



The effects of plant hormones, rooting media, and intermittent mist on the rooting and transplanting of herbaceous, evergreen, and hardwood cuttings  
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A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Horticulture  
Montana State University  
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**Abstract:**

Experiments were designed to determine the responses of herbaceous, evergreen, and hardwood cuttings to various treatments including different concentrations of indolebutyric acid, various rooting media, and presence or absence of intermittent mist. Experiments were also designed to determine the response of herbaceous cuttings to various combinations of soil and transplanting treatments.

Based on the rooting percentage or root quality or both, the results of the experiments indicated that herbaceous and hardwood cuttings rooted well when treated with low to intermediate concentrations of IBA. Chrysanthemum cuttings rooted best with 1,000 ppm IBA, carnation with 2,000 ppm IBA, and German ivy with all concentrations tested. Potentilla, caragana, and sand cherry all rooted best when treated with 2,000 ppm IBA.

Evergreen cuttings rooted best when treated with high concentrations of IBA. Pfitzer junipers rooted best when treated with 8,000 ppm IBA.

Species adaptability to media did not follow the same pattern as hormone response. In addition it did not seem as important. However, in most cases certain media aided in rooting to some degree. Carnation and sand cherry rooted best in 100% perlite. Pfitzer juniper rooted best in a 75% perlite and 25% peat medium. A 50% perlite and 50% peat medium proved to be best for potentilla. Chrysanthemums rooted best in a 50% sand and 50% peat medium as did caragana.

Intermittent mist treatments benefitted Carnation, juniper, and potentilla rooting. However, Chrysanthemum, Caragana, and sand cherry cuttings rooted better under non-mist.

Transplants of cuttings resulting from the cutting experiments had nearly 100% survival under all treatments tested. The only exception was sand cherry which proved difficult to transplant under all conditions.

THE EFFECTS OF PLANT HORMONES, ROOTING MEDIA, AND INTERMITTENT MIST  
ON THE ROOTING AND TRANSPLANTING OF HERBACEOUS, EVERGREEN,  
AND HARDWOOD CUTTINGS

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### ABSTRACT

Experiments were designed to determine the responses of herbaceous, evergreen, and hardwood cuttings to various treatments including different concentrations of indolebutyric acid, various rooting media, and presence or absence of intermittent mist. Experiments were also designed to determine the response of herbaceous cuttings to various combinations of soil and transplanting treatments.

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## INTRODUCTION

Many plants are reproduced under natural conditions by asexual means. Asexual or vegetative propagation of plants is that form of plant propagation in which the new individual possesses exactly the same characteristics as the parent plant from which it was taken.

The early history of asexual propagation was essentially the history of grafting. It was not until the 17th century that detailed information on the propagation of plants by means of layers and cuttings was available. Probably no other single operation in asexual propagation is more important than cuttage, because the average nurseryman depends very largely upon this type of propagation. Cuttage may be described as a method of propagating plants by the use of detached vegetative plant parts which, when placed under conditions favorable for regeneration, will develop into a complete plant.

The main advantages of propagation by cuttage are the relative simplicity of the operations, the low unit cost of production, and the ease with which plants will reestablish themselves. Therefore, this method of propagation is highly practical and economically important. It is used extensively to propagate ornamental plants, including deciduous types, broad-leaved evergreens and coniferous forms. Fruits such as grapes and figs have been propagated in this manner since ancient times.

This thesis is a report of research on several factors and techniques affecting rooting of cuttings which have been developed in recent years, including rooting media, hormones, and intermittent mist, and some

important factors affecting transplanting of rooted cuttings.

Experiments were made on the effect of indolebutyric acid on rooting of herbaceous, evergreen, and hardwood cuttings; the effect of rooting media on root formation and root quality; and the effect of intermittent mist on root formation. They were designed to determine the response of herbaceous, evergreen, and hardwood cuttings to different concentrations of indolebutyric acid, varying proportions of perlite, peat, and sand in the propagation medium, and the presence or absence of intermittent mist over the propagating bench.

