ROOTING RESPONSES OF SELECTED ORNAMENTAL PLANTS AS INFLUENCED BY VARIOUS NUTRIENT MISTS AND SPRAYS

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Bachelor of Science

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1957

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
May 27, 1962

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ACKNOWLEDGEMENT

The author wishes to express his appreciation to Dr. David G. White whose guidance, supervision, and patience made possible this study. Appreciation is, also, due to Dr. Samuel C. Wiggans for his assistance in the writing of this thesis. Thanks are due to Dr. H. B. Cordner and Professor Richard N. Payne for their interest and assistance in the design portion of the problem.

A certain amount of genuine appreciation and gratitude is due Professor W. R. Kays, Head, Department of Horticulture, Oklahoma State University, for his gift of a true and lasting interest in horticulture and human understanding.

Gratitude is expressed to the author's wife for constant encouragement and assistance during the entire course of study.

Further acknowledgement is made by the author to the following who gratuitously contributed their time and energies: Mr. David Bradford, Mr. Joe Maxson, Mr. Bobby Burk, and the entire greenhouse staff.

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INTRODUCTION

Vegetative propagation of plants has been practiced for over 2000 years. Theophrastus, an early Greek biologist, wrote a description of the making of cuttings, some 300 years before the birth of Christ (22). Since that time many changes and improvements have been made in the propagation of plants.

Although synthetic root promoting chemicals are extremely important in vegetative propagation, the use of fertilizers as aids to the rooting of cuttings are also important. Most fertilizer investigations, however, have been limited principally to stock plant nutrition studies and fertilizer application studies after the cuttings are rooted. Krause and Kraybill in 1919 showed that the carbohydrate/nitrogen ratio definitely influenced the rooting of cuttings. However, about this time most plant physiologists had turned their attention to hormone and auxin investigations, thus reducing the intensive studies of the nutrient status of cuttings which were needed before commercial applications could be made of their discovery.

The objectives of the study reported herein are: (a) to investigate the effects of the use of a complete fertilizer dissolved in the mist of an intermittent mist system on the rooting of cuttings, and (b) to investigate the effects of nitrogen and sugar sprays on the foliage of cuttings which are being rooted.

REVIEW OF LITERATURE

Many different materials have been used as rooting media for the propagation of various types of plants. The first commercial, and still widely used rooting medium, is a plaster's grade of builders' sand (11).

In a study conducted in 1928 Hitchcock (10) experimented with 46 different genera. He concluded that, under the environmental conditions of his experiment, 90 per cent of the cuttings rooted better in a mixture of one part peat moss and one part sand than they did in sand alone.

In other studies (8 and 21) it was found that cuttings properly handled will root satisfactorily in a wide variety of media, with a mixture of one part perlite to one part peat moss, by volume, giving the best results.

According to Mahlstede and Haber (15) the qualities necessary to constitute a desirable rooting medium are: (a) to be of such a nature as to hold the cuttings upright during the rooting process, (b) have a good water retention capacity, and (c) be sufficiently porous to provide for the gaseous exchange of oxygen and carbon dioxide necessary in the rooting process.

One of the most important advancements in the vegetative reproduction of plants has been the use of mist propagation, in particular intermittent mist propagation (6). The use of such systems has greatly reduced the time required for rooting cuttings of all types (21). The first successful use of this type of system apparently was made by a commercial nursery man in West DePere, Wisconsin in 1940 (15) using softwood cuttings. His mist system resulted in conditions which provided good drainage as well as reducing the amount of water used over that of the constant mist systems.

The on and off cycle in the intermittent mist system does not lower the temperature of medium as much as does the constant mist system (7). However, the cuttings remain cooler in the intermittent mist system since evaporation of the thin film of water on the leaves radiates some of the heat. The cuttings transpire less water in the intermittent mist system and wilting is prevented. This produces a greater supply of carbohydrates by maintaining a larger area of foliage when the cuttings are taken. In addition the intermittent mist is superior to constant mist since less nutrients are leached from the cuttings (23). The cuttings can be hardened off more readily after rooting. Drainage problems are greatly minimized, and conditions favoring plant disease organisms are reduced.

There is no need for heavy shading with the intermittent mist system since high light intensities apparently are not detrimental to the rooting of cuttings (15).

The application of mist in cycles only during the daylight hours was found to be equal to or to be better than a mist system using a cycle of a longer period (6). Although actual misting time was reduced it was sufficient for a thorough wetting of the leaves with a minimal amount of water.

The discovery in 1935 by Thimann of the effect of synthetic hormone-like chemicals on the rooting of cuttings stimulated many researches in this area (2). The use of such materials resulted in the production of more roots on cuttings in a shorter length of time. Species which were previously hard to root from cuttings responded with regularity. However, the specific action with which these substances act on cuttings is still not clearly understood (2).

Few experiments using fertilizers applied to the cuttings have been reported. One experiment with poinsettias, however, indicated (25) that fertilization every two or three days with three pounds of 25-10-10 water soluble fertilizer in 100 gallons of water as soon as the cuttings have started to callus prevented leaching and starvation of the cuttings. In an experiment carried out at the University of Illinois (12) the basal one inch of chrysanthemum and carnation cuttings were soaked in a 0.06% solution of a complete fertilizer prior to being treated with a potassium salt of naphthalene acetic acid. The cuttings then were stuck in a standard sand filled propagation bench. In general, the use of the fertilizer increased the rooting by approximately 10 per cent.

