A PLASTIC COVERED MIST PROPAGATING
STRUCTURE FOR OUTDOOR USE
IN OKLAHOMA

By

FRANK ROBERT ELMORE

Bachelor of Science

University of Arkansas

Fayetteville, Arkansas

1954

Submitted to the Faculty of the Graduate School of
The Oklahoma State University
in partial fulfillment
of the requirements
for the degree of
MASTER OF SCIENCE
August, 1958

A PLASTIC COVERED MIST PROPAGATING

STRUCTURE FOR OUTDOOR USE

IN OKLAHOMA

Thesis Approved:

Robert P. Ealy
Thesis Adviser

Fred LeCrone

David G. White
Head of the Department

Robert MacVicar
Dean of the Graduate School

ACKNOWLEDGMENTS

The writer wishes to express his sincerest appreciation to Dr. Robert F. Ealy, who not only directed attention to the problem, but also gave his time, attention and support in connection with this research.

Appreciative recognition is also extended to Dr. Frank B. Cross, Dr. H. B. Cordner, and Professor Fred LeCrone. Professors Herman A. Hinrichs, Raymond Kays, Edward Odom and Franklin Romshe provided helpful suggestions and rendered constructive assistance.

TABLE OF CONTENTS

LIST OF TABLES

Table | Page

LIST OF FIGURES

Figure | Page

INTRODUCTION

Two methods of rooting cuttings have evolved over the centuries, and are regarded as standards for the production of new plants from softwood and semi-hardwood plant cuttings. One of these, the "syringing" method, consists of placing the cuttings in a well drained rooting medium, supplying shade and protective structures, and syringing the cuttings and rooting medium several times a day until roots have developed. The other method, known as the "Sweat-box" method, requires a rooting medium with a high moisture retention capacity and a closed rooting case. Very little syringing is needed, but a constant vigil must be maintained for diseases which may develop rapidly under these conditions.

Within the past twenty years, a relatively new method of applying moisture to softwood cuttings during the period they are developing roots has been devised. It has been given the name "mist propagation". A careful review of the literature covering the subject reveals that this method has not been fully tested under all conditions. Only in recent years has progress been made in its development and because of recent favorable reports published in professional journals and periodicals, it is now being more widely tested and accepted. There are quite a number of contradictory reports in the literature relative to recommended procedures and material required in the use of this method of propagation.

Basically, mist propagation involves the rooting of cuttings in full leaf in a coarse, well drained medium under constant or intermittent applications of a fine mist or spray. In favorably moist areas, most mist propagation units are placed out of doors with little or no protection. Outdoor use has not been reported, however, from arid or windy areas. Because of this lack of information concerning the use of mist in the southwestern part of the United States, it was believed that at least a preliminary investigation of its practicability should be undertaken. Such an investigation was undertaken and the resulting data are reported on comparative rooting in protective structures under the windy, dry conditions prevailing at Stillwater, Oklahoma.

REVIEW OF LITERATURE

Reproducing a plant from a vegetative part is a very ancient practice. Morrison (18) wrote that such practices predate written history, and Doran (4) indicated that the art is at least two thousand years old. Only in the last two or three hundred years, however, with the advent of recorded scientific data, have superstitions associated with asexual plant reproduction been disproved and replaced by real knowledge (18). Many of our selected horticultural varieties have originated as bud sports and the only means of maintaining these specific characteristics is by asexual propagation.

The propagation of plants by cuttings, one of the easier means of asexual reproduction, permits rapid multiplication of a selection or variety and is becoming increasingly important since the advent of widespread landscaping of small homes and the resulting demand for specific plant materials. In this regard the two standard methods of rooting softwood cuttings have certain limiting factors. Labor and equipment costs are high and the range of materials that can be rooted by the syringing and sweat-box methods is limited. Diseases and transplanting hazards also tend to reduce the range of plant materials that can be propagated by cuttings.

Fillmore (5) wrote that the first work with a new method of propagating cuttings was probably done by G. E. L. Spencer on cacao in 1936 at the Imperial College of Tropical Agriculture, Trinidad. This new method, termed "mist" propagation, was tried in this country and reported by Gardner (6) in 1941 from West de Pere, Wisconsin. His tests included 194 plant species and varieties; however, his report was primarily concerned with the equipment used and no listing of the materials or rooting results was included. All work reported to date has been from areas where existing climatic conditions include a high relative humidity and little or only light winds.

The chief principle of mist propagation is the maintenance of a film of moisture over the leaf surfaces of the cuttings while subjecting them to full or near full sunlight. In order to fulfill this requirement, several conditions must be met. First, a constant source of water must be available; second, a means of applying the mist must be devised; third, a well drained rooting medium must be provided; fourth, some means of protecting the cuttings from wind must be supplied; fifth, a location exposed to full sunlight is necessary; and sixth, the proper type of cuttings must be used. Workers in different localities have used different materials and methods to meet these requirements.

Adriance and Brison (1), Templeton (27), Wells (33), and others (18) (24), describe or outline the two standard methods of rooting softwood cuttings, namely, (1) by syringing and

(2) by placing cuttings in a sweat-box. The cuttings used in each instance were to be taken from mature, current season growth with some leaves attached. Since the late 1930's, synthetic growth-regulating substances have been used on cuttings to aid root initiation. Commercial preparations are available containing various concentrations of the active ingredient (indole-acetic acid or indole-butyric acid) and plant lists have been developed, based on experimentation, showing which preparation to use on cuttings of specific plants.

In the syringing method of rooting cuttings, a coarse sand or other material with good drainage and aeration should be used. The basal ends of the cuttings are inserted into the medium one and one-half to three or more inches deep. The cuttings, rooting medium, floors, and walls of the structure used are syringed several times daily by hand to maintain a high humidity and to avoid wilting of the cuttings. To aid in keeping temperatures down, the cuttings are almost always partially shaded. Once the cuttings are rooted, they are removed and transplanted to the field or shade house.

In the sweat-box method, a rooting medium with a high water-holding capacity inside a glass covered case usually is necessary for rooting cuttings. The cuttings are inserted into the medium more deeply than with the syringing method and more leaves are left attached to the cuttings. The cuttings and the medium are lightly sprinkled and the case tightly closed. More shade is also required. Extreme care must be exercised in sanitation. The cuttings should be treated not only with a root inducing chemical, but also with one of the more effective general fungicides if serious damage is to be avoided.

The Basic Mist System

A mist system consists of a bed or bench filled with a coarse, well drained medium. Mist nozzles are either suspended above the bed, over the center or along the two sides, or placed on risers down the center of the bed and spaced from two to four feet apart on the water lines, and from one and one-half to three feet from the cuttings. If controls are used, they should be placed in the main line. Because the water is applied as very fine particles, it is necessary to prevent air currents from carrying it away from the cuttings. Little or no shading is considered necessary by users of this system.

Mist Systems Described

Templeton (27) stated that the factor used in developing his "Phytotektor" system of mist propagation was, "What will it cost?" His system utilized modified soil covered with one inch of sand as a rooting medium, railroad ties as bed frames, welded wire fence or concrete reinforcement wire as hoop type frames, plastic sheeting as covers for mist dispersion control, and alternate mist as a means of supplying the water. Some shading was provided on extremely bright or hot days, but other than the shade, no attempt was made to control temperatures. Once the cuttings were rooted, they were allowed to establish themselves in the beds before transplanting. Excellent results were achieved by Templeton at Winchester, Tennessee, with those deciduous plants normally propagated by cuttings.

Wells (34), who worked with mist both in and outdoors, suggested the use of a propagation house so as to utilize the rooting beds the year around. Wells also preferred a bench with a sand rooting medium and a controlled mist supplied from parallel overhead lines with mist nozzles placed in alternate positions on the line every eighteen inches. For a propagation house 180 feet long, he recommended supplying water from both ends of the line in order to maintain equal pressure throughout the system.

Watkins (28) outlined a mist propagation system which he found suitable for Florida conditions. He recommended the use of a bench set on the "lee" side of a building. The bench should have an open bottom of hail screen covered with gravel and topped with sand as the rooting medium and a continuous mist supplied from overhead lines on both sides of the bench. He also recommended using no shade under conditions prevailing in Florida.

Lowenfels (15) working in New York used a sash house with the sash removed. Mist was supplied from overhead lines. At West de Pere, Wisconsin, Gardner (6) used a glass house in the fall and winter and a waxed cloth house during the summer. He preferred the semi-alternating mist application which resulted from a rotary nozzle of his own development. Fillmore (5), in Iowa, and Kemmerer and Kamp (13), in Illinois, used cold frames with cloth or plastic side walls, and no top or shade. Shugert (23) used this same type of system in Missouri, but with a top cover for shade and mist dispersion control. He also used tomato lugs to hold his rooting medium and cuttings and set them on a deep bed of gravel. In each of the three aforementioned instances, alternating mist was indicated as preferable to constant mist.

Types of Mist Nozzles

Originally in this country the oil burner type nozzle was used for applying mist. Although it delivers low quantities of water in a fine mist, it clogs easily, requires a high pressure for proper functioning, and the delivered moisture covers too small an area (25). The "Florida 'T'" nozzle works well in conjunction with intermittent mist applications, but delivers too much water for a constant mist application system (12). The "Monarch" nozzle appears to be satisfactory for water with low mineral content (12). With the "A-6 Humidomist" nozzle, clogging was practically eliminated with the incorporation of a self-cleaning device; a needle which drops through the nozzle orifice when the mist is shut off (25).