Experiments were also made on the effect of various soil and transplanting treatments on rooted herbaceous evergreen and hardwood cuttings which resulted from the cutting experiments.

The author wishes these preliminary results to be a reference for nurserymen and people who are interested in propagation work, but more research work needs to be done in this field.

#### LITERATURE REVIEW

The history of propagation by cuttings can be traced to the 17th century. In the ensuing years, many techniques and methods have been evolved. In recent years, much information has been developed concerning internal and external factors affecting rooting of cuttings. Internal factors affecting rooting of cuttings include the amount of stored food in cuttings, the age and maturity of tissue, the formation of callus and adventitious roots and the presence of leaves and buds on cuttings. The external factors include rooting media, chemical and hormone treatments,

light, temperature, mechanical treatment and mist spray.

Internal or Physiological Factors:

Internal or physiological factors represent conditions within a cutting, which may influence its ability to form roots and to develop into a plant.

It has been shown repeatedly that available carbohydrate and nitrogen markedly affect the rooting of cuttings. Cuttings with a high starch content formed better roots than those with low starch contents (88). Cuttings from plants that have a carbohydrate accumulation in excess of inorganic nitrogen, are more likely to root properly (1).

Both maturity of the tissues and age of cuttings (juvenility) affect the readiness of cuttings to root. Many early papers indicated that cuttings of a suitable degree of maturity (1, 22, 54, 79, 91) from a juvenile plant will root more readily than cuttings from older plants.

Juvenility, first described by Goebel as a physiological condition, may be characterized not only by morphological characteristics, such as lack of pubescence, thinness of leaves, leaf shape modification and thorniness, but also by the inability of the plant or plant parts to initiate flower buds (25). The seat of juvenility or that portion of plant where the juvenile influence remains longest and exerts its greatest influence is at or just below ground level and probably extends well into the lateral roots (52). Juvenile wood can be induced to form on many plants by cutting back and disbudding greenhouse forced stock (22, 66, 83).



Root primordia are sometimes present within stems of normally growing plants and require only favorable conditions to grow out as roots. Although root primordia are not ordinarily present in stems of most plants, they may be induced to form on cuttings placed under favorable conditions for a period of time. Plant hormones aid in hastening the formation of roots on cuttings (71).

Through an anatomical study of adventitious root development in stems, it was concluded that roots originate in cambium and phloem and project through the callus or through cortex and epidermis. This suggests that if some means could be provided to dissolve the cuticular and epidermal layers and the pericyclic fibers, rooting percentage might be improved (48).

Callus formation at the basal end of the cutting was at one time considered to be a vital factor in the rooting of hardwood cuttings. Callus formation may be of benefit in sealing the ends of the cuttings and preventing decay. In some cases, callused cuttings also respond more readily to chemicals used to aid in root formation than those not callused (87). More recently it has been accepted that callus formation does not play an important part in root formation. Rather, callus formation and root development are processes not directly interdependent, and are favored by different environmental factors: callusing by a very moist, heavy medium, and root formation by a light well aerated medium (43).

The presence of leaves on cuttings provides a favorable influence on the rooting of herbaceous, semi-hardwood and evergreen cuttings. Leaves

and buds form a substance which promotes root formation in cuttings. Growing leaves are reported to promote cell division in the cambium (63). Root formation on Hibiscus cuttings depends upon both auxin and the presence of leaves. In auxin treated cuttings, the number of roots formed increases with the number of leaves left on the cuttings (53). The amount of leaf area allowed to remain on a cutting partly determines the extent and amount of root production (7).

External or Environmental Factors:

The rooting and growth of cuttings depends upon certain external or environmental factors which represent treatments that are applied just before the cuttings are set in the bed, or the conditions to which the cuttings are subjected in the bed.