The spraying of dilute fertilizers over cuttings in the propagation bench was reported by Schwartze and Myhre (17 and 18). Hardwood cuttings of highbush blueberry (Vaccinium corymbosum) were used with a rooting medium consisting of a mixture of peat moss and sand. Various concentrations of the following fertilizers were sprayed on the cuttings after they had been rooted: ammonium phosphate (11-48-0), tankage in a water solution (6-10-0), and a soluble compound (VHPF), said by the manufacturer to be a complete fertilizer equivalent to 5-25-15 fertilizer plus vitamins, hormones, and minor elements. Ammonium phosphate and VPHF gave the best rooting results.

Krause and Kraybill found that too much nitrogen in the cutting inhibited the production of roots of tomato cuttings (13). Staring (20) and Cordner (3) found the same inhibitory effect of nitrogen. Other experiments in different locations have confirmed these results. In all cases when the carbohydrate/nitrogen ratio was high rooting was stimulated.

METHODS AND MATERIALS

The studies reported herein were conducted in the Oklahoma State University Department of Horticulture Greenhouses during the late winter, spring, and summer of 1961. Cuttings of the various species used were propagated utilizing an automatic intermittent mist system, with deflection type nozzles[1] spaced at 36 inch intervals in ¼ inch pipe. Separate mist lines were installed 40 inches above two benches in Experiments 1 and 2, and 14 inches above the pots in Experiment 3. A 10 second mist cycle per 6 minute period on Experiments 1 and 2 was controlled by an automatic electric cycle control. A 9 second mist cycle per 6 minute period was used in Experiment 3. An electric time clock was used to turn the mist on at 7 AM and off at 6 PM each day. During the late winter and spring an approximate night air temperature of 60-65 degrees F. was maintained and during the summer an approximate night air temperature of 70-75 degrees F. was maintained. Day temperatures rose to 10° to 20° F. above the night temperature.

Experiment 1

Stem cuttings from each of four species, Evergreen Euonymus (*Euonymus japonicus*), Scarlet Firethorn (*Pyracantha coccinea*), Andorra Creeping Juniper (*Juniperus horizontalis plumosa*), and Lavender-cotton (*Santolina*

[1]ROJT mist nozzles which deliver one gallon of water per hour at 40 p.s.i., manufactured by or for Jednak Floral Company, Columbus, Ohio.

chamaecyparissus) were cut on February 23. The basal ends of the cuttings were dipped into either (1) Hormodin No. 2[2], (2) Hormodin No. 3[3], or (3) Rootone with Fungicide[4]. The cuttings were then stuck into the two propagation benches, each containing two rooting media, (1) builder's sand or (2) a 50:50 mixture of perlite and peat moss as shown in Figure 1. The cuttings were placed in a randomized block design with 2 replications (Figure 2). There were 24 cuttings per treatment. A water soluble 20-20-20 fertilizer with chelated trace elements[5], was injected up-stream in the mist line over one bench by means of a 5-gallon garden power-sprayer used as an injector, and a Walden Chemical Mixer[6] utilized to insure even mixing and distribution of the fertilizer (See Figure 3). The fertilizer was applied through the mist line at an average rate of 5 ounces per day to the 67.4 square feet of bench area during the experiment. The second bench received only tap water through the mist line during the course of the experiment.

On April 26, the experiment was terminated and each cutting was dug and rated according to Mahlstede and Lana rooting scale (16) modified as follows (Figure 4): 1 - no callus or root formation; 2 - callus and/or the beginning of some root development; 3 - root growth totaling $1\frac{1}{2}$

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[2]300 parts per million (ppm) indolebutyric acid (IBA), Merck & Company, Rahway, New Jersey.

[3]800 ppm IBA, Merck & Company, Rahway, New Jersey.

[4]A mixture of 670 ppm of napthylacetamide (NAAm), 330 ppm of 2-methyl-1-Naphyl-acetic acid (MeNA), 130 ppm of 2-methyl-1-Naphthylamide (MeNAm), 570 ppm of IBA, and 4% tetramethyethiuramdisulfide (Thiram), AMCHEM Products, Ambler, Pennsylvania.

[5]General Purpose 20-20-20, Robert B. Peters Co., Inc., Allentown, Pennsylvania.

[6]Designed for this experiment by James R. Walden.

