SUMMER TRANSPLANTING, CONTAINER-GROWING, AND FORCING OF SELECTED ORNAMENTAL PLANTS

Thesis for the Degree of M. S.

MICHIGAN STATE UNIVERSITY

James Lee Taylor

1957

SUMMER TRANSPLANTING, CONTAINER-GROWING, AND FORCING OF SELECTED ORNAMENTAL PLANTS

By

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A THESIS

Submitted to the School for Advanced Graduate Studies of Michigan State University of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Department of Horticulture

1957

ACKNOWLEDGEMENT

The author wishes to express his sincere appreciation to Dr. Fred B. Widmoyer for his constant guidance, patience, and valuable assistance; to Dr. Donald P. Watson for his respected counsel; and to Dr. Alvin L. Kenworthy and Dr. Walter E. Ballinger for their constructive suggestions.

The author also wishes to thank Mr. Robert L. Richter of Richter's Gardens for his suggestions and assistance in marketing the plant materials.

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INTRODUCTION

The nursery industry has been continually hampered by serious economic and labor handicaps which have resulted from employing large labor forces during the spring and fall when most nursery stock has been sold and transplanted. Methods of reducing these handicaps were studied in an attempt to extend the spring and fall planting seasons and to stimulate summer and winter sales.

One method studied was to determine the feasibility of transplanting selected deciduous and evergreen ornamentals during the summer months, utilizing different transplanting techniques in an effort to overcome seasonal concentrations of sales and labor.

Another method was to grow plants in containers, a practice commonly called container-growing. This study was to determine the adaptability of specific plants to such cultural practices. Selected deciduous flowering shrubs were container-grown and marketed in flower at Easter and Mother's Day during April and May. Selected evergreens were container-grown and marketed as living Christmas trees during December.

A third method studied was to force selected perennials for marketing at Easter and Mother's Day to determine the market potential of such plants.

LITERATURE REVIEW

Transplanting

High mortality rates in transplanting ornamental plants are common. Emerson and Hildreth (1933) reported that mortality rates of 50 to 100 percent are not uncommon in transplanting various species of coniferous evergreens in the semi-arid Great Plains region. They attributed the loss to (1) climatic factors favorable to high transpiration; (2) the necessity of moving evergreens in full foliage; and (3) the slow rate of root regeneration.

Working with pine seedlings, Wakely (1954) reported that weather at planting time was not an important cause of initial failure of the seedlings.

Thompson (1954) believed that, in general, a well-balanced fibrous root system was most important for successful transplanting. It was concluded that root pruning prior to transplanting encouraged the development of a fibrous root system.

Feasibility of this procedure was demonstrated by Faulkner in 1953. Root pruning one-year-old "Corsican" pine seedlings (*Pinus laricio corsicana* Loud.) resulted in a marked increase in the number of fibrous roots produced in the soil above the point of root severance.

Loomis (1925) found that large vegetable plants were more seriously injured by transplanting than small plants, because the proportion of roots retained at transplanting was less. In 1923, he had concluded that plants hardened before transplanting became established more rapidly after transplanting.

According to Goff (1897), failure of a tree to resume growth following transplanting was not always caused by insufficient soil moisture and that water pressure within the bud, supplied largely through root pressure, caused the expansion of leaves. Undisturbed plants maintained root pressure by water absorption through root hairs. By supplying water under pressure to a plant root, he was able to show that buds of treated trees expanded more rapidly than those of untreated trees.

Kramer reported in 1939 that root pressure had never been observed in gymnosperms. In 1945, he concluded that root pressure ordinarily supplied less than 5 percent of the water required by a rapidly transpiring plant.

Transplanting seriously reduced growth of Quercus palustris (Pridham, 1941). It was concluded that the reduced growth could not be entirely attributed to root or top pruning. Season, soil, and handling were important factors affecting growth.

In a review of literature, Whitten (1919) reported that the majority of investigators had recommended spring transplanting. According to Thompson (1954), some authorities have recommended fall transplanting, some winter, some spring, and some have pointed out that plants may be moved successfully during any season of the year, but with higher survival rates during some seasons than others, depending primarily on geographical location, climate, and species to be transplanted. He further stated that although plants were moved every month of the year, greater injury occurred if the plant was disturbed during its period of rapid growth.

From transplanting experiments in Michigan, Miller, Neilson, and Bandemer (1937) concluded that certain species of woody plants can be transplanted long after the usual spring planting season, if necessary. Cut-leaf maple (*Acer palmatum dissectum*), American elm (*Ulmus americana*), and common blue lilac (*Syringa vulgaris*) survived transplanting on July 18. Foliage present at the time of transplanting died, but new leaves developed from adventitious buds on most experimental plants.

Rogers (1921) reported that Western white pine (*Pinus monticola* Dougl.) could be transplanted successfully in Montana as late as June 15, although it was not a recommended practice. No single weight or measurement indicated consistently the degree of transplanting shock.