Many papers present studies on the effect of various media for rooting cuttings (4, 10, 27, 35, 40, 72, 82, 87). Vermiculite, perlite, and other products have been and are being tested with a view of improving plant propagation methods.

It has been the concensus of opinion with plant propagators that No. 7 silica sand is the best grade to use as a rooting medium (49).

The acid reaction of peat is considered beneficial (46) or necessary for some cuttings (34).

Vermiculite is used widely as a medium for rooting cuttings. The No. 2 grade has proven to be most satisfactory for most ornamental deciduous shrubs (51). In this medium cuttings produce a desirable fibrous branched type of roots (27, 72). Vermiculite is valuable in the

rapid rooting of soft cuttings such as chrysanthemum, carnation, dahlias, etc., (87).

Many mixtures have been used as media for propagation. Cuttings of some plants which root poorly in sand often root satisfactorily in mixtures of equal volumes of sand and peat (10, 12, 35). A mixture of equal parts of peat and sawdust was satisfactory for rooting of rabbiteye blueberry. A mixture which contained 1 part of peat, 1 part of sand, and 1 part of sawdust also proved satisfactory (4).

In general, any medium which holds moisture and supplies air is satisfactory. However, different media cause variations in root quality (40). Of 43 kinds of plants propagated by stem cuttings, 30 produced finer and more flexible roots in peat moss than in sand due to the reduced aeration and increased moisture (45).

Many chemicals have been used in efforts to induce root formation in plant species difficult to propagate or to improve rooting quality (2, 8, 13, 41, 62, 71, 80, 90). Sugars, nitrates, zinc, boron, manganese, iron, phosphorus, acetic acid, potassium permanganates, and carbon monoxide have been reported effective but results of experiments have been so variable that the advisability of using them appears very slight (8, 13, 41, 43, 90). However, hormone treatment has proved effective.

The importance of hormones in the rooting of cuttings was clearly established in 1935 when indoleacetic acid in lanolin paste was first used successfully to stimulate the rooting of lemon, lantana, and acalypha cuttings by Cooper (15). Since then many plants have been tested to

ascertain the effectiveness of hormones in inducing or improving root formation (2, 5, 26, 27, 28, 53, 55, 56, 62, 63, 73, 80). Also, many other similarly active chemical compounds have been discovered; indolebutyric, indolepropionic and naphthaleneacetic acids, naphthaleneacetamide, 2, 4-dichlorophenoxyacetic acid, 2, 4, 5-trichlorophenoxyacetic acid and trichlorophenoxypropionic acid all induce root formation but their activity varies considerably (2, 39, 62, 67, 71, 73, 80).

Indolebutyric acid (IBA) and naphthaleneacetic acid (NAA) and its derivative naphthaleneacetamide (NAd) are the materials in most common use for rooting of cuttings. The potassium salts of IBA and NAA appear equally effective and have the advantage of being readily soluble in water. The indole compounds usually produce a more fibrous root system than the naphthalene compound. Also, IBA does not inhibit the growth of terminal buds as much as NAA (71). A mixture of IBA and NAA is more effective on both IBA and NAA sensitive cuttings (38).

Numerous methods of applying the plant hormone to cuttings have been used. At the present time three methods of application have come into widespread practical use; the hormone powder method (2, 37, 71), the concentrated solution dip-method (2, 16, 28, 37) and the dilute solution soaking method (2, 5, 26, 59, 71).

Weak solutions of hormones coupled with prolonged soaking were widely used in early work. The effective concentrations range from 10 ppm to 100 ppm. Duration of treatment ranges from a few hours to 24 hours (2, 5, 26). It was shown that the chief disadvantage of the method was that the

long period of treatment allowed for variations in external conditions which influenced the hormone effect (59).

The concentrated solution dip-method was first proposed by Hitchcock and Zimmerman. The concentrations tested were from 1,000 ppm to 20,000 ppm (37). Others indicate that IBA at 4,000 to 10,000 ppm will induce rooting on most kinds of cuttings (2).