Control Mechanisms for Application of Mist

Several mechanisms for controlling mist applications have been developed. Gardner (6), in an effort to reduce excess water, worked out a rotating nozzle which covered a much larger area with mist. Another early development was the use of a humidistat (12) (27). Due to the lag in turning the mist on and off, the humidistat was not completely satisfactory. The next control mechanism used was a short period time clock; however, it applied excessive amounts of water when regulated to maintain the necessary film of moisture on the cuttings. Better results were obtained by combining the humidistat and the time clock, and best results were obtained by placing the humidistat in the major control position (25) (27). A light intensity electronic control was another device studied in the control of mist applications. Its faults were more serious than those of the earlier control mechanisms, especially when used under outdoor conditions. There were too many times, when wind was high and the air dry, that light intensity was insufficient to operate the mechanism often enough to maintain a film of moisture on the cuttings (12). Snyder and Hess (25) developed an electronic leaf control that has proven the most successful of all controls tested to date. They credit Templeton with the original idea. It has a fault, however, in that mineral deposits left by the water drying on the plastic leaf must be removed regularly or they short out the control, and thus stop the mist applications (12) (25).

It was found that the electrically operated solenoid valves used in conjunction with the controls could be a problem. Langhans (14) found it necessary to use spring loaded electric solenoid valves since the other types did not close properly or rapidly enough to shut off the mist. Nozzle dribbling, resulting from the failure of the valve to function properly, caused a drainage problem and wasted water. Templeton (27) also recommended the installation of a manually operated by-pass valve for use in the event of a power failure.

Protective Structures

Structures used in mist propagation range from the raised bench used by Watkins (28) on the lee side of a building to the propagation house recommended by Wells (34). Templeton (27) used polyethylene plastic sheeting to cover the hoop-type wire frame over the rooting medium. The ends of the frame were closed with sheet metal, and he used a shade cloth over the whole structure on the brighter, warmer days. Shugert (23) and Fillmore (5) surrounded the beds with cloth or plastic covered panels. Shugert also used cloth covered panels to cover the system on bright or windy days. Lowenfels (15) preferred to use a sash house with the sash removed when conditions permitted. Gardner (6) carried on his trials in 1940 inside a waxed cloth tent. During the colder season, he moved into a lean-to greenhouse.

Rooting Media

A number of rooting media have been tested, and the findings indicate certain types superior to others for rooting cuttings under mist. Templeton (27) reported excellent results with one inch of sand over a modified soil. Gardner (6) used a mixture of equal parts of sand and peat for best results. Wells (34), Snyder and Hess (25), and Kemmerer and Kamp (13) recommend the sand-peat mixture for rooting acid loving plants, and a coarse sand for general rooting under mist. Joiner and Sheehan (10) indicated little difference between sand, sand-peat, vermiculite, pea gravel, and sawdust. Other rooting media tested included Perlite, sand-soil mixtures, soil-peat mixtures, sand-sawdust mixtures, sand-soil-peat mixtures, and Krillium treated soil (10) (13) (17). The material used as a rooting medium apparently depends to a large extent on the mist application method used, the amount of protection given the system, and the type of propagating bed involved.

Types of Cuttings Used

Templeton (27) wrote that "old time" propagators were aware that succulent current growth would give the most rapid rooting response because the tissues had not fully differentiated. He found that cuttings of the terminal one-half inch to one inch rooted the most rapidly under mist, even when they were not inserted into a rooting medium. He stated that the more succulent, tender or "gelatin" like tissue of the plant's growing tips responded the most rapidly to mist propagation, but that the main problem in using cuttings of this type lay in the small size and ease of injury. Generally, all workers found that cuttings made of tissues less than one year old were satisfactory, and processing did not require the speed and care necessary in handling the more succulent tip cuttings.

Joiner and Sheehan (10) stated larger cuttings could be rooted very rapidly under mist, thereby saving time in growing out salable plants. They also found that leaf cuttings and leaf bud cuttings were satisfactory. Kemmerer and Kamp (13) found that chrysanthemum and carnation cuttings rooted in seven to ten days, and Langhans (14) rooted cuttings of poinsetta in two weeks.

Sharpe (22), working in Gainesville, Florida, found that better rooting was achieved with muscadine grape cuttings made from immature tips collected in May and June. Gardner (6) suggested tests be run on timing of cuttings collection, and most of those workers reporting on specific plant response are in agreement that collection of cuttings for propagation under mist may be made earlier than for the standard methods of rooting cuttings (10) (14) (27) (34).

Results of Mist Propagation

All reports on mist propagation indicate its superiority over the standard methods of rooting softwood cuttings of practically all deciduous and evergreen broad-leaf plant species. With most narrowleaf evergreens, it has proven to be detrimental. Fillmore (5) was the only person reporting any success with narrowleaf evergreen plants. He had an eighty per cent rooting response from Blue Spruce, but made the statement that he was not sure the experiment could be repeated. Wells (34) recommended the use of standard procedures with narrowleaf evergreen materials.

Research workers reporting comparisons between different methods of mist application indicated that alternating applications gave better results than continuous applications (6) (8) (13) (27) (32). Reports also showed more rapid rooting of cuttings under mist. Pecan (7), muscadine grape (22), and other previously difficult or impossible to root plant species (32), also responded to mist, some rooting as much as one hundred per cent (7). Gardner (6) and Templeton (27) indicated that the hormone treatment of cuttings, though generally beneficial, was not necessary for rapid rooting of most plant species under mist. They also indicated that treatment with weaker concentrations of hormones was desirable under mist than with standard rooting methods.

Other possible uses for mist were reported. Gardner (6) found that placing bare rooted plants under mist for a few days prior to transplanting resulted in a higher percentage of survival and also that it permitted out-of-season transplanting. Langhans (14) reported using mist in the greenhouse as a freshener for flowers and succulents. Joiner and Sheehan (10) indicated that mist could be used in maintaining a high humidity in the greenhouse, thus reducing labor costs.

All workers noted that plant diseases failed to develop under mist propagation conditions (6) (8) (13) (14) (17) (20) (21) (22) (27) (28) (34). This lack of plant diseases was attributed to the method of applying water without splashing and the leaching effect of the excess water on the disease spores.

MATERIALS AND METHODS

In the investigation undertaken at Oklahoma State University, the materials and methods used were based on the findings and recommendations of several published reports, primarily those of Templeton (27), Wells (34), Shugert (23), and Snyder and Hess (25). The beds, frames, and covers were designed to follow the principles of Templeton's "Phytotektor" system; the mist source duplicated his middle of the bench on four foot centers, and the controls were those set up by Templeton and developed by Hess in the Electronic Leaf. Shugert's and Templeton's use of shade during periods of extreme temperature, and Templeton's use of the natural soil with some modification as the rooting medium were employed.

Two locations were established for setting up the tests, one location completely exposed to all climatic conditions and the other in an area protected from the prevailing winds.

The Protective Structure

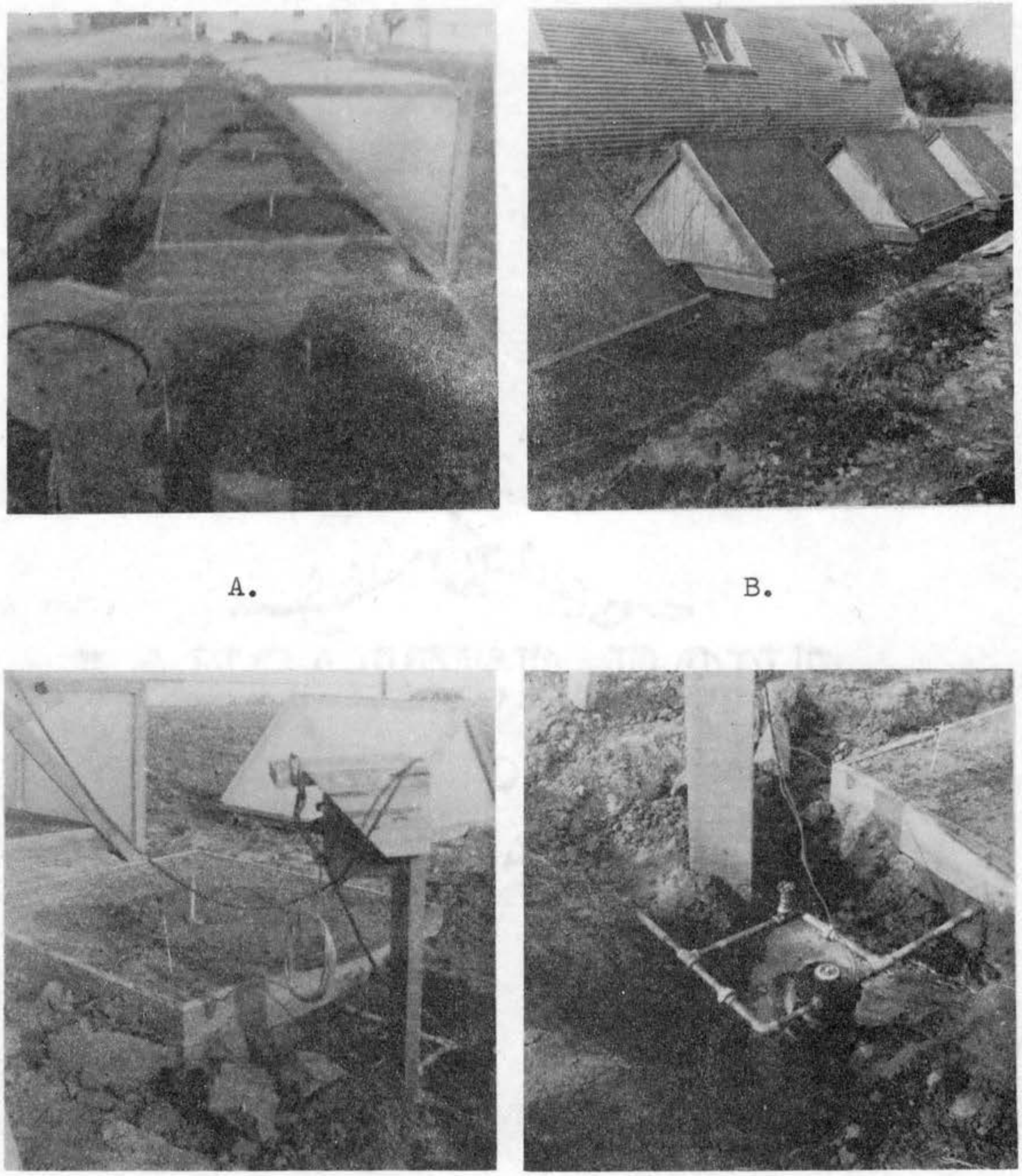
The protective structure was built of cypress because of its resistance to deterioration. A frame four feet square and six inches deep was made to enclose the rooting medium and act as a foundation for the removable cover. An A-frame type of cover with a box type base was constructed to overlap the sides of the foundation in order to reduce the air movement within the mist space. This was sheeted over with clear "Visqueen" polyethylene plastic of 0.003 inch thickness. A separate, removable piece of 52 per cent light restricting Saran cloth, four feet wide and six feet long, and weighted at each end, was used to provide shade during the peak temperature period of the day. Nine frames were constructed in this fashion and located, five in the exposed location and four in the sheltered location. Figure 1 shows the completed units in both locations as well as the mist control unit and the manual by-pass water valve for the exposed location system.

