In order that you may have a chance to look over the constitution before the business meeting, we have copies here for distribution to the members of the Society.' I only have 150, so will those of you that are guests, please do not take a copy. Let's restrict them because of the number, to the members. Look them over. If there are any questions you have about the constitution, the proposed constitution, consult with some member of the Executive Committee or the Constitution Committee, and we will try to explain it to you. It is basically the old constitution adapted to the procedures which we have developed during our previous 11 years of existance. They are here. I think to save a little bit of time I will not pass them out right now. We will pass them out at the end of the session.

The first part of this morning's program is a Symposium —Propagation of Plants by Means of Cuttings. The Moderator for the Symposium is Mr. Roger Coggeshall of Cherry Hill Nurseries, West Newbury, Massachusetts. I will turn the meeting over to Roger.

MODERATOR COGGESHALL: At this time, before we start the symposium, I would like to ask the speakers who are to participate in this morning program to please come up to the stage and sit at the table to my left.

The symposium this morning, as you can see on your program and as has been pointed out already to you, deals with the Propagation of Plants by Means of Cuttings, and to save time in the symposium, we will hear from all of the speakers and at the end of this time you can direct your questions to them We will not allow time for questions after each speaker but just as an overall period at the end of this morning's symposium.

At this time I would like to introduce to you a man who is certainly no stranger, who will speak to us first — Dr. W. E. Snyder of the Department of Horticulture, Rutgers University, who will speak to us on Plant Anatomy as Related to the Rootings of Cuttings. Dr. Snyder.

PLANT ANATOMY AS RELATED TO THE ROOTING OF CUTTINGS

WILLIAM E. SNYDER
Department of Horticulture
Rutgers, the State University
New Brunswick, N. J.

It is necessary for us to understand the structure of the stem before we examine the origin of roots on stem cuttings.

The vegetative parts of a seed-producing plant are the roots, stems and leaves. Each of these organs is composed of tissues and the tissues of cells. Some of these cells have become specialized, however others have remained almost unchanged since the time they were formed. Such unspecialized cells are called parenchyma. It is these relatively unspecialized cells which are important in the development of roots on stem cuttings.

Growth in plants is said to be primary or secondary. Growth resulting from cells formed by the growing points of stems and roots is primary growth and results in the elongation of the plant axis. Secondary growth results in an increase in diameter of the stem or root. It is the formation of additional vascular tissue (the tissue through which water, minerals, food, hormones, etc. are transported up and down the stem) by the cambium and of the bark as the stem or root increases in size. The place of origin of roots on stem cuttings depends on whether the base of the cutting has only primary growth or whether secondary growth has taken place.

Simply, we can compare the root-stem axis to a pencil. The pencil is composed of three concentric cylinders—the outer cylinder is the paint, the intermediate cylinder is the wood and the inner cylinder is the lead. Likewise, the stem-root axis is composed of three concentric cylinders—the outer cylinder is the epidermis, the intermediate cylinder is the cortex and the inner cylinder is the stele (Figure 1). In a young stem, such as the new growth of a woody plant, a chysanthemum or a bean, the roots originate in the inner portion of the intermediate cylinder, the cortex, and grows outward through the remainder of the intermediate cylinder and through the outer cylinder, the epidermis. In stems with secondary growth, the roots originate in vascular tissue formed by the cambium and grow outward through the stem.

Let us now examine, in more detail, the origin and development of roots in a stem cutting made from current season's growth. Examination of cross sections of stems will show that there are three major types of arrangements of the vascular tissue. These three types of vascular tissue arrangements are illustrated in Figure 1. It is immaterial which type of arrangement we find in a stem as far as the initiation of roots is concerned. The activity always occurs adjacent to and usually outward from the outer edge of the vascular tissue. This area is known as the pericycle and constitutes the inner portion of the cortex—the intermediate cylinder.

For some reason, which we cannot explain at present, groups of these pericycle cells, usually adjacent to the vascular tissue, begin to undergo cell division. As more and more cells are formed, the new mass of tissue gradually becomes a small tapered cylinder, called a

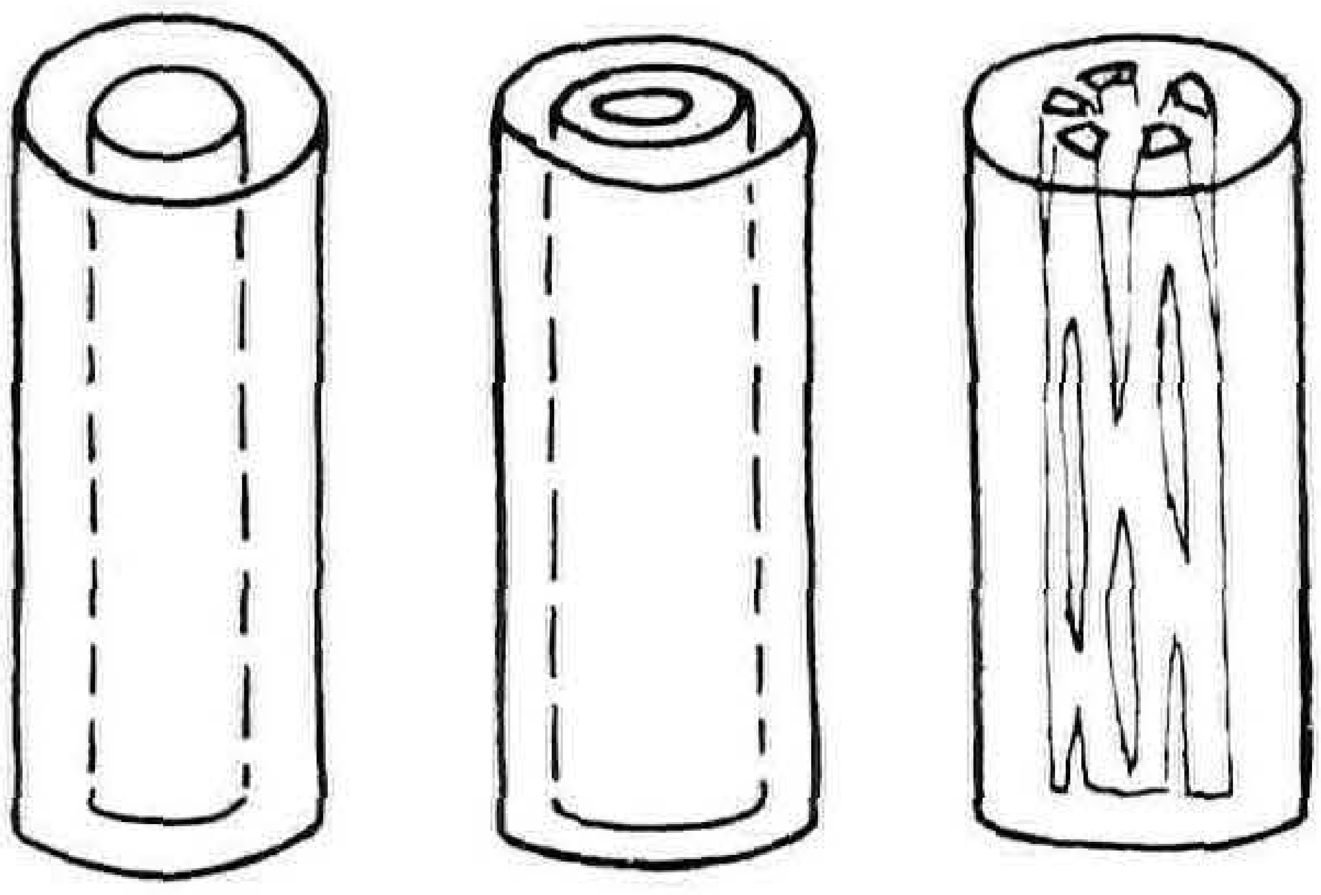

Fig. 1. Major Arrangements of Steles (Vascular Tissue) found in stems.

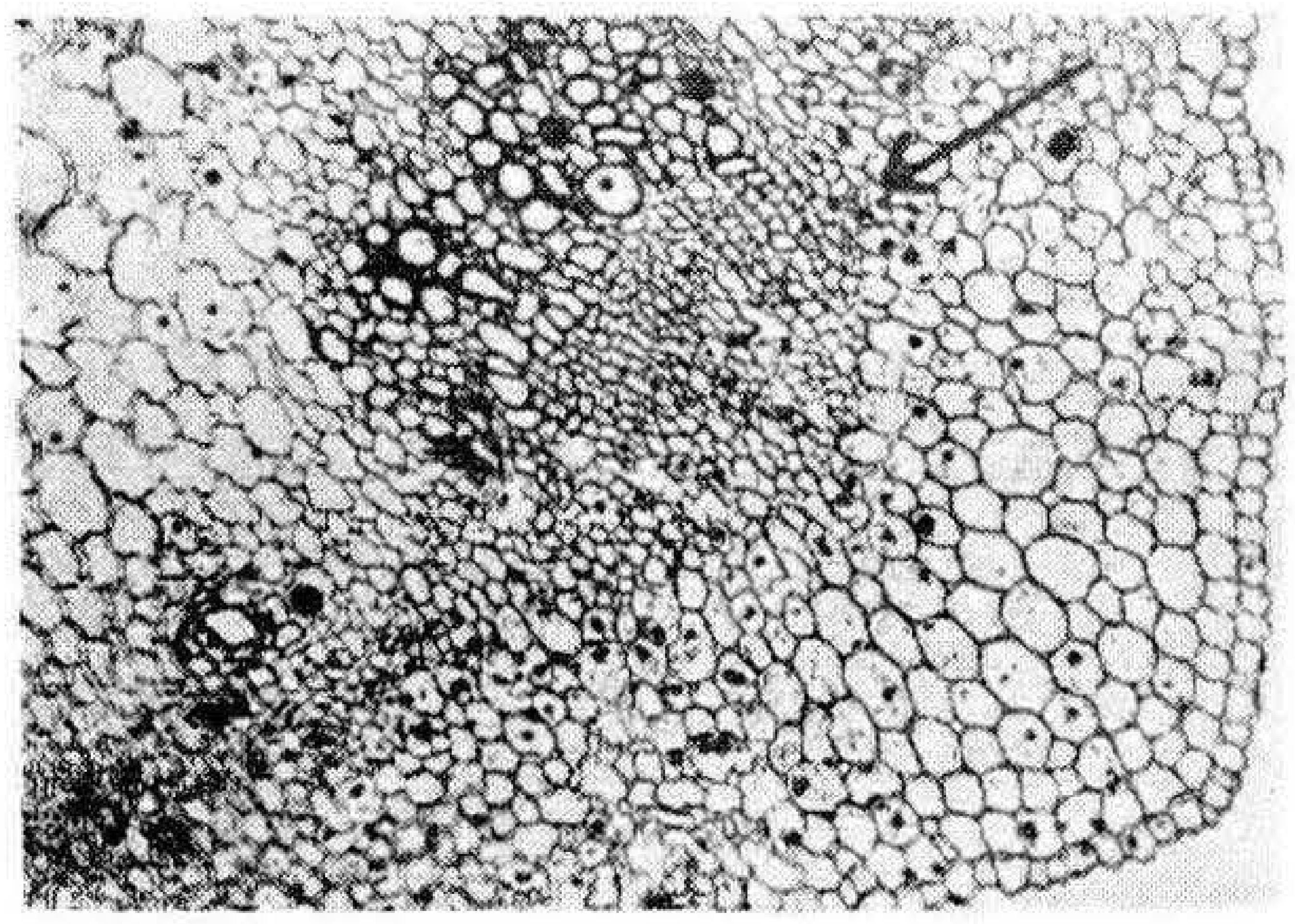

Fig. 2. Section of a chrysantheum stem showing location of root initial (at arrow) in pericyclic parenchyma at flank of a large vascular bundle. (from Stangler)

root primordium. An area of very active cell division develops in the point of this cylinder and the tip of the cylinder is pushed outward through the stem until it finally emerges as the new root. As this new root develops and grows, it reproduces the three concentric cylinders —the epidermis, the cortex and the stele—and each cylinder of the root becomes continuous with the appropriate cylinder of the stem.

Stangler (2) has studied the origin of roots on stem cuttings of the chrysanthemum and the carnation. The three concentric cylinders are recognizable in the small section of the chrysanthemum stem shown in Figure 2. Only one of the five major vascular bundles is shown in the illustration. A small area of cell division, indicated by the arrow, can be seen in the pericycle tissue on the flank of the large vascular bundle. Continued cell division eventually gives rise to a root structure which grows outward through the cortex and the epidermis. Figure 3 shows the stem structure and root origin in a carnation stem cutting. The vascular tissue is a continuous ring and the outer portion of the pericycle has become specialized as supportive fibers. The root primordium has started to develop in the area above the arrow. It will grow outward until it reaches the fibers of the pericycle; then, because of the mechanical barrier, grow downward and emerge through the basal cut surface.

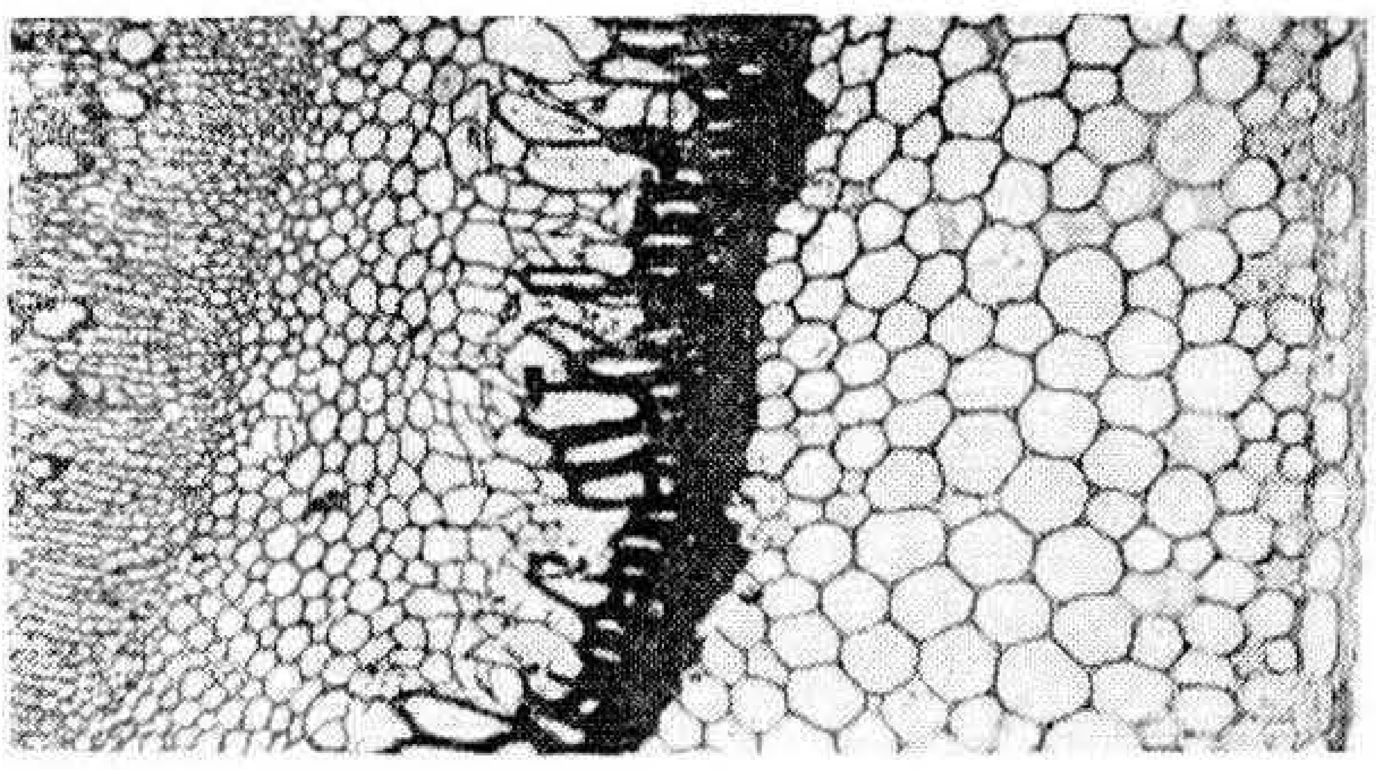

Fig. 3. Section of a carnation stem showing fibers in the outer portion of the pericycle. (from Stangler)

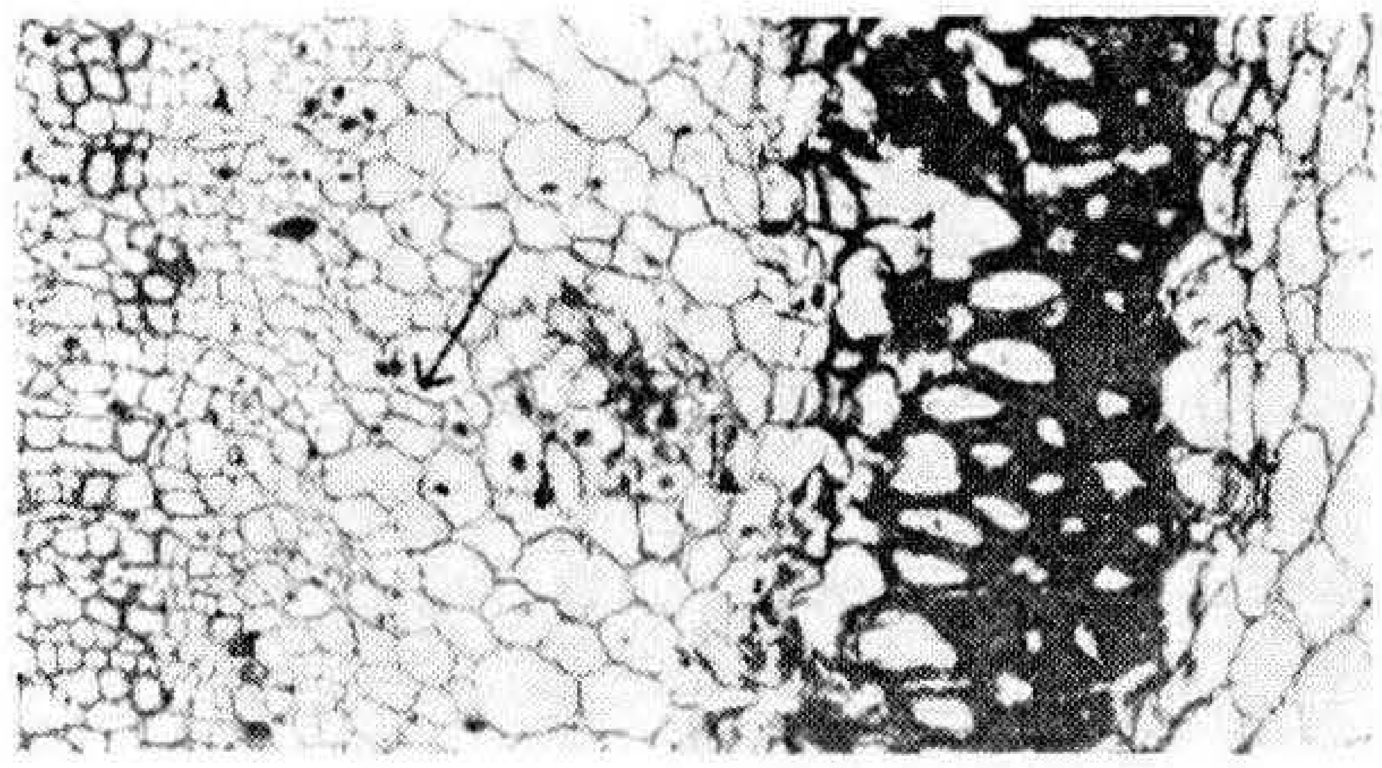

Fig. 4. Section of a carnation stem showing root primordium (above arrow) in pericycle parenchyma. (from Stangler)

Certainly by mid-or late-summer stems of woody plants have become somewhat more complicated by the formation of secondary growth. The cambium has formed and given rise to additional vascular tissue—xlem on the inside and phloem on the outside of the cambium. As these new cells are formed, the cells of the pericycle, cortex and epidermis gradually age, lose their ability to form new cells and are replaced by the bark.

In order to apply the pencil analogy to the stem with secondary thickening, we must imagine that the lead increases in size, thereby pushing the wood and paint cylinders outward. Eventually, as the amount of new lead increases, the wood and paint cylinders will be sloughed off and replaced by a new covering. This new covering is comparable to the bark of the stem.

Hiller (1) has studied the origin of roots in stem cuttings of the Japanese yew (*Taxus cuspidata*). A one-year old stem (Figure 4) has the three concentric cylinders described for the chrysanthemum and carnation—epidermis, cortex and stele. There has been considerable new vascular tissue produced by the cambium, however the cortex and epidermis still remain intact. The vascular tissue is arranged similar to the carnation. In the new vascular tissue there occur radial bands of unspecialized cells (parenchyma), called rays. The root primordium, as can be seen in Figure 5, develops in the portion of the ray located in the phloem. This root primordium grows outward through the stem until it emerges as the new root.

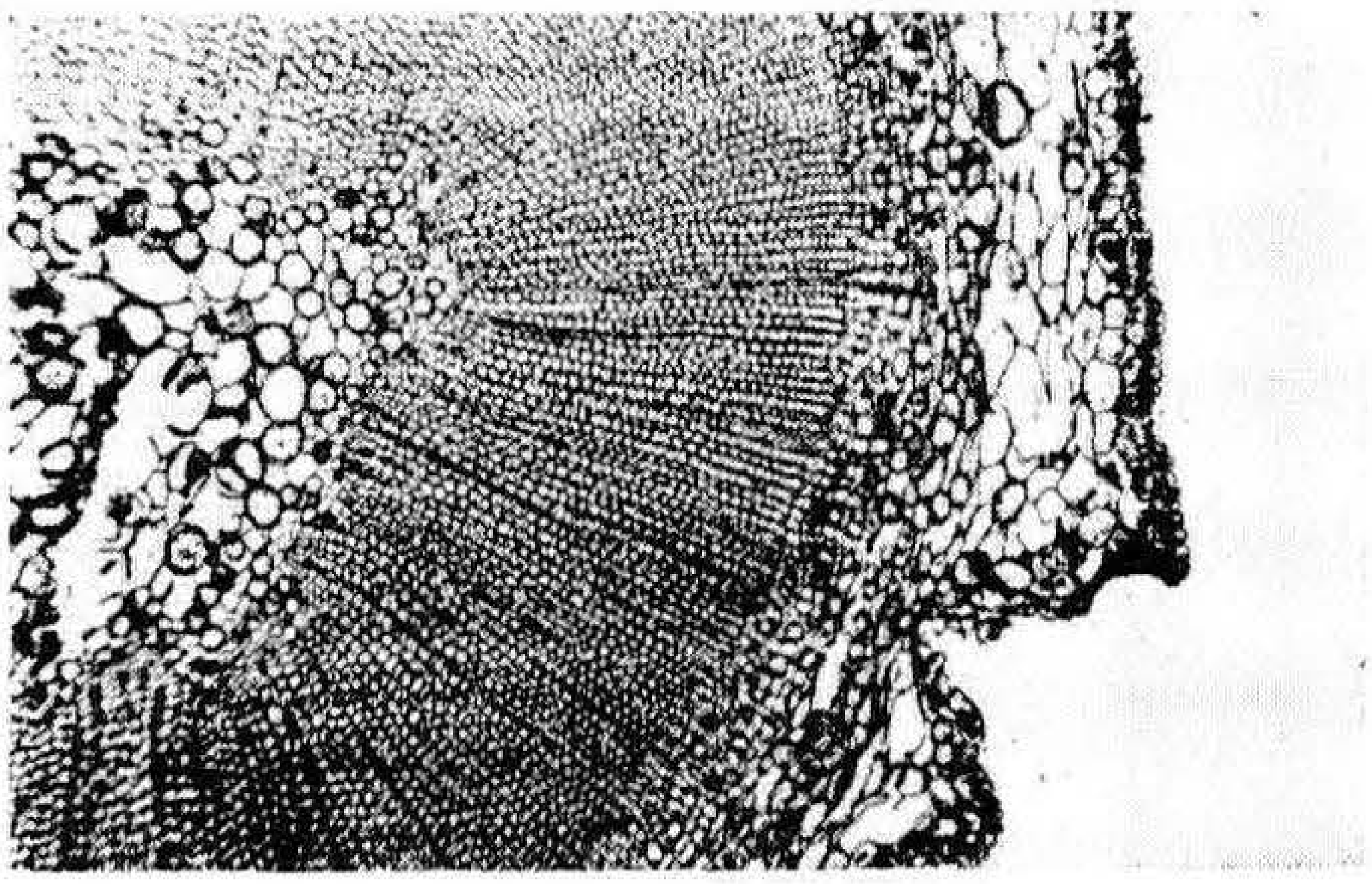

Fig. 5. Section of a one-year old stem of Japanese yew showing secondary vascular tissue formed by the cambium. (from Hiller)

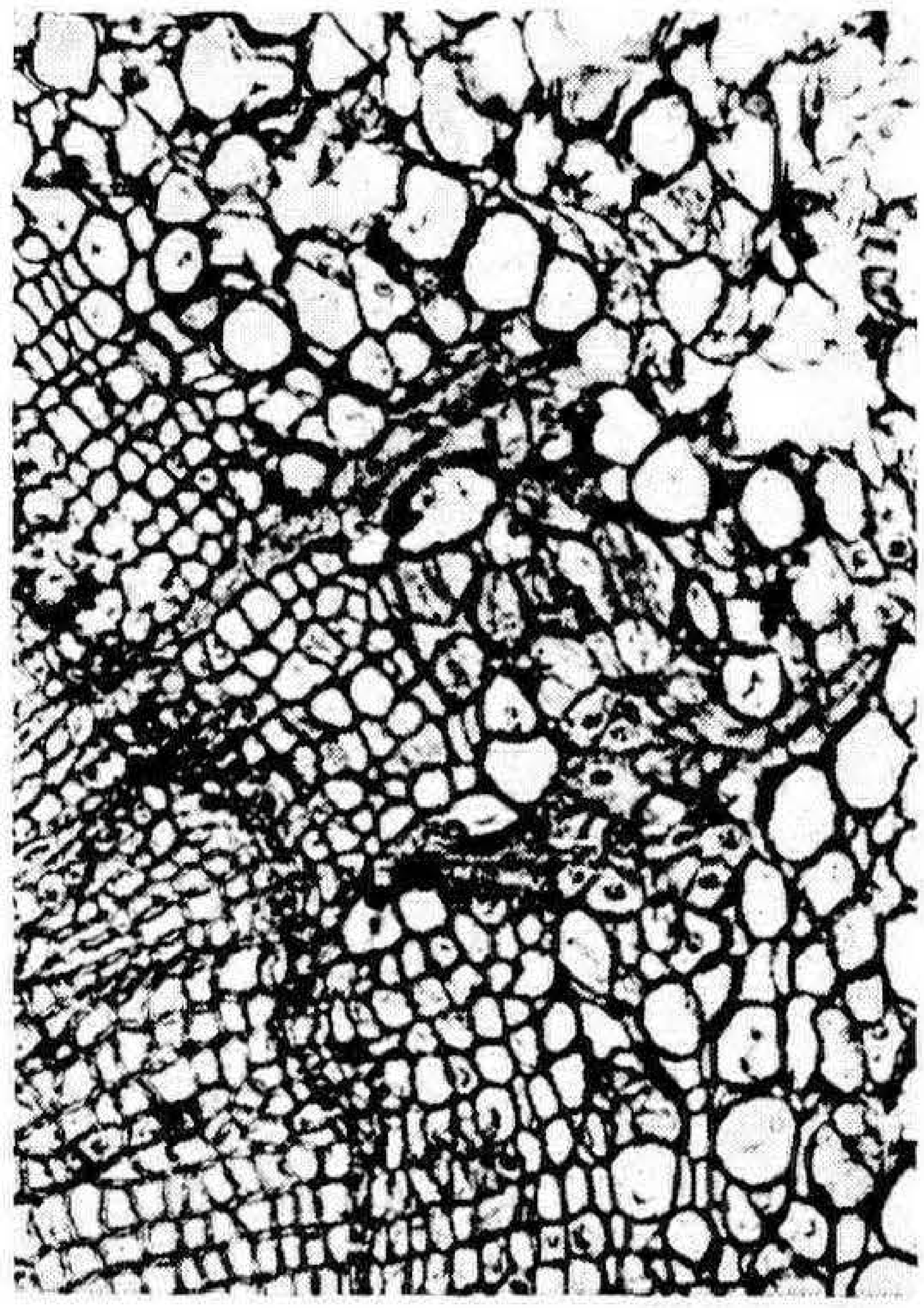

Fig. 6. Section of Japanese yew stem showing developing root primordium in phloem portion of the vascular ray. (from Hiller)

These studies have shown that the first root primordia to form are located just above the cut surface, usually within a quarter of an inch above the cut. Slightly later, root primordia are formed higher on the stem.

The only observed effects of the use of root-inducing chemicals are to increase the number of root primordia formed and to decrease the time required for the primordia to develop. The same tissues are involved regardless of whether or not a chemical stimulant is used.

By way of summary, let us now return to the pencil. Stems which are composed only of primary growth, such as those of herbaceous plants and very young woody stems, are composed of three concentric cylinders: 1) the outer cylinder, the paint of the pencil is the epidermis of the stem; 2) the intermediate cylinder, the wood of the pencil is the cortex of the stem; and 3) the inner cylinder, the lead of the pencil is the stele of the stem. Roots originate in the innermost portion of the intermediate cylinder, i.e., the pericycle portion of the stem which is the wood portion of the pencil nearest the lead.

If secondary growth has occurred, the vascular tissue (the lead of the pencil) has increased in size and contains radial bands of unspecialized cells, called rays. The pericycle (the inner wood portion of the pencil) ages and loses its ability to form new cells. However, the unspecialized ray cells, especially those in the newest phloem tissue, are capable of forming new cells which, under the proper stimulus, will develop into root primordia and eventually into new roots.

REFERENCES CITED

1. HILLER. Charlotte H. 1951. A study of the origin and development of callus and root primordia of *Taxus cuspidata* with reference to the effects of growth regulator. Cornell Univ. MS Thesis. .
2. STANGLER, B. 1956. Origin and devolopment of adventitious roots in stem cuttings of chrysanthemum, carnation and rose. Cornell Agric. Exp. Sta. Memoir 342. 24 p.

PRESIDENT SNYDER: If there are any questions I will be glad to answer them during the question period.

MODERATOR COGGESHALL: The second speaker on the symposium this morning is Mr. James Wells, Wells Nursery. Inc. Red Bank, New Jersey. He will speak to us on Wounding of Cuttings as a Commercial Practice. I also understand Mr. Wells has some slides which he will show at a later date in the program, not this morning. Mr. Wells!

MR. JAMES WELLS: I dislike reading a paper, but when faced with this august assembly I don't think there is any alternative because I want to know precisely what I said.

WOUNDING CUTTINGS AS A COMMERCIAL PRACTICE

JAMES S. WELLS

The practice of wounding plant material as an aid to successful rooting is not a recent development. Textbooks of last century, describing methods to use for layering, say that the stem should be bent into a sharp U where it is fixed to the ground, and that for best results, the stem should be "nicked" at this point. This, of course, is a wound. Burbidge [2], in his book published in 1875, indicates the need for ringing the stem of many plants which are to be propagated by marcottage, a method which may more readily be recognized today as air layering. Old time growers recommended the splitting of the base of carnation stems and Sheat [10] mentions this for cuttings of *Daphne odora*.

Yet, despite the general acceptance of wounding in one form or another in old gardening journals, it is only recently that the method has been tested and applied in a scientific manner to the propagation of a wide range of plant materials.

In searching through the literature, I was not able to find many references until 1932. Day [4], then wrote a most interesting paper in which he showed that the rooting of cuttings of California Privet (*Ligustrum ovalifolium*), *Chaenomeles*, and Muscat grapes was greatly improved by wounding. His results appeared to indicate that wound had a definite effect upon the rapidity and quantity of water absorbed by the unrooted cutting, and furthermore, that the water sue, are capable of forming new cells which, under the proper stimulus, will develop into root primordia and eventually into new roots.

REFERENCES CITED

1. HILLER. Charlotte H. 1951. A study of the origin and development of callus and root primordia of *Taxus cuspidata* with reference to the effects of growth regulator. Cornell Univ. MS Thesis. .

2. STANGLER, B. 1956. Origin and devolopment of adventitious roots in stem cuttings of chrysanthemum, carnation and rose. Cornell Agric. Exp. Sta. Memoir 342. 24 p.

PRESIDENT SNYDER: If there are any questions I will be glad to answer them during the question period.

MODERATOR COGGESHALL: The second speaker on the symposium this morning is Mr. James Wells, Wells Nursery, Inc. Red Bank, New Jersey. He will speak to us on Wounding of Cuttings as a Commercial Practice. I also understand Mr. Wells has some slides which he will show at a later date in the program, not this morning. Mr. Wells!

MR. JAMES WELLS: I dislike reading a paper, but when faced with this august assembly I don't think there is any alternative because I want to know precisely what I said.

WOUNDING CUTTINGS AS A COMMERCIAL PRACTICE

JAMES S. WELLS

The practice of wounding plant material as an aid to successful rooting is not a recent development. Textbooks of last century, describing methods to use for layering, say that the stem should be bent into a sharp U where it is fixed to the ground, and that for best results, the stem should be "nicked" at this point. This, of course, is a wound. Burbidge [2], in his book published in 1875, indicates the need for ringing the stem of many plants which are to be propagated by marcottage, a method which may more readily be recognized today as air layering. Old time growers recommended the splitting of the base of carnation stems and Sheat [10] mentions this for cuttings of *Daphne odora.*

Yet, despite the general acceptance of wounding in one form or another in old gardening journals, it is only recently that the method has been tested and applied in a scientific manner to the propagation of a wide range of plant materials.

In searching through the literature, I was not able to find many references until 1932. Day [4], then wrote a most interesting paper in which he showed that the rooting of cuttings of California Privet (*Ligustrum ovalifolium*), *Chaenomeles,* and Muscat grapes was greatly improved by wounding. His results appeared to indicate that wound had a definite effect upon the rapidity and quantity of water absorbed by the unrooted cutting, and furthermore, that the water absorption through the wound was also affected by the application of a film of clay to the wounded surface. Further tests indicated that it was apparently the finely divided state of the clay particles which produced this effect because similar results were obtained with finely powdered lime.

In 1938, Stuart and Marth [12] published an excellent paper on the rooting of *Ilex opaca* in which they showed that a far better root system was produced when the cuttings were wounded. This result was confirmed by Chadwick and Swartley [3] in 1941.

Two reviews on propagation include brief references to the value of wounding. R. J. Garner [7], in a technical bulletin published in 1944, gives a brief review, while Thimann and Behnke [13], in 1947, give a more complete table of results reported to date. Immediately prior to the last war the Dutch growers in Boskoop were testing the practice widely, and in the first year book of the Boskoop Trial Grounds, [5] published in 1941, there are some most interesting and valuable reports. Work has continued at Boskoop to the present, and for a really definitive survey I can refer you to a most excellent report published this year by the Boskoop Trial Grounds [8], for it combines up-to-date records on wounding together with optimum timing, mediums and hormone treatments.

Now, what are the practical aspects of wounding? First, what do we mean by wounding? A wound can take many forms and it would appear that there is hardly a variation which has not been tried somewhere. Bridgers [1] lists a number of wounds which were tested on rhododendrons, but generally speaking, we are concerned with two types — the so-called light wound, and a heavy wound. The light wound is made by drawing the tip of a sharp knife blade down the base of the stem of the cutting for a distance of about one and a half inches. The cut is not deep, and usually goes through the outer bark and soft cells beneath to touch, but not to deeply penetrate the central woody tissue. This type of wound can be made by the propagator with a knife used for trimming the cutting, but a simple tool can

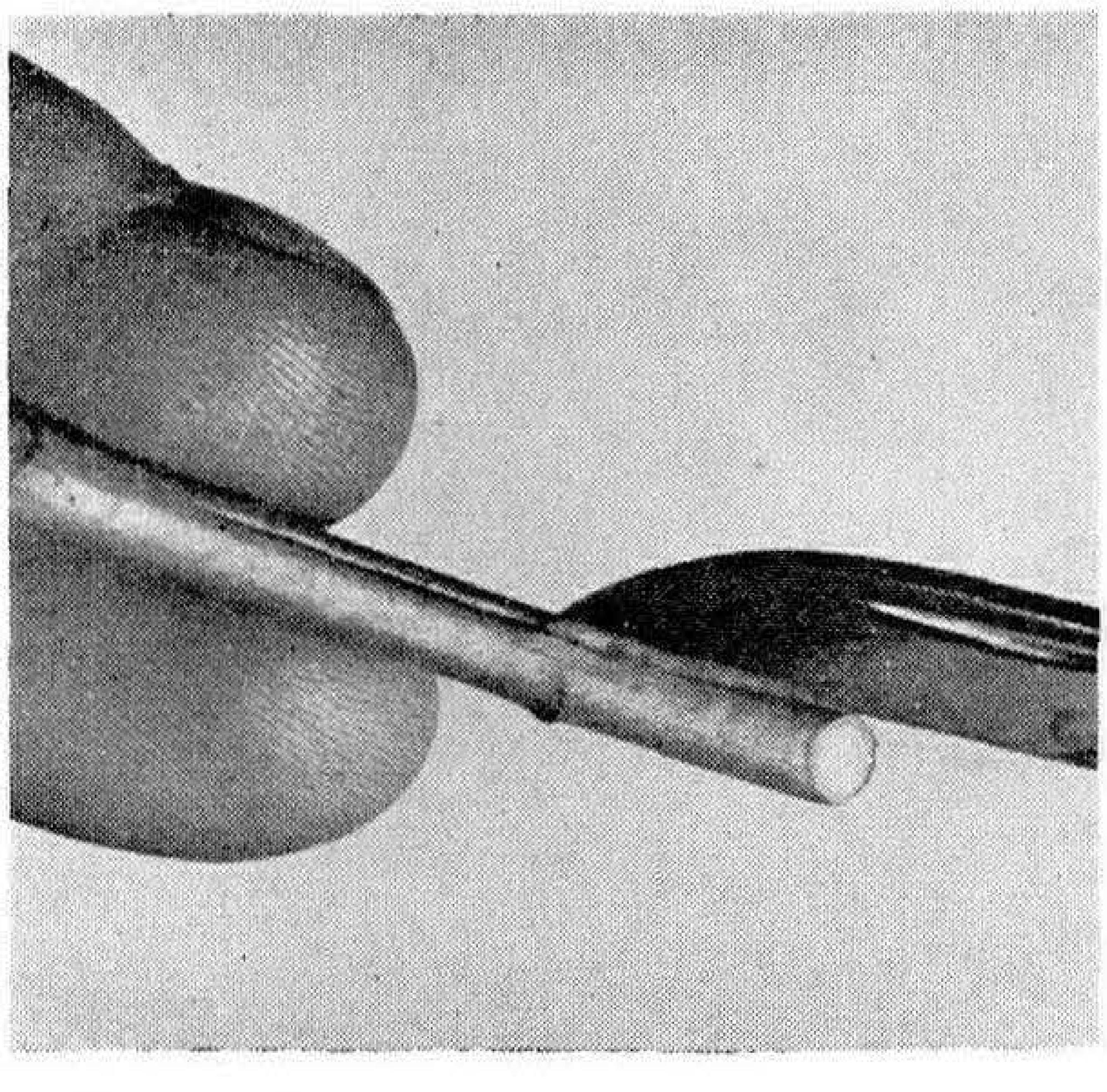

Figure 1. Making a light wound.

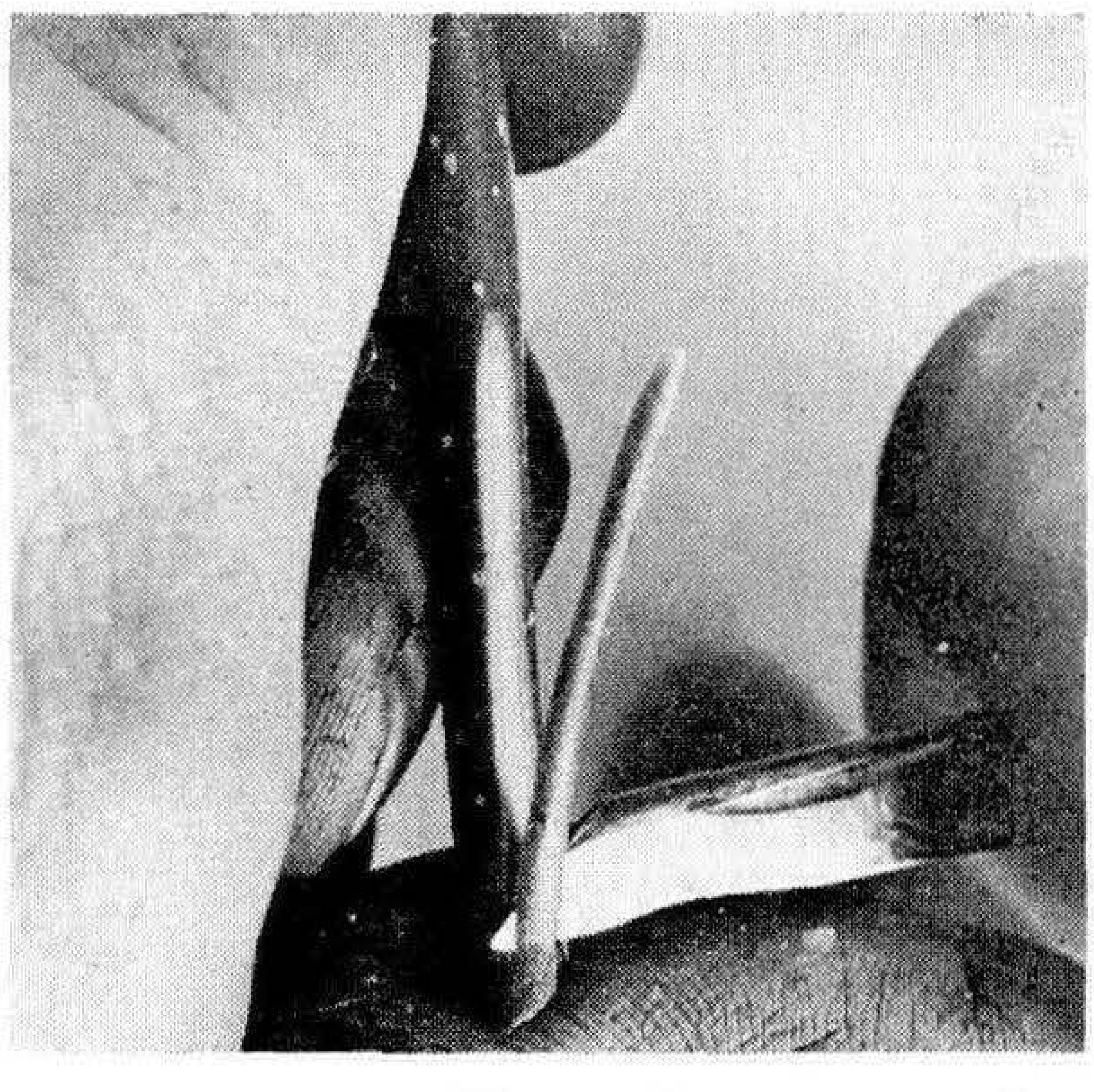

Figure 2. Making a heavy wound.

also be constructed for this purpose by soldering together four single edge razor blades.