Rooting powder containing approximately 500 to 2,000 ppm IBA, NAA or naphthalene-acetamide is effective in stimulating root formation of the more easily rooted cuttings. Concentration from 10,000 to 20,000 ppm is required to root more difficult cuttings (2).

Stoutemyer concluded that three concentrations of IBA, NAA or NAD rooting powder were effective in rooting three groups of plants; 1,000 ppm for easy-to-root plants; 4,000 ppm for intermediate groups and 10,000 to 20,000 ppm for difficult-to-root plants (71).

The concentrated hormone solution dip-method and the hormone powder method are used most commonly and are the most convenient methods to use (16, 28).

Control of temperature is very important in the rooting of cuttings. Steady and even bottom heat in a bench is beneficial in rooting hardwood cuttings and for winter propagation work (87). The cutting bench should be maintained around 65° to 70° F. (about 6 to 10° F. warmer than the surrounding air) to give satisfactory results with many plant species (1, 87). However, Swingle found that the optimum rooting temperature for apple cuttings was between 75 to 85° F. (76).

The light effect on cuttings is mainly an indirect factor. Light is essential for photosynthesis to produce food which is necessary for producing roots. A number of papers reported the effect of light on rooting (23, 50, 61, 68, 69, 70). Cuttings rooted faster and more abundantly in June than when days were shorter (50).

Mechanical treatments of various kinds have been used to stimulate root formation (17). But the most important mechanical consideration has proven to be the location of the basal cut. A basal cut 1/2 inch below the bottom node was superior for 41 of the 86 common shrubs tested as compared with 17 which rooted best with a cut at the node. In 23 cases, the position of the cut was unimportant. In some cases, the position of the basal cut influenced the number of roots and in other cases it influenced the time of rooting (9, 11, 13).

The type of wood at the base has an important influence on the rooting of cuttings of some plants. In general, cuts made at the base of the current season's growth aided rooting. Mallet cuttings made to include a small portion of last season's wood generally rooted poorly (36). The use of a small portion of 2-year old wood at the base of a cutting did not appear to help the rooting of coniferous cuttings (89).

Wounds at the base of cuttings often cause better root formation. They increase the area in which roots may form; roots often develop along the margins of the wound. It is not clearly understood why wounds stimulate rooting. Some people suggest that a wound hormone is produced which aids in healing the mutilated tissue, while others theorize that

wounding stimulates cambium cells into active division to seal up the wound (1, 87). Some people think it is due to the increase of water adsorption (17).

Wounding is of particular value on conifers, which are propagated from stem cuttings. In a series of tests on Juniperus Pfitzerana, Juniperus stricta, and Thuja orientalis pyramidalis wounding increased the percentage of rooting more than any other treatment (87).

The use of mist for rooting cuttings was introduced by Raines (57, 58), Gardner (24), and Fisher (20, 21). That these reports appeared so nearly at the same time suggests that the concept of mist propagation was developed simultaneously by these people. Interest in this field was aroused, but rapid progress did not occur until the early 1950's when various research stations and commercial firms studied propagation factors, developed equipment, and applied their results to the practical field.

The environmental factor most difficult to control is water which is important in all physiological processes. Mist propagation involves the use of apparatus which disperses fine droplets or particles of water in such a manner that the surfaces of leaves and stems are covered with a thin film of water. Water evaporates from the surface film to the atmosphere but little or no water is lost from the leaf tissue. In this way, mist helps to maintain the turgidity of the cuttings (64).

Mist lowers leaf temperatures thereby reducing food utilization. However, cuttings are able to manufacture larger amount of foods since

they can be exposed to full light intensity without wilting. Thus, a large amount of reserve foods, which are utilized in the rooting process, accumulate in the cuttings. Therefore, the rooting potential of cuttings under mist are much greater than cuttings under other methods (32).