Roeser (1932) reported that coniferous seedlings of different species respond differently to changes in conditions affecting transpiration. In 1919, Weaver and Mogensen reported that deciduous trees do not transpire more than conifers under late summer conditions on an area for area basis. It was further concluded that water losses of coniferous trees were relatively no greater with the needles intact than the losses from deciduous trees after the leaves had fallen.

It was reported by Hamner, Carlson, and Tukey (1945) that succulent plants and cut flowers could be maintained in a turgid condition four to thirty-six hours longer than untreated plants by submerging them in water and partially evacuating the air by using a vacuum pump.

Container-Growing

The practice of placing young plants in containers (usually metal) and then growing them to saleable sizes was begun commercially in the early part of the twentieth century (Barker, 1956). Advantages of container-grown stock include (1) extension of the growing season, (2) stock does not have to be planted immediately, (3) the potential of selling plants in flower, and (4) larger plants can be produced more quickly in containers (Stoutemyer, 1955, 1957, and Barker, 1956).

Mulholland (1951) reported four major factors involved in container-growing; climate, soil, water, and fertilization, listed in descending order of their importance. Drainage and aeration were very important according to Hill (1955). Roller (1955) emphasized that adequate drainage was the most important factor involved in selecting a soil mixture for container-growing. Loehwing (1934) reported that abundant soil aeration favored root branching and profuse root hair production.

Winter protection tests conducted by Barker (1956) indicate that the production of container-grown stock was entirely feasible in the North Central States. The work of Hill (1955) in Illinois concurred with Barker, and added further support to the practice of container-growing as a commercial practice.

Forcing

Fisher (1945) concluded that generally any small flowering tree or shrub on which the flower buds are formed during the previous fall growing season will force well. Cultural recommendations for forcing many shrubs and perennials are available (Toole, 1934; Swoboda, 1941; Fisher, 1945; Chabot, 1946; Laurie and Kiplinger, 1948; and Wyman, 1955).

Shrubs used for forcing required treatment in advance. All useless branches were removed and a fibrous root system developed either by root pruning or transplanting to containers (Chabot, 1946 and Laurie and Kiplinger, 1948).

In general, the earlier in the season plants are moved into greenhouses for final forcing, the time required to have plants in full bloom increases. For early forcing, plants were usually shifted into cool greenhouses and later transferred to 60° F houses for flowering. Daily syringing caused the buds to develop and open more evenly (Fisher, 1945; Chabot, 1946; Laurie and Kiplinger, 1948; and Wyman, 1955).

Kammerer (1941) produced a time schedule for forcing branches indoors. He reported that branches used for forcing must come from plants that had passed through a period of dormancy.

In 1955, Wyman produced a similar schedule. He found that plants dug with a ball of soil adhering to the roots could be forced into flower in approximately the same length of time as cut branches.

Plants that have been forced usually required two growing seasons to regain their normal vigor and flowering ability, according to Fisher (1945), and Chabot (1946).

PROCEDURE

Perennials

On June 19, twenty of each of the following selected perennials* - Aquilegia vulgaris 'Giant Mixed'; Armeria laucheana; Dicentra eximia; Iberis sempervirens 'Purity'; Penstemon newberryi; and Veronica spicata 'Minuet' were potted in 6-inch clay pots and placed in coldframes where they remained until the time of forcing. A uniform potting mixture of two parts soil, one part sand, and one part peat was used, to which was added two ounces of urea formaldehyde (38-0-0) and two ounces of double superphosphate (0-45-0) per bushel of mixture. Urea formaldehyde fertilizers are reaction products of urea and formaldehyde containing nitrogen largely in an insoluble but slowly available form. Double superphosphate contains more available phosphoric acid than superphosphate. It is manufactured by treating phosphate rock with phosphoric acid instead of sulfuric acid, as used in the manufacture of superphosphate.

Deciduous Shrubs

On July 6, twenty-four Spiraea bumalda 'Anthony Waterer', 18 to 24 inches tall, were dug and transported to the greenhouse where all adhering soil was carefully washed from the roots. Branches of the plants were pruned six to eight inches to form a balanced plant. Shrubs were subjected

*Courtesy of Wayside Gardens, Mentor, Ohio to the following treatments, using six plants per treatment:

1. Potted and placed in shaded coldframes.
2. Potted and placed in shaded coldframes under mist.
3. Subjected to vacuum, potted, and placed in shaded coldframes.
4. Subjected to vacuum, potted, and placed in shaded coldframes under mist.

The potting mixture was similar to the one used for the perennials. The amount of shade in the coldframes was determined to be 15 percent of direct sunlight using a Weston Illumination meter. Misting occurred only during the daylight hours, based on the procedure reported by Sweet and Carlson (1955). Mist was applied constantly using 3-gallon-per-hour nozzles. After five days under mist, plants were removed and placed under shade for two additional days.