The Mist System

The mist system was devised to conform to the protective structures and to allow for regular removal of the frame covers. A one-half inch pipe with risers extending above it to a height of 15 inches was placed in the soil at a depth of 3 inches down the middle of each series of beds, leaving the nozzles 12 inches above the surface of the soil. An Electronic Leaf control mechanism was established at the head of each line. A manually operated by-pass valve was also installed after operations had started in order to off-set power failure.

The Rooting Medium

The rooting medium used was the natural soil, Kirkland silty clay loam, in the two test areas modified with sharp



A. B.

C. D.

Figure 1. Test Units and Operating Controls.

A. Exposed Test Unit. Mist Pattern Due Primarily to Wind.
B. Sheltered Test Unit.
C. Electrical Mist Control.
D. Manual By-Pass.

sand. The soil in each area was thoroughly broken and sand was mixed with it at a rate of approximately one part sand to two parts of soil by volume, to a depth of eight inches. The areas were fumigated with MC-2 Dowfume at the recommended rate of application. A plastic cover was used to retain the fumigant within each area.

The Installation

The mist system was installed in each area and the protective structures centered around each riser. A drainage ditch was dug along two sides of each series of frames deep enough to expose the bottom edge of the foundation frame. The soil enclosed by the foundation was level with the top edge at the beginning of the operation. Upon completion of these installations, each system was given a preliminary operations test.

Each of the nine frames enclosed 16 square feet of rooting space or a total of 144 square feet. The cost of materials used, including the installation of the power source and labor, was two dollars and fifty-eight cents ($2.58) per square foot of bed space. The breakdown of the costs is shown in Table I. This is probably more than the cost for a commercial unit which would utilize only one power source installation and control unit for a much larger bed area.

The Collection and Treatment of Cuttings

Available species of plants were selected for the tests.

TABLE I

CONSTRUCTION MATERIALS AND COSTS

Material Description	Amounts	Cost Each	Total Cost
Pecky Cypress, board feet	294	$ 0.11	$ 32.34
Hormone, can	2	3.15	6.30
Granulated Peat Moss, bale	3	3.95	11.85
Visqueen Plastic Sheeting, linear foot, 10½ feet wide	36	0.23½	8.46
Galvanized Nails, pound			2.90
Electronic Leaf Control Units	2	30.70	61.40
Builders Sand, ton	3	2.50	7.50
52% Shading Saran Cloth, square yard	34 2/3	0.49	16.99
Galvanized Pipe and Fittings			22.01
Mist Nozzles	9	1.31½	11.81
Electrical Solenoid Valves	2	19.95	39.90
Dowfume MC-2, can	9	0.68	6.12
Power Installation			63.28
Labor, estimated at six hours per frame	54	1.50	81.00
Total Cost			$371.86

NOTE: Cost per square foot of rooting bed for nine frames four feet square each, square feet, 144; cost per square foot, $2.582.

These ranged from narrow-leafed evergreen woody plants to herbaceous greenhouse flowering plants, including those difficult as well as those easy to root. The cuttings were made from June 13 to June 29 and most of the cuttings were inserted in the beds the day they were collected. In a few instances, as will be noted later, it was necessary to store cuttings overnight under refrigerated conditions. Most of the cuttings were made in the early morning and were kept moist until they were inserted in the beds.

All cuttings of any one test material were of comparable characteristics as to source, stem diameter, leafiness, and length. An approximately equal amount of leaf surface was left on cuttings of a given species. The basal ends of the cuttings of all species and varieties were treated with Hormodin as recommended by the manufacturer, except pecan, in which case only one-half of the cuttings were treated.

The prepared cuttings were inserted one and one-half to two inches into the rooting medium in the area or areas within each bed allocated to the specific variety or species. No preparatory openings were made in the rooting medium to receive the cuttings because of the softness of the medium, except where pure sand was used in the greenhouse.

Tests and Controls

In planning the experiment, it was decided that a wide range of plant materials should be used as regards both type and rooting ability. In Table II, the plant materials are

TABLE II

PLANT SPECIES TESTED, THEIR TYPES AND NORMAL ROOTING RESPONSE

Plant Material	Plant Type	Normal Rootings*
Major Species Tested		
Narrowleaf Evergreen		
1. Andorra Creeping Juniper *Juniperus horizontalis plumosa*	procumbent shrub	easy
2. Canaert Juniper *Juniperus virginiana HV Canaert*	upright tree	extremely difficult
Broadleaf Evergreen		
3. Wintercreeper Euonymus *Euonymus fortunei radicans*	procumbent shrub	easy
4. Cherry Laurel *Prunus laurocerasus*	upright tree/shrub	very difficult
Deciduous Plants		
5. Amur River Privet *Ligustrum amurense*	upright shrub	easy
6. Stuart Pecan *Carya illinoensis HV Stuart*	upright tree	very difficult
Additional Species Tested		
7. Chrysanthemum *Chrysanthemum morifolium*	herbaceous flowering	easy
8. Crapemyrtle *Lagerstroemia indica*	upright shrub	easy
9. Winter Jasmine *Jasminum nudiflorum*	procumbent shrub	easy

TABLE II (continued)

	Plant Material	Plant Type	Normal Rootings*
10.	East Malling VII Crabapple *Malus pumila HV East Malling VII*	upright tree	very difficult
11.	East Malling IX Crabapple *Malus pumila HV East Malling IX*	upright tree	very difficult

*Normal Rooting as given here was based on information published by Adriance and Brison (1) and Avery, et al. (2).

listed according to type and the relative ease with which they root under standard methods of propagation. To allow for the slow rooting species, the tests were continued for a total of sixty days, at the end of which time all remaining cuttings were removed and examined. In some instances periodic removal of a part of the cuttings was done to check on the rate and vigor of rooting. Tables III through XII show the number of cuttings removed, dates of removal, and the notes made as to rooting responses. Table XIII is a summary of Tables III through XII, and includes treatment of the cuttings, dates of insertion into the rooting medium and the minimum and maximum number of days in the rooting medium.

Five classifications of rooting response were recorded. Each of these was based on a specific group of qualifications and overlapping between classes was eliminated as much as possible. The classifications and their qualifications follow:

(1) DEAD: Any cutting that was dead or obviously could not survive for any length of time.

(2) CALLUSED: Any cutting showing signs of healing to heavily callused cut ends, but without evidence of developing root initials.

(3) POOR ROOTING: Cuttings with evident root initials and with roots of not more than one-half inch in length.

(4) FAIR ROOTING: Cuttings with one or more roots over one-half inch in length but less than one and one-half inches in length.

TABLE III

ROOTING RESPONSE OF ANDORRA JUNIPER CUTTINGS

Battery Locations	Number Cuttings	Total Days	Rooting Response: Dead	Callused	Poor	Fair	Good	Percent
Exposed Frame								
1	100	30	39	60	1	0	0	1
2	100	37	42	51	3	4	0	7
3	100	44	32	48	12	2	6	20
4	100	51	64	28	3	2	3	8
Total	400	--	197	187*	19	8	9	9
Sheltered Frame								
1	100	30	98	2	0	0	0	0
2	100	30	98	2	0	0	0	0
3	100	37	98	2	0	0	0	0
4	100	37	96	4	0	0	0	0
Total	400	--	390	10*	0	0	0	0

*This difference is possibly due to difference in time in refrigerated storage, stage of growth, or other factors.

TABLE IV

ROOTING RESPONSE OF CANAERT JUNIPER CUTTINGS

Battery Locations	Number Cuttings	Total Days	Rooting Response					
			Dead	Callused	Poor	Fair	Good	Percent
<u>Exposed</u> Frame								
1	100	30	95	5	0	0	0	0
2	100	37	92	8	0	0	0	0
3	100	44	99	1	0	0	0	0
4	100	51	91	9	0	0	0	0
Total	400	--	377	23*	0	0	0	0
<u>Sheltered</u> Frame								
1	100	30	100	0	0	0	0	0
2	100	30	100	0	0	0	0	0
3	100	37	100	0	0	0	0	0
4	100	37	100	0	0	0	0	0
Total	400	--	400	0*	0	0	0	0

*This difference is possibly due to difference in time in refrigerated storage, stage of growth, or other factors.