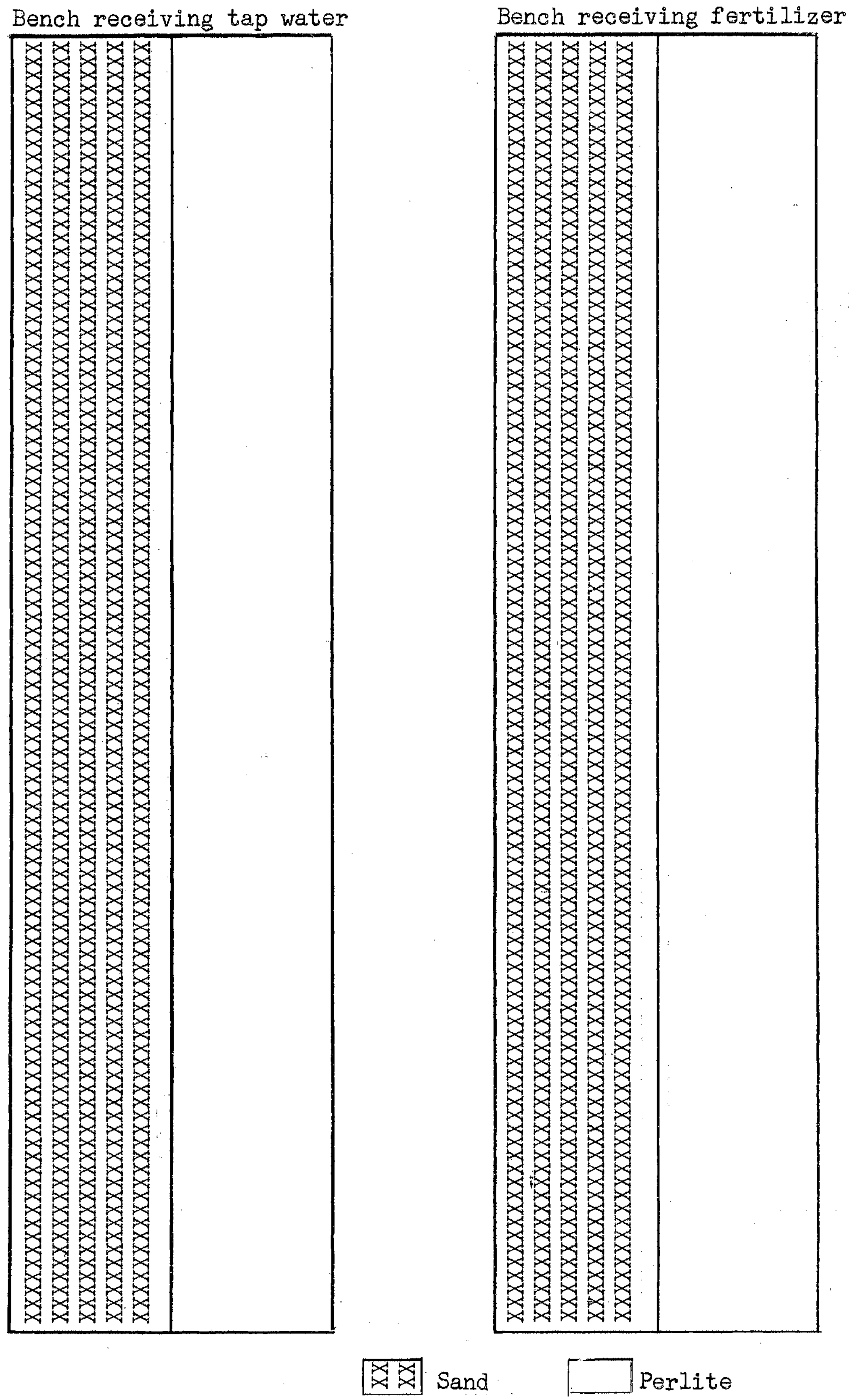
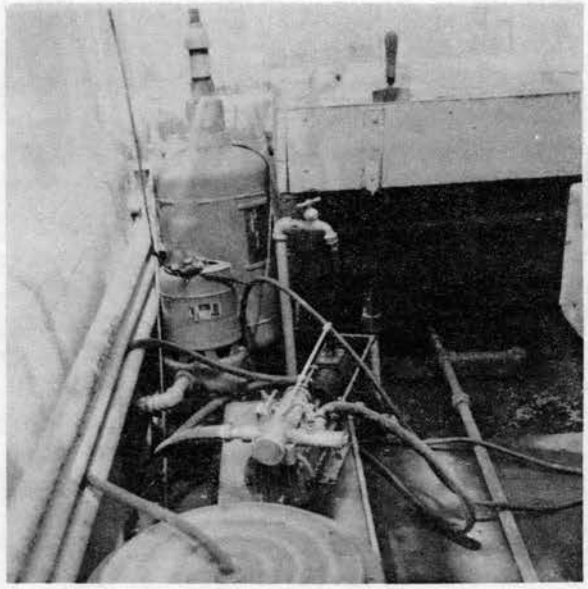


Figure 1. Bench arrangement showing the benches receiving fertilizer mist and water mist.

