5-1966

A Review of Plant Propagation Methods

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A REVIEW OF PLANT PROPAGATION METHODS

by

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A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Horticulture

UTAH STATE UNIVERSITY
Logan, Utah

1966

ACKNOWLEDGEMENTS

I wish to express my deepest gratitude to Dr. L. H. Pollard, major professor, for his helpful suggestions, deep interest, whole hearted support, and timely advice given in this study.

Deep appreciation is also extended to committee members, Dr. A. R. Hamson and Dr. T. W. Daniel, for their helpful advice and assistance.

Special gratitude is expressed to my parents for their excellent support and encouragement, and special thanks go to all others who have helped in any way.

Somsong Aritajat

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INTRODUCTION

The purpose of this study was to consider how the rooting of cuttings may be affected by such methods and factors as: type of cutting, time of year when cuttings are best taken, differences between individual species, use of chemicals for the treatment of cuttings, rooting media, and the care of cuttings in the propagation beds.

In the past 35 years scientists have done considerable experimenting with the application of organic chemicals on the roots, stems and leaves of various plants. These organic chemicals have come to be known as "plant hormones" or "plant regulators." They have proved to be extremely useful and have affected the plants in rather unusual ways. Growth regulating chemicals are no longer on trial. They now are being used with several kinds of farm crops and ornamental plants.

Hormones or growth regulators are chemical substances, made in one part of an organism and transported to other parts where they produce their effects, and they are effective in very minute amounts. This paper will give the present status of knowledge on the use and effectiveness of growth regulators in plant propagation.

OBJECTIVES

This study had the following objectives:

1. To collect all important references on chemical treatments used in the propagation of ornamental plants.

2. Summarize the publications showing:

   (a) The effect of the different chemicals on ornamental plants

   (b) The most effective methods of chemical application

   (c) The best time of year fro propagating plant materials

   (d) The best time of year for collecting propagative materials as well as the recommended temperatures and rooting media.

CHEMICAL ABBREVIATION OR TRADE NAMES

IAA	Indoleacetic acid
IBA	Indolebutyric acid
NAA	Napthaleneacetic acid
NAD	Nephthalene-acetamide
GA	Gibberellic acid
TNA	4-thianaphtheneacetic acid
2,4,5-T	2,4,5-trichlorophenoxyacetic acid
2,4,5-TP	2,4,5-trichlorophenoxy alpha propionic acid
Hormodin No. 1	contain 1 mg./gm. of IBA
Hormodin No. 2	contain 2 mg./gm. of IBA
Hormodin No. 3	contain 8 mg./gm. of IBA
Hormo-Root C	contain 0.08 per cent IBA and 15 per cent thiram
Phygon XL	contain 50 per cent 2,3-dichloro-1,4 napthoquinone
Rainbow Rooting Powder Woody	contain 0.006 per cent 2,4,5-T and 0.012 per cent sodium-napthaleneacetate
Rainbow Rooting Semi Woody	contain 0.003 per cent 2,4,5-T and 0.006 per cent sodium-naphthaleneacetate
Rootone	naphthaleneacetic acid

REVIEW OF LITERATURE

History of Propagation

"The propagation of plants in a fundamental occupation of mankind. Civilization is largely based upon man's ability to propagate and grow specific kinds of plants which can be used for food and provide shelter, clothing, recreation, and aesthetic fulfillment." (66)

Naturally plants perpetuate their kind most frequently by seeds. Root sprouting, layering and suckering are other means of natural reproduction. However, since ancient times man has used cuttings and grafting to reproduce and improve certain desirable qualities found in individual plants. Under carefully controlled conditions quality plants are perpetuated and increased. Were it not for the efforts of commercial propagators such as the plant breeder, the bulb producer, the nurseryman, and seedman the new improved forms would not be available as they are today (173).

Early in the twentieth century considerable advancement was made in the raising and growing of all kinds of plants. New and better methods evolved in propagation especially of trees and shrubs. Much of this experimental work was carried on in such institutions as the Royal Botanic Gardens, Kew England and the Royal Botanic Garden Edinburgh, Scotland. The Boyce-Thompson Institute of Plant Research and the Federal Horticultural Board in America also conducted considerable research on vegetative propagation (143).

Much interesting and useful work was done at Kew since it was the leading botanic garden in the world and had an unrivalled collection of trees and shrubs. From a suggestion of Professor Balfour, the Propagation School at Edinburgh experimented to discover exactly at what time of year a typical garden species from every genus of tree and shrub growing in the garden would propagate most readily by vegetative means. The preliminary work for this study commenced about 1919 and was continued at Edinburgh by working through every natural family, grouping two or three together and taking every individual species of each genus in the particular family. This extensive investigation ranks as a valuable contribution to horticultural research and plant propagation (143).

Propagation Procedures Previous to the Application of Chemicals

Long before the isolation of auxins botanists tried to stimulate cuttings to root by the application of a variety of substances. Extra nutrients for growth was a common practice and the application of solutions of cane sugar produced considerable success. On the other hand, nitrate treatment prior to planting had the reverse effect (Knight as cited by Audus, 2). It was also found that better rooting could be obtained by inserting a germinating wheat grain in a slit made in a cutting, no doubt because of a stimulation by an auxin from the grain. Great care was taken in selecting the best types of cuttings at the right time and subjecting the cuttings to optimum conditions such as:

a. Adequate water supply to the whole cutting.

b. Adequate aeration of the base of the cutting.

c. Suitable diffuse lighting and maintenance of an optimum temperature.

A comprehensive survey of early work with these various stimulants will be found in the review by Pearse (Cited by Audus, 2).

History of Plant Growth Substances

German botanist, Sachs, as early as 1880, hit upon the idea that minute amounts of chemicals, moving polarly through the plant were responsible for differentiation of roots and flower parts (66) and that there was a specific rooting substance produced in the leaves (2).

The term hormone as applied to plants was first used by H. Fitting in 1910. Boysen-Jansen (as cited by Audus, 2) was the first to demonstrate hormone-like effects in plants. A Dutchman (von der Lek as cited by Audus, 2), published the first extensive investigation of the role of these internal factors in the rooting of cuttings. He suggested that hormones formed in the developing buds and were conducted in the bark to the base of the cutting, where, he thought they initiated rooting (2).

F. A. F. C. Went and his son, F. W. Went (as cited by Audus, 2), proved that a root-forming material, which they called "rhyzocaline" is formed by the leaves. Thimann and Went reported on the chemical nature of this hormone (76). This led Thimann and Koepfli (as cited by Audus, 2) to direct testing of synthetic IAA and a clear proof that the root-forming hormone was an auxin. That same year in the Boyce Thompson Institute in America workers demonstrated

that other synthetic substances, vix. phenylacetic acid, phenylpropionic acid, IPA, and NAA were effective in promoting rooting (Hitchcock, and Zimmerman and Wilcoxon, as cited by Audus, 2). Ausins as practical growth regulators were now truly launched (2).

Growth promoting compounds affect differently not only the quantity but also the quality of the roots they induce. Roots which rapidly become long with a strong fibrous root system results from IBA treatment. On the other hand the phenoxyacetic acids produce dense thick roots and a bushy and stunted root system. Appropriate mixture of these compounds induce roots with intermediate characteristics. In many cases a greater number of roots result from mixtures of IAA and NAA or of IBA and NAA in equal proportions, than from either compound alone at the same total concentration. By using appropriate mixtures of suitable synthetic auxins it is hoped that the precise size and structure of the induced root system can be regulated (2).

In addition to these well-established auxin, reports have been made on a considerable number of other organic compounds for stimulating root production in cuttings. These chemicals such as naphthaleneacetic acid, indolebutyric acid, and 2,4-dichlorophenoxyacetic acid have auxin activity but they have not been isolated from plant tissues (66). Norman and Weintraub (as cited by Audus, 2) give a long list of these chemicals. Some of these substances may augment the effective auxin levels, e.g. by acting as synergists. Indole is such a compound (van Roalte and Gorter, as cited by Audus, 2).

In the late seventeenth century it was recognized that plants had some kind of coordinating system for maintaining the proper balance of growth rates among the several organs. As early as 1907 the presence of a plant hormone in some plants was suggested and in 1930 a definite chemical substance was isolated and identified as a hormone. This hormone and other chemical substances were known as plant growth hormones and their main role was to control of the growth rate of various plant organs (2).

Pincus and Thimann (as cited by Audus, 2), in 1948, defined these growth regulating substances as phytohormone (plant hormone) and auxins. A phytohormone is "an organic substance produced naturally in higher plants, controlling growth or other physiological functions at a site remote from its place of production and, active in minute amounts." An auxin is "an organic substance which promotes growth (i.e. irreversible increase in volume) along the longitudinal axis, when applied in low concentrations to shoots of plants freed as far as practicable from their own inherent growth-promoting substances (145). Auxins may and generally do have other properties, but this one is critical." (66, 72). With increased knowledge of the subject, Yobuta and Sumiki (as cited by Audus, 2), in 1938 isolated new hormones called gibberellins. These compounds seems to greatly enhance stem elongation and accelerate seed germination in some plant species (2).

PROPAGATION OF DIFFERENT ORNAMENTALS

Abelia

Abelia grandiflora (André) Rehd. Softwood cuttings taken in early August rooted 100 per cent in 7 weeks without treatment and in 4 weeks after a treatment with IBA, 12.5 mg./l. for 24 hours. Rooting of July cuttings was also hastened by NAA, 1 mg./gm. talc and by Hormodin No. 1, even though the latter material retarded shoot growth (140).

Abies

Abies alba Mill., Silver Fir. Cuttings taken in January and made so that the base of the cuttings consisted of two-year-old wood showed 80 per cent rooting in sand when treated with 200 mg./l. for 24 hours. Cuttings made of younger or older wood rooted less well (44).

Abies concolor (Gord.) Engelm., Colorado Fir. Cuttings taken in early December failed to root without treatment, but they showed 50 per cent rooting after a treatment with IBA, 100 mg./l. for 20 hours, followed by Phygon XL-talc, 1:1 (140). In another instance, cuttings taken in late January rooted 76 per cent in eight months without treatment, and 100 per cent after a treatment with Hormodin No. 3.

Abies korena. Wils., Korean Fir. Cuttings taken in early November rooted 67 per cent with a treatment of IBA, 50 mg./l. for 20 hours, but only

7 per cent without treatment. In another instance, cuttings taken in January rooted 70 per cent when treated with IAA, 20 mg./l. for 24 hours and 25 per cent without treatment (44).

Abies Pinsapo Boiss., Spanish Fir. Rooting of cuttings taken in winter was improved by IBA, 40 to 80 mg./l. for 24 hours, or by 12 mg./gm. of talc (80).

Abies Veitchii Lindl. Cuttings taken in late December rooted 60 per cent with Hormodin No. 3. Rooting of winter cuttings has also been improved by IBA, 40 mg./l. for 24 hours, or 12 mg./gm. talc (80).

Acanthopanax

Acanthopanax Sieboldianus Mak. Cuttings taken in late June failed to root without treatment, but rooted 73 per cent in 27 days after a treatment with IBA, 20 mg./l. for 24 hours (78). Cuttings taken in August rooted 50 per cent without treatment and 80 per cent with IBA, 100 mg./l. for 20 hours (108).

Acer

Acer campestre, Hedge Maple. A wuick-dip was combined with rooting under intermittent mist. Treatment of cuttings taken in May, June and July with 100 mg./ml. and 20 mg./ml. of IBA initiated root development (20).

Acer ginnala. Cuttings taken from February to October rooted successfully with treatments of 10 mg./ml. and 20 mg./ml. of IBA plus intermittent mist treatment. Cuttings taken from April to July rooted prolifically

with treatments of 20 mg /ml. IBA (20).

Acer palmatum Thunb., Japanese Maple. Hardwood cuttings rooted well when treated with 1 per cent IBA in talc, and potted in a mixture of sand, peat and styrofoam. Specifications are given for a propagation bench covered with polyethylene film which reduces the work of watering and ventilating. No extra shade is needed from mid September to April 1 (18). In another instance, cuttings taken from April to July were rooted under mist after a treatment with 20 mg./ml. of IBA; May and June cuttings provided the best percentages (20). In another instance, cuttings of the variety atropurpureum (Vanh.) Schwer. rooted well when they were made in early summer from soft tips. These were wounded, treated with hormone powder containing 2 per cent IBA, inserted in a media of 90 to 95 per cent peat and 5 to 10 per cent corase sand, and kept under constant high humidity at a 70° F day temperature (165).

Acer platanoides, Norway Maple. Cuttings taken in May and June developed root initials under mist after being dipped in either a 10 mg./ml. or 20 mg./ml. IBA solutions (20).

Acer rubrum L., Red Maple. Cuttings treated with 20 mg./ml. of IBA and placed under mist; rooted best when taken during May, June, and July (20). In another instance, cuttings taken in late June and treated with IBA, 200 mg./l., for 6 hours, rooted well, whereas those taken about three weeks later did not root at all (126).

Acer saccharinum, Silver Maple. The best results were obtained from cuttings taken during April, May and June. A quick-dip was combined with

rooting under intermittent mist. Cuttings treated with 20 mg. of IBA/ml. gave the best results (20).

Acer saccharum Marsh., Sugar Maple. Cuttings taken in early June did not root when treated with Hormodin No. 2 or No. 3 but showed 57 per cent rooting with Hormodin No. 1. The untreated ucttings failed to root. Cuttings taken in mid-June failed to root when untreated, but rooted 46 per cent after an instant dip in IBA, 2.5 mg./ml. In another instance, a quick-dip was combined with intermittent mist. Rooting percentages with sugar maple cuttings after the hormone treatment were 90 per cent in June and 92 per cent in July; rooting was better with 20 mg. of IBA/ml. than with 10 mg./ml. (20).

Cuttings of sugar maple taken in late June or early July from twigs 4 to 6 inches long, and given an instantaneous dip in IBA, 0.1 per cent in 50 per cent alcohol showed 29 per cent rooting. All but two or three leaves were removed from the cuttings, with best results in constant mist in open beds in a greenhouse (46). In another instance, the most consistent rooting of cuttings of sugar mpale was obtained when they were taken in mid-June rather than in July and treated with IBA, 50 mg./l. for 3 hours. Cuttings made from twigs 4 inches long rooted better than those 6 inches long. Cuttings in an outdoor shaded bed rooted in two and one-half to three and one-half months (126).

Actinidia

Actinidia arguta Mig., Bower Actinidia. Cuttings taken in September rooted 86 per cent in sand in one month after being treated with IBA 5 mg./l.

for 24 hours, whereas only 42 per cent rooted without treatment (130).

Actinidia chinensis Planch. Cuttings taken in July rooted 100 per cent in sand-peat after a treatment with IAA, 100 mg./l. for 48 hours, and 60 per cent without treatment (115).

Allamanda

Allamanda cathartica. Stem cuttings showed 55 per cent rooting when treated with 100 ppm. IAA solution or 10,000 ppm. IAA dust and showed 30 per cent rooting when treated with 100 ppm. IAA solution. The controls did not root (117).