TABLE V

ROOTING RESPONSE OF CHERRY LAUREL CUTTINGS

Battery Locations	Number Cuttings	Total Days	Rooting Response: Dead	Callused	Poor	Fair	Good	Percent
Exposed Frame								
1	50	30	5	45	0	0	0	0
2	50	31	0	50	0	0	0	0
3	50	38	5	37	8	0	0	16
4	50	38	13	36	1	0	0	2
Total	200	--	23	168	9	0	0	4.5
Sheltered Frame								
1	50	31	2	45	3	0	0	6
2	50	31	19	28	3	0	0	6
3	50	38	13	36	1	0	0	2
4	50	38	33	17	0	0	0	0
Total	200	--	67	126	7	0	0	3.5

TABLE VI

ROOTING RESPONSE OF AMUR PRIVET CUTTINGS

Battery Locations	Number Cuttings	Total Days	Dead	Callused	Poor	Fair	Good	Percent
			Rooting Response					
Exposed (young plants)								
Frame								
1	100	23	20	19	21	9	31	61
2	100	24	0	29	25	25	21	71
3	100	26	4	12	13	17	54	84
4	100	27	2	6	13	13	66	92
Total	400	--	26	66	72	64	172	79.5*
Exposed (old plants)								
Frame								
5	400	27	11	321	57	7	4	17**
Sheltered								
Frame								
1	100	23	1	92	7	0	0	7
2	100	24	0	70	26	3	1	30
3	100	26	27	59	12	1	1	14
4	100	27	8	76	9	6	1	16
Total	400	--	36	297	54	10	3	16.7**

*This response was by cuttings taken from young vigorously growing plants.
**This response was by cuttings taken from older, less vigorous plants.

TABLE VII

ROOTING RESPONSE OF WINTERCREEPER EUONYMUS CUTTINGS

Battery Locations	Number Cuttings	Total Days	Rooting Response					
			Dead	Callused	Poor	Fair	Good	Percent
<u>Exposed</u> Frame								
1	25	35	0	10	13	2	0	60
4	25	39	17	3	5	0	0	20
Total	50	--	17	13	18	2	0	40

TABLE VIII

ROOTING RESPONSE OF STUART PECAN CUTTINGS

Exposed* Battery	Number Cuttings	Total Days	Dean	Callused	Rooting Response: Poor	Fair	Good	Percent
(Treated) Frame								
1	5	30	3	2	0	0	0	0
2	5	37	5	0	0	0	0	0
3	5	37	3	2	0	0	0	0
3	5	51	5	0	0	0	0	0
4	5	44	3	1	0	1	0	20
Total	25	--	19	5	0	1	0	4
(Untreated) Frame								
1	5	30	1	4	0	0	0	0
2	5	37	5	0	0	0	0	0
3	5	37	1	2	1	1	0	40
3	5	51	5	0	0	0	0	0
4	5	44	2	1	2	0	0	40
Total	25	--	14	7	3	1	0	16

*Only the exposed location was used for pecan. All cuttings were made from the same tree. The basal ends of one-half of the cuttings were treated with "Hormodin" 3.

TABLE IX

ROOTING RESPONSE OF CHRYSANTHEMUM CUTTINGS

Battery Locations	Number Cuttings	Total Days	Rooting Response					
			Dead	Callused	Poor	Fair	Good	Percent
Exposed Frame								
1	6	10	0	0	0	0	6	100
Sheltered Frame								
1	20	10	0	4	8	8	0	80
2	20	10	1	3	7	9	0	80
3	20	10	0	6	10	4	0	70
4	20	10	0	1	12	6	1	95
Total	80	10	1	14	37	27	1	81
Propagation House Constant Mist	25	10	0	2	5	3	15	92
Tropical Room Syringed	20	10	1	6	9	2	1	65

TABLE X

ROOTING RESPONSE OF CRAPEMYRTLE CUTTINGS

Battery Locations	Number Cuttings	Total Days	Rooting Response Dead	Callused	Poor	Fair	Good	Percent
Exposed Frame								
2	31	11	2	3	4	12	10	93.5
Sheltered Frame								
1	20	10	0	0	0	12	8	100
2	20	10	1	0	3	6	10	95
3	20	10	0	0	3	9	8	100
4	20	10	0	0	0	7	13	100
Total	80	--	1	0	6	34	39	98.7
Propagation House								
Constant Mist	10	10	0	0	0	0	10	100
Tropical Room								
Syringed	20	10	5	15	0	0	0	0

TABLE XI

ROOTING RESPONSE OF WINTER JASMINE CUTTINGS

Battery Locations	Number Cuttings	Total Days	Rooting Response: Dead	Callused	Poor	Fair	Good	Percent
Sheltered Frame								
1	20	15	0	4	13	2	1	80
2	20	14	0	5	8	6	1	75
3	20	13	3	12	4	1	0	25
4	20	12	0	11	9	0	0	45
Total	80	--	3	32	34	9	0	53.7
Tropical Room Syringed	20	15	3	6	8	3	0	55

TABLE XII

ROOTING RESPONSE OF EAST MALLING VII AND IX CUTTINGS

Battery Locations	Number Cuttings	Total Days	Rooting Response Dead	Callused	Poor	Fair	Good	Percent
<u>Exposed</u>								
EM VII Frame								
1	10	20	0	10	0	0	0	0
2	10	30	1	9	0	0	0	0
3	10	30	0	10	0	0	0	0
4	10	30	0	10	0	0	0	0
5	10	30	0	10	0	0	0	0
Total	50	--	1	49	0	0	0	0
EM IX Frame								
1	10	20	2	8	0	0	0	0
2	10	30	1	9	0	0	0	0
3	10	30	0	10	0	0	0	0
4	10	30	1	9	0	0	0	0
5	10	30	1	9	0	0	0	0
Total	50	--	5	45	0	0	0	0

TABLE XIII

SUMMARY SHEET - TREATMENTS & RESULTS

Plant Material	Number Cuttings	"Hormodin" Treatment	Date & Days Benched	Percent Rooted by Location: Exposed Frame	Sheltered Frame	Syringed G. H.	Mist G. H.
Narrow leaved Evergreens:							
1. Andorra Juniper	400	#2	6/13+(30-51)	9.0			
	400	#2	6/23+(30-37)		0.0		
2. Canaert Juniper	400	#3	6/14+(30-51)	0.0			
	400	#3	6/23+(30-37)		0.0		
Broad leaved Evergreens:							
1. Cherry Laurel	200	#3	6/15+(30-38)	4.5			
	200	#3	6/23+(31-40)		3.5		
2. Euonymus	50	#2	6/15+(34-39)	40.0			
Deciduous Plants:							
1. Amur Privet	400	#3	6/15+(23-27)	79.5*			
	400	#3	6/18+(23-27)		16.7**		
	400	#3	6/18+(27)	17.0**			
2. Crapemyrtle	31	#2	6/14+(11)	93.5			
	80	#2	6/30+(10)		98.7		
	10	#2	6/30+(10)				100.0
	20	#2	6/30+(10)			0.0	
3. E. Malling VII	50	#3	6/29+(20-30)	0.0			
4. E. Malling IX	50	#3	6/29+(20-30)	0.0			

TABLE XIII (continued)

Plant Material	Number Cuttings	"Hormodin" Treatment	Date & Days Benched	Percent Rooted by Location: Exposed Frame	Sheltered Frame	Syringed G. H.	Mist G. H.
5. Pecan	25	#3	6/15+(30-51)	4.0			
	25	None	6/15+(30-51)	16.0			
6. Winter Jasmine	80	#2	6/30+(12-15)		53.7		
	20	#2	6/30+(15)			55.0	
Herbaceous Plants:							
1. Chrysanthemums	6	#2	6/16+(10)	100.0			
	80	#2	6/29+(10)		81.0		
	25	#2	6/29+(10)				92.0
	20	#2	6/29+(10)			65.0	

*All cuttings made from young plants.
**All cuttings made from old plants.

(5) GOOD ROOTING: Cuttings with one or more roots over one and one-half inches in length.

Rooting percentages, based on classes 3, 4, and 5, pages 23 and 36, do not include cuttings which had only calluses; however, all cuttings which showed any root initials were included in the totals.

Figure 2 shows the general area in which the test sites were established. The area immediately south of the equipment barn was subject to fairly high, constant winds. To the south and west was an open field with nothing to obstruct the prevailing summer winds within a hundred yards of the test unit.

Two tall hedges situated in conjunction with a series of quonset buildings protected the sheltered test unit. This location was subject to very little air movement, but was completely exposed to the sun.

The space in each of the frames was divided into sixteen equal sized sections with numerical designations. Figure 3 shows the numbering and placement systems used in the frames.

Four species of plants were used in the tests and each species was replicated four times in each of four frames in both locations. The fifth frame in the exposed unit was occupied entirely by one plant species. The plots were randomized in each frame. After the loss of the cuttings in the sheltered location, which will be discussed later, difficulty was experienced in obtaining sufficient cuttings of the original species selected and others were added to the program

