethylene increased costs about $0.02 per sq ft (less than $0.01 per gallon container and about $0.01 for either a 2-or 3-gallon container) over not covering them. Adding a thermal blanket increased them an additional $0.03 per sq ft (about $0.02 per gallon container, $0.02 per 2-gallon container, and $0.03 per 3-gallon container).

Most costs increased directly with degree of winter protection provided. However, there may be some question as to which system is best. For example, is a plant

TABLE 10.—Summary of Annual Fixed, Variable and Total Costs (Cents) of Overwintering Nursery Plants Differentiated by System, Square Foot, and Container Size in USDA Climatic Zones 5 and 6, 1984.

System	Costs per Square Foot	Total Costs per Container 1-Gallon*	2-Gallon*	3-Gallon*
Structure-less (14' x 96')				
1. Plants Covered with One Layer of Polyethylene Film	30	10	18	27
2. Plants Covered with a Thermal Blanket Plus One Layer of Polyethylene Film	33	11	20	30
3. Plants Surrounded by Bales of Straw	40	14	24	35
Polyhut Covered with One Layer of Polyethylene Film (6' x 96')				
4. No Direct Covering of Plants	44	15	26	40
Polyhouse Covered with One Layer of Polyethylene Film (14' x 96')				
5. No Direct Covering of Plants	56	22	38	57
6. Plants Covered with One Layer of Polyethylene Film	58	22	39	58
7. Plants Covered with a Thermal Blanket Plus One Layer of Polyethylene Film	61	24	41	61
Polyhouse Covered with Two Layers of Polyethylene Film with Air Blown Between the Films (14' x 96')				
8. No Direct Covering of Plants	61	24	41	62
9. Plants Covered with One Layer of Polyethylene Film	63	24	42	63
10. Plants Covered with a Thermal Blanket Plus One Layer of Polyethylene Film	66	26	44	67
Polyhouse Covered with Two Layers of Polyethylene Film with Air Blown Between the Films Plus Heat (14' x 96')				
11. No Direct Covering of Plants	93	36	62	94

*Placed container to container except for a 2-foot aisle down the middle of the polyhouses.

better protected in a polyhouse covered with one layer of polyethylene film with a thermal blanket placed directly on the plants and the thermal blanket then covered with a layer of used polyethylene film or in a polyhouse covered with two polyethylene films with air blown between the layers but no additional covering of plants? The budgeted costs for the two systems were almost identical.

SUMMARY

Eleven systems for overwintering plants in nurseries were delineated. Costs per square foot of overwintering space ranged from \$0.30 to \$0.93. They ranged from \$0.30 to \$0.40 in structure-less systems, were \$0.44 in polyhuts, ranged from \$0.56 to \$0.61 in polyhouses covered with a single layer of polyethylene film, ranged from \$0.61 to \$0.66 in polyhouses covered with a double layer of polyethylene film, and were \$0.93 in a polyhouse covered with a double layer of polyethylene film and heated. In general, costs of providing overwintering varied directly with the degree of protection provided.

LITERATURE CITED

1. Taylor, Reed D., Harold H. Kneen, David E. Hahn, and Elton M. Smith. 1983. Costs of Establishing and Operating Container Nurseries Differentiated by Size of Firm and Species of Plant in USDA Climatic Zone Six. Southern Coop. Ser. Bull. 301.

This page intentionally blank.

OSU

The Ohio State University
Ohio Agricultural Research and Development Center