Mist apparatus are of two basic types: the over-head system and the in-bed system. In-bed system has three advantages: no water dripping occurs, no support is necessary for the feeder lines and a larger number of cuttings can be placed in the propagation bed. Nozzles used in mist operations are of three types: oil burner nozzles, self-cleaning nozzles and deflection nozzles (64).

Most of the early work on mist was concerned with the use of continuous mist during daylight hours only or on a 24-hour per day basis (20, 24, 57, 58, 84, 85, 86). More recently the use of intermittent mist has been advocated (18, 29, 30, 31, 32, 33, 44, 47, 64, 74, 75, 77, 78).

Comparing the constant mist system with the intermittent mist system, Hess found that the temperature of the medium under constant mist was reduced due to the excessive amount of mist to a point where the rooting response was actually inhibited. The temperature of the medium under "electronic leaf" controlled intermittent mist was always near or above the optimum because only enough mist was applied to maintain a film of water on the foliage of cuttings. There was no excess mist leading to low medium temperature (32).

Methods of operating an intermittent mist system are hand controls (42), timer mechanisms (31), solar control mechanisms (64), humidistats



(77) and electronic leaf (32, 64, 78). Of these methods, the "electronic leaf" was the most effective mechanism for controlling mist. Because it is weather sensitive, it affords automatic protection on a 24-hour basis, it requires a minimum of water but affords maximum protection. It is relatively easily constructed at a reasonable price (64).

Suitable well drained rooting medium (20, 21, 57, 75, 84, 85, 86, 87), hormone treatment (29, 30, 42, 47) and time of collecting cuttings (24, 84) are the important factors affecting successful rooting under mist propagation.

Among the narrow leaf evergreens, the Pfitzer juniper represents plants in which mist is of marked benefit to rooting in regard to rooting percentage and root quality. Thuja occidentalis elegantissima is also noticeably benefited by the mist (64).

In a large commercial test involving some 50,000 azaleas of most common varieties and 25,000 magnolias, the azaleas rooted 100 per cent. All the standard varieties of the magnolias rooted with such rapidity that the more easily rooted varieties were potted in four weeks and the more difficult ones in six (87).

Many ornamental trees and shrubs rooted freely and quickly under mist from very soft cuttings. Carnations, chrysanthemum and dahlia cuttings all rooted 100 per cent under mist conditions within three weeks of insertion (42). Peach, several clones of mahaleb cherries and EM VII apple root stock rooted satisfactorily under mist propagation (74).

Mist propagation in open frames (81) or under lath house (65) are

promising and economical methods for commercial propagation of cuttings during the summer months.

Cuttings under mist produce long unbranched succulent roots, which later branch; at the later stage a cutting of this type is easier to transplant (6).

Cuttings under mist, regardless of whether they are rooted under glass or in open beds can not withstand an abrupt shift from the mist. It was suggested that cuttings be potted and returned to the mist bench. The potted plants are then hardened by gradually decreasing the period of mist. A simpler method is to leave the rooted cuttings in the bench under mist until maximum rooting has been obtained. The cuttings are then hardened by a gradual decrease in the mist periods until they are capable of withstanding the more severe conditions of the greenhouse or outside planting (14, 64). It was also reported that by using shading both softwood and evergreen cuttings were transplanted successfully from the mist bed (19, 60).

#### MATERIALS AND METHODS

All the experiments reported herein were conducted in the Horticultural greenhouse at Montana State College during the period November 1956 to April 1957. A temperature of approximately 65° F. was maintained in the propagation bench. The mean daily temperature was 60° F.

##### A. Rooting of Cuttings

###### (1) Plant Materials -

Three types of cuttings, herbaceous, evergreen and hardwood,

were used. The plant species were chrysanthemum (Chrysanthemum morifolium), carnation (Dianthus caryophyllus), German ivy (Senecio mikanioides), Pfitzer juniper, (Juniperus chinensis pfitzeriana), caragana or Siberian pea shrub (Caragana arborescens), potentilla or bush cinquefoil (Potentilla fruticosa), sand cherry (Prunus besseyi) and McIntosh apple (Malus spp.). These will be referred to as chrysanthemum, carnation, German ivy, Pfitzer juniper, caragana, potentilla, sand cherry, and Malus.