Amelanchier

Amelanchier, Shadbush. Softwood cuttings taken in summer rooted 25 per cent with IAA, 50 mg./l. for 24 hours, whereas they did not root as well without treatment (82). In another instance, softwood cuttings rooted readily if taken when the new growth was 3 to 6 inches long and kept in a mist propagating frame. Rooting was increased by the use of 0.3 to 0.8 per cent IBA in talc. Bottom heat (70^{o}F) extended the period when cuttings could be rooted (65).

Annona

Annona, Cherimoya. The basal 2 centimetres of cuttings are inserted through the holes of inverted 7-8 centimetres flower pots, and held in place by

moss packing. The pots were sunk 2 centimetres deep in moss litter in a tray, under which was located a thermostatically controlled low temperature heater. Cuttings were successfully rooted at 28-30°C. Both IBA and IAA hastened the rooting of the cuttings (99).

Arctosaphylos

Arctostaphylos Uva-ursi Spreng., Bearberry. Untreated cuttings taken at various times rooted as follows: October, 88 per cent in 22 weeks; November, 90 per cent in 18 weeks; and January, 86 per cent in 12 weeks. Rooting of October cuttings was hastened by using IBA, 3 mg./gm. talc, as 96 per cent rooted in 15 weeks (44).

About 90 per cent of the February cuttings rooted in 11 weeks, when terminal cuttings with three or more shoots on one branch were treated with IBA and planted in bottom heat at 76°F (30). Effective concentrations are IBA, 40 mg./l. for 24 hours, or 12 mg./gm. talc (80). Treated October cuttings rooted better when made from the basal parts of shoots rather than from the tips (69).

Aristolochia

Aristolochia durior Hill., Dutchman's pipe. Softwood cuttings are better for propagating than are hardwood cuttings (101). Summer cuttings rooted 40 per cent in sand-peat in 30 days after a treatment with IAA, 200 mg./l. for 24 hours (115).

Berberis

Berberis Julianae. Early January cuttings showed a high percentage of rooting. Root development was more rapidly after treatment with Hormodin No. 2 (140).

Berbis Sargentiana Schneid. Cuttings taken in early November rooted 100 per cent in 14 weeks without treatment, and IBA was of no benefit (140). In another instance, cuttings rooted 80 per cent in 51 days after a treatment with IBA, 50 mg./l. for 24 hours, while 60 per cent rooted with it (92).

Berberis Thungergii DC., Japanese barberry. Cuttings treated with 5-aminotetrazole or 1-phenyl-3-methylpyrazolene-5 at 100 and 200 mg./l. generally showed increased rooting percentage as well as an increase in the root and shoot growth (89). In another instance, cuttings were rooted in sand under normal, 18-hour and 24-hour photoperiods. Rooting was improved with extended daylengths and the use of IBA on softwood cuttings in active growth (111).

Berberis verruculosa. Rooting of July cuttings was hastened by IBA (108).

Betula

Betula lutea. Cuttings were dipped in Hormodin No. 3, and were set into perlite at a depth of one and one-half to two inches. Roots developed on 34 per cent of the cuttings, but fewer than 5 per cent of the rooted cuttings survived the winter, and even these died soon after breaking dormancy. The

failure was apparently not due to unfavorable temperature; which were kept at a fairly constant temperature of 32°F. at the root level (57).

Betula nana L. Cuttings taken in summer responded to a treatment with IAA, 50 mg./l. for 17 to 24 hours (93).

Betula nigra. Cuttings treated with 2 per cent IBA showed good rooting under mist (14).

Betula papyrifera Marsh., Canoe Birch. Cuttings treated with IBA, 20 mg./l. for 24 hours showed 50 per cent rooting (1).

Betula pendula Roth., European Birch. Cuttings rooted 24 per cent after a treatment with IAA, 50 mg./l. for 2-3 hours; while none of the cuttings rooted without treatment (82).

Betula populifolia March; Gray Birch. Currings taken in July, with the terminal bud removed, showed 30 per cent rooting after being treated with IBA, 50 mg./l. for 6 hours (1).

Bougainvillea

Bougainvillea. Sten and leaf cuttings were kept in 0.005 and 0.0005 per cent solutions of IAA, NAA, IBA, IAA + NAA, IAA + IBA and NAA + IBA for 7 days, at which stage callus formation was observed. They were then transferred to a water cultures for root development. After 14 days roots developed on the cuttings that had been treated with 0.005 per cent NAA, 0.0005 per cent IAA + IBA and 0.0005 per cent NAA + IBA. Shoots also appeared following all of the hormone treatments except IAA (107).

Brompton

Brompton. Rooting of cuttings was improved by treating with 50 mg./l. of IAA (28).

Buddleia

Buddleia alternifolia Maxim. Untreated cuttings taken in late June or early July and inserted in sand rooted 83 per cent. Treatments with IBA, 33 mg./l. for 24 hours (149), or with IBA, 50 mg./l. for 17 hours (93), hastened the rooting of June cuttings.

Buddleia Davidi Franch. Untreated cuttings taken in late June or early July and inserted in sand rooted 100 per cent. Treatments with IBA, 5 mg./l. for 24 hours, had a favorable effect upon the rooting of cuttings planted in sand in October (91).

Buxus

Buxus, Box. Currings treated with IBA in powder form, resulted in greater production of roots than NAA, and the dusting method of application was better than the immersion method (13). In another instance, rooting was improved on cuttings sprayed several weeks previously with an aquesous solution of 2,4,5-T at concentrations of from 10 to 100 mg/l. One g./l. of Na lauryl sulfate was used as a spreader (135).

Buxus microphylla Sieb. and Zucc. Rooting of July, October, and January (91) cuttings was hastened by a treatment with 20 mg./l. for 24

hours, or 12 mg./gm. talc (80).

Buxus sempervirens L. Common Box. Cuttings taken in late November rooted 89 per cent in 24 weeks without treatment, 96 per cent in 12 weeks after an instantaneous dip with 2,4-dichlorophenoxyacetic acid, 200 mg./l. (44). In another instance, rooting of July, October, and January (91) cuttings was hastened by a treatment with IBA, 40 mg./l. for 24 hours, or 12 mg./gm. talc (80). Fall cuttings rooted 96 per cent in 56 days with IBA, 60 or 80 mg./l. for 24 hours, and 24 per cent with water alone (142).

Buxus sempervirens var. Myrtilfolia. January cuttings rooted 39 per cent in 30 weeks without treatment, and 65 per cent in 25 weeks after a treatment with 2,4-dichlorophenoxyacetic acid, 200 mg./l. (44).

Buxus sempervirens var. suffruticosa. November cuttings rooted 48 per cent without treatment, 79 per cent with IBA 50 mg./l. for 23 hours, and 94 per cent with IBA followed by a dip in talc (44).

Callicarpa

Callicarpa Bodinieri Leol. Cuttings taken in late June rooted 100 per cent in 20 days after a treatment with IBA, 5 or 10 mg./l. for 24 hours (78).

Callicarpa dichotoma. K Koch, Purple Beautyberry. Untreated summer cuttings showed a high percentage of rooting in sand (174). Rooting of August cuttings was hastened by a treatment with IBA, 5 mg./l. for 24 hours (130). Hardwood cuttings taken in January rooted 100 per cent in sandy soil in two months without treatment and in one month after being treated with

IBA, 40 mg./l. for 18 hours (44).

Callicarpa japonica Thunb., Japanese Beautyberry. Untreated cuttings taken in early October and set in sand rooted 75 per cent. Rooting of cuttings was hastened by a treatment with IBA, 20 mg./l. for 24 hours (91). Tips of shoots gave better restuls (79) and responded more to treatments with low concentrations of IBA than cuttings made from basal parts of the plant (69).

Calluna

Calluna vulgaris Hull, Scotch heather. Cuttings taken in early December rooted 100 per cent in 72 days without treatment and 100 per cent in 46 days after a treatment with IBA, 40 mg./l. for 24 hours. Optimum concentrations for the treatment of cuttings are IBA, 20 to 40 mg./l. for 24 hours, and 12 mg./gm. talc (80).

Calycanthus

Calycanthus floridus L., Carolina Allspice. Cuttings taken in early July rooted 93 per cent in sand in 60 days after a treatment with Hormodin No. 2. Untreated cuttings rooted poorly (44).

Camellia

Camellia. Cuttings, taken when new growth is only moderately hard, with sand-peat as the rooting media are very easy to propagate (64). Live green sphagnum moss has proved a suitable rooting media for cuttings (56).

Cuttings treated with NAA talc dusts at about 1:1,000 has greatly accelerated rooting (171). In another instance, the application of a mixture of IAA and nicotinic acid (50 + 50 mg./l.) improved the rooting of cuttings that showed new growth in the winter but retarded rooting in cuttings with dormant buds. The treatment only affected the length and number of roots in cuttings taken from young plants (67).

Camellia japonica L. Semi-hardwood cuttings were made about 8 inches long and about 0.5 centimetre thick. The best results were obtained with all treatments during the rainy months of June to September, and by dipping in Hortomone A solution plus pre-callusing. The highest percentage of rooting, 80 per cent, was obtained in August (43). In another instance, accelerated rooting as a high percentage of rooting was obtained when cuttings were taken in October and November and treated with 60 and 80 ppm. IBA solution for 24 hours (95). Cuttings rooted readily after a treatment with IBA, 4 to 10 mg./ml., applied by the concentrated solution-dip method (70), or IBA, 40 to 80 mg./l. for 24 hours, or IBA, 12 mg./gm. talc (80). July cuttings rooted 100 per cent in 10 weeks after a treatment with IBA, 100 mg./l. for 24 hours (140).

Camellia japonica L. var. alba plena. Hardwood cuttings 10 centimeters long showed the best results after 8 months in sand in a cold frame when the cuttings were treated with 100 mg. IBA per 100 liters distilled water and with Vigortone powder. These treatments resulted in 85 and 60 per cent rooting, respectively, as compared to 50 per cent for the controls. The treated cuttings also had better root and shoot growth (31).

Caragana

Caragana arborescens Lam., peatree. Cuttings rooted more than 80 per cent in sand when taken in late July (137). IBA or NAA treatments given cuttings caused injury or retarded shoot growth (140). In another instance, softwood cuttings attained maximum rooting after a treatment with Rootone under intermittent mist and bottom heat (24).

Caragana boisii Schneid. Cuttings treated with all treatments-IBA, 10 mg./l., for 24 hours, 2 to 5 mg./gm. of talc, the concentrated solution-dip method, or 4 mg./ml., were equally effective in the rootings of cuttings (70).

Caragana frutex K. Koch, Russian Peatree. The rooting of cuttings taken in early November was improved or hastened by IBA, 20 mg./l. for 24 houts (91).

Carya

Carya Pecan var. Posey, Pecan. Hardwood cuttings made of wood two to four years old, were taken in early April, allowed to callus in moist sphagnum at 68°F. to 78°F. for about three weeks, then treated with IBA, 100 mg./l. for 24 hours, and set in sand at 70° F. with bottom heat. Large cuttings, one-half inch in diameter, rooted 63 per cent after such treatment but smaller cuttings did not root as well. All of the untreated cuttings, large or small, failed to root (70).

Caryopteris

Caryopteris incana (Thunb) Miq., Blue-beard. The rooting of cuttings set in sand in October was improved by IBA, 10 mg./l. for 24 hours. Cuttings taken late April and set in sand-pear rooted well without treatment, but they rooted better with IBA, 20 mg./l. for 24 hours (91).

Ceanothus

Ceanothus Delilianus Spach. Cuttings taken in July rooted 100 per cent in 30 days after treatment with IAA, 100 mg./l. for 24 hours (115). Rooting of fall cuttings was hastened by a treatment with 20 mg./l. for 24 hours (148).

Ceanothus ovatus Desf. Cuttings taken in early October and inserted in sand gave a higher percentage of rooting after a treatment with IBA, 10 mg./l. for 24 hours, than cuttings that were not treated (91).

Celastrus

Celastrus orbiculata Thunb., Oriental Bittersweet. Harwood cuttings taken in April produced more roots after a treatment with IBA, 40 mg./l. for 24 hours. There was even more benefit from treatment with NAA (69). Equivalent concentrations of IBA for treating hardwood cuttings of this species are 40 mg./l. for 24 hours, 2 mg./gm. talc, or by the concentrated solution-dip method, 1 to 4 mg./ml. (70).

Celastrus scandens L., Waxwork or American Bittersweet. Cuttings taken in July rooted 90 per cent in 70 days without treatment, and 90 per cent in half that time after a treatment with IBA, 50 mg./l. for 20 hours (174). There was 100 per cent rooting of cuttings in 50 days, by treating with IBA, 30 mg./l. for 6 hours (108). Cuttings taken in early October rooted 40 per cent in sand-peat without treatment, 74 per cent after a treatment with NAA, 50 mg./l. for 21 hours, and 100 per cent in 53 days after a treatment with NAA, 50 mg./l. and potassium nitrate, 20 mg./l. for 21 hours. Cuttings that received potassium nitrate had the best root development (44).

Cephalanthus

Cephalanthus occidentalis L., Buttonbush. Softwood cuttings taken in late July and early August rooted 100 per cent in sand-peat in one month without treatment. There was no beneficial effect of treating the cuttings with IBA (44).

Cephalotaxus

Cephalotaxus drupacea Sieb. and Zucc. Japanese plum-yew. Cuttings taken in November and inserted in sand rooted 100 per cent in 67 days after a treatment with IBA, 60 mg./l. for 24 hours, whereas only 24 per cent rooted without treatment (142).

Cephalotaxus harringtonia drupacea. Tip cuttings taken in June were rooted under intermittent mist in coarse sand in the greenhouse. Three growth

substance treatments were compared. The best rooting (100 per cent very heavily rooted) was obtained with Rainbow Rooting Powder Woody. The second best rooting (66 per cent heavily rooted) was obtained from the untreated controls. Rainbow Rooting Powder Semi-woody gave 40 per cent roots, and Hormo-Root C gave only 6 per cent very light rooting, possibly owing to toxicity (52).

Chaenomeles

Chaenomeles japonica (Thunb.) Lindl. Cuttings taken in mid-July rooted 64 per cent in 38 days after a treatment with NAA, 1 mg./gm. talc. There was no rooting of untreated cutting (140).

Chaenomeles lagenaria (Loisel.) Koidz., Japan Quince. Softwood cuttings taken in early June, rooted at least 90 per cent in sand in four weeks after a treatment with IBA, 12.5 mg./l. for 24 hours, while not more than 30 per cent rooted without treatment. Cuttings taken in late June rooted 24 per cent in 44 days without treatment and 78 per cent in 21 days with Hormodin No. 2. Such cuttings have also responded to a treatment with NAA, 50 mg./l. for 17 to 24 hours (93). High humidity is also desirable. Softwood cuttings treated with IBA, 1:250, in talc, rooted 95 per cent in 29 days (131).