The vacuum treatment used was similar to one reported by Widmoyer (1954) and consisted of immersing the plants in a container of water and partially evacuating the air through a valve in the cover by means of a Cenco-Pressovac 4 Pump. After a vacuum had been drawn on the system, it was gradually released, causing water to infiltrate the leaves and stems of the submerged plants. This process was repeated several times until the foliage became partially water-soaked in appearance. Weights of the plants were recorded before and after vacuum treatments to determine the increase in the amount of water in the plant (Table 3).

Upon completion of the treatments, plants were potted in 8-inch plastic pots and placed in coldframes. Weather data were recorded (Table 1).

A similar number of *Philadelphus virginalis* and *Syringa vulgaris* were subjected to the same treatments on July 7. *Philadelphus* were pruned four to six inches before treatment, and *Syringa* were left unpruned.

Syringa were removed from mist ten days after treatment and shaded three additional days before being exposed to direct sunlight. *Philadelphus* were removed from mist twelve days following treatment and shaded three additional days. Deciduous shrubs remained in coldframes until March 28, when they were shifted into the greenhouse for forcing.

Evergreen Trees

On August 3, 4 and 5, forty-eight balled and burlapped Black Hills Spruce (*Picea glauca densata*), 18 to 24 inches tall, and a similar number of Scots Pine (*Pinus sylvestris*) were subjected to the following treatments, using eight plants per treatment.

1. Potted bareroot and placed in shaded coldframes.
2. Potted bareroot and placed in shaded coldframes under mist.
3. Subjected to vacuum, potted, and placed in shaded coldframes.
4. Subjected to vacuum, potted, and placed in shaded coldframes under mist.

5. Potted with a ball of soil and placed in shaded coldframes.
6. Potted with a ball of soil and placed in shaded coldframes under mist.

The procedure used was similar to the one used for deciduous shrubs. Following treatment, some root pruning and reduction in size of the soil ball was necessary before potting the plants in 8-inch plastic pots.

For the first week after transplanting, mist was applied constantly during daylight hours, followed by a hardening-off period when the mist was operated during the afternoon. Shade was removed four weeks after transplanting. Survival rates for the different transplanting methods are recorded in Table 4. The evergreens remained in coldframes until December when they were removed to a local retail garden center in Lansing*, where they were marketed as living Christmas trees.

Forcing

On March 28, all perennials and deciduous shrubs were removed from the coldframes where they had been placed after potting the previous summer, and were transferred to a 65° F (night temperature) greenhouse for forcing. A Bendix-Friez hygrothermograph was used to record temperature and humidity fluctuations in order to maintain uniform growing conditions. Mist was applied several times daily to increase the humidity while the buds were opening. Artificial light was not used during the forcing period.

*Richter's Gardens, 4801 South Cedar, Lansing, Michigan

General Maintenance

Frequent fertilizer applications and insect and disease sprays were necessary to maintain the plants in a vigorous growing condition. Bimonthly applications of liquid cattle manure were made throughout the summer and fall on perennials and deciduous shrubs. Weekly applications of Tri 40,* a complete liquid fertilizer (10-20-10), were made during the forcing period of the plants.

Plants were sprayed with Captan to control crown rot; Karathane to control powdery mildew; and Malathion to control insects. Deciduous shrubs and evergreens not under mist, were sprinkled from overhead two or three times a day for the first few weeks after transplanting.

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*Scope Chemicals, 279 Ninth St., Benton Harbor, Michigan

RESULTS

Transplanting

Weather: During the transplanting period of July 6 to August 5 and continuing to September 2, weather conditions were favorable for high survival rates (Table 1). The amount of precipitation recorded at the East Lansing Weather Station during July and August was 5.89 inches, which was 0.93 inches above the normal for a 30-year period at East Lansing, Michigan. Precipitation was reported on 39 different days during these two months. Total precipitation during September, October and November was 2.05 inches, which was 5.75 inches below normal, based on a 30-year average at East Lansing, Michigan. Average daily mean temperatures were fairly uniform during the project, except October, when the average was 57.4°F, or 6.9° above normal. The low amount of sunshine and high relative humidity during July and August were favorable to low transpiration rates and were caused by the frequent cloudy and overcast sky conditions that accompanied the above-normal precipitation.

Deciduous Shrubs: All deciduous shrubs survived transplanting. The quality of surviving plants varied considerably, depending on the treatment, species, and date of observation (Table 2).

Plants were rated poor, fair, good, or excellent at four selected intervals during the project. A poor rating was used for plants that had

Table 1. East Lansing Weather Data for the Period June to November, 1956.

Month	Temperature (°F)		Precipitation (Inches)		Ave. Relative Humidity (%)*	Sunshine - Percent of Possible
	Ave. Daily Mean	Departure from Normal	Total	Departure from Normal		
June	70.2	+2.8	1.80	-1.57	61	77
July	69.8	-1.3	2.69	+0.41	68	67
August	70.0	+1.0	3.20	+0.52	71	68
September	60.0	-1.8	0.53	-2.52	65	72
October	57.4	+6.9	0.28	-2.17	63	74
November	39.3	+1.4	1.24	-1.06	72	23

Note: From U. S. Department of Commerce, Weather Bureau, East Lansing, Michigan. Normal is based on a thirty-year average.