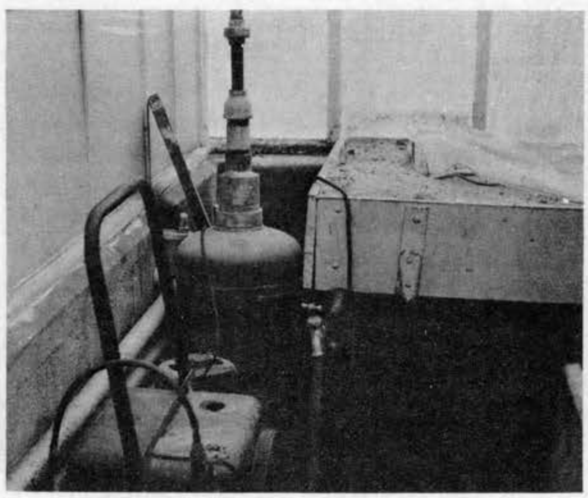
Bench Receiving Tap Water		Bench Receiving Fertilizer	
Sand	Perlite and Peat Moss	Sand	Perlite and Peat Moss
Rootone 1 3 4 2	Hormodin #3 2 3 1 4	Hormodin #2 1 4 3 2	Control 4 1 3 2
Control 1 4 2 3	Hormodin #2 1 4 2 3	Rootone 3 4 1 2	Hormodin #3 3 1 4 2
Hormodin #2 4 2 3 1	Control 4 1 3 2	Hormodin #3 1 3 2 4	Rootone 1 4 3 2
Hormodin #3 3 1 2 4	Rootone 3 1 4 2	Control 4 2 1 3	Hormodin #2 3 2 1 4
Hormodin #2 2 3 1 4	Control 4 2 3 1	Rootone 4 1 3 2	Hormodin #3 4 3 1 2
Rootone 1 3 2 4	Hormodin #3 2 3 4 1	Control 4 2 3 1	Hormodin #2 1 3 2 4
Hormodin #3 2 3 4 1	Rootone 1 3 2 4	Hormodin #2 1 4 3 2	Control 3 2 4 1
Control 4 1 3 2	Hormodin #2 3 4 2 1	Hormodin #3 2 3 1 4	Rootone 1 4 2 3

1. Evergreen Euonymus (*Euonymus japonicus*)
2. Scarlet Firethorn (*Pyracantha coccinea*)
3. Andorra Creeping Juniper (*Juniperus horizontalis plumosa*)
4. Lavender-cotton (*Santolina chamaecyparissus*)

Figure 2. Bench arrangement showing the benches receiving fertilizer and water mists, the placement of cuttings and root promoting substances used in Experiment 1.



Walden Chemical Mixer with Fert-O-Ject



Walden Chemical Mixer with Garden Sprayer

Figure 3. Installations showing the two fertilizer injectors used with the chemical mixer.

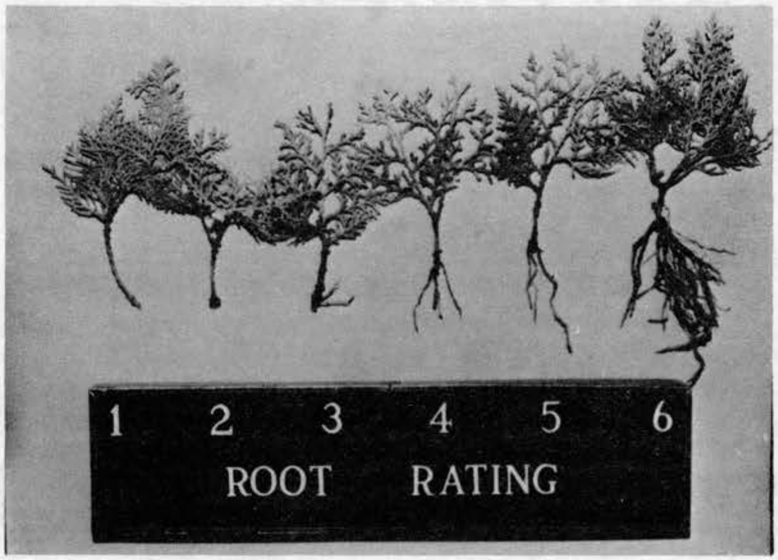


Figure 4. An illustration showing the modified Mahlstede and Lana rooting scale.

inches or less; 4 - root growth totaling $1\frac{1}{2}$ to 3 inches; 5 - root growth totaling 3 to 6 inches; and 6 - root growth totaling 6 inches or more.

The cuttings were sprayed with a fungicidal mixture, containing one tablespoonful each of Orthocide 50[7], Terraclor[8], and Fermate[9], per gallon of water on March 1, March 16, and April 1.

Experiment 2

The basal ends of hydrangea (Hydrangea macrophylla), Rose Supreme, stem cuttings approximately 5 inches in length, were treated with (1) Hormodin No. 1[10], (2) Hormodin No. 2[2], or (3) Hormodin No. 3[3] as described in Experiment 1. Before being treated the basal section of each cutting was cut at a slant so as to expose as much dermatogen and periblem as possible. There were 30 cuttings per treatment. Treated cuttings were stuck in either the sand filled or perlite and peat moss filled benches on June 3 (See Figure 1). The cuttings were placed in the benches in a systematic block design with two replications (Figure 5). Only water was used in the mist system on June 3 and June 4. Beginning June 5, a water soluble 20-20-20 fertilizer[5] was injected into the mist line over one bench. The 20-20-20 fertilizer, 8 ounces per 100 gallons of water, was supplied at the rate of 2.88 ounces of fertilizer per 67.4 square feet of bench space per day. The fertilizer was injected into the mist line by a hydraulic motor and pump[11]. The second bench received only

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[7] Wettable powder of 50% trichloromethylmercapto-4-cyclohexene-1, 2 dicarboximide. California Spray-Chemical Corp., Richmond, Calif.

[8] 75% pentachloronitrobenzene, Olin Mathieson Chemical Corp., Chicago, Ill.

[9] 76% ferric dimethyldithio-carbamate, DuPont, Wilmington, Del.

[10] 100 ppm IBA, Merck & Company, Rahway, New Jersey.