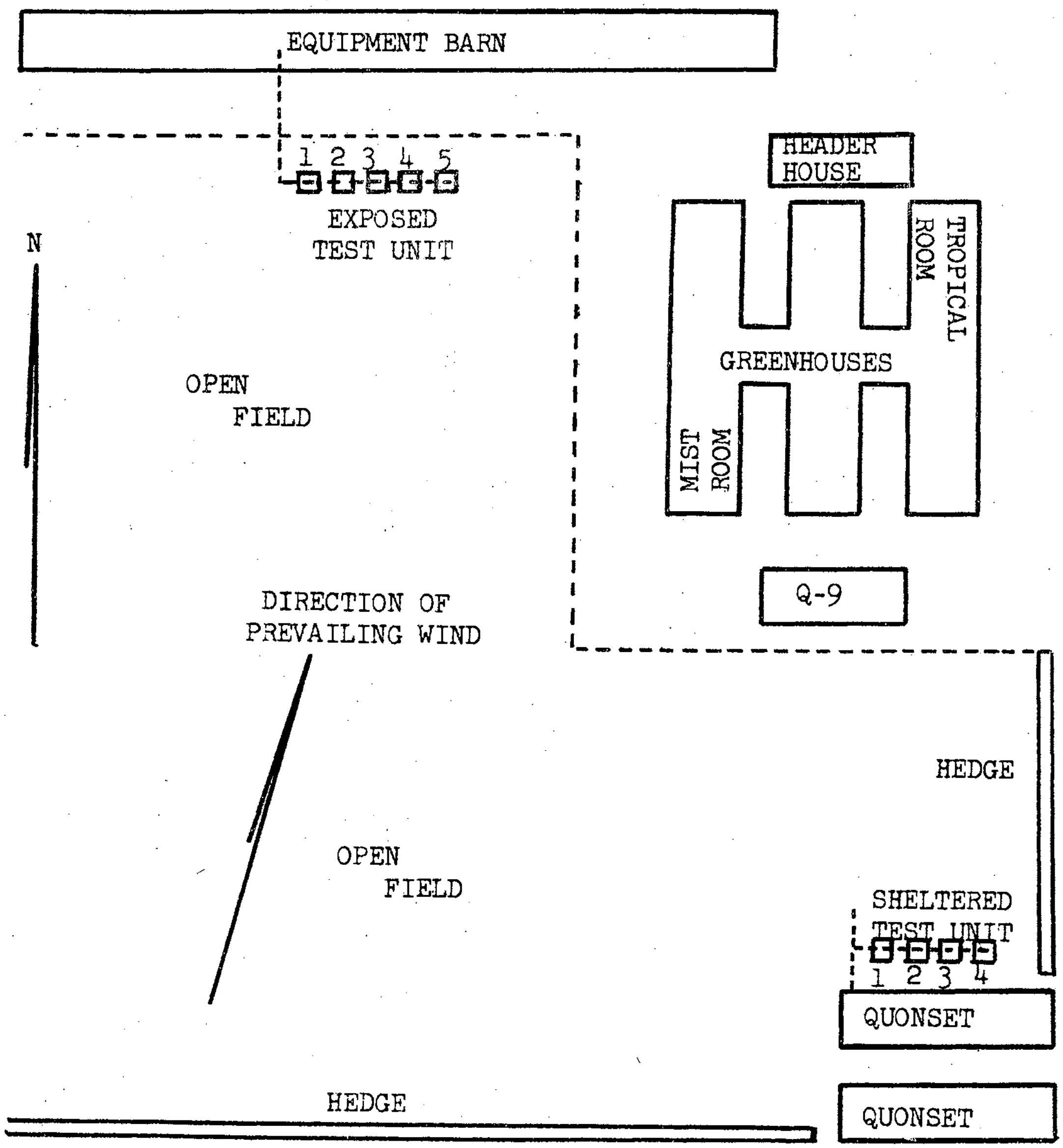


Figure 2. Placement of Propagation Units

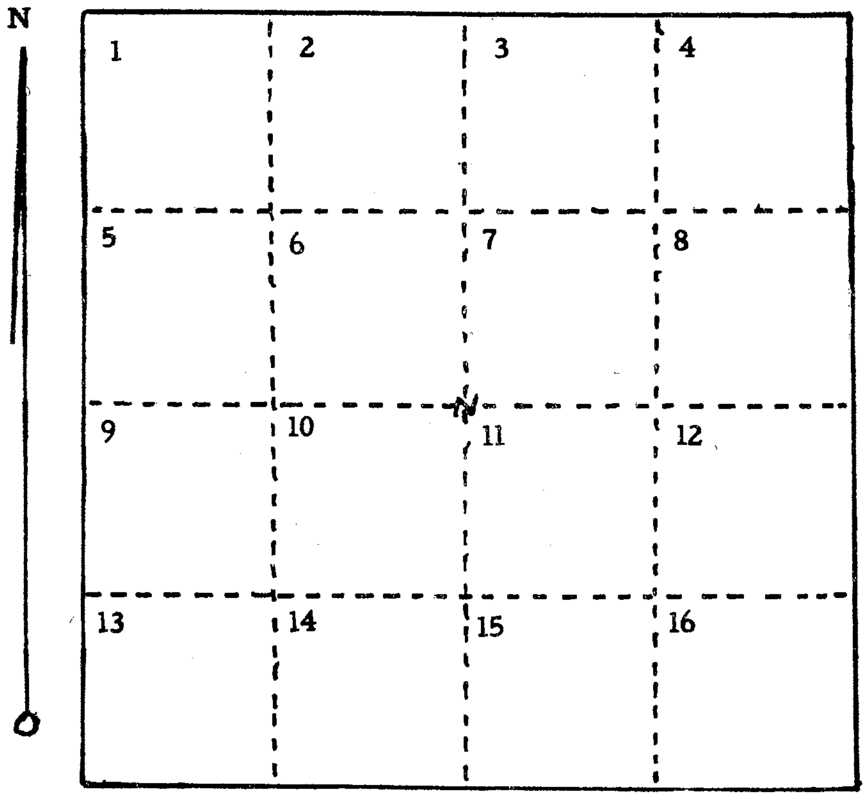


Figure 3. Division of Mist Beds and Placement of Plant Material.

Cuttings were placed in the beds of each test unit according to the following plan:

Andorra Juniper = 1 Cherry Laurel = 3
Canaert Juniper = 2 Amur Privet = 4

Frame 4	Frame 3	Frame 2	Frame 1
2-1-3-4	3-4-2-1	4-3-1-2	1-2-4-3
3-4-2-1	4-3-1-2	1-2-4-3	2-1-3-4
4-3-1-2	1-2-4-3	2-1-3-4	3-4-2-1
1-2-4-3	2-1-3-4	3-4-2-1	4-3-1-2

including control materials. Three of the original species of plants were present in sufficient quantities to be represented by four replicates; only two replicates were used for Cherry Laurel, the fourth species. Ten cuttings of some plant species were used per frame to supplement the test.

In the course of the tests, several modifications of the original plan had to be made. The first of these was due to a failure of the power which caused a stoppage of the mist in the exposed unit soon after the test period began. As a result, cuttings of the two Juniper varieties which had been collected had to be held under refrigeration at 55 degrees F for two days. The results of this delay will be discussed later. A manually operated control was installed, by-passing the electrical control. The second and only other water failure in the exposed unit occurred for a period of approximately three hours when the water line was broken during the third week of operations.

Due to faulty wire in the Electronic Leaf control mechanisms, both controls failed to function at one time. In both instances, the malfunction time was probably for more than twelve hours. In the exposed unit, the circuit failed to close and the mist remained on constantly until the wire was replaced. In the sheltered unit, the circuit shorted out, shutting off the water completely. This failure was not discovered until a thousand cuttings had died. These cuttings were then replaced.

A hygrothermograph was placed for approximately forty-eight hours in each of the areas of operation between July 30 and August 10, and the recordings were compared with those secured by the meteorology department at a location less than a block away. The results of these comparisons are shown in Figure 4 and will be discussed in proper sequence.

It was originally decided that, due to available information on rooting results by the standard methods, no check plots would be necessary. However, after operations had been in progress for some time, a reconsideration resulted in the setting up of several controls in order to determine possible differences in rooting responses based upon stage of development of the plant tissues. The results secured with these control cuttings are included in the tables.

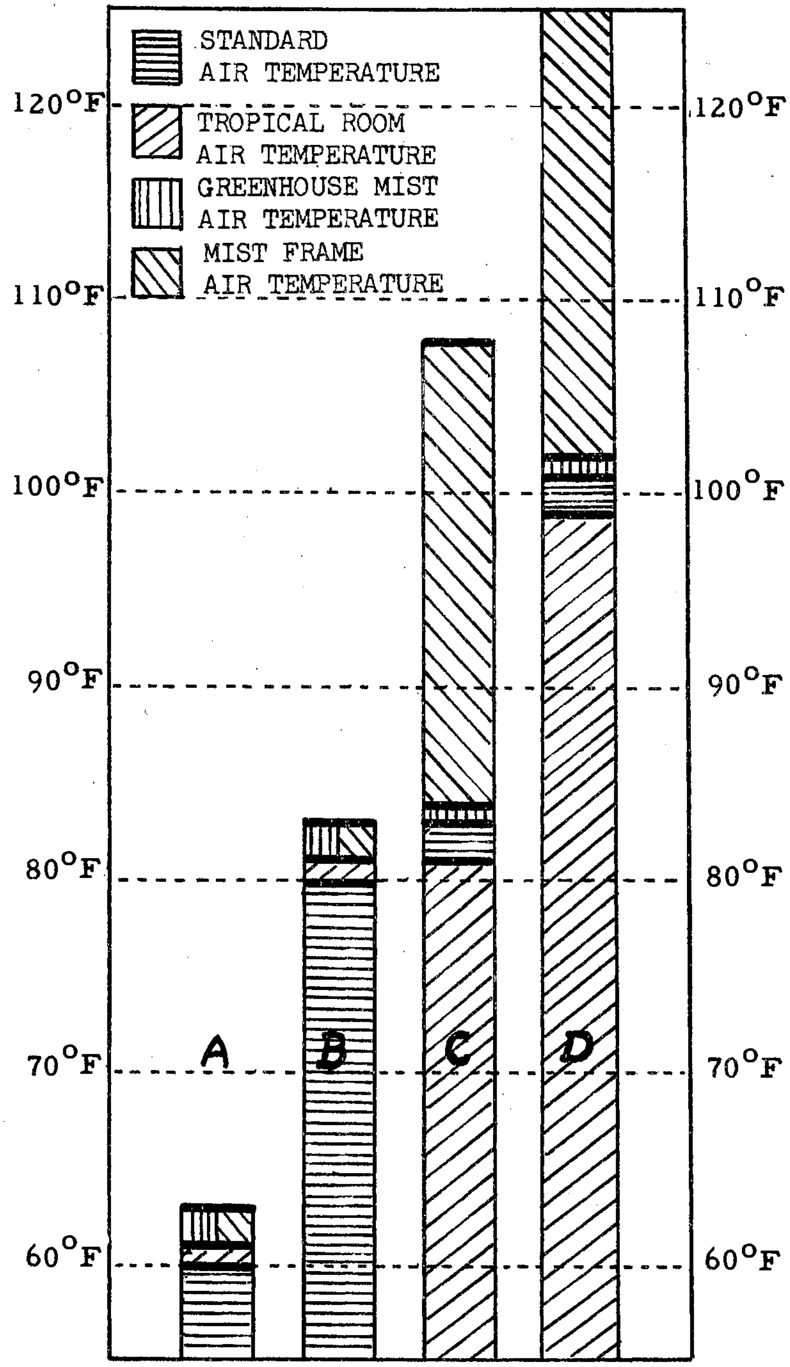


Figure 4. Temperature Ranges Based on Thermograph Readings Taken Between July 30 and Aug. 13, 1955.