A heavy wound is made by removing a thin slice for a distance of about an inch from the side of the stem of the cutting with a sharp knife, cutting through the outer bark and the soft cells beneath to reveal, but not to cut into, the central woody tissue. This heavy wound is sometimes applied twice to opposing sides of the same stem ,and this is known as a double heavy wound.

Why do we wound? Let me say at once that in my opinion wounding will not root any cutting which would otherwise not have rooted, if given sufficient time. It has little effect upon the ultimate percentage of rooting, but it does have a most definite and immediate effect upon the vigor, quality and quantity of roots produced, upon the speed of rooting, and, because of all these things, upon the percentage of plants ultimately produced. I need hardly remind you that, interesting as figures of percentage rooting may be, they can be misleading. A cutting with one small root loosely attached might be considered rooted for statistical purposes; but for practical purposes, it is not. Here then lies the value of wounding. Let me quote an example.

Stuart and Marth [12] treated a number of cuttings of *Ilex opaca* by splitting the base of the stem for a distance of a quarter of an inch with two right angle cuts. The cuttings were then treated with indolebutyric acid at .01% for 18 hours. All cuttings so treated were strongly rooted in 23 days.

We wound, therefore, first to speed up the rooting process; second, to increase the number of roots produced; and third, to improve the points of attachment between the root system and the cutting.

I first came into contact with wounding when I paid a very brief visit to Boskoop in 1946. At the time, the Trial Grounds had been running tests for some years and their first yearbook [5], dated 1941, gave some interesting reports on tests made that year. Example: Cuttings of *Chamaecyparis lawsoniana erecta* were taken on April 18th, and examined on August 26th. The unwounded control had rooted 30% while the wounded batch had rooted 90%.

CHAMAECYPARIS LAWSONIANA ERECTA

	Taken April 18th, 1941	
	Lifted August 26th, 1911	
	Medium Peat and sand	
	Cuttings in the greenhouse	
Control	No treatment	30% rooted
Control	Wounded	90% rooted

By 1942, almost all plants were being tested in Boskoop by wounding, and the yearbook [6] for that year gives much information as to the value of this treatment. Cuttings of *Juniper* pfitzer taken on October 23rd, and lifted on February 4th, showed 43% well rooted on the control, but 93% well rooted when the cuttings had been wounded.

The influence of wounding alone on the percentage of well rooted plants is clearly indicated by a series of tests which I carried out in

1946, immediately after coming to this country [15]. The purpose was to determine whether cuttings with a heel would root better than those without a heel, and whether wounding on either type of cutting would improve rooting. To these series of tests were added additional treatments with various strengths of hormone powders. The plants tested were *Juniper* pfitzer, *Juniper stricta, Thuja globosa,* and *Thuja pyramidalis.* There was a clear picture on all of these plants which can best be illustrated by the following results picked from a mass of information:

JUNIPER PFITZER — Treated with IBA 3 mg/g
Taken December 27th, 1946 — Lifted February 26, 1947
Medium — Half peat, half sand — Bottom heat of 70° F. In greenhouse 8 weeks

With a heel	40% well rooted
Without a heel	56% well rooted
Without a heel, light wound	81% well rooted

JUNIPER STRICTA — No treatment
Taken January 8, 1947 — Lifted February 27, 1947
Medium — Half peat, half sand — Bototm heat of 70° F. In greenhouse 6 weeks 1 day

With a heel	8% well rooted
With a heel and wounded	16% well rooted
Without a heel and wounded	24% well rooted

Combine these effects with a hormone treatment and the same picture is to be seen. For instance,

JUNIPER STRICTA — Treated with 5 mg/cc concentrated dip IBA
Taken January 8, 1947 — Lifted February 27, 1947
Medium — Half peat, half sand — Bottom heat of 70° F. In greenhouse 6 weeks 1 day

With a heel	36% well rooted
With a heel and wounded	52% well rooted
Without a heel and wounded	84% well rooted

THUJA PYRAMIDALIS — Treated with IBA 3 mg/g
Taken January 14th, 1947 — Lifted March 6th, 1947
Medium — Half peat, half sand — Bottom heat of 70° F, In greenhouse 7 weeks

Wth a heel	36% well rooted
With a heel and wounded	68% well rooted
Without a heel and wounded	84% well rooted

There is, therefore, a clear influence from wounding alone, and secondly, an even greater influence when wounding is combined with a suitable hormone treatment.

Why does wounding improve rooting? There seems to be no clearcut answer, for many factors are involved. It was thought at one

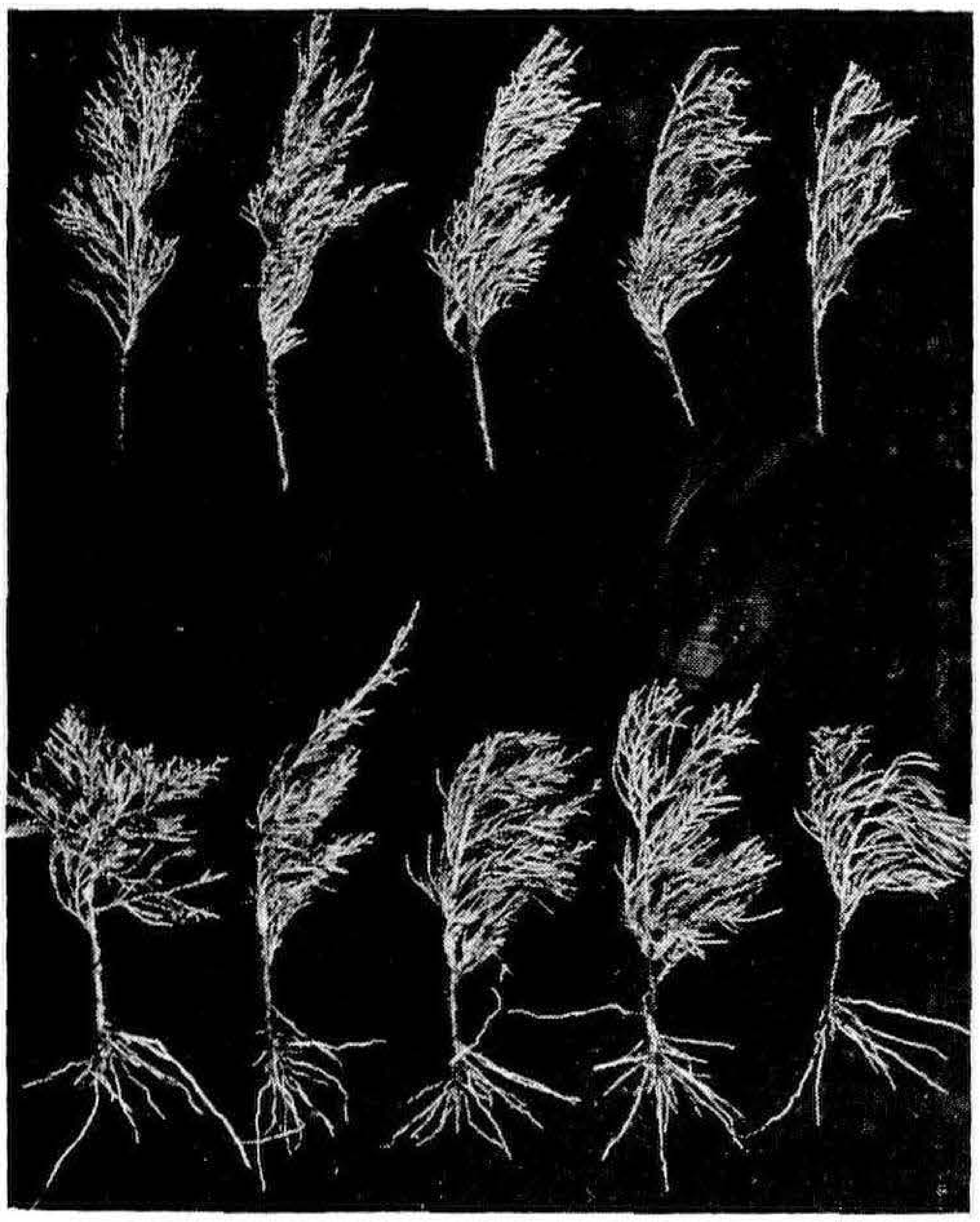

Figure 3. The influence of wounding upon rooting. Upper row—not wounded; lower row—wounded.

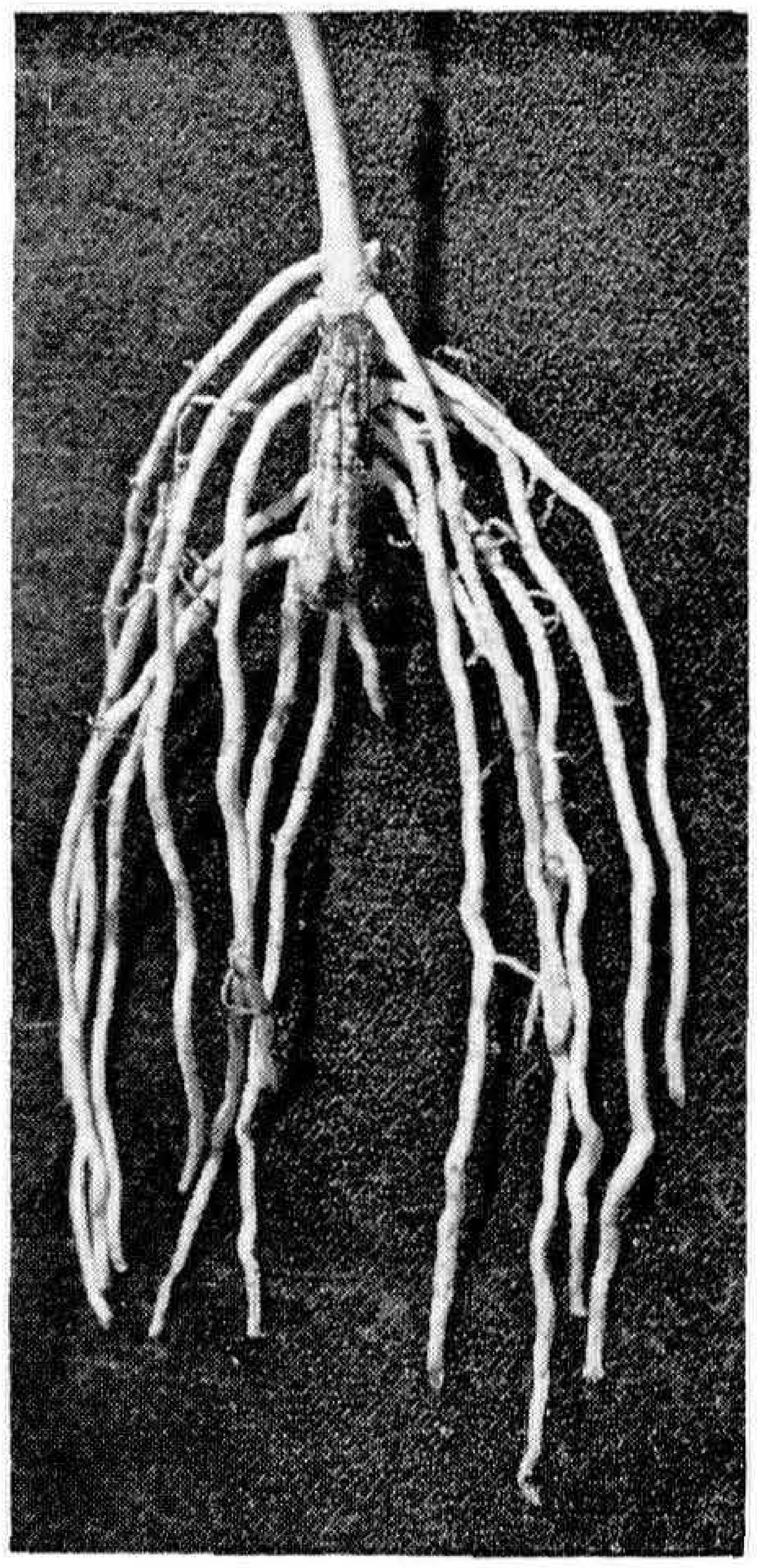

Figure 4. Roots emerging adjacent to heavy wound.

time that a "wound hormone" was produced by the plant which stimulated healing, suberin and callus formation, and thus encouraged rooting. I do not think that this theory has ever been proven. Day [4] showed that the wound clearly influenced the uptake of water by the unrooted cutting and that this water intake was further enhanced by treating the wound surface with a clay-like material. Talc which is used as a carrier for most hormone powders no doubt has a similar effect. The effect of wounding upon the water economy of unrooted cuttings is now being investigated by Dr. Snyder at Rutgers, and we may expect some interesting information from the tests now under way. Snyder [11] also suggests another possible reason for the value of wounding. Many plants have a band of thick walled cells, external to the point of origin of the root. The root grows outward to these cells but cannot grow through them. Some roots may emerge from the base of such a stem, but the number is necessarily limited. A wound, on the other hand, allows free egress for the newly formed roots. It seems to me that the wounding of a cutting must certainly allow for the more rapid and complete penetration of a hormone treatment into the base of the cutting and this has been proven by the effect of wounding upon cuttings of *Taxus Browni*. In tests which I carried out in 1955, the wounding of cuttings of *Taxus Browni* followed by a fairly strong hormone treatment produced an excessive and unnatural root system, while the same treatment applied to unwounded cuttings produced an adequate and more normal rooting system. In parenthesis I would add here that the whole *Taxus* group appear to be plants upon which wounding is not really necessary.

I believe that the real value of wounding lies in two clear areas. The first is the improvement of the root system on a plant which normally produces a somewhat sparse root system. In this group practically all of the conifers must be included. Those of you who have wounded and compared the root system on *Juniper* pfitzer with unwounded cuttings will know what I mean. The second area in which it is of real value is to aid in the rooting of really difficult subjects, and as an example, I would give rhododendrons. Now is seems so commonplace at this time to root rhododendrons that you may wonder why I place this plant in the difficult category. But, it is no longer difficult because we have learned how to grow them. A review of the methods was given in our first proceedings [14]. In order to root rhododendrons and obtain a good percentage of sound root systems well attached to the cutting, we have to use every aid at our command, including, in particular, wounding. We must take cuttings of the right kind at the right time. We must wound them with a double heavy wound. We must treat them with an appropriae hormone powder and set them in the right medium. We must provide a continuously and carefully controlled set of conditions by the use of mist, bottom heat, and good drainage; and if we do this in the proper manner, good rooting will result. Omit any one of these factors and rooting becomes poor. We can wound and not treat with hormones and rooting is uneconomically slow. We can treat with hormone powders and not wound and results will be poor. We can do both of these things

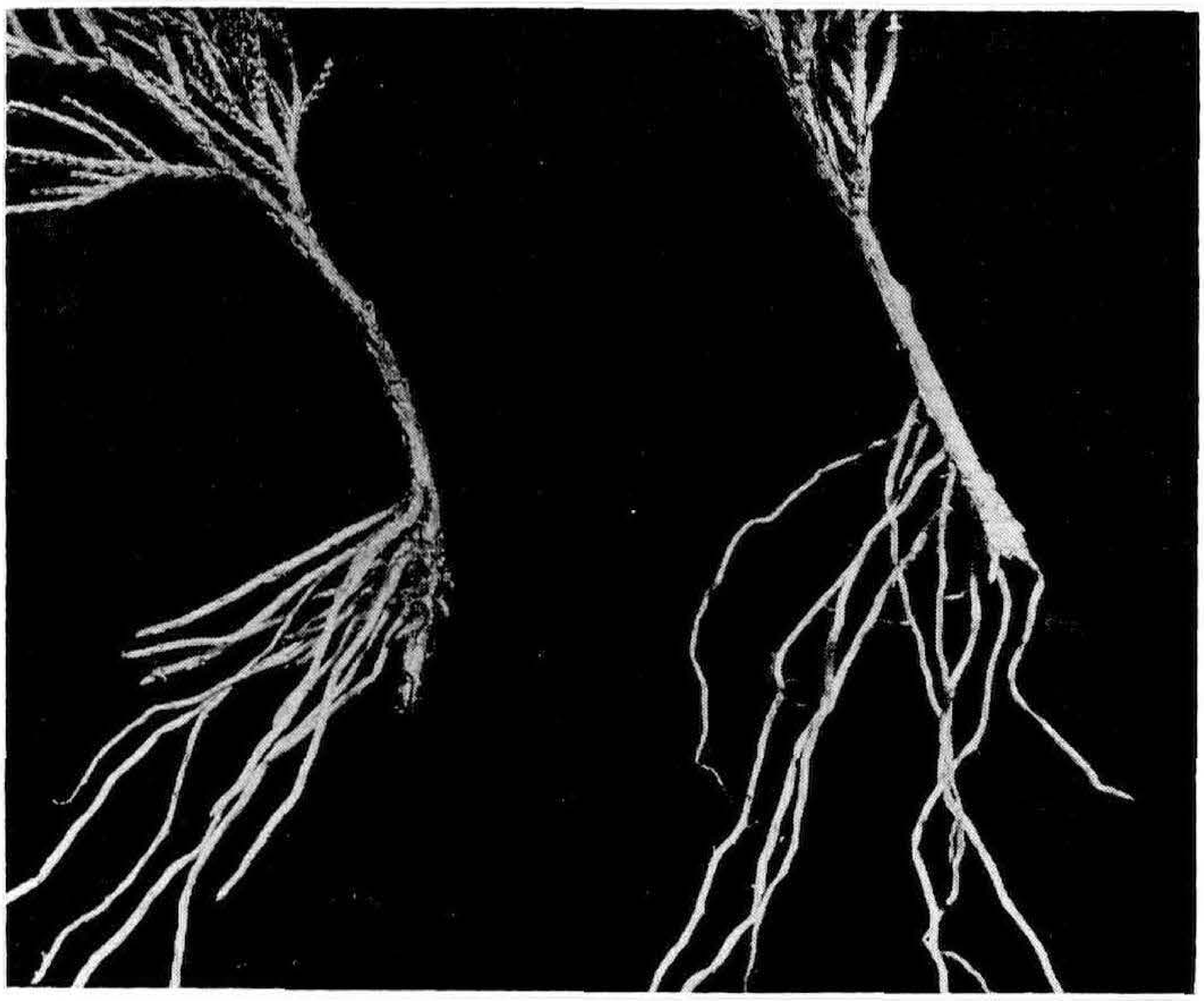

Figure 5. Roots emerging from a heavy wound.

and not provide mist or some other means of control of water loss, and obtain low percentages. If we take the wrong kind of cutting at the wrong time, and do everything else, the results are equally poor. So, here we have a plant in which a whole series of requirements have to be accurately met if we are to propagate it successfully. As suggested by Nearing [9], wounding is a vital and integral part of this chain of events. Without it we could not possibly succeed.

It is interesting to note here that the depth of the wound is apparently of some importance on rhododendrons. In 1959 we ran a series of tests on cuttings of *Rh Catawbiense* Boursault to determine the effect on the root system of a very shallow, a medium, and a very deep wound. The wound in all cases was the so called double heavy wound, wherein two slices were removed from the base of the cutting. The only difference was in the depth of the cut. On the very shallow wound, only the thinnest possible shaving was removed, and certainly none of the central woody tissue could be seen. On the medium wound the cuts were made down to, but not into, the central woody tissue, while on the deep wound the cuts went quite deeply into the woody center. Cuttings were then all treated with similar hormone powders and inserted on December 17th. They were lifted for evaluation in February 16th. Rooting was evaluated numerically on the basis of quantity and state of development. In all tests there was a clear indication that the very deep wound was detrimental and while in most cases all cuttings finally rooted 100%, the quality of the rooting was clearly superior on those given a very shallow or a medium wound.

I am glad to be able to add to this brief paper part of the list compiled and published this year by the Trial Grounds at Boskoop, Holland. This table lists a wide range of plants, recording the best time to take the cuttings; the best mediums to use; whether the cuttings should be wounded or not; and the optimum hormone treatment for successful propagation. You will see from this list that a very substantial number respond to wounding.

To conclude, if you are having difficulty in propagating any plant from cuttings, it is well to consider how best to marshall the many aids at our disposal — one by one — until you have assembled sufficient "propagating power" to achieve success. Wounding is one of the most important of these aids, for on many plants it can make the difference between indifferent failure and resounding success.

Name	Time	Medium	Wound	Hormone Treatment
Acer. palm atropurpureum	May-June	4P IS	H	IBA 2%
Acer. palm Dissectum	May-June	2P IS	H	NA .1%
AZALEA Mollis	May-June	P	L	
BERBERIS JULINAE	Oct.-Nov	2P IS	H	IBA 1%
" Thun atro nana	Aug.	2P IS	L	IBA 1%
CAMMELLIA JAPONICA	April or July	4P IS	H	IBA 1%
Chaenomeles Simonii	June-July	2P IS	H	IBA 1%
CHAMAECYPARIS obtusa nana gracilis	Oct-March	4P IS	L	IBA 100 mg/l
" Pisifera Boulevard	Oct.-March	4P IS	L	IBA 100 mg/l
CLEMATIS jackmanii	May-June	2P IS	L	NA .01%
CORNUS FLORIDA RUBRA	July	2P IS	H	IBA 1%
COTINUS COGGYRIA RUBRIFOLIUS	May-June	2P IS	L	IBA 1/2%
COTONEASTER HORIZONTALIS	July	IP 2S	L	IBA 2%
" PRAECOX	July-Aug	2P IS	L	IBA 2%
CRYPTOMERIA JAP. BANDAI SUGI	Sept.	2P IS	L	NA 25 mg/l
CYTISUS PRAECOX	Sept.	IP 4S	L	NA 50 mg/l
DAPHNE SOMERSET	Aug.-Sept	IP 4S	L	IBA 1%
ILEX AQUIFOLIUM	July-Aug.	2P IS	H	IBA 1% or IBA 2%
ILEX OPACA	July-Sept	2P IS	H	IBA 2%
JUNIPER STRICTA	Oct.-March	4P IS	L	IBA 2%
JUNIPER PROCUMBENS	Oct.-March	2P IS	L	NA 25 mg/l
" SINENSIS MOUNTBATTEN	Oct.-March	2P IS	L	NA 25 mg/l
" VIRGINIANA GLAUCA	Oct.-March	2P IS	L	NA 100 mg/l
MAGNOLIA DENUDATA	July	2P IS	H	IBA 2%
" SOULANGEANA	July	2P IS	H	IBA 1%
" STELLATA	June-July	4P IS	H	IBA 2%
METASEQUOIA GLYPTOSTROBOIDES	July	2P IS	H	NZ .1%
PHILADELPHUS CORONARIUS AUREUS	June	2P IS	H	IBA 1%
PICEA PUNGENS KOSTERI	Aug.	2P IS	H	None
PRUNUS CISTENA	June	2P IS	H	IBA 1/2%
PYRACANTHA LLANDII	Aug.	2P IS	H	IA 1/2%
RHODODENDRONS	July	P	H	IBA 2% Many varieties are listed. Treatments range from 1/2% IBA to 4% IBA
SPIREA ARGUTA	May-June	4P IS	L	IA 50 mg/l
THUJA OCC. VARS	Oct.-April	4P IS	L	NA 50 mg/l
VIBURNUM BURKWOODII	June-July	IP IS	H	IBA 1%
WISTERIA SINENSIS	July	2P IS	H	IA ½%

It should be remembered that this data is correct for plant materials and conditions in Boskoop, Holland. Timing, optimum treatment and optimum medium may have to be adjusted to local conditions.

BIBLIOGRAPHY

1. BRIDGERS, B. T. 1952
Studies of factors inhibiting the rooting of rhododendrons.
Oct. 1952 Bulletin — American Rhododendron Society.
2. BURBIDGE, F. W. 1875
The propagation and improvement of cultivated plants.

3. CHADWICK, L. C., AND SWARTLEY, J. C. 1941
Further studies on the effect of synthetic growth substances on cuttings and seed.
Proc. Am. Soc. Hort Sci. 38-690-694.
4. DAY, LEONARD H. 1932
Is the increased rooting of wounding cuttings sometimes due to water absorbtion?
Proc. Am. Soc. Hort. Sci. 29- 350-351.
5. DE PROEFTUIN TO BOSKOOP 1941
6. DE PROEFTUIN TO BOSKOOP 1942
7. GARNER, R. J 1944
Propagation by cuttings and layers. Some recent work and its application with special reference to pome and stone fruits.
IAB Technical Communication #4
8 HET STEKKEN VAN BOOMKWERKERIJ GEWASSEN. BOSKOOP 1962
9. NEARING, G. G 1953
How the side slice cutting came to be.
April 1953 Bulleitn — Am Rhodo. Soc.
10. SHEAT, WILFRED 1948
Propagation of trees(shrubs, and conifers. p. 137.
11. SNYDER, W. E. 1954
The rooting of leafy stem cuttings.
Nat. Hort. Magazine. Jan 1954.
12. STUART AND MARTH 1938
Comparison of rooting American Holly cuttings as affected by treatment with indolebutyric acid.
Proc Am. Soc. Hort. Sci 35 - 839-844.
13. THIMANN AND BEHNKE 1947
The use of auxins in the rooting of woody cuttings.
Harvard Forest. Bulletin #1.
14. WELLS, J. S. 1951
1st Proceedings. Plant Prop. Society Page 12.
15. — — — — — 1955
Plant Propagation Practices Pgs. 93-96

MODERATOR COGGESHALL: Thank you very much, Jim.

We will now go on to the next speaker, Dr. Sidney Waxman, University of Connecticut, Storrs, Connecticut, who will speak on the subject of Physiology of Evergreen Cuttings from Collection Through Rooting. Dr. Waxman!

DR. SIDNEY WAXMAN: I, too, do not like to read from a paper, but I have a feeling I will be sticking my neck out on some of these statements I am going to make and I would rather be confined to those statements than any I might make beyond that.

THE PHYSIOLOGY OF AN EVERGREEN CUTTING FROM THE TIME IT'S TAKEN UNTIL THE TIME IT IS ROOTED

SIDNEY WAXMAN
Plant Science Department
Storrs Agricultural Experiment Station
University of Connecticut

To thoroughly cover such a topic as this, the physiology of evergreen cuttings from time of taking to time of rooting would, of course, take considerably more time than 20 minutes. When I accepted the request of our program chairman to give this talk, I didn't realize just

3. CHADWICK, L. C., AND SWARTLEY, J. C. 1941
Further studies on the effect of synthetic growth substances on cuttings and seed.
Proc. Am. Soc. Hort Sci. 38-690-694.
4. DAY, LEONARD H. 1932
Is the increased rooting of wounding cuttings sometimes due to water absorbtion?
Proc. Am. Soc. Hort. Sci. 29- 350-351.
5. DE PROEFTUIN TO BOSKOOP 1941
6. DE PROEFTUIN TO BOSKOOP 1942
7. GARNER, R. J 1944
Propagation by cuttings and layers. Some recent work and its application with special reference to pome and stone fruits.
IAB Technical Communication #4
8 HET STEKKEN VAN BOOMKWERKERIJ GEWASSEN. BOSKOOP 1962
9. NEARING. G. G 1953
How the side slice cutting came to be.
April 1953 Bulleitn — Am Rhodo. Soc.
10. SHEAT, WILFRED 1948
Propagation of trees(shrubs. and conifers. p. 137.
11. SNYDER, W. E. 1954
The rooting of leafy stem cuttings.
Nat. Hort. Magazine. Jan 1954.
12. STUART AND MARTH 1938
Comparison of rooting American Holly cuttings as affected by treatment with indolebutyric acid.
Proc Am. Soc. Hort. Sci 35 - 839-844.
13. THIMANN AND BEHNKE 1947
The use of auxins in the rooting of woody cuttings.
Harvard Forest. Bulletin #1.
14. WELLS, J. S. 1951
1st Proceedings. Plant Prop. Society Page 12.
15. — — — — — 1955
Plant Propagation Practices Pgs. 93-96

MODERATOR COGGESHALL: Thank you very much, Jim.

We will now go on to the next speaker, Dr. Sidney Waxman, University of Connecticut, Storrs, Connecticut, who will speak on the subject of Physiology of Evergreen Cuttings from Collection Through Rooting. Dr. Waxman!

DR. SIDNEY WAXMAN: I, too, do not like to read from a paper, but I have a feeling I will be sticking my neck out on some of these statements I am going to make and I would rather be confined to those statements than any I might make beyond that.

THE PHYSIOLOGY OF AN EVERGREEN CUTTING FROM THE TIME IT'S TAKEN UNTIL THE TIME IT IS ROOTED

SIDNEY WAXMAN
Plant Science Department
Storrs Agricultural Experiment Station
University of Connecticut

To thoroughly cover such a topic as this, the physiology of evergreen cuttings from time of taking to time of rooting would. of course, take considerably more time than 20 minutes. When I accepted the request of our program chairman to give this talk, I didn't realize just how difficult it would be merely to decide on *how* to present it. Also, John was clever enough to make this request well in advance of the meeting. Six months seemed so far in the future that it was very easy to agree.

However, I've decided to present this talk by discussing the status of growth of the cutting at the time it's taken and how it may have some bearing on its ability to initiate roots.

Concerning the physiology of the cutting itself, the ideal situation for rapid root initiation would be one in which the following conditions exist:

1. The presence in the stem of young cells that can quickly be induced to become meristematic.

As you have heard from Bill Snyder's presentation, it is necessary that certain cells near the base of the cutting become meristematic, and start dividing as the first step in the construction of an organized root.

2. The second condition is the need for a reserve of carbohydrates. The process of growth which includes cell division and enlargement can proceed only if there is a constant source of energy. The source of energy is derived from the oxidation of sugars that are synthesized by the leaves. If the supply of these carbohydrates is limited, rooting will also be limited.

3. The third condition is: *The presence of a balance of all the substances necessary for rooting to occur.*

In 1934 it was demonstrated by Went (1934) that auxin was highly effective in controlling root initiation.

More recently it was found that not only auxin, but other materials produced by the leaves were also required. Among these were certain vitamins and some organic nitrogen compounds. Hess (1961) working with English Ivy has shown evidence of four additional cofactors, all of which apparently have to be present for root initiation to occur. The lack, or inbalance of one or more of these substances could prevent or delay rooting.

To put it all in fairly simple terms, rooting occurs as a result of the following course of events:

Substances made in the leaves and buds flow down and accumulate near the base of the cuttings, where they cause certain cells or group of cells, to start dividing. The energy necessary for all this work to occur is derived from the reserve of carbohydrates originally synthesized in the leaves and translocated to the place where the roots are being initiated. Unfortunately, it is only rarely that we find all of these conditions operating at the same time and at an optimal level.

In spite of the fact that at a particular time one of these conditions may be below the desired level, it is still possible to encourage rooting. This can be accomplished by the appropriate treatment of the cutting and by controlling the environment during rooting. Actually it is really not this simple. We know of the considerable variability that exists among different species, not to mention differences among varieties within a given species. We also know that even within a clone the degree of rooting will vary according to the time of the year, the age of the plant, the age of the cutting, the selection of juvenile or mature wood, the position on the plant, the nutrition of the plant, etc. It becomes necessary to be familiar with the characteristics of the plant we are working with in order to develop the most effective method of propagating it, and this, of course, is where experience really helps.

Generally speaking, the time of the year, and the temperatures and daylengths that correspond with it, appears to have the most consistent controlling influence on the physiology of the plant. When selecting cuttings to be rooted, we certainly must consider this and how it may effect rooting.

Perhaps it would be more accurate to consider the stage of growth of the stock plant rather than the time of the year, since many evergreens start their vegatative growth at various times and often at repeated intervals.

I've grouped the various stages of growth into four categories according to their physiolgical and anatomical status.

The first category, to which I refer as the *active growth stage*, concerns the period during which growth in length is occurring. Cuttings taken of these shoots are composed of tender stem tissue with thin leaves. There is a high rate of meristematic activity, the cells are actively dividing and elongating, hormone production is at a relatively high level, and the cells at the base of the stem are young enough to be quickly reactivated, i. e. to become meristematic ones again and to divide and produce masses of cells that will eventually develop into roots. Internally, they appear to be ideally suited to initiate roots in a fairly short period of time.

However, at this very early stage of growth, there is a low supply of reserve foods. Considerable energy is needed for the development of the new shoot. This is derived from both the stored carbohydrates of the stock plant and from the leaves of the new shoot that are capable of photosynthesizing, although at a relatively low rate. Also, the new shoot with its thin and not fully expanded leaves has not been in existence long enough to synthesize a surplus of sugars.

In other words, most of the carbohydrate entering the new stem via translocation and by photosynthesis is most likely used up as a source of energy needed for the growth of the stem. The net result is a low reserve of foods.

The second category is the *summer dormant stage*. During this period the rate of cellular activity has declined and growth in length has come to a halt while photosynthesis goes on at a high level.

The great demand of energy for cell growth has subsided and, consequently, the content of carbohydrate within the stem increases with time. During this period the plant catches up with itself, cell walls become thicker and both the leaves and stems increase in thickness and in rigidity. A layer of cutin is gradually being deposited over the leaves and, on the whole, the shoot is beginning to harden off.

The terminal and lateral buds appear to be dormant at this time, but with many evergreens this is only temporary. Additional spurts of growth may occur during mid and late summer.

The third category is the *winter rest stage;* here, all active growth in length has come to a halt. The leaves are thicker, and have a heavy layer of cutin. The stems are more rigid and of greater diameter. There is a relatively low rate of cellular activity.

The terminal and lateral buds are in winter rest and usually will not grow unless given a period of low temperature or long photoperiods. Hormone production is approaching its lowest level while certain growth inhibiting materials are at their highest level. Because of the cessation of growth the need for energy has decreased, and, as a consequence, the carbohydrate supply is at its highest level.

The fourth stage of growth referred to as the *revival stage* for lack of a better name, is one in which the cuttings are dormant but have been exposed to low temperatures.

Anatomically there appear to be no differences existing between cuttings of the *winter rest stage* and those of the *revival stage.* Physiologically, however, there have been changes brought about in the buds by exposure to the low temperatures.

In comparing the physiological and anatomical status of these four categories, we find that insofar as rooting is concerned, there are both favorable and unfavorable factors with each one. It is necessary that we first consider the various stages of growth mentioned and the anatomical and physiological status associated with them. We must then make a decision on how to handle such cuttings to make up, somehow, for the lack of one or more of the conditions necessary for rooting to occur.

In propagating cuttings during the *active growth stage,* we have a sort of dilemma. On one hand we have tissue that appears to be perfect for the rapid initiation of roots, i. e. relatively high concentration of rooting factors, and cells young enough to quickly be induced to initiate roots, but we do not, on the other hand, have a sufficient storage of foods to serve as a source of energy for this to occur. It becomes necessary, therefore, to expose the leaves to bright sunlight to manufacture these foods, but this brings up a problem concerning moisture. Shoots as tender as these will lose water from the leaves in bright light faster than it can be replaced through the stem.

The leaf has not as yet developed the wax-like protective layer of cutin over its surface. The cells have not begun to form the secondary walls that would aid in supporting both the stem and the leaf. Cuttings taken at this stage of growth would very quickly wilt. It would be necessary to place them under a fairly heavy shade to slow down their loss of water. However, this would be detrimental, because the degree of shade necessary to keep the cuttings moist would be so dense as to permit too low an intensity of light for the leaves to use as a source of energy for a sufficent rate of photosynthesis. As a result under these low light conditions, the level of carbohydrates would soon be depleted and the cutting would collapse.

The solution of these two problems inherent in the rooting of tender cuttings came about through the development of mist propagation. Under mist, the cuttings are kept cool and wet, and in these conditions they do not wilt but remain turgid in spite of being exposed to high intensities of sunlight. Because no heavy shade is required, the cuttings can synthesize sugars that can be used as a constant source of energy necessary for the production of roots. The addition of synthetic auxins here would depend on the species involved. Although there is a peak of auxin production during this stage, the quantity necessary to induce rooting may within certain species be greater than what has accumulated at the base of the stem

Cuttings during *winter rest* present an entirely different problem. Two factors that may play a part in delaying rooting are:

1. The decreased production of auxin and other rooting co factors that correspond with decreased cellular activity in the buds and leaves and,

2. The relatively high level of inhibiting substances that are present at this stage of growth. The advantages of taking cuttings at this time are that the reserves of carbohydrates are at a high level and the ability of the leaf to lose excessive water is reduced.

Mist propagation at this stage is, therefore, not a necessity. A plastic tent, double glass, or a cold frame, could be used. The shading necessary for all of these methods could be applied without seriously causing a depletion of carbohydrates. To offset these factors that may delay or prevent rooting, we can apply synthetic auxins and bottom heat as well as wound it as a means of inducing the "dormant" cells at the base of the stem to become meristematic once again. Another thing that we can give them is time, and according to the rooting response of certain evergreen species, this becomes a necessity.

The *summer dormancy* stage of growth presents a situation that is intermediate of the *active* and the *winter rest stage* both physiologically and structurally.

Determining the most effective method of handling cuttings taken at any particular time during this stage would require some experience with the species used.

Perhaps the most important factor to be concerned with in deciding whether to root them under mist or plastic is their carbohydrate reserves. Cuttings high in reserves can be rooted under higher temperatures and lower light intensities as you would have in a plastic tent. Cuttings that appear to be low in reserves would have a better chance if they were rooted under higher intensities and at cooler leaf temperatures.

The extent of the accumulation of these carbohydrates depends on the length of time that elapsed since growth in length stopped as well as the conditions under which the stock plant had grown.

The taking of cuttings in the *revival stage* should be limited to those species known to initiate roots more rapidly at that time than at any other period. Because the rest within the buds has been overcome, the terminals will hasten to grow once they are exposed to warm temperatures.

Taxus cuttings taken at this time would very quickly make a top growth usually at the expense of the roots. The taking of Taxus cuttings should be carried out before the rest in the buds has been completely broken. The Umbrella Pine, on the other hand, will initiate roots more readily during this stage than at any other.

The possibility exists that substances effective in promoting rooting are produced by the buds after exposure to a long period of low temperature. Also, growth inhibitors, known to be present in buds during the winter, are usually destroyed by early spring. Rooting may come about as a result of both of these occurrences.

The rooting of cuttings in this stage of growth might best be accomplished by mist with the addition of bottom heat to encourage the roots to develop before the top does.

To summarize, I've discussed the status of the evergreen at four different stages of growth. In the first, the *active growth stage*: A high level of auxins and possibly other root-inducing substances is associated with active cell multiplication in the terminal buds and leaves. During this period the cells within the newly developed tissues are of a primary type, i. e. they can quickly become meristematic and proceed to develop into an organized root system. The carbohydrate content at this point is, however, at its lowest level and, because of this, rooting may not be possible. The recommendation for rooting such cuttings is to place them under mist with little or no shade.

The second category, the *summer dormant stage,* is one in which the rate of cell multiplication in the terminal buds has come to a temporary or permanent halt for that season. Associated with this is the decrease in the production of auxins and other rooting factors. Anatomically the cutting at this stage is intermediate to those of the *active growth* and the *winter rest stages.* Carbohydrate reserves are greater here than during *active growth*, but less than if they were in *winter rest.*

The third category, that of *winter rest* is one in which growth of the terminal bud has stopped. Associated with this is the auxin content which is at its lowest level. Also at this time inhibiting substances present in the buds and leaves are at their highest level. The tissue cells at the base of the stem is composed mostly of older secondary cells that are more difficult to re-activate. However, the carbohydrate reserve is at its highest level and would serve as a good source of energy needed for the relatively long period of time required for rooting to occur at this stage.

Rooting of such cuttings could be accomplished under plastic or mist. The application of auxins, bottom heat and wounding are recommended.

Finally, the *revival stage* is similar to the *winter rest stage* except that the buds have been exposed to a long period of low temperature and as a result are now devoid of growth inhibitors and are ready to resume growth as well as produce a relatively high level of auxins and possibly other rooting substances.

Taking cuttings at this time is recommended only on a trial basis for certain evergreens that will not root at other stages of growth. Cool air temperatures, mist, bottom heat, and wounding are recommended in this instance.

In presenting this talk I referred to evergreens only in general terms. I fully realize that some evergreen species vary in their physiology and therefore demand specific conditions as a prerequisite for rooting. All I could attempt to do during this brief talk was to discuss in general what may occur within the cuttings at the time it is severed and to suggest some treatments that would be appropriate.

MODERATOR COGGESHALL: Thank you very much Dr. Waxman.

The final speaker on the panel this morning is Mr. Edwin Kubo, Oki Nursery, Inc., Sacramento, California, who will speak on Care and Management of Cuttings from Collection Through Rooting. Mr. Kubo.

CARE AND MANAGEMENT OF CUTTINGS FROM COLLECTION THROUGH ROOTING

EDWIN KUBO
Oki Nursery, Inc.
Sacramento, California

Before discussing my subject, "Care and Management of Cuttings From Collection Through Rooting," I would like to give you a brief resume of Oki Nursery. Located in Sacramento, Oki Nursery, one of the largest container nurseries in California, was founded by Mr. M. Oki in 1907. The approximate production acreage of the Nursery is 56 acres and the annual production is in the excess of 2 million container grown plants. Our production is based on the U.C. system in which the use of clean soil, clean stock, sanitation, standardization, systemization and mechanization plays an important role.

To increase the efficiency of our production program, we have emphasized careful planning of our production through the use of good record keeping. Our annual production projection schedule plays an important part in determining the varieties and quantities to produce for the year. The Seeding schedule and Cutting schedule are used as a guide before executing production. Once in production a careful set of records is kept for each item for future reference.

In our completed record for cuttings we have the following information:

1. Date, number of cuttings stuck, and location.
2. Date, number of liners planted, and location.
3. Date, number of gallons planted, and location.
4. Source of Wood
5. Treatments. (Dip and Drench)
6. Type of growth regulator or hormone.
7. Type of medium used in rooting.
8. Percentage of rooting.
9. Percentage take of liners
10. Remarks. (Used for evaluation)

We have standardized and systemized all procedures from the collection of the cutting through the rooting process as follows:

Cutting Wood Collection and Treatment

In presenting this talk I referred to evergreens only in general terms. I fully realize that some evergreen species vary in their physiology and therefore demand specific conditions as a prerequisite for rooting. All I could attempt to do during this brief talk was to discuss in general what may occur within the cuttings at the time it is severed and to suggest some treatments that would be appropriate.

MODERATOR COGGESHALL: Thank you very much Dr. Waxman.

The final speaker on the panel this morning is Mr. Edwin Kubo, Oki Nursery, Inc., Sacramento, California, who will speak on Care and Management of Cuttings from Collection Through Rooting. Mr. Kubo.

CARE AND MANAGEMENT OF CUTTINGS FROM COLLECTION THROUGH ROOTING

EDWIN KUBO
Oki Nursery, Inc.
Sacramento, California

Before discussing my subject, "Care and Management of Cuttings From Collection Through Rooting," I would like to give you a brief resume of Oki Nursery. Located in Sacramento, Oki Nursery, one of the largest container nurseries in California, was founded by Mr. M. Oki in 1907. The approximate production acreage of the Nursery is 56 acres and the annual production is in the excess of 2 million container grown plants. Our production is based on the U.C. system in which the use of clean soil, clean stock, sanitation, standardization, systemization and mechanization plays an important role.

To increase the efficiency of our production program, we have emphasized careful planning of our production through the use of good record keeping. Our annual production projection schedule plays an important part in determining the varieties and quantities to produce for the year. The Seeding schedule and Cutting schedule are used as a guide before executing production. Once in production a careful set of records is kept for each item for future reference.