The cuttings were about five or six inches in length and were trimmed to just below a bottom node. They were divided into lots as nearly equal in vigor as possible. The caragana, potentilla and sand cherry cuttings were given a 108 day callusing treatment (November 12, 1956 to March 2, 1957) and Malus a 28 day treatment (February 4, 1957 to March 2, 1957). The callusing treatment consisted of burying the cuttings in damp peat maintained at a temperature of approximately 40° F. Hormone treatments were applied after callusing.

## (2) Rooting Media -

Four rooting media were used: 100% perlite, 75% perlite and 25% peat, 50% perlite and 50% peat, and 50% sand and 50% peat.

Perlite is a synthetic rooting medium consisting of 95% aluminum silicate plus traces of calcium, iron, magnesium, sodium, potassium and minor element salts. It is neutral in reaction. In its manufacture, it is expanded about eight times in volume resulting in a great increase in water holding capacity and aeration. Canadian peat

and clean washed bank-run sand were used in making the mixtures.

(3) Intermittent Mist -

The automatic mist system used was of an "In-bed" type with Type A-6 "Humido-mist" nozzle (self-cleaning) in which the mist was controlled by an "electronic leaf". The electronic leaf consisted of a small rectangle of plastic about one inch long and 1/2 inch wide, two carbon electrodes inserted in the plastic 3/4 inch apart. A wire led from each electrode to the Thyatron tube control unit. When a film of water was on the leaf, an electric current passed between the electrodes and the control mechanism kept the solenoid valve closed. When the film of water evaporated the "leaf current" circuit was interrupted and the control mechanism opened the solenoid valve to start the mist. The "on" period for the mist varied from a minimum of three seconds to a maximum of about twenty seconds. The "off" period depended on the rate of evaporation of the water film. The electronic leaf was located about 6 inches above bench level in the center of the bench.

(4) Hormone -

Indolebutyric acid (IBA) was selected as it was the most commonly used rooting hormone. It was used in powder form for herbaceous cuttings and in concentrated solution form for evergreen and hardwood cuttings.

The hormone powder was made by dissolving 400 mg. of IBA in about 50 c.c. of 95% ethyl alcohol. This solution was stirred into

100 grams of talc to form a paste which was allowed to stand until the alcohol evaporated. All lumps were eliminated by stirring and crushing to form a uniform 4,000 ppm IBA powder. Fifty grams of 2,000 ppm IBA rooting powder was made by mixing 25 grams of the 4,000 ppm IBA powder with 25 grams of talc. Fifty grams of 1,000 ppm IBA rooting powder was made by mixing 12.5 grams of IBA 4,000 ppm rooting powder with 37.5 grams of talc.

The concentrated hormone solution was made by dissolving 400 mg. of IBA in 50 ml. of 50% ethyl alcohol to form an 8,000 ppm IBA solution. Twenty-five ml of 8,000 ppm IBA solution was diluted with 25 ml of 50% ethyl alcohol to form a 4,000 ppm IBA rooting solution. Twenty-five ml of 4,000 ppm IBA solution was diluted with 25 ml 50% ethyl alcohol to form a 2,000 ppm IBA rooting solution.

#### (5) Methods -

The experimental design for all three experiments was a factorial arrangement of treatments in randomized plots. As it was impossible to randomize mist treatments, half of the bench received intermittent mist and half received no mist. Four media were randomized in each half of the bench. Plant species were randomized in each medium in rows. Each row consisted of 24 cuttings of a single species extending the full width of the bench. Four hormone treatments were randomized in each row in plots of 6 cuttings each.