A. June 13, 14, 15 and Aug. 14 - Lowest of Low Nightly Temperatures.
B. July 8 - Highest of Low Nightly Temperatures.
C. June 19 - Lowest of Daily High Temperatures.
D. Aug. 30 - Highest of Daily High Temperatures.

EXPERIMENTAL RESULTS

The Protective Structure

It was noted that the type framing used for the mist beds was sufficiently heavy and closed to withstand wind pressures; however, insufficient support was provided for the plastic covering material of the frames in the exposed location, as the plastic was stretched and sagging at the end of the test. It was still pliable and clear, indicating it might be used further. Considerable whipping of the plastic sheeting by the wind was noted in the exposed location, which indicated that additional fastening down was needed if extra support was provided, in order to prevent the plastic sheeting from being shredded against the under supports. The weighted shade cloth tended to make the plastic more resistant to wind damage.

Toward the end of the experiment, temperature and humidity readings were taken in all locations and comparisons made on an hourly basis with standard temperature recorded by the meteorology department. Figure 4, page 41, presents the differences found by these comparisons. Temperatures in the mist frames ranged from 25 to 30 degrees higher during the day's high than standard air temperature and two to four degrees higher than the day's low. In the tropical room of the greenhouse where the syringing controls were located, temperatures were regularly three degrees lower during the day's recorded high standard air temperature and one degree higher than the day's low. Under constant mist in the greenhouse, the temperature was only one degree higher than the day's recorded high and three degrees higher than the day's recorded low. Maximum temperatures in the mist frames exceeded the recording instrument's chart range of 117 degrees F. Estimates placed the temperature in these frames occasionally as high as 122 degrees F to 123 degrees F. This was approximately 40 degrees higher than the recommended temperatures for best rooting with the syringing method.

The air was at the saturation point in the mist frames and the constant mist area of the greenhouse at all times. During the night in the tropical room of the greenhouse, humidity reached the saturation level, but during the day it dropped to as low as 35 per cent. The tight construction and plastic covering prevented the dissipation of heat and exchange of atmosphere, indicating the need for some means of ventilation, probably at the peak of the frame. In all frames, the corner areas remained relatively dry. Cuttings placed in these areas died from lack of moisture. A pressure reading was taken on the water systems and the pressure was found to be quite adequate, 55 to 60 pounds per square inch. This is 15 to 20 pounds greater than Templeton's recommendation (27). This also indicated that the shape of the frames was not conducive to proper mist distribution and that a frame with a rounded shape would be more effective due to the circular pattern of mist dispersion from the nozzle shown in Figures 1, page 17, and 5. Tests with protective structures of other shapes appear to be desirable.

The Mist System

Several of the functionings of the mist system as set up were noted as appearing to be detrimental to the rooting results. Excessive moisture was delivered to the area of the rooting medium within 10 inches of the mist riser. This was due partly to the shape of the protective structure; however, on occasions it was observed that the electric solenoid valve did not completely shut off the moisture supply when closing. The Electronic Leaf control mechanisms functioned very well until sufficient salts were deposited on the plastic surfaces connecting the poles to act as an electrical conductor and thereby shut off the moisture supply. At the beginning of the operation, as previously outlined, a power failure resulted in the failure of the system and the installation of a manual by-pass valve which, when utilized, resulted in a constant application of moisture. Some dribble was noted at the nozzles when the systems were applying mist, and each time the electric solenoid valves closed. Best rooting was obtained in the area of the rooting medium located between 10 and 20 inches away from the mist riser. Only in the outer six inches of the beds were any disease or fungal growths noted, except on the leaf surfaces of the cuttings of

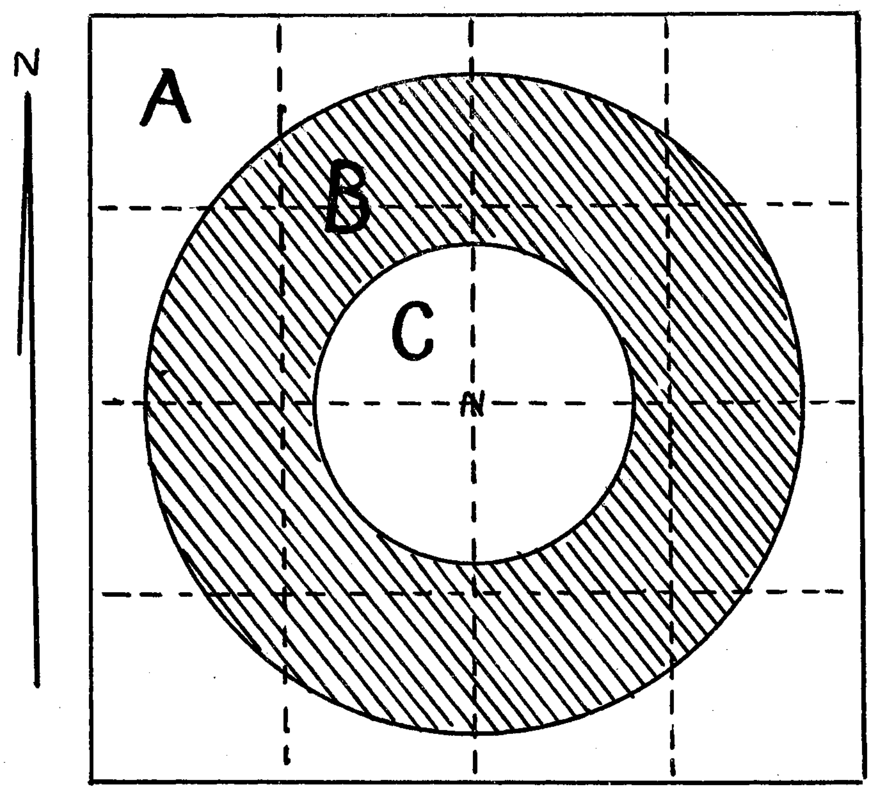


Figure 5. Efficiency of Mist Nozzles

Observed mist dispersion pattern to the rooting medium.

A. Edges too dry.
B. Area of efficiency.
C. Center too wet.

East Malling VII and IX, on which a mildew developed, resulting in their defoliation. Further tests with systems employing improved nozzles, more rapidly operating and tighter closing solenoid valves, and an electronic leaf not subject to salt deposition, seem indicated.

The Rooting Medium

Though effective rooting was noted in the area 10 to 20 inches away from the mist riser, a saturated condition existed in the rooting medium inside this area. No compacting or puddling was noted; however, drainage was insufficient generally. Possibly the addition of more sand to the soil or a surface covering of one or two inches of sand over the modified soil would have improved this situation.

Andorra Juniper, *Juniperus horizontalis plumosa*

Cuttings were collected the morning of June 11, 1955. These were processed immediately and were kept moist during the entire handling period. These cuttings were stored for a two day period in a refrigerator at approximately 55 degrees F until the evening of June 13, when they were inserted. All cuttings were treated with Hormodin #2. At the end of thirty days and at weekly intervals thereafter, all cuttings were removed from one frame, starting with frame 1, and classed according to rooting response. New cuttings for the protected test unit were processed on June 22. These cuttings were held in the refrigerator at 55 degrees F overnight before insertion into the rooting medium.

Approximately fifty per cent of the cuttings in the exposed test unit showed some rooting response, whereas those in the protected unit were a total loss. This compares with a rooting of ninety per cent or more of cuttings rooted by standard methods. However, differences in the response between the two propagation units may bear further investigation to determine whether these differences should be attributed to the refrigerated storage period, the difference in locations, or the time of collection.

Canaert Juniper, Juniperus virginiana HV Canaert

The collection and handling of the cuttings of this variety was the same as for Andorra Juniper. The rooting responses were similar to Andorra Juniper, but as expected, to a markedly less degree. Where low rooting occurred with Andorra Juniper cuttings, none occurred with the Canaert Juniper cuttings. Cuttings of this variety of Juniper have not been successfully rooted by any method of propagation. The cuttings in the protected units had to be replaced when the mist control mechanism failed.

Cherry Laurel, Prunus laurocerasus

Collection of the cuttings of this variety was completed shortly after mid-day under cool, cloudy conditions on June 14, 1955. The cuttings were processed, held overnight in the refrigerator at 55 degrees F and inserted the following morning. As with the Canaert Juniper cuttings, very little rooting response to the mist in either location was noticed. Cherry Laurel also does not respond to other methods of propagation by cuttings. All cuttings in the protected unit had to be replaced for the same reason as the cuttings of Andorra Juniper and Canaert Juniper. Replications in both units contained only one-half as many cuttings as originally planned.