*Relative humidity is recorded twice daily. The average of the weather report readings was used in computing the monthly averages for this study.

Table 2. Observations of Deciduous Shrubs at Selected Intervals Following Transplanting on July 6 and 7.

Treatment	Observation Date	No. Days After Transplanting	Appearance of Plants: Philadelphus virginalis	Spiraea bumalda 'Anthony Waterer'	Syringa vulgaris
Bareroot	July 10	4	Poor	Good	Good
	July 23	17	Poor	Good	Good
	Sept. 26	82	Good	Excellent	Excellent
	May 2	300	Excellent	Excellent	Excellent
Bareroot and Mist	July 10	4	Fair	Excellent	Good
	July 23	17	Fair	Excellent	Good
	Sept. 26	82	Good	Excellent	Excellent
	May 2	300	Excellent	Excellent	Excellent
Vacuum and Bareroot	July 10	4	Poor	Good	Poor
	July 23	17	Poor	Good	Poor
	Sept. 26	82	Good	Excellent	Excellent
	May 2	300	Excellent	Excellent	Excellent
Vacuum, Bareroot and Mist	July 10	4	Fair	Excellent	Poor
	July 23	17	Fair	Excellent	Poor
	Sept. 26	82	Good	Excellent	Excellent
	May 2	300	Excellent	Excellent	Excellent

Rating Scale: Poor - over one-half of the leaves wilted, dying, or dead.
Fair - one-quarter to one-half of the leaves wilted, dying, or dead.
Good - having a few wilted leaves, or developing new leaves.
Excellent - vigorously growing plants.

one-half or more wilted, dying, or dead leaves. Plants with one-fourth to one-half of their leaves in a similar condition were rated fair. A good rating was given plants that had a few wilted leaves, or that were developing new leaves. Plants rated excellent were growing vigorously, and had no wilted or dead leaves.

The Philadelphus plants rated poor on July 10 had over one-half of their leaves wilted and by July 23 the leaves were dead. On September 26, all Philadelphus plants had formed new leaves and were rated good. With the exception of three plants, the Philadelphus were growing vigorously and developing flower buds when the last rating was made on May 2, and were rated excellent.

Syringa plants rated poor had over one-half of their leaves wilted, whereas plants rated good had few wilted leaves. The leaves of all Syringa plants that wilted regained their turgidity at night. By September 26, all Syringa had recovered from transplanting and were growing vigorously.

Spiraea rated good had a few wilted leaves, but had recovered from transplanting and were growing vigorously by September 26.

Mist was beneficial on Philadelphus and Spiraea, but did not affect Syringa. Philadelphus and Spiraea under mist had more turgid leaves and lost fewer leaves than plants not misted.

All shrubs subjected to a vacuum exhibited uniform increases in weight following treatment. They increased from 9.5 to 11.4 percent (Table 3). Shrubs subjected to vacuum and not placed under mist lost the most leaves.

The Philadelphus plants placed under mist lost approximately one-fourth of their leaves, while plants not under mist dropped one-half to three-fourths of their leaves. In general, the use of vacuum on Philadelphus, Spiraea, and Syringa increased the time required for the plants to recover from transplanting.

Spiraea and Syringa recovered from transplanting more quickly than Philadelphus and were in excellent condition on September 26, eighty-two days after transplanting. With the exception of three Philadelphus plants, all deciduous shrubs were growing vigorously on May 2, ten months after transplanting.

Evergreen Trees: Twenty-eight percent of the evergreen trees did not survive transplanting (Table 4). Picea and Pinus, potted with a ball of soil adhering to the roots, had the highest survival rate. Trees subjected to a vacuum had the lowest survival rate. Mist improved the survival rate of bareroot transplants of Pinus, but produced little effect on Picea.

Picea had a higher survival rate than Pinus. At the time of transplanting, it was observed that Picea had a more fibrous root system than Pinus.

Table 3. Weights of Deciduous Shrubs Before and Following Vacuum Treatments.

Plant	No. of Plants	Weight Before Treatment (Lbs)	Weight After Treatment (Lbs)	Difference (Lbs) Increase	Percent Difference Increase
Philadelphus virginalis	12	8.12	8.92	0.80	10.2
Spiraea bumalda 'Anthony Waterer'	12	4.67	5.16	0.49	9.5
Syringa vulgaris	12	11.84	12.88	1.04	11.4

Trees listed in Table 4 as surviving in poor condition were unsaleable as living Christmas trees as a result of an excessive loss of needles. No measurable differences in weights of trees were attributed to vacuum treatments.