Chamaecyparis

Chamaecyparis Lawsoniana Fletcheri. Rooting of cuttings was improved by treating with IBA 40 to 80 mg./l. for 24 hours, or 12 mg./gm. talc (80).

Chamaecyparis obtusa (Sieb. and Zucc.) Endl., Hinoki Cypress. Cuttings of this species or of its varieties compacta, filicoides, gracilis, lycopodioides, magnifica, nana were taken 11 times between late September and late January. The average rooting of untreated cuttings was 41 per cent. The average rooting of cuttings treated with IBA, 50 or 100 mg./l. for 18 to 24 hours, or with Hormodin No. 3, was 96 per cent. Cuttings treated with IBA, 50 mg./l. for 18 hours, rooted 100 per cent in 5 months and cuttings totally immersed in that solution for 18 hours rooted 100 per cent in two and one-half months. Rooting was more improved by IBA, 100 mg./l. for 18 hours, followed by powder-dip treatment with Orthocide-talc 1:15 than by the IBA treatment alone. Treatment with NAA was less effective than a treatment with IBA (55).

Chamaecyparis pisifera (Sieb. and Zucc.) Endl., Sawara Cypress. Cuttings of the varieties filifera and squarrosa taken in late November rooted 90 to 100 per cent after a treatment with IBA, 75 mg./l. for 24 hours. From 45 to 63 per cent of the cuttings rooted without treatment but development was not as rapid. This treatment hastened the rooting of October cuttings of the variety plumosa by seven weeks and the rooting of December cuttings was hastened by Hormodin No. 3. Early November cuttings of the variety minima, in sand-peat, rooted 55 per cent without treatment, and 91 per cent after a treatment with monobasic potassium phosphate, 1.0 per cent for 19 hours. Cuttings of the variety plumosa taken in mid-April was markedly improved by IBA, 40 mg./l. for 24 hours (91). Effective treatments for cuttings of this varieties were IBA, 40 to 80 mg.,l. for 24 hours, or 12 mg./gm. talc (80).

Chamaecyparis plumosa aurea Cuttings rooted well in sand when taken in October and November and treated with IBA solution at concentrations of 60 and 80 ppm. of water for 24 hours (95).

Chamaecyparis thyoides (L.) B. S. P., White Cedar. Cuttings taken in mid-November and treated with IBA, 125 mg./l. for 24 hours, rooted 96 per cent in sand-peat in six months. Results were not so good with lower concentrations, and only 33 per cent of the untreated cuttings rooted. Cuttings taken in mid-December and set in a sand-peat media rooted 14 per cent without treatment, and 70 per cent with Hormodin No. 3. The IBA at 75 mg./l. for 20 hours was not too effective (157).

Chionanthus

Chionanthus retusus Lindl. and Paxt., Fringe-Tree. Cuttings taken in early June showed 72 per cent rooting when treated with IBA in talc, 1:250, and inserted in 1:1 mixture of sand and mica insulation, in a greenhouse humidified by means of a centrifugal atomizer. There was almost no rooting of untreated cuttings (132).

Cinnamonum

Cinnanonum. Cuttings were successfully rooted at 28-30° C when the basal 2 centimeters of the cuttings were inserted through the holes of inverted 7-8 centimeters flower pots, and held in place by moss packing. The pots were sunk 2 centimeters, deep in moss litter in a tray, under which was placed a thermostatically controlled low temperature heater. To speed up

rooting IBA or IAA was applied to the cuttings (99).

Clematis

Clematis montana DC. Cuttings taken in the summer responded to a treatment with IBA, 50 mg./l. for 17 hours (93). A treatment with IAA, 100 mg./l. for 18 hours, hastened the rooting of cuttings of C. montana rubens (44).

Clematis paniculata Thunb. The rooting of cuttings taken in late July or in mid-October and set in sand was improved by a treatment with IBA, 100 mg./l. for 24 hours (91).

Clematis vedrariensis Vilm. Rooting of June cuttings was improved or hastened by IBA, 33 mg./l. for 24 hours (44). Cuttings of the variety Ramona taken in mid-July rooted 67 per cent without treatment, and rooting was slightly hastened by IBA, 50 mg./l. for 22 hours.

Clethra

Clethra alnifolia L., Sweet Pepperbush. Summer cuttings root readily in sand-peat, and not as well in sand without treatment (83). Cuttings taken in late June rooted 100 per cent in 20 days after a treatment with IBA, 10 mg., /l. for 24 hours (78).

Clethra barbinervis Sieb. and Zucc. Cuttings taken in mid-June rooted 36 per cent without treatment, 47 per cent with IBA, 25 mg./l. for 11 hours, and 74 per cent with IBA, 25 mg., and Phygon XL, 0.3 gm./l. for 17 hours (41).

Cocculus

Cocculus laurifolius. Cuttings rooted best in the spring and summer. Rooting of autumn cuttings was improved with IBA. Subterminal cuttings were better than terminal ones (34). In another instance, subterminal cuttings taken from the lower part of the plant and treated with 1,000 ppm. IBA gave the highest percentage of rooting (109).

Codiaeum

Codiaeum. Cuttings were successfully rooted at 28-30° C. The basal 2 centimeters of cuttings were inserted through the holes of inverted 7-8 centimeter flower pots and held in place by moss packing. The pots were sunk 2 centimeters deep in moss litter in a tray, under which was arranged a thermostatically controlled low temperature heater. Treatment with IBA or IAA was found to speed up rooting (99).

Coleus

Coleus blumei. Cuttings rooted more satisfactorily after being soaked for 22 hours in 1-naphthoic acid or 6-quinolinecarboxylic acid. Maximum root stimulation was obtained at 100 ppm. 1-naphthoic acid and 1,000 ppm. 6-quinolinecarboxylic acid (12).

Colutea

Colutea media Willd. Cutings taken in early November rooted 29 per cent without treatment, but failed to respond to NAA. Treatment with IBA, 100 mg./l. for 18 hours resulted in 73 per cent rooting (44).

Coriaria

Coriaria L. Early June cuttings rooted about 57 per cent without treatment and 85 per cent in sand after a treatment with NAA, 1:1,000 in talc (129).

Cornus

Cornus alba L. Tatarian dogwood. Cuttings taken in late June rooted 80 per cent in 30 days after treatment with IBA, 50 mg./l. for 24 hours, whereas none often cuttings rooted without treatment (78). It was found that cuttings treated with 5-aminotetrazole or 1-phenyl-3-methylpyriazolone-5- at 100 and 200 mg./l. generally showed an increase in the rooting percentage as well as root and shoot growth (89). Cuttings of C. alba Gouchaltii treated with captan before storage also increased the rooting percentage (153). The rooting of cuttings of C. alba elegantissima was improved by a treatment with 50 mg. of IBA/l. (28).

Cornus Amomum Mill., Silky Dogwood. Cuttings taken in July rooted well without treatment, although there were more roots per cutting after a treatment with IBA, 30 mg./l. for 20 hours (174).

Cornus florida L. Flowering Dogwood. Cuttings taken in early June rooted 47 per cent in sand and 64 per cent in sandy soil without treatment. On the other hand 73 per cent rooted in sand, and 95 per cent in sandy soil in 34 days after a treatment with IBA, 12.5 mg./l. for 24 hours. Other effective concentrations were IBA, 10 mg./l. for 24 hours (78), and 5 mg./gm. talc (70). Cuttings treated with IBA, 1:250 in talc, rooted 93 per cent under humidification (105).

Wounding cuttings taken in early June from the current season's growth followed by a treatment with 20 mg. of IBA in g. of talc resulted in 100 per cent rooting. Unwounded cuttings and treatment with lower rates of IBA or a mixture of IBA + IAA + NAA gave less satisfactory rooting (8). Greenwood tip cuttings taken in May rooted under intermittent mist. Cuttings were soaked for 24 hours in 170 ppm. in sucrose solution, which was combined with NAA powder before insertion in the rooting media. The sucrose treatment improved rooting in the mixture of 60 per cent Perlite No. 8 + 40 per cent peat, and 60 per cent Perlite No. 8 + 40 per cent Perlite No. 30 (33).

Rooting of cuttings of flowering dogwood may also be improved by treatment with a fungicide. Cuttings taken in early June rooted 35 per cent without treatment, and 77 per cent after a treatment with Phygon XL-talc 1:4 (41). Cuttings taken in mid-June rooted as follows: untreated, 40 per cent in 93 days; with IBA, 12.5 mg./l. for 24 hours, 83 per cent in 93 days; with IBA, 12.5 mg./l., and Phygon XL, 0.3 gm./l. for 24 hours, 100 per cent in 40 days (44).

Cornus florida rubra. Cuttings were taken from 15-year-old trees. Cuttings, 6 inches long, were made with a straight basal cut below a node, and a thin strip of wood was removed from each side of the base. Cuttings taken in April to June rooted 100 per cent when dipped in 20,000 ppm. IBA, and set in sand in a greenhouse bench under intermittent mist (50).

Cornus Kousa Hance. Untreated cuttings taken in early July rooted 20 per cent in sand and 53 per cent in sandy soil. Similar cuttings treated with IBA, 25 mg./l. for 24 hours, rooted 62 per cent in sand, and 82 per cent in sandy soil in eight weeks. Cuttings taken in September responded to a treatment with IBA, 50 mg./l. for 17 to 24 hours (137). Tips of shoots made good cuttings (143).

Cornus mas L. Cornelian Cherry Dogwood. Untreated cuttings taken in July rooted only 25 per cent in either rooting media but similar cuttings after a treatment with IBA, 25 mg./l. for 24 hours, rooted 100 per cent in sandy soil, and only 25 per cent in sand.

Cornus racemosa Lam., Gray Dogwood. Cuttings taken in mid-July rooted 100 per cent in sand in 37 days after a treatment with NAA, 1 mg./gm. talc, and only 8 per cent without treatment (140). Cuttings rooted 66 per cent after a treatment with IBA, 80 mg./l. for 4 hours, and much less without treatment (174).

Cornus sanguinea L., Red Dogwood. Cuttings taken in late June rooted 44 per cent without treatment, and 68 per cent in three weeks after a treatment with IBA, 30 mg./l. for 12 hours (108).

Corylopsis

Corylopsis Willmottiae Rehd. and Wils. Cuttings taken in summer and treated with IBA, 17 mg./l. for 24 hours, rooted much better than untreated cuttings (148).

Corylus

Corylus Avellana L., European Hazel. Softwood cuttings taken in summer failed to root without treatment and rooted 22 per cent after a treatment with IAA, 100 mg./l. for 24 hours (82). Cuttings taken in mid-June responded to a treatment with IBA, 5 mg./gm. talc (70).

Corylus maxima Bill., Filbert. Cuttings taken in mid-July failed to root without treatment, but rooted 52 per cent in sand after being treated with IBA 4 mg./gm. talc or Hormodin No. 2 (139).

Softwood cuttings of the Corylus hybrid ?mildredensis" rooted 75 per cent in 50 days after a treatment with IBA, 1:250, in talc (131).

Cotinus

Cotinus Coggygria purpureus. Softwood cuttings have responded to a treatment with IBA, 50 mg./l. for 17 to 24 hours (93). Cuttings of this variety taken in mid-June did not root without treatment, but cuttings treated with Hormodin No. 3 and covered with a polyethylene film rooted well (18).

Cotoneaster

Cotoneaster B. Ehrh. The rooting of cuttings was improved by Phygon when applied undiluted or variously diluted with talc or IBA powder, or with water. Conjunction with IBA and in a few cases with NAA, the percentage of rooting was generally greater than when the root-inducing substances were used alone (41).

Cotoneaster adpressa, Creeping Cotoneaster. Cuttings taken in late December rooted 50 per cent without treatment, and 72 per cent with IBA, 100 mg./l. for 19 hours (44).

Cotonester apiculata, Cranberry. Cuttings taken in mid-August rooted 29 per cent in 133 days without treatment. No improvement was shown with Hormodin No. 2, but they rooted 70 per cent after a treatment with a mixture, 5:1, of Hormodin No. 3 and Phygon XL (44).

Cotoneaster Henryana (Schneid). Rehd. and Wils. December cuttings set in sand-peat, rooted 48 per cent without treatment, and 100 per cent in four weeks after a treatment with IBA, 100 mg./l. for 20 hours.

Cotoneaster horizontalis, Rock. Cuttings taken in early August rooted 61 per cent without treatment and 73 per cent after a treatment with IBA, 50 mg./l. for 16 hours (174).

Cryptomeria

Cryptomeria japonica (L. f) D Don., Sugi. Cuttings treated with NAA under 10, 25 and 50 per cent light intensities gave the best rooting (94). Sodium

alpha naphthaleneacetate is more effective for promoting rooting and saccharose solution is more effective than is potassium permanganate solution as a pre-treatment (175). In another instance, small green-shoot cuttings were treated with potassium-beta-indoleacetate in a concentration of 0.04, 0.12 and 0.2 per cent. The highest amount of rooting was about 65 per cent (15). Effective treatments for cuttings taken in December were IBA, 40 to 80 mg./l. for 24 hours, or 4 to 10 mg./ml. by the concentrated solution-dip method (40), 0r 12 mg./ gm. talc (80).

Cryptomeria japonica var. Bandai-Sugi. Cuttings gave 80 per cent rooting after dipping in 25 mg./l. NAA (26).

Cryptomeria japonica var. Jindai-Sugi. Cuttings gave 70 per cent rooting after a treatment with 25 mg. of IBA/l. (26).

Cryptomeria japonica var. Ryowa-Sugi. A 0.1-0.5 per cent solution of KM_nO_4 was effective in improving the rooting percentage and amount of roots regenerated (98).

Cupressus

Cupressus macrocarpa Gord., Monterey Cypress. Cuttings responded to a treatment with IBA, 40 to 80 mg./l. (80).

Cydonia

Cydonia oblonga Mill., Quince. Softwood cuttings taken while still growing in the spring, rooted well after a treatment with IBA, 20 mg./l. for

24 hours (103).

Cyrilla

Cyrilla racemiflora L., Leatherwood. Softwood cuttings should be taken while the plant is still actively growing, and it is important that a high relative humidity be maintained. Untreated softwood cuttings rooted more than 50 per cent in eight weeks, but their rooting was hastened or improved by IBA, 1 mg./gm. talc (134).

Cytisus

Cytisus. Cuttings of a hybrid taken in late October rooted 69 per cent without treatment, and rooted 100 per cent after a treatment with IBA, 75 mg./l. for 20 hours. Rooting was also improved by IAA, 40 mg./l. for 20 hours (68).

Cytisus scoparius (L.) Lk., Scotch brown, cuttings responded to a treatment with IAA, 50 mg./l. for 17 to 24 hours (93).

Daphne

Daphne Burkwoodii Burkwood var. Somerset. Cuttings taken in the summer were made from half mature side shoots and included a heel (119). Hormodin No. 2 improved rooting of August cuttings.