Amur Privet, Ligustrum amurense

Four hundred plus cuttings of Amur Privet were made the morning of June 14, 1955. These were processed, held overnight at 55 degrees F in the refrigerator, and placed in the first four frames of the exposed unit. On June 18, eight hundred plus cuttings were made, processed and inserted in frame 5 of the exposed unit and the four frames of the protected unit. All cuttings were treated with Hormodin #3. Starting with frame 1 of both propagation units, cuttings were removed at the end of 23, 24, 26, and 27 days respectively. All cuttings were removed from frame 5 of the exposed unit at the end of 27 days. Comparing the rooting response of the cuttings from frame 5 of the exposed unit to the response in the protected unit, very little difference was found. However, a considerable difference was noted between the cuttings of the two collection dates. The earlier collected cuttings were made from young plants, and the later cuttings were taken from older plants. The cuttings from the older plants were slower in developing roots, though both groups of cuttings showed a more rapid and vigorous rooting response under mist conditions, and after three to four weeks compared favorably to the rooting response of cuttings under standard methods at the end of five to six weeks.

Stuart Pecan, _Carya illinoensis HV Stuart_

Due to local interest in pecan production, this plant was included in the test. The pecan is a plant well known in propagation circles for its inability to initiate roots on cuttings. It is also a plant that has difficulty in developing new roots to replace those lost in transplanting.

On the morning of June 15, 1955, fifty cuttings of current season's growth were collected from a Stuart pecan tree that was in good condition and about twenty-five years old. These were paired according to cutting length, stem diameter, and leafyness. The basal ends of all cuttings were split for about one-half inch and wedged open. One-half of the cuttings were treated with Hormodin #3; the balance were untreated. Five pairs of cuttings were inserted into the rooting medium in frames 1, 2, and 4, and ten pairs were placed in frame 3 of the exposed unit. Five pairs of cuttings were examined and classed as to rooting response in the following order of frames and number of days: frame 1 at thirty days, frame 2 at thirty-seven days, frame 3 at thirty-seven days, frame 4 at forty-four days, and frame three at fifty-one days. Those cuttings which had not been treated responded best to the mist treatment. Of the untreated cuttings, 16 per cent rooted and 22 per cent survived, compared to four per cent rooted and 12 per cent survival of the treated cuttings. It appears desirable that further tests be made on pecan.

East Malling VII and IX, _Malus pumila HV EM VII and IX_

Fifty cuttings of current season's growth of each clone were made on June 29, 1955, from one year transplants and treated with Hormodin #3. Ten cuttings of each clone were placed in each frame of the exposed unit. At the end of twenty days, the cuttings in frame 1 were removed and examined. The rest of the cuttings were removed at the end of thirty days. Only six of the cuttings died; the balance were callused and about one-third were heavily callused. A few cuttings appeared to be showing root initials in the callus tissue, but positive identification of the tissue would have required microscopic study. Again it appears that further tests should be undertaken. Apple is propagated by budding or mound layering because of the difficulty in rooting cuttings by standard methods.

Crapemyrtle, _Lagerstroemia indica_

Crapemyrtle is a woody decisuous shrub which is quite easy to root by standard methods as hardwood or softwood cuttings. The usual rooting time for softwood cuttings of this plant is between two and three weeks. Thirty-one softwood cuttings were placed in frame 2 of the exposed unit, and twenty-six, or 84 per cent, rooted in eleven days. Rooting was vigorous as is shown in Figure 6. One hundred plus cuttings were made on June 30, 1955, and processed. Ten cuttings were placed under constant mist in the greenhouse propagation room, and twenty cuttings were inserted in sand in the tropical room of the greenhouse and syringed by hand. Groups of twenty cuttings were placed in each frame of the protected unit. All of the cuttings were treated with Hormodin #2. At the end of ten days, all the cuttings were removed and examined. Only one of the cuttings under mist had died; the other eighty-nine were rooted to varying degrees. The ten cuttings under constant mist were all heavily rooted. One-fourth of the control cuttings had died and the balance were in varying stages of callus development. No root initials had developed enough to be visible.

Winter Jasmine, *Jasminum nudiflorum*

Winter Jasmine is a low growing semi-woody perennial shrub that tends to tip layer quite readily. Softwood cuttings also root well in four or five weeks under standard practices and treated with Hormodin #2 or its equivalent.

Cuttings collected and processed on June 30, 1955, were placed in groups of twenty in each frame of the protected test unit and in the tropical greenhouse for syringing. At the end of twelve days, 45 per cent of those in frame 4 had rooted. In frame 3, only 25 per cent had rooted at the end

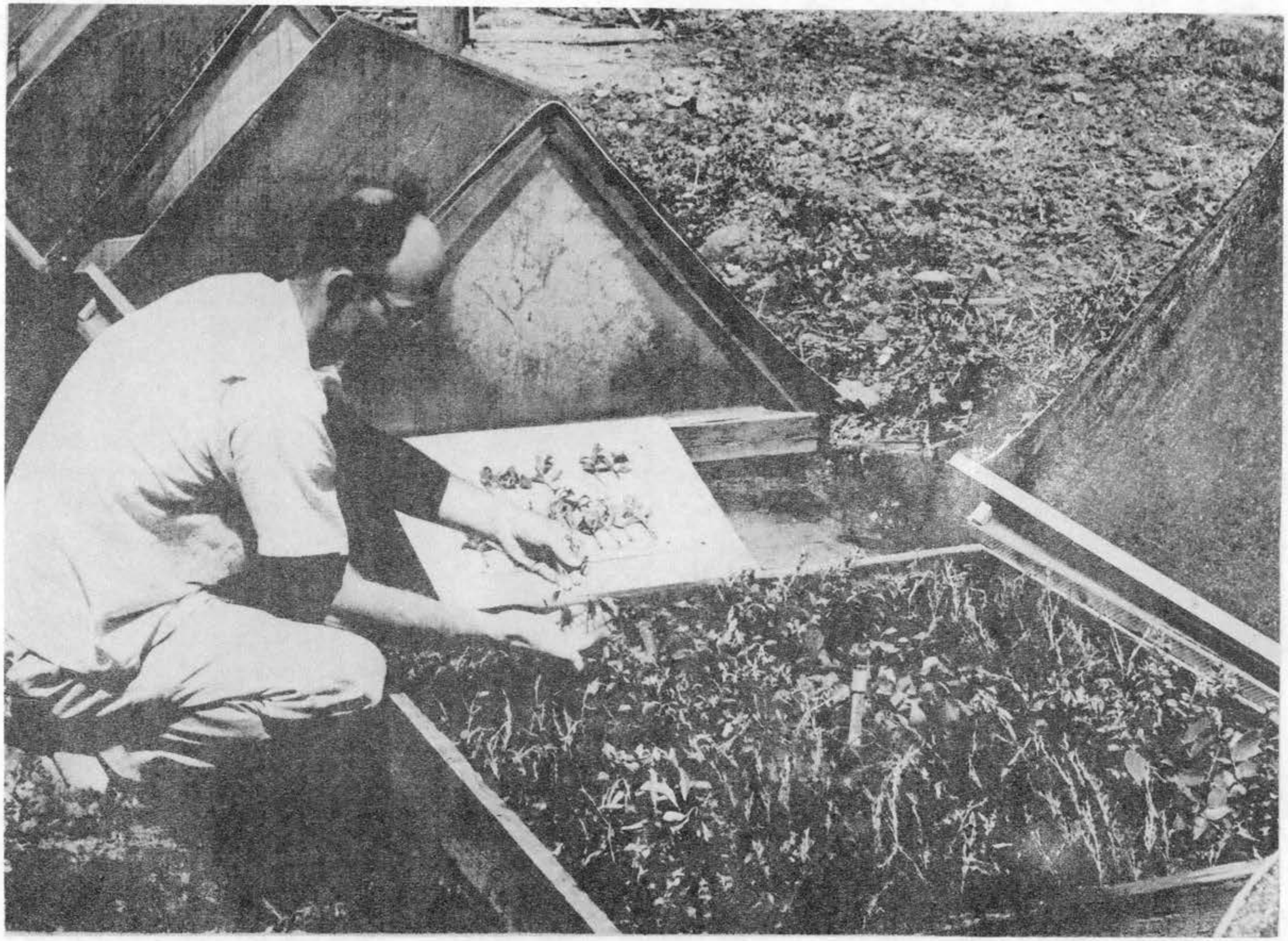


Figure 6. Rooted Crapemyrtle Cuttings From the Exposed Test Unit.

of thirteen days, and three cuttings had died; however, after fourteen days in frame 2, the cuttings were 75 per cent rooted, and at fifteen days 80 per cent of the cuttings were rooted as compared to 55 per cent of those in the control for the same period. The 80 per cent is seven to twelve per cent higher than rooting percentages listed by Avery, et al (2), for four to five weeks rooting time by standard methods.

Chrysanthemum, _Chrysanthemum morifolium_

In two or three weeks Chrysanthemum cuttings will root from 80 to 100 per cent without treatment or with a very mild treatment of indolebutyric acid at concentrations of 2.5 to 100 ppm in talc. Six cuttings were made and inserted in frame 1 of the exposed test unit. At the end of ten days these cuttings were heavily rooted with some individual roots ranging over six inches in length. It was decided to include this plant in the experimental tests. Cuttings collected and processed on June 29, 1955, were placed in the frames of the protected unit and in the greenhouse under control conditions in groups of twenty to twenty-five. All cuttings were examined at the end of ten days. Where 65 per cent of the syringed controls had rooted, 70 to 95 per cent of the cuttings under mist had rooted, indicating a more rapid rooting response under mist than with syringing.

Wintercreeper Euonymus, _Euonymus fortunei radicans_

Fifty cuttings were made and treated with Hormodin #2 on June 15, 1955, separated into two lots of twenty-five cuttings, and placed in frames 1 and 4 of the exposed test unit. Under standard propagation methods, this plant roots 75 to 80 per cent in three to five weeks. At the end of thirty-five days in frame 1, 60 per cent of the cuttings had rooted, and in frame 4 after thirty-nine days, 20 per cent of the cuttings had rooted. The rooted cuttings were located in the mist areas within the frames that seemed to give the best results. These areas will be found in Figure 5, page 45, and are discussed on page 44 in proper sequence. It appears that further tests should be undertaken with this plant.