Container-Growing

Deciduous and evergreen plants were grown in 8-inch plastic pots throughout the project. These pots were not damaged from over-wintering. Fifty percent of the 6-inch clay pots in adjoining coldframes were damaged from over-wintering and were replaced. No over-wintering, nutritional, disease or soil-mix difficulties were encountered in growing the deciduous and evergreen plants in containers.

Forcing

The perennials Dicentra, Iberis, and Penstemon flowered more uniformly when forced (Table 5). Dicentra flowered after 13 days in the greenhouse and Iberis and Penstemon after 23 days. Armeria failed to flower evenly, although some plants flowered profusely after 16 days. Aquilegia flowered unevenly after 32 days. Flower spikes were produced unevenly by Veronica after 42 days, but did not flower in time to be marketed.

The Philadelphus flowered profusely and evenly after 40 days. Three of the twelve plants subjected to a vacuum were less vigorous and developed fewer flower buds and leaves.

Table 4. Survival Rate of Transplanted Evergreen Trees Subjected to Various Transplanting Techniques on August 3, 4, and 5 (Eight Plants per Treatment).

Treatment	Surviving in Good Contition		Surviving in Poor Condition		Not Surviving	
	Pinus sylvestris	Picea glauca densata	Pinus sylvestris	Picea glauca densata	Pinus sylvestris	Picea glauca densata
Bareroot	1	4	1	2	6	2
Bareroot and mist	6	4	2	3	0	1
Vacuum and bareroot	0	2	0	3	8	3
Vacuum, bare-root and mist	1	3	3	2	4	3
Balled	8	7	0	1	0	0
Balled and mist	4	6	4	2	0	0

Note: Plants surviving in poor condition were alive, but not saleable as living Christmas trees.

Table 5. Forcing Results for Selected Ornamentals Brought into a 65° F Greenhouse on March 28.

Plant	Normal Date of Flowering Outdoors	Estimated Days Until Flower	Observed Days Until Flower	Flowering Even or Uneven
Aquilegia vulgaris 'Giant Mixed'	Late May	42-49	37-45	Uneven
Armeria laucheana	Mid May	21-28	16-21	Uneven
Dicentra eximia	Early May	21-28	13	Even
Iberis sempervirens 'Purity'	Early May	21-28	23	Even
Penstemon newberryi	Mid May	21-28	24	Even
Philadelphus virginalis	Mid June	42-49	40	Even
Spiraea bumalda 'Anthony Waterer'	July	42-49	50-54	Even
Syringa vulgaris	Mid May	21-28	21-25	Uneven
Veronica spicata 'Minuet'	July	42-49	56-70	Uneven

Note: Based on night temperature of greenhouse.

The 24 Spiraea plants were all equally vigorous when forced and their flower buds developed uniformly. Only seven of the 24 Syringa plants flowered because few flower buds had been initiated during the transplanting period. These seven plants flowered unevenly.

Marketing

Perennials were marketed at a local retail garden center* during the week of Easter (April 21) and Mother's Day (May 12). Armeria, Aquilegia and Dicentra marketed well, while there was little demand for Penstemon. Iberis marketed better than Penstemon, but not as well as Armeria, Aquilegia, and Dicentra.

Syringa plants were received favorably at Easter at the same garden center, but insufficient plants were marketed to fully evaluate the marketing possibilities. A flowering Syringa placed near dormant stock of similar varieties stimulated sales.

The Philadelphus plants were marketed for Mother's Day similarly to Syringa and were also favorably accepted. The Spiraea plants were marketed after Mother's Day and were favorably received.

Evergreen trees were marketed as living Christmas trees during December at the same garden center. Growing instructions for both Picea and Pinus were printed on 4 by 6 inch cards and accompanied each Christmas tree purchased (Figure 1).

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*Richter's Gardens, 4801 S. Cedar, Lansing, Michigan

This is a Black Hills Spruce (Picea glauca densata) a slow growing compact tree maturing at a height of 40-95 feet.

1. Place tree in a cool part of the room.

2. Water every two to four days; apply enough water so that it drains out the bottom of the pot.

3. Tree should not be kept in a warm room longer than two weeks.

4. Remove tree to cool basement and store until spring or plant immediately.

5. If you plant immediately: (a) Have a hole prepared in advance and filled with leaves, straw or manure to prevent freezing. (b) Remove plant from pot, place in hole, pack soil, water heavily and mulch; soil in pot should be in a dry condition when removed from pot. (c) Continue watering the tree as needed throughout the winter, summer and fall.

6. If you store tree in basement: (a) Place tree in a cool, lighted room and keep soil from drying out. (b) Transplant in spring when ground is tillable and water heavily. (c) Water throughout summer and late fall before freezing.

Figure 1

Sample of cultural directions which accompanied each Christmas tree marketed.

The trees were well accepted although many customers would have preferred a slightly larger tree than the 18- to 24-inch size offered. Picea proved more satisfactory as living Christmas trees than Pinus because of their finer texture, more dense form, and greener color.