Daphne Cneorum L., Rose Daphne. December cuttings failed to root without treatment, but rooted 56 per cent after a treatment with IAA, 100 mg./l. for 16 hours (29). Cuttings taken in mid-November rooted 64 per cent

without treatment or with IBA, 50 mg./l. for 22 hours, but they rooted 86 per cent when that treatment was followed by powder-dip treatment with Phygon XL. Rooting of cuttings taken in September was at least hastened by IBA, 50 mg./l. for 5 hours. In nine weeks, there was 66 per cent rooting of the treated cuttings, and 40 per cent rooting of the untreated. July cuttings rooted 74 per cent without treatment, and 93 per cent with Hormodin No. 1 (44).

Daphne Laureola L., Spurge Laurel. November cuttings rooted 100 per cent in 12 weeks after a treatment with IAA, 50 mg./l. for 24 hours (152).

Daphne odora Thunb., Winter. Cuttings taken in the fall rooted 14 per cent without treatment, but 80 per cent in six weeks after a treatment with IAA, 100 mg./l. for 18 hours (35).

Davidia

Davidia involucrata Baill., Dove-tree. Leaf-bud cuttings of half-ripened wood taken in September consisted of the basal half of one leaf with the auxillary bud and a small piece of the stem. Cuttings were treated with Hormodin No. 2 and set in coarse sand, shaded, and frequently syringed. There was 85 per cent rooting of cuttings in five weeks (44).

Deutzia

Deutzia magnifica (Lemoine) Rehd. and D. scaba Thunb. Cuttings taken in late June rooted 89 per cent or more in five weeks after a treatment with Hormodin No. 1. They rooted more slowly without treatment (91).

Deutzia scabra Thunb. Rooting of July cuttings was at least hastened by NAA or IBA, 1 mg./gm. talc; NAA giving the better results (59). Hardwood cuttings taken in January developed more roots per cutting after a treatment with NAA, 60 mg./l. for 24 hours. There was similar, although less, response to IBA (69).

Diervilla

Diervilla Lonicera Mill. Rooting of cuttings taken in late October was improved by a treatment with IBA, 20 mg./l. for 24 hours (91).

Dipelta

Dipelta floribunda Maxim. Cuttings taken in early summer responded to a treatment with NAA, 50 mg./l. for 17 hours (93).

Elaeagnus

Elaeagnus angustifolia L., Oleaster. Rooting of cuttings taken in mid-October was improved by a treatment with IBA, 40 mg./l. for 24 hours. There was no rooting of untreated cuttings (91).

Elaeagnus pungens Thunb., Thorny Elaeagnus. Cuttings were rooted in sand under normal, 18 hour, and 24 hour photoperiods. Rooting was improved under the extended day lengths and use of IBA and by using softwood cuttings in active growth (111). Cuttings taken in October rooted 72 per cent in sand without treatment, and 100 per cent when treated with IBA,

30 mg./l. for 4 hours (174). Cuttings taken in January rooted 30 per cent without treatment, but 75 per cent with IBA, 40 mg./l. for 6 hours (159).

Enkianthus

Enkianthus campanulatus. Cuttings taken in early June rooted 83 per cent in ten weeks without treatment, and 100 per cent in six weeks after a treatment with IBA, 50 mg./l. for 20 hours (44).

Epigaea

Epigaea repens L., Mayflower. Untreated cuttings taken in late August rooted 94 per cent in sand-peat in five weeks. The rooting of cuttings taken in October was hastened by treating with NAA, 50 mg./l. for 24 hours (149).

Erica

Erica carnea var. Vivelli. Cuttings treated with 2 per cent IBA gave 93 per cent rooting while untreated cuttings showed 87 per cent rooting in a greenhouse (26).

Erica Tetralix L., Cross-leafed Heath. Untreated cuttings taken in late June rooted 93 per cent in eight weeks. They rooted less well when taken in August. Rooting was improved or hastened by treating with IBA 40 mg./l. for 24 hours or 12 mg./gm. talc (80).

Euonymus

Euonymus alata, Winged Evonymus. Hardwood cuttings taken in early April and immediately set in the field rooted 100 per cent in four months with a treatment of IBA, 5 to 10 mg./l. for 24 hours (44).

Euonymus japonica, Evergreen euonymus. Rooting of cuttings taken in late March was improved by a treatment with IBA, 10 mg./l. for 24 hours (91).

Euonymus Fortunei (Turcz.) Hand.-Mazz. var. colorata and minima. Cuttings taken in mid-August rooted more than 90 per cent in five weeks without treatment. Rooting was hastened by treating with IBA, 2 mg./gm. talc or 1 to 5 mg./gm. talc (44).

Euonymus Fortunei minima. Cuttings taken in early December rooted 57 per cent without treatment, but 100 per cent rooted after a treatment with Semesan, 1:400, in water. Rooting of cuttings has been hastened by treating with IBA, 1 to 5 mg./gm. (44).

Euonymus kiautschovica. Rooting of cuttings was improved by treating with IBA, 5 to 10 mg./l. for 24 hours.

Euphorbia

Euphorbia fulgens. Cuttings, rooted well when treated with 0.5 per cent or 2 per cent IBA and kept under an intermittent mist (44).

Exochorda

Exochorda racemosa (Lindl.) Rehd., Pearl-bush. Softwood cuttings taken in June or July will root without treatment, although usually not in large percentages (6, 206). Cuttings taken in July responded to a treatment with IAA, 50 mg./l. for 17 to 24 hours (93). Untreated July cuttings did not root in sand but rooted 40 per cent in a sphagnum peat media (83).

Fagus

Fagus sylvatica L., European Beech. This plant has been propagated by softwood cuttings taken when the last one to two leaves on the twig were beginning to develop (63). They responded to a treatment with IAA, 200 mg./l. for 24 hours showing 50 per cent rooting in sand-peat in 37 days (115).

Feijoa

Feijoa. Sub-terminal cuttings taken from the lower part of the plant and treated with 1,000 ppm. IBA have given the highest percentage of rooting (109).

Feijoa Selloqiana. Cuttings from the lower position of the plant rooted better than those from the upper part of the plant. Cuttings treated with 8,000 ppm. IBA have given the highest per cent of rooting (34).

Ficus

Ficus elastica. The percentage of rooting was improved and the time required for root development was reduced when the cuttings were treated with NAA dust 2,000 ppm. (142).

Ficus mysorensis. One year cuttings gave the best results when taken in March. Soaking the bases of cuttings in IBA at 100 and 200 ppm. for p2 hours gave maximum rooting. The response to NAA was essentially similar (49).

Fontanesia

Fontanesia Fortunei Carr. Untreated cuttings taken in mid-July rooted 100 per cent in sand in eight weeks. Cuttings taken in late June rooted 53 per cent in three weeks after a treatment with IBA, 5 mg./l. for 24 hours. Rooting was not as satisfactory greater concentrations (78). Rooting of cuttings taken in October was improved by a treatment with IBA, 20 mg./l. for 24 hours (91).

Forsythia

Forsythia var. Spring Glory. Softwood cutting taken throughout the season and soaked for 24 hours in GA in solution or in talc at 40 ppm. GA in talc had little effect at any concentration. The solution markedly inhibited the rooting of cuttings.

Forsythia intermedia. The rooting of cuttings taken in October was improved or hastened by treating with IBA, 10 mg./l. for 24 hours (91).

Cuttings taken in late June showed good rooting when treated with IBA 5 mg./l. for 24 hours (78).

Forsythia suspensa (Thunb.) Vahl. The rooting of cuttings taken in late June was hastened by a treatment with IBA, 50 mg./l. for 6 hours (108).

Fothergilla

Fothergilla Gardeni Murr. July cuttings set in sand-peat rooted 67 per cent without treatment, and 100 per cent in 43 days after a treatment with IAA, 200 mg./l. for 24 hours (115). July cuttings also responded to a treatment with IBA, 50 mg./l. for 17 to 24 hours (93).

Franklinia

Franklinia alatamaha Marsh., Franklinia. August cuttings rooted 83 per cent in sand in 29 days treating with IBA, 30 mg./l. for 24 hours, and equally well but more slowly without treatment (174).

Cuttings taken in early November rooted 93 per cent in 64 days after a treatment with IBA, 50 mg./l. for 24 hours, and 67 per cent without treatment. Rooted cuttings taken in November made more top growth than those taken in August. Cuttings taken in mid-December rooted 60 per cent without treatment in nine weeks and 100 per cent after a treatment with IBA, 50 mg./l. for 24 hours (44). Cuttings taken in October failed to root without treatment, but rooted 78 per cent after a powder-dip treatment with Phygon XL Hormodin No. 3, 1:4 (41).

Gardenia

Gardenia. Cuttings responded to a treatment with IBA, 40 mg./l. for 24 hours, or 2 mg./gm talc (80). Cuttings taken from greenhouse plants in late November showed 90 per cent rooting with or without treatment with IBA. The treatment appeared slightly hastened rooting. On the other hand cuttings taken in April rooted 56 per cent without treatment, and 88 per cent in 53 days after a treatment with IBA (44).

Genista

Genista. Cuttings taken in late November rooted 52 per cent in 94 days without treatment, and 93 per cent in 30 days after treating with IBA, 50 mg./l. for 23 hours (44).

Ginkgo

Ginkgo biloba L., Maidenhair-tree. Cuttings made from the basal half of the new growth gave a larger per cent and more rapid rooting after treating with IBA, 50 mg./l. for 23 hours, or with Hormodin No. 3 than untreated cuttings. Similar cuttings, whether or not treated with IBA, rooted less well when taken in late July rather than in mid-June (42). Untreated cuttings taken in early summer rooted 48 per cent in sand at 85 to 90 per cent relative humidity, and 44 per cent, at 65 to 70 per cent relative humidity (11). Such cuttings rooted 96 per cent in sand in 36 days after treating with IBA, 50 mg./l. for 24 hours, but untreated cuttings rooted almost as well (174).

In another instance, shoots, about 10 inches long, growing on a 10-year-old tree were cutoff close to the base at the end of June. The soft tips were removed, thus leaving semi-hardwood cuttings about 5-6 inches long. The bases of these were dusted with Auxan and were inserted about 3 inches deep into a mixture of two-thirds sharp sand and one-third peat moss in a cold frame without bottom heat. The cuttings showed 100 per cent rooting within 3 weeks. The softer tips treated in the same manner died (144). The rooting of male Ginkgo cuttings taken in July showed the best rooting with Hormodin No. 3. The type of tree appeared to affect the rooting ability (155).

Halesia

Halesia, Silverbell-tree. Cuttings of H. carolina and H. monticola (Rehd.) Sarg. taken in July rooted showed no more than 40 per cent rooting without treatment, whereas they rooted 80 per cent in sandy soil in six weeks after a treatment with IBA, 25 mg./l. for 20 hours. Both treated and untreated cuttings rooted better in sandy soil than in sand (36).

Hamamelis

Hamamelis mollis Oliv. Cuttings taken in mid-July rooted 59 per cent in sandy soil and less well in sand without treatment. Those treated with IBA, 50 mg./l. for 20 hours, rooted 73 per cent in sandy soil. In another year, cuttings of that same species taken in late July rooted 100 per cent in sand-peat in eight weeks after a treatment with IBA, 50 mg./l. for 22 hours. With

humidification, softwood cuttings rooted 60 per cent in 66 days after treatment with IBA, 1:1,00, in talc (131).

Hibiscus

Hibiscus rosasinensis L., Chinese Hibiscus. Dipping semi-hardwood cuttings for 5 seconds in a solution containing 6,000 ppm. of IBA or NAA gave over 90 per cent rooting as compared to 10 per cent in untreated cuttings (116). Softwood cuttings rooted 70 per cent after a treatment with 25 ppm. IBA soak and 2,000 ppm. IBA quick dip. They rooted 75 per cent with 1,000 ppm. NAA dust treatment (117). Cuttings of one year's growth rooted 85 to 95 per cent after a treatment with the NAA soak method (118).

Hibiscus syriacus L., Shrubby Althaea. Softwood cuttings taken in July and set in sand rooted 65 per cent without treatment, but 96 per cent in 57 days after treating with Hormodin No. 3 (44). In another instance, July cuttings rooted 52 per cent without treatment, but 100 per cent in 36 days after treating with IBA, 50 mg./l. for 6 hours (108). Cuttings taken from October to February showed improved rooting when treated with IBA, 40 to 60 mg./l. for 24 hours, or 4 to 10 mg./ml. applied by the concentrated solution-dip method, or 2 to 12 mg./gm.talc (69).

Hydrangea

Hydrangea macrophylla (Thunb.) DC., Bigleaf Hydrangea. Rooting of cuttings taken in June was hastened by IBA, 10 mg./l. for 24 hours (91).

Hydrangea paniculata. Rooting of cuttings was hastened by IBA, 20 mg./l. for 24 hours (115).

Hydrangea petiolaris, Climbing Hydrangea. Cuttings made from terminal shoots of new growth are best taken in late spring or early summer before the stems turn brown (85). Cuttings taken in early July and treated with Hormodin No. 3 rooted 35 per cent in sand in 78 days (140).

Hydrangea quercifolia. Cuttings taken in mid-July wooted 10 per cent in 39 days without treatment, whereas 100 per cent rooted after a treatment with Hormodin No. 2. Many of the rooted cuttings, died the first winter, even though they were protected in a cold frame (140). The rooting of cuttings of this species was also improved or hastened by treating with IBA, 4 mg./gm. talc (139) or with IBA, 30 mg./l. for 10 hours (108).

Idesia

Idesia polycarpa Maxim. Cuttings taken in late July and set in sandy soil rooted 40 per cent without treatment, but 76 per cent rooted after treating with IBA, 25 mg./l. for 16 hours (44).

Ilex

Ilex aquifolium, English holly. Cuttings 3 to 6 inches long are best taken in October and November from the tips of the current season's terminal growth. Standing the cuttings with their bases in a 50 ppm. solution of IBA for 24 hours immediately before planting is helpful. For rooting a media of

either sharp, clean sand or a 50:50 mixture by volume of sand and sphagnum peat moss is satisfactory (25). The rooting percentage, number, and length of roots on cuttings were increased, and the rooting was hastened by soaking the bases of the cuttings overnight in a 50 ppm. IBA solution to which 25 ppm. boric acid had been added (161). Cuttings taken in October and November and set in sand-peat showed a high percentage of rooting after treating with 60 and 80 ppm. IBA solution for 24 hours (95).

Semi-hardwood terminal cuttings taken in autumn and early winter, were treated by soaking the base of the cuttings for 12 hours in aqueous solutions of boric acid in combination with IBA. There was an increase in the percentage of rooting, the number and length of roots produced and the speed of rooting. Boric acid alone had no effect on rooting (160). Hardwood cuttings potted in a mixture of sand, peat and styrofoam have all been successfully rooted after a treatment with 1 per cent IBA in talc (17).