[11] Fertoject - Model PR Injector, Fert-O-Ject, La Habra, Calif.

Bench Receiving Tap Water

Sand	Perlite and Peat Moss
Hormodin #1	Hormodin #1
Hormodin #2	Hormodin #2
Hormodin #3	Hormodin #3
Control	Control
Hormodin #1	Hormodin #1
Hormodin #2	Hormodin #2
Hormodin #3	Hormodin #3
Control	Control

Bench Receiving Fertilizer

Sand	Perlite and Peat Moss
Hormodin #1	Hormodin #1
Hormodin #2	Hormodin #2
Hormodin #3	Hormodin #3
Control	Control
Hormodin #1	Hormodin #1
Hormodin #2	Hormodin #2
Hormodin #3	Hormodin #3
Control	Control

Figure 5. Bench arrangement showing the benches receiving fertilizer and water mists, root promoting chemicals used, and location of media in Experiment 2.

tap water through the mist line. The cuttings were sprayed with the same fungicide mixture as in Experiment 1, on June 10 and 18. The cuttings were dug and a root rating made June 24 according to the same scale described for Experiment 1.

Experiment 3

In this experiment, conducted in a fiberglass greenhouse, the influence of carbohydrate and nitrogen treatments upon the production of roots was studied. Stem cuttings of Goldspire Arborvitae (*Thuja orientalis*) HV Goldspire were dipped into either (1) Hormodin No. 3[3] or (2) Rootone[4]. They were then placed in either sand-filled or 50:50 perlite and peat moss-filled 6 inch pots on February 26. The cuttings were placed in the bench in a randomized block design (Figure 6) and sprayed with: (a) $\frac{1}{2}$ ounce of urea (45-0-0) per gallon of water, (b) 1 ounce of urea per gallon of water, (c) 3 per cent sucrose solution, (d) $\frac{1}{2}$ ounce of urea per gallon of 3 per cent sucrose solution, or (e) 1 ounce of urea per gallon of 3 per cent sucrose solution. There were 10 cuttings per treatment with 6 replications. The sprays were applied at 3 day intervals from February 26 until May 9. The treatment intervals were extended to every 6 days, from May 15 until June 26. The pots were rotated within the replication from south to north along the length of the bench at 3 and 6 day intervals to insure more uniform environmental conditions. The pots were completely rotated six times throughout the experiment. During the experiment the greenhouse was fumigated once with Thiodan[12]. The cuttings were sprayed once with a mixture of

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[12]15% hexachloro-hexahydro-methano-2,4,3 benxodionathiepin oxide, Plant Products Corporation, Long Island, New York.

Treat. No.	Media	Root. Treat.	Spray Treat.
1	P & P[a]	Control	0
2	"	"	I
3	"	"	II
4	"	"	III
5	"	"	IV
6	"	"	V
7	"	Hormodin #3	0
8	"	"	I
9	"	"	II
10	"	"	III
11	"	"	IV
12	"	"	V
13	"	Rootone	0
14	"	"	I
15	"	"	II
16	"	"	III
17	"	"	IV
18	"	"	V
19	Sand	Control	0
20	"	"	I
21	"	"	II
22	"	"	III
23	"	"	IV
24	"	"	V
25	"	Hormodin #3	0
26	"	"	I
27	"	"	II
28	"	"	III
29	"	"	IV
30	"	"	V
31	"	Rootone	0
32	"	"	I
33	"	"	II
34	"	"	III
35	"	"	IV
36	"	"	V

	22	29	34	27	7	9
	12	18	5	8	1	20
Rep. 1	35	21	24	15	25	31
	33	30	4	13	36	19
	3	11	17	10	28	23
	14	16	26	32	2	6
	3	33	27	26	5	10
	35	7	8	13	24	2
Rep. 2	6	21	14	18	25	12
	16	36	4	29	28	15
	19	31	23	30	11	9
	20	17	1	32	34	22
	13	30	2	33	17	4
	27	15	9	20	26	12
Rep. 3	16	21	35	10	5	29
	36	23	31	3	14	19
	7	22	24	25	11	32
	6	28	18	1	34	8
	9	1	11	16	10	28
	5	18	14	8	19	21
Rep. 4	34	6	13	27	7	32
	17	12	29	33	31	15
	35	4	23	22	30	26
	20	25	3	36	2	24
	22	28	6	1	15	31
	34	18	26	12	30	24
Rep. 5	25	11	5	8	3	7
	4	27	14	2	13	17
	29	33	36	10	9	32
	35	16	21	20	19	23
	30	35	12	18	24	23
	28	16	7	36	6	8
Rep. 6	34	17	13	14	20	4
	29	5	25	22	33	27
	2	1	11	26	19	32
	10	9	15	21	31	3

Figure 6. The pot arrangement and treatments used in Experiment 3.

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a--Perlite and Peat Moss (50:50)
0--No Spray
I--$\frac{1}{2}$ oz urea/gallon of water
II--1 oz urea/gallon of water
III--3% sucrose solution
IV--$\frac{1}{2}$ oz urea/gallon 3% sucrose
V--1 oz urea/gallon 3% sucrose

Isotox[13]. The cuttings were rated June 26 as in Experiments 1 and 2 and a statistical analysis made.