In our completed record for cuttings we have the following information:

1. Date, number of cuttings stuck, and location.
2. Date, number of liners planted, and location.
3. Date, number of gallons planted, and location.
4. Source of Wood
5. Treatments. (Dip and Drench)
6. Type of growth regulator or hormone.
7. Type of medium used in rooting.
8. Percentage of rooting.
9. Percentage take of liners
10. Remarks. (Used for evaluation)

We have standardized and systemized all procedures from the collection of the cutting through the rooting process as follows:

Cutting Wood Collection and Treatment

We have found that mother blocks and container plants that have been properly fertilized and sprayed produce our best cutting wood. Our cutting wood is collected in new 4 mil polyethylene sheets. After the cutting wood is collected, it is taken immediately to the cutting shed to be properly treated to prevent desiccation. The cutting wood is dumped onto a wire bottomed bed and washed thoroughly. A continuous over head mist is used to prevent desiccation.

Cutting Procedure

For preparation of cuttings, we prefer using a sharp shear. Cuttings are made 3 to 4 inches long. We normally take soft and semi hardwood cuttings. The cuttings are then bundled and placed in wire bottom boxes. When the boxes are filled, the cuttings are treated with a pesticide. Our cuttings are treated with a solution of Morton's soil drench C. It is diluted 1 oz. to 35 gallons of water and the cuttings treated for 10 minutes. We have found this Mercury fungicide to be satisfactory in our operation. Recently we have been experimenting with a new fungicide introduced by Shell Development Company. This material is known as SD 345. Our results thus far have shown great promise for this product when used as a dip or soil drench.

Sticking Operation

The cuttings are removed from dip, drained and placed in a wire bottomed box. The cuttings are then treated with growth regulators and stuck in a 18″ x 18″ x 3″ sterilized flat. Coarse perlite is used as a rooting media. The type of growth regulators used are the Hormodin 1, 2, and 3. We have also adapted the quick dip method using I.B.A. Crystal in 50% alcohol solution. We have found that certain difficult to root varieties can be rooted successfully by using 5000 ppm of I.B.A. alcohol solution dip. After the cuttings are stuck into flats, and before they are taken into the greenhouse they are again drenched with Morton's soil drench C. This insures that our mist Greenhouses will remain free of contamination.

Misting

The cuttings are left in the mist greenhouse to root. The misting in our propagation house is controlled by a light activated interval switch. We have found this control to be more effective than the clock timed control switch The frequency of misting in our greenhouse varies with the sunlight intensity. A photoelectric tube controls the basic mechanism of this operation. On bright days, when evaporation is greatest, the frequency of misting is increased by the light activated switch. On cloudy days when evaporation is lower, the misting is less frequent. We were forutnate to have Mr. Carl Schmidt of Point Reyes, California assemble this switch for our use. Mr. Schmidt obtained the blue prints from the Agricultural Engineering Department of the University of Connecticut, and modified the control to suit our needs.

After the cuttings are rooted, the misting is gradually reduced until no misting is necessary. Normally this operation takes two weeks.

The cuttings are then lifted and planted into our liner greenhouses. As the rooted cuttings are lifted, they are again treated with

Morton's Soil Drench C to insure prevention of disease. Rooted cuttings are potted in $2\frac{1}{4}''$ peat pots.

In our program we take great measures in preventing disease problems. The following precautionary measures are taken:

1. Disinfecting all tools with Chlorox 1:4 with water.
2. Spraying copper napthanate solution on all exposed wood surfaces.
3. Washing concrete floors of the propagation house daily.
4. Washing cutting benches with Chlorox solution daily.
5. Personal cleanliness of each employee.
6. Periodic drenching of cuttings, and liners with Morton's Soil drench C to prevent contamination.

MODERATOR COGGESHALL:

Our next speaker will be Dr. Harold B. Tukey, Jr., Department of Floriculture and Ornamental Horticulture, Cornell University, who will speak to us on the Leaching of Nutrients from Cuttings and Its Effect on Subsequent Growth. Dr. Tukey!

DR. HAROLD B. TUKEY, JR.: Thank you, Mr. Chairman, Members of the Society, and Guests: It is a great pleasure to be with you at your annual meeting. In spite of the snow, let me tell you I would rather be here than in the northern part of New York, so I thank you for the excuse to come.

LEACHING OF METABOLITES FROM ABOVE-GROUND PLANT PARTS, WITH SPECIAL REFERENCE TO CUTTINGS USED FOR PROPAGATION

H. B. Tukey, Jr.

Department of Floriculture and Ornamental Horticulture, Cornell University, Ithaca, New York

That leaves and other above-ground plant parts, including fruits and stems, may absorb water and nutrients, is now well established. The cuticle layer of foliage, once thought to be continuous and impermeable to the passage of nutrients, has now been found to be discontinuous, with numerous cracks and projections which allow the passage of nutrients in aqueous solutions. That these same plant parts may also give up or lose materials into their external environment is less well understood and appreciated. And yet for at least 150 years there have been reports of this phenomenon, indicating that metabolites, both organic and inorganic, could be leached from foliage by aqueous solutions (2). Despite the considerable experimental evidence and speculation which followed these early reports, the concept of leaching was not fully appreciated. Full and adequate proof was seemingly provided by the use of radioisotopes which conclusively demonstrated that labeled materials, absorbed by plants, could be leached by water, including rain and mist (6,11). The magnitude and diversity of these losses make them important in many aspects of plant science, including plant propagation.

The term "leaching" is herein defined as the removal of materials from plants by aqueous solutions. No distinction is made between

Morton's Soil Drench C to insure prevention of disease. Rooted cuttings are potted in 2¼" peat pots.

In our program we take great measures in preventing disease problems. The following precautionary measures are taken:

1. Disinfecting all tools with Chlorox 1:4 with water.
2. Spraying copper napthanate solution on all exposed wood surfaces.
3. Washing concrete floors of the propagation house daily.
4. Washing cutting benches with Chlorox solution daily.
5. Personal cleanliness of each employee.
6. Periodic drenching of cuttings, and liners with Morton's Soil drench C to prevent contamination.

MODERATOR COGGESHALL:

Our next speaker will be Dr. Harold B. Tukey, Jr., Department of Floriculture and Ornamental Horticulture, Cornell University, who will speak to us on the Leaching of Nutrients from Cuttings and Its Effect on Subsequent Growth. Dr. Tukey!

DR. HAROLD B. TUKEY, JR.: Thank you, Mr. Chairman, Members of the Society, and Guests: It is a great pleasure to be with you at your annual meeting. In spite of the snow, let me tell you I would rather be here than in the northern part of New York, so I thank you for the excuse to come.

LEACHING OF METABOLITES FROM ABOVE-GROUND PLANT PARTS, WITH SPECIAL REFERENCE TO CUTTINGS USED FOR PROPAGATION

H. B. Tukey, Jr.

Department of Floriculture and Ornamental Horticulture, Cornell University, Ithaca, New York

That leaves and other above-ground plant parts, including fruits and stems, may absorb water and nutrients, is now well established. The cuticle layer of foliage, once thought to be continuous and impermeable to the passage of nutrients, has now been found to be discontinuous, with numerous cracks and projections which allow the passage of nutrients in aqueous solutions. That these same plant parts may also give up or lose materials into their external environment is less well understood and appreciated. And yet for at least 150 years there have been reports of this phenomenon, indicating that metabolites, both organic and inorganic, could be leached from foliage by aqueous solutions (2). Despite the considerable experimental evidence and speculation which followed these early reports, the concept of leaching was not fully appreciated. Full and adequate proof was seemingly provided by the use of radioisotopes which conclusively demonstrated that labeled materials, absorbed by plants, could be leached by water, including rain and mist (6,11). The magnitude and diversity of these losses make them important in many aspects of plant science, including plant propagation.

The term "leaching" is herein defined as the removal of materials from plants by aqueous solutions. No distinction is made between either the source and form of the materials or the mechanism of removal, only that the materials were derived from the plant.

In order to better understand the phenomenon of leaching as it pertains to plant propagation, it is necessary to review the experimental work done on the subject. This is particularly true, as the results of our preliminary experiments have indicated that the results obtained with other crops are directly applicable to the propagation methods and materials with which we are familiar. In our experiments, young seedlings and rooted cuttings of a number of plant species were grown in either aerated nutrient solution cultures or in a soil medium to which in some cases, radioisotopes of several nutrients were added and were absorbed by the plants as they grew. The plants, both radioactive and nonradioactive, were leached by exposure to an atomized mist spray of distilled water for periods of up to 24 hours. The leachates were passed through ion-exchange resins which absorbed the charged leached metabolites. The resins were later eluted with appropriate chemicals and the eluates were analyzed for radioactivity and for nonradioactive nutrients. Organic metabolites were analyzed qualitatively by chromatographic techniques.

Using these techniques, the phenomenon of leaching was investigated. The first experiments investigated the general occurrence of leaching in nature, using a number of diverse plant species. From these studies and others reported in the literature, leaching is apparently wide spread in nature, with losses now reported from over 115 species. These plants include representatives of deciduous forest and shade trees, coniferous forest trees, deciduous tree fruits, small fruits and grapes, tropical and sub-tropical fruits, vegetable crops, grains, grasses, and forage crops, woody ornamentals, greenhouse and herbacous ornamentals, plantation crops, and tropicals and conservatory plants. From each and every plant studied, metabolites could be leached, and in fact, we know of no plant yet studied which cannot be leached (10).

Now of course there are differences in the ease in degree of leaching of metabolites from various plants, as presented in Table 1. This

Table 1. Loss of Inorganic Nutrients from Young Plants by Leaching With Distilled Water for 24 Hours.

Species	Nutrient			
	Ca	Mg	P	K
	(percent leached)			
Acalyphia wilkensiana	31.1	27.1	20.0	12.7
Chrysanthemum morifolium	10.7	8.1	2.2	1.7
Cucurbita pepo	10.7	19.5	2.5	16.5
Eranthemum nervosum	8.4	7.1	5.1	3.4
Kohleria tubiflora	5.0	6.1	6.0	3.4
Peperomia obtusifolia	2.5	5.0	1.0	1.0
Phaseolus vulgaris	14.1	22.6	4.3	10.1
Pisum sativum	2.4	11.0	0.9	0.4
Ruellia spp.	7.9	9.8	8.8	4.2

table compares the losses by leaching of calcium, magnesium, phosphorus, potassium from a representative sampling of plant species including commercial floriculture crops, vegetable crops, and herbaceo ornamentals. Some species are more susceptible to leaching of these nutrients than are others. For example, squash, bean, and *Acalypha* are more susceptible to the leaching of these nutrients than are *Peperomia* and pea. The other species ranked somewhere in between this range.

Not only are there differences among species but also there are differences in the leachability of cultivars of the same species, and even leaves of the same plant. These differences are apparently related to the internal conditions of the plant and the physical properties of the leaf. Leaves with a smooth, waxy leaf surface, such as pea and *Peperomia,* which are wetted with difficulty, are less subject to the leaching acion of aqueous soluions. However, the leaves of squash and bean which are relatively large, flat-surfaced, pubescent, and wetted with ease are more easily leached. Similarly, leaves of many ornamental tropicals are easily wetted and easily leached.

Table I also shows differences in the leachability of individual metabolites from the same species. For example, losses of magnesium from pea were high, although losses of the other nutrients from this species were low in comparison to the other species studied. A greater amount of potassium and phosphorus was leached from *Kohleria* than from chrysanthemum, but in the case of calcium and magnesium, the situation was reversed.

Thus, the leaching phenomenon appears specific for each species and for certain materials. Differences between leachability of inorganic nutrients are seemingly related to their functions and involvement in plant metabolic processes. For example, phosphorus, is not easily leached from actively growing plants where it conceivably would be utilized rapidly and converted into unleachable forms; whereas calcium and potassium may exist in the so called "free space" areas of leaves, and thus more likely to be leached.

However, regardless of the specificity of plants and nutrients to leaching, each and every plant so far studied has been found capable of nutrient loss by leaching to some degree at least. Several species studied are tropical plants with a thick cuticle and a smooth waxy leaf surface, characteristics which might make them less susceptible to leaching. However, nutrients are leached from even these naturally protected leaves.

Since leaching is such a wide spread natural phenomenon, it is of interest to determine the nature of the metabolites leached from plants. In the case of inorganic nutrients, all the major essential nutrient elements can be leached, and in addition those minor elements which have been studied can be leached.

Typical quantitative losses from young leaves are presented in Table I. The quantity of loss depends upon the nutrient and upon many internal and external variables. However, in general, potassium and sodium are leached with relative ease. Calcium, magnesium, and sulfur are leached with moderate ease, and phosphorus, chlorine, iron, and zinc are leached with difficulty. Losses by leaching by 24 hours may be as high as 80 to 90% of the potassium content, 50 to 60% of the calcium content of mature leaves which are more susceptible to leaching than are younger leaves. Losses of iron, phosphorus, and zinc from young leaves in 24 hours may be less than 1% of the nutrient content of the foliage. It has been calculated that from an acre of crop plants during 18 to 24 hours of rainfall, 62 pounds of ash constituents, 39 pounds of phosphoric acid equivalent, and 5 pounds of CaO are leached (See 11). Dalbro (3), has reported losses from apple foliage of 25 to 30 pounds of potassium, 10½ pounds of calcium and 9 pounds of sodium per acre in one year. Thus, large quantities of essential nutrients can be leached, even from young actively growing plants.

Large amounts of nutrients are also leached from cuttings under mist. Sharp (8) and his co-workers in Florida, using peach, grape, and blueberry cuttings, reported a 16 percent decrease in the nitrogen content, a 23 percent decrease of phosphorus, and a 43 percent decrease of the potassium content of the cuttings after 30 days of constant mist. They also showed that the mineral content of peach foliage was decreased to a greater degree by constant than by intermittent mist.

In addition to inorganic materials, large amounts of organic materials, principally carbohydrates can be leached from leaves. Dalbro (3) reported losses of 800 pounds of carbohydrates per acre from apple foliage per year. From young bean leaves 6 percent of the dry weight

Table 2. Metabolites Leached From Plant Foliage

Inorganic	Carbohydrates	Amino Acids	Organic Acids
calcium	fructose	alanine	aconitic
chlorine	galactans	arginine	adipic
iron	glucose	asparagine	ascorbic
magnesium	lactose	aspartic acid	citric
manganese	pectic substances	b-alanine	fumaric
nitrogen	raffinose	cysteine	glutaric
phosphorus	sucrose	g-aminobutyric	glycolic
potassium	sugar alcohols	glutamic acid	lactic
silica compounds		glutamine	maleic
sodium		glycine	malic
strontium		histidine	malonic
sulfur		hydroxproline	pyruvic
zinc		isoleucine	succinic
		leucine	tartaric
		lysine	acidic glycosides
		methionine	
		phenylalanine	
		proline	
		serine	
		threonine	
		tryptophan	
		tyrosine	
		valine	

was leached 24 hours in the form of sugars (11). The carbohydrates identified in the leachates from leaves include free sugars, polysaccharides, and sugar alcohols. In addition, large numbers of essential amino acids are leached from foliage. In fact, of the soluble amino acids in plant foliage, we have found 21 in the leachates from leaves (10).

There are also large quantities of organic acids present in the leachates from leaves, organic acids which play an important part in the growth processes of plants.

The metabolites leached from the foliage of plants are summarized in Table 2. The losses of a diversity of such metabolically important materials as inorganic nutrients, carbohydrates, amino acids, and organic acids greatly increases the significance and importance of the leaching phenomenon. Leaching affects the quality, yield, and nutritional value of commercial food crops. This is particularly well illustrated in tropical regions where crops during a rainy season may be inferior to those during the dry season, due in part to leaching of metabolites by rain. In addition, during the process of plant growth and development, loss of any of these important metabolic materials, particularly at a critical time will greatly influence the subsequent behavior of the plant.

It should be re-emphasized that the results obtained with intact plants are directly applicable to cuttings of plants propagated beneath mist, both quantitatively and qualitatively.

The variations in leachability which exist between plants and even between two individual leaves of the same plant indicate that there are many factors involved and which influence the process. A list of factors which have been investigated is presented in Table 3. A greater amount of nutrient loss occurs from older leaves than from younger leaves. Young leaves, although they appear delicate and fragile are less susceptible to leaching than are more mature leaves, which may lose a majority of the nutrient content in 24 hours of leaching. Losses are influenced by the type and nature of the plant, the

Table 3. Factors Affecting the Leachability of Metabolites

Internal	External
Type and Nature of Plant	Leaching solution
Metabolite Being Leached	Light-Darkness
Leaf Characteristics	Temperatures
a). wettability	Duration of Leaching Period
b). waxiness	Intensity and Amount of Rain
c). cuticle	Injury (disease, insect, mechanical, climatic, nutritional)
d). pubescence	
e). hydathodes	
Physiological Age of Leaf	Dew
Plant Nutrient Status	
Physiological Disorders	Nutrition in Root Medium

metabolite leached, and leaf characteristics as mentioned earlier in this paper.

Losses are also increased when there is an adequate supply of nutrients to the leaf and within the plant than when the plant is nutritionally deficient. For example, losses of nutrients over a several day leaching period may total 3 to 8 times the amount of the nutrient initially in the plant, indicating a very effective replenishment mechanism in plants, by which leached nutrients are replaced by nutrients from other parts of the plant. This is well illustrated in autoradiograms resulting from the uptake and distribution in several plants of radioactive materials which were leached from cucumber leaves. This illustrates the recycling principle of nutrients in nature in which nutrients are absorbed by the roots, are translocated in the stems to the leaves and are leached to the soil beneath by rain and dew, and there are reabsorbed by roots of the same or a different plant. This is apparently an important process in nature and certain plants receive a considerable proportion of their nutrition through this means. This process also occurs to a lesser degree to nutrients and plants in a mist propagation bench.

Losses of metabolites are increased when the plant is injured, as by disease, insect attack, physiological disorders, mechanical means, chemicals, adverse temperatures, and nutritional and moisture deficiencies. It should be pointed out that some horticultural practices injure plants intentionally, such as pruning, some propagation procedures, and applications of herbicides.

Light has little influence upon the leaching of most mineral nutrients, but losses of carbohydrates, phosphorus, and sulfur are greater in the light than in the dark. An increase in temperature increases the losses of calcium, potassium, and magnesium, but the effect of temperature is minimized in the case of carbohydrates, phosphorus, and sulfur.

Of special interest in regards to mist propagation is the fact that a light mist falling over a long period of time is more effective in leaching nutrients than is a brief but heavy rain shower. Wetting and re-wetting the foliage of plants makes them more susceptible to leaching than would the same amount of water applied as a continuous drench. In addition, salts in the leaching solution such as sodium and potassium increase the nutrient loss by leaching, but calcium seems to inhibit leaching.

Plant propagators utilizing mist propagation techniques have all recognized that nutrients can be leached from cuttings by the mist. Evans (4) reported losses of nutrients from *Cacao* propagated under mist. Sweet and Carlson (9) noted the appearance of deficiency symptoms in leafy cuttings rooted under mist. Later, Long *et al* (6) using radioisotopes, were able to effectively demonstrate that nutrients could be leached from cuttings. Losses of phosphorus from cuttings of sweet potato, bean, and poinsettia varied from 2 to 12½% of the nutrient in the leaf during two 4-hour leaching periods. This was in comparison to only trace losses from intact plants. Langhans (5) and

Ang (1) have also showed loss of phosphorus from herbaceous crops under mist.

It is difficult to assess directly the effect of leaching upon the subsequent behavior of cuttings as it is almost impossible to receive the beneficial effect of mist and prevent leaching at the same time. One indirect method of assessing the effects of leaching is to attempt to replace the leached metabolites by application of nutrients through the mist system. Morton (7) has been working on this problem using chrysanthemum and poinsettia cuttings. Initially, cuttings of chrysanthemums contain 5 percent nitrogen, 5 percent potassium and 0.5 percent phosphorus. After being exposed to intermittent mist for 28 days, control plants showed a considerable depletion of all three nutrients. Applications of urea through the mist system maintained the nitrogen content of the foliage but, of course, the phosphorus and potassium content were still low. When a complete, all-soluble fertilizer material was applied through the mist, levels of nitrogen and phosphorus were maintained, but potassium which is the most readily leachable nutrient of any, was still at a considerably lower concentration than that present initially in the cuttings. Very similar results were obtained with poinsettia where it was shown that applications of a complete nutrient solution such as Half-Hoagland solution and a complete fertilizer through the mist seemed to counteract the loss of nitrogen and phosphorus, but did not counteract the losses of potassium.

The influence of such applications of nutrients through the mist was appreciable upon the subsequent behavior of the cuttings. Cuttings which received a complete fertilizer applied through the mist as compared to control plants were 30 percent taller had a greater dry weight, a more luxuriant root development, and a greener color at the end of the mist period. There was no effect upon time of rooting. Cuttings which received nutrients through the mist eventually produced more growth, blossomed earlier and were of considerably greater vitality than control plants which were leached of nutrients during the propagation period.

These results suggest that applications of nutrients through the mist successfully replenished the materials leached from the cuttings, except in the case of the readily-leachable potassium. However, these are preliminary results and are not presented as recommendations. As pointed out earlier, plants are very specific in regards to the leaching phenomenon and recommendations must be worked out for each plant and each nutrient. Of course, in many propagation establishments and with particular crops it is already a common practice to add nutrients through the mist lines in an effort to replace leached nutrients.

Nutrient loss may not always be harmful to plants. Experimentally, plants grown in nutrient solutions may accumulate toxic concentrations of salts, but survive if syringed daily. In this sense leaching becomes important as an ecological factor in plant adaptation and distribution. The effect of rainfall and mist on plant distribution and development has always been thought of in terms of moisture requirements and tolerances. Perhaps rainfall and mist may play an equally important role in conditioning the plant to fit its environment through leaching (10).

This may also be the case in some of the responses in terms of rooting that one observes using mist propagation techniques. An analogy might be made in the comparison of a large man and a small man. The large man may be able to do certain things better, such as playing football and lifting heavy loads. On the other hand, the small man may be able to run faster and jump higher. And yet, both men may be able to do some things equally well, such as thinking, speaking and writing. Similarly, with certain plants, loss of a particular nutrient may be *harmful when a plant is at a critical time of development* such as loss of phosphorus prior to rooting or fruit set. On the other hand, loss of nutrients at another stage of the plant development may *have no harmful effects and* may even be *beneficial*.

The leaching phenomenon is a relatively old but poorly understood concept in plant production which has been sadly neglected. Research *has shown what an important role it may play in the behavior* of plants. The leaf now assumes an even broader role beyond the classical concepts of transpiration and photosynthesis — a dynamic role of uptake and loss of water and metabolites from plants, helping to adjust a plant to its environment and influencing its growth and development.

BIOGRAPHY

1. Ang. Jan-Kee The effect of mist on the uptake and leaching of potassium and phosphorus by *Chrysanthemum morifolium* and *Dianthus caryophyllus* cuttings. M. S. thesis. Cornell University. 1958.
2. Arens, K Die kutikulare Exkretion des Laubblattes. Jahrb. wiss. Botan. 80:248-300. 1934.
3. Dalbro, S. Leaching of nutrients from apple foliage. Proc. XIV Intern. Hort. Cong. 770-778. 1955.
4. Evans, H. Investigations on the propagation of cacao Trop. Agr. 28:147-203. 1951.
5. Langhans, R. W. *Some effects of intermittent foliar water applications on the physiology of plants and the growth of greenhouse roses.* Ph.D. thesis. Cornell University. 1958.
6. Long, W. G., D. V. Sweet, and H. B. Tukey. The loss of nutrients from plant *foliage by leaching as indicated by radioisotopes. Sci. 123:1039-1040. 1956.*
7. Morton, W. M.S. thesis, Cornell University. In preparation.
8. Sharpe, R. H. Mist propagation studies with emphasis on mineral content of foliage Proc. Florida State Hort. Soc. 68:345-347. 1955.
9. Sweet. D. V. and R. E. Carlson. Rooting of cuttings in air-cooled mist chambers. Mich. State Agr. Expt. Sta. Quart. Bul. 38:258-267. 1955.
10. Tukey, H. B., Jr. and J. V. Morgan. The occurrence of leaching from above-ground plant parts and the nature of the material leached. Proc. XVI Intern. Hort. Cong. (In press).
11. Tukey, H. B., Jr., H. B. Tukey and S. H Wittwer Loss of nutrients by foliar leaching as determined by radioisotopes. Proc. Am. Soc Hort. Sci. 71:496-506. 1958.

MODERATOR COGGESHALL: At this time would the four previous speakers on this morning program please come up on the stage?

Just one word before we ask these gentlemen a question or series of questions. When you stand, please give your name loud enough so it can be heard down front, so the question can be attached to somebody, shall I say. At this time we will entertain questions.

MR. MARTIN VAN HOF: I would like to start off with Jim Wells. He told us wounding was almost essential. Well, I almost agree with him, but with the common arborvitae he said he had better results by wounding than not wounding. With me, it is just the opposite way.

When we take pyramidalis cuttings, the cuttings from the bottom branches will root more readily than tip or leader cuttings. We treat both with No. 3 Hormodin powder. In due time, with difficulty, they will root and will be just as heavy as the others. We surely do get them 90 per cent.

Wounding of rhododendron—when we came over yesterday we were talking with one another about rhododendron. There are people who just cut the outer bark either with a sharp knife or with a glass cutter and get better results than with heavy wounding.

Now I want to ask Dr. Tukey about leaching under mist propagation. Does the same thing hold true with evergreens?

DR. TUKEY: What was the question?

MR. VAN HOF: I mean the feeding with urea or something.

DR. TUKEY: I can tell you better about leaching from evergreens than I can about feeding urea, applying this nutrient through the mist, because we haven't done this yet. *Taxus* and juniper are now being run. We can perhaps let you know at a later time. Certainly, leaching does occur from evergreen cuttings. Surprisingly, it can occur in greater amounts than from some of the herbaceous plants. As a general rule, the losses from the herbaceous plants such as chrysanthemum and poinsettia are greater than they are from the woody plants. The taxus seems to be less susceptible to leaching than juniper. Juniper leaches two to three times as much as taxus in our experience. What response this has or what effect this has on subsequent growth, I don't know. Certainly, you can get nice deficient cuttings and have poor color under certain conditions.

DR. KENNETH REISCH: In relation to the wounding of *Ilex*. Jim, we reported at last year's meeting that wounding did not give as good results as cuttings treated with growth substance or with no treatment. This was one under mist, whereas the others were not. We did not get a beneficial effect from wounding *Ilex opaca*.

MODERATOR COGGESHALL: Another question?

MR. CASE HOOGENDOORN: I have a question here for Dr. Waxman or Dr. Snyder. We were trying to root Juniper San Jose, which seems to be rather difficult. We didn't have any luck in the sand, so we tried it in sand and perlite and they rooted very well. The only thing, after they started to root some of them started to turn yellow and then they died. What happened then? I want to tell you one more thing — it was not because the medium was too wet. You don't have to tell me that.

DR. WAXMAN: Maybe it was too dry.

MR. HOOGENDOORN: The only thing I can tell you, when they finally rooted there was at least 15 per cent. Then we picked them up and planted them. After that we didn't have any more losses. Was it that peat that might have had an effect on the rooting?

DR. WAXMAN: Was it sand and perlite when you got the yellow?

MR. HOOGENDOORN: No, peat and perlite.

DR. WAXMAN: I know Charlie once mentioned about injuries in connection with the perlite. Is that a possibility?

DR. CHARLES HESS: I picked this up from Ohio. I don't think those injuries were from the straight perlite.

MODERATOR COGGESHALL: Any other comment?

MR. JACK HILL: I have one for Dr. Tukey. Will you describe the mechanics of the system which you have found most effective in getting this fertilizer or these various nutrient solutions into your mist system, recognizing the highly corrosive effect of most of the nitrogen fertilizers.

DR. TUKEY: Perhaps we haven't been in this business long enough to run into corrosion problems, but as yet we haven't had them. I expect we will. We have done this on an experimental basis, just two or three benches are all that we can use. We use all soluble material, such as those that are plentiful on the market and inject them with an ordinary pump system into the lines, rather than using the proportional injection system you find for automatically watering. As a rule these put on too much material and you get injury to the foliage. So we have to cut this down by gauging and use of solenoid to cut in the pump so the nutrients solution is injected into the lines rather than the water solution.

It goes on as a rule three times a day, this nutrient mist, for about one or two-hour periods. At other times we have used a nutrient mist during the entire misting period and the results have been no different, so we have cut down on the amount of nutrition.

As yet. we haven't had the problem of corrosion so I can't answer it. Certainly it would be a problem to the commercial nursery.

MR. HILL: Just to make sure, I understand you are applying a diluted fertilizer for a 2-3 hour period.

DR. TUKEY: We are applying it as an intermittent mist of ten seconds every two and a half or three minutes for three or four hour periods.

MR. JOHN MAHLSTEDE: A question for the California delegate. You mentioned that you keep track of the number of cuttings your girls make. I am wondering what ranges in numbers and the respective wages paid for a number of cuttings per hour as piece work.

MR. KUBO: Shall I tell them, George? Well, you put me on the spot, John. As I have said, the reason for the use of the boxes was to keep count of our cutting girls. The purpose for it is not to increase the speed of the faster ones but to increase the ones that are slow. That is the purpose, and as far as the amount of cuttings we make a day, of course, depends on the variety. It varies from 2,000 to 6,000 depending on the item. Like any of the junipers we cut approximately 3,000 in a day's time. As far as the wages we pay, I think I will skip that.

MODERATOR COGGESHALL: Another question?

MR. VINCENT BAILEY: I have another question on economics. Somebody mentioned the light-activated mist switch. Can anyone tell me approximately what this switch costs? That sort of appealed to me. I have never used one.

DR. WAXMAN: When we first published this description from Connecticut, we stated that for the single bench or single line system it would cost about $60 if you put it together yourself. There is a company that produces these now, and I think they sell for about $120.

MODERATOR COGGESHALL: Another question?

MR. JIM WELLS: I want to ask for some more data on this Morton Soil Drench C. Mr. Kubo mentioned that he used it a number of times. First of all, you damp your cuttings down or wash them with ordinary water.

MR. KUBO: Yes.

MR. WELLS: Then you dip them in Morton Soil Drench C. and submerge them for ten mnutes. They are under complete cover.

MR. KUBO: Right.

MR. WELLS: They come out and are on the wire racks where they drain, to be made into cuttings. When they are made, they are drenched again.

MR. KUBO: I think you got a little confused there. We first wash the cuttings with ordinary water. then a continuous mist is applied until the cutting operation. The women take the cutting wood, sit at the cutting bench and make their cuttings and they bundle them for ease in handling in applying hormones. When the basket or the wire bottom box is filled, then they apply the Morton Soil Drench. After the cuttings are taken out of the dip, then they are drained and the sticking operation takes place.

MR. WELLS: They are treated with hormones?

MR. KUBO: After they are drained.

MR. WELLS: They are still moist or will they have dried?

MR. KUBO: They are still moist.

MR. WELLS: Then you stick them and then apply Morton's Soil Drench?

MR. KUBO: Yes. I have been asked why we use Morton's Soil Drench so many times. As I have mentioned, our program is based on prevention more than control. Therefore, whenever there is a human element involved we go ahead and apply Morton Soil Drench just to insure no contamination. It is just used as insurance. Once we find contamination takes place, rather than trying to treat it, we dump the whole planting.

MR. HILL: Why don't you dip the workers?

MR. WELLS: The Shell material which you are now using is what?

MR. KUBO: It is known as SD 345. I have talked to one of the Shell representatives and he said in the near future it will be out for sale and it will be under the name of Shell 345. It is still in the experimental stage and is still not for sale.

· MODERATOR COGGESHALL: A question right here.

MR. RALPH SHUGERT: While you are up, would you explain briefly your greenhouse sterilization procedure?

MR. KUBO: The copper naphthenate we mentioned is 8 per cent and is diluted one to four. The number of times we apply copper naphthenate is after each crop. In the lining houses, if the liner takes two months to produce, as it comes out we copper naphthenate. The recommendation is once every six months, but we find rather than try to keep time, it will be a lot easier to go in and apply it after each crop.

MR. MERTON CONGDON: Mr. Kubo, I was quite amazed at the amount of free water and drench you use on these cuttings. Some years ago in the early days of the Society here, we had some lengthy discussions on the effect of free water when you take the cuttings and the effect on the rooting. We have found, at least in our nursery ,there is a definite effect on the rooting capacity of the cutting by the use of too much free water. Do you not find any material that is affected so far as the rooting?

MR. KUBO: The conifers are affected. We keep away from continuous misting. One thing to consider is the area we are located in. In Sacramento the relative humidity goes down as far as ten per cent, so it is necessary to keep your cutting wood as moist as possible to prevent dessication. I think we have more heat damage than over-irrigation or over-watering.

MODERATOR COGGESHALL: Another question?

MR. ALBERT LOWENFELS: With respect to applying fertilizer through a mist system, many of us use city water. Would you recommend, therefore, that we turn off our mist and give them a little dose of some fertilizer or not? Use that in place of misting for a period?

MR. TUKEY: There are available commercially certain injection systems which can inject directly into a water line. The only problem with this, as I mentioned before, is that you put on too many nutrients. This is mostly designed to go on root systems. If you inject with commercial injection systems, which are now available. the nutrient accumulation on the whole is too great. So definitely, you have to go to some modification of this, whether it is injecting at only certain times at infrequent intervals or a separate system altogether which comes in automatically and substitutes. We couldn't inject directly into the water system we have. That is why we use a separate system. It definitely is a technological problem.

MR. LOWENFELS: Wouldn't it be a good idea to take a sprinkling can and go over your cutting bed?

DR. TUKEY: You always think toward the way things were before the mist propagation, and of course, good propagators try to use the mist propagation. I don't know why it couldn't be done. This is a labor problem, of course. Most of us don't like to do it. We would rather do it automatically and hook it up automatically.

MR. RICHARD JAYNES: I would like to ask Dr. Tukey — I wonder particularly under conditions of the intermittent mist where you have high evaporation whether there are times when you get an accumulation, particularly of some of the salts that occur in city water, rather than actual loss.

DR. TUKEY: This you can see in the literature, of course, in the case of calcium. You can get an accumulation of calcium. In some water systems there is enough calcium to replace that which is lost. Certainly, if you cut down on the amount of water you can get an accumulation of these salts on the foliage, even so much they will burn very definitely. This is rather easily taken care of by a little additional water, as a rule. So here you have to judge. You can't have your cake and eat it, too. You have leaching going on with more water and you also have beneficial effects. You can't prevent leaching and have the mist. The same with the accumulation of materials, but additional water will take it off.

MR. JACK HILL: I have a question for Ed Kubo. Ed, have you ever been able to determine any rooting inhibition of your cuttings that is traced to the application of Panogen? I raise this question because we seem to have been able to clearly associate reluctance to root with the use of Panogen. Therefore, we have discontinued it on particular varieties. We were heretofore using it much as you do.

MR. KUBO: Jack, on that qustion we have found some damage, not damage but a little stunting of the plants if we use too much of the Panogen or the Morton Soil Drench C. However, we have found that the setback is not great enough to give up the Panogen. As far as the root injury, we have found none whatsoever.

MR. HILL: Was this stunting effective as a result of your application of Panogen to the unrooted cuttings or rather to the drenching of liners?

MR. KUBO: Both, because last year I found out when one of the Shell experimental men came over and we were testing the Morton Soil Drench, one with untreated conditions and one by using the SD 345. We have found both the SD 345 and the Panogen or Morton Soil Drench C have some effect. The higher the dosage the more the stunting.

MR. PETER VERMEULEN: Mr. Kubo, in your greenhouse sterilization, is copper naphthenate the only sterilizer you use?

MR. KUBO: As far as for root exposure, that is all. As far as the washing of the benches and of our tools, we use Cholorox, and for sterilization of soil we use steam and, of course for your bulk soil in the container we use methyl bromide and just stock piling.

MR. VERMEULEN: The copper naphthenate is applied to the surfaces of the greenhouse? What is your carrier? You mentioned diluting 1 to 4. Is that right?

MR. KUBO: Eight per cent, on with thinner.

MR. VERMEULEN: How do you apply it?

MR. KUBO: As a spray. We put the solution in the Hudson tank and spray it on. We find it just as effective as if you were to paint it with a brush.

MR. GEORGE HOYSIC: Have you used anything like plastic spray to prevent any leaching of the material on your plants. Has leaching had anything to do with changing the hardiness of plants?

DR. TUKEY: Let me answer the first question about preventing leaching. We have not done it, but it has been brought to our attention. One of the rubber companies in the southeast area was interested in bringing in plants into production earlier. Here they would have a problem; since carbohydrates, sugars, are important, they are interested in preventing the loss of these. They tried preventing the loss by a plastic coating and they were able to bring the plant into production of latex two or three years earlier. Here is an extreme example of where it works. Whether it would be effective in our own systems I couldn't say. We have no evidence directly on leaching and its effect on hardiness. However, there is some evidence that application or use of foliar sprays before the dormant season will increase hardiness, particularly some of the nitrogen compounds. Whether this has any effect on increasing hardiness as they are taken out of the mist propagation bench is only theoretical. We have no evidence. I think theorectically it would. This is not good enough; you have to have evidence.

MR. ROBERT De WILDE: This morning I gathered from Dr. Snyder's talk and from Mr. Wells that plants which would benefit from wounding are those plants with which you would remove a barrier between the inner cortex where the root primordium is initiated and the epidermis. I gathered also there was mention of a wounding hormone which is produced and I spoke briefly to Dr. Hess during our break. He mentioned there is a rooting hormone which has been isolated. I would like to know a little bit more about this wounding hormone. Has it been synthesized? Has it been used as a root promoting substance in itself?

PRESIDENT SYNDER: I would like to speak very briefly about the first statement you made, Bob. If there is any mechanical barrier in the stem, then certainly the removal of that by wounding should enchance the rooting, but we do get benefits from wounding when we do not have the mechanical barrier there. If we have it, it should help but we get help when we don't have the mechanical barrier.

I will let Charlie take the wounding.

DR. CHARLES HESS: The wound hormone is called traumatic acid and it is commercially available from chemical supply houses. We have tried it on the mung bean rooting test, and it is effective.

One thing we would like to try and we have never had a chance to do it yet, is to see if the application of traumatic acid would have any beneficial effect on graft union formation. Has anyone given this a try?

QUESTION: What concentration?

DR. HESS: It would be fairly dilute, around 10 p.p.m.

MR. DeWILDE: That is what I had in mind, in grafting, if this substance could be used.

DR. HESS: So far the application of auxins to the graft union has not given good results, but this might be another possibility.

MR. BENJAMIN: In the third stage you mentioned auxins and you also mentioned inhibitors. Are you here associating the presence of these inhibitors with rooting at all?

DR. WAXMAN: That is a very good question. That is why I told you in the beginning I was sticking my neck out. Inhibitors are *associated with inhibiting growth of cells, but we haven't tied this up* too definitely. The work Charlie has been doing with mung bean shows portions of these inhibitors have decreased the rooting of the mung bean. Is that right?

DR. HESS: Yes.

DR. WAXMAN: Whether these inhibitors are the same ones Charlie is using, and if they increase at that time of the year, is still unanswered.

MR. JOHN MAHLSTEDE: At a conference last spring in Hershey, there were a lot of states looking with fear at the various injection systems that are being connected to the water line. They are worried about the water drop and poor check valves resulting in nutrients siphoning back into the main water supply line and causing some contamination. I think a lot of growers that are using these systems might be looking into the references on it, because I think it might be a problem in the months ahead.

MODERATOR COGGESHALL: At this time I would like to thank the panel for starting the program off this morning with a very, very good discussion. Thank you very much.

PRESIDENT SNYDER: We will resume in this room at 1:30.

(The session recessed at 12:30 o'clock.)

RECESSED

THURSDAY AFTERNOON SESSION

December 6, 1962

The second session convened at 1:45 o'clock, President Snyder presiding.

PRESIDENT SNYDER: This afternoon's session is a Panel Discussion on Cultural Aspects of Plant Propagation. The moderator is Fred C. Galle, Ida Cason Galloway Gardens, Pine Mountain, Georgia.

MODERATOR GALLE: We are a little bit behind, so our first panelist will talk on Chemicals and Soil Amendments — Dr. J. B. Gartner, Department of Horticulture, University of Illinois, Urbana, Illinois.

CHEMICALS AND SOIL AMENDMENTS

J. B. GARTNER
Department of Horticulture
University of Illinois

First of all, when John Mahlstede asked me to appear, I told him I would be happy to. I thought I would have a message I could present, but the more I think about it the more I wonder why I am up here. There are probably two good reasons why I accepted. One was the fact that at Universities we don't get the opportunity to travel at will, and it gave me the opportunity of attending the Society Meeting, which I am happy to do. Another reason is that we were conducing some experiments pertaining to chemicals and soil amendments. I will discuss these later.

First of all, I would like to go back and review some of the older materials that have been used as aids in transplanting.

Wax Emulsions

In 1937, Dr. Miller of Michigan State University developed a wax emulsion that proved successful in reducing transpiration when applied to nursery stock. This material was placed on the market and sold under the trade name of Dow Wax. For a number of years, this material was used by nurserymen in transplanting nursery stock.

Plastics became popular during the war and in 1948, while at Michigan State University, O'Rourke, Hamner and myself became interested in some of the new plastics. One of these new plastics looked very promising as an aid to transplanting since it was nontoxic, transparent and dried at room temperature. The plastic is a polyvinylchloride resin which at the time was named Geon 31X. Today this material is sold as Transplant Coat, Wiltpruf, and many other trade names. When we first started testing this material, we tried it on cut Christmas greens and cut Christmas trees. We had excellent results with this experiment and was able to reduce the dry-

THURSDAY AFTERNOON SESSION

December 6, 1962

The second session convened at 1:45 o'clock, President Snyder presiding.

PRESIDENT SNYDER: This afternoon's session is a Panel Discussion on Cultural Aspects of Plant Propagation. The moderator is Fred C. Galle, Ida Cason Galloway Gardens, Pine Mountain, Georgia.

MODERATOR GALLE: We are a little bit behind, so our first panelist will talk on Chemicals and Soil Amendments — Dr. J. B. Gartner, Department of Horticulture, University of Illinois, Urbana, Illinois.

CHEMICALS AND SOIL AMENDMENTS

J. B. GARTNER
Department of Horticulture
University of Illinois

First of all, when John Mahlstede asked me to appear, I told him I would be happy to. I thought I would have a message I could present, but the more I think about it the more I wonder why I am up here. There are probably two good reasons why I accepted. One was the fact that at Universities we don't get the opportunity to travel at will, and it gave me the opportunity of attending the Society Meeting, which I am happy to do. Another reason is that we were conducing some experiments pertaining to chemicals and soil amendments. I will discuss these later.

First of all, I would like to go back and review some of the older materials that have been used as aids in transplanting.

Wax Emulsions

In 1937, Dr. Miller of Michigan State University developed a wax emulsion that proved successful in reducing transpiration when applied to nursery stock. This material was placed on the market and sold under the trade name of Dow Wax. For a number of years, this material was used by nurserymen in transplanting nursery stock.

Plastics became popular during the war and in 1948, while at Michigan State University, O'Rourke, Hamner and myself became interested in some of the new plastics. One of these new plastics looked very promising as an aid to transplanting since it was nontoxic, transparent and dried at room temperature. The plastic is a polyvinylchloride resin which at the time was named Geon 31X. Today this material is sold as Transplant Coat, Wiltpruf, and many other trade names. When we first started testing this material, we tried it on cut Christmas greens and cut Christmas trees. We had excellent results with this experiment and was able to reduce the drying of these materials from 25-30%. This was a considerable aid in keeping cut trees and greens fresh.