Ilex cornuta Burfordii. Cuttings have rooted well when taken as late as January. Rooting was hastened by treating with IBA, 30 to 80 mg./l. for 24 hours (174), or 40 mg./l. Treated cuttings showed 100 per cent rooting in 35 days (156).

Ilex crenata, Japanese holly. Untreated cuttings taken in mid-December did not give less than 90 per cent rooting in sand in eight days. Cutting rooted well in sand but probably rooted better in sand-peat, and responded to a treatment with IBA, 20 mg./l., for 24 hours, or 2 mg./gm. talc (80). Cuttings taken in early October rooted much more rapidly as a result of a treatment

with IBA, 3 mg./gm. talc. Cuttings taken in November of another year rooted 84 per cent in 56 days without treatment; 97 per cent in 56 days with IBA, 50 mg./l., for 24 hours, followed by Hormodin No. 3 (174). Cuttings set in a 50:50 mixture of sharp sand and acid peat treated with IBA showed increased rooting. Bottom heat of 75^{o}-85^{o} F. was found desirable, along with an intermittent mist (169). Hardwood cuttings potted in a mixture of sand, peat and styrofoam have all been successfully rooted after a treatment with 1 per cent IBA in talc, and placed in a propagating bench covered with polyethylene film. No extra shade has been found to be necessary from mid-September to April 1 (17).

Ilex glabra (L.) Gray, Inkberry. Untreated cuttings taken in mid-January rooted 73 per cent in 20 weeks. There was a beneficial effect of a treatment with IBA, 20 mg./l., for 24 hours, and 2 mg./gm. talc (80). Cuttings taken in the summer rooted 90 per cent in sand without treatment, but rooting was hastened by IBA, 50 mg./l., for 24 hours (174). Cuttings taken in late December showed 36 per cent rooting in sand in 59 days, whereas there was no root development without treatment (140). Rooting has also been hastened by IBA, 10 mg./l. for 24 hours (78).

Ilex montana macropoda. With sand-peat as the rooting medium, cuttings taken in early November rooted 50 per cent without treatment, and 69 per cent in 5 months after treating with NAA, 25 mg./l., for 24 hours. There was no response to IBA as used (44).

Ilex opaca Ait., American Holly. Cuttings treated with IBA, 40 to 80 mg./l., for 24 hours, or 12 mg./gm. talc have been beneficial (80). Cuttings

taken in late August rooted 49 per cent without treatment, and 96 per cent after treating with IBA, 50 mg./l., for 20 hours (44). Cuttings taken in late October rooted 50 per cent in 23 weeks without treatment, and 79 per cent in 19 weeks after a treatment with IBA, of 100 mg./l., for 20 hours. In another instance, October cuttings rooted 90 per cent in two months without treatment and in half that time after a treatment with IBA, 100 mg./l., for 18 hours (174). Rooting of cuttings taken in winter was more improved by IBA, 30 or 50 mg./l., than by greater concentrations (78). Cuttings taken in November rooted 23 per cent without treatment, 39 per cent with Hormodin No. 2, and 67 per cent with a mixture, 1:3, of Phygon XL and Hormodin No. 3(44).

Terminal cuttings of American holly taken from August to November treated with Rootone No. 10 above damaged many of the cuttings, but there was little damage when treated with potassiumpermanganate. The latter treatment often produced the highest percentage of rooting and the heaviest root system (16). Cuttings treated with 1 per cent 2,4,5-TP talc showed 100 per cent rooting (170). The tip growth of the current season taken from the end of August until January or February showed good rooting when treated with IBA and 2,4,5-TP (166). In another instance, it was found that it was desirable to wounded the base of the stem and treat with Merck's No. 2 or No. 3 hormone powder when cuttings are taken in late summer and placed in frames or placed in a greenhouse during the winter (163).

Ilex opaca var. East Palatka. Half ripened greenwood tip cuttings taken in May were soaked fro 24 hours in 170 ppm. of sucrose solution, which

was combined with NAA powder. Cuttings responded to the sucrose-hormone dip before then were placed in the rooting media, composed of 20 per cent peat + 80 per cent shavings; or 40 per cent peat + 60 per cent shaving; and 60 per cent Perlite No. 8 + 40 per cent Perlite No. 30. All treatments were tested under intermittent mist (33).

Ilex Pernyi Veitchii. Cuttings taken in November rooted 54 per cent without treatment, but showed 100 per cent rooting after a treatment with IBA, 60 mg./l. for 24 hours (95).

Ilex rotunda. Subterminal cuttings taken from the lower part of the plant rooted best after a treatment with 1,000 ppm. IBA (109).

Ilex rugosa Fr. Schmidt. Cuttings taken in November rooted 100 per cent in five months without treatment, and 100 per cent in three months after treating with IBA, 100 mg./l. for 18 hours (44).

Ilex verticillata (L.) Gray, Black-alder. Summer hardwood cuttings rooted better in peat moss than in sand (83). Cuttings rooted in 18 days at 80° F., but roots developed much more slowly at 59° F. (176). Treating the cuttings with IBA, 40 to 80 mg./l. for 24 hours, or 12 mg./gm. talc has proved to be beneficial (80). Cuttings taken in late June rooted 22 per cent without treatment, 38 per cent with Hormodin No. 3, and 66 per cent after a treatment with a 1:3 mixture of Phygon XL and Hormodin No. 3 (41).

Ilex vomitoria Ait. Yaupon. Cuttings rarely rooted without treatment, but they rooted after treating with NAA, 1:1,000, in talc (130).

Ilex yunnanensis Franch. Cuttings taken in late December rooted 80 per cent in 26 weeks without treatment or in 16 weeks after treating with

IBA, 50 mg./l. for 24 hours (44).

Indigofera

Indigofera amblyantha Craib. Cuttings taken in mid-December rooted 18 per cent in sand-peat without treatment, and 64 per cent in nine weeks after a treatment with NAA, 50 mg./l., 20 hours. There was less response to IBA (119).

Jasminum

Jasminum grandiflorum. Hardwood cuttings treated with 1,000 ppm. IAA and in softwood cuttings 500 ppm. NAA have shown 90 per cent rooting as compared to 30 per cent in the controls in each case (123).

Jasminum sambac Ait., Arabian jasmine. Rooting of February cuttings made from 2-year-old branches responded to a treatment with IAA, 25 pmm. solution for 24 hours in the dark (48). Dipping in 0.04 per cent IAA gave the b est results with hardwood cuttings and 0.02 per cent NAA with semi-hardwood cuttings. The percentage of rooting in coarse sand was 86 in both cases compared with 21 and 14 per cent for the controls (4).

Juniperus

Juniperus chinensis L., Chinese juniper. Cuttings have responded to IBA, 40 mg./l. for 24 hours (91). Effective concentrations are 40 to 80 mg./l. for 24 hours, or 12 mg./gm. talc (80). Cuttings taken in early December

failed to root without treatment, but rooted 44 per cent after a treatment with IBA, 50 mg./l. for 24 hours. Cuttings taken in early February rooted 11 per cent without treatment, but 50 per cent after a treatment with NAA or IBA, 50 mg./l. for 20 hours, and 83 per cent in sand-peat after treating with NAA followed by Hormodin No. 3 (44).

Juniperus chinensis pfitzeriana Spaeth., Pfitzer's juniper. April cuttings responded to IBA, 100 mg./l. for 24 hours, but IBA, 40 mg./l. for 24 hours, gave better results with November or January cuttings (91). Rooting of cuttings taken in December was improved by IBA, 50 mg./l. for 24 hours, but that treatment was apparently injurious to the August cuttings. Cuttings taken in early February rooted 20 per cent without treatment, but 92 per cent in sand in about 15 weeks after treating with Hormodin No. 3 (138). November cuttings rooted 3 per cent without treatment, 27 per cent with IBA, 50 mg./l. for 23 hours, and 87 per cent with IBA, 50 mg./l. for 23 hours, followed by phygon XL Hormodin No. 3, 1:2 (41). Rooting of cuttings was improved by IBA, 100 ppm. for 12 hours (110).

Juniperus chinensis torulosa. Cuttings were taken in October from vigorous 1-year-old wood and set in sand in a lath house for 4-6 months until they had callused. The callus was then broken off and the cuttings were dipped in Hormodin No. 3 and rooted in a greenhouse with bottom heat at 78-80°F. After 60 days 60-65 per cent rooting was obtained (58).

Juniperus chinensis variegata. Cuttings taken in late December rooted 8 per cent without treatment, 58 per cent with Hormodin No. 3, and

100 per cent after a treatment with potassium nitrate 500 mg./l. for 24 hours, following a treatment with Hormodin No. 3 (44).

Juniperus communis Ashfordii. Cuttings treated with IBA, 100 mg./l. for 22 hours, rooted 90 per cent in sandy soil, but less well in sand (86).

Juniperus communis depressa, Prostrate juniper. Cuttings taken in October or February responded to treatment with IBA, 40 mg./l. for 24 hours. Cuttings so treated rooted better when taken in early February rather than in March or October (91).

Juniperus communis hibernica, Irish Juniper. December cuttings treated with IBA, 100 mg./l. for 20 hours, rooted 78 per cent in sand in six months, and 100 per cent in sandy soil in three months. Untreated cuttings rooted equally well but developed roots more slowly. Cuttings taken in mid-October of another year rooted 40 per cent without treatment, 57 per cent with Hormodin No. 2, and 100 per cent with Phygon XL-Hormodin No. 3, 1:3 (44).

Juniperus conferta, Shore Juniper. Tip cuttings in December and January rooted 86 per cent by dipping them in Fermate and Hormodin No. 2, and rooting them under mist in a peat-perlite media with bottom heat of 80^{o}F (150).

Juniperus excelsa Bieb. var. stricta Gord. Cuttings taken in early October and inserted in a sand-peat media rooted 100 per cent in 11 months

without treatment, and 92 per cent in five months after treatment with IBA, 50 mg./l. for 18 hours (44).

Juniperus hibernica. Cuttings taken in October and November and inserted in sand rooted well with a treatment of IBA, 60 and 80 ppm. solution for 24 hours (95).

Juniperus procumbens (Endl.) Sieb. & Zucc. Rooting of cuttings taken in April was poor and slow and only slightly improved by IBA, 80 mg./l. for 24 hours (91). Untreated cuttings rooted more than 90 per cent in sand-peat when taken in November, and less well when taken in February (44).

Juniperus Sabina tamariscifolia. Untreated cuttings taken in late November rooted 90 to 100 per cent in sand-peat or sandy soil, and less well in sand. Cuttings have responded to a treatment with IBA, 40 mg./l. for 24 hours (91), and November cuttings rooted 92 per cent in sand in 99 days after a treatment with IBA 60 mg./l. for 24 hours; whereas only 24 per cent of the untreated cuttings rooted (142).

Juniperus squamata Lamb., Meyeri. Cuttings taken in late December rooted 80 per cent in a sand-peat media in 18 weeks without treatment and 93 per cent in 15 weeks after a treatment with Hormodin No. 3. There has also been some response to a treatment with IBA, 80 mg./l. for 24 hours (91).

Juniperus squamata Meyeri. Cuttings taken in late November rooted 79 per cent without treatment, and 95 per cent in five months after treating with IBA, 100 mg./l. for 23 hours (44).

Juniperus virginiana L., Red Cedar. Cuttings taken in late September rooted 27 per cent without treatment, 38 per cent with IBA, 100 mg./l. for 18 hours, and 83 per cent with IBA, 100 mg./l. for 18 hours followed by Phygon XL talc 1:4 (41).

Juniperus virginiana glauca. Cuttings taken in mid-December failed to root without treatment, but rooted 92 per cent after treating with IBA, 100 mg./l. for 18 hours (44).

Juniperus virginiana Kosteri. The rooting of cuttings taken in December was improved by treating with NAA 50 mg./l. for 21 hours, and IBA, 100 mg./l. for 20 hours (44).

Kalmia

Kalmia latifolia L , Mountain Laurel. Cuttings taken in late August and treated with Hormodin No. 3 rooted 33 per cent. Untreated cuttings did not root (44). Untreated November cuttings rooted 100 per cent in a 1:1 mixture of cinders and peat, with bottom heat at 80°F. Treatment of late July cuttings with IAA, 90 mg./l. for 24 hours, improved their rooting more than those treated with IBA (124). Cuttings taken in early winter rooted 12 per cent in five months without treatment and 66 per cent after a treatment with IAA, 100 mg./l. for 48 hours (148). Leaf-bud cuttings taken in late July rooted 20 per cent without treatment, and 80 per cent in 19 weeks after treating with IBA, 90 mg./l. for 24 hours (124).

Kigelia

Kigelia pinnata. Rooting of hardwood cuttings was successfully initiated by a 12-hour treatment with 20 ppm. IAA solution (122).

Kolkwitzia

Kolkwitzia amabilis. Beautybush. Softwood cuttings rooted well after treating with 2 per cent IBA in talc. Rooting of untreated cuttings was slower (114).

Lagerstroemia

Lagerstroemia indica Hardwood cuttings without leaves in both the rainy season and the spring season treated with IAA, 0.04 per cent gave 63 per cent rooting in cuttings with leaves, while only 28 per cent rooting was obtained with NAA. Cuttings with leaves are superior to cuttings without leaves (3).

Lantana

Lantana camara, Common Lantana. Petioles of leaves were dipped for 24 hours in aqueous solutions of IBA ranging from 2.5 to 50 ppm., and subsequently grown in tap water, rooted 70 per cent whereas only 10 per cent of the untreated cuttings rooted (112).

Larix

Larix decidua Mill., European Larch. Tip cuttings from terminal shoots taken in August and September and inserted in sand rooted well under mist control after a treatment with Hormodin No. 3 (14).

Larix sibirica Ledeb., Siberian Larch. Rooting was successful with softwood cuttings taken in early summer and treated with IAA, 50 mg./l. for 24 hours. Untreated cuttings failed to root (82).

Lespedeza

Lespedeza Thunbergii (DC) Nakai. Cuttings taken in early October failed to root without treatment, but rooted 66 per cent in sandy soil after a treatment with IAA 100 mg./l. for 18 hours (101).

Leucothoe

Leucothoe Catesbaei (Walt.) Gray., Drooping Leucothoe. Softwood cuttings taken in July and made with the basal cut a half inch below a mode rooted 100 per cent in sand-peat in 12 weeks without treatment. Their rooting was only slightly hastened by treating with IBA, 10 mg./l. for 24 hours (124). Cuttings may also be taken in winter. Cuttings taken in mid-January rooted 100 per cent in 18 weeks without treatment or in 11 weeks after a treatment with IBA, 4 mg./gm. talc (125).

Ligustrum

Ligustrum amurense. The rooting of July cuttings was hastened by IBA, 80 mg./l. for 24 hours, but cuttings of this species made from soft tips, although taken in October, rooted fairly well in sand in 45 days (70).

Ligustrum compactum Hook. f. and Thoms. Rooting of cuttings was hastened after treating with NAA, 60 mg./l. for 24 hours (130).