Customers reported that three of the 25 trees marketed failed to survive during the following five month period.

The total cost of production and selling price of plants used in the project are shown in Table 6.

Table 6. Cost of Production and Selling Price of Plants

Plant	Total Estimated Cost of Production of Forced Plants and Evergreens	Selling Price (Retail)	
		Forced Plants	Dormant Plants
Aquilegia vulgaris 'Giant Mixed'	$.50	$1.00	$.75
Armeria laucheana	.45	.50	.35
Dicentra eximia	.45	1.00	.85
Iberis sempervirens 'Purity'	.45	1.00	.80
Penstemon newberryi	.45	1.00	.90
Philadelphus virginalis	1.25	2.50	1.25
Spiraea bumalda 'Anthony Waterer'	1.25	2.50	1.25
Syringa vulgaris	1.50	2.50	1.50
Veronica spicata 'Minuet'	.60	Not marketed	.90
Picea glauca densata	2.75	4.00	4.50
Pinus sylvestris	2.75	4.00	4.00

Note: The total estimated cost of production was for the year 1956-1957 and includes such items as original cost of the plants, labor, pots, spray materials, fertilizers, greenhouse space, and potting soils.

DISCUSSION

Transplanting

Weather: The frequent rains during July and August reduced the exposure of the plants to sunlight. Consequently, the amount of transpiration was decreased. The accompanying high relative humidity favored a lower rate of transpiration.

Deciduous Shrubs: Mist reduced the amount of water loss from transpiration by increasing the relative humidity and the amount of foliar absorption of water.

The turgidity of the leaves of most plants under mist was more uniformly maintained than that of plants not under mist. This indicated that the leaves absorbed water directly. Since the plants not under mist were sprinkled two or three times a day for the first few weeks after transplanting, appreciable foliar absorption of water may have occurred. This may partially explain the lack of response of *Syringa* to mist.

The reason for the slow recovery rate of *Philadelphus*, as compared to the other shrubs, is not definitely known. Differences in root systems of the shrubs were not observed at transplanting. One possible explanation may involve the pubescence of the lower epidermis of the leaves. Absorption of water may have been prevented by the entrapment of air within the pubescence.

The amount of water that infiltrated the leaves of plants subjected to a vacuum was probably influenced by the amount of leaf surface exposed, and by anatomical differences in the leaves.

Evergreen Trees: Plants potted with a ball of soil adhering to the roots had the highest survival rate (78%) because a larger proportion of the root system was retained at transplanting. Thus, the absorption of more water through the root system was possible. This conclusion agrees with the work of Thompson (1954). Most water absorption occurs in the terminal or younger, unsuberized portions of roots. These roots are usually lost during transplanting (Loomis, 1925).

Water did not enter the needles of evergreen trees submerged in water and subjected to a vacuum. This may be partially explained by the fact that *Picea*, *Pinus*, and most conifer needles have sunken stomates, a thick cuticle that covers the epidermis, thick epidermal walls, and a low surface to volume ratio which tends to prevent the uptake of water (Marco, 1939).

No reason was determined for the low survival rate of plants subjected to a vacuum.

The higher survival rate of *Pinus* subjected to mist may indicate that some water-vapor was absorbed through the needles. Stone *et al* (1950) reported that foliar absorption of water-vapor is possible in some conifers.

It was found that Pinus Coulteri, in a condition of permanent wilting, was able to absorb water-vapor from the atmosphere. Plants that retain a small proportion of their root system at transplanting may be in a somewhat similar condition and consequently may absorb water-vapor through their leaves.

Mist may have reduced or prevented the water loss by transpiration. The survival rate of Picea was not influenced by mist. Apparently little or no water was absorbed through the needles. This indicated that the root system was able to absorb sufficient water to prevent the plants from reaching a condition of permanent wilting.

The cause of the 28 percent mortality of evergreen trees was attributed to the inability of the roots to absorb sufficient water. Twice as many Pinus as Picea failed to survive. This suggests that more water was absorbed by the fibrous root system of Picea which would agree with the work of Thompson (1954).

Container-Growing

The 8-inch plastic pots used throughout the project were satisfactory for growing 18- to 24-inch plants.

All plants were successfully over-wintered in open coldframes without protection which agrees with the conclusions of Hill (1955) and Barker (1956).

The plastic pots showed no signs of deterioration from over-wintering. However, some care in handling was necessary during freezing weather to prevent the pots from cracking. Pots frequently cracked when lifted by the top with one hand. The cracks which occurred did not make immediate replacement necessary. No cracking occurred when both hands were used for lifting.

Fifty percent of the 6-inch clay pots were damaged from over-wintering and required immediate replacement. Clay pots require protection for over-wintering out-of-doors in this area.

Forcing

Aquilegia, Dicentra, and Iberis forced evenly and were acceptable pot plants. They required little attention and forced easily.