Since the results were good with the cut trees, experiments were started on live material. During the month of July, Norway Spruce were treated and transplanted bare root without any supplemental water. This was a severe test since it is unheard of to transplant evergreens in the middle of July bare root. The loss was high with only a 25% survival of the treated plants, however, in the controls there was a loss of 100%.

Since these results were favorable, several species of deciduous shrubs, apple trees, and flowering crabapples, that were left over after the normal transplanting season, were treated with Geon 31X. In this experiment the survival was from 25-50% higher in the treated than in the untreated. It was found that there was a cessation of growth in the treated plants. This cessation of growth was not permanent and it only retarded growth temporarily. When growth did recur, it was better than in the untreated plants. This cessation of growth was caused by a reduction of respiration as well as a physical barrier around the buds. Evergreens at several nurseries were treated for protection from winter injury. There was less winter burn on treated plants than untreated. This was especially true with *Taxus*.

This work was done in 1947 and '48 and today many commercial growers are using this material with excellent results. In talking with several nurserymen some of them are not having the results they should have. There are several possible reasons why good results are not being obtained. If proper coverage is not obtained, drying out will still occur and the material will peel off more easily. To insure good coverage a wetting agent should be used. We used sodium laurel sulphate (Dreft) as a wetting agent and sprayed to incipient run-off. In addition both lower and upper side of the foliage should be sprayed. If the material is used when temperatures are below 40° F., or if the material is frozen in storage or shipment it will crystalize and not form a good film.

In later experiments, Dr. Hamner found that when 2,4-D was incorporated with this latex, grasses were killed which are tolerant of 2,4-D. If sprayers are not cleaned out properly toxic effects may occur when using this latex. These are some of the reasons for failure.

I understand that Dr. Snyder is trying several anti-desiccants on the rooting of cuttings. Professor O'Rourke used Geon Latex at Michigan State without too much success in increasing precentage or speed of rooting. We recently had a graduate student at the University of Illinois who tried Geon Latex with other anti-desiccants on the rooting of cuttings with no increase in rooting.

These anti-desiccants have their place in transplanting, storage of nursery stock, and for protection from winter burn.

Krillium

The next material I would like to discuss is Krillium. I am not going to say too much about Krillium because it has not worked out as well as expected. Several years ago, Krillium was in the limelight and was tried on many crops. Krillium is a cementing agent for soils which improves the soil structure and increases the aggregation and gives better aeration and drainage. This was proven on problem soils especially on clays and other heavy soils. It gave fair results; however, just as good a results were obtained with the use of manure, peat, and other organic soil additives. Since organic matter produces the same results, this material has gone by the wayside. I doubt if Krilliu can be purchased today. We had one worker who was interested in Krillium and tried to obtain some and had a difficult time locating a source of supply.

Transplantone

Transplantone is another material that was used in transplanting several years ago. Transplantone is an auxin solution that the roots are dipped in prior to transplanting and is supposed to aid in root development. This material worked with tomatoes and other tender annuals, however, the results were insufficient for general use. It did not prove satisfactory on nursery stock. There was very little information on this material in the scientific literature. I have never worked with this material myself and will leave it with these comments, as it is probably another one of the materials that should be investigated more thoroughly to see if it will aid in the transplanting of nursery stock.

Aqua Gro

One of the newest materials that has come on the market is Aqua Gro which is a non-ionic wetting agent or an organic wetting agent. Again, there is very little information in the scientific literature about Aqua Gro, and we have to go on the commercial recommendations of the manufacturer. I do have a letter from the Aquatrols Corporation of America and they state that there are several pieces of research work being conducted at various universities. Dr. Boodley of Cornell Universiy is working with this material on transplanting from peat pots. Dr. Widmoyer of Connecticut University is working with container grown nursery stock and Mr. Robert Nuss of Penn State University is also working on container production and found that 50% less water is needed to maintain plants. Possibly, these workers from these institutions could give more detailed information than I am able to give you. These non-ionic wetting agents are supposed to give better penetration of water. This has been proven through the U.S.D.A. Soil Conservation Service. Soils that have been treated with a wetting agent would wet deeper and give better drainage and maintain a more uniform soil moisture. These results would give a more uniform and faster establishment of plants.

The only comment that I can make on this material either pro or con is that we are running into a lot of problems with our water today because of our sewage and drainage systems. We are building up a considerable amount of detergents which are not removed in filtration or other water purification methods. These detergents are contaminating our water supply. This is especially true when using city water from reservoirs. Actually all detergents are wetting agents and in the future we may have enough naturally in our water supply.

Hexadecanol

As I mentioned previously, the one main reason that I accepted this talk earlier, is that I thought I would have some information that would be of value on transplanting. At the University of Illinois, we have been working with a new material called Hexadecanol. This material did show a lot of promise in original experiments. Dr. Roberts of the Illinois Water Survey found that hexadecanol which is a fatty alcohol, would reduce evaporation on a water surface. What this fatty alcohol does is form a mono-layer over the water surface and prevents evaporation. The Botany Department at the University of Illinois became interested in this new material and found that it would reduce the amount of evaporation at the soil surface. They conducted experiments with turf grass with excellent results. The Agronomy Department found it worked with corn and we set up experiments with hexadecanol on ornamentals in the Ornamental Horticulture Division. Our original experiments were on Carnations, Snap Dragons and Coleus. At first we used a straight greenhouse soil and we did not have the results that were previously reported. We then switched to a peat-perlite mix to obtain a uniform mixture that could be easily controlled. This did give us excellent results and we reduced the rate of transpiration by 25%. In addition to reducing transpiration, the evaporation from the container was reduced from 15% to 19% depending upon the type of container used. This was excellent and we thought that we had something worthwhile, so when Dr. Mahlstede asked me to appear on this program I said I would be most happy to since I thought we would have something new to report. However, when we further analyzed the data, we found our fresh weight was the same irregardless of treatment and when we measured our dry weights, we found the treated to be less than the controls. In other words, we actually had a reduction in total growth and therefore we cannot recommend this material at this time. We are continuing our experiments with this material since we feel it still has potential since this material is applied to the soil and the material is taken up by the roots and does reduce transpiration.

Our Botany Department has had excellent results on turf grass, and they have had one student obtain his Ph.D. degree working with this material and it has worked on corn. However, in our greenhouse control cultures, we did not obtain the results that were attained with corn or grass since we had a reduction in dry weight. At this time we cannot recommend this material, but these fatty alcohols have good potential if one can be found that would reduce transpiration without decreasing growth. This process would be much simpler than spraying plants with an anti-desiccant since you are able to treat the soil instead of spraying the plants as you do with anti-desiccants. This material will be especially helpful in container grown nursery stock, since watering is a constant problem with container grown stock. We have experiments underway but do not have any results to date, and do not anticipate any striking results due to the outcome of our earlier work. Since we are running behind time I will close with these remarks, and I will be glad to answer any questions in the discussion period after the next speaker.

MODERATOR GALLE: Our next discussion on Root Pruning, Mudding, Fertilization, will be given by Ralph Shugert, Neosho Nurseries, Neosho, Missouri.

ROOT PRUNING, MUDDING, FERTILIZATION

RALPH SHUGERT
Neosho Nurseries Company
Neosho, Missouri

It is indeed a very great pleasure to appear on this year's program. John Mahlstede has given me a triple-barrelled topic, so we shall approach them one at a time.

In giving some thought to this paper, I reviewed all the back issues of our Society Proceedings, that are in my library. On the topic of Root Pruning there undoubtedly is a diversity of opinion. At our meeting in 1956, after Bill Flemer presented his paper on "Propagation of *Sophora japonica* by Budding," he was asked by Mr. Carl Kern, "I understand that the roots of *Sophora* trees grow straight down, like the horseradish. If permitted to grow in the nursery, the main root will go three or four feet straight down. Therefore, root pruning is necessary." Bill's answer was, "It is true they have deep taproots. Our experience has been that we get better growth if we dig the *Sophora* as two-year-old trees and actually tranplant them, than if we merely run a blade under them and leave them where they are. The same thing is true of honeylocust trees. I think Jack Siebenthaler will agree. If you run the blade under them, it glazes the ground or something underneath the tree, and they stand still and refuse to grow; whereas, if you transplant them and prune them severely with the shears, they grow much more rapidly." Those of us who have grown *Sophora*, and other plants with a comparable root structure, will readily agree. We know that the majority of the coniferous seedling growers will run their digger under two and three year seed beds of *Pinus*, *Picea*, etc., (with the lifters off the digger) to initiate fibrous root development. Without question this fiber root system reduces transplant shock and will benefit many plant varieties. Another value of root pruning is, of course, the stimulation of flower buds. A good point in question would be that of *Wisteria*—in many cases a good root pruning will force a *Wisteria* into a prolific blooming plant. Just a few varieties that have been mentioned in our own proceedings in the light of root pruning have been *Cotoneaster* (1956), Pfitzer Juniper (1959), and Dogwood (1959). My own personal conviction is that most nurseries should be doing more root pruning than is being done.. Perhaps this could be summed up well by referring to the 1956 proceedings when Harold Hicks asked Case Hoogendoorn this question, "Do you think it is better to trim the roots of Junipers and try to get new growth in the spring, or would you plant them earlier in the spring if you could, or would you prewith these remarks, and I will be glad to answer any questions in the discussion period after the next speaker.

MODERATOR GALLE: Our next discussion on Root Pruning, Mudding, Fertilization, will be given by Ralph Shugert, Neosho Nurseries, Neosho, Missouri.

ROOT PRUNING, MUDDING, FERTILIZATION

RALPH SHUGERT
Neosho Nurseries Company
Neosho, Missouri

It is indeed a very great pleasure to appear on this year's program. John Mahlstede has given me a triple-barrelled topic, so we shall approach them one at a time.

In giving some thought to this paper, I reviewed all the back issues of our Society Proceedings, that are in my library. On the topic of Root Pruning there undoubtedly is a diversity of opinion. At our meeting in 1956, after Bill Flemer presented his paper on "Propagation of *Sophora japonica* by Budding," he was asked by Mr. Carl Kern, "I understand that the roots of *Sophora* trees grow straight down, like the horseradish. If permitted to grow in the nursery, the main root will go three or four feet straight down. Therefore, root pruning is necessary." Bill's answer was, "It is true they have deep taproots. Our experience has been that we get better growth if we dig the *Sophora* as two-year-old trees and actually tranplant them, than if we merely run a blade under them and leave them where they are. The same thing is true of honeylocust trees. I think Jack Siebenthaler will agree. If you run the blade under them, it glazes the ground or something underneath the tree, and they stand still and refuse to grow; whereas, if you transplant them and prune them severely with the shears, they grow much more rapidly." Those of us who have grown *Sophora,* and other plants with a comparable root structure, will readily agree. We know that the majority of the coniferous seedling growers will run their digger under two and three year seed beds of *Pinus, Picea,* etc., (with the lifters off the digger) to initiate fibrous root development. Without question this fiber root system reduces transplant shock and will benefit many plant varieties. Another value of root pruning is, of course, the stimulation of flower buds. A good point in question would be that of *Wisteria*—in many cases a good root pruning will force a *Wisteria* into a prolific blooming plant. Just a few varieties that have been mentioned in our own proceedings in the light of root pruning have been *Cotoneaster* (1956), Pfitzer Juniper (1959), and Dogwood (1959). My own personal conviction is that most nurseries should be doing more root pruning than is being done.. Perhaps this could be summed up well by referring to the 1956 proceedings when Harold Hicks asked Case Hoogendoorn this question, "Do you think it is better to trim the roots of Junipers and try to get new growth in the spring, or would you plant them earlier in the spring if you could, or would you prefer to have new roots?" Case answered by, "Sure, you can trim them and plant them." In our own nursery, the bulk of our root pruning is accomplished by transplanting. For example, all our conifer cuttings and grafts are planted from the bench in late April into the field spaced closely in the row. The following January, the liners are lifted and sent to the nursery fields for customary field spacing. In our opinion, the additional growing year is of great benefit, in particular to Juniper grafts. We, also, have a better transplant than one growing for the eight month period in a pot with a constricted root system.

Now to move to Root Puddling or Mudding. In discussing this topic with growers around the country, apparently not many believe in its practice today. The only two references I could find in our proceedings were in 1953 in regard to *Wisteria* and in 1956 it came up again with this question from Bill Flemer, "Do you think there is any value in puddling — that is dipping the roots in a mud solution as they used to do in the old-time nursery, or do you think it mats the roots together and doesn't improve the stand?" He was answered by Case Hoogendoorn, "Years ago we used to dip in thin mud, but then we found when you get dry weather and the soil is dry, you pull the plant up, the mud will cake to the roots, and naturally, it is going to be that much harder for the young roots to break through. We have eliminated puddling and we just dip in clear water and plant." Apparently the answer is the soil used in the mudding slurry. For those of us who have visited the Shenandoah, Iowa, area, we have certainly seen evidence of mudding in that region. Concrete mudding vats are still in evidence where the roots of all stocks are dipped in a mud slurry before they are ricked in storage. Today most of the *Crataegus* and *Betula* varieties from the west coast are puddled before shipment. Many of the fine *Cornus* growers down south, for example, Hoskin Shadow, mud the root system of their plants prior to shipment. At Neosho we have a pseudo puddling technique that might be interesting to you. We harvest about 100,000 fruit trees annually, and after they are graded and tied in bundles of ten, they are all dipped prior to going into refrigerated storage. We use a four-hundred gallon tank which is two-thirds filled with water. Nicotine Sulphate is added to the tank for control of Aphids in storage. However, as a greater number of trees are dipped, much of our fine Haggerstown silt loam is washed off the roots and thus as a 'by-product' we puddle virtually all of our fruit trees. I personally feel this is an important factor in our Pear and Cherry holding up in storage, since these are the last fruit trees we harvest. Anyone who grows Pear and Cherry knows they will many times go bad in storage in late March or April.

The final phase of this discussion concerns Fertilization. This important topic has, of course, been discussed on many, many occasions during past meetings. In fact, there is mention of fertilizing in every issue of our Proceedings since 1953. That year our Vice-President, John Mahlstede, discussed fertilization in his paper on "Principles of Rooting Softwood Cuttings of Deciduous Shrubs."

However, in a few moments I will discuss our fertilizer program in relationship to transplanting. As a bit of background, we build our soil with a green manure program, using cowpeas at the rate of one bushel per acre on all our fallowed ground. We are, also, fortunate being in a chicken broiler area, in that we clean out many chicken houses during the so-called 'slack' seasons. We believe we are receiving about 117 lbs. of Nitrogen, 96 lbs. of Phosphorus, and 77 lbs. of Potash per two tons of litter per acre, plus much humus advantage, during the plow-down of the manure. In general, most all plants, particularly evergreen grafts and slow-growing shade trees, are given a top-dressing of 12-12-12 fertilizer every winter. We do not fertilize at the time we plant our transplants, however, we will on occasion water in Broadleaf Evergreens with a Rapid-Gro solution, if the planting date is late in the spring. We are normally blessed with some open weather in Mid-January, and most all of our conifer planting is accomplished at this time. If weather causes us to plant in March or April, we will water in the transplants with water-soluble fertilizer. During the growing season, we use foliage fertilizer every time the spray rig leaves the barn. Our theory is that the machine and labor costs will be there anyway, and the small amount of the fertilizer cost (about $5.25 per 400 gallons of water) is quite justified.

In summation, I would say all three subjects in this discussion could be important aids to successful transplanting. It goes without saying that no two of us will handle transplants in precisely the same manner, but we all know the importance of going to the field with the finest liner we can grow. We are all, I am sure, constantly trying to improve our techniques from year to year.

MODERATOR GALLE: Thank you, Ralph.

We are moving right along. We are now going to the panel on Hardening Plant Materials for Winter, and the first on the panel is Mr. Roland deWilde of Bridgeton, New Jersey.

HARDENING OF PLANT MATERIALS FOR WINTER (EAST)

ROLAND DEWILDE
Rhodo-Lake Nurseries, Bridgeton, New Jersey

In considering this topic, I felt it wise to begin with a definition of the word "hardening." For the purpose of this talk, let's define it as "treatment of plant materials so as to promote the greatest resistance to damage from cold weather conditions."

There is no area in which we might find a greater difference of opinion and a smaller amount of scientific knowledge. We all know of times when things survived well and times when damage was great, and yet we cannot definitely state what caused the difference in results.

There are some measures we can take, which over the years have become standard practice. These might be divided into what might be termed "cultural practices" — and the things we do which might

However, in a few moments I will discuss our fertilizer program in relationship to transplanting. As a bit of background, we build our soil with a green manure program, using cowpeas at the rate of one bushel per acre on all our fallowed ground. We are, also, fortunate being in a chicken broiler area, in that we clean out many chicken houses during the so-called 'slack' seasons. We believe we are receiving about 117 lbs. of Nitrogen, 96 lbs. of Phosphorus, and 77 lbs. of Potash per two tons of litter per acre, plus much humus advantage, during the plow-down of the manure. In general, most all plants, particularly evergreen grafts and slow-growing shade trees, are given a top-dressing of 12-12-12 fertilizer every winter. We do not fertilize at the time we plant our transplants, however, we will on occasion water in Broadleaf Evergreens with a Rapid-Gro solution, if the planting date is late in the spring. We are normally blessed with some open weather in Mid-January, and most all of our conifer planting is accomplished at this time. If weather causes us to plant in March or April, we will water in the transplants with water-soluble fertilizer. During the growing season, we use foliage fertilizer every time the spray rig leaves the barn. Our theory is that the machine and labor costs will be there anyway, and the small amount of the fertilizer cost (about $5.25 per 400 gallons of water) is quite justified.

In summation, I would say all three subjects in this discussion could be important aids to successful transplanting. It goes without saying that no two of us will handle transplants in precisely the same manner, but we all know the importance of going to the field with the finest liner we can grow. We are all, I am sure, constantly trying to improve our techniques from year to year.

MODERATOR GALLE: Thank you, Ralph.

We are moving right along. We are now going to the panel on Hardening Plant Materials for Winter, and the first on the panel is Mr. Roland deWilde of Bridgeton, New Jersey.

HARDENING OF PLANT MATERIALS FOR WINTER (EAST)

ROLAND DEWILDE

Rhodo-Lake Nurseries, Bridgeton, New Jersey

In considering this topic, I felt it wise to begin with a definition of the word "hardening." For the purpose of this talk, let's define it as "treatment of plant materials so as to promote the greatest resistance to damage from cold weather conditions."

There is no area in which we might find a greater difference of opinion and a smaller amount of scientific knowledge. We all know of times when things survived well and times when damage was great, and yet we cannot definitely state what caused the difference in results.

There are some measures we can take, which over the years have become standard practice. These might be divided into what might be termed "cultural practices" — and the things we do which might be termed for want of a better term "mechanical practices."

Under "cultural practices" —

Plants should be grown well — with enough nutrients to obtain normal color, proper growth rate, and good wood formation. Over fertilizing — to the extent that growth does not harden well — is to be discouraged. Some types of plants — notably *Azaleas*, Rhodo's and *Ilex crenata*, can be injured severely by too much available Nitrogen in the soil late in the growing season. It is generally conceded that the available nitrogen should be balanced by an adequate supply of phosphorous and potash for proper wood formation. Experiments have shown that tomato plants grown in soils containing the higher levels of potash had greater resistance to frost damage. I believe that is true of woody plants as well.

We have found that a basic fertilization program on plants that are sometimes troublesome, is to feed a modest amount of a complete fertilizer tailored to the results of a soil test early in the Spring. The N in this mix should be at least 50% in a quickly available form, the balance in the slower organics. We like to think that this would be used up by late summer or earlier. At that time we try to put soluble fertilizers in the irrigation water. These are usually gone at the end of two weeks, so that an inspection of the plants can help to determine if another application is necessary. If hardening is slow, the potash in the solution may be increased and the N. decreased.

Under "mechanical" practices:

There are ways in which plant material may be hardened by lifting and transplanting, either to different areas or by resetting in the same block. We do this especially with *Azalea* liners. We used to have considerable trouble with stem splitting, especially on varieties such as *Indica alba*, but it can occur in all varieties if the first frost is severe enough. Lifting the plants and transplanting them has virtually eliminated this problem. It must, of course, be done before danger of frost is likely.

If crops are mulched, removing the mulch before frost is likely. will help to stop growth and will promote the escape of heat from the soil and the consequent raising of the temperature at the plant level.

Root pruning will tend to stop growth earlier, with consequent development of hardier wood, and less likelihood of damage.

In most cases, what the young plant needs is protection from sudden low temperatures. This can be done by covering with shades where practical and in case of late rooted cuttings by covering with sash. By opening the sash and airing whenever the temperature is above freezing, you can extend the time needed for the plant to adjust to cold temperatures.

MODERATOR GALLE: Thank you. You have noted that we have three men talking on the same thing, but it is in relation to different regions. Now we are going to the central area — almost at home. Mr. Collins of Cole Nursery, Painesville, Ohio.

HARDENING PLANT MATERIALS FOR WINTER (CENTRAL)

W. C. Collins

Cole Nursery Company, Painesville, Ohio

Several factors are involved in hardening plants for winter. Some are directly related to cultural practices and can be partially controlled by the nurserymen. Others, for example, not so manageable, are. inherent plant hardiness and major unseasonable weather conditions.

Two examples of important, *less controllable factors* are: (1) the relationship between the normal hardiness of a specific plant and the location in which it is being grown, and (2) those extended periods or severe changes of unseasonal weather that alter the seasonal maturing process.

Two examples of more or less *controllable factors* are these: (1) one is the deliberate plan to locate the nursery within a desired area possessing the largest number of stabilizing factors such as suitable soil type, air drainage and nearness to large bodies of water. (2) Another is the planned reduction or cessation of those cultural practices that encourage vigorous and rapid vegetative growth.

Relationship of 'Hardening' to Hardiness

The degree of inherent hardiness or cold resistance varies with different species and varieties, and varies for the same species in different climatic areas. L. H. Bailey said, "In general, however, the unqualified word 'hardy' indicates that the plant is able to withstand the winter of a given place." It follows then that attaining the winter hardiness of a specific plant becomes increasingly difficult the farther it is grown from its so-called adaptable area. This selection of kinds to propagate is a factor each nurseryman can determine for the area in which he grows stock. The greater the distance a specific plant is grown from the area it is normally hardy, the greater the problem of hardening becomes.

Effect of Unseasonable Weather on Hardiness

Another factor over which the nurseryman has little control is injury following unseasonal temperature changes. Unseasonal weather may occur during the normal 'hardening-up' period in late summer, fall and early winter or during early winter after the plant has achieved its normal cold resistance. An extended mild temperature period during the normal fall ripening season may so delay ripening that the plant has inadequate time to become properly ripened. Likewise, some plants which have become normally hardened may be injured because of an extended late season warm period with its usual drying effects.

Several years ago Southern Canada experienced such a winter. The following spring a number of horticultural authorities urged the public not to give up growing many choice, desirable plants just because of this particular unusual winter. It was reported that 70 per cent of the roses were killed in the Toronto area alone.

Choice of Nursery Location Important

Certain nursery growing areas within the same temperature hardiness zone are more favorably located than others. For example, many nurseries are situated near or within a sizeable weather stabilizing area, such as the shore areas of the Great Lakes. To varying degrees these areas are present in Wisconsin, Illinois, Indiana, Michigan and Ohio. These locations frequently overlap fruit growing areas, and they were originally selected because they permitted the economically important annual cropping of both bush and tree fruits. The problem of hardening nursery stock in these areas is less important.

While the above factors may seem somewhat irrelevant to the practical aspects of hardening plants for winter, they are important in such major decisions as the selection of nursery growing areas and the choice of plant material grown at a specific location.

Field Cultural Practices Affecting Hardening for Winter

The cultural practices which nurserymen can use to induce winter hardiness are in many ways almost in direct contrast of the practices he uses to initiate and maintain maximum vegetative growth during the growing season. The following dates are based primarily on the field operations of The Cole Nursery Company at its Painesville, Ohio nursery.

Cultivation: Stop field cultivation not later than August 15th. The competition of late weed and grass growth aids in ripening the stock as well as reducing heaving of light stock.

Fertilizing: The fertilization of evergreens stopped about July 5th and that of deciduous stock by the 20th of July.

Irrigation: Irrigation of field stock curtailed after the 20-25th of August. This does not apply to broad-leaved evergreens which transpire all winter and which should be well watered as they enter the winter season.

Pruning: No pruning on deciduous stock done after August 20th. This permits time for adequate wound healing and reduces killback below the cuts. No trimming of evergreens after July 20th.

Planting: Good seedbed preparation coupled with early planting of stock helps to assure deep and profuse rooting and a longer period for growth and ripening. Site selection within the nursery can reduce hardening hazards. Plant late maturing kinds on high and well drained soils. Adequate tiling will help on less favorably drained soils.

Pest Control: While admitting the unquestioned value of a pest control program, the presence of healthy, vigorous foliage persisting on certain kinds of plants, sometimes until freeze-up, does not encourage the early maturing of stem tissue.

Root Pruning: Root pruning by undercutting during the growing season certainly hastens the maturing of the stock so treated, although the purpose may be to produce a more fibrous root system near the base of the plant and to assume greater transplanting success the following seasons. It can be done in early spring or in August depending upon soil conditions.

Seed and Propagation Beds

1. Fertilizing stopped by August 20th. Three pounds of Kapco in 100 gallons of water used about every 10 days.
2. Lath shades removed from the propagation beds on Labor Day — give or take a week according to the season.
3. Irrigation of the irrigated beds stopped about Labor Day unless dry weather prevails; then it is applied as needed.
4. Greenhouse mist propagated softwood cuttings hardened off before removal.
5. Mist on outdoor propagation beds shut off gradually when cuttings are rooted.

MODERATOR GALLE: Now we are going to the Midwest to Iowa, and Mr. George Rose will present that.

HARDENING PLANT MATERIALS FOR THE WINTER WITH SPECIAL REFERENCE TO MIDWEST CONDITIONS

GEORGE ROSE
Henry Field Seed and Nursery Company
Shenandoah, Iowa

Midwest winter conditions are very difficult on plant material, because of the frequent, very rapid changes in temperature and humidity. Many plants, which are hardier in much colder climates, often come to grief in midwest areas because of freeze damage to unripened tissues, caused by early freezes and by the usual lack of a snowblanket to keep the temperatures and humidity surrounding the plants from fluctuating widely.

Narrow-Leaf Evergreens

My talk will not cover field grown narrow leaf evergreens, as we do not handle this material at the Henry Field Seed and Nursery Company.

We do not produce container evergreens grown in soil or the other common mixtures either, but the common winter preparation procedure with this material in our area is to pull the evergreens together in tight groups and mulch heavily around the edges of the groups with shingletow or hay. This is the way container evergreens are wintered at Plumfield Nurseries and they very seldom experience any winter damage. No particular hardening off procedures are practiced.

To produce material that is merchandiseable for our mail order business, we have, over the years, developed a method of growing narrow-leaf evergreens in containers of light weight growing medium, composed of ground sphagnum moss to which about 10% peat is added. The peat is used to retain the slow release nitrogen fertilizers, either Uramite or Borden #38, which are added to the potting media cess the following seasons. It can be done in early spring or in August depending upon soil conditions.

Seed and Propagation Beds

1. Fertilizing stopped by August 20th. Three pounds of Kapco in 100 gallons of water used about every 10 days.
2. Lath shades removed from the propagation beds on Labor Day — give or take a week according to the season.
3. Irrigation of the irrigated beds stopped about Labor Day unless dry weather prevails; then it is applied as needed.
4. Greenhouse mist propagated softwood cuttings hardened off before removal.
5. Mist on outdoor propagation beds shut off gradually when cuttings are rooted.

MODERATOR GALLE: Now we are going to the Midwest to Iowa, and Mr. George Rose will present that.

HARDENING PLANT MATERIALS FOR THE WINTER WITH SPECIAL REFERENCE TO MIDWEST CONDITIONS

George Rose
Henry Field Seed and Nursery Company
Shenandoah, Iowa

Midwest winter conditions are very difficult on plant material, because of the frequent, very rapid changes in temperature and humidity. Many plants, which are hardier in much colder climates, often come to grief in midwest areas because of freeze damage to unripened tissues, caused by early freezes and by the usual lack of a snowblanket to keep the temperatures and humidity surrounding the plants from fluctuating widely.

Narrow-Leaf Evergreens

My talk will not cover field grown narrow leaf evergreens, as we do not handle this material at the Henry Field Seed and Nursery Company.

We do not produce container evergreens grown in soil or the other common mixtures either, but the common winter preparation procedure with this material in our area is to pull the evergreens together in tight groups and mulch heavily around the edges of the groups with shingletow or hay. This is the way container evergreens are wintered at Plumfield Nurseries and they very seldom experience any winter damage. No particular hardening off procedures are practiced.

To produce material that is merchandiseable for our mail order business, we have, over the years, developed a method of growing narrow-leaf evergreens in containers of light weight growing medium, composed of ground sphagnum moss to which about 10% peat is added. The peat is used to retain the slow release nitrogen fertilizers, either Uramite or Borden #38, which are added to the potting media at the time of planting. These potted plants have additional foliar feeding as needed through the growing season. We have used several different fertilizers and a formula somewhere around 10-15-5 seems very satisfactory.

It has been our practice to stop all fertilizing with the event of the first frost. Actually, from late summer on the fertilizer feedings are reduced, as continual soil testing always indicates a slower usage of fertilizer after the actual growing period is over.

As is commonly understood, evergreens need to go into winter season with the growing media in a moist condition, therefore watering is continued right up until the time the ground freezes, although as the air cools and the usual fall rains occur, it is usually not necessary to water very often, from early October on.

After two or three severe freezes, usually about the end of October, the container grown evergreens, which are in outside frames, are enclosed in polyethylene tents. This was not a new idea with us as Dr. Chadwick at Ohio State developed this method of winter protection some time ago. Two mil poly seems sufficiently strong for this purpose. Racks are left over the evergreens to reduce the heat from the sun and the whole frame is enclosed in the poly tent. To prevent snow damage it is better to put a ridge pole of 2 x 2's or pipe down the center of the frame and lay the poly over this, tacking it tightly to the frame sides and ends.

We find it very necessary to see that the poly enclosure is airtight as far as possible, in that, where openings have occurred, plants in the immediate vicinity of the openings have been very badly burned during the winter. This undoubtedly is due to de-hydration caused by dry air and low temperatures.

Should there be a long spell of unseasonably warm weather in the winter, it might be necessary to open the ends of the frame to allow a circulation of air to cut down the heat inside the frame, but we have never experienced this particular problem and have allowed our poly tents to be tightly closed throughout the winter.

It is best to leave the poly tent over the frames in the spring until extreme cold weather has passed — then the determination of how long the poly is to remain over the frame is based upon the condition that you want the plant to be in, as you offer it for sale. In the mail order business, a dormant evergreen handles much better than one with new soft growth on it and therefore we find it best to remove the poly tent after the most severe weather is over, to keep the plants dormant as long as possible. Possibly for road-side or over-the-counter sale, the tent should be left on, to act as a greenhouse to produce early growth on the plants, thus improving their appearance. It must be borne in mind however, that once the plants have been forced into growth, a late severe freeze will be very likely to kill all the new growth and spoil the plants for sale for the season.

We have also produced a limited line of container grown deciduous material produced in the same light weight media. One item we have produced successfully, although the sales for it so far have not been exciting, has been some of the red berried Cotoneasters.

These have grown very well in the light weight media and we have wintered them in the same manner as the narrow leaf evergreens without the least bit of trouble. We have also produced good plants of the evergreening *Euonymous* varieties and of *Mahonia*, using these same wintering methods.

The Winter Protection Of Deciduous Field Stock

Due to the sudden and often extreme changes of temperature and humidity, which occur during the winter in the Shenandoah area. young, nursery grown, deciduous stock is very subject to winter damage. Every attempt possible must be made to harden up the stock as early in the fall as is possible. Therefore, with most deciduous stock, no fertilizing is done after early July and cultivating is usually discontinued in September.

By mid October, it is necessary to dig the tender stock and that which has a tendency to be tender as young plants in the nursery row. With us these varieties include *Caryopteris*, *Deutzia*, *Buddleia*, *Althea*, Crape Myrtle if grown, Boston Ivy and Silver Lace Vine — there are probably many other plants in the same tender category, but of those we handle, the above are the varieties most subject to early freeze damage.

With the *Buddleia*, we immediately trim them to one cane and store. On the rest of the material the leaves are sweat off and the plants are then put in refrigerated storages as usual.

The remainder of the deciduous material is dug as soon as freezes take off the leaves. We have the same trouble with some of the Privet and Chinese Elm that other sections do, in that, these plants lose their leaves about the last of all and therefore are the last varieties to be dug. They include Ibolium and Amoor River Privet and Chinese Elm, particularly seedling Chinese Elm.

We do not use chemical defoliants on any nursery stock. Our experience with test lots of stock chemically defoliated, has been that it does not store, or keep as well as other stock.

On years that our storage has been crowded, we have heeled in apples and plums, Chinese Elm, Willows, Pin Oaks and Hybrid Elm. My own personal opinion is, that Willows and Pin Oak properly heeled in, come through the winter better outside than with inside storage, even refrigerated storage. In fact, our experience has been that most nursery stock heeled in properly comes through very well in outside heel beds, if it enters the winter in a well ripened condition.

MODERATOR GALLE: Thank you, Mr. Rose.

We are now moving on to the Winter Protection of Late-Propagated Plant Materials. We have a change in speakers. Mr. Hans Hess, Hess Nurseries, will be the speaker in place of Mr. Fisher.

WINTER PROTECTION FOR LATE PROPAGATED PLANT MATERIAL

HANS HESS
Hess Nurseries
Wayne, New Jersey

The use of mist for the production of nursery stock both outside and in the greenhouse during the summer period has made the propagation of many plants much easier than in past years.

Generally speaking material propagated in this way is much tougher than the same plant produced in a heavily shaded greenhouse or under double glass with heavy shading. However, in many cases the plants are not sufficiently mature or tough enough to withstand the severe changes of winter weather. This is especially true in Wayne, New Jersey which according to the chart is part of Zone #6 but really belongs to Zone #5.

We propagate a wide variety of material during the summer in open mist beds and some *Rhododendron* hybrids in the greenhouse. The first year that we tried the open mist on a commercial scale the question came up, what do we do with these plants for the winter? Many varieties had been tested experimentally for a few years but there were several untested groups. From past experience we knew that the only safe thing for this material was frame protection.

Two heated frames were built and all material known to need protection plus the doubtful groups were put in these heated frames. Temperature controls were set at 34 degrees. Sash are lined with plastic which saves a lot of oil and the frames are ventilated daily when the outside temperature rises to just above freezing. The plants are kept perfectly dormant this way and begin to grow naturally in the spring. Some shading on the glass is beneficial in March as the light intensity increases.

This method is the surest and safest to have live plants in the spring. It is not the cheapest by any means since it does require moving your cuttings and heating frames, although the amount of oil used to keep the frames frost free is small, the initial building cost of course is the large item of expense.

In these frames we store *Azaleas,* Pines, *Magnolias,* Maples, *Ilex, Gingko, Rhododendrons* and Cherry varieties. All evergreens and many deciduous items such as *Pyracantha, Berberis.* Crimson Pygmy, *Cotoneasters, Forsythia* and other flowering shrubs can be left in the mist bed using a light salt hay covering for winter protection.

Areas which are somewhat milder than North Jersey can overwinter *Azaleas, Ilex* and Maples in a deep cinder block frame with equally good success as a heated frame.

Some nurseries in South Jersey and Delaware have successfully carried over the more tender material by putting plastic over the cuttings for the winter. This involves a certain amount of risk, and in a severe winter losses can be heavy.

The best policy for the individual grower is to experiment and decide what is best for his area.

In conclusion, the safest way to overwinter late propagated cuttings is a heated storage frame or greenhouse. If you are in a reasonably mild area a deep cinder block or concrete frame will suffice. For those who like to gamble and want something inexpensive, metal bows of flat iron or pipe covered with plastic will serve the purpose. You, the individual propagator must decide what is best for your business.

MODERATOR GALLE: Hans, you might like to come back up. I would like to call all the other speakers back up. We do have some time and I would like to have discussion.

One thing that wasn't mentioned and for some of us in the southern regions it is important — what do you do about protecting the plant propagator himself in this winter weather? This is a fact we overlook.

Again, if you have any questions, when you stand up please give your name and then the question for the panel.

MR. JIM WELLS: I would like to ask Mr. Rose to enlarge a little on the lightweight medium he has used. Has he tried any other formulations? Is this the result of a normal test and how does the growth in this medium compare with more conventional mediums?

MR. ROSE: Yes, we have worked with this some eight years now, I believe. We have tried such mixtures as peat and perlite, soil and perlite, and a small group with soil and peat. In each case we found where perlite is used we have problems that are not common in any business but the mail order trade. That is once a package of ours gets into the hands of kindly Uncle Sam, he can do more with that package before it gets to the customer than you would believe possible. If you use perlite, by the time the customer gets the package, it has been shaken so much that practically all the perlite is in the bottom. Therefore, we have to use something that binds and stays in place. Sphagnum moss gives us a better result in that respect.

As far as we could see, mixtures of peat and perlite, peat and sphagnum, and all various combinations did not give us any better growth than straight sphagnum.

Now we find this, if we start off with young potted cuttings, that these cuttings grow very slowly in the ground sphagnum. Therefore, we start off with transplants rather than extremely young material. That action, as some of you may be able to inform me, is possible because there is so much aeration in the sphagnum.

As far as fertilizing is concerned, we found by adding ordinary fertilizer to sphagnum moss we got no better growth than with Borden 38. Your urea might be good for long-range nitrogen effects. We use Borden's 38 because we think it is milder than urea might be and if we would put it in a small amount of peat and incorporate the peat into the sphagnum. it retained the fertilizing value very well. Have I answered your question, Jim?

MR. WELLS: Yes. Could I just extend this and ask you what soluble feeding program you use, how frequently you maintain it after you have got the plant established in the moss?

MR. ROSE: We do not have a program of weekly or timed period of feeding, but we analyze the media about every week or ten days and when the fertilizer is low, then we fertilize. We have been using instant Vigero, which gives us very fine results, and we have it in our store anyway for retail sales. We found as we analyzed the medium going on throughout the late summer and fall that the times that we needed to fertilize were less and less.

MR. CASE HOOGENDOORN: You say you take a lot of this material early in the fall and put it in storage. What temperature do you run on your controlled storage?

MR. ROSE: Just about freezing, Case. It is hard to get the big storage cellars down to anywhere near freezing, as you would know, when the weather is warm outside. We try to get it down in the forties and then down to the thirties. That is the best we can do.

MR. HOOGENDOORN: I would also like to ask Hans a question about overwintering in frames. What is your temperature in the frames during the daytime?

MR. HANS HESS: The temperature goes up. We open the sash up.

MR. HOOGENDOORN: In freezing weather?

MR. HANS HESS: Yes. Once the sun comes up we open the sash on the lee side of the wind, so we don't get a blast of cold air, but the frames are adjacent to the greenhouses so they are protected from too much wind.

MR. HOOGENDOORN: Still you are going way above 34 where you have a thermostat set.

MR. HANS HESS: That is right.

MR. HOOGENDOORN: What is the result? When we have tried over wintering, in the spring the plants start to die from the top down. In other words, they haven't had sufficient cold to break dormancy.

MR. HANS HESS: Well, that has not been our experience so far. Everything we have carried there, that includes some grafting material like dogwood and beeches, which you speak of, and Japanese maples from cuttings, have come through very well. Maybe we ventilate a little more than you do, I don't know.

MR. HOOGENDOORN: Do you overwinter any climbing hydrangeas in the frame?

MR. HANS HESS: Yes.

MR. HOOGENDOORN: We cut them in the fall and put them in the frame. We lost some of those, and the ones we didn't lose, showed hardly any new growth. Why?

MR. HANS HESS: We make some hydrangea cuttings also. We make them directly in a pot, and don't pot them after they are rooted. We transfer them into the frame for the winter, and so far at least they have come into growth in the spring. We have had some losses the same as you have, but those that have come through have grown nicely.

MR. HOOGENDOORN: You have had some growth, so have we, but it didn't amount to anything. We have tried something different and it has worked out beautifully, that is why I was asking you about cold storage. Our storage runs anywhere from 34 to 38° F., a small controlled storage. Anyhow, we have a dark and constant temperature vault which seems to be sufficient to break dormancy. We put the cuttings up in poly bags, put them in the cold storage for about three months. In March we take them out and pot them. Then we bring them outside in the frame, and we have shoots anywhere from 8 to 15 inches. Then we have them growing.

MR. ROLAND deWILDE: Maybe I could make a suggestion. We have always been poor as far as capital investment is concerned. One thing we did, and some of you have seen it, was to build greenhouses which are comparatively low. I suppose the optimum height runs around five feet from the soil level to the ridge. We have no heat whatsoever in those. I have taken rhododendron grafts and taken them right out of the grafting bench, which we run at 70 degrees, cut the stocks off at the proper time, planted them in a soil mixture right in the greenhouse and kept the greenhouse frost free. The way we do that, is to have the glass on, put reed mats over the glass and throw salt hay over the mats, so no light and no frost can get in. Along about the first of March, whenever the temperature seems to settle down to something reasonable, we start taking some of that off. We don't worry about giving them light until it is pretty safe to take all the cover off except the glass. We find we get very nice growth on a number of things that way, because we have done it with dogwood cuttings, with azaleas, and with evergreens. We take them right out of the heat and put them in there and very seldom have any trouble. The only one problem was apple cuttings, and I kind of think it is a special problem. They keep all right until spring and about the time they start blooming and growing, they kind of wilt away. I don't think that had anything to do with the storage.

That is a comparatively cheap way of storing with little work involved. We water the plants when we put them in and we don't touch them until they are sold.

MR. HOOGENDOORN: Yes, but that is in South Jersey. You can't do that in New England.

MR. deWILDE: If you put the salt hay on, you can do it. It is like insulating with expensive building material.

MR. PETER VERMEULEN: Some years ago, I don't quite remember how long ago, John spoke on the styrafoam. Has anyone had any experience with overwintering with styrafoam?

MR. JACK HILL: Maybe I can answer that question. We have had an experimental lot of perhaps 200 or 300 plants that we have wintered now two years in belted styrafoam material. Actually, it is made right near Dundee. We have not observed any difference in overwintering in those beautifully insulated containers from the 10 gallon can. The plants grow just as well — no better, no worse.

MR. PETER VERMEULEN: I have one more question. We haven't touched yet on hardening where chemicals are concerned. Does anyone have any experience on that?

MR. JIM WELLS: I can make a comment but I don't know whether it is pertinent. We have a couple of plants in the back of the room, rhododendrons which were treated with CCC. This is a growth regulator. It is a dwarfing compound. It is intended to induce budding. I think it does on a strong growing variety of rhododendron like *roseum superbum* which naturally make a third set of growth late in the summer for us. A treatment of CCC in May reduced the size of the plant to some extent, induced budding and prevented this late growth. This is only one treatment and we don't know what the plant is going to do throughout the winter, whether the buds are any good. There are a lot of things to be determined, but it did prevent late growth on this variety.

MR. HILL: (In reference to Ralph Shugert's paper on root pruning). The argument of root pruning versus transplanting or perhaps not even transplanting is perennial in our camp, and we are clearly divided ino two groups, those who are for and those who are against and they are both very strong in their convictions. I think you have upright junipers, the *virginiana,* which are truly difficult to transplant especially in early fall just when that plant is at the very peak in appearance and marketability. We have to a large extent solved that problem by using the *Glauca hetz* as understock rather than the classic *virginiana* or *Chinensis.* We get a root system which is superior to any root system we get with *virginiana,* and they have a higher per cent of livability.