Experiment 1: Chrysanthemum, carnation and German ivy cuttings were treated with 1,000 ppm, 2,000 ppm, and 4,000 ppm indolebutyric acid

(IBA) powder by dipping the basal end (1/2 to 1 inch) of the cuttings in tap water, shaking off the excess and dipping in the hormone powder. All excess powder was removed by gently shaking the cuttings which were then inserted into the media. Treatments were made on November 24 to 26, 1956. Rooting records were taken on December 16 and 17, 1956.

Experiment 2: Pfitzer juniper cuttings were treated with 2,000 ppm, 4,000 ppm, and 8,000 ppm of IBA solution by dipping the basal inch of the cuttings in the rooting solution for 3 seconds. The treated cuttings were then inserted in the rooting media. Treatments were made on November 27, 1956. Rooting records were taken on February 27, 1957.

Experiment 3: Caragana, potentilla and sand cherry cuttings were subjected to a 108 day callusing treatment and Malus cuttings to a 28 day treatment by storing them in damp peat in a plastic sack at a temperature of about 40° F. The callused cuttings were treated with 2,000 ppm, 4,000 ppm and 8,000 ppm of IBA solution by dipping the basal inch of the cuttings in the hormone solution. The treated cuttings were then inserted into the rooting media. Treatments were made on March 2, 1957. Rooting records were taken on April 12, 1957.

B. Transplanting rooted cuttings

(1) Plant materials -

Rooted cuttings of chrysanthemum, carnation, German ivy, Pfitzer juniper, caragana, potentilla, and sand cherry which resulted from

the cutting experiments were selected for transplanting. Selection was based upon root development with the best ones being selected from each experiment. The cuttings which rooted under intermittent mist were kept separate from those which rooted under non-mist conditions. In order to minimize the carry over effect of hormone treatments the numbers of cuttings treated with various concentrations of IBA were selected as equal as possible. However, no attempt was made to equalize the number of cuttings rooted in each medium in these experiments.

(2) Soil treatments -

Two soil treatments were used: a greenhouse potting mixture and the same potting mixture to which skim milk was added. The potting mixture contained 50% Huffine silt loam soil, 25% sand and 25% well rotted manure. The potting mixture plus skim milk was the same potting mixture as above plus skim milk powder at the rate of 1/2 ounce per flat. The flats used were 20.5" x 12.0" x 3.5". Flats were used for all species except Pfitzer juniper which was transplanted into six inch standard pots.

(3) Transplanting treatments -

Flats containing cuttings rooted under intermittent mist were placed under one of two conditions immediately following transplanting. One of the conditions was an immediate transferal to non-mist conditions. The other condition was a hardening process in which the flats were placed in intermittent mist which was decreased by 2 hours

a day until non-mist conditions were obtained. All flats containing cuttings rooted under non-mist conditions were placed only under non-mist conditions.

(4) Methods -

The design of this experiment varied for different species as the availability of rooted cuttings varied. Chrysanthemum, carnation and German ivy were the only species which produced sufficient numbers of rooted cuttings on which to conduct all the phases of the experiment.

Seventy-two cuttings of chrysanthemum were divided into 24 lots of 3 each. Sixteen of the lots had been rooted under intermittent mist and 8 under non-mist conditions. Eight of the lots of cuttings rooted under intermittent mist and 4 of the lots of cuttings under non-mist were transplanted into flats containing a greenhouse potting mixture. The remaining lots of cuttings were transplanted into flats containing the potting mixture plus skim milk.

Seventy-two rooted cuttings of carnation and 72 rooted cuttings of German ivy were divided into lots in the same way. Then they were transplanted into the flats containing the rooted chrysanthemum cuttings following the same plan of selection. Thus, each flat contained rooted cuttings which had received as near identical pre-transplanting treatments as possible.

The flats were divided into three lots of 8 flats each. Two lots contained the cuttings which had rooted under intermittent mist and the third lot contained cuttings which had rooted under non-mist.



Each lot consisted of four flats filled with the potting mixture and four filled with the potting mixture plus skim milk. One of the lots containing cuttings rooted under intermittent mist was put through a hardening process. The remaining two lots were placed directly under non-mist condition.