Penstemon forced evenly, but was not a desirable pot plant due to an unfavorable spreading growth habit. Additional light, or a reduced forcing temperature, may possibly overcome some of this difficulty.

Armeria did not flower evenly, or grow well in pots. The amount of moisture and light apparently did not influence growth of the plants. A potting mixture containing more sand may have produced better results.

Veronica produced flower spikes unevenly and required an excessive period of time for forcing. They were too spreading for acceptable pot plants. Apparently 56 to 70 days are required for flowering at this season.

Philadelphus were excellent container-grown plants and required the least attention of the deciduous shrubs. They produced flower buds profusely and uniformly.

Spiraea required more attention than the other deciduous shrubs because frequent applications of insecticides were necessary. They required a longer period of time for forcing. Many tall shoots were produced which resulted in an unbalanced plant. Many of these shoots had to be pruned before marketing. Additional light, a reduced forcing temperature, and less nitrogen may have helped overcome this difficulty.

Only seven of the 24 Syringa plants flowered because few flower buds were initiated during the preceding fall growing season. During this time, the plants were recovering from transplanting, consequently, few flower buds were formed. Syringa must be transplanted before July if a normal number of flower buds are to be initiated that year. The plants, however, may be transplanted after the buds have formed in the fall. No relationship existed between the plants that flowered and their specific transplanting methods.

The uneven flowering of Syringa may possibly be attributed to uneven flower bud initiation during the previous fall. Syringa required a minimum of cultural care. If more plants had flowered, they would have been excellent container-grown plants.

The plants generally forced into flower in their natural flowering sequence. Plants that flower earliest out-of-doors forced in the shortest period of time. These observations agree with Kammerer (1941) and Wyman (1955).

Marketing

Armeria, *Aquilegia*, and *Dicentra* marketed well because of abundant attractive flowers. *Armeria* were priced below the other perennials which increased their demand (Table 6).

Iberis sold slowly because of price. Customers preferred to wait until the plants flowered under normal conditions, since they are then sold at a much lower price. *Iberis* had attractive flowers which persisted for three continuous weeks.

Penstemon did not market as well as the other perennials because of its low, spreading habit and also because prospective customers were not familiar with the plants. *Veronica* were not marketed as the time required for flowering exceeded the planned date of sale.

The *Philadelphus* were exceptionally popular at Mother's Day because of the large number of fragrant, attractive flowers.

The *Spiraea* marketed at Mother's Day in bud did not sell well. Because of cool temperatures, the plants displayed out-of-doors at the garden center failed to flower. Consequently, they were marketed after Mother's Day.

The few Syringa marketed at Easter were favorably received.

In all cases, sales were stimulated by displaying a flowering shrub near dormant stock of similar varieties. In this way the customers were able to compare dormant and flowering stock. This is important since many customers do not recognize shrubs except when in flower. It is difficult for most customers to identify plants from pictures. Color and other characteristics of plants are difficult or impossible to reproduce by pictures.

Flowering shrubs were favorably received because they had attractive fragrant flowers; they added variety to the Easter and Mother's Day markets; they were hardy plants which could be used in home landscaping; they were priced below some of the popular holiday plants; they were a novelty; and customers were willing to pay a higher price for a plant in flower, compared to a dormant plant.

Customers preferred Picea to Pinus because of its fine texture, dense form, and dark green color. The Pinus were coarse, open-branched, and yellowish green in color.

Three of the 25 Christmas trees marketed did not survive. Most of the needles of the trees examined had turned brown. Over-watering, under-watering, high temperature, low humidity, and low light intensity may have caused this loss. These factors could not be evaluated, since the plants were not examined until four months after they had been marketed. No observations of the plants had been made during this time. Apparently, insect and disease problems were not involved. The trees may not have completely recovered from transplanting, although this is doubtful since the plants appeared to be alive and vigorous when marketed in December.

All deciduous and evergreen plants were potted in six different colors of containers. The colors were white, yellow, green, blue, red, and mottle. Customers showed no preferences for any color.

Although there is a market for flowering container-grown deciduous shrubs, few nurserymen possess adequate facilities for forcing the plants. Consequently, it may be necessary to either construct greenhouses for this purpose, or contract the forcing of the plants. Concurrently, the conversion of existing propagation structures may be practical.

Production costs and selling prices for the plants used in the project are shown in Table 6. Retail prices for similar dormant plants are shown for comparison. The cost of production on a commercial basis may not be as high as indicated, because of more efficient utilization of labor. Much of the labor involved may be performed during summer and winter months when there is a reduced demand for labor and sales.

The production of Aquilegia, Dicentra, Iberis, Philadelphus, Spiraea, Syringa, Picea, Pinus, and perhaps Penstemon proved to be economically feasible. The production costs were estimated and included the original cost of the plants, labor, pots, spray materials, fertilizers, greenhouse space, and potting soils.

Selling prices were calculated according to standard commercial practice. Armeria sold at this profit would require a huge volume of sales to be economically feasible. Retail prices for dormant stock were obtained from local nursery catalogues.