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[13] 5% lindane (gamma isomer of benzene hexachloride), 10% malthion (-O-O-dimethyl dithophosphate of diethyl mercaptosuccinde), 5% DDT (dichloro diphenyl trichloro-ethane), and 3% 2,4,5,4, - tetrachlorodiphenyl sulphone, in a 20% aromatic petroleum derivative solvent, California Spray Chemical Corporation, Richmond, California.

RESULTS

Experiment 1

In this experiment the effects of various rooting media, mist applications, and pretreatments with root promoting chemicals on the rooting of cuttings of four species, Evergreen Euonymus (*Euonymus japonicus*), Andorra Creeping Juniper (*Juniperus horizontalis plumosa*), Scarlet Firethorn (*Pyracantha coccinea*), and Lavender-cotton (*Santolina chamaecyparissus*), were compared after 56 days.

Table I shows the average root ratings, over-all mist applications and rooting media, obtained from each species with each pretreatment with growth promoting chemicals. The best over-all root rating was obtained with the Hormodin #3 treatment, being 24% better than the control. The Hormodin #2 treatment gave an 18% better over-all root rating than the control and the Rootone treatment an 8% better rating. Lavender-cotton produced the highest root rating with each of the chemical treatments and Andorra Creeping Juniper the lowest.

In Table II the root rating of each species, over-all chemical treatments and rooting media, under each mist treatment is given. The greatest increase in root rating occurred under the fertilizer mist with the Andorra Creeping Juniper and the least with Lavender-cotton. There was a 53% better average root rating over-all species using the fertilizer mist than the water mist.

TABLE I

THE AVERAGE ROOT RATING AFTER 56 DAYS, OVER-ALL MIST APPLICATIONS AND ROOTING MEDIA, ACCORDING TO THE MODIFIED MAHLSTEDE AND LANA SCALE (FIG. 4), OF FOUR SPECIES, EVERGREEN EUONYMUS, SCARLET FIRETHORN, ANDORRA CREEPING JUNIPER, AND LAVENDER-COTTON, TREATED WITH ROOTONE, HORMODIN #2, AND HORMODIN #3. EACH FIGURE REPRESENTS AN AVERAGE OF 48 CUTTINGS.

Species	Control	Rootone	Hormodin #2	Hormodin #3	Average Root Rating
Evergreen Euonymus	3.9	4.1	4.3	4.6	4.3
Andorra Creeping Juniper	3.6	3.9	4.3	4.5	4.2
Scarlet Firethorn	3.8	4.1	4.5	4.7	4.4
Lavender-cotton	3.8	4.3	4.7	4.9	4.6
Average	3.8	4.1	4.5	4.7	
Percent Increase over control	----	8%	18%	24%	

TABLE II

THE AVERAGE ROOT RATING AFTER 56 DAYS, OVER-ALL CHEMICAL TREATMENTS AND ROOTING MEDIA, ACCORDING TO THE MODIFIED MAHLSTEDE AND LANA SCALE (FIG. 4), OF FOUR SPECIES, EVERGREEN EUONYMUS, SCARLET FIRETHORN, ANDORRA CREEPING JUNIPER, AND LAVENDER-COTTON UNDER BOTH WATER MIST AND FERTILIZER MIST. EACH RATING REPRESENTS AN AVERAGE OF 96 CUTTINGS.

Species	Water Mist	Fertilizer Mist	Percent Increase in Root Rating
Evergreen Euonymus	3.3	5.2	58%
Andorra Creeping Juniper	3.3	5.3	61%
Scarlet Firethorn	3.4	5.2	53%
Lavender-cotton	3.7	5.2	41%
Average	3.4	5.2	53%

Table III shows the root rating, over-all chemical treatments and mist applications, of each species with each rooting medium. Each species gave approximately a 7% increase in root rating in the perlite and peat moss medium over that obtained in the sand medium.

Experiment 2

The average root rating of hydrangea (Hydrangea macrophylla) cuttings rooted in either sand or in perlite and peat moss and treated with Hormodin #1, Hormodin #2, and Hormodin #3 are shown in Table IV. After 21 days neither the chemical treatment or mist treatment made any difference in the average root rating of the cuttings. Cuttings in all treatments rooted equally well.

Experiment 3

The over-all root rating, after 121 days, of cuttings from Goldspire Arbovitae (Thuja orientalis) H. V. Goldspire with each rooting and spray treatment is shown in Table V. The best root rating was obtained from cuttings over-all chemical pre-treatments sprayed with 1 ounce of urea per gallon of 3% sucrose in a perlite and peat moss medium. The poorest root rating was obtained from cuttings over-all chemical pre-treatments sprayed with 1 ounce of urea per gallon of 3% sucrose in a sand medium. The highest root ratings over-all chemical spray treatments were obtained with Hormodin #3. The lowest average root rating over-all chemical spray treatments was obtained in the control treatments in perlite and peat moss.

The data in Table VI represents an analysis of variance of this experiment. The rooting medium was highly significant. The root promoting substances used were highly significant, with Hormodin #3

TABLE III

THE AVERAGE ROOT RATING AFTER 56 DAYS, OVER-ALL CHEMICAL TREATMENTS AND MIST APPLICATIONS, ACCORDING TO THE MODIFIED MATHLSTEDE AND LANA SCALE (FIG. 4), OF FOUR SPECIES, EVERGREEN EUONYMUS, SCARLET FIRETHORN, ANDORRA CREEPING JUNIPER, AND LAVENDER-COTTON, ROOTED IN SAND AND IN PERELITE AND PEAT MOSS. EACH RATING REPRESENTS AN AVERAGE OF 96 CUTTINGS.