MODERATOR GALLE: I believe this completes our time. I would like to thank all the members of the panel for their participation.

We now have a follow-up on something of what we had in discussion this morning — Systems and Mechanization in a Container Nursery — and Mr. George Oki, of Oki Nursery, Inc., Sacramento, California will present it.

SYSTEMS AND MECHANIZATION IN A CONTAINER NURSERY

GEORGE S. OKI
Oki Nursery, Inc.
Sacramento, California

The most urgent need of the California nursery industry, within its present market, is for lowered cost of production. This is the opening sentence of Dr. Kenneth F. Baker's Manual 23 or "The U.C. System for Producing Healthy Container Grown Plants." This Manual 23 was edited in September, 1957.

With annual increases in general operational costs, labor, materials, and all taxations on local, state and national levels, this urgent need is becoming more significant for business survival.

Systems and mechanization is an integral part of the U.C. System along with the general practices as outlined in Manual 23. Some of the important factors in integrating systems and mechanization are:

MR. JIM WELLS: I can make a comment but I don't know whether it is pertinent. We have a couple of plants in the back of the room, rhododendrons which were treated with CCC. This is a growth regulator. It is a dwarfing compound. It is intended to induce budding. I think it does on a strong growing variety of rhododendron like *roseum superbum* which naturally make a third set of growth late in the summer for us. A treatment of CCC in May reduced the size of the plant to some extent, induced budding and prevented this late growth. This is only one treatment and we don't know what the plant is going to do throughout the winter, whether the buds are any good. There are a lot of things to be determined, but it did prevent late growth on this variety.

MR. HILL: (In reference to Ralph Shugert's paper on root pruning). The argument of root pruning versus transplanting or perhaps not even transplanting is perennial in our camp, and we are clearly divided ino two groups, those who are for and those who are against and they are both very strong in their convictions. I think you have upright junipers, the *virginiana,* which are truly difficult to transplant especially in early fall just when that plant is at the very peak in appearance and marketability. We have to a large extent solved that problem by using the *Glauca hetz* as understock rather than the classic *virginiana* or *Chinensis.* We get a root system which is superior to any root system we get with *virginiana,* and they have a higher per cent of livability.

MODERATOR GALLE: I believe this completes our time. I would like to thank all the members of the panel for their participation.

We now have a follow-up on something of what we had in discussion this morning — Systems and Mechanization in a Container Nursery — and Mr. George Oki, of Oki Nursery, Inc., Sacramento, California will present it.

SYSTEMS AND MECHANIZATION IN A CONTAINER NURSERY

GEORGE S. OKI
Oki Nursery, Inc.
Sacramento, California

The most urgent need of the California nursery industry, within its present market, is for lowered cost of production. This is the opening sentence of Dr. Kenneth F. Baker's Manual 23 or "The U.C. System for Producing Healthy Container Grown Plants." This Manual 23 was edited in September, 1957.

With annual increases in general operational costs, labor, materials, and all taxations on local, state and national levels, this urgent need is becoming more significant for business survival.

Systems and mechanization is an integral part of the U.C. System along with the general practices as outlined in Manual 23. Some of the important factors in integrating systems and mechanization are:

1. Type of crop.
2. Size of operation.
3. Geographical location and climate
4. Existing facilities.
5. Personnel acceptance.

Oki Nursery's principal crop is standardized to containers of 1 gallon and 5 gallon size. Varieties range from tropical *Hibiscus* and philodendrons to general varieties such as junipers and many deciduous varieties. In all, over 600 varieties are in production. At present, more than 2 million containers are in production covering over 50 acres.

We are located near Sacramento, a scant 75 miles from the cool sophisticated city of San Francisco. Metropolitan Sacramento is rapidly passing the half million mark in population and has access to over 5 million people within a 3 hour drive by auto.

Within this 150 mile radius climatic changes are unbelieveable. Annual rainfall from 70 inches to nil, temperature ranges from desert conditions to minus zero, with just as unpredictable relative humidity can be expected.

In spite of these fluctuations, Sacramento has been gifted with beautiful distinct 4 season weather. A low of 17 degrees is not unusual and can be expected once or twice a year. Our summers are usually in the 90s with 35-65% relative humidity. Our record high occurred in the summer of 1961 with 27 days of 100 degree plus weather. Annual rainfall average is 17 inches, commencing to rain in December to mid-April. The rains are usually gentle with rare thunder showers.

Oki Nursery can boast of its outstanding facilities. There are more than 7 acres of glass and poly-houses, more than 3 thousand square feet of workable area in the propagation houses, complete with refrigeration facilities, and more than 75 pieces of motorized special equipment of all conceivable sorts from orchard sprayers to planting machines as well as fork lifts, fertilizer injectors, and automatic electrical equipment.

We use two basic soil blends. One is used for potting only, mixture being half peat moss and half sand, and brought to optimum fertility range. This soil is put up in small boxes for ease in handling and sterilized by steam. The second soil blend is for all other container planting. The basic mix is 1/3 sand, 1/3 redwood sawdust, and 1/3 rice hulls. Redwood sawdust is used in place of peat moss and rice hull as a cheap organic filler. Both of these are by-products of local industries.

The soil is blended by a rotating drum capable of mixing 150 yards per day and piled in heaping 1200 cubic yard piles. Sterilization is accomplished by the heat generated by nitrogen additives and supplemented with the use of methyl bromides and polyethylene sheets.

Mr. O. A. Matkin and Fred Petersen of the Soil and Plant Laboratories of Orange, California, play a very important role in all phases of the production program. Soils are blended under their direction to maintain optimum fertility rates. Pathological control, cost analysis as well as monthly feeding programs are just a portion of the services rendered in obtaining the best finished product. Economy and growing techniques are under constant surveillance.

Let us take a typical crop from the beginning. From past production records and its sales performance a new production figure is projected on an annual production tally sheet. These figures are then transposed to a specific variety program sheet. The program sheet informs us of the length of time necessary to complete each phase either from seed or cutting, liner or canned, to the best marketing dates.

The marketing dates and quantities are just determined and then the seeding and cutting dates are determined, compensating for seasonal growing variables in each phase. From the variety program sheets the seedling and cutting schedules are prepared.

The many fast growing varieties need extra attention in programming in order to insure supply. We have also found that many of the deciduous varieties to be heat sensitive rather than being influenced by photo-light periods. The heated polyhouses are extensively used for not only tropical and sub-tropical crops but for many of the deciduous varieties as well.

The variety program sheet is again checked for potting dates as the rooted or seeded plants are ready for potting and only then are the plants planted in either peat or plastic pots. 2¼ inch round peat pots are used for faster growing crops and 2½ inch square plastic pots are used for the slower varieties. The potting operation takes place in heated greenhouses on raised wooden benches where all plants in this phase are grown. The pots and sterilized soil in boxes are conveniently placed in advance to accelerate the potting operation. Potting records are kept daily by variety for reference and then transposed to a history record or performance sheet. History record sheets inform us of the germination or cutting mortality and performance in each phase.

When plants near maturity as scheduled, they are sized and flatted and racked in pallet racks (capacity 2400 plants) for the canning operation or moved for further growing in a cooler polyethylene house.

All benches are then washed and sprayed with copper napthanate solution for pathogen control. Usual crop time in growing in this phase is 20 to 90 days.

We utilize 2 methods in planting into 1 gallon containers. The normal procedure is utilizing the canning machines in the field where the plants are to be placed. The planting machine dispenses tubed plantainers on a spaced conveyor, filled with soil, compressed, and pot dyed. One person then places a peat potted plant into this depression. The canned plants then proceed on a swinging conveyor to be placed in a systematic check or block. Only water is used for soil firming after planting. Since each block holds 2400 plants the pallets with the plants are strategically spaced by forklift for the day's planting. Personnel required is five; plus the following equipment: 1 planting unit: 1 soil truck and container truck. Daily average capacity is 10 to 12 thousand units per day. Record capacity was attained on August 29th of this year of 13,176 units. The alternate emergency method is placing filled containers in the checks and plugging the peat potted plants into the loose soil. This method is only used in emergencies or when an area is too small to accomodate the canning machine unit. Needless to say this method is costlier and slower.

Daily planting records are again kept by variety. These figures are then transposed to the history performance sheet as we have done in each of the previous phases. The section and area the plants were planted is then recorded. This process aids us in locating plants from records for control in assembly of orders.

Very little remains to be done after the plants are canned. Irrigation is by sprinkler which was designed by Mr. William Fry of the Agricultural Extension Service, Irrigation Department of the University of California at Davis. Each area is designed to receive a half inch of fertilized water through Rainbird #29 heads, this usually takes approximately 2 hours and is cycled by an electric time clock for complete automatic control. Approximately two acres are sprinkled in each cycle, pumping about 275 g.p.m. of fertilized water.

We are on a constant feed fertility program using a R-16 Smith proportioner for the injection of the fertilizer concentrate. The fertilizing program is under the direction of Soil and Plant Laboratories, and may vary after each routine monthly fertility analysis.

For routine insect control a Bean Orchard Sprayer with blower is used. The coverage being nearly 70 feet from the sprayer-blower, we traverse each 80 feet check. Two million plants on the fifty acres can be sprayed in a few scant hours. Special touch up spraying with a smaller power sprayer is done for known chronically vulnerable plants.

There again spraying record sheets are used to facilitate pest control. These records are kept to alert us for future reference for like problems. The information carried on these sheets are:

1. Type of insect or pest.
2. Location of pest.
3. Pesticide type and dosage.
4. Completion of spray and date.

Outside of containers, weed control is attained in the growing areas by using dinitrol, diesel oil and water and a low pressure (less then 20 p.s.i.) power sprayer. Emphasis must be placed on precaution as this mixture is extremely injurious to plants. There should be little or no wind and the operator thoroughly trained and oriented. Persistent and routine spraying is done and usually the 50 acres of growing area can be controlled by just one man in less than a week's time. Usual frequency is 6 weeks.

This leaves us with a segment of a program where mechanization is difficult to implement. Staking and tying still must be manually done as well as pruning and sizing. Perhaps in the near future this tedious operation can be improved. Time and California sunshine then completes a typical crop cycle.

Since we are all creatures of habit, we seek security in past performances and any alteration or complete change in systems is difficult to implement. I wish to place special emphasis on management and personnel acceptance of ideals and systems. All personnel at all levels must be thoroughly trained and oriented especially to think positively.

When a procedure is altered in any way, the success of the change in system lies strictly with management alone.

Some of our outstanding production performances are:

1. *Betula Alba,* seed to 8 ft. in height, ¾-1 inch caliper, less than 10 months.
2. *Liquidambar* seed to 4 ft. in height, 150 days, October seeding.
3. *Lantana*: Cuttings to a 12 inch bush, less than 90 days.

With these accelerated production performances, programming is the most essential keynote to success next to market development and market development is another interesting story.

ANNUAL PRODUCTION SCHEDULE

(Estimate For The Yearly Production Is Recorded On This Sheet)

Year ....

Item	Meth. Of Propagation	Amount Needed	Approx. % of Root or Germ.	Approx. Amt. to Cut or Seed	Best Month	Alternate Month

USED FOR DETERMINING THE SELLING DATE OF EACH VARIETY

SOURCE: .... SEEDS PER ....

YEAR: .... YEAR: .... YEAR: ....

	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
CUT																																			
LINER																																			
1 G. C.																																			
FIVES																																			

VARIETY: ....

CUTTING CHECK LIST

By Season

Winter, Spring, Summer, Fall

Item	Amt. Needed	Approximate Amt. to Cut	Total Amount Cut

SEEDING CHECK LIST
By Maturing of the Seeds

Item	Sched. Sowing Months	Ea. Sowing No. of Flats To Sow	Treatments

ACTUAL RECORD OF EACH DAY'S CUTTINGS
Propagation By Cuttings

Date	ITEM	Sticking Count

BOTANICAL NAME ....

COMMON NAME ....

SEEDS			LINERS			CANS		
Date	Amt.	Loc.	Date	Amt.	Loc.	Date	Amt.	Loc.

Source of Seeds .... Date Gathered ....

Treatments ....

Media ....

% Germination .... % Take ....

Remarks ....

....

SEEDS			LINERS			CANS		
Date	Amt.	Loc.	Date	Amt.	Loc.	Date	Amt.	Loc.

Source of Seeds .... Date Gathered ....

Treatments ....

Media

% Germination .... % Take ....

Remarks ....

....

Permanent Record For Each Variety (Seeds)

BOTATNICAL NAME ....

COMMON NAME ....

CUTTINGS			LINERS			CANS		
Date	Amt.	Loc.	Date	Amt.	Loc.	Date	Amt.	Loc.

Source of Wood ....

Treatments: ....

Growth Regulator .... Media ....

% Rooted .... % Take ....

Remarks ....

....

SEEDS			LINERS			CANS		
Date	Amt.	Loc.	Date	Amt.	Loc.	Date	Amt.	Loc.

Source of Wood ....

Treatments: ....

Growth Regulator .... Media ....

% Rooted .... % Take ....

Remarks ....

....

Cuttings Permanent Record For Each Variety

PEST CONTROL

1. Agrimycin
2. Bordeaux
3. D.D.T.
4. Diazinon
5. Chlordane
6 Karathane
7. Kelthane
8. Malathion
9. Panogen
10. Parzate
11. ____________
12. ____________

Date	Location	Variety	Pest	Type	Dosage	Int

PRESIDENT SNYDER: Our International Secretary-Treasurer Louis Vanderbrook will tell about the Western Region meeting held at San Dimas, California, on October 18th through the 20th.

SECRETARY VANDERBROOK: We were wonderfully received and escorted by Don Hartman and his lovely wife over to our motel. In the evening we had a meeting of the board of governors of the International Society. Don was presiding at that meeting and I guess we worked until half past one or two o'clock in the morning. California time. Being a cardiac, I said to Don Hartman, "Do you realize Bill Snyder and I have been working twenty-three and a half hours?" They said it was time to quit and we went to bed.

In the morning we journeyed over to Monrovia Nursery, which many of you may know. It is a fantastic organization. Those fellows know what they are doing. You might call it assembly line culture. I saw many plants that were completely strange to me and a few things I did know I recognized.

Monrovia served us a fine lunch, and then we all were transported over to San Dimas, to the Cal Poly conference grounds where we were duly registered. The boys out there work you more than we do here — every minute, morning, afternoon and evening in session. They don't have any time off. You are on conference ground and there is nowhere else to go. They don't have any bars. If you have bars of any kind they are candy bars.

Their meetings were very interesting. They had some excellent talks there. While they had good speakers on the West coast, the one that kind of impressed me the most, and I thought was really outstanding was that man from the East, Charlie Hess. I have never seen him but what he has done a good job, and he always shows enthusiasm. The whole meeting was arranged and handled by Percy Everett and I publicly commended him on the selection of speakers and his program. Percy did an excellent job.

At the conclusion of the meetings we had another session of the International Board for about half an hour to clean up some of our business and the election of officers. At that electin of officers your President, Bill Snyder, was elevated to the post of President of the International Society, and Herman Sandkuhle, Past President of the Western Region, was elevated to Vice President, and Percy Everett was put on the Board and will proceed up the line later on.

PRESIDENT SNYDER: I am going on to the last part of our program this afternoon. We have our Editor, Charles E. Hess, Department of Horticulture, Purdue University, and his subject is Propagation Facilities on the Continent.

PROPAGATION FACILITIES ON THE CONTINENT

Charles E. Hess
Purdue University
Lafayette, Indiana

We have learned a great deal this morning and this afternoon, starting with the anatomy of cuttings by Bill Snyder. Jim Wells told us about the wounding of cuttings and Hal Tukey showed us that we can actually melt in the rain after all. Fred Galle told us some of the things we should avoid, and George Oki has our systems and mechanisms all back in order.

I think that just before supper it might be nice to relax a little bit and take a quick tour through some of Europe, emphasizing, as much as possible, plant propagation. We will start in France.

We took the opportunity to see many of the famous sights in Paris, including those dealing with anatomy, but the real reason for coming to Paris was to visit the small town of Gif-sur-Yvette which is the site of the centre National de la Recherche Scientifique. One of our members, Dr. J. P. Nitsch, is assistant director of a phytotron located at the center. The phytotron is designed to study the effects of the environment upon plant growth and development. Air temperature, humidity, and daylength are precisely controlled and almost any climate can be duplicated in the laboratories.

We left Paris by train and went to Munich, Germany. We visited the excellent botanical gardens in Munich and then spent several days in the Bavarian Alps.

In Belgium we saw one of the earliest techniques used to control moisture loss from cuttings — bell jar propagation. In contrast we saw a new electronic leaf that was also controlled by temperature. The "leaf" would regulate the mist as long as the temperature did not exceed a pre-set maximum. If the air temperature exceeded the maximum, the controller would turn the mist on until the temperature dropped below the limit and then the "leaf" took over the controls again.

A highlight on the trip was a 3 day visit to the research institutes at Wageningen, Netherlands. The research center is equivalent to the U.S.D.A. laboratories at Beltsville, Maryland. It is very impressive that a country the size of the state of Maryland can establish and operate such an extensive research organization. We saw a very interesting stock-scion interaction. When a melon scion is grafted on a *Cucurbita fitsafolia* understock the combination grows vigorously as long as a few leaves are left on the stock. If the few leaves are removed, the entire combination dies. Apparently the stock leaves produce a substance essential for growth, and the melon leaves do not synthesize this substance.

A great deal of work utilizing radiation is also being conducted. Seeds are exposed to high levels of radiation and then are germinated. A small percentage of the population will be mutants, that is genetically different from the parents. The mutant seedlings are grown on to determine if they have any immediate practical use or if they will serve as new genetic material in the breeding program.

At the nursery experiment station in Boskoop, Netherlands, we learned from Mr. Van Doesburg that a combination of captan and a root promoting substance gave better results than when a root promoting substance was used alone. With *Tsuga canadensis* 'Pendula' for example, 23% of the controls rooted; 24% of the cuttings treated with 50 mg/l indolebutyric acid (IBA) rooted, but when 50 mg/l IBA was combined with 5% captan, 74% of the cuttings rooted. Similarly, with *Chamaecyparis obtusa* 'Filicoides' 30% of the controls rooted, 46% of the cuttings treated with 50 mg/l IBA rooted, and 78% of the cuttings rooted when treated with 50 mg/l IBA plus 5% Captan. At present it is not known whether the stimulation is due to the fungicide action of the captan or because of an interaction between Captan and IBA.

The Captan-IBA mixtures were prepared as follows. Ten percent Captan was used as the starting material. If the final strength of IBA was to be 1% then the starting material would be 2% IBA in talc. Then equal portions by weight of the 10% Captan and the 2% IBA were mixed. The final concentrations would then be 5% Captan and 1% IBA.

If 0.5% IBA were desired, then the starting material would be 1% IBA and 10% Captan. In other words whatever the concentration IBA you wish to use, you start with twice that concenration dilute it with the 10% Captan. Similar results were obtained when naphthaleneacetic acid was used.

I hope that you have had a chance to relax little, gained some useful information or ideas, and are ready for supper. Thank you very much.

PRESIDENT SNYDER: I want to thank the Moderator and the speakers who were on the program today and I think it was a very excellent program. We thank Dr. Mahlstede for the planning and the speakers on the panels for getting their points across and staying very close to time. I am sure we all appreciate it.

We will adjourn until 8:00 o'clock tonight and then until 9:30 tomorrow morning. Thank you.

(The session recessed at 5:30 o'clock.)

RECESSED

(*Editor's Note*: On Thursday evening a special session on teaching was held. Dr. L. C. Chadwick was moderator. The following people participated on a panel which discussed teaching techniques with particular emphasis upon the laboratory:

Dr. Thomas Cannon
North Carolina State College
Dr. John Mahlstede
Iowa State University
Dr. Robert Meahl
Pennsylvania State University
Dr. Robert O. Miller
Ohio State University

The session was not recorded).

FRIDAY MORNING SESSION

December 7, 1962

The session convened at 9:35 o'clock, President Snyder presiding.

PRESIDENT SNYDER: Gentlemen, if you will take seats we will get started. We have a rather full program this morning.

Last Wednesday evening the Membership Committee met and elected 12 new members, and if those members are present I would like for them to stand when I call their name.

Floyd K. Armfelt — Ohio C — Jr.
Ray A. Baugher — Ohio C
Dr. L. P. Benjamin — Ontario, NC — Jr.
Paul E. Case — Pennsylvania C
Leon N. Cox — Tennessee C
Earl Cully — Illinois C
Wm. S. Cumming — Manitoba NC
Glynn Hobbs — Tennessee C
Frank Krall — Wisconsin NC
Wolfang Matzke — Austria NC
G. B. Smith — New Zealand C
John B. Wight — Georgia C

This morning we have the Speaker – Exhibitor Symposium. It has been arranged under the direction of Dr. Jim Kelley of Kentucky and Don J. Hillenmeyer. They have a rather full program, and without further ado I will turn it over to the Moderator — Don J. Hillenmeyer, Hill and Pat Farms, Lexington, Kentucky.

MODERATOR HILLENMEYER: In the last News Letter that came out, they put out an extra call for help, that we were a little short of speakers. We had a good response to that last request and we have some additional speakers, other than what you will find on your program. The speakers will come in the order they are on your program and then we will add the others at the end. They are interesting speakers I can assure you.

Our first speaker today is Professor Joseph C. McDaniels, University of Illinois, who will speak on New Cultivars in Two American Hardy Hydrangeas. Professor McDaniel.

NEW CULTIVARS IN TWO AMERICAN HARDY HYDRANGEAS

JOSEPH C. McDANIEL
University of Illinois
Urbana

Hydrangea arborescens and *H. quercifolia,* two of the American hardy species most widely cultivated, are remarkable for going so many years without the introduction of new cultivar forms. Until the recent introduction of the clone named 'Annabelle,' there had been no really improved cultivar of *arborescens* introduced to the nursery trade since E. G. Hill brought out 'Snowhill' in 1906. With *quercifolia* the situation has been even more static. It has been in cultivation in this country and abroad for more than 160 years, with largely vegetative propagation but also with much collection of seedlings from woods in the southeastern states. (It is found sparingly to Louisiana, north as far as Hardin and Wayne counties in Tennessee, and south into Florida, but Georgia and particularly Alabama have the most native *H. quercifolia.*) Yet there seems never to have been a named cultivar form in the trade up to now. My father and I have now registered the very showy flowered form developed by him in Alabama, I have cutting increase of it under way, and as soon as sufficient stock is built up it will be introduced as *H. quercifolia* 'Harmony.'

H. arborescens 'Annabelle,' which appears to be the best form of its species yet found, is a native of the woods in Union County, Illinois, where the mother of the late Hubbard Kirkpatrick, and an aunt, Miss Amy R. Kirkpatrick, found it in 1910 and brought it to the yard of their home on Chestnut Street, Anna, Illinois, where a clump of it still grows.

It is probably fortunate that they found it when they did, and brought it to cultivation before Hill's introduction of 1906 at Richmond, Indiana, had become known at Anna. As Mr. Kirkpatrick related its history to me shortly before he died a year and a half ago, his mother was horseback riding along a wooded trail in the hills near Anna when she saw the original plant in flower. When she returned home she asked her sister-in-law, "Have you ever seen a wild Hydrangea with a snowball bloom?" Amy never had, but she was interested, so the two of them went back to the woods, collected the little plant,

Figure 1. *Hydrangea arborescens* **'Annabelle' growing at Urbana, Illinois.**

and transplanted it to town, where it grew. If it had been a year or two later, they probably would already have seen a 'snowhill' bush in flower, and have passed by the plant in the woods which had not yet reached its full splendor. But they saved it, passed out starts to their neighbors, and soon it was all around town.

The Kirkpatricks wrote to the Burpee Seed Company at Philadelphia, asking if a snowball variety of the wild hydrangea was known to them. Burpee replied, with information on the then-recent introduction of 'Snowhill,' which had been brought to private gardens from its original source near Yellow Springs, Ohio, before Mr. Hill took it up commercially a few years earlier. Thus the Kirkpatrick selection went 50 years more without a name or a commercial sponsor. The people around Anna appreciated it, though, and it got scattered to other Illinois towns, reaching Urbana, so far as I can trace the records, about 1935. I saw it here in 1960, traced it back to Anna, named and registered it, and have already interested several nurseries in it. The first one to catalogue it, in 1962, was probably our member Albert B. Ferguson of the Linn County Nurseries, Center Point, Iowa. The Louis Gerardi Nursery, O'Fallon, Illinois, is another source for 'Annabelle' liners. It is as easy as any *H. arborescens* to propagate, either from dormant wood or greenwood leafy cuttings.

In the same year I rediscovered 'Annabelle,' I registered another *H. arborescens* clone, widely grown around Champaign-Urbana and superior to 'Snowhill' in landscape value, as the 'Champaign' cultivar. I have since seen this clone or form at many other places, clear back to Wysox, Pennsylvania, whence John Carey, before 1840, collected the specimens upon which Torrey and Gray, in their Flora

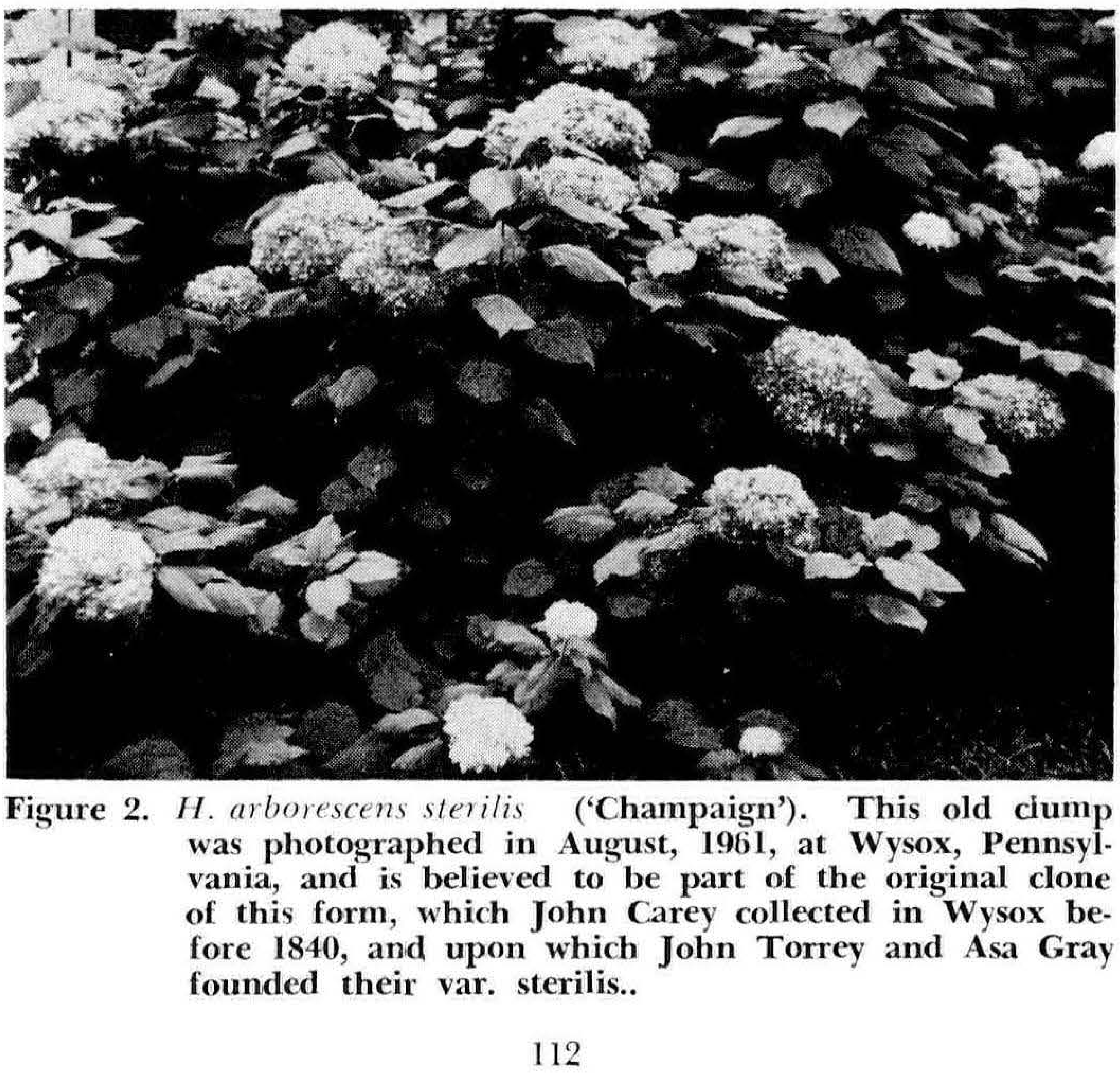

Figure 2. *H. arborescens sterilis* **('Champaign'). This old clump was photographed in August, 1961, at Wysox, Pennsylvania, and is believed to be part of the original clone of this form, which John Carey collected in Wysox before 1840, and upon which John Torrey and Asa Gray founded their var. sterilis..**

of North America, based their *H. arborescens* var. *sterilis.* It agrees with their description, except for having many non-sterile, seed-producing flowers, principally in the interior of the flowerhead, where the showy so-called "sterile" flowers (actually staminate in function) tend to obscure them, particularly in pressed specimens. I believe that the old variety *sterilis,* far from being probably lost to cultivation, as Sargent and later authors would have it, has survived all this time at Wysox and elsewhere, and is still very much with us. I have seen it recently, under the *H. arborescens grandiflora* (or 'Snowhill') label in at least two Illinois nurseries.

The leaves differ, as well as the flowerhead shape, in each of these *H. arborescens* cultivars, and I believe each has originated independently of the other two, as a mutant with many more showy flowers than the normal wild type. 'Annabelle' makes the largest, most symmetrical heads; 'Snowhill' has the largest individual florets and the most floppy heads; *sterilis* ('Champaign') is the tallest growing and actually the least nearly sterile of the three. All of them produce viable seeds which self-sow occasionally. They may be cultured to give a high proportion of seedlings with flowerheads of the showy type. I am using 'Annabelle' in crossing with an extremely short stemmed *arborescens* clone (also from Anna) to select for a more compact white "snowball" hydrangea.

Figure 3. *H. quercifolia* **'Harmony' showing second flowering in Alabama, July, 1962.**

H. quercifolia also has mutated once, and only once, so far as any records show, to a form with nearly all showy flowers, whose heads are even more dense than those of the well-known *H. paniculata* var. *grandiflora* ("Peegee"). This occurred in the 1890's in early cultivation around an apple orchard that my grandfather had on his farm in northern Alabama, in part of the range where *H. quercifolia* (locally called "seven bark") is most plentiful in the rocky woods. My father, then a young boy, first propagated the "double" *quercifolia* by layered offsets on the family farm. He moved, the plants were neglected, and thought lost, but I rediscovered three old clumps of this clone still surviving in the area recently. It has been possible to increase it more rapidly by greenwood cuttings, treated with Hormodin No. 3, both in a well aerated mist bed and under plastic. Semi-soft wood will root in a few weeks under these treatments, anytime from mid-spring to as late as October in the greenhouse. June is the preferred month in Alabama. We are multiplying this *H quercifolia* 'Harmony' now, and hope to introduce it about 1965. Besides having more showy flowering, this plant seems typical of native *H. quercifolia* in its north Alabama range. Fall color is red

'Harmony' bears only an occasional perfect flower, and has not been known to ripen any seed. Its pollen, though, appears normal under a microscope, and could probably be used in breeding.

MODERATOR HILLENMEYER: Professor McDaniel, did you have someone you wanted to say a few words?

PROFESSOR McDANIEL: Mrs. Stone of the Brooklyn Garden has been breeding magnolias for nine years now and she has some crosses that are almost flowering. I will turn it over to her.

MRS. DORIS M. STONE (Hastings-on-Hudson, N.Y.): Thank you very much. We have been breeding magnolias in Brooklyn for about eight years and we have tried to do some crossing between the Asiatic and the native American ones and so far we have got some quite promising crosses with using *Magnolia acuminata* as the female parent. We used the *acuminata* with the *liliflora* and there is one tree that we are really watching that is quite interesting. It has very interesting color. It has some of the yellow of the *acuminata* a sort of greenish-yellow with some of the purple of the white variety — nigra. We have a dusty pink color which is really quite attractive but as my boss, Mr. Avery, says, we must watch it and watch it for some time before we can say.

We have had quite a lot of apomictic seedlings. I didn't really know until I got into doing work that there was so much of it. One try I worked on for years and then realized that all my seedlings were apomictic. I found it was very successful and had lots of fruit. We wasted lots of time.

I really don't have anything more to say except we do have 1,000 hybrids growing in Westchester County, which is 50 miles north of Brooklyn and the temperatures are quite low, no watering system, so anything that survives there is very hardy, and this particular specimen that we are looking at, is up in Westchester area and it has survived. We are really pleased since we are looking for hardiness chiefly and dwarfness also. Unfortunately, this one is growing quite strongly. It is now about nine feet high, which disturbs us somewhat.

I don't think, Professor McDaniel, I have anything else more to say, unless anyone has any questions later. Thanks very much.

MODERATOR HILLENMEYER: • Thank you, Mrs. Stone.

Our next speaker is Mr. Vincent Bailey, J. V. Bailey Nurseries, St. Paul, who will speak on Softwood Rooted Cuttings of *Prunus cistena* and *Prunus triloba*. Mr. Bailey.

PROPAGATION OF PRUNUS CISTENA & TRILOBA BY SOFTWOOD CUTTINGS

VINCENT K. BAILEY
J. V. Bailey Nurseries
St. Paul, Minnesota

This subject was discussed with you two years ago by Rodney Bailey but I feel it is of sufficient importance to again bring it to your attention. The superiority of own root plants over those budded on *Prunus americana* or some other root stock is so obvious that I will not take time on that but rather will discuss our method of producing plants from soft wood cuttings.

Our schedule during the past summer was as follows:

	Stuck	When	Rooted	%
Prunus cistena	29,000	July 12	18,445	64
Prunus triloba	20,000	July 15	12,875	64

The per cent of *cistena* rooted in 1960 and 1961 was 80 and 65 per cent *triloba* rooted.

The greenhouse is equipped with air conditioning and humidification. The air conditioning allows us to use much more sunlight which I believe is important to success. The relative humidity is carried at 80 to 85 percent for the first 3 to 4 weeks and this contributes to success.

A mild solution of Indolebuteric acid is used as a soak. It is important to take cuttings at proper stage of maturity.

The rooted cuttings as you see them on exhibit in this room, are lifted in late November and rolled up in Polyethelene sheets, 250 to 500 per bundle. These are then stored without packing in a room at about 34 to 35 degrees F. until planting time in late April. They are then placed in 40 inch field rows 8 to 10 inches apart. We are getting about 90 per cent survival (estimated) and a very good growth. (80 per cent finished saleable plants). Most of these are grown two years when the highest per cent of the plants will be 2/3′ grade. A few of the *cistena* are grown 3 years to obtain some 4 to 5 foot sizes.

You can readily see the low cost of production under this method where no potting is done and several thousand plants can be carried to the planting site in a matter of minutes. If we are to progress as an industry, we must be always alert to means of offering a better product to the public at a price that returns a profit to the producer. Thank you.

MODERATOR HILLENMEYER: Thank you, Mr. Bailey.

Our next speaker for this morning is Mr. J. Peter Vermeulen of John Vermeulen & Sons, Inc., Neshanic Station, New Jersey, who will talk on the subject Communication in Propagation. Peter Vermeulen!

COMMUNICATION IN PROPAGATION

J. PETER VERMEULEN
John Vermeulen and Sons, Inc.
Neshanic Station, New Jersey

Notwithstanding all of the brain power represented by this assembly today I think it safe to say that none of us has ever had a completely original thought. I hasten to add that by original I mean one that is totally independent of something previously spoken, written or accomplished. Never before has a society been so progressive or so dependent upon progressiveness. Our very survival depends on the continuous satisfaction of an endless and prodigious hunger for education, innovation, instigation, participation. In this we have a responsibility to future generations as well. Henry Ward Beecher has said, "We should so live and labor in our time that what came to us as seed may go to the next generation as blossom, and what came to us as blossom may go to them as fruit. This is what we mean by progress."

One of the most important and far reaching ingredients of progress is communication. Why even to retain the status quo, we must communicate and communicate well at that. Everything that we say or do or think to do is linked through communication to something said or done previously.

Communication is easy to define but difficult to picture in all of its many aspects. It can be quite simple such as the cocked eyebrow or shy smile or the cheery "Hi" of the kid across the street. Similarly it can be intricately complex as Telestar or the Project Mercury Tracking system or the huge automatic data processing machines.

What has all this to do with propagation? Simply stated it is this. Without communication, progress in propagation is dead. And it appears on the surface, that our communication is lacking.

Back in September of this year there was distributed to the membership a request and application form for participation in this Speaker-Exhibitor Symposium. Toward the end of October I received from Dr. Kelley a letter stating that the response to his request was poor. He asked that, since I had participated once before, I might consent to do so again. The thought occurred to me then that individually, as members of a fine organization, we were lacking in one of the essentials and that the essential in this instance is participation, or in a broad sense, communication. What can we do about it?

We are formed into a society and meeting here today because of the farsightedness of a much smaller group of men. These men had a common interest and a common quality. Their interest was propagation. Their quality was a recognition of the need for and a desire to do something about better communication; talking about and freely exchanging their thoughts, ideas, opinions, accomplishments and even failures. These men did meet; they did talk and exchange their ideas; and most important they did act. As a result we enjoy today this wonderful, enriching and inspiring organization. Through the years — and this is the 12th meeting — we have grown and we have progressed. But are we doing all we can? Is each one of us giving our full support? Are we all communicating fully and sufficiently?

What do we now know about the very plants we produce or the techniques we use to produce them? If we but honestly face the facts we realize that it is still very little. We have the potential in this society of ours to create a chain reaction that will completely revolutionize plant propagation as we know it today. In our own society we have a homogeneous-heterogeneous group. By this I mean that while on one hand we have common interests there are at the same time understandable differences in both physical and mental capabilities as well as differences in our levels of exposure to propagation procedures and practices. Yet each and everyone of us has something to contribute to each other. Each and everyone of us can benefit from learning what the other fellow knows or thinks.

It is vitally important to us individually and collectively that we all give serious thought to just how we can best exchange and distribute among our members every bit of information that will further our common efforts. It may be desirable and opportune to now ask for suggestions and comments. However I do not believe the program affords us the luxury of the amount of time that this would require. Instead then may I suggest as fuel for your thinking caps and for your further consideration:

1. That an appropriate paper be required of each new member at the time of his or her acceptance.
2. That notwithstanding present attendance requirements, appropriate papers or program or project participation be required of all members periodically thereafter.
3. That a committee be appointed to determine a suitable time schedule for receipt of such papers and further to edit and economically reproduce and distribute them to the membership.
4. That the executive committee consider and explore the need for and recommend new procedures for better communication.
5. That future Speaker-Exhibitor Symposiums be comprised of a certain number of the most appropriate papers submitted during the previous years. It would be preferable, but not required, to have the author present his own paper. The paper should not be previously circulated.

I thank you for your attention. We hope for your participation. I close with the following:

To weigh our fate, communicate;
Matriculate; participate;
Educate and elevate;

Create, collate and circulate:
Relate, debate, articulate:
Perpetrate; illuminate;
Generate, not imitate;
Innovate, then instigate;
Stimulate and propagate;
Reiterate — COMMUNICATE!

MODERATOR HILLENMEYER: Thank you. I hope your words will be heeded well by the members.

Our next speaker this morning is Mr. James S. Wells, James S. Wells Nursery, Inc., Red Bank, New Jersey. Mr. Wells is to speak on New Misting Equipment from England.

NEW MISTING EQUIPMENT FROM ENGLAND

JAMES S. WELLS
James S. Wells Nursery, Inc.
Red Bank, New Jersey

I would like to ask first that the "gentleman" who lifted one of my jets from the back table for closer inspection please return it. There were two there yesterday. There is only one now and I didn't put it in my pocket.

I went home to England this summer for the first time in 11 years and I didn't go to look at nurseries; I just went to relax. I went to the Mat Penny Company in France to look at their misting system because I had heard such a lot about it. Harvey Templeton will know we have become a little disillusioned with the electronic leaf because of the problem of maintaining it in good order. We are using a timeclock and have been so for a number of years.

I must own that I was very impressed by the appearance of the Mat Penny equipment. It is in the back of the room. I will very briefly run through the points which they consider make it superior.

First of all, the jet which some of you may have seen is ruggedly constructed. It is of the Florida type, a baffle type. It should be adjusted with a feeler gauge to one ten thousandths of an inch. It works at low or high pressures. It works very well at low pressures. It has a very easily removable strainer on the bottom. It is available in four different orifices which provides different coverage on benches and beds.

The control equipment is a transistorized unit. There are no tubes and it operates on AC current which they tell me is superior to DC current because it reduces the buildup of minerals on the leaf. The leaf is a plastic block with two carbon electrodes set in it. They say the easiest and simplest way to clean it is just take the leaf and run it for a second or so on an emory wheel. This you can do many, many times before the block is worn down and they have had them in continuous use in that way for about seven years.

Create, collate and circulate:
Relate, debate, articulate:
Perpetrate; illuminate;
Generate, not imitate;
Innovate, then instigate;
Stimulate and propagate;
Reiterate — COMMUNICATE!

MODERATOR HILLENMEYER: Thank you. I hope your words will be heeded well by the members.

Our next speaker this morning is Mr. James S. Wells, James S. Wells Nursery, Inc., Red Bank, New Jersey. Mr. Wells is to speak on New Misting Equipment from England.

NEW MISTING EQUIPMENT FROM ENGLAND

James S. Wells
James S. Wells Nursery, Inc.
Red Bank, New Jersey

I would like to ask first that the "gentleman" who lifted one of my jets from the back table for closer inspection please return it. There were two there yesterday. There is only one now and I didn't put it in my pocket.

I went home to England this summer for the first time in 11 years and I didn't go to look at nurseries; I just went to relax. I went to the Mat Penny Company in France to look at their misting system because I had heard such a lot about it. Harvey Templeton will know we have become a little disillusioned with the electronic leaf because of the problem of maintaining it in good order. We are using a timeclock and have been so for a number of years.

I must own that I was very impressed by the appearance of the Mat Penny equipment. It is in the back of the room. I will very briefly run through the points which they consider make it superior.

First of all, the jet which some of you may have seen is ruggedly constructed. It is of the Florida type, a baffle type. It should be adjusted with a feeler gauge to one ten thousandths of an inch. It works at low or high pressures. It works very well at low pressures. It has a very easily removable strainer on the bottom. It is available in four different orifices which provides different coverage on benches and beds.

The control equipment is a transistorized unit. There are no tubes and it operates on AC current which they tell me is superior to DC current because it reduces the buildup of minerals on the leaf. The leaf is a plastic block with two carbon electrodes set in it. They say the easiest and simplest way to clean it is just take the leaf and run it for a second or so on an emory wheel. This you can do many, many times before the block is worn down and they have had them in continuous use in that way for about seven years.

The part of their equipment which I like very much was the weather unit which can be attached to the misting control to provide a definite number of squirts of mist to another bench to harden off already rooted cuttings. By switching the switch you can choose to have one shot of mist every third time, every sixth time or every twelfth time that the leaf control calls for mist, and you have a cross service switch in which you can alternate either the ordinary leaf control or the weather unit within the two beds.