The herbaceous cuttings were transplanted into flats on December 17, 1956 and the results were observed on March 27, 1957.

Forty rooted cuttings of Pfitzer juniper were divided into 12 lots of cuttings, 8 of the lots contained 4 cuttings each and 4 of the lots contained 2 cuttings each. All cuttings had rooted under intermittent mist conditions. One half of the lots were transplanted into pots containing greenhouse potting mixture soil. The other half of the lots were transplanted into pots containing the potting mixture soil plus skim milk.

The pots were then divided into two lots of 6 pots each. Each lot consisted of three pots filled with the potting mixture soil and three pots filled with the potting mixture soil plus skim milk. One of the lots was put through a hardening process and the other lot was placed directly under non-mist conditions.

The juniper cuttings were transplanted into pots on February 28, 1957 and the results were observed on June 10, 1957.

Twenty-four rooted cuttings of potentilla were divided into 12 lots of 2 cuttings each. Six of the lots had been rooted under intermittent mist and 6 under non-mist conditions. Three of the lots of

cuttings rooted under intermittent mist and 3 of the lots of cuttings rooted under non-mist were transplanted into flats containing a greenhouse potting mixture soil. The remaining lots of cuttings were transplanted into flats containing the potting mixture soil plus skim milk.

Twenty-four rooted cuttings of caragana and 24 rooted cuttings of sand cherry were divided into lots in the same way as potentilla. Then they were transplanted into the flats containing the rooted potentilla cuttings following the same plan of selection as potentilla. Thus, each flat contained rooted cuttings which had received as near identical pre-transplanting treatments as possible. All flats were placed directly under non-mist conditions.

The hardwood cuttings were transplanted into flats on April 12, 1957 and the results were observed on June 11, 1957.

#### EXPERIMENTAL RESULTS

##### A. Rooting of cuttings

Experiment 1. The results of rooting herbaceous cuttings of chrysanthemum, carnation, and German ivy are summarized in Tables 1, 2, and 4, and illustrated in Figure 1. The analysis of variance is summarized in Table 3. The analysis of variance shows that the effect of different concentrations of hormone (IBA) treatments, plant species and their first order interaction were all highly significant. There was no significant difference between intermittent mist and non-mist treatments nor any among the four media.

Table 1. Number<sup>a</sup> of herbaceous cuttings rooted under different concentrations of indolebutyric acid (IBA), mist, and non-mist, and different kinds of media.

Species	Media <sup>b</sup>	Hormone concentration									
		Check		1,000 ppm IBA		2,000 ppm IBA		4,000 ppm IBA		Total	
		Mist	Non-Mist	Mist	Non-Mist	Mist	Non-Mist	Mist	Non-Mist	Mist	Non-Mist
Chrysanthemum	A	4	6	4	6	5	6	5	1	18	19
	B	5	6	6	6	6	4	4	5	21	21
	C	6	6	6	6	6	5	6	4	24	21
	D	5	6	5	6	5	6	3	6	18	24
Total		20	24	21	24	22	21	18	16	81	85
Carnation	A	4	4	5	6	6	6	6	4	21	20
	B	4	1	6	6	6	5	5	5	21	17
	C	5	0	5	6	6	6	6	5	22	17
	D	3	0	6	1	5	6	5	6	19	13
Total		16	5	22	19	23	23	22	20	83	67
German ivy	A	5	5	6	6	5	6	5	6	21	23
	B	6	4	6	6	6	6	6	6	24	22
	C	6	6	6	6	6	6	6	5	24	23
	D	6	6	6	6	6	6	6	6	24	24
Total		23	21	24	24	23	24	23	23	93	92

a Six cuttings per treatment.

b Media were as follows: A. 100% perlite  
 B. 75% perlite and 25% peat  
 C. 50% perlite and 50% peat  
 D. 50% sand and 50% peat.





















































