Species	Sand	Perlite and Peat Moss	Percent Increase in Root Rating
Evergreen Euonymus	4.1	4.4	7%
Andorra Creeping Juniper	4.0	4.3	8%
Scarlet Firethorn	4.1	4.4	7%
Lavender-cotton	4.3	4.6	7%
Average	4.1	4.4	7%

TABLE IV

THE AVERAGE ROOT RATING AFTER 21 DAYS, ACCORDING TO THE MODIFIED MATHLSTEDE AND LANA SCALE (FIG. 4), OF HYDRANGEA CUTTINGS TREATED WITH HORMODIN #1, HORMODIN #2, AND HORMODIN #3 IN SAND AND IN PERLITE AND PEAT MOSS MEDIA. EACH FIGURE REPRESENTS AN AVERAGE OF 60 CUTTINGS.

		Chemical Pre-treatment of Cuttings			
Media	Mist Treatment	Check	Hormodin #1	Hormodin #2	Hormodin #3
Sand Medium					
	Fertilizer Mist	6	6	6	6
	Water Mist	6	6	6	6
Perlite and Peat Moss Medium					
	Fertilizer Mist	6	6	6	6
	Water Mist	6	6	6	6

TABLE V

THE AVERAGE ROOT RATING AFTER 121 DAYS ACCORDING TO THE MODIFIED MAHLSTEDE AND LANA SCALE (FIG. 4), OF GOLDSPIRE ARBORVITAE CUTTINGS TREATED WITH ROOTONE, AND HORMODIN #3, STUCK IN EITHER SAND OR IN PERLITE AND PEAT MOSS MEDIA, AND SPRAYED WITH VARIOUS CONCENTRATIONS OF NITROGEN AND SUCROSE. EACH FIGURE REPRESENTS AN AVERAGE OF 60 CUTTINGS.

Media	Spray Test	Control	Hormodin #3	Rootone	Average
Sand	Control No Spray	2.3	3.0	1.8	2.4
"	$\frac{1}{2}$ oz urea/gal of water	2.2	3.0	2.1	2.4
"	1 oz urea/gal of water	2.3	2.8	2.0	2.4
"	3% sucrose solution	2.3	2.6	2.1	2.3
"	$\frac{1}{2}$ oz urea/gal 3% sucrose	2.1	2.9	2.0	2.3
"	1 oz urea/gal 3% sucrose	2.1	2.9	1.9	2.3
	AVERAGE	2.2	2.9	2.0	2.4
Perlite and Peat Moss	Control No Spray	1.8	2.9	2.4	2.4
"	$\frac{1}{2}$ oz urea/gal of water	1.8	3.0	3.1	2.6
"	1 oz urea/gal of water	2.0	2.7	3.2	2.6
"	3% sucrose solution	1.9	2.5	2.7	2.4
"	$\frac{1}{2}$ oz urea/gal 3% sucrose	2.2	2.8	2.4	2.5
"	1 oz urea/gal 3% sucrose	1.8	3.4	2.9	2.7
	AVERAGE	1.9	2.9	2.8	2.5

TABLE VI

A STATISTICAL ANALYSIS OF THE ROOTING DATA OF THE GOLDSPIRE ARBORVITAE CUTTINGS

Source of Variation	DF	SS	MS	F values
Total	215	8751		
Media	1	228	228	8.14**
Spray	5	102	20	0.71
Rooting Chemical	2	2501	1250	44.60**
Replication	5	286	57	2.03
Error	202	5634	28	

**Significant at the 1% level.

giving the best results as shown in Table V. The spray treatments were not significant. The variance for replication, also, was not significant.

DISCUSSION

Various experiments have shown that there may be considerable foliar leaching of nutrients from established plants (23). It is thus reasonable to assume that cuttings propagated under mist might also be subjected to this action. Cuttings do not have root systems which are capable of replacing lost nutrients, as in the case of the established plant, therefore, it would seem desirable to supply nutrients externally in order to obtain optimum rooting. The 20-20-20 fertilizer was added in a very dilute form to the water in the mist system in an attempt to replace the nutrients which might have been leached out of the cuttings or might be needed for better rooting.

Just as is the case in fertilization of individual species for optimum plant growth, there probably is a different nutrient level which must be maintained for optimum rooting of cuttings of different species. The nutrient requirements could be determined for the cuttings of individual species by the addition or reduction of certain essential elements. Relatively lesser amounts of nitrogen compared to the potassium and phosphorus might have produced better results than were obtained in this study. Several studies (3, 13, 20) have indicated that high amounts of nitrogen present in the cuttings or applied to cuttings in some manner retard the development of roots.