It looks like a very well-engineered piece of equipment. I have not tried it yet. I am sorry to say that most British companies are awfully slow off the mark. It took two months to obtain this unit.

I have two plants of *Rhododendron album elegans* in the back of the room which were treated with CCC. I see someone has marked on my slip there that it isn't *album elegans,* but *alba novum.* I don't know who did it. I bet it was Martin Van Hof.

MR. MARTIN VAN HOF: It was not. I don't know who it was.

MR. VUYK: It was me. I bet $25.00.

MR. WELLS: It is the plant I have been growing as *alba elegans* not only in my nursery but elsewhere. Perhaps I have been wrong for 25 years. I think it is *album elegans.* Anyway those two plants are two years old. They were growing side by side. One was treated as follows and one was not treated.

Sixteen plants were taken at random and treated with CCC on August 9, 1961. Now this was just about at the end of the first year's growth of these plants. They were quite small, normal one-year plants coming to the end of their growing season. The treatment was made up of two gallons of water in a watering can and to this was added 50 c.c. of a 50 per cent aqueous solution of CCC.

Now no effect was noticed after treatment in 1961, but in this last year the plants grew as you see. There was, of course, a distinct dwarfing and all the plants which were treated budded quite heavily and the plants immediately adjacent did not bud at all. The plant which is untreated there is typical.

There is no question that this material has a very definite effect upon the formation of buds on rhododendron. How good the buds are, how good the plant will come through the winter, what it subsequently will be -- all these things we don't know yet.

Essentially the same effect was obtained by using much less CCC at the same strength but applied as a spray in the middle of May of this year, and I do believe, as I remarked yesterday, that there is a definite value in the use of this material for stopping late fall growth on vigorous growing varieties.

We have tested CCC Phosphon and another chemical under number B 995 and have found CCC to be superior to any of the others.

The treatments were made in the middle of May by spraying and in most instances the plants have responded well. However, certain varieties which normally grow and in a very compact manner have been severely stunted and they are quite unfavorable and quite useless.

It is clear that this is not something to buy by the carload and start spraying on with a big tank. It is critical in the amount needed and I think that the timing will be important in relation to the effect by the end of the year. If we just want to slightly slow down the plant and get a bud on it, then we are going to have to very carefully choose our time and our strength. Some varieties which normally grow in a fairly compact manner I don't think need it at all or if they do, they need a very, very light dose.

We are going on with treatments and testing next year, but only on a very small scale.

MODERATOR HILLENMEYER: Thank you, Mr. Wells. We have an important announcement. Mr. Louis Vanderbrook.

SECRETARY VANDERBROOK: There will be a meeting of the Executive Committee and the Membership Committee tonight up in 516 and 518 immediately after the conclusion of the question box period.

MODERN HILLENMEYER: Our next speaker this morning is Professor F. L. O'Rourke, from Michigan State University, East Lansing, who will speak on the subject of Propagation in the Pacific Coast Area. Professor O'Rourke!

PROPAGATION IN THE PACIFIC COAST AREA

F. L. S. O'Rourke
Michigan State University
East Lansing, Michigan

Mr. Moderator, Fellow Members: I had long wanted to visit the Pacific Coast and see the horticulture that we heard so much about. This past summer and fall I spent about two months out there and I was literally amazed at the growth of some of the plants which I saw. I know quite a number of you folks have been there and you know what I mean.

It is an area of wholesale growing for America as well as production for their own locality. The coast of Oregon and Washington is quite rainy. It is an area where holly, rhododendron, and other broadleaf plants grow exceptionally well. There are some nurseries there which are making quite an effort to produce these in quantity, and I have found out that some rhododendrons which were being grown within 100 yards of the Pacific Ocean are shipped as far east as New York City. Amazing but true.

In deciduous material, quite a bit of emphasis is put on fruit and shade trees in the interior valleys. In these areas water is limited, but they do seem to have sufficient irrigation to supply the needs of these plants. Most of the irrigation is by gravity, although in the Willamette valley around Portland they are bringing in some overhead irrigation.

It is really amazing to see the growth of these plants in one year. The shade trees are usually budded in August or in late summer, cut

It is clear that this is not something to buy by the carload and start spraying on with a big tank. It is critical in the amount needed and I think that the timing will be important in relation to the effect by the end of the year. If we just want to slightly slow down the plant and get a bud on it, then we are going to have to very carefully choose our time and our strength. Some varieties which normally grow in a fairly compact manner I don't think need it at all or if they do, they need a very, very light dose.

We are going on with treatments and testing next year, but only on a very small scale.

MODERATOR HILLENMEYER: Thank you, Mr. Wells. We have an important announcement. Mr. Louis Vanderbrook.

SECRETARY VANDERBROOK: There will be a meeting of the Executive Committee and the Membership Committee tonight up in 516 and 518 immediately after the conclusion of the question box period.

MODERN HILLENMEYER: Our next speaker this morning is Professor F. L. O'Rourke, from Michigan State University, East Lansing, who will speak on the subject of Propagation in the Pacific Coast Area. Professor O'Rourke!

PROPAGATION IN THE PACIFIC COAST AREA

F. L. S. O'Rourke
Michigan State University
East Lansing, Michigan

Mr. Moderator, Fellow Members: I had long wanted to visit the Pacific Coast and see the horticulture that we heard so much about. This past summer and fall I spent about two months out there and I was literally amazed at the growth of some of the plants which I saw. I know quite a number of you folks have been there and you know what I mean.

It is an area of wholesale growing for America as well as production for their own locality. The coast of Oregon and Washington is quite rainy. It is an area where holly, rhododendron, and other broadleaf plants grow exceptionally well. There are some nurseries there which are making quite an effort to produce these in quantity, and I have found out that some rhododendrons which were being grown within 100 yards of the Pacific Ocean are shipped as far east as New York City. Amazing but true.

In deciduous material, quite a bit of emphasis is put on fruit and shade trees in the interior valleys. In these areas water is limited, but they do seem to have sufficient irrigation to supply the needs of these plants. Most of the irrigation is by gravity, although in the Willamette valley around Portland they are bringing in some overhead irrigation.

It is really amazing to see the growth of these plants in one year. The shade trees are usually budded in August or in late summer, cut back the following spring and in one year's time they may obtain a whip of anywhere from 8 to 15 feet, depending upon species and so forth. Some of them are cut back again to a single bud at the end of the first growing season in order to get a larger shoot at the end of the second year. It seems as if this is the area where fruit trees and shade trees can be grown most economically even though the transportation to the east is expensive.

They have their problems there as well as elsewhere. One is virus, particularly in fruit trees. It has meant that a great many of the nurserymen have had to establish isolated orchards as seed sources and for budwood, and have the trees inspected periodically by the plant pathologist of the state concerned in order that they can keep them free of virus. I found the nurserymen cooperating very heartily in such a program. It is expensive, but it is necessary.

I believe that this virus problem may spread to other plants, other than fruit. Perhaps we will have to think of the same isolated plots in respect to budwood, seed sources, and propagating material of shade and ornamental plants. The conifers are grown in large numbers but I didn't find there was anything too impressive in that line, somewhat about the same as in the east.

There is one thought that I would like to make, and that is where should we develop new clones of all kinds of nursery stock? Should it be done out there in the production section of the west or should it be done in the east where we can more readily observe the growth and performance of the trees?

Now, as you know, the automobile industry creates new forms, and so forth, at Detroit, and then impresses its dealers with the need of selling these to the public. I don't think that it is quite the same with nursery stock. If a tree developed very well in Portland, Oregon, that doesn't necessarily mean that it would be good for Nashville, Tennessee or Sandusky, Ohio. All of us all over the United States should be alert for better forms and propagate these into clones and perhaps send our budwood to the Pacific Coast for growing. You will probably find that it can be done more economically there and you will get a better tree in a shorter space of time than you can in the east. That is something to keep in mind. There are a great many contract growers out there. They produce 50,000 or 100,000 or any other thousand of trees to your specifications if you send them the budwood.

It is amazing the quantity of plants in one nursery. I looked over the field in one nursery in which they told me they had 19 million apple and pear seedlings. I took their word for it. I couldn't count them.

While I am speaking I would like to have your indulgence to make a few comments on the talk so ably presented by Peter Vermeulen just a few moments ago. I heartily endorse what he said, in fact, I would go further and I would say that the Plant Propagators' Society should reserve an entire day for members to make short presentations. As Bill Flemer so aptly pointed out last evening, not even a great many college graduates can write, and I don't think it is necessary that a man need to write to give out some information. He can make a demonstration. He can show something, and he can talk in his own way to give this information out to others. Why couldn't we have a whole day devoted to membership presentations, five or ten minutes for each?

I have attended every meeting of the Plant Propagators' Society since 1951 when we started, except when I was overseas, and my personal experience is that we have derived more information from the rather short speaker-exhibitor talks than from any other feature of the program. So let's try to encourage participation among the membership-at-large.

MODERATOR HILLENMEYER: Thank you very much, Professor O'Rourke.

Our next speaker is Roy Nordine, The Morton Arboretum, who will speak to us on the subject of Juniper Species. Mr. Nordine!

A FEW LOW JUNIPERUS SPECIES AND CULTIVARS

ROY M. NORDINE
The Morton Arboretum
Lisle, Illinois

Although the Juniper collection contains a great many species and clones, we will confine this discussion to a number of junipers that remain low in stature. We plan to quote the age and dimensions of these plants, information that should have some value whenever plants are considered for landscape use — especially when used in foundation plantings. All plants receive only a very small amount of trimming during their early years in the nursery rows; once they are placed in their permanent locations, the plants are allowed to grow and develop into their natural form and shape.

The late Prof. Maney raised a number of seedlings from *Juniperus chinensis* var *sargenti*. Four plants were selected and named; they are frequently called the Iowa Junipers, and they are the first four plants to be registered under the program instituted by the American Association of Nurserymen in 1947. *Juniperus chinensis* 'Ames' at 14 years old has a pyramid shape, being 4′ wide at the base and tapering to a point about 9′ tall. There are some sharp or juvenile needles among the dusty green foliage, and a few berries are present. 'Iowa' and 'Story' are much alike in general shape, 'Iowa' being 4′ wide and 10′ high; 'Story' is 3′ wide and 12′ high, and they both maintain a uniform width to a point past the middle before tapering off to the top. Both plants have only soft or adult foliage, of a gray-green color. 'Iowa' is a female. 'Story' is a male plant with less branches and foliage than either 'Ames' or 'Iowa.' 'Maney' is a wide-spreading, irregular shaped plant about 7′ high and 12′ wide; several large branches have broken from heavy snow loads. Both types of foliage are present, although the sharp foliage predominates; the color is a fine dark blue, and the plant is a female. All four plants are the same age; they were grafted in 1948.

sary that a man need to write to give out some information. He can make a demonstration. He can show something, and he can talk in his own way to give this information out to others. Why couldn't we have a whole day devoted to membership presentations, five or ten minutes for each?

I have attended every meeting of the Plant Propagators' Society since 1951 when we started, except when I was overseas, and my personal experience is that we have derived more information from the rather short speaker - exhibitor talks than from any other feature of the program. So let's try to encourage participation among the membership-at-large.

MODERATOR HILLENMEYER: Thank you very much, Professor O'Rourke.

Our next speaker is Roy Nordine, The Morton Arboretum, who will speak to us on the subject of Juniper Species. Mr. Nordine!

A FEW LOW JUNIPERUS SPECIES AND CULTIVARS

ROY M. NORDINE
The Morton Arboretum
Lisle, Illinois

Although the Juniper collection contains a great many species and clones, we will confine this discussion to a number of junipers that remain low in stature. We plan to quote the age and dimensions of these plants, information that should have some value whenever plants are considered for landscape use — especially when used in foundation plantings. All plants receive only a very small amount of trimming during their early years in the nursery rows; once they are placed in their permanent locations, the plants are allowed to grow and develop into their natural form and shape.

The late Prof. Maney raised a number of seedlings from *Juniperus chinensis* var *sargenti*. Four plants were selected and named; they are frequently called the Iowa Junipers, and they are the first four plants to be registered under the program instituted by the American Association of Nurserymen in 1947. *Juniperus chinensis* 'Ames' at 14 years old has a pyramid shape, being 4′ wide at the base and tapering to a point about 9′ tall. There are some sharp or juvenile needles among the dusty green foliage, and a few berries are present. 'Iowa' and 'Story' are much alike in general shape, 'Iowa' being 4′ wide and 10′ high; 'Story' is 3′ wide and 12′ high, and they both maintain a uniform width to a point past the middle before tapering off to the top. Both plants have only soft or adult foliage, of a gray-green color. 'Iowa' is a female. 'Story' is a male plant with less branches and foliage than either 'Ames' or 'Iowa.' 'Maney' is a wide-spreading, irregular shaped plant about 7′ high and 12′ wide; several large branches have broken from heavy snow loads. Both types of foliage are present, although the sharp foliage predominates; the color is a fine dark blue, and the plant is a female. All four plants are the same age; they were grafted in 1948.

Juniperus chinensis f. *globosa* was purchased as a plant in 1938 and has maintained without trimming a fine rounded shape, being now 6′ wide and 7′ high. There is a small amount of sharp needles among the short twig growth: the foliage is a fine clear green, and there are no berries present. A plant of *Juniperus chinensis* var. *sargenti* that was purchased in 1937 and was originally trained to a short stake, is now a graceful mound to 3′ high and 6′ wide. Branches are short and the predominant short sharp needles are crowded to make a dense plant of a dark green color.

There are now about a dozen different clones of *J. chinensis* f. *pfitzeriana*. Not all have grown to a size where they can be mentioned. Our largest and oldest Pfitzer was set into the Rose Garden as a 4′ plant in the spring of 1936. It is now 5′ high and 20′ wide, and the sides have been controlled by public traffic for 5 years. A plant of Armstrong Pfitzer was brought in 1943 and is now 4′ high and 6′ wide. This plant branches from the ground and lost a third of the plant in one winter. All foliage is soft or adult: twig growth is slow and short, and foliage color is a fine clear green.

There are two plants of "Kallay's Pfitzer" that are 23 years old and have grown together. They are only 3′ high and 9′ wide: the plants are thick and dense with short twig growth and with sharp foliage predominating. The color is like that of the common Pfitzer The plants of "Pfitzeriana nana" were acquired in 1950 and are now 4′ x 4′. They resemble the common Pfitzer in color and foliage, the difference being in much shorter and slower twig growth. Pfitzer 'Old Gold' came recently from Holland. The young plants keep their good yellow color in the growing tips the year around. It is a better color than found in 'Pfitzeriana Aurea.'

The Hetz Juniper is very rapid growing, extending itself upward and outward at the same rate. No one knows its mature size or height. It is a female plant with a good blue color and only a small amount of sharp foliage. Pfitzer "Silver Blue" and 'Pfitzeriana Glauca' from all appearances are identical with 'Hetzii': they may be Hetz Juniper under other names.

Pfitzer "Nick's Compact" are 2½′ high by 6′ wide from small plants in 1954. Height comes slowly to this plant, with predominantly sharp foliage that has a blue cast among the green foliage. This is a male plant. "Dwarf Pfitzer" is now 2½′ high by 4′ wide. This male plant has a light, almost yellowish green adult foliage; all new growth is short and points upward. Pfitzer "Nelson's Compact" is now 3′ high and 5′ wide from 1957 plants. It has the growth rate of the common Pfitzer growing in all directions, and promising more height than spread. It is a male plant with nearly all the dusty blue foliage with sharp needles. This plant is open and would require shearing. The "Moraine Pfitzer" is a slower growing, compact plant. from small plants purchased in 1954 and now 2½′ high x 5-6′ wide. The majority of foliage is green and sharp, but there is a blue case: there are no berries. "Pfitzeriana plumosa" is a rapid growing pfitzer; our plant was purchased in '58 and is now 4′ high and 8′ wide. It is a male plant with nearly all foliage sharp and of a bluish color.

Juniperus davurica, started as a graft in 1951, is now two feet wide and 8-9′ high. It is in all ways similar to Swedish Juniper except it is hardier and less subject to wind damage.

Juniperus horizontalis is native in all the northern states across the continent to the Rocky Mountains, and occurs in variations of color, height, foliage, and growth habits. The most popular in this group is "Andorra" with a green color in summer and a plum color in winter, a plant that matures at less than 2′ high. The form *alpina* is the tallest with horizontal ground branches from which other branches grow vertically, becoming 3-4′ high. It is not an attractive plant. 'Bar Harbor' is the lowest of all, less than a foot high with a year-round attractive green foliage. There are several good blue clones; "argenteus" has a fine blue color with long whipcord branches on a plant that becomes 18″ tall; "venusta" is a darker blue and very low, less than a foot high at the center. 'Wiltoni' and "Blue Rug" are so similar they may all be the same plant. "Gray Carpet" has a gray-blue color with short branches, the mature plant 18″ high. One of the most attractive plan's in this group is one called J. h. "filicinus minimus" (small fern-like foliage). A twenty-five year old plant is 15″ high in the center and 8′ in diameter. The short branches have small and crowded foliage; the summer color is dark green, the winter color a bluish green.

Juniperus procumbens, Jap-garden Juniper, has long been popular and commonly grown. One plant is now 3′ high in the center and 15′ wide, very dense in growth with all branches turning upward slightly. The color is bluish green and all needless are sharp.

There are two hedges of Junipers. The oldest is 15 years and is made of staked common Pfitzer. The hedge is 4′ high and 4′ wide and in good condition with a good bottom line at the base. The other hedge is only 4 years old and planted with *Juniperus virginiana* "O'Conner." This originated as a witches' - broom on a *J. virginiana* f. *glauca* in the former Donaldson Nursery, Sparta, Kentucky. The plant has a natural globe shape; no leaders have been produced so far. The foliage is steel blue on rather long branches; it is a much faster growing plant than the parent. At the present time this is a fine looking hedge.

MODERATTOR HILLENMEYER: Thank you very much, Mr. Nordine.

Our next speaker this morning is Mr. Alfred J. Fordham, of Arnold Arboretum, who will speak to us on Winter Survival of Some Difficult Cuttings.

WINTER SURVIVAL OF SOME DIFFICULT CUTTINGS

Alfred J. Fordham
Arnold Arboretum
Jamaica Plain, Massachusetts

Many kinds of cuttings which root easily present a survival problem during the subsequent winter, for when potted or flatted after rooting they go into a dormancy from which they never recover. In

Juniperus davurica, started as a graft in 1951, is now two feet wide and 8-9′ high. It is in all ways similar to Swedish Juniper except it is hardier and less subject to wind damage.

Juniperus horizontalis is native in all the northern states across the continent to the Rocky Mountains, and occurs in variations of color, height, foliage, and growth habits. The most popular in this group is "Andorra" with a green color in summer and a plum color in winter, a plant that matures at less than 2′ high. The form *alpina* is the tallest with horizontal ground branches from which other branches grow vertically, becoming 3-4′ high. It is not an attractive plant. 'Bar Harbor' is the lowest of all, less than a foot high with a year-round attractive green foliage. There are several good blue clones; "argenteus" has a fine blue color with long whipcord branches on a plant that becomes 18″ tall; "venusta" is a darker blue and very low, less than a foot high at the center. 'Wiltoni' and "Blue Rug" are so similar they may all be the same plant. "Gray Carpet" has a gray-blue color with short branches, the mature plant 18″ high. One of the most attractive plan's in this group is one called J. h. "filicinus minimus" (small fern-like foliage). A twenty-five year old plant is 15″ high in the center and 8′ in diameter. The short branches have small and crowded foliage: the summer color is dark green, the winter color a bluish green.

Juniperus procumbens, Jap-garden Juniper, has long been popular and commonly grown. One plant is now 3′ high in the center and 15′ wide, very dense in growth with all branches turning upward slightly. The color is bluish green and all needless are sharp.

There are two hedges of Junipers. The oldest is 15 years and is made of staked common Pfitzer. The hedge is 4′ high and 4′ wide and in good condition with a good bottom line at the base. The other hedge is only 4 years old and planted with *Juniperus virginiana* "O'Conner." This originated as a witches' - broom on a *J. virginiana* f. *glauca* in the former Donaldson Nursery, Sparta, Kentucky. The plant has a natural globe shape: no leaders have been produced so far. The foliage is steel blue on rather long branches: it is a much faster growing plant than the parent. At the present time this is a fine looking hedge.

MODERATTOR HILLENMEYER: Thank you very much, Mr. Nordine.

Our next speaker this morning is Mr. Alfred J. Fordham, of Arnold Arboretum, who will speak to us on Winter Survival of Some Difficult Cuttings.

WINTER SURVIVAL OF SOME DIFFICULT CUTTINGS

ALFRED J. FORDHAM
Arnold Arboretum
Jamaica Plain, Massachusetts

Many kinds of cuttings which root easily present a survival problem during the subsequent winter, for when potted or flatted after rooting they go into a dormancy from which they never recover. In an effort to avert this loss of material a method of handling these difficult cuttings without disturbing them was tried. Plastic flats were filled with rooting medium suitable for the material being tested, the cuttings inserted and the units placed in the propagating case. When rooted they were left in the flats, given a light liquid feeding, and hardened off. In November the units were transferred to cold storage and in March were returned to the greenhouse where new growth soon appeared.

Enkianthus cernuus rubens and *E. perulatus* are two subjects that have shown very poor winter survival. This slide shows 30 rooted cuttings of *E. cernuus rubens* which were left undisturbed before overwintering; all of them survived. Twenty-four cuttings of *E. perulatus* were treated similarly and of them 21 were planted out this spring and are in excellent condition. In contrast twenty-five excellently rooted cuttings of *E. perulatus* were transplanted to flats in the normal manner after rooting and in spring all were dead.

Rhododendron prunifolium which with us has always shown some losses in the first winter survived at the rate of 121 out of 130 cuttings.

Viburnum carlesii was also tried. Twenty cuttings were left undisturbed while 20 well rooted cuttings were potted. From start to finish these lots were kept side-by-side. Those not disturbed showed a complete survival while the control which was potted survived at the rate of 35% which for this plant is very good.

Not only was survival improved using this treatment, but by eliminating the intermediate steps of potting and handling time and labor were saved.

MODERATOR HILLENMEYER: Thank you, Mr. Fordham.

Our next speaker this morning is Mr. Case Mahlstede of the Mahlstede Brothers Nursery, Cleveland, Ohio, will speak to us on A New Technique in Grafting Blue Spruce.

A NEW TECHNIQUE IN GRAFTING BLUE SPRUCE

Case Mahlstede
Mahlstede Bros. Nursery
Cleveland, Ohio

Advantages of grafting blue spruce on unpotted understock are: Save the time of potting up and room in the greenhouse. You can put graft lower on the understock.

The disadvantage is that the graft does not make quite the growth as on potted stock.

To begin with, we ordered 500 transplanted Norway spruce about pencil thickness for early spring delivery. We like to graft as soon after the middle of March as the stock can be had, and start grafting right away, leaving the understock in the cool barn. Take out a bundle at the time, make it ready for grafting and put on a scion 1 year's growth when heavy enough; otherwise, a scion with two an effort to avert this loss of material a method of handling these difficult cuttings without disturbing them was tried. Plastic flats were filled with rooting medium suitable for the material being tested, the cuttings inserted and the units placed in the propagating case. When rooted they were left in the flats, given a light liquid feeding, and hardened off. In November the units were transferred to cold storage and in March were returned to the greenhouse where new growth soon appeared.

Enkianthus cernuus rubens and *E. perulatus* are two subjects that have shown very poor winter survival. This slide shows 30 rooted cuttings of *E. cernuus rubens* which were left undisturbed before overwintering; all of them survived. Twenty-four cuttings of *E. perulatus* were treated similarly and of them 21 were planted out this spring and are in excellent condition. In contrast twenty-five excellently rooted cuttings of *E. perulatus* were transplanted to flats in the normal manner after rooting and in spring all were dead.

Rhododendron prunifolium which with us has always shown some losses in the first winter survived at the rate of 121 out of 130 cuttings.

Viburnum carlesii was also tried. Twenty cuttings were left undisturbed while 20 well rooted cuttings were potted. From start to finish these lots were kept side-by-side. Those not disturbed showed a complete survival while the control which was potted survived at the rate of 35% which for this plant is very good.

Not only was survival improved using this treatment, but by eliminating the intermediate steps of potting and handling time and labor were saved.

MODERATOR HILLENMEYER: Thank you, Mr. Fordham.

Our next speaker this morning is Mr. Case Mahlstede of the Mahlstede Brothers Nursery, Cleveland, Ohio, will speak to us on A New Technique in Grafting Blue Spruce.

A NEW TECHNIQUE IN GRAFTING BLUE SPRUCE

CASE MAHLSTEDE
Mahlstede Bros. Nursery
Cleveland, Ohio

Advantages of grafting blue spruce on unpotted understock are: Save the time of potting up and room in the greenhouse. You can put graft lower on the understock.

The disadvantage is that the graft does not make quite the growth as on potted stock.

To begin with, we ordered 500 transplanted Norway spruce about pencil thickness for early spring delivery. We like to graft as soon after the middle of March as the stock can be had, and start grafting right away, leaving the understock in the cool barn. Take out a bundle at the time, make it ready for grafting and put on a scion 1 year's growth when heavy enough; otherwise, a scion with two side branches. Cut on both sides. Last year we used rubber bands for tying, but they don't rot quickly enough so we are going to tie again with waxed cotton.

Our greenhouse bench is 45″ wide and 13″ deep and we heel in the grafts in about 8″ of Canadian peat. Damp the peat just wet enough that by squeezing it hard, a couple of drops of water come out. We get 50 to 60 grafts in a row, and the rows we have about 8″ apart so we can wet the peat-moss when it becomes dry without wetting the plants. The grafts are heeled in standing straight up with the grafts covered with peat. It takes about 9′ of bench space for the 500. We keep the greenhouse temperature at 60-65° and on sunny days cover the grafts with newspapers. We wet every once in a while. The greenhouse is shaded by that time with white lead and gasoline which we spray on as it sticks better than anything we know. We leave them in the greenhouse 5 or 6 weeks so scion and understock are grown together.

The first week in May we like to take them out of the greenhouse and plant them outside in a bed, after cutting off about half of the understock and putting the grafts under. The bed is 6′ wide and we plant the grafts 5″ by 5″ so it takes about 15′ of bed. The understock is planted towards the outside of the bed. The bed is covered with shades and for the first 3 or 4 weeks, the shades covered with burlap. About the end of August or beginning of September the rest of the understock is cut off and the shades removed. The first winter they are covered with salt hay. From this spring's grafts, of the 500 grafted, 312 are growing. It should be more, but last spring we could not get the understock until the middle of April and we had July weather in April and May and the grafts were planted out the first week in May and were not grown together well enough. Two years ago we sold 480 1-year-olds of the 500 grafted. Last year we had the understock in the fall and cleaned them for grafting and heeled them in outside. In the spring most of the roots were rotted. I hoped that they would make new roots in the bench, but they kept on rotting and the end was that only 12 survived. The usual stand we have is 70-85%.

MODERATOR HILLENMEYER: Thank you, Mr. Mahlstede. Our last speaker this morning is Mr. Albert Lowenfels from White Plains, New York, who will speak to us on Plastic for Greenhouses.

PLASTICS FOR GREENHOUSES

ALBERT LOWENFELS
White Plains, New York

I was having breakfast this morning with Roy Nordine. I said I was in a very fortunate position, I don't have to think of the fast buck. I have another business, so I can experiment, and in 1947 I built a greenhouse and at that time Polyflex was advertised heavily. I think I saw a house in Columbus, Ohio that had it on. So I covered my greenhouse with Polyflex and in about a year it started to side branches. Cut on both sides. Last year we used rubber bands for tying, but they don't rot quickly enough so we are going to tie again with waxed cotton.

Our greenhouse bench is 45″ wide and 13″ deep and we heel in the grafts in about 8″ of Canadian peat. Damp the peat just wet enough that by squeezing it hard, a couple of drops of water come out. We get 50 to 60 grafts in a row, and the rows we have about 8″ apart so we can wet the peat-moss when it becomes dry without wetting the plants. The grafts are heeled in standing straight up with the grafts covered with peat. It takes about 9′ of bench space for the 500. We keep the greenhouse temperature at 60-65° and on sunny days cover the grafts with newspapers. We wet every once in a while. The greenhouse is shaded by that time with white lead and gasoline which we spray on as it sticks better than anything we know. We leave them in the greenhouse 5 or 6 weeks so scion and understock are grown together.

The first week in May we like to take them out of the greenhouse and plant them outside in a bed, after cutting off about half of the understock and putting the grafts under. The bed is 6′ wide and we plant the grafts 5″ by 5″ so it takes about 15′ of bed. The understock is planted towards the outside of the bed. The bed is covered with shades and for the first 3 or 4 weeks, the shades covered with burlap. About the end of August or beginning of September the rest of the understock is cut off and the shades removed. The first winter they are covered with salt hay. From this spring's grafts, of the 500 graft ed, 312 are growing. It should be more, but last spring we could not get the understock until the middle of April and we had July weather in April and May and the grafts were planted out the first week in May and were not grown together well enough. Two years ago we sold 480 1-year-olds of the 500 grafted. Last year we had the understock in the fall and cleaned them for grafting and heeled them in outside. In the spring most of the roots were rotted. I hoped that they would make new roots in the bench, but they kept on rotting and the end was that only 12 survived. The usual stand we have is 70-85%.

MODERATOR HILLENMEYER: Thank you, Mr. Mahlstede. Our last speaker this morning is Mr. Albert Lowenfels from White Plains, New York, who will speak to us on Plastic for Greenhouses.

PLASTICS FOR GREENHOUSES

ALBERT LOWENFELS
White Plains, New York

I was having breakfast this morning with Roy Nordine. I said I was in a very fortunate position, I don't have to think of the fast buck. I have another business, so I can experiment, and in 1947 I built a greenhouse and at that time Polyflex was advertised heavily. I think I saw a house in Columbus, Ohio that had it on. So I covered my greenhouse with Polyflex and in about a year it started to break down. Then I covered it with other plastics and eventually they not only broke down, but I found that the light doesn't come through the plastic as well as it should. The plastics discolor.

So then I decided to try something else and I saw the ads for Fiberglas and there is an agency in our town. I inquired where I could get it and they said Lord and Burnham, which is a leading greenhouse manufacturer. So I rang up a fellow I know there, who put up the greenhouse for me, and he said, "I won't put it in." In our climate the heavy snow breaks it down. Some of the people that advertise in the trade magazines may not like this, but I am back to glass, and that ends my short remarks.

MODERATOR HILLENMEYER: Thank you, Al.

We will now have any questions from the floor.

MR. ROLAND deWILDE: I would like to know whether any attempt has been made to propagate some of these magnolia hybrids? The reason I am asking this is because we have tried to propagate these hybrids from cuttings, and we haven't got to first base from the standpoint of getting a commercial stand.

MRS. DORIS STONE (Brooklyn): I am sorry I am not the person to answer this because we haven't propagated any. We are just watching our hybrids to see what happens, for as the previous speaker said, some of them may be just nice little puppies, and I don't know what they are going to grow into.

I know at the National Arboretum, and Dr. March is here, they have propagated Freeman variety with great success. Maybe he would like to answer that question.

DR. SYLVESTER G. MARCH (National Arboretum): We have propagated Freeman hybrids, using cuttings from young plants. We find this is the key to the whole problem. If a cutting is taken from the original tree, the results are very poor. It is a matter of getting some of the original cuttings to root and then to take your cuttings from the young juvenile plants. This past year we distributed over 100 plants of the Magnolia Freeman selection.

QUESTION: Any grafting success?

DR. MARCH: No, we haven't had. I think people have tried and without much success, but if you can root a plant from cuttings this is much better than a grafted plant.

MR. PETER VERMEULEN: How are your cuttings treated?

DR. MARCH: The cuttings are taken when semi-hard, dipped in Hormodin 3, and placed under mist for a period of about eight weeks.

MR. CASE HOOGENDOORN (Newport, R.I.): I would like to ask Mr. Bailey about the rooted cuttings of *Prunus triloba* and *cisterna*. You put these in a controlled cold storage and in the spring you took them out and planted them. What I would like to know, do you take them straight from the storage and plant them direct, or do you have them around in a warmer place for a few days before you plant them?

MR. VINCENT BAILEY: Case, we take these direct to the field, right out of the cold storage, which is at 34 degrees. Somebody remarked yesterday that these cold storages cost too much money, but I think they are one of the best paying investments a nurseryman can make. We like them and the stock survives.

MR. ART VUYK: I would like to ask Mr. Bailey if you can do the same thing with broad leaf evergreens, like cuttings from holly, and so on.

MR. BAILEY: I don't know. St. Paul is a little too far north and we haven't done any work with the broad leaf evergreens.

MR. VUYK: Were the cuttings of the *Prunus* defoliated before you put them into the cold?

MR. BAILEY: They defoliate naturally. We do not use any chemicals to take the foliage off. We defoliate by cooling the greenhouse down to 32 degrees, and in Minnesota, the St. Paul area, at this time of year they are completely defoliated. These have all been removed from the bench about ten days ago.

MR. RALPH SHUGERT: I would like to know, Vince, what per cent of your *Prunus* were two to three, three to four at the end of the third year — just a rough percentage figure which might help from an economic standpoint.

MR. BAILEY: As I stated, with the two-year-old plants, the majority of the growth is two to three feet.

MR. SHUGERT: About 75 per cent?

MR. BAILEY: No, about 55 to 60% are two to three. There would be some three to four and some 18 to 24 inch in the two-year block. The three year block will have some four to five but the majority of them will be three to four perhaps 60 per cent three to four, and then of course, the two to three.

MR. PETER VERMEULEN: I would like to ask Mr. Mahlstede on his grafting of the spruce to go over again the selection of the scion and also when you cut off the understock.

MR. CASE MAHLSTEDE: We cut the scions from big trees, we imported about 35 years ago from Holland.

When we plant the grafts out, we cut off about half the understock. This year it was the first week in September when we cut it off.

MR. PETER VERMEULEN: Just one more question. You say you selected scions from old trees, but the type of scion you collected was current year's flush of growth or did you try to use one-year wood?

MR. CASE MAHLSTEDE: We used very old wood. It was heavier. When we can't find enough one-year old wood, we go to two-years, with the top and side branches.

MR. CASE HOOGENDOORN: Do you find any difference in the date when you use one year old or two year old?

MR. CASE MAHLSTEDE: No.

MR. MARTIN VAN HOF: May I ask Mr. Mahlstede this? Do you get growth from the terminal bud? Do they do well?

MR. MAHLSTEDE: The first year there is probably about three or four inches growth.

MR. VAN HOF: The terminal bud?

MR. CASE MAHLSTEDE: The terminal bud breaks, but I did not count them.

MR. McDANIEL: Are the scions taken in March from outdoors?

MR. CASE MAHLSTEDE: I graft the middle of March. This year it was the middle of April.

MR. JAMES WELLS: I would like to ask Mr. Mahlstede if he has done any work on the depth of cut made on the scion and understock in relation to the percentage of stand.

MR. CASE MAHLSTEDE: Well, we don't cut very deep in the scions, especially the outside cut on the scion is very light. We don't cut through the middle of the scion, the heart, at all.

MR. WELLS: I asked this question because I recall some tests we did at Hills some years ago in which it seemed to us that the very lightest and shadowest cut on both sides of the scion greatly improved the percentage take, but the depth of the cut made on the understock was not critical. Again, I think it is wise not to cut really deeply into the stem of the understock, but it was apparently much more critical in regard to the depth of the cut made on the scion.

This is not easy to do on a spruce because of the resins in the wood – you have to keep on cleaning your knife. You have to have a knife that is extremely sharp. The whole thing is a meticulous, individual task, not one for assembly line work.

MR. HANS HESS: I am sorry, Mr. Mahlstede, that I am not quite clear on how you handle the grafts after you prune them in the peat moss. What did you do to them? You said you put newspaper over them. Is that correct?

MR. CASE MAHLSTEDE: The greenhouse is shaded heavily, but when the sun is bright and hot, we put newspapers over the glass.

MR. HANS HESS: When it is cloudy you remove the newspaper and only put it on when it is sunny?

MR. CASE MAHLSTEDE: : That is right.

MR. RALPH CRAWFORD: I would like to ask Mr. Bailey whether there are any disease problems involved?

MR. VINCENT BAILEY: The question as I understand it, is, Are there any disease problems involved in the production of softwood cuttings? I presume he refers to *Prunus* specifically. Yes, of course, there are disease problems. Sanitation is very important. I take it for granted that we all understand there are sanitation problems that are necessary.

We use some fumigation. I can't tell you the exact material now, but I might say that we replace the sand just before the placing of all of our softwood cuttings. The clean sand we think starts us off with a sanitary condition.

MR. CASE HOOGENDOORN: You don't use any outdoor frames at all.

MR. BAILEY: Yes, we do. We propagate some of the easier to root items outside in mist beds. The *Prunus* are a little harder to root, at least for us, so we put them in the greenhouse. The 64 percent I mentioned that were rooted this year is not something we are particularly proud of. I know it can be improved upon and we are going to improve upon it, but the way we will improve it will be in more attention paid to the age of the cutting itself. We feel that the growth was too soft on some of the cuttings this year.

MR. RALPH SHUGERT: I would like to have Roy Nordine explain to me the difference between the so-called Armstrong juniper and the pfitzer nana. How do they differ?

MR. NORDINE: They are in all respects very similar. Just referring back again to the pictures I showed you of various blue forms of *Juniperus horizontalis glauca, filicinus minimus,* Gray Carpet, and what have you. They come to us under different names. This is an old nursery practice.

At the present time they look very, very similar.

MR. PETER VERMEULEN: I would like to ask you once more, Mr. Mahlstede about the position of the graft once it is placed in the trench. You said upright.

MR. CASE MAHLSTEDE: The graft is upright.

MR. PETER VERMEULEN: Is the position critical? Could the graft be laid down.

MR. MAHLSTEDE: I think when you lay the graft down you couldn't water in between there when it is dry.

MODERATOR HILLENMEYER: I would like to recognize Dr. Jim Kelley from the University of Kentucky. He did all the work on this program. I just stood up here and made the introductions on the work he performed. I would like to thank Dr. Kelley for the program this morning.

I think Dr. Snyder has some announcements.

PRESIDENT SNYDER: Thank you very much, Don. I certainly want to add the appreciation of the Executive Committee, the Chairman of the Program Committee, John Mahlstede, and myself for the excellent program. The planning was well done and each and every speaker was very good and held to time. I think that is one thing that is remarkable about this meeting, more so than our previous meetings, that we have stayed on schedule and without hurrying too much.

The tour, as Louis Vanderbrook told you, is being modified because of excessive snow in Dayton and Louisville. We will expand the tour of nurseries here so you will get a full afternoon.

Again, 8:00 o'clock tonight for the question box.

We stand adjourned.

(The session recessed at 12:30 o'clock.)

RECESSED

I think you will see this is very, very important. Thank you very much.

PRESIDENT SNYDER: Thank you, John. We thought perhaps we might get some additional information from you while your ideas about the 12th program are still fresh.

This morning we have a symposium on Propagation of Plants by Budding and Grafting. The Moderator is David Leach from Brooksville, Pennslyvania.

MODERATOR LEACH: I see the session this morning is a *symposium. It occurred to me to look up and see what the definition* of symposium was. To my surprise I found it is a convivial meeting for drinking, conversation and intellectual matters. It is my observation there are symposiums going on constantly in the bar, but what we have got this morning is a plain old-fashioned meeting.

The first session this morning is on the Propagation of Plants by Budding and Grafting. Most of us believe that any plant is better off on its own roots, but a plant may not be sufficiently vigorous on its own roots or it may not be practical to propagate it commercially that way.

It is an interesting thought that this portion of the proceedings may become just a historical curiosity because it seems likely with the progress in research, the time will soon come when it will not be necessary to propagate plants by budding and grafting or some of the methods which are still needed today; but presently, without budding and grafting, some of the most valuable and some of the rarest and interesting of plants would never come on the market.

We have a distinguished panel this morning and the first speaker will talk on Anatomical Aspects of Budding and Grafting — Dr. Fred B. Widmoyer, Plant Science Department, University of Connecticut, Storrs, Connecticut.

ANATOMICAL ASPECTS OF BUDDING AND GRAFTING

FRED B. WIDMOYER
Department of Plant Science
University of Connecticut
Storrs, Connecticut

Graftage is the recognized means of propagating plant materials which are either difficult or impossible to obtain from seeds or cuttings. Propagators using grafting have unknowingly recognized plant anatomy when they speak of "compatabilities" and "incompatabilities." Most frequently, the reference is to the relationship of stock to scion.

Budding and grafting involve the same principles, differing only in the number of growing points on the scion. In all cases, wounding occurs in the process. Healing may be attributed to the activity of the cambial layer in some species, phloem, xylem and ray parenchyma in others. The basic phenomena occuring during the reestablishment of buds and grafts will be discussed.

Roberts (1949) has thoroughly reviewed the literature as it related to the techniques and physiology of graftage. More recently, Rogers and Beakbane (1957) discussed stock and scion relations. Of the histological research reported most of it has been on fruit varieties.

In order to better understand the problems of wound healing, certain basic botanical terms are required. Examination of the transverse (cross) section of the stems of the genus *Rosa* and *Chaenomeles*, show anatomical differences. In these stem sections certain regions stand out.

The outer covering of a young stem is a single layer of cells called epidermis. Later a periderm is formed beneath this which protects the inner tissues of the stem or root. The outer portion, cork, is composed of dead cells.

The cortex is composed primarily of parenchyma cells. These function in many ways — food manufacture, storage, and protection. This region may be from a few to many cells in thickness.

The vascular system is composed of phloem, cambium and xylem. The cambium is a meristematic layer which produces cells which become phloem externally and xylem internally. Each cambial cell divides to produce potential phloem and xylem cells alternately. Young phloem cells are more likely to retain or revert to meristematic conditions than are the xylem cells.

Radiating from the pith to the cortex are more or less parenchymatous strands called interfascicular, pith, or medullary rays. Within the vascular tissues are the fascicular rays composed of xylem and phloem rays.

The central portion of a stem is generally occupied by the pith. Most of the parenchyma of this region is specialized as storage tissue.

This completes the basic anatomy of the stem. Let us examine the process of wound healing. Several phenomena probably occur simultaneously. The most important is the early proliferation of parenchyma cells to form callus which preceeds other cellular activity. These thin walled, relatively large cells are easily torn and susceptible to desiccation. The propagator assists mother-nature by the type of graft selected (whip and tongue, being more rigid) and by tying and waxing techniques. Sanitary conditions and care reduce disease infections.

Parenchyma cells are produced by both the stock and scion, which are relatively unspecialized. Wound healing, regeneration, formation of adventitious roots and shoots and union in grafts are made possible through resumption of the meristematic activity by these parenchyma cells.

Some dicot wood has few to no parenchyma cells. The xylem area of angiosperm plants generally has considerably more parenchyma than do the coniferous plants. This perhaps is why plant propagators select certain graft types for certain clones. Parenchyma is primarily located in the phloem and cortical regions of the gymnosperm. If parenchyma is present in the wood it may have secondary walls or become otherwise specialized. At this stage of development, the ability to remain meristematic is reduced. However, the cells actually injured form a plate of dry necrotic tissue which cover the cut surfaces. The actual proliferation occurs adjacent to this layer. According to Buck (1952) these cells rupture the necrotic layer and produce callus strands from one to several cells wide on the graft interfaces. The production of callus is chiefly from the *ray* parenchyma (primarily phloem) although some does originate from any of the other living cells. The increased number of parenchyma cells force the necrotic tissue further into the graft interface, producing islands of dead, non-functional cells. By this time, the cells are intermingled in such a way that their origin is difficult to ascertain. The existing cambium of the graft pair probably contributes the least to wound healing.