Ligustrum ovalifolium Hassk., California Privet. Treating with IBA may hasten rooting or increase the number of roots per cuttings. Optimum concentrations are 80 mg./l. for 24 hours, or 12 mg./gm. talc (80). Softwood cuttings have responded to treatments with equal parts of NAA and IBA applied in solution (87).

Ligustrum ovalifolium var. Regelianum. Rooting of November cuttings was improved by IBA 80 mg./l. for 24 hours, but untreated cuttings rooted 100 per cent in sand in 83 days when taken in early summer (11).

Liriodendron

Liriodendron tulipifera L., Tulip-tree. Cuttings taken in August rooted well after a treatment with 10 mg./ml. IBA solution (44). Rooting of cuttings taken in summer and inserted in sand-peat was hastened by treating with IAA in a relatively high concentration (115).

Lonicera

Lonicera fragrantissima Lindl. & Paxt. Cuttings taken in July rooted 56 per cent in sand without treatment, and 70 per cent in 24 days after a treatment with Hormodin No. 1 (140). Rooting of cuttings taken in June was hastened by IBA, 10 mg./l. for 24 hours (78).

Lonicera nitida Wils. Box Honeysuckle. Cuttings taken in July rooted 100 per cent in two weeks after a treatment with IBA, 5 mg./l. for 24 hours (78).

Lonicera sempervirens L. Trumpet Honeysuckle. Cuttings taken in August rooted 100 per cent after a treatment with Hormodin No. 2. The percentage of cuttings which rooted was lower and development was slower without treatment (140).

Lonicera syringantha Maxim. Cuttings taken in January rooted 55 per cent in three months in sand-peat without treatment, and 92 per cent in two months after treating with IBA, 50 mg./l. for 22 hours (44).

Lonicera tatarica L., Tatarian Honeysuckle. Hardwood, early spring cuttings responded to a treatment with IAA: 50 mg./l. for 48 hours, for the first species, and 50 mg./l. for 24 hours, for the latter species (62).

Maclura

Maclura pomifera (Raf.) Schneid, Osage-orange. Cuttings taken in July and inserted in sand-peat rooted 32 per cent without treatment and 100

per cent in 42 days after treating with IAA, 100 mg./l. for 24 hours (115).

Magnolia

Magnolia liliflora nigra. Cuttings taken in early July responded to a treatment with IBA, 50 mg./l. for 17 to 24 hours (44).

Magnolia Soulangeana. Cuttings taken in late June rooted 32 per cent without treatment and 100 per cent in 35 days after treating with IBA, 50 mg./l. for 24 hours (174).

Mahonia

Mahonia soulangeana. Cuttings of about 3 internodes were taken between mid-June and the end of July, and their leaves were cut in half. The cut ends toward the base were immersed in a warm (20°C) solution of IAA or its sodium salt. The cuttings were potted in a mixture of 1 part of peat to 3 parts of sand and kept in a closed frame, with bottom heat at 24-26°C. Rooting took place in about 6-9 weeks with a variation between 74 and 88 per cent (84).

Malus

Malus arnoldiana (Rehd.) Sarg. Cuttings rooted 60 per cent after a treatment with IBA, 50 mg./l. for 25 hours, whereas none rooted without treatment (174).

Malus baccata (L.) Borkh., var. mandschurica, Siberian crab. Cuttings root with difficulty, but those taken in mid-July and treated with Hormodin No. 2, and set in sand-vermiculite, 1:1, rooted 57 per cent (12).

Malus pumila Mill. var. Eleyi. Early July cuttings rooted 70 per cent in sand after a treatment with IBA, 50 mg./l. for 4 hours. The untreated cuttings did not root at all (174).

Malus pumila var. Northern Spy. Cuttings rooted well when taken in the spring or early summer before growth had been completed and treated with NAA, 20 mg./l. for 24 hours (103).

Malus pumila var. Grimes Golden. Rooting of cuttings taken in May or when shoots were 4 to 7 inches long was successful when treated with IBA, 8 mg./gm. powder, and inserted in sand under a shade in the greenhouse (3). From 75 to 100 per cent of the hardwood cuttings taken from November to February rooted when made from the tips of the most recent year's growth, treated with IBA, 40 mg./l. for 24 hours, and immediately buried in moist peat moss (69, 70).

Metasequoia

Metasequoia glyptostroboides. Cuttings were set under mist in June, July and August. In an untreated group the August cuttings died, and only light rooting occurred in 36 per cent of the July and 42 per cent of the June cuttings. The best results were obtained by treating with 20,000 ppm. IBA in distilled water, as 90 per cent of the June and all of the July cuttings

rooted heavily, and all of the August cuttings very heavily. Next in effectiveness came a mixture of 0.8 per cent IBA and 15 per cent thiram, which gave medium rooting of 86 per cent of the June and 98 per cent of the July cuttings, and very heavy rooting of 100 per cent of the August cuttings. Mixtures of 2,4,5-T and NAA sodium salt gave poor results (51). Rooting of cuttings was improved by a treatment with 0.3 per cent lanolin paste of IAA (120).

Morus

Morus australis Poir. Cuttings taken in late October rooted 30 per cent without treatment, whereas 87 per cent rooted in sand in 13 weeks after treating with IBA, 100 mg./l. for 24 hours (93).

Morus nigra L. Black Mulberry. Cuttings taken in late September responded to a treatment with NAA, 50 mg./l. for 17 hours (93).

Myrica

Myrica cerifera L. Wax-myrtle. Cuttings taken from mid-July to mid-August and treated with Hormodin No. 2 rooted 100 per cent in sand in 35 days. Cuttings from female plants were slower to root than those from male plants (12).

Myrica Gale L. Sweet Gale. Cuttings taken in July rooted 60 per cent in sand-peat without treatment and 100 per cent in 38 days after treating with IAA, 100 mg./l. for 24 hours (115).

Neillia

Neillia longiracemosa Hemsl. Softwood cuttings rooted 70 per cent in 48 days after a treatment with IBA, 1:1,000, in talc (131).

Orixa

Orixa japonica Thunb. Cuttings taken in late October rooted 20 per cent in sand without treatment and 53 per cent in eight weeks after a treatment with IBA, 100 mg./l. for 24 hours, or that treatment followed by talc, powder-dip. The best roots were on the cuttings that had received both IBA and talc (119).

Osmanthus

Osmanthus Americanus. Cuttings taken in August were wounded and placed in peat-sand mixture over bottom heat. Treatment with cut-start 18-X, resulted in 70 per cent strongly rooted cuttings by February, whereas weaker concentrations and 2 per cent IBA gave less satisfactory results. Only 5 per cent rooting was obtained in the untreated controls (168).

Osmanthus ilicifolius (Hassk.) Mouillef, Holly Osmanthus. Untreated cuttings taken in late July rooted more than 90 per cent but rooting was hastened by a treatment with IBA, 150 mg./l. for 4 hours (174), or IAA, 20 mg./l. for 24 hours (148).

Osmaronia

Osmaronia cerasifornis (Torr. and Gr.) Greene. Cuttings taken in late December rooted 32 per cent in sand without treatment and 70 per cent in four weeks after treating with IBA, 50 mg./l. for 24 hours (44).

Oxydendrum

Oxydendrum arboreum (L.) DC., Sorrel-tree. Cuttings taken in late July rooted 80 per cent in sand-peat in eight weeks after treating with IBA, 90 mg./l. for eight hours. They did not root so well in sand, and untreated cuttings did not root at all (124).

Pachistima

Pachistima Canbyi Gray. Cuttings taken in early August rooted 87 per cent in 20 weeks without treatment and 100 per cent in six weeks after treating with Hormodin No. 2. October cuttings treated with Hormodin No. 3 rooted well in 10 to 12 weeks. Cuttings taken in early October rooted more than 90 per cent in sand-peat without treatment (12).

Pachysandra

Pachysandra terminalis Sieb. and Zucc. Cuttings taken in late June rooted 60 per cent without treatment, and 100 per cent in 28 days after treating with IBA, 30 mg./l. for 6 hours. (108). Cuttings may also be taken in winter.

Concentrations effective with winter cuttings were NAA or IBA, 20 to 40 mg./l. for 24 hours (68, 70) and IBA, or IBA, 5 to 12 mg./gm. talc (70).

Paeonia

Paeonia suffruticosa, Tree Peony. Side shoot cuttings rooted 60 per cent after a treatment with 0.1 per cent NAA. The "eye" cuttings gave poor rooting (26).

Pelargonium

Pelargonium grandiflorum. The percentage of rooting was improved and the time taken to root reduced when cuttings were treated with NAA dust ppm. (142).

Philadelphus

Philadelphus L., Mock-Orange. Cuttings treated with 5-aminotetragole or 1-phenyl-3 methylpyrozolone-5 at 100 and 200 mg./l. generally showed an increase in the rooting percentage (89).

Philadelphus coronarius. The percentage of rooting was increased when cuttings were treated with IBA, 50 mg./l. for 20 hours (108). The rooting of cuttings taken in late October was improved by IBA, 20 mg./l. for 24 hours (91).

Philadelphus cymosus Rehd. There was an increase in the rooting of cuttings when they were treated with IBA, 30 to 80 mg./l. for 4 hours (174).

Philadelphus var. Virginal. Cuttings rooted well after treating with 50 mg. of IBA/l. (28). Cuttings were taken at the end of February and treated with a solution of IAA, 50 mg./l. before being stored. These were planted outside in April, and 87 per cent rooted by November (27). Hardwood cuttings taken in early February and set in sand-peat rooted 58 per cent in 11 weeks without treatment; 100 per cent in nine weeks after a treatment with NAA, 50 mg./l., 6 hours; and 100 per cent in five weeks after a treatment with Hormodin No. 3. The rooting of cuttings taken in late October was improved by IBA, 20 mg./l. for 24 hours (91).

Photinia

Photina glabra (Thunb.) Maxim. Cuttings taken in fall rooted 5 per cent without treatment, and 100 per cent after a treatment with IBA, 50 mg./l. for 18 hours (44).

Photina serrulata. Cuttings taken in summer rooted 20 per cent without treatment, and 80 per cent after treating with IBA, 20 mg./l. for 6 hours (159).

Phyllanthus

Phyllanthus nivosus var. atropurpurea. Soaking the bases of one year old cuttings taken in July in IBA at 25 and 50 ppm. for 12 hours, gave maximum rooting. Responses to NAA were essentially similar (49).

Physocarpus

Physocarpus opulifolius (L.) Maxim, Ninebark. Cuttings taken in November rooted 80 per cent in 53 days without treatment. There was only a slight response to IBAA, 50 mg./l. for 40 hours (10).

Picea

Picea Abies (L.) Karst., Norway Spruce. Cuttings from the upper and lower regions of tree were treated with 1,000 ppm. IAA in talc. Ten weeks after being planted in sand, 43 per cent of the upper and 75 per cent of the lower region cuttings were rooted (60). Application of naphthylbutyric acid at the 2,000 ppm. resulted in rooting of 98 per cent of the cuttings. Mean root length was increased by the application of 50 ppm. each of thiamin and nicotinic acid (61).

Picea glauca conica Rehd, Dwarf Spruce. Late winter cuttings responded to a treatment with IBA, 40 to 60 mg./l. for 24 hours, or 2 to 12 mg./gm. talc, or by the concentrated solution-dip method, 4 mg./ml. (70). Cuttings taken in December rooted better in sand-peat than in sand, and the percentage that rooted was increased by IBA, 70 mg./l. for 20 hours. Cuttings taken in mid-September rooted 30 per cent without treatment and 63 per cent after a powder-dip treatment with Phygon XL (41).

Picea pungens Engelm., Colorado Spruce. Cuttings taken in April rooted 80 per cent in eight weeks after treatment with IBA, 100 mg./l. for

24 hours, but bud development was retarded for a few months (146). It has been found that IBA 40 to 80 mg./l., for 24 hours, or 12 mg./gm. talc is also effective (80).

Picea sitchensis (Bong.) Carr., Stilka Spruce. Cuttings made from the current year's wood and taken in late winter rooted 100 per cent in sand-peat in 60 days after treatment with IBA, 25 mg./l. for 24 hours. The results were not as satisfactory when the cuttings were not treated or when they were taken in the fall (64).

Pinus

Pinus densiflora, Japanese Red Pine. Short cuttings of lateral twigs rooted fairly well in a quartz-sand media after treating with IBA 10 mg./gm. talc powder (75).

Pinus Strobus L., Eastern White Pine. Cuttings taken in mid-March from the lower part of a tree about 30 years old rooted 70 per cent in a sand-peat media in three months after treating with IBA, 200 mg./l. for 5 hours (39). The rooting of cuttings from young trees was improved by a treatment with IAA, 200 mg./l. for 24 hours (146). Cuttings from four year old trees taken in early April rooted 95 per cent after a treatment with 1 per cent IBA in talc (172).

Pinus virginiana, Virginia Pine. Cuttings collected in December and taken at the crowns of 8 or 9 year old trees rooted 72 per cent when grown in perlite under intermittent mist and treated with 0.2 per cent IBA talc (127).

Platanus

Platanus acerifolia. Cuttings rooted 54 per cent after a treatment with 25 mg./l. IAA (153).

Poncirus

Poncirus trifoliata (L.) Raf. Cuttings taken in late October failed to root without treatment, but rooted 76 per cent after a treatment with NAA, 50 mg./l. for 24 hours. Cuttings taken in December rooted 60 to 84 per cent in a sand-peat media in ten weeks after a treatment with NAA, 100 mg./l. for 15 hours (44).

Populus

Populus nigra L., Black Poplar. Hardwood cuttings rooted poorly without treatment, whereas they rooted very well after a treatment with IBA 50 mg./l. for 30 hours, or 100 mg./l. for 18 hours (82).

Prunus

Prunus cerasifera var. Myrabolan B., Softwood cuttings taken in early June and inserted in sand in a greenhouse, failed to root without treatment, but 52 per cent rooted after treating with Hormodin No. 2, and 68 per cent after treating with NAA, 12.5 mg./l. for 24 hours (45).

Prunus cerasifera Ehrh., Cherry Plum. Softwood cuttings made from terminal shoots that were still growing only rooted 20 per cent without treatment,

whereas 100 per cent rooted in four weeks after treating with IAA, 30 mg./l. for 12 hours (104).

Prunus Laurocerasus L. Cherry Laruel. Cuttings taken in January did not root without treatment, but 80 per cent rooted in 34 days after treating with IBA, 40 mg./l. for 6 hours (159).

Prunus Mahaleb L., Mahalev Cherry. After a period of 38 days, cuttings which were taken in mid-July and inserted in sand rooted 5 per cent without treatment, 10 per cent with Hormodin No. 1, and 90 per cent after a treatment with Rootone No. 7 (140).

Prunus Padus L., European Bird Cherry. Cuttings taken in July rooted 32 per cent without treatment, and 52 per cent after a treatment with IBA, 22 mg./l. for 20 hours (86).