Automatic mist propagation systems have long been used in the vegetative propagation of plants. Many improvements and modifications have been made in the last few years in attempts to improve the quality of cuttings and to shorten the time required to secure desirable rooting. Various systems for adding fertilizers to water lines used to water plants have also been developed. Thus, it was relatively easy to design and construct a system which would inject a dilute fertilizer into an intermittent mist system. However, the use of the Fert-O-Ject and the power garden sprayer did not result in a thorough mixing of the dilute fertilizer in the mist line since they were of a simplex type pump and only pumped on one stroke. This type of action places the fertilizer solutions into the mist lines in positions spaced between spots of water. Some type of a flow line mixer was needed, hence the Walden Chemical Mixer which was composed of several baffle plates with perforated traps encased in an 18 inch steel pipe (Fig. 3) was developed. The Fert-O-Ject injector worked with less trouble than did the converted garden sprayer.

The rooting of cuttings probably was better in the perlite and peat moss medium than in the sand medium because perlite and peat moss, in general, has a higher water holding capacity than sand. Perlite and peat moss also provides better drainage and aeration around the root zone.

The time element is of prime importance in a study of this type. In the second experiment the cuttings should perhaps have been rated at 14 days or sooner instead of at 21 days in order to obtain differences in rooting with the different mist and chemical treatments. The basal end of the hydrangea cuttings which were of nearly semi-hardwood type were high in carbohydrates. This fact coupled with the unusually cool weather for June in this particular geographic location produced optimum rooting conditions as evidenced by the 100% heavy rooting.

In Experiment 3 there seemed to be an inhibitory effect of the sugar solutions on the action of the root promoting substances in both the sand and the perlite and peat moss medias. The statistical analysis indicated that essentially the same results would have been obtained with four replications, thus if space was a limiting factor in an experiment of this type an area which was one-third smaller probably would give comparable results.

The electrical timer devices used in this study were not completely satisfactory since at times the actual mist time was longer than desired. An improved "electrical leaf" probably would be much better than the automatic timed sequence because it would supply water when the leaves actually became dry.

The deflection type nozzle used also was not completely satisfactory because it was easily stopped up by rust and corrosion particles in the water supply lines. An improvement could be made by the use of an oil burner type nozzle which probably would be more satisfactory since it is equipped with a strainer.

CONCLUSIONS

1. Under the conditions of these experiments it is concluded that:
    a. The perlite and peat moss medium produced better rooted cuttings than did sand.
    b. The fertilizer mist treatment gave up to 61% better rooting than did the water treatment with Andorra Creeping Juniper.
    c. The use of root promoting chemicals, particularly indole-butryric acid, produced better rooted cuttings.
    d. The use of sugar and urea sprays did not significantly increase rooting.
2. In future experiments the following points should be considered:
    a. A closer observation of rooting progress should be made so that root readings could be made sooner if conditions warranted it.
    b. More and different rooting media should be used.
    c. More and different root promoting chemicals should be used.
    d. The effect of bottom heat applied to the pots should be investigated.
    e. The effect of a change of pH of the medium on the rooting of the cuttings should be studied.
    f. The effect of photoperiod and light intensities on the rooting of the cuttings should be studied

g. In addition to making root rate readings it perhaps would be desirable to rate the leaf growth or flower formation of cuttings in each treatment in such an experiment.

SUMMARY

The studies reported herein deal with the nutritional status of un-rooted cuttings of selected ornamental plants. Terminal stem cuttings of five different species, Evergreen Euonymus (Euonymus japonicus), Andorra Creeping Juniper (Juniperus horizontalis plumosa), Scarlet Firethorn (Pyracantha coccinea), Lavender-cotton (Santolina chamaecyparissus), and Hydrangea (Hydrangea macrophylla) H. V. Rose Supreme were used for rooting tests. Two rooting media, sand or a 1:1 perlite and peat moss mixture, and 4 root promoting preparations, Hormodin #1, Hormodin #2, Hormodin #3, or Rootone, were used in these experiments. Either tap water or a liquid fertilizer solution containing a dilute 20-20-20 fertilizer with all trace elements added was supplied as an intermittent mist to the cuttings in the propagation benches, with a 10 second mist cycle during each six minute period. The liquid fertilizer was injected into the lines with a Fert-O-Ject injector or with a converted garden sprayer and mixed with a Walden Chemical Mixer before being misted.

In general, the cuttings rooted better in perlite and peat moss than in sand. The Evergreen Euonymus, Andorra Creeping Juniper, Scarlet Firethorn, and Lavender-cotton cuttings treated with the fertilizer mist had a 53% better average over-all root rating than those rooted under the water mist. The root ratings of the Hydrangea cuttings showed no appreciable differences in any of the treatments.

In another experiment, cuttings of Goldspire Arbovitae (*Thuja orientalis*) H. V. Goldspire were treated with two different root promoting chemicals, Hormodin #3 and Rootone, and stuck in two different rooting media, sand and a 1:1 perlite and peat moss mixture. All cuttings were placed under an intermittent water mist. The water mist was supplied as an intermittent mist with a cycle of 9 seconds mist applied in each six minute period. The cuttings were sprayed by hand with various concentrations and combinations of nitrogen and sucrose solutions. The nitrogen and sucrose sprays were applied to the foliage of the cuttings at three and six day intervals.

The statistical analysis showed that root promoting substances and media were significant at the 1% level. Perlite and peat moss gave better root ratings than sand. Hormodin #3 and Rootone gave higher root ratings than the control, with Hormodin #3 being slightly better than Rootone. The spray treatments were not significant.

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