Specialization of certain cells of the callus develops. Adjacent to the cambium layers of stock and scion cambia-like bands are produced. Divisions of these cells continue both tangentially and radially until the cambium layers are joined. The newly completed cambial layer begins to produce xylem cells to the inside and phloem cells to the outside. The early cells are usually smaller with a mass of dense protoplasm. These cells are oriented into "bridging" tissue, which insure continuity of the vascular tissues between stock and scion. According to Yeager (1944) even though stock and scion contributed to the callus formation, the new vascular tissues arise solely from the scion. *A successful graft union is accomplished by cells produced after the graft has been made.*

The time of healing varies, depending upon the accuracy in which the parts are aligned, vigor and growth activity of stock and scion, temperature, humidity, disease and insect control. Any condition which adversely affects vegetative growth, also reduces the healing of a graft union.

Several examples of anatomical failures which are purely technical are as follows:

1. poor matching of stock and scion cambia
2. phloem specifically fails to unite
3. phloem degenerates and the graft does not survive
4. failure of the cambia to unite — producing instead of xylem and phloem, masses of undifferentiated parenchyma
5. components of the graft not differentiating xylem and phloem at a comparable rate
6. failure of xylem to unite.

From the following studies, many of these anatomical phenomena will be evident.

Show slides:

Slide 1 — Rose and *Chaneomeles* — comparative tissues and cells.

Slide 2 — This is a new whip and tongue graft. The stock is the lower part and the scion is the upper part. One of the prerequisites of a successful graft is closeness of fit. Even though cambial layers are not exactly aligned, the wound tissues may be produced, but at a much slower rate. At this point along the interfaces proliferation of some parenchyma is already occuring. The blue stained cells are parenchyma and other non-woody tissue. The red stained and black stained cells are woody cells which are no longer living.

Slide 3 — The stock is on the left and "bridging" cells are on the right. At this stage of development, it is impossible to determine the origin of the mass of parenchyma. These cells are the connecting strands between the stock and scion. By this time survival of the scion is assured if adequate bridging tissues have been produced. Stimulation of cell divisions occurs with increases of temperature, in the range of 45° - 90° F. The darkened cells are the remains of necrotic cells ruptured by the growth of the parenchyma cells.

Slide 4 — This shows more clearly the rapid proliferation of parenchyma cells on the graft interface. Remember, the blue stained cells are living parenchyma cells. This mass in the lower right is bridging tissue showing continuity between stock and scion.

Slide 5 — Further development of the stock-scion union of *Malus* on *Sorbus*.

Slide 6 — Cross sectional view of a whip and tongue graft which shows the completion of a graft union, continuous cambial layer xylem and a resumption of xylem and phloem cell production, all of which originated from callus tissue.

These slides were furnished through the courtesy of Dr. Mahlstede and Dr. Buck of Iowa State University and Drs. Watson and Davidson of Michigan State University and George Evans, who is currently teaching at the University of Montana.

REFERENCES

Buck, G J. 1953. The Histological Development of the Bud Graft Union in Roses. Proc. ASHS 62·497-502.

Esau, Katherine. 1960 Anatomy of Seed Plants. New York. John Wiley and Sons.

Evans, George, Donald P. Watson and Harold Davidson. 1961. Initial Evaluation of Grafting Some Species of the Rosaceae. Proc. ASHS 78:580-585.

Hartmann, Hudson T. and Dale E Kester. 1959. Plant Propagation: Principles and Practices New Jersey. Prentice-Hall, Inc.

Mahlstede, John P. and E. S. Haber 1957. Plant Propagation. New York. John Wiley and Sons.

Roberts, A. N. 1962. Scion-Bud Failure in Field-Grown Roses. Proc. ASHS 80:605-614.

Roberts, R. H. 1949. Theoretical Aspects of Graftage. Bot. Rev. 15 (7) :423-463.

Rogers, W. S. and A. Beryl Beakbane. 1957. Stock and Scion Relations. Ann. Rev. Pl. Physiol. 8:217-236.

Yeager, A. F. 1944 Xylem Formation from Ring Grafts. Proc. ASHS 44:221-222.

MODERATOR LEACH: Thank you, Dr. Widmoyer, for one of the best talks on anatomical aspects of budding and grafting that the Society has ever had.

Next we are to hear some Unusual Methods of Budding and Grafting from Dr. J. C. McDaniel, Department of Horticulture, University of Illinois.

DR. McDANIEL: I will depart a little bit from the announced title of the program and will call on two men to talk briefly on some successful methods of budding and grafting which they have used recently.

One is Mr. Ben Davis of the Ozark Nurseries at Tahlequah, Oklahoma, on his method of performing the modified patch bud. This is used particularly with such thick-barked species as walnut, pecan and some of the other nut trees, persimmons. It is applicable to thick-barked hardwood tree species generally.

THE MODIFIED PATCH BUD

BEN DAVIS II
Ozark Nurseries Company
Tahlequah, Oklahoma

This method of budding was developed by Mr. Hoyt Cockrell of Cockrell's Riverside Nursery at Goldthwaite, Texas. I have never heard of this method being used anywhere else until we adopted it two years ago. Mr. Cockrell tells me that they are nearly always 90 to 95 percent successful in their Pecan budding using this method.

The outstanding characteristic of this method of patch budding is that a single blade knife is used, while in other method of patch budding, special knives are required. Another advantage of this method is its speed. Our budding crew was averaging 260 buds per man per 8 hour day, by the end of the season, and for most of them it was the first time to use this method. Some individuals who had done some of this type budding the year before were putting in 400 to 500 buds per 8 hour day. About half of the crew consisted of high school boys who had never done budding of any type. This method is fairly easy to teach, provided the student is reasonably adept at handling a knife.

We used this method of budding on Pecans, Japanese Persimmons, English Walnuts and Black Walnuts. We were especially pleased with the results obtained on budding English Walnuts. We have been grafting these for several years with very poor results. Last summer we decided to try patch budding them, and obtained a 78 percent stand. Because of this, we have decided to quit grafting English Walnuts altogether and use the modified patch bud exclusively.

This method was also highly successful on Japanese Persimmons, although we budded a limited amount of these.

The results we obtained on Pecan budding were not nearly as successful and we got only a 33 percent stand. I think that this was due to the fact that the budding crew was not familiar with the method, and also their lack of understanding of the importance of a *perfect match.* This is especially important in Pecan budding, as it is a very difficult item to propagate at best. On the limited amount of Pecan budding which I did myself, being very careful to match at the top and one side, I obtained something like a 90 percent stand.

DR. McDANIEL: I will depart a little bit from the announced title of the program and will call on two men to talk briefly on some successful methods of budding and grafting which they have used recently.

One is Mr. Ben Davis of the Ozark Nurseries at Tahlequah, Oklahoma, on his method of performing the modified patch bud. This is used particularly with such thick-barked species as walnut, pecan and some of the other nut trees, persimmons. It is applicable to thick-barked hardwood tree species generally.

THE MODIFIED PATCH BUD

BEN DAVIS II
Ozark Nurseries Company
Tahlequah, Oklahoma

This method of budding was developed by Mr. Hoyt Cockrell of Cockrell's Riverside Nursery at Goldthwaite, Texas. I have never heard of this method being used anywhere else until we adopted it two years ago. Mr. Cockrell tells me that they are nearly always 90 to 95 percent successful in their Pecan budding using this method.

The outstanding characteristic of this method of patch budding is that a single blade knife is used, while in other method of patch budding, special knives are required. Another advantage of this method is its speed. Our budding crew was averaging 260 buds per man per 8 hour day, by the end of the season, and for most of them it was the first time to use this method. Some individuals who had done some of this type budding the year before were putting in 400 to 500 buds per 8 hour day. About half of the crew consisted of high school boys who had never done budding of any type. This method is fairly easy to teach, provided the student is reasonably adept at handling a knife.

We used this method of budding on Pecans, Japanese Persimmons, English Walnuts and Black Walnuts. We were especially pleased with the results obtained on budding English Walnuts. We have been grafting these for several years with very poor results. Last summer we decided to try patch budding them, and obtained a 78 percent stand. Because of this, we have decided to quit grafting English Walnuts altogether and use the modified patch bud exclusively.

This method was also highly successful on Japanese Persimmons, although we budded a limited amount of these.

The results we obtained on Pecan budding were not nearly as successful and we got only a 33 percent stand. I think that this was due to the fact that the budding crew was not familiar with the method, and also their lack of understanding of the importance of a *perfect match.* This is especially important in Pecan budding, as it is a very difficult item to propagate at best. On the limited amount of Pecan budding which I did myself, being very careful to match at the top and one side, I obtained something like a 90 percent stand.

By very closely supervising the budding crew and allowing them to become experienced, I believe we will eventually be able to get 90 percent stands and better.

Procedure:

1. The knife blade is held on a plane approximaely 30 degrees from parallel to the seedling and a cut is made down and inward cutting just through the bark.
2. This will raise a flap of bark which is gripped between the thumb and the knife blade and a downward tear is started.
3. The bark flap should then be pushed back in place to prevent drying while cutting the bud.
4. To cut the bud from the budstick, the knife should be held at the same angle as was used to cut the seedling. A cut is made into the wood above the eyes deep enough so that the bud shield will be nearly the same width as the cut on the seedling.
5. At this point the knife is twisted, causing the wood to split and the knife is drawn down the budstick to obtain the length of shield desired. We found that the larger the shield the better the stand, so it should be a minimum of 1¼ to 1½ inches long. The shield should be as wide as possible, taking into consideration the size of the seedlings, and the eyes should be nearly centered on the shield.
6. After the shield is cut to proper length, it is cut at the bottom by pressing the knife just through the bark.
7. The shield is then grasped between the thumb and forefinger and popped off with a slight twist. If the shield has a hole in it, it should be discarded.
8. The shield is held between the thumb and forefinger and inserted in the seedling from the top of the incision. At the same time the other hand is used to tear the bark of the seedling downward enough to allow the bud to slide into place.
9. The bark flap is then cut off leaving about ¼ inch to lap over the bottom of the shield. This holds the shield in place while wrapping is begun.
10. The first round of the wrap is started at the top to hold the shield in place.
11. Before wrapping is continued, the bud should be positioned so that it fits perfectly flush at the top, with no gap nor any overlap. The shield must also fit along one side of the incision. If the shield is fitted to the left side, the wrap should be wound clockwise. If it is fitted to the right side, the wrap should be wound counter clockwise. This will pull the shield securely into place.
12. The bud should be wrapped down the seedling and then back up, lapping enough to seal out all air. One eye should be left protruding from the wrap, but none of the cut surfaces should be exposed to the air.
13. The wrap should be cut off as soon as the bud shield has healed on, evidenced by callus tissue around the wound. In our experience this is about 2 weeks.

Condition of Budwood:

Current season's growth is used. The budwood should have sap enough so that the bark is slipping freely. However, it must be mature enough so that the bark has a dark cast rather than a greenish cast. The wood should be hard and of smooth, round, regular shape in cross section. Wood which has ridges in it under the buds will cause the buds not to conform to the shape of the seedling. For this reason the irregular shaped and soft portion of the budsticks, at the upper end, should be discarded.

Condition of Seedlings:

Seedlings should be ⅜ inch and up in diameter for the ideal budding conditions. Smaller seedlings may be budded, but it is difficult to obtain a good match and the sap is often not good in very small seedlings. To get the proper size, we bud Pecan and Persimmon seedlings in their second summer of growth. The Persimmon seedlings actually get too large and we are going to try transplanting one year seedlings late in the spring to retard growth. Walnut seedlings are budded in their first summer of growth. It is possible that seedlings would have to be grown an extra year farther north, to obtain large enough size.

Time of Budding:

Budding is begun as soon as the budwood becomes sufficiently mature in the summer. In our location this is about August first or a little sooner. Budding may continue until cool weather drives the sap down so that the bark will not slip.

Understock Used:

Pecan:

Seedlings of Moore Papershell, Riverside Papershell and Native Pecan were used. Moore was found to be the most vigorous, making larger size than Riverside or Native. It also has a more fiberous root system. Native seedlings grow very slowly and many of them do not grow large enough in two years to be budded. We plan to use Moore altogether in future plantings, with the exception of some Major seedlings for understock for Northern varieties.

Walnut:

Seedlings of Hinds Black Walnut and Native Black Walnut were used. Both English Walnuts and Black Walnuts were budded on both understocks, with equally good results. The Hinds Black Walnut makes a larger seedling than the Native and is therefore easier to bud. There is some question, however, whether this understock would be hardy farther north.

Persimmon:

Common Native Persimmon seedlings were used with good results.

Wrapping Material:

We use the medium weight ½″ width polyethylene tape manufactured by L. E. Cooke Company. In the past, Cockrell's Nursery used waxed muslin patches, tied with rubber, but they have since gone to the poly tape.

Knife:

We use a standard single blade knife, the same as is used for T budding.

Copies of the slides shown with this presentation may be obtained from:

Frank Rogers & Son Studio
4309 Avondale
Dallas 19, Texas
Price: $15.00 per set of 15 slides

DR. McDANIEL: That method essentially I think is in Garner's Handbook. One of the other things it is used for is the Brazilian Rubber Tree in southeast Asia plantations for producing high rubber clones and for succeeding stocks.

I might say the use of plastic wrap which we have used casually in this connection, is one of the most recent developments for assured success in rather difficult budding operations.

What would you say, Mr. Davis, to be the difference in stand comparison between wrapping with plastic and wrapping with the standard eight-inch rubber strip?

MR. DAVIS: If you use the rubber strip you would have to use a waxed muslin patch to seal out the air. We learned this from Mr. Cockrell of Riverside Nursery at Goldthwaite, Texas. He was using the wax patch with rubber, and since then he has gone to polytape. We have never used anything but polytape, so I couldn't say from my own personal experience.

DR. McDANIEL: I think it is worth a trial for all who are not satisified with the budding we get under present methods. I have used the principle with chip budding in summer, shallow chip, and budded successfully sassafras, several magnolias, and persimmons.

The second man I would like to call on is Dr. Richard Jaynes of the New Haven Experiment Station in Connecticut. He will describe his application of the Buried-Inarch Graft on the Propagation of Chestnuts on their own roots. This, incidentally, is about what Garner calls the succulent method whereby the top of a scion or cutting is grafted on the established tree and the lower part of the cutting buried in the ground.

DR. RICHARD A. JAYNES: I might mention before I say anything about the technique that I have used that I don't really know that this would have any commercial application as such. I actually used it three or four years ago when it was necessary for me to be able to obtain roots on either young seedling chestnuts or some sterile older trees we had, because I wanted to make some chromosome counts. I found the only way I could make a satisfactory preparation to count chromosomes was to get roots.

The technique is basically very simple. As a stock plant we used a two or three year old seedling. Actually, Dr. Davis used the older trees up to 10 or 15 years old, but I think it works easier with the young seedling that are one half an inch in diameter.

We dug a small hole in the soil next to the seedling. We used a scion approximately six or eight inches long, making a wedge-shaped cut on the terminal end of the scion, usually one cut a little longer than the other. A slanting cut is made up into the stock, and the scion, with at least one bud above the ground is inserted. If the scion was eight inches, we would bury about five inches in the ground and have one bud above the ground level, put the scion into the cut in the stock, replace the soil in the hole we had made, wrap the insertion with budding tape or any other wrap, and wax it. If you get a union formed, the upper bud will break and callus tissue forms at the base of the scion, followed by rooting.

We have had approximately 30 per cent to root. I should have said the grafting is done about the first of May in Connecticut and the following fall or the next spring the scion can be severed from the stock, and if you are lucky you have a scion on its own roots.

As I say, I was primarily interested in getting the roots for cytological studies, but it is a way you could propagate certain hard to root species and get them on their own roots. Thank you.

I might say for anyone who is interested further, I have a publication in the 52nd Annual Report (1961) of the Northern Nut Growers Assn., Inc. in which the technique is described in detail.

MODERATOR LEACH: Thank you, Dr. Widmoyer and Dr. McDaniel, Mr. Davis and Dr. Jaynes.

We will have a brief question and answer period. It will have to be brief because we are a little behind schedule. We want to leave some time for questioning the next two speakers. We are ready for the first question.

DR. BOOKER T. WHATLEY: I have a question for Mr. Davis. My question is, Why did you remove the flap?

MR. DAVIS: I am not much of a scientist. I really couldn't say why it was removed, only that flap is no longer needed.

DR. WHATLEY: Now in budding rubber, the flap is retained and it is the opinion that you get a better seal if you use the flap. In other words, insert the scion and then keep your flap on and wrap it up.

MR. DAVIS: One problem we have, you would be likely to break off the eyes if you pressed the flap against the shield.

DR. McDANIEL: I think that would be the principal reason for removing the flap with pecan, but with apple or persimmon it is better with the flap over the bud.

MR. RICHARD FILLMORE: I have a question for Mr. Davis also. I would like to ask him if he is positive that bud heals on the top first.

MR. DAVIS: That is what I was told. In my observation, the callus tissue forms on both sides of the shield on the top first.

DR. McDANIEL: Does the callus come from the bud patch or the stock?

MR. DAVIS: It comes from the stock.

MR. CASE HOOGENDOORN: I would like to ask a question. Why do we have difficulty with budwood on certain items, cherries and I notice. —

MR. VAN HOF: Don't look at me. I can't read your mind.

MR. HOOGENDOORN: I will stay with the cherries. At least I didn't forget. We have difficulty sometimes when budding cherries. You will take the bud and you will remove the wood and what we call the heart and eye also. You remove what you want to keep in there. Why? I know it will happen when you use the budwood too hard. Do you think if the bud is correct that it will still happen?

MODERATOR LEACH: Your question is directed to whom?

MR. HOOGENDOORN: Anyone who wants answer.

DR. WIDMOYER: I am not absolutely certain, Case, if I have the picture on that, but what I envision is that you are using budwood a little too hard and you take some of the xylem or wood from the interior portion of the stick. Is that right, Case?

MR. HOOGENDOORN: Yes.

DR. WIDMOYER: And you want to know if this is as satisfactory as if you were to take out the wood.

MR. HOOGENDOORN: No, by taking the wood out you are also removing the heart of the eye.

DR. WIDMOYER: Well, part of this reason is that you have to remember the buds have a continuity of vascular system with the wood. Consequently, they tear out.

MR. HOOGENDOORN: You can overcome that by cutting your bud lighter and leaving the wood in, and now by that time you have a coarse stick. You come down to a very narrow shield. Lots of times it isn't detrimental at all because you haven't enough sap in that to get the bud to take in the first place.

DR. McDANIEL: I will volunteer. I think in that case it would be better to switch to patch bud or so-called Jones Method of Budding rather than doing it by the Tee Method.

MR. HOOGENDOORN: Jones Method?

DR. McDANIEL: Described in Farmer's Bulletin 1567.

MODERATOR LEACH: One more question.

MR. MARTIN VAN HOF: I would like to ask Richard Jaynes about the insertion in your stock. How long is that wound and how deep do you go into it? Also, is your stock established in the ground?

DR. JAYNES: Yes, they were done in the field. The stocks were established, the cut was actually made in the wood and was probably in the neighborhood of an inch and a half long.

MODERATOR LEACH: Gentlemen, thank you very much for answering the questions. We will go now to the next speaker.

May I introduce now Mr. Ian Mackay, Conard-Pyle Company, West Grove, Pennsylvania, who will talk on Collection, Storage, and Use of Dormant Budwood.

THE COLLECTION, STORAGE AND USE OF BUDWOOD

IAN MACKAY
Conard - Pyle Co.
West Grove, Pennsylvania

In the propagation of field grown roses, budding can be performed over almost the entire growing season of the understocks, which in southeastern Pennsylvania extends from mid-May until late October. In fact we can start several weeks earlier than the current season's budwood is available, a point which can be illustrated by noting that while it is possible to start on May 15 using stored budwood, we would have to wait until June 15 for wood from the stock block or July 15 before it is available from the main crop.

It is only by the use of budwood stored from the previous year that we can gain a month over nature and start in May, an operation made possible by the use of refrigerated storage and the comparatively recent knowledge of how to use it successfully. The adoption of this method has brought with it several money saving improvements which are, first, that by being able to start four weeks earlier, the same number of budders are able to produce 25% more plants during the season, secondly, the budwood can be cut late in the season when it is in prime condition and when it places the least burden on our work schedule, and lastly, it removes the need for maintaining that expensive nuisance in the rose world, a stock block. In short, overwinter storage of budwood allows us increased operating flexibility by lengthening our budding season by one month.

As a result, we are now cutting budwood for two purposes during the year, some for long term winter storage, and some for short term storage and use in the current season. Both collections share the two most essential requirements in that they must be carefully selected from plants which are typical of the variety, and also that they come from plants free of symptoms of virus or other diseases. Failure to pay attention to these points could result in the degradation of the variety either by the wood being collected from a plant which has mutated in some fashion or from plants infected with certain bud transmitted virus diseases. Also in both collections it is important that as little time as possible elapses between the time of cutting and the placing of the wood in refrigeration, and that there be no unnecessary exposure to the drying effect of the air.

The collection in the field is made by a competent specially trained worker, who selects and cuts the wood, assisted by a helper who carries it to a covered pick-up truck. It is then watered down and covered with wet burlap to prevent drying. At this stage it is important that it never be allowed to wilt or stay in high temperatures for any length of time. To prevent this, the helper returns at frequent intervals to the handling shed where the wood is trimmed of dead flowers and placed in refrigerated storage for from two to three weeks. The degree of maturity of the wood cut is determined by the period of storage to which it is to be exposed and by the budding technique involved. Where it is to be budded during the current season, it can be softer and less mature than wood for long term storage, and, where the "wood out" technique of budding is used, should preferably be taken just as the flower on the cane passes maturity and the petals begin to fall. However where the "wood in" method is the rule, budwood can be of any stage of maturity from petal fall to wood that is completely dormant and taken in mid-winter. Ideally, we prefer to collect our wood for overwinter storage in late September and early October using canes of good maturity and medium caliper.

In many respects wood for short and long term storage is handled the same. The flower head is removed together with the top of the cane down to the first good five leaflet leaf, and the remaining leaves are pulled off, but the next operation depends on the destination of the wood. That for the current season's use has the prickles removed before being made up in bundles of about 50 canes (or 200 eyes) and sealed in a polyethylene bag for storage at about 36°. However budwood for overwinter storage has the prickles left on and, after bundled as before, is wrapped in polyethylene lined butcher's paper. It is then enclosed in two thicknesses of wet newspaper before being placed in a polyethylene bag and sealed. Important points to follow are that as much air as possible be excluded from the packages, that the budsticks be dry when packaged, and that no pieces of leaf, petal or other material adhere to the sticks. If these points are followed, *Botrytis* mold does not become a problem and the use of fungicides does not appear to be necessary, but where strict sanitation is not practiced, even the use of fungicides seem to be of little avail in preventing rot. Finally, the bags are placed in small wooden crates and stacked in refrigérated storage with each layer being separated by wooden battens and with a 4″ air space adjacent to the walls to allow free air circulation. Successful storage from this point on is dependent on the keeping of a constant temperature in the 28° to 31° range. Fluctuations much below this range or above 32° appear to result in loss due to mold. From experience a very worthwhile investment is the inclusion of two thermostats, one being set to operate a degree below and a degree above the other, and also an alarm system to operate if the temperature rises above 32°.

In the spring the packages are removed from storage a few days prior to use and placed in a temperature of about 36°. Afterwards they are unpacked, prickled, and then treated in the same manner as newly collected budwood, eventually being replaced in polyethylene bags and kept under 40° refrigeration until needed by the budder in the field.

In budding we use the ordinary T method with the "wood in" but instead of using rubber bands, for some years we have been using the Speed-Easy bud patch. This patch besides being faster to use than rubber bands, has resulted in an improvement in the take which today averages over 90% in a normal year, which in our climatic condition rates as excellent.

In conclusion let me say that occasional unexplicable failures will still occur in budwood storage, for it has still not been pinpointed to an exact science. However, reasonably consistent results will be obtained provided strict attention is paid to the details of the operation, especially that the wood be healthy, mature, protected from drying and stored at a constant temperaure.

MODERATOR LEACH: Thank you, Mr. Mackay.

The next speaker is Ray Halward of the Royal Botanic Gardens, Hamilton, Ontario, and he will speak on Collection, Storage and Use of Dormant Scionwood.

COLLECTION, STORAGE AND USE OF DORMANT SCIONWOOD

RAY HALWARD
Royal Botanical Gardens
Hamilton, Ontario, Canada

Selection of Scionwood

I hardly think it necessary to delve at any length into the importance of the selection of suitable scionwood and to what extent it affects the Propagator's success in grafting. This has been emphasized in many previous papers presented to this society.

Selection of Scionwood should be from known plants whose performance in the past has been observed and found to have the most desirable characteristics of the species and varieties involved, and permanently labelled or charted to prevent errors. It is equally important to be sure that the wood to be used for grafting is kept free of insects and diseases. Weakened Scionwood is a poor risk.

Maturity of Scionwood in respect to grafting, in most cases, has not been reached until it has been exposed to a period of near freezing temperatures. This process in nature can be duplicated by the use of refrigeration. This allows early collection where necessary, particularly where importation is desirable or extreme weather conditions prevail or where scions are needed from plants which might suffer from winter injury.

Storage of Scionwood

Most of the growers were of the opinion that storage was unnecessary except for a day or two in advance of actual use. When storage for any length of time is necessary most sources were agreeable that plastic bags or wrap, and refrigeration with a constant temperature between 35 and 40 degrees is best. In some cases slightly moist sphagnum moss or sawdust is used in conjunction with plastic. Whenever storage is necessary humidity should be kept high to prevent any dehydration of scionwood. Mr. DeGroot of Sheridan Nurseries suggested layering evergreen scions in boxes, with snow between the layers, in snowbelt areas. He added a word of caution, all frozen scions should be thawed in cold water before using. An older method of storage is the use of a trench covered with boards in a shady location, using sand as medium for heeling in the Scionwood.

Use of Scionwood

The selection of the material to be used as understock is equally important as the selection of scionwood. Is the understock compatiobtained provided strict attention is paid to the details of the operation, especially that the wood be healthy, mature, protected from drying and stored at a constant temperaure.

MODERATOR LEACH: Thank you, Mr. Mackay.

The next speaker is Ray Halward of the Royal Botanic Gardens, Hamilton, Ontario, and he will speak on Collection, Storage and Use of Dormant Scionwood.

COLLECTION, STORAGE AND USE OF DORMANT SCIONWOOD

RAY HALWARD
Royal Botanical Gardens
Hamilton, Ontario, Canada

Selection of Scionwood

I hardly think it necessary to delve at any length into the importance of the selection of suitable scionwood and to what extent it affects the Propagator's success in grafting. This has been emphasized in many previous papers presented to this society.

Selection of Scionwood should be from known plants whose performance in the past has been observed and found to have the most desirable characteristics of the species and varieties involved, and permanently labelled or charted to prevent errors. It is equally important to be sure that the wood to be used for grafting is kept free of insects and diseases. Weakened Scionwood is a poor risk.

Maturity of Scionwood in respect to grafting, in most cases, has not been reached until it has been exposed to a period of near freezing temperatures. This process in nature can be duplicated by the use of refrigeration. This allows early collection where necessary, particularly where importation is desirable or extreme weather conditions prevail or where scions are needed from plants which might suffer from winter injury.

Storage of Scionwood

Most of the growers were of the opinion that storage was unnecessary except for a day or two in advance of actual use. When storage for any length of time is necessary most sources were agreeable that plastic bags or wrap, and refrigeration with a constant temperature between 35 and 40 degrees is best. In some cases slightly moist sphagnum moss or sawdust is used in conjunction with plastic. Whenever storage is necessary humidity should be kept high to prevent any dehydration of scionwood. Mr. DeGroot of Sheridan Nurseries suggested layering evergreen scions in boxes, with snow between the layers, in snowbelt areas. He added a word of caution, all frozen scions should be thawed in cold water before using. An older method of storage is the use of a trench covered with boards in a shady location, using sand as medium for heeling in the Scionwood.

Use of Scionwood

The selection of the material to be used as understock is equally important as the selection of scionwood. Is the understock compatible? Will it produce the best plant under variable growing conditions. Is it easy to get, or will it propagate readily? Is it abnormally affected by insects or diseases? These are some of the questions a grower must consider. I believe this is best illustrated by the change from *Juniperus virginiana* to *Juniperus chinensis glauca Hetzi* as understock for Juniper grafting.

Two methods of using dormant Scionwood are described below. One with Evergreens, the other with deciduous plants. Mr. Jens Pederson, Rose Arbor Nurseries, Oakville, explained his method of Juniper grafting using Hetz understock. About the end of October two year old understock plants are dug and graded for size and quality. They are gradually potted up and benched in a cold house. On or about the middle of December the heat is turned on. The sides of the benches are partially closed in to give a higher temperature for bottom heat. The thermostats located under the bench are set at 80 degrees. This gives about 65 degrees in the bench.

Grafting using the veneer or side graft is started about the middle of January, using scions collected the previous day and thawed with cold water if necessary. After tying with rubber or plastic bands the pots are plunged in peat at an angle and the union slightly covered with peat. The whole bench is enclosed with plastic for about five weeks. They are gradually hardened off for planting by the last of May or early June.

On bare root grafting of deciduous shrubs and trees Mr. William Vanderkruk, Watertown, Ontario, of Connon Nurseries contributed his method. The understock is lifted in late fall and layered in boxes of peat moss slightly moistened. These boxes are stored in a cold storage shed where the temperature frequently drops to well below freezing. Near the end of February the stock is brought in, thawed and grafted with scions collected as needed. On completion of the grafting operation the grafts are tied, dipped in grafting wax and relayered in the peat. Storage temperature for the next 5 or 6 weeks is kept about 55 to 60 degrees where callusing takes place. When sufficiently callussed they are moved outdoors in cold frames to await suitable conditions for lining out. This is the method used for deciduous trees and shrubs considered not difficult to graft.

Following is a list of Genera, type of scionwood, type of graft, time to graft, understock used and remarks. The list was formulated by G. Leiss of Erindale Nurseries, Streetsville.

Name of Plant	Type of Scionwood	Type of Graft	Time	Remarks — Understocks
Acer palmatum & Vars.	1 yr. - mature	veneer	Aug-Spring	on plants in active growth - A. palmatum
Acer platanoides & Vars.	1 yr. - mature	side, splice - whip & tongue	Spring - Late Winter	leave bud on back of understock Acer platanoides
Acer rubrum & Vars.	1 yr. - mature	side, splice	Spring "	possible on A. saccharinum best on A, rubrum
Actinidia vars.	1 yr. - mature	side	Spring "	on own roots
Aesculus hippo. & Vars.	1 yr. - mature	side in Spring T cut in Aug.	Spring "	on own roots
Alnus vars.	1 yr. - mature short scions	side & splice	Spring "	on own roots, potted plants
Amelanchier vars.	1 yr. - mature	side & splice	Spring "	bareroot possible on Crataegus, Sorbus
Ampelopsis Vars.	1 yr. - mature	side or splice	Spring "	on Parthenocissus
Aralia Vars.	1 yr. - mature	side or splice	Spring "	on own roots
Aristolochia	1 yr. - mature	splice	Spring "	on own roots
Berberis Vars.	1 yr. - mature	side or splice	Spring - Aug. L. Winter	evergreen varieties on B. vul. atropurp. or B. thunbergi atropurpurea
Betula Vars.	2 yr. -	side or splice	Spring - Late Winter	in greenhouse on potted stock grafts waxed outside possible
Buddleia vars.	green	wedge	Summer	on own roots
Carpinus betulus vars.	1 yr. - mature	side or splice	Spring "	in greenhouse on potted stock, waxed on C betulus
Carya sp. & var.	1 yr. - mature	side or splice	Spring "	on own roots possible on Juglans nigra
Castanea sp. & hyb.	1 yr. - mature	side or splice	Spring "	on potted stock in greenhouse Castanea mollissima, outside also
Catalpa vars.	1 yr. - mature	side or splice	Late Spring	on C. speciosa
Ceanothus vars.	green	side or splice	Spring - Late Winter	forced in greenhouse
Celtis	1 yr. - mature	side or splice	Spring "	on own rt. potted stock in greenhouse

Name of Plant	Type of Scionwood	Type of Graft	Time	Remarks — Understocks
Chaenomeles	1 yr. - mature	side or splice	Spring ″	on own roots, bareroot stock also Malus
Chionanthus	1 yr. - mature	side or splice	Spring ″	on Fraxinus ornus, stock bareroot
Clematis	green	wedge	Spring	on C. vitalba under double glass
Colutea vars.	1 yr. - mature	side & splice	Spring - Late Winter	own roots, also Caragana arb.
Cornus florida vars.	1 yr. - mature	veneer	Spring ″	own roots
Corylopsis	2 yr. -	veneer	Spring ″	on C. spicata. potted, or Hamamelis
Corylus	1 yr. - mature	side or splice	Spring ″	on C. avellana potted
Cotoneaster	1 yr. - mature	side or splice	Spring ″	on C. bullata, C. acutifolia, C. dielsiana Standards on Sorbus & Crataegus
Crataegomespilus	1 yr. - mature	side or splice	Spring ″	on Crataegus monogyna
Crataegus	1 yr. - mature	side or veneer	Spring ″	on roots C. monogyna C. oxycantha
Cytisus	1 yr. - mature	veneer	Spring - Aug.	on C. scopariuus, or C. nigricans for strong powers
Daphne	1 yr. - mature	side or veneer	Late - Spring Winter	on roots D. laureola
Davidia	1 yr. - mature	side or splice	Winter - Spring	on Nyssa
Diospyros	1 yr. - mature	side or splice	Winter - Spring	on D virginiana or D. lotus potted
Elaeagnus	1 yr. - mature	side or splice	Winter - Spring	colored leaf vars. of E. pungens on E. multiflora
Evodia	1 yr. - mature	side	Winter - Spring	on Phellodendron potted
Euonymus	1 yr. - mature	side or splice	Winter - Spring	on E. europaea for standards
Fagus	2 yr. - mature	side	Winter - Spring Aug.	on potted stock in greenhouse on stock in nursery rows
Fraxinus	1 yr. - mature	side	Late Winter Spring	on own roots with bud on back of understock
Genista	1 yr. - mature	side	Late - Spring Winter	on G. tinctoria seedlings
Gleditsia	1 yr. - mature	veneer	Winter - Spring	on G. triacanthos

Name of Plant	Type of Scionwood	Type of Graft	Time	Remarks — Understocks
Halimodendron	1 yr. - mature	side	Winter - Spring	H. purpurea on Caragana arborescens
Hamamelis	1 yr. - mature	side or veneer	Winter - Spring	on 2 year seedlings potted of H. virg. grafts waxed
Hedera helix arb.	1 yr. - mature	side	Winter	on Hedera helix
Hibiscus syr. vars.	1 yr. - mature	side	Fall Late - Spring	on H. syr.
Ilex vars.	1 yr. - mature	side or splice	Late - Spring Winter	on potted stock in greenhouse on I. aquifolium, I. crenata
Juglans	1 yr. - mature	veneer or side	" "	bareroot or on potted stock in greenhouse on Laburnum anagyroides
Laburnocytisus	1 yr. - mature	side	" "	on Laburnum anagyroides
Laburnum	1 yr. - mature	side	" "	on own roots potted in greenhouse
Liriodendron	1 yr. - mature	side	" "	on potted stock in greenhouse on M. kobus
Magnolia	1 yr. - mature	side or veneer	" "	on potted stock in greenhouse, on M. kobus for slow on M. acuminata for fast
Mahonia	1 yr. - mature	side or splice	" "	on M. aquifolium for M. Fortunei and M. Beali
Malus	1 yr. - mature	side or splice	" "	American on on apple seelings M. prunuifolium
Mespilus	1 yr. - mature	side or splice	" "	on own roots or Crataegus
Morus	*1 yr. - mature*	*splice*	*Spring*	*after sap starts to flow on M. alba*
Osmanthus	1 yr. - mature	side	Winter - Spring	on Ligustrum vulgaris
Ostrya	1 yr. - mature	side	" "	on Carpinus betulus potted in gr. house
Paeonia arb.	Current seasons	side	Aug. "	on P. lactiflora, wax and tie with lead wire
Parrotia	1 yr. - mature	side	Late - Spring Winter	on Hamamelis potted in greenhouse
Phillyrea	1 yr. - mature	side	" "	on Ligustrum vulgaris
Photinia	1 yr. - mature	side	" "	on Crataegus or Cydonia
Pyrus	1 yr. - mature	side	" "	on own root, some on Chaenomeles
Populus	1 yr. - mature	side	" "	P. Bolleana on P. nigra italica
Ptelea	1 yr. - mature	side		on P. trifoliata

Name of Plant	Type of Scionwood	Type of Graft	Time	Remarks — Understocks
Quercus	2-3 yr. - mature	side or veneer	after sap flow	also on potted stock, graft on same group
Rhamnus	1 yr. - mature	side	Late - Spring Winter	bareroot or in field
Rhododendron	1 yr. - mature	side	" "	on Rhod. ponticum under dlb. glass
Rose	green with leaf	side - behind the bark	Winter	double glass
Sambucus	1 yr. - mature	side	Late - Spring Winter	on S. nigra & S. racemosa
Sophora	1 yr. - mature	side	" "	vars. on S. japonica
Sorbus	1 yr. - mature	side	" "	on S. aucuparia & S. americana S. aria on Crataegus
Syringa	1 yr. - mature	side or saddle	" "	on Ligustrum vulgaris
Ulmus	1 yr. - mature	side or splice	" "	on same species
Viburnum	1 yr. - mature	side or splice	Aug or Spring	on V. lantana, potted
Wisteria	1 yr. - mature	Whip & tongue, side or veneer	Late Spring Winter	on own roots
Zelkova	1 yr. - mature	side	" "	on Ulmus
Abies	1 yr. - mature	veneer - V cut of Terminal bud	Spring - Aug.	on potted stock, double glass
Chamaecyparis	1 yr. - mature	veneer	Late - Aug. Winter - Spring	on own root potted, also Thuja orient.
Cryptomeria	1 yr. - mature	veneer	" -Aug.	on C. japonica
Juniperus	1 yr. - mature	side or veneer	Winter - Aug.	on J. Chin. gl. Hetzi, best also J virginians
Larix	1 yr. - mature	veneer	Spring - Aug.	
Picea	1 yr. - mature	veneer	Spring - Aug.	potted under double glass
Pinus	1 yr. - mature curren seasons- Aug.	veneer	Spring - Aug. - Nov.	on same type
Pseudotsuga	1 yr. - mature	veneer	Spring - Aug.	on own — under double glass potted
Tsuga	1 yr. - mature	veneer	Spring - Aug.	" — " " " "

MR. HALWARD: I would like to mention the names of the fellow Canadian members who contributed information to this paper: Mr. Constant deGroot of the Sheridan Nurseries, Jens Pederson from Rose Arbor Industries, Oakville; William Vanderkruk, from Waterdown, John Cannon Nurseries; George Leiss from Erindale; Robert Fleming, Vineland Experiment Station and also Louie Forester from the Royal Botanical Gardens, Hamilton. If it hadn't been for these fellows, I wouldn't be up here today.

MODERATOR LEACH: Gentlemen, we are far enough behind schedule that I am afraid we are going to have to track down Mr. Mackay and Mr. Halward in the recess that is coming up in a moment and address your questions to them personally. In the meantime I want to thank Dr. Widmoyer, Professor McDaniel, Mr. Davis, Mr. Jaynes, and Mr. Mackay and Mr. Halward, for their fine contributions this morning.

The next session on the program this morning relates to the propagation of Plants by Seeds. The first speaker is Ken Reisch, of the Department of Horticulture in Ohio State University, who will talk on After Ripening as Related to Germination and Seedling Growth.

AFTER RIPENING AS RELATED TO GERMINATION AND SEEDLING GROWTH

K. W. Reisch
Department of Horticulture
Ohio Agricultural Experiment Station
Wooster, Ohio

Seeds of many plant species do not germinate readily for various reasons or combinations of reasons and to introduce the subject I will define some common terms relating to this.

Seed Dormancy is an all inclusive term indicating that seed will not germinate and produce seedlings due to unfavorable environmental or internal conditions (the inhibitory factors may be external, internal or a combination of both).

Quiescence relates to the fact that seed will not germinate and produce seedlings due to unfavorable external conditions. Contributing factors are moisture, temperature, oxygen, light, or others such as pH, nutrients, carbon dioxide, or toxic conditions. This can be overcome by simply supplying the contributing factors at optimum for germination.

Rest or Internal Dormancy describes the situation where seed will not germinate and produce seedlings due to unfavorable factors or conditions specific to the seed. These may be classified in the following eight areas. Seed coat, endosperm, embryo development, embryo rest, epicotyl rest, root and epicotyl rest, cotyledons, and combinations of these. The inhibitory action of these factors or conditions can be overcome by seed coat treatments, furnishing food materials, cold temperatures, warm temperatures, combinations of warm

MR. HALWARD: I would like to mention the names of the fellow Canadian members who contributed information to this paper: Mr. Constant deGroot of the Sheridan Nurseries, Jens Pederson from Rose Arbor Industries, Oakville: William Vanderkruk, from Waterdown, John Cannon Nurseries; George Leiss from Erindale; Robert Fleming, Vineland Experiment Station and also Louie Forester from the Royal Botanical Gardens, Hamilton. If it hadn't been for these fellows, I wouldn't be up here today.

MODERATOR LEACH: Gentlemen, we are far enough behind schedule that I am afraid we are going to have to track down Mr. Mackay and Mr. Halward in the recess that is coming up in a moment and address your questions to them personally. In the meantime I want to thank Dr. Widmoyer, Professor McDaniel, Mr. Davis, Mr. Jaynes, and Mr. Mackay and Mr. Halward, for their fine contributions this morning.

The next session on the program this morning relates to the propagation of Plants by Seeds. The first speaker is Ken Reisch, of the Department of Horticulture in Ohio State University, who will talk on After Ripening as Related to Germination and Seedling Growth.

AFTER RIPENING AS RELATED TO GERMINATION AND SEEDLING GROWTH

K. W. Reisch
Department of Horticulture
Ohio Agricultural Experiment Station
Wooster, Ohio

Seeds of many plant species do not germinate readily for various reasons or combinations of reasons and to introduce the subject I will define some common terms relating to this.

Seed Dormancy is an all inclusive term indicating that seed will not germinate and produce seedlings due to unfavorable environmental or internal conditions (the inhibitory factors may be external, internal or a combination of both).

Quiescence relates to the fact that seed will not germinate and produce seedlings due to unfavorable external conditions. Contributing factors are moisture, temperature, oxygen, light, or others such as pH, nutrients, carbon dioxide, or toxic conditions. This can be overcome by simply supplying the contributing factors at optimum for germination.

Rest or Internal Dormancy describes the situation where seed will not germinate and produce seedlings due to unfavorable factors or conditions specific to the seed. These may be classified in the following eight areas. Seed coat, endosperm, embryo development, embryo rest, epicotyl rest, root and epicotyl rest, cotyledons, and combinations of these. The inhibitory action of these factors or conditions can be overcome by seed coat treatments, furnishing food materials, cold temperatures, warm temperatures, combinations of warm and cold temperatures, the use of light, leaching. and possible chemical treatments.