Pseudotsuga

Pseudotsuga taxifolia (Poir.) Britt., Douglas-fir. Cuttings taken in late winter rooted 80 per cent in sand-peat after treating with IBA, 50 mg./l. for 24 hours, whereas they did not root as well without treatment or when they were taken in the fall or early winter (64). Cuttings rooted better when treated with IBA followed by Arasan than with IBA above (74).

Pterocarpus

Pterocarpus indicus Willd., Narra. Cuttings taken from sprouts on three year old stumps were treated with Rootone powder for 12 hours. The

treated cuttings rooted in 26 days and untreated cuttings rooted in 38 days. After 4 months the average survival was 38 per cent for the treated and 30 per cent for the untreated cuttings (96).

Purshia

Purshia tridentata, Antelope Bitterbrush. Sten cuttings treated with 0.1 per cent IBA resulted in 50 to 65 per cent successful rooting in 58 days. Higher acid concentrations gave less success (97).

Pyracantha

Pyracantha coccinea Roem, Scarlet Firethorn. The rooting of cuttings was improved by IAA, 50 mg./l. for 24 hours (108).

Pyracantha coccinea var. Lalandii. September cuttings responded to a treatment with IBA, 50 mg./l. for 17 to 24 hours (93).

Pyracantha crenulata (Roxb.) Roem., Nepal firethorn. Cuttings taken in September rooted 6 per cent without treatment and 75 to 100 per cent with IAA, 25 mg./l. for 20 hours (152).

Quercus

Quercus borealis Michz. f., Red Oak. Cuttings from mature trees failed to root; but 82 per cent rooted when taken from the basal parts of four-year-old trees and treated with IAA, 400 mg./l. for 24 hours. Only 22 per cent of the untreated cuttings rooted (138).

Quercus robur L., English Oak. Cuttings taken in July from trees six to eight-year-old did not root without treatment, but 56 per cent rooted after a treatment with IAA, 50 mg./l. for 18 hours. Cuttings from a twenty-year-old English oak showed 34 per cent rooting after a treatment with IAA, 200 mg./l. for 18 hours (82).

Rhododendron

Rhododendron, Azalea. Cuttings were taken from the end of May to mid-June. After removing the growing tips from the cuttings, they were treated with 75 ppm. of IBA solution for 15 hours. The cuttings were placed in a shaded outdoor frame which contained a 1:1 peat moss/sand mixture topped with one-fourth of an inch of coarse sand (5). Stem cuttings taken from short negative shoots rooted well after a treatment with 1 per cent IBA in talc and planted inside the frame. The media consisted of sand, peat, and styrofoam in equal parts by volume (19).

Rhododendron calendulaceum, Flame Azalea. The rooting of June cuttings was more improved by IBA, 50 mg., and Phygon XL, 300 mg./l. for 23 hours, than by IBA alone (44).

Rhododendron carolinianum. Terminal cuttings have been successfully rooted under intermittent mist in late autumn and winter in mixtures of peat moss with sand, perlite or weblite that were warmed to 70-75°F. After wounding the cuttings by removing an inch long strip of bark from one side of the stem they were dipped for 10 seconds in 50 per cent alcohol containing

5,000 ppm. IBA (9).

Rhododendron catawbiense. The rooting of cuttings was more improved by a treatment with Hormodin No. 3—Fermate, 1:3 than by using Hormodin No. 3 alone (7).

Rhododendron catawbiense album elegans. Cuttings taken in late September rooted 21 per cent without treatment, 48 per cent with IBA, 75 mg./l. for 21 hours, and 62 per cent with IBA, 75 mg./l., and Phygon XL, 300 mg./l. for 21 hours (44).

Rhododendron var. Dr. Dresselhuys. Excellent results were obtained in the rooting of cuttings by using a 1 per cent dust of 2,4-dichlorophenoxy alpha propionic acid or 2,4,5-TP. There was a great increase in rooting when the houses were kept under a constant mist during the day (164, 170).

Rhododendron var. E. S. Rand. Stem Cuttings taken on August 8 and treated with 2,4,5,-TP showed only 30 per cent rooting, whereas 100 per cent of those taken on September 5 rooted. Cuttings that had been wounded and treated with 2 per cent IBA in talc failed to root. Re-wounding and re-treatment with 0.8 per cent IBA resulted in rapid rooting of nearly 80 per cent of the cuttings (167).

Rhododendron gandavense, Ghent Azalea. The best time for taking cuttings was found to be while the new growth was still green but had just begun to harden. Cuttings which were 4-6 inches long and placed in a rooting media of 2 parts fibrous German peat and 1 part sharp sand rooted well under mist in 6 weeks with a treatment of Hormodin No. 3 as a dry dip (88). In

another instance, cuttings made in late May or early June and placed in a mixture of equal parts of sand, peat and ground styrofoam rooted well in 2 to 3 months with a treatment of Hormodin No. 3. Polyethylene plastic was covered over the cuttings and bottom heat of 72° F. was used under the media (21).

Rhododendron indicum var. Formosa. Greenwood tip cuttings taken in May of half ripened plants rooted well after soaking for 24 hours in a sucrose solution which was combined with NAA powder. The cuttings were than placed in the rooting media under intermittent mist (33).

Rhododendron ponticum. Thin cuttings, 3-4 inches long, were obtained from side growth. These rooted well when they were treated with .008 per cent IBA dust after they had been wounded by removing a thin piece of bark about one and one-half inches long, from the base of the cuttings (164).

Rhododendron purpureum elegans. Leaf-bud cuttings rooted 100 per cent in 15 weeks after a treatment with IBA 120 mg./l. for 20 hours, whereas 88 per cent rooted in 18 weeks without treatment (125).

Rhododendron waterer. Cuttings taken in February from one-year-old wood without flower buds and wounded by slicing at the base gave 66 per cent rooting in a 1:1 sand-peat media after with Hormodin No. 3-Fermate used as a 3:1 mixture. The cuttings were waxed after being treated (7).

Rhododendron var. V. H. Rutgers. Cuttings readily produced adventitious roots when a mixture of 100 mg. IBA + 37.5 mg. arginine + 0.5 mg.

vitamin B_1 in 10 grams lanolin paste was applied to both sides of the basals cut. Rooting was better in a propagating frame heated by hot water than in one heated by electricity (6).

Rhodotypos

Rhodotypos scandens (Thunb.) Mak. Cuttings taken in late May showed 86 per cent rooting in sand in eight weeks without treatment, whereas 100 per cent of the cuttings rooted in three weeks after being treated with IBA, 25 mg./l. for 24 hours. None of the cuttings taken in late June rooted while 84 per cent rooted in seven weeks after a treatment with IBA, 1:1,000 in talc (139). Cuttings taken in late July failed to root in 52 days without treatment, but 84 per cent rooted with Hormodin No. 1 and 88 per cent with NAA, 1:1,000, in talc (140).

Robinia

Robinia Pseudoacacia L. Swingle, Black Locust. Hardwood stem cuttings taken in winter or early spring and treated with IAA or NAA, 100 mg. / l. for 24 hours rooted well (133).

Rosa

Rosa var. Hybrid Teas Garden. August cuttings showed a higher percentage of wooting after being treated with IBA, 2.5 mg./l. for 24 hours or 2 mg./gm. talc (81).

Rosa multiflora Thunb. The rooting of summer cuttings was improved by the use of IBA, 5 mg./l. for 24 hours or 2 mg./gm. talc. Dormant cuttings responded to IBA, 5 to 10 mg./l. for 24 hours or 2 mg./gm. talc. The IBA had little effect if the treated cuttings were not given a temperature of more than 60° F. (81).

Salix

Salix discolor Muhl., Pussy Willow. The rooting of June and July cuttings was hastened by using IBA, 5 mg./l. for 24 hours (78).

Salvia

Salvia officinalis L., Garden Sage. Cuttings taken in late June rooted 79 per cent in sand in seven weeks without treatment, and 100 per cent in three weeks after a treatment with IBA, 40 mg./l. for 24 hours. January cuttings rooted 85 per cent in sand-peat without treatment and 92 per cent in 48 days after being treated with IBA, 50 mg./l. for 24 hours (44). The treatment of cuttings with Hormodin No. 3 increased the percentages that rooted as well as the number of roots per cutting (102).

Sciadopitys

Sciadopitys verticillata (Thunb.) Sieb and Zuvv., Umbrella-Pine. Short leteral cuttings were taken in January from the most recent year's growth on the lower branches of trees about 50 years old. All of the cuttings failed to

root without treatment but 92 per cent rooted in sand-peat in 20 weeks after being treated with NAA, 100 mg./l. for 20 hours. There was less response to IBA (44). Cuttings taken in January from trees about seven years old did not root without treatment but 70 per cent rooted in eight months after a treatment with IBA, 20 mg./l., for 20 hours (44). Other reports indicated that cuttings should be taken in March, and treated with Hormodin No. 2 or No. 3. It was also reported that making 2 wounds per stem was better than making 1 or 3 wounds (53).

Spiraea

Spiraea arguta. The rooting of October cuttings was improved by a treatment with IBA, 10 mg./l. for 24 hours (44).

Spiraea Bumalda var. Anthony Waterer. Cuttings taken in June rooted 55 per cent without treatment and 100 per cent in four weeks after a treatment with IBA, 10 mg./l. for 24 hours (78).

Stauntonia

Stauntonia hexaphylla Decne. Softwood cuttings treated with IBA, 1:1,000 in talc, showed 65 per cent rooting in 56 days with humidification and 55 per cent without humidification (131).

Stewartia

Stewartia koreana. Only 10 per cent of the late June cuttings rooted in sand without treatment, while 89 per cent rooted when treated with IBA, 8 mg./gm. talc. Cuttings taken in mid-June responded to a treatment with IBA, 50 mg./l. for 17 to 24 hours (93).

Styrax

Styrax japonica. Late July cuttings treated with IBA, 12.5 mg./l. for 18 hours showed 50 per cent rooting in sand and 90 per cent in sandy soil. Cuttings treated with IBA, 50 mg./l. for 4 hours or showed 100 per cent rooting in three weeks. Cuttings rooted well in eight weeks without treatment (174).

Symplocos

Symplocos paniculata (Thunb.) Mig., Asiatic Sweetleaf. Untreated softwood cuttings taken in early June showed 36 per cent rooting in sand, and 55 per cent in sandy soil. After a treatment with IBA, 50 mg./l. for 24 hours, 58 per cent of the cuttings rooted in sand and 92 per cent in sandy soil (11).

Syringa

Syringa var. Marie Legraye. Cuttings taken in mid-June showed 22 per cent rooting without treatment and 100 per cent in 90 days after a treatment with IBA, 25 mg./l. for 24 hours (70).

Syringa var. Mme. Lemoine. Cuttings taken in early July rooted 17 per cent without treatment, 34 per cent with IBA, 25 mg./l. for 22 hours, and 63 per cent with NAA, 100 mg./l. for 5 hours (44).

Syringa var. Reine Elizabeth. Cuttings rooted 100 per cent in about four weeks after being treated with IBA, 12 mg./gm. talc (70).

Syringa vulgaris, Common Lilac. Softwood cuttings responded to a treatment with equal parts of NAA and IBA solution. The rooting response increased with an increase in the sucrose content (87).

Taxus

Taxus baccata, English Yew. Cuttings taken in December rooted 100 per cent in five months without treatment and in three months after a treatment with IBA, 75 mg./l. for 24 hours (44).

Taxus baccata aura. Cuttings taken in October and November rooted well after a treatment with IBA, 60 and 80 ppm. of water for 24 hours (95).

Taxus canadensis stricta. Cuttings taken in late December from one-year-old wood rooted 56 per cent without treatment and 88 per cent after a treatment with IBA, 50 mg./l. for 18 hours (44).

Taxus cuspidata capitata. Tip cuttings taken in October rooted well under short days after a treatment with Chloromone (77).

Taxus media Hicksii. The rooting of cuttings taken in March and April was improved by treating with IBA, 80 mg./l. for 24 hours (91).

Thryallis

Thryallis glauca. Terminal cuttings taken in winter and spring rooted well after a treatment with 8,000 ppm. IBA (34). Sub-terminal cuttings taken from the lower part of the plant and treated with 1,000 ppm. IBA have given the highest percentage of rooting (109).

Thuja

Thuja, Arbor-vitae. Cuttings treated with 5-aminotetrazole or 1-phenyl-3-methylpyrazolone-5 at 100 and 200 mg./l. showed an increase in the rooting percentage as well as root and shoot grwoth (89).

Thuja occidentalis, American Arbor-vitae. Cuttings responded to a treatment with IBA, 40 to 80 mg./l. for 24 hours or 12 mg./gm. talc (80).

Thuja occidentalis Douglasii pyramidalis. December cuttings showed 62 per cent rooting without treatment and 100 per cent with IBA, 50 mg./l., for 24 hours (78).

Thuja orientalis, Oriental Arbor-vitae. Cuttings taken in December rooted 37 per cent without treatment, and 78 per cent with IBA, 50 mg./l., for 24 hours (78). Cuttings taken in mid-October rooted 10 per cent without treatment, 28 per cent with NAA, 33 mg./l., for 20 hours, and 76 per cent when that treatment was followed by a powder-dip in Phygon XL (41).

Tsuga

Tsuga canadensis, Canada Hemlock. Cuttings taken in November failed to root without treatment but 73 per cent rooted after a treatment with Hormodin No. 3, and 100 per cent rooted in 14 weeks after being treated with IBA, 200 mg./l., for 16 hours. There was no rooting of untreated January cuttings, but they rooted 87 per cent in 20 weeks after a treatment with NAA, 50 mg./l. for 4 hours (37).

Tsuga canadensis pendula. Cuttings taken in early September showed 34 per cent rooting without treatment and 83 per cent rooting in a sand-peat media after a treatment with IBA, 50 mg./l. for 24 hours (32).

Tsuga caroliniana Engelm., Carolina Hemlock. The rooting of cuttings taken in August was much improved by using IBA, 8 mg./gm. talc. Likewise the rooting of October and December cuttings was improved by using IBA, 200 mg./l. for 22 hours (44).

Ulmus

Ulmus, Elm. The rooting of wood tip cuttings at least 5 inches long, taken in June or July and placed in peat under mist was hastened with IBA in talc (90).

Ulmus Americana L., White Elm. Early June cuttings rooted poorly without treatment but showed 94 per cent rooting after being treated with IBA 50 mg./l. for 24 hours (44).

Ulmus japonica (Rehd.) Sarg., Japanese Elm. Softwood stem cuttings taken in early June, did not root without treatment but 78 per cent rooted with Hormodin No. 2 and 89 per cent after a treatment with IBA 100 mg./l. for 4 hours (44).

Viburnum

Viburnum alnifolium Marsh., Hobble-bush. Cuttings taken in mid-July and treated with IBA, 50 mg./l. for 20 hours rooted 25 per cent in sand and 67 per cent in sandy soil (44).