Conclusions and Recommendations

Container-growing and summer transplanting of deciduous and evergreen trees are feasible in the Ingham County area of Michigan as methods of utilizing labor and plant materials more efficiently. Watering is the most important factor involved.

Frequent watering is necessary for high survival rates.

Frequent applications of readily soluble fertilizers are necessary during periods of active growth of container-grown plants, since a small amount of soil is present in the container.

Leaf drop does not seriously affect the survival of deciduous plants after transplanting, since new leaves are soon produced.

There is a demand for living Christmas trees, potted flowering perennials, and flowering container-grown deciduous stock for specific holiday markets. Displaying flowering deciduous shrubs near dormant stock of similar varieties stimulates sales.

Aquilegia, *Dicentra*, and *Iberis* are satisfactory for forcing and marketing as pot plants. *Philadelphus*, *Spiraea*, and *Syringa* are satisfactory for forcing and marketing as container-grown plants.

Larger living Christmas trees may market better than the 18- to 24-inch size used in this project.

A potting mixture containing more sand than the soil, sand, and peat mixture of 2:1:1 utilized in this study may be more satisfactory for survival and growth of evergreens.

SUMMARY

Various methods were studied by which the nursery industry can extend the spring and fall planting seasons and stimulate summer and winter sales. The methods studied were summer transplanting, container-growing, and forcing selected perennials, deciduous flowering and evergreen shrubs for marketing.

Philadelphus virginalis, Picea glauca densata, Pinus sylvestris, Spiraea bumalda 'Anthony Waterer', and Syringa vulgaris were selected for transplanting and container-growing studies. Transplanting techniques compared using evergreens included bareroot, mist, vacuum, and balled treatments. The highest survival rate occurred when plants were potted with a ball of soil adhering to the roots. Mist was beneficial on Pinus, but had no affect on Picea.

All shrubs used in transplanting studies were also used for container-growing. Picea and Pinus were marketed as living Christmas trees during December. There was a good demand for both species but Picea was preferred to Pinus because of finer texture, denser form, and greener color. There was also a preference for slightly larger trees than the 18- to 24-inch size offered.

The deciduous flowering shrubs were forced in a 65° F greenhouse

for holiday markets. Syringa flowered unevenly and were marketed for Easter. Philadelphus and Spiraea flowered uniformly and were marketed in early May. All deciduous shrubs were favorably received at the retail garden center where they were marketed.

No over-wintering, nutritional, disease or soil-mix difficulties were encountered in growing the deciduous and evergreen plants in containers.

Aquilegia vulgaris 'Giant Mixed', Armeria laucheana, Dicentra eximia, Iberis sempervirens 'Purity', Penstemon newberryi, and Veronica spicata 'Minuet' were the perennials selected for forcing. Dicentra, Iberis, and Penstemon forced well and flowered evenly.

Aquilegia, Armeria, and Veronica were not as satisfactory for forcing due to uneven flowering and undesirable growth habit.

Aquilegia, Armeria, Dicentra, and Iberis were marketed for Easter and Mother's Day and were favorably received.

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SUMMER TRANSPLANTING, CONTAINER-GROWING, AND FORCING OF SELECTED ORNAMENTAL PLANTS

By

JAMES LEE TAYLOR

AN ABSTRACT

Submitted to the School for Advanced Graduate Studies of Michigan
State University of Agriculture and Applied Science
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Horticulture

1957

Approved ____________

JAMES LEE TAYLOR ABSTRACT

Various methods were studied by which the nursery industry can extend the spring and fall planting seasons and stimulate summer and winter sales. The methods studied were summer transplanting, container-growing, and forcing selected perennials, deciduous flowering and evergreen shrubs for marketing.

Philadelphus virginalis, Picea glauca densata, Pinus sylvestris, Spiraea bumalda 'Anthony Waterer', and Syringa vulgaris were selected for transplanting and container-growing studies. Transplanting techniques compared using evergreens included bareroot, mist, vacuum, and balled treatments. The highest survival rate occurred when plants were potted with a ball of soil adhering to the roots. Mist was beneficial on Pinus, but had no affect on Picea.

Transplanting techniques compared using deciduous shrubs included bareroot, mist, and vacuum treatments. All shrubs survived transplanting and most were in excellent condition ten months later.

All shrubs used in transplanting studies were also used for container-growing. Picea and Pinus were marketed as living Christmas trees during December. There was a good demand for both species but Picea was preferred to Pinus because of finer texture, denser form, and greener color.

There was also a preference for slightly larger trees than the 18- to 24-inch size offered.

The deciduous flowering shrubs were forced in a 65° F greenhouse for holiday markets. Syringa flowered unevenly and were marketed for Easter. Philadelphus and Spiraea flowered uniformly and were marketed in early May. All deciduous shrubs were favorably received at the retail garden center where they were marketed.

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Accompanied by one figure and six tables.

Date Due