SUMMARY

Cuttings of certain plants can be satisfactorily rooted under outdoor, plastic covered, protective structures with the aid of mist under the hot, dry, windy conditions prevalent in Oklahoma in the summer.

Best rooting responses were obtained from those plant varieties which usually respond well to standard propagation methods. However, in the plastic mist frames, rooting was more rapid and better root systems were produced. Young succulent tissue responded best.

It is worthy of note that some rooting response was obtained from pecan cuttings which are quite difficult to root. The best response (16 per cent) was from untreated cuttings in a protected frame.

On the other hand, the narrow leaved evergreens tested failed to root as well under the mist as when handled normally.

During the period of maximum daily temperature, the temperature inside the frames exceeded standard outdoor figures by 25 to 30 degrees and recommended greenhouse maximums by 40 to 45 degrees. Humidity was maintained at or near 100 per cent relative humidity when the system was operating properly.

The "A" type of framing and the cypress material used

proved quite satisfactory insofar as their ability to withstand the elements, particularly the wind, were concerned. Likewise, the Visqueen clear polyethylene plastic of 0.003 inch thickness proved adequate for one season of use. The rooting medium was fairly satisfactory, but the surface drainage adjacent to the units was not fully satisfactory. No disease problems were encountered.

Certain modifications as improvements might be suggested as a result of three observations.

(1) The square frame shape was not efficient due to the circular shape of the misted area, which left a dry area around the periphery, especially in the corners. In a long bed, this might be overcome by overlapping misted areas. For the homeowner, a round, parasol shaped frame should be much more efficient for a single nozzle installation.

(2) A cover of wire mesh (e. g., concrete reinforcing mesh) would perhaps be as good as the more expensive cypress wood frames if used in conjunction with a wind barrier.

(3) An improved "electronic leaf", so constructed as to eliminate mineral salt deposits on the electrodes and intervening plastic plate, would be highly desirable.

(4) The rooting media, and more particularly the surface drainage, need to more adequately drain away the water accumulation than was accomplished under the conditions of this experiment.

This preliminary study indicates the feasibility of such a propagation technique under Oklahoma conditions and should prove useful to the commercial propagator as well as the hobbyist.

LITERATURE CITED

1. Adriance, G. W. and F. R. Brison. Propagation of Horticultural Plants. McGraw-Hill Book Company, 1939, pp. 126-148.

2. Avery, G. S., Jr., Elizabeth Bindloss Johnson, Ruth W. Addoms, and Betty F. Thompson. Hormones and Horticulture. McGraw-Hill Book Company, 1947, pp. 13-121.

3. Brandstaetter, Marie. "Mist Propagation Reviewed During Lake County School", American Nurseryman, CI, 7: 52-59, April 1, 1955.

4. Doran, W. L. "Conifers by Cuttings," The National Horticulture Magazine, 33, 1:58-60, Jan., 1954.

5. Fillmore, R. H. "Open Frame Propagation of Cuttings Under Mist," American Nurseryman, C, 4:12+, Aug. 15, 1954.

6. Gardner, E. J. "Propagation Under Mist," American Nurseryman, 73, 9:5-7, May 1, 1941.

7. Gossard, A. C. "Propagating Pecan, Rooting Softwood Cuttings Under Continuous Mist," Proc. Amer. Soc. Hort. Sci., 44:251-254, 1944.

8. Hess, C. E. and W. E. Snyder, "Better Rooting Noted: Interrupted Mist Found Superior to Constant Mist in Tests With Cuttings," American Nurseryman, C, 12:11+, Dec. 15, 1954.

9. Hitchcock, A. E. and P. W. Zimmerman. "Comparative Activity of Root-inducing Substances and Methods of Treating Cuttings," Cont. Boyce Thom. Inst., 10, 4:461-480, 1939.

10. Joiner, J. N. and T. J. Sheehan. "Mist Propagation," Fla. Agri. Exten. Ser. Circ. (Feb., 1955), 127.

11. Kains, M. G. and L. M. McQuesten. Propagation of Plants. Orange Judd Pub. Co., Inc., 1951, pp. 82-172, 576-580.

12. Kamp, J. R. "Mist Propagation," Ill. State Flor. Assoc. Bul., May-June, 1955, 161.

13. Kemmerer, H. R. and J. R. Kamp. "The Rooting Responses of Cuttings of Two Carnation and Two Chrysanthemum Varieties in Several Medias Under Constant Mist

Conditions," Ill. State Flor. Assoc. Bul., 162:1-7, July-Aug., 1955.

14. Langhans, R. W. "Mist Propagation and Growing," N. Y. State Fl. Grw. Assoc. Bul. 103, reprinted by Supreme Electric Products Co., Rochester, N. Y., Mar., 1954.

15. Lowenfels, A. "Taking the Mystery Out of Mist Propagation," The Amer. Home, LIII, 4:128+, Mar., 1955.

16. Meyer, B. S. and D. B. Anderson. Plant Physiology. (2nd ed.), D. Van Nostrand Co., Inc., 1952, pp. 309-334, 555-579.

17. Mitchell, W. G. "Propagating by Constant Mist," Plants and Gardens, 9:280-281, Winter 1953-54.

18. Morrison, Y. B. "Introduction," The Nat'l. Hort. Mag., 33, 1:viii, Jan., 1954.

19. Platt, D. "Iowans Tour Nurseries." Amer. Nurs., C, 6:74, Sept. 15, 1954.

20. Plants and Gardens. "Within the Brooklyn Botanic Garden; Our Use of Mist in Plant Propagation," Plants and Gardens, 9, 4:281-282, Winter 1953-54.

21. Pridham, A. M. S. "Educational New York Meet; Mist Propagation Research," Amer. Nurs., C, 6:16+, Sept. 15, 1954.

22. Sharpe, R. H. "Rooting of Muscadine Grapes Under Mist," Proc. Amer. Soc. Hort. Sci., 63:88-90, 1954.

23. Shugert, R. "Outdoor Propagation Under Constant Mist in Missouri," Amer. Nurs., CI, 2:13+, Jan. 15, 1955.

24. Snyder, W. E. "The Rooting of Leafy Stem Cuttings," The Nat'l. Hort. Mag., 33, 1:1-18, Jan., 1954.

25. Snyder, W. E. and C. E. Hess. "Recommendations for the Installation of a Mist System for Rooting Cuttings of Nursery Crops," Dept. of Flor. and Orna. Hort., N. Y. State Col. of Agri., Jan. 20, 1955, 9 pp.

26. Stoutemyer, V. T. "Apparatus and Materials," The Nat'l. Hort. Mag., 33, 1:48-53, Jan., 1954.

27. Templeton, H. M., Jr. "The Phytotektor System," Amer. Nurs. Assoc. Bul. reprinted from Ohio Nursery Notes, 23, 4:7 pp., April, 1954.

28. Watkins, J. V. "Propagation of Ornamental Plants," _Fla. Agri. Exten. Ser. Bul._ 150, 1952.

29. Wells, J. S. "Outdoor Propagation Under Constant Mist," _Amer. Nurs._, 97, 11:14+, June 1, 1953.

30. __________. "More About Outdoor Propagation Under Mist," _Amer. Nurs._, 98, 3:17+, August 1, 1953.

31. __________. "Pointers on Propagation; Further Notes on Constant Mist," _Amer. Nurs._, 98, 11:12-13+, Dec. 1, 1953.

32. __________. "Open Frame Mist Propagation," _Amer. Nurs. Assoc. Bul. reprinted from Ohio Nursery Notes_, 23, 3:4 pp., Mar., 1954.

33. __________. "Pointers on Propagation; Ideal Propagating House," _Amer. Nurs._, 99, 11:12-13+, June 1, 1954.

34. __________. "Pointers on Propagation; Where Do We Stand on the Use of Mist?" _Amer. Nurs._, CI, 5:17+, Mar. 1, 1955.

VITA

Frank Robert Elmore

Candidate for the Degree of

Master of Science

Thesis: A PLASTIC COVERED MIST PROPAGATING STRUCTURE FOR OUTDOOR USE IN OKLAHOMA

Major Field: Horticulture

Biographical:

Personal Data: The writer was born in Butte, Silverbow County, Montana, U. S. A., December 29, 1920, the son of Frank B. Elmore and Theda Mize Elmore.

Education: Graduated from Borger High School, Borger, Texas, 1938; attended Texas Technological College, Lubbock, Texas, 1938-39 term; graduated from 19th Wing Technical School, Rio Hato, Republic of Panama, October, 1940 (Mechanic); completed Aviation Cadet College Training at Central Washington College of Education, June, 1944, Ellensburg, Washington; received the Bachelor of Science degree in Agriculture from the University of Arkansas, Fayetteville, Arkansas, February, 1954; completed requirements for the Master of Science degree in Horticulture at Oklahoma State University, Stillwater, Oklahoma, August, 1958.

Experiences: General Labor, Phillips Petroleum Company, 1939; U. S. Air Force (Enlisted), January, 1940, to August, 1945; Lumberyard Clerk and Bookkeeper, October, 1945, to October, 1946; Self employed, November, 1948, to March, 1948, Grocer; Bread-Wrapper Operator, April, 1948, to September, 1948; Rig-Builder Apprentice, October, 1948, to February, 1949; Motel Manager, February, 1949, to June, 1951; Research Assistant in Cotton Insect Control, Summer, 1954; Half time Teaching Assistant, Horticulture, Oklahoma Agricultural and Mechanical College, 1954-55 term; Full time

Instructor of Horticulture, Arkansas State College, State College, Arkansas, September, 1955, to July, 1958.