Viburnum Burkwoodii, Burkwood. Cuttings taken in mid-August rooted 89 per cent in 73 days without treatment and 100 per cent in 39 days after a treatment with IBA, 4 mg./gm. talc (12).

Viburnum Carlesii, Korean spice viburnum. Cuttings taken in early June rooted 59 per cent in seven weeks after a treatment with IBA, 20 mg./l. for 18 hours. Cuttings taken in late August rooted 50 per cent in 81 days without treatment, and 100 per cent in 45 days after a treatment with IBA, 3 mg./gm. talc (12).

Vitex

Vitex Agnus-castus L., Chaste-tree. Cuttings in mid-December and immediately planted in sand-peat in the greenhouse rooted 63 per cent in five months without treatment whereas 90 per cent or more rooted in two months after a treatment with NAA, 25 mg./l. for 17 hours, or IBA,

50 mg./l. for 17 hours (108).

Weigela

Weigela florida. Late June cuttings showed 72 per cent rooting in 20 days after a tratment with IBA, 50 mg./l. for 12 hours (108).

Wisteria

Wisteria floribunda (Willd.) D. C., Japanese Wistaria. Softwood cuttings taken in mid-July, rooted 80 per cent without treatment, and 100 per cent in sand-peat in two months after being treated with IBA, 25 mg./l. for 24 hours (115).

Zanthoxylum

Zanthoxylum schinifolium. Only 12 per cent of the stem cuttings taken in late December rooted without treatment, while 46 per cent rooted in 4 months in a sand-peat media after a treatment with IBA, 100 mg./l. for 20 hours (119).

DISCUSSION

Types of Cuttings

Hardwood cuttings (deciduous species) are usually prepared during the dormant season in late fall, winter, or early spring from wood of the previous season's growth. Many deciduous ornamental shrubs are started by hardwood cuttings. Some common ones are privet, forsythia and honeysuckle. But hardwood cuttings of Amelanchier alnifolia were difficult to root (65). Hardwood cuttings of Lagerstroemia indica with leaves were superior to cuttings without leaves (3). Two nodes of hardwood cuttings of Briarcliff rose with the lower leaf removed and the tip leaflet removed from the upper leaf rooted best (38).

Tip cuttings from terminal shoots rooted more easily than the basal portion of Larix (14). Shoot cuttings of Ginkgo biloba taken from the young plants developed a mass of healthy roots (144).

Softwood cuttings are prepared from the soft, succulent, new spring growth of deciduous or evergreen species of trees. Softwood cuttings generally root easier and quicker than other types. Many ornamental woody shrubs can also be started by softwood cuttings. Stem cuttings of Ginkgo biloba, Amelanchier alnifolia, made from growth of the current year rooted well (42). Small diameter cuttings from side shoots are the most suitable for Rhododendron (164). Cuttings should be taken while the new growth is

still green but has just begun to harden Rhododendron gandavense (88). Cuttings of Japanese privit taken in early summer root better if made from the growing tip rather than older wood (174). The best type of cuttings of Ilex opaca is made from the tip growth of current season taken from the end of August until January or February (166). Lencothoe catesbaei is easily propagated by softwood cuttings made with the basal cut a half inch below a node (44). Ligustrum is propagated by softwood cuttings taken in summer or by hardwood cuttings taken in winter or early spring (151). Cuttings of Liguidambar Styraciflua will root if taken in summer and made from half-ripened wood with a heel (63). Best rooting of Mahonia Aquifolium took place when the basal cut was made at the base of the current year's growth or when a heel of older wood was included (85). Cuttings of Juniperus communis depressa rooted about equally well when made from wood that was one, two, or three years old (86).

Sub-terminal Cocculus cuttings rooted better than terminal ones. Cuttings from the lower position of Feijoa and Cocculus plants rooted better than those from the upper part of the plant, but with Ilex the position from which cuttings were taken made no difference. Only terminal cuttings were taken of Thryallis, and these rooted best in the winter and spring (34).

The best results were obtained from semi-hardwood cuttings of Camellia japonica taken from June to September with all treatments. The highest percentage (80 per cent) was obtained in August. In another experiment 50 per cent success was obtained from leaf cuttings which were planted

in pure sand in July and August. Rooting took place 2-3 months sooner than with the semi-hardwood cuttings and early growth was more vigorous (113).

Factors Affecting Rootings

Season of cuttings. The age of the wood from which cuttings are made or the time of year at which they are taken is significant. The best results for most plants appeared to be obtained from February to mid-April (158). In autumn and winter the upper terminal cuttings rooted better than lower terminal cuttings (34). In English holly cuttings 3 to 6 inches long are best taken in October and November from the tips of the current season's terminal growth (25). Cuttings of Juniperus chinensis torulosa did not do satisfactorily when placed directly in the greenhouse, but good results were obtained when they were overwintered in a lath house before being brought into warm condition for rooting (58). Mahonia Aquifolium cuttings usually show a large percentage of rooting if the cuttings are taken in late July or early August (55). Ilex opaca can be propagated in late summer in frames, or during the winter in greenhouses (163). The time at which cuttings were taken proved to be very important for Rhododendron var. E. S. Rand. Those taken on August 8, though treated with 2,4,5-TP, showed only 30 per cent rooting whereas 100 per cent rooted of those taken on September 5 (167).

Age of plant. The age of plants from which cuttings are taken has an effect on rootings. The effect of a treatment with a root-inducing substance is sometimes affected by the age of plants and the cuttings. Generally cuttings

rooted better when taken from very young trees rather than from mature trees such as Camellia japonica (23), Costanea Chestnut (177), Gingko gilola (42), Gleditsia triacanthosa (136), Juniperus excelsa (154), Pterocarya (101), Robinia Pseudoacasia (141).

Generally, young cuttings from any age tree rooted better than older cuttings such as cuttings of Pseudotsuga taxifolia rooted in larger percentages if made from one-year-old wood rather than from older wood (74). But the species is important as in Arabian jasmine. Two-year-old cuttings did better than one-year cuttings (48).

Rooting Conditions

Rooting media. The rooting media is an important factor in the rooting of cuttings. The several media commonly used are discussed as follows:

Sand and sand-peat. Sand and coarse sand are the rooting media which have been most commonly used. Sand-peat is a mixture of equal parts, by volume, of sand and peat moss. For cuttings of some species the proportion of two parts sand to one part peat moss is used. Sand-peat is better than sand for cuttings of ericaceous plants. Sand or sand-peat (78) are good rooting media, better than sandy soil. Camellia japonica rooted well in sand-peat (95). Semi-hardwood cuttings of Camellia japonica, showed the best results after 8 months in sand in a cold frame (31).

Peat moss and peat perlite. Peat moss and perlite are commonly used for cuttings of some species such as Rhododendron Caolinianum (9), Ilex opaca (169), Pittosporum tobira variegatum (22), Cornus florida (33).

Propagation under constant mist. In rooting cuttings, the water supply may be automatically provided by a mist. This is one type of humidity control which has many advantages, and is commonly used in rooting leafy cuttings. The mist provides a film of water over the leaves, thereby lowering the temperature and reducing transpiration (44).

Mist beds can be built either in a greenhouse for use in summer and winter, or out-of-doors in a lath house or in open sun for use during the warmer months of the year. Over these beds, nozzles which produce a fine fog-like mist are spaced so as to give complete coverage of the bed. Holly cuttings often difficult to root gave good results when rooted under fog nozzles in a shaded and specially constructed cold frame (106). Softwood cuttings rooted readily if taken when the new growth of Amelanchier alnifolia was 3-6 inches long and kept in a mist propagation frame (65). Softwood cuttings rooted very well under intermittent mist and with bottom heat.

Propagation under bottom heat. Propagation of Caragana arbescens softwood cuttings under intermittent mist prolonged the period in which cuttings would root successfully. Maximum rooting was attained by the application of bottom heat (24). Warming the soil by electricity or by covering it with black plastic for winter cuttings in bins improved rooting percentage and the degree of rooting of Cornus alba var. Gouchaltii (153). There were 86 per cent

of the tip cuttings of Juniperus conferta which rooted when taken in December and January, dipping them in Fermate and Hormodin No. 2, and rooting them under mist in a peat-perlite medium with bottom heat of 80° F. (150). Softwood cuttings of azaleas and dwarf rhododendrons rooted very well under intermittent mist and with bottom heat (162).

Use of a plastic film over cuttings. Specifications are given for a propagation bench covered with polyethylene film, which retains moisture, yet lets air penetrate. The plastic reduces the work of watering and ventilating (17).

Treatments with Chemicals

The treatment with growth substances shortened the pride required for rooting and increased percentage of rooting. The root-inducing substances or auxins most frequently mentioned are indole-3 butyric acid (IBA), naphthaleneacetic acid (NAA) and indole-3-acetic acid (IAA). These acids and their salts are effective root-inducing substances.

IBA gave better results with cuttings of more species that were more difficult to root (139) such as Juniperus hibernica (95), Lantana camara (112), Ginkgo biloba (42), Camellia japonica (31), (95), Chamecyparis plumosa aurea (95), Cocculus laurifolius (109), Corton (44), Erica carnea (26), Euphorbia fulgens (44), Feijoa sellowiana (34), Ilex rotunda (34), Ilex rotunda (109), Ginkgo biloba (42) with the exceptions of Pillosporum tobia variegatum (22).

IBA and NAA combined were more effective with cuttings of some species than either alone (71).

IBA gave better results than IAA with cuttings of most species. Among the exceptions were Allamanda cathartica (117), Pyracantha coccinea, Lonicera Korolkowii (108).

Indolebutyric is also probably more effective than NAA for cuttings of most species such as Buxus (13), Juniperus chinensis pftizeriana, Thuja orientallis (110) among the exceptions are Cryptomeria japonica var. Bandai-Sugi (98), Hibiscus rosasinensis (117). Cuttings of these plants responded more to a treatment with NAA.

Naphthaleneacetic acid is probably more effective than IAA with species such as Japanese yew, Camellia japonica (69, 70).

Indole-e-acetic acid is also probably more effective than NAA for cuttings of a species such as Lagerstroenia indica (3).

The different chemicals are effective on the following ornamental:

IAA: Brompton (28), Bignoniaceae (122), Arabian jasmine (48), Jasminum grandiflorum (123), Kigelia pinnata (122), Kolkwitzia amabilis (114), Philadelphus (27).

NAA: Coleus blumei (121), Cryptomeria japonica (94), Ficus elastico (142), Jasminum grandiflorum (123).

2,4,5-TP: Ilex opaca (170), Rhododendron (170).

Hortomone A: Camellia japonica

Rootone: Caragana arbescens (24).

Hormodin No. 3: Juniperus chinensis torulosa (58), Ginkgo biloba (42).

Rainbow Rooting Powder Woody: Cephalotaxus harringtonia drupacea (52).

6-quinolinecarboxylic acid: Coleus blumei

5-aminotetrazole or 1-phenyl-3 methylopyrazolone: Cornus alba (89)

alpha-naphthaleneacetate and saccharose: Cryptomeria japonica D. Don (175)

Hormodin No. 2 and Fermate: Juniperus conferta (150)

4-thianaphtheneacetic acid (TNA) is a new chemical used as a root-inducing agent which appears to be equal to or better than NAA. It has shown good results on the following plant species: Buxus sempervirens, Euonymus fortunei vegetus, Forsythia intermedia, Ligustrum obtusifolium, Lonicera fragrantissima, Pachysandra terminalis, Pyracantha coccinea lalandi (100).

Application of the Chemicals

Growth-regulating substances may be prepared for rooting in the form of dusts, liquids or pastes. Liquids can be applied by dipping, immersing or spraying the cuttings. For the best results each method requires different amounts of the growth-regulating substance for the plant species used.

Powder-dip method. This method of treating cuttings is probably the simplest and most popular. The powder-dip method consists in moistening the basal ends of cuttings in water and then dipping them in a powder, usually talc,

which contains a certain number of milligrams of a root-inducing substance per gram of talc or other carrier. Even talc alone has improved the rooting of cuttings of some species (70, 130). The powder-dip method did not give as good results with conifer cuttings as the solution-immersion method. The powder-dip method has, in some instances, given results inferior to the solution-immersion method. For example, cuttings of male-berry rooted well after a powder-dip treatment whereas they rooted poorly after immersing in the solution (125).

Concentrated solution dip method. This treatment consists of dipping the bases of the cuttings for a few seconds in a concentrated solution containing the root-inducing substance in a mixture of 1 ml. of alcohol and water. This method is apparently as effective at optimum concentrations as the solution-immersion method, which requires several hours. For example the rooting of cuttings of Caragana was effective after a treatment with 4 mg. of IBA per ml. (70).

Solution-immersion method. The solution-immersion method is used less now than it was formerly, but it has been found to be useful with cuttings of species that are difficult to root (44). Cuttings are set with about an inch of their basal ends in a solution of a root-inducing substance, in a glass or nonmetal container for several hours. For example, the basal ends of the cuttings of Mahomia soulangeana were immersed in a warm solution of IAA. The cuttings were potted in a mixture of one part of peat to three parts of sand and kept in a closed frame, with bottom heat at 24-26°C. Rooting took

place in about 6-9 weeks with a variation between 74 and 88 per cent (84). On the other hand the immersion of the entire cuttings has given good results with conifers (44).

Spraying method. Some success has been obtained by spraying leaves with a dilute aqueous solution of auxins. Spraying with dilute aqueous solution of chemicals the top of cuttings after they have been placed in the rooting media may be satisfactory in mass production of some species, for instance rooting was improved on cuttings taken from Burus, Ligustrum, and Rhodoendron which were sprayed several weeks previously with an aqueous solution of 2,4,5-T at concentrations from 10 to 100 mg./l. One gm./l. of sodium lauryl sulfate was used as a spreader.

Lanolin paste method. This method of treating cuttings is not so convenient to use as other methods. Lanolin is a soft fat which is prepared from wool and will dissolve auxins. The paste, when applied to the base of the cutting, sticks firmly to it, does not dry out, and maintains a reasonably constant concentration of the auxin in contact with the treated part (2). For example cuttings of Rhododendron var. E. S. Rand readily produced adventitious roots when a mixture of 100 mg. IBA + 37.5 mg. arginine + 0.5 mg. vitamin B_1 in 10 gm. lanolin paste was applied to both sides of the basal cut (6).

SUMMARY

The effects of chemicals on the rooting of woody ornamental plant cuttings have been summarized from a review of the literature from 1930 to the present. The emphasis in the literature review has been to cover the work done since William L. Doran's publication in 1957. In summarizing the effects of the chemicals, the results have been treated with regard to the influence of the age of plant, type of cuttings, the age of cuttings, season of the year at which the cuttings are taken and the rooting conditions. Few new chemicals have been added in recent years. Instead workers have been interested in a concentration of chemicals as well as the rooting media and the treatment of new species. One new chemical TNA has been tried recently on a few species and appears to be comparable to NAA. The results for each species have been cataloged in the list of plants.

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