After Ripening is basically a series of physiological or chemical changes occurring within the seed which bring to a close the rest period and make germination possible. Conditions favoring after-ripening include cold temperature, warm temperature, alternating temperatures, ample oxygen, moist stratification and probably light.

Important changes which have been found to occur in some seed during after ripening are increased water holding capacity, increased acidity, increased enzyme activity (specifically catalase, perioxidase, and oxidase), increase in sugar content, decrease in fat content, translocation of food materials from endosperm to embryo, increase in respiration,and in increase in the vigor of the seed which is believed to reduce susceptibility to fungal incidence.

Many workers have studied these problems, although much of the research dates back many years. An excellent review of the subject of seed dormancy was presented by Dr. Dale Kester at the first Western Propagator's Conference in 1960 and I refer you to his thorough article in the 1960 Proceedings of the Plant Propagator's Society. Because of this, the material in this paper will be restricted to one aspect of dormancy which is very perplexing and at the same time somewhat fascinating.

This relates to epicotyl rest. which is a major factor giving rise to many so-called two year seed. The epic work on this subject dates back to 1933 when Barton (3) reported that seed of Tree Peony exhibited epicotyl dormancy and that seed planted outdoors in May, June or July did not give good seedling production until the following spring. She indicated that if earlier production was desired it was necessary to sow seeds in flats and hold them in a warm greenhouse for three months until root production was complete and then transfer the flats to temperatures of 1-10°C for 2½ to 3 months to overcome epicotyl dormancy and then again to a greenhouse, at which time shoots grew.

Epicotyl dormancy or correctly, epicotyl rest, simply refers to the fact that the terminal growing point of the embryo will not grow unless special treatment is given to overcome the rest condition. Seeds with this type of rest are unique in that only the radicle or root will grow under warm stratification, and a further cold treatment is necessary to overcome the rest of the epicotyl. If the latter treatment is not given, the root will continue to grow until the food supply is exhausted and the seed dies. Some hypotheses have been proposed to explain this phenomenon and several workers indicated that the inhibition in Viburnum seed may be seated in the cotyledons, the waxy coat, or in the integument: however, to my knowledge, no one has ever discovered a proven satisfactory explanation for epicotyl rest.

Reports on research, much of it from the Boyce Thompson Institute, have described seeds of a number of plant types having epicotyl rest in addition to the Tree Peonies mentioned earlier. In 1936 Barton (1) reported that seed of six lily species required warm plus cold temperature stratification to produce seedlings. Fordham (8) speaking at the Plant Propagator's Society Meeting in 1960 pointed out that this type of dormancy existed on Chionanthus retusus and Davidia involucrata. Barton (4) in a later work, also included in this category seed of Asarum canadense, Sanguinaria canadensis, Polygonatum commutatum, Trillium grandiflorum, and Caulophyllum thalictroides. She indicated that another, more complex condition, was found in the Trillium and Caulophyllum seed, where both roots and epicotyl are dormant and two separate cold treatments were necessary to bring about seedling production. After working with Convallaria majalis and Smilacina racemosa, Barton and Schroeder (6) reported another unique and different aspect. Low temperature treatment was required for shoot growth after root growth had occurred. However, it was only effective if given after the shoot had started to grow and had broken through the cotyledonary sheath. The recommended treatments were given as follows. Three months at cold temperature to after ripen the partially dormant roots; two months at greenhouse temperature to grow the root system and develop the first leaves; three to five months at cold temperature to after ripen the shoot bud; and then a transfer to the greenhouse for seedling production.

Studies with Viburnum have probably been of greatest interest to the woody plant propagator and to review briefly I refer to Giersbach's (9) original work in 1937. She indicated that seed of some Viburnum species such as nudum and scabrellum offered no germination problems but that seed of V. acerifolium, dilatatum, lentago, opulus, prunifolium, and rufidulum, had to be exposed to warm temperature stratification for germination and root development, followed by a cold period to force epicotyl development. This work was reviewed by Barton (2) in the 8th Annual Proceedings of the Plant Propagator's Society.

Fordham (8) reported that five months warm stratification treatment on seed of Viburnum sargenti flavum was more than necessary for radical emergence and that the seed could have been placed in the cold temperature treatment after three months.

Smith (10) found that maximum germination of Viburnum lantana occurred after fifty-six days treatment at 40° F. He also noted that percentages as high as 47 per cent germination occurred after only 14 days of 40° F storage. The recommendations in the Woody Plant Seed Manual (11) indicate considerable variation between treatments for different Viburnum species, however, the basic treatment is stratification at warm temperature of approximately 70° F, or possibly fluctuating warm temperatures, followed by a storage period at cold temperature of approximately 40° F. The other alternative recommended is to sow seed outdoors in the spring or early enough in the summer so that sixty warm days will elapse before winter. Seedling production will occur the following spring.

Barton and Chandler (5) found that gibberellic acid was effective in overcoming epicotyl rest of Tree Peony, replacing the need for low temperature treatment, however, they indicated that abnormal growth with spindly stems and small leaves resulted.

The use of controlled storage temperature treatment raises some practical problems. If, as Barton indicated at the 1958 meeting of the Plant Propagator's Society (2), the radicle must protrude before the cold treatment is given, the seed should be sown in flats and carried through the treatments in this way. If this is not done the radicle will be broken off when the seeds are sown after the warm temperature treatment. On the basis of observations by Chadwick (7), this may not be an absolute rule with most species of Viburnum, since some types appeared to produce epicotyls even though radicles were not protruding at the time of exposure to cold temperature.

Research with Viburnum seed was begun at the Ohio Agricultural Experiment Station in 1961. The results at this time are only of the most preliminary nature, however, some of the general observations will be presented. The primary objective of the research was to determine whether it is absolutely necessary that the radicle of Viburnum seed protrude before the cold temperature treatment will be effective, and also to study in greater detail the elongation of the embryo. Species studied included V. dentatum, latana, lentago, opulus, dilatatum setigerum, and trilobum. The treatments were 1, control — greenhouse; 2, 70° F storage only; 3, 40°F storage only; 4, 70°F storage followed by 40°F storage for varying periods ranging from six weeks to fifteen weeks.

General observations of results to-date include the following.

Germination of Viburnum lantana seed was very low, however, after no warm treatment and ten weeks of 40°F treatment, fifteen percent of the seed which germinated produced seedlings. Smith (10) indicated this in earlier work and it appears that V. lantana may be one of the exceptions to the rule that the radicle must protrude before seedling production will result.

No benefit was found from re-exposure to cold temperature treatments if these were interrupted with a warm temperature. This supports results of earier work indicating that the cold treatment effects are not additive. In some instances it appeared that the total period in warm temperature stratification plus the cold temperature treatments may be as important as the time in each individual temperature treatment. Measurements of the embryo — radicle length of Viburnum trilobum seed indicated that in seed stratified at 70°F. the radicle did not protrude until after eight weeks at which time the length was approximately 5 mm. The embryo-radicle increased gradually to approximately 20 mm at 12 weeks storage time and then rapidly to over 37 mm. between the 12 and 13 week storage period.

With Viburnum trilobum seed stored at 11, 12 and 13 weeks at 70°F, radicle emergence increased, embryo-radicle length increased, and ultimate epicotyl emergence increased with time. In contrast to this, 8, 9, and 10 week periods of 40°F treatment resulted in no increase in radicle emergence, no increase in embryo-radicle length. and an increase in epicotyl emergence with time.

These studies are being continued and final results will be published later.

In summary, the germination problems with Viburnum seed appear to be due to a number of factors. There is considerable variation between species, variation between individual plant seed sources, variation due to environmental effects, as well as variation due to the time seed is collected. In this study, as in others, it was found that the use of short periods in the warm and cold temperature treatments resulted in low germination percentages; however, the fact that a small percentage of seed did germinate, indicates a variation that exists even within individual seed from the same plant.

BIBLIOGRAPHY

1. Barton, L. V., Germination and Seedling Production in *Lilium* sp., Contrib. Boyce Thompson Inst., 8: 297-309.-1936.
2. Barton, L. V., Germination and Seedling Production of Species of Viburnum, Proc. Plant Propag. Soc., 8:126-135, 1958.
3. Barton, L. V., Seedling Production of Tree Peony, Contrib. Boyce Thompson Inst. 5: 451-460, 1933.
4. Barton, L. V. Some seeds showing special dormancy, Contrib. Boyce Thompson Inst. 13:259-272, 1944.
5. Barton, L. V. and C. Chandler, Physiological and morphological effects of gibberellic acid on epicotyl dormancy of Tree Peony. Contrib. Boyce Thompson Inst. 19:201-214, 1957.
6. Barton, L V. and E. M. Schroeder, Dormancy in seeds of *Convallaria* majalis and *Smilacina* racemosa, Contrib. Boyce Thompson Inst., 12:277-300, 1942.
7. Chadwick, L. C., Dept. of Horticulture, The Ohio State University, Personal correspondence.
8. Fordham, Alfred, Germination of double-dormant seeds, Proc. Plant Propag. Soc, 10.206-208, 1960.
9. Giersbach, J., Germination and seedling production of species of *Viburnum*, Contrib Boyce Thompson Inst., 9:79-99, 1937.
10. Smith, B. C., An investigation of the delayed germination of the seed of *Cotoneaster divaricata, C zabeli, Viburnum lantana, and V. lentago,* Unpubl. Diss The Ohio State University, 1952.
11. U.S.D.A. Woody Plant Seed Manual, Misc. Publ. 654.369-372, 1948.

MODERATOR LEACH: Thank you, Dr. Reisch.

The subject of Stimulating Germination by Chemical and Mechanical Means has been divided into two discussions, the first by Thomas S. Pinney, Jr., of Evergreen Nursery Company, Sturgeon Bay, Wisconsin, who is going to talk to us about Commonly Propagated Ornamentals.

STIMULATING GERMINATION OF SEED BY CHEMICAL AND MECHANICAL MEANS

THOMAS S. PINNEY, JR.
Evergreen Nursery Co.
Sturgeon Bay, Wisconsin

There have been a number of techniques developed to overcome the problem of rest or internal dormancy of various seeds. Chemical and mechanical treatments may be helpful in overcoming internal dormancy that is caused by: (1) seed coat (i.e.) *Gleditsia, Gymnocladus* (2) hard endosperm which acts as a seed coat (i.e.) *Tila* and (3) when seed coat is one of the factors which contribute to the in-

In summary, the germination problems with Viburnum seed appear to be due to a number of factors. There is considerable variation between species, variation between individual plant seed sources, variation due to environmental effects, as well as variation due to the time seed is collected. In this study, as in others, it was found that the use of short periods in the warm and cold temperature treatments resulted in low germination percentages; however, the fact that a small percentage of seed did germinate, indicates a variation that exists even within individual seed from the same plant.

BIBLIOGRAPHY

1. Barton, L. V., Germination and Seedling Production in *Lilium* sp., Contrib. Boyce Thompson Inst., 8: 297-309.-1936.
2. Barton, L. V., Germination and Seedling Production of Species of Viburnum, Proc. Plant Propag. Soc., 8:126-135, 1958.
3. Barton, L. V., Seedling Production of Tree Peony, Contrib. Boyce Thompson Inst. 5: 451-460, 1933.
4. Barton, L. V. Some seeds showing special dormancy, Contrib. Boyce Thompson Inst. 13:259-272, 1944.
5. Barton, L. V. and C. Chandler, Physiological and morphological effects of gibberellic acid on epicotyl dormancy of Tree Peony. Contrib. Boyce Thompson Inst. 19:201-214, 1957.
6. Barton, L V. and E. M. Schroeder, Dormancy in seeds of *Convallaria* majalis and *Smilacina* racemosa, Contrib. Boyce Thompson Inst., 12:277-300, 1942.
7. Chadwick, L. C., Dept. of Horticulture, The Ohio State University, Personal correspondence.
8. Fordham, Alfred, Germination of double-dormant seeds, Proc. Plant Propag. Soc, 10.206-208, 1960.
9. Giersbach, J., Germination and seedling production of species of *Viburnum*, Contrib Boyce Thompson Inst., 9:79-99, 1937.
10. Smith, B. C., An investigation of the delayed germination of the seed of *Cotoneaster divaricata, C zabeli, Viburnum lantana, and V. lentago*, Unpubl. Diss The Ohio State University, 1952.
11. U.S.D.A. Woody Plant Seed Manual, Misc. Publ. 654.369-372, 1948.

MODERATOR LEACH: Thank you, Dr. Reisch.

The subject of Stimulating Germination by Chemical and Mechanical Means has been divided into two discussions, the first by Thomas S. Pinney, Jr., of Evergreen Nursery Company, Sturgeon Bay, Wisconsin, who is going to talk to us about Commonly Propagated Ornamentals.

STIMULATING GERMINATION OF SEED BY CHEMICAL AND MECHANICAL MEANS

THOMAS S. PINNEY, JR.
Evergreen Nursery Co.
Sturgeon Bay, Wisconsin

There have been a number of techniques developed to overcome the problem of rest or internal dormancy of various seeds. Chemical and mechanical treatments may be helpful in overcoming internal dormancy that is caused by: (1) seed coat (i.e.) *Gleditsia, Gymnocladus* (2) hard endosperm which acts as a seed coat (i.e.) *Tila* and (3) when seed coat is one of the factors which contribute to the internal dormancy of the seed (i.e.) *Cotoneaster, Viburnum, Malus* and *Crataegus*.

There are several chemicals which may be used to overcome the seed coat or endosperm internal dormancy in the seed. There has been considerable work done using a chemical such as sulphuric acid to break down the hard seed coat or endosperm. An acid resistant type of container such as a wooden barrel or plastic container is used. Usually the seeds are placed in some type of basket that is acid resistant so the seeds may be lifted easily out of the chemical at the proper time.

Generally 95% sulphuric acid commercial grade 1.84 (specific gravity) is used and the temperature of the acid should be maintained between 60-80 degrees F. The higher the temperature, the faster the reaction. The seeds remain in the acid from 15-60 minutes. The difficulty in this method is to determine the optimum length of time the seeds should stay in the acid. Under-treated seed coats will still be quite glossy while an over-treatment may deeply pit and even expose the endosperm or the embryo resulting in permanent damage of the seed. When the seeds are treated for the optimum length of time, they will appear dull. A cutting test will help you determine how much of the seed coat remains. Usually as much of the seed coat as possible is removed without exposing the endosperm or embryo.

A supply of water is necessary for rinsing the acid from the seed and also it should be located some place where the water used for rinsing the acid from the seed can safely run off.

There is an additional complication since the seed coats vary within the same batch and from year to year. This means that seeds might be treated for 15 minutes one year and may require 25 the next or the reverse may be true. Occasionally other acids such as nitric acid have been used, but most of the work has been done with sulphuric acid.

Another method that is considerably simpler to use is soaking the seed in water. The seeds are placed into water that is between 170-210 degrees F and allowed to soak for 12 hours as the water gradually cools. The theory is that as the temperature cools it will reach a point of optimum temperature for overcoming the internal dormancy caused by the seed coat. This method has been suggested for use on Eastern Red Cedar where there is a wax coating over the seed coat which inhibits the passage of water into the seed. P. O. Rudolph in 1950 (Cold Soaking — A Short Cut Substitute for Stratification? Journal of Forestry Vol. 48 pp. 31-32) attempted to use cold water at 41 degrees F. as a substitute for cool stratification.

One serious problem with the water soak is that the seeds become sticky, hold together and often times swell so that you are unable to put them through the regular mechanical seeding apparatus. This means that they have to be sown by hand and you have no real way of calibrating your seeding operation for replication from year to year.

There have been a great number of mechanical devices used for the scarification of seeds. Dr. Chadwick at Ohio State University has felt that one of the better types of scarifiers is the Ames Scarifier. Generally these machines consist of some abrasive type of material and a rotation of a drum or agitator which causes the seed to rub against the scarifying material, thus mechanically wearing down the seed coat. There are a number of advantages to this method in that it is quite simple and there is no need to work with dangerous materials such as acids or controlled temperatures. However, the seeds must be watched carefully so as not to injure the endosperm or the embryo by excessive abrasion and this method usually fails when the seeds have a soft or fleshy seed coat since this would gum up the abrasive material. The seeds are also more susceptible to pathogenic organisms than untreated ones.

It has been my experience in our particular nursery which specializes in propagation of common ornamentals by seed, that the methods I have previously discussed are not too practical in our particular nursery. We have never experienced a great deal of difficulty in germinating the common coniferous seed that we grow when a few simple practices are followed.

We plant as much of our coniferous seed in the fall as possible. Sometimes this is difficult, since securing seed before freeze-up is not always possible, especially when some species are obtained from foreign countries. When we are not able to plant in the fall we do store the seed in a damp common cold storage in polyethylene bags that are placed in tightly covered steel barrels to protect them from rodents.

We find that in most cases the conifer seeds do not need the high moisture used in normal cool stratification methods. Some coniferous seeds are difficult to store and may be better stored in a tightly sealed container in this same cool, damp environment. These stored seeds may then be planted in the spring or early summer with still very good germination.

The seeds of deciduous plants are a little more difficult to work with commercially, but we still follow a few very simple rules and it seems to have worked out quite well for us. We never plant a fleshy fruit, and we always clean our seeds with a machine designed for this purpose. The seed cleaner is made by the Dybvig Nursery Company at Colton, S.D. and we purchased it in 1954 for $275.00. It has proved to be very successful and the pulp is cleaned from the seed by maceration using water. The machine is powered by any belt power from a tractor or small implement. On some seeds such as Red Cedar we have also used this machine to attempt to remove the wax coating using warm water.

Since we plant all of our deciduous seeds without any pre-treatment other than might be given it with the cleaning machine, we realize that some of the seed such as Viburnums and Cotoneasters will not germinate until the second year. We feel that since many of our evergreens in the seed bed areas are there for three full years anyway, that the delay of the germination of the deciduous seed until the second year is not really a serious problem. The deciduous liners are usually sold as one and two year olds.

We have found that mechanical, chemical and stratification methods hastening germination can become quite complicated, time consuming and not conducive to mass production methods. It creates problems in calibrating our seeder and thus we are unable to accurately sow the seed. We practice a very simple method — plant the seeds and allow Mother Nature to do her work in the normal way. Since we have to assemble a tremendous amount of equipment each time we want to make seed beds, this allows us to plant all of our seed at one time and to make the best use of mass production methods. Also, we have attempted to do some stratification in storage and have found that so often these seeds are ready to be planted exactly when we are busiest in the spring of the year.

In conclusion I realize that my viewpoint is strictly from the commercial angle and I certainly feel that continued research must be done in hastening the germination of seed since sometimes nurserymen are caught short and would like to produce seedlings in shorter periods of time. We should have this information available to us for use for such an emergency basis. Also, the universities and other research institutes are helped a great deal by these various methods of hastening germination. For those that are interested there are two very excellent references in the field of seed dormancy. (1) Woody Plant Seed Manual, 1948, Prepared by the Forest Service, USDA Miscellaneous Publication No. 654. (2) A reference sheet prepared by Dr. L. C. Chadwick, Ohio State University.

I feel that most nurserymen still rely upon Mother Nature to take care of the dormancy problems in seed propagation. No doubt as the nursery industry becomes more and more specialized and more and more advanced, these techniques of hastening seed germination may become part of our commercial practices.

MODERATOR LEACH: The other half of the subject *Stimulation of Germination by Chemical and Mechanical Means* as applied to Exotic Plant Materials is to be discussed by Alfred J. Fordham, Arnold Arboretum.

METHODS OF TREATING SEEDS AT THE ARNOLD ARBORETUM

Alfred J. Fordham
The Arnold Arboretum
Jamaica Plain, Massachusetts

The USDA Woody-Plant Seed Manual and Contributions from the Boyce Thompson Institute are invaluable sources of information for those concerned with germinating seeds of trees and shrubs. However, when it comes to many woody ornamental plants and the more remote botanical garden subjects, information as to germination becomes hard or impossible to find. No doubt, at times in the past, people have known how some kinds of seeds perform but much was unknown and little recorded for the information of others. Among that which is written it is not uncommon to find erroneous informa-

We have found that mechanical, chemical and stratification methods hastening germination can become quite complicated, time consuming and not conducive to mass production methods. It creates problems in calibrating our seeder and thus we are unable to accurately sow the seed. We practice a very simple method — plant the seeds and allow Mother Nature to do her work in the normal way. Since we have to assemble a tremendous amount of equipment each time we want to make seed beds, this allows us to plant all of our seed at one time and to make the best use of mass production methods. Also, we have attempted to do some stratification in storage and have found that so often these seeds are ready to be planted exactly when we are busiest in the spring of the year.

In conclusion I realize that my viewpoint is strictly from the commercial angle and I certainly feel that continued research must be done in hastening the germination of seed since sometimes nurserymen are caught short and would like to produce seedlings in shorter periods of time. We should have this information available to us for use for such an emergency basis. Also, the universities and other research institutes are helped a great deal by these various methods of hastening germination. For those that are interested there are two very excellent references in the field of seed dormancy. (1) Woody Plant Seed Manual, 1948, Prepared by the Forest Service, USDA Miscellaneous Publication No. 654. (2) A reference sheet prepared by Dr. L. C. Chadwick, Ohio State University.

I feel that most nurserymen still rely upon Mother Nature to take care of the dormancy problems in seed propagation. No doubt as the nursery industry becomes more and more specialized and more and more advanced, these techniques of hastening seed germination may become part of our commercial practices.

MODERATOR LEACH: The other half of the subject *Stimulation of Germination by Chemical and Mechanical Means* as applied to Exotic Plant Materials is to be discussed by Alfred J. Fordham, Arnold Arboretum.

METHODS OF TREATING SEEDS AT THE ARNOLD ARBORETUM

ALFRED J. FORDHAM
The Arnold Arboretum
Jamaica Plain, Massachusetts

The USDA Woody-Plant Seed Manual and Contributions from the Boyce Thompson Institute are invaluable sources of information for those concerned with germinating seeds of trees and shrubs. However, when it comes to many woody ornamental plants and the more remote botanical garden subjects, information as to germination becomes hard or impossible to find. No doubt, at times in the past, people have known how some kinds of seeds perform but much was unknown and little recorded for the information of others. Among that which is written it is not uncommon to find erroneous information e.g. A comparatively recent, widely circulated publication, says regarding *Liquidambar styraciflua*, "Propagated by seeds which, if stratified, do not usually germinate for two years." Such false information is misleading to those wishing to propagate *L. styraciflua* for 2 months of cold stratification will produce a general germination.

Those involved with seed germination realize the importance of seed age and methods of storage. Many kinds of seeds will perform predictably after periods of storage, others go through changes which alter their characteristics, and those which are microbiotic (with viability of short duration) become worthless.

Many of the seeds used to obtain the information that follows were collected in the Arnold Arboretum. For these the method of handling was known, but others were received as exchange material from domestic and foreign botanical institutions where it is customary to collect the fruits as they ripen, separate the seeds and place them in dry storage. Seed lists are then circulated, usually in the late fall or early winter, and correspondents desiring seeds can check their wants. Where this is the common practice, it seems reasonable to assume that the seeds from such sources were collected from the past season crop and kept in dry storage.

Seed Coat Dormancy

Germination of many woody legumes is hindered by hard seed coats which prevent the imbibition of water. If such seeds are not pretreated before being sown germination can be intermittant and prolonged, sometimes extending over a period of many years. To obtain a prompt and uniform germination a rapid means of effecting the entry of water becomes necessary. Several procedures will accomplish this. Large type legume seeds, in small quantities, are perforated with a file, knife or some such means while smaller type seeds, or seeds handled in volume can be treated with hot water or sulphuric acid. An organization such as ours does not handle seeds in sufficient quantity to warrant the employment of mechanical scarifiers. Treatment with hot water consists of putting the seeds in a container and pouring water heated to a temperaure of abou 200° over them. The seeds are then left in the water over night. The amount of water used should be five or six times the volume of seed and this is important as too small a quantity can cool before it has the desired effect on the seed coats. On being removed from the water the seed is sown at once without being allowed to dry out. A second method is to sow the seed and then pour boiling water over the seed pan or seed flat.

Two years ago we conducted trials with seeds of *Albizia julibrissin rosea*. Concentrated sulphuric acid treatments at room temperature of ½ hour, 1 hour, and 2 hours were tested. A hot water treatment was also tried. Each treatment produced a general germination in ten days, but with hot water time was saved and the precautions involved when working with acid were avoided.

The sulphuric acid treatments consist of placing the dry seeds in glass containers and carefully pouring acid over them until they are covered. When treatments are terminated the acid is poured into a glass container so that it can be reused. The seeds are then thoroughly rinsed in running water to remove any remaining acid. We do not use a neutralizer after acid treatments and have never noticed detrimental effects for not having done so.

Acid Treatment of Cotoneasters

Many species of cotoneasters are characterized by double-dormancy which first requires modification of the hard, impermeable seed coats, followed by a period of cold stratification to induce germination. Using the polyethylene bag system (see below) this will be accomplished by 5 or 6 months of warm stratification followed by 3 months of cold. The USDA Woody - Plant Seed Manual recommends soaking *Cotoneaster horizontalis* seeds in concentrated sulphuric acid for 1½ hours followed by 90 to 120 days at 41° to 50° F as a method of germinating this particular species. It also suggests that such a procedure might be effective with others. Some cotoneasters were tried using acid for various periods of time followed by 3 months of cold stratification at 40°. Two hour acid treatments followed by 3 months stratification at 40° worked well with *Cotoneaster adpressa, C. adpressa praecox, C. apiculata, C. franchetii* and *C. frigida.*

One cannot generalize when considering seed dormancies. This is brought out by the fact that in the last few years we had experience with three cotoneasters which acted as though their seeds were without inhibitors. *Cotoneaster wardii, C. microphylla* and its variety *C. microphylla thymifolia* each behaved like a handful of grass seed and germinated without pretreatment. Although each was from a foreign source and treatment before we received them was unknown, it seems safe to assume that dormancies did not exist for it is unlikely that storage methods would alter impervious seed coats.

Stratification

At the Arnold Arboretum our pretreatment of seeds requiring periods of stratification is done by using polyethylene plastic bags. This method has been employed for some years and the procedure is reasonably well known, however a few remarks might be in order.

Polyethylene film has the property of being air permeable yet vapor proof, with the result that oxygen is available to the contents by diffusion. The stratifying medium to be used is dampened, the emphasis here is on the word dampened for too wet a medium could exclude sufficient oxygen. In proportion, the medium should not exceed two or three times the volume of seed. (This too is stressed as at planting time the seeds are not separated from the medium but the entire contents of the bag are sown.) The seeds are distributed throughout the medium and placed in the bag which is then twisted at the mouth and made vapor tight with a rubber budding band using much the same technique employed to bind a graft union. A properly sealed bag providing it has no flaws, will not require attention during pretreatment no matter how long this period might be.

Bags of seeds needing pretreatment by cold are placed in a refrigerator, set at about 40°F for the required time. Those needing two stages of pretreatment to overcome double-dormancy are placed on a greenhouse bench to undergo warm stratification; after this is done they are transferred to the refrigerator to fulfill the cold requirement.

This method of handling seeds has a number of distinct advantages. No attention is needed during treatment periods, making it care free; and the possibility of human misjudgment or neglect are eliminated, making it dependable. Seeds treated in the conventional manner, if kept under wet soggy conditions or if permitted to dry out through human error, can through such mistreatment, pass into new dormancies or perish. The transparent wall of the bag has the advantage that visual inspections can be made to reveal any activity that occurs within. For example, when dealing with materials such as *Davidia, Chionanthus* and many of the *Viburnums* which have epicotyl, or shoot bud dormancy, the extent of radicle development can be easily observed in this way.

Stratifying Media

The stock medium used for this purpose is composed of half sand and half peat moss. A few tests of stratifying media have been made using a variety of materials such as Perlite, sand, peat moss, sphagum moss, unsterilized potting soil and vermiculite. It was found that three peonies performed best in a medium of plain sand but with other subjects there was no improvement over the sand and peat moss combination. Some people use sphagnum moss as a medium and for seeds needing only periods of cold, this would be satisfactory. However, for seeds dependent upon the break-down of impervious coats by micro-organisms, its use becomes questionable as sphagnum moss has anti-biotic properties which could retard this action.

Whenever it is practicable, counted numbers of seeds are used when making tests to acquire germination data. If they are small, and counting would be too time-consuming or difficult, measured amounts are used so that reasonable comparisons of germination can be made. The percentage of sound seeds is usually determined by a cutting test but no tests of germinative capacity have been performed.

When working with seeds at a botanical institution one is called upon to handle material from a wide variety of species from many parts of the world, some of which have never been in cultivation. Furthermore seed gathered at such an institution often provides sufficient quantities even of rare subjects to allow a dozen or more treatments, while work involving seeds from other sources may be limited by the supply.

Experiences with Some Selected Materials

This final section will describe a selection of experiences with such materials. The importance of variability in seed dormancies should be stressed. Many will perform consistantly in a manner similar to these examples, yet when collected from other sources, or when stored by different methods, behavior of some might be unpredictable.

Ilex serrata when subjected to eight experimental pretreatments, responded best to 3 months at 40° F producing a good germination in 7 days. One lot sown without pretreatment produced a single seedling in 7 months.

Ilex latifolia, I. integra, and *I. yunnanensis* when provided with 5 months of warm followed by 3 months of cold produced a general germination for each.

Ilex crenata convexa produced a germination without pretreatment of 76% and a 90% stand after 3 months at 40°. Two months of warm stratification followed by 2 months of cold also produced a germination of 90%, whereas longer treatments of 3 months warm followed by 3 months of cold reduced the stand to 72%.

Actinidia polygama germinated generally in 20 days after three months of cold while *A. kolomikta* provided its best germination in 23 days after 3 months of warm followed by 3 months of cold stratification.

In Styracaceae—*Pterostyrax corymbosa* and *P. hispida* performed best after 3 months of cold. *P. corymbosa* when sown without pretreatment started an erratic germination in 8 days which was still continuing 5 months later. One lot provided with 3 months of cold produced a uniform stand in 12 days.

Styrax obassia and *S. japonica* are each doubly-dormant and germinated best after 5 months of warm followed by 3 months at 40°. However, in each case some sound seeds remained which would perhaps have germinated if longer warm periods were given or sulphuric acid scarification was tried.

When tried with 5 pretreatments *Cornus controversa* and *C. racemosa* each did best with a 5 month warm and 3 month cold combination. *C. hessei* needed only a single treatment; 3 months of cold for germination.

Four months of warm followed by 3 months of cold satisfied the requirements needed to germinate both *Staphylea trifolia* and *S. colchica.*

Ptelea nitens performed as does our native *P. trifoliata* and germinated after receiving 3 months of cold.

When sown without pretreatment *Poncirus trifoliata* produced an 85% germination in 9 months but with 3 months of cold stratification a 140% germination took place in 24 days. This figure sounds ridiculous but as these seeds were polyembrionic more than one seedling developed from some of the seeds.

Prinsepia sinensis has no dormancy. After 14½ months of dry storage it still produced a general germination, the longest period for which we have a storage record.

Pseudolarix amabilis germinated erratically without pretreatment but after two months of cold stratification a uniform stand of seedlings appeared in 10 days.

Of six *Kalopanax pictus* pretreatments 4 months of warm followed by 3 months of cold produced a 15% germination, 5 months warm and 3 months cold a 37% germination and 6 months warm 3 months cold a germination of 47%.

Seeds of *Acanthopanax henryi* were received from Czechoslovakia in the month of May. Their period of stratification was planned so that if germination occurred it would take place under conditions favorable to seedling growth. That is during the lengthening days of late winter rather than the short days of late autumn or early winter when growth is less vigorous and disease possibility more prevalent. When seeds are thought to be doubly-dormant the warm treatment is lengthened to arrive at such timing. Stratification periods of 6 months and 3 months resulted in a late February sowing date and a germination which was completed in 7 days.

Celastrus stephanotifolius behaved as our native *C. scandens* does with general germination occurring after 3 months of cold stratification.

Eucommia ulmoides, which has a reputation for germinating poorly, produced a germination of 40% in ten days when given a 2 month cold period. These were the best results in two instances.

In cooperation with a graduate student, working on the quinces, seeds of the three species of *Chaenomeles* and a large number of cultivars were germinated. In all cases a 2 month period of cold proved to be the best method of treating both *Chaenomeles* and*Cydonia*.

The period of longevity of *Albizia julibrissin* seeds in dry storage is extremely long. Seeds collected in China in 1793 were stored in a box at the British Museum of Natural History. In September of 1940, during the course of an air raid fire, the box became wet and the seeds germinated after 147 years of dry storage. Should a person worry about the hazards of working with acid, or not have facilities to provide hot water, he still has another method of germinating *Albizia julibrissin* seeds — just store them in a box for 147 years and then soak them down with a fire hose.

MODERATOR LEACH: Thank you, Mr. Fordham.

We have five minutes for questions which is on a subject of great interest as I can see, looking at the audience.

MR. JAMES WELLS: I would like to ask Al Fordham what treatment he gives Amabilis.

MR. FORDHAM: A cold period of about five months followed by three months — we have had good success with three months of each, but I think a longer period of warm stratification would be better.

MR. SHUGERT: I would like to address this to Tom. Tom, have you had any experience in the germination of virginianas?

MR. PINNEY: The *Juniperus virginiana* — we have had considerable trouble with variation in the storage and germination characteristics of this seed.

MR. HILL: Tom, will you give us a brief description of this Dybvig machine for cleaning and flushing the seeds?

MR. PINNEY: Yes, Jack, it is a little cylinder. The whole machine isn't over two and a half feet high and I imagine 18 inches around. There is a series of discs. The tighter you put the discs down or screw them down, and the amount of water you use, and speed you rotate the discs determines the efficiency of the cleaning operation. You can clean some very delicate seeds with it very nicely by changing speed and by changing the pressure. Sometimes we use this in *Juniperus virginiana,* trying with water to get the waxy coat off.

MR. LOWENFELS: Wasn't some work done on viburnum at these proceedings where the seed was germinated better if it was picked before it was ripe? Have you done anything on that?

MR. FORDHAM: We have tried this with a few things but we haven't had very much success by picking seed prior to ripening.

DR. REISCH: Chad, would you comment on this work done at Ohio State by B. P. Smith years ago on the time the seed was collected? I wasn't around at that time.

DR. CHADWICK: Back some 20 years ago there was a report that came out of Iowa by the city forester who had been collecting and germinating seed of viburnum for several years. He stumbled onto the fact that if the seed was collected just previous to the time it was ripe, I would say probably two to three weeks before you normally would collect it, and if it was taken at that time and sown directly, that germination was considerably better than going through the regular stratification period.

Now we attempted to repeat that work at Ohio Stae and I must say that we were not successful in getting the same results that he reported.

MODERATOR LEACH: I might be able to add just a word. Japonica if collected in the middle of November will scarely germinate at all. If you take the seed about the middle of August and dry in an oven at 102 degrees and sow immediately, it will germinate very well.

I believe we have time for one more question.

MR. WAYNE LOVELACE: For the past four years we have picked *Viburnum triloba* and *Viburnum dentatum* just prior to ripening and all four years seeded directly to the field in August and got germination the following spring. We did that again this year and upon inspecting our seedling areas, the Japonica apparently were well germinated. We have also done this with *Cornus mas.* So apparently there is something to consider here.

DR. REISCH: How many warm days do you have following sowing?

MR. LOVELACE: Again we normally sow that immediately upon collection, which is in August. Of course, we have a good warm August and September.

MODERATOR LEACH: Gentlemen, I am sorry to have to cut off this discussion. It is a subject of great interest to all of you, I know, and I hope you can corner Dr. Reisch, Tom Pinney and Mr. Fordham after this session. To all three we are greatly indebted.

I will turn this meeting back to President Bill Snyder.

PRESIDENT SNYDER: Thank you very much, Dave.

The meeting this afternoon will commence at 1:15.

(The session recessed at 12:10 o'clock.)

RECESSED

SATURDAY AFTERNOON SESSION

December 8, 1962

The final session convened at 1:30 o'clock, President Snyder presiding.

PRESIDENT SNYDER: We will get started on the afternoon program. The panel discussion is on the Propagation of Specific Plants. The Moderator is John B. Roller, Verhalen Nursery Company, Scottsville, Texas.

MODERATOR ROLLER: Thank you, Bill!

The first subject under discussion is the Propagation of Oaks. To discuss the propagation of Unusual Oaks is Mr. R. Roy Forster, Horticultural Experiment Station, Vineland, Ontario, Canada.

UNUSUAL OAKS

R. Roy Forster
Horticultural Experiment Station
Vineland Station, Ontario

Before I undertook a short study necessary for the preparation of this discussion, my knowledge of oaks was limited to perhaps a dozen or so species commonly found in tree and shrub collections. I learned that there are 300 species of Oak in the temperate regions, less than a third of which are in cultivation. If all the cultivars and hybrids are included with the species there is a wide variety for the grower to choose from. There are shrubs and small trees, deciduous or evergreen. There are fastigiate and pendulous forms. Some have variegated or colored leaves, while others have deeply cut leaves like those of a fern.

There seems to have been little, if any, systematic breeding work done with Oaks. This is hardly surprising considering the generally slow growth rate of the trees. Propagation is slow if not difficult. Most of the hybrids and variants have arisen by chance, and few seem to have been distributed beyond Botanical Gardens and other collections

During a recent trip to England I was able to browse around the Oak collection at Kew Gardens. For the purposes of this talk I might better have visited Botanical Gardens in the United States, but this was not possible.

Thus my selection of Oaks reflects my own background, which is in Britain, and more recently in Canada.

America is a rich continent in Oak species. I am unfamiliar with most of these, so it would be foolish for me to attempt to describe them. Of the Oaks I will attempt to describe, not all are being grown in this country. Some of them you might not consider unusual but they are unusual to me -- and above all, attractive trees.

Q. castanaefolia. Chestnut-leaved Oak.

A large deciduous tree up to 100 feet. The leaves have a striking resemblance to the chestnut. Caucasus and Algeria. Zone VII (Rehder).

Q. coccifera. Kermes Oak, Grain Tree.

Evergreen shrub to 12 to 20 feet, resembling a holly with stiff leaf spines. Host plant of the Kermes insect once used as a dye. Mediterranean region. Zone VIII (Rehder).

Q. cerris. Turkey Oak.

A deciduous tree to 120 feet of quick growth. k Southern Europe. Asia Minor. Zone VI (Rehder).

var. *variegata.* A good variegated form.

Q. georgiana.

Deciduous shrub of the red oak group, noted for autumn color. Georgia, U.S.A.

Q. ilex. Holly or Holm Oak.

An evergreen tree of the Mediterranean region. A striking tree in the landscape in regions where it is hardy. Very variable in leaf characteristics and has many cultivars. Zone VIII (Rehder).

Q. x *lucombeana.* Lucomb Oak.

A hybrid (Q. cerris x suber) having many forms some of them up to 100 feet high.

var. *diversifolia.* An evergreen small tree with a variety of leaf shapes and corky bark. Zone VII to VIII (Rehder).

Q. pontica. Armenian Oak.

Small spreading tree up to 20 feet, having large handsome leaves. A rather exotic looking tree and one of the best small oaks. Zone V (Rehder).

Q. robur. English or Common Oak.

The type is a large spreading tree to 100 feet. Europe, North Africa, West Asia. Zone IV (Rehder). There are many cultivars. Three of the best are var. *asplenifolia*, var. *atropurpurea,* var. *fastigiata.*

Q. velutina. Black Oak, Yellow Bark Oak.

Deciduous tree to 100 feet. A yellow dye is extracted from the bark. One of the finest native oaks especially var. *rubrifolia.* Zone IV (Rehder).

Q. canariensis syn. *mirbeckii.*

A deciduous tree to 120 feet which retains its leaves into the winter. A well shaped densely clad tree with attractive leaves. North Africa, S.W. Europe. Zone VII (Rehder).

Acknowledgments.

I am grateful to the following who supplied lists of oaks growing in the various Arboreta which were of great help in making the selection of Species.

A. R. Buckley, National Arboretum, Ottawa.

Dr. Richard A. Howard, Arnold Arboretum.

Sylvester G. March, U.S. National Arboretum.

Roy M. Nordine, Morton Arboretum.
L. Laking, Royal Botanical Gardens, Hamilton, Ontario.
Fred Galle, Ida Cason Galloway Gardens, Pine Mountain, Georgia

MODERATOR ROLLER: Thank you, Mr. Forster.

Next is Propagation of Oaks from Seed, and we will hear again from Roy Nordine of Morton Arboretum.

PROPAGATION OF OAKS BY SEED

Roy Nordine
The Morton Arboretum
Lisle, Illinois

The genus *Quercus* L. or Oak contains about 275 species and 50 hybrids. 45 species and 30 hybrids are found in North America. They are distributed through the colder and temperate regions of the Northern Hemisphere and southward into the mountains of the tropics. They include evergreen and deciduous trees and shrubs. They are found on nearly all soil types from rich, moist, and sometimes swampy sites and heavy, tight soils to the drier, rocky, sandy, and barren sites.

The oaks are divided into two groups, the white oak group and the black or red oak group. The white oak group is identified by the rounded outer margins of the leaves, while the leaves in the black or red oak group have pointed margins. The two groups are also separated by the ripening of the acorns. Plants in the white oak group ripen the acorn in one year; those in the black or red oak group require two years to ripen. The only known exception is *Quercus agrifolia* (California Live Oak), which, though belonging to the black oak group, ripens the acorns in one year.

The oaks are monoecious. The staminate flowers are borne in slender, pendulous catkins; the pistillate flowers are located in the axils of the young leaves. The flowers are pollinated by the wind, which can carry the pollen for a considerable distance. Oaks hybridize readily, more so when single or scattered trees are among other species belonging to the same large group. There are no known hybrids between plants of the white oak and the black or red oak groups.

The fruit is a one-seeded nut, surrounded at the base or sometimes almost enclosed by a cup-like involucre. The acorns vary widely in size, but all have a hard outer shell that contains an embryo with two large cotyledons.

All the oaks are spring flowering, ripening the acorns in the fall. Among the tree-sized oaks, plants do not become seed-bearing until twenty or more years old. The shrubby oaks can start fruiting when only three or four years old. Seed years through the geographical range of a species may be frequent, while in a local area seed years may be very infrequent, ranging up to ten or more years between good crops. An example of this condition occurred this fall with Northern Red Oak. We had no seed in our extensive woodlands,

Roy M. Nordine, Morton Arboretum.
L. Laking, Royal Botanical Gardens, Hamilton, Ontario.
Fred Galle, Ida Cason Galloway Gardens, Pine Mountain, Georgia

MODERATOR ROLLER: Thank you, Mr. Forster.

Next is Propagation of Oaks from Seed, and we will hear again from Roy Nordine of Morton Arboretum.

PROPAGATION OF OAKS BY SEED

Roy Nordine
The Morton Arboretum
Lisle, Illinois

The genus *Quercus* L. or Oak contains about 275 species and 50 hybrids. 45 species and 30 hybrids are found in North America. They are distributed through the colder and temperate regions of the Northern Hemisphere and southward into the mountains of the tropics. They include evergreen and deciduous trees and shrubs. They are found on nearly all soil types from rich, moist, and sometimes swampy sites and heavy, tight soils to the drier, rocky, sandy, and barren sites.

The oaks are divided into two groups, the white oak group and the black or red oak group. The white oak group is identified by the rounded outer margins of the leaves, while the leaves in the black or red oak group have pointed margins. The two groups are also separated by the ripening of the acorns. Plants in the white oak group ripen the acorn in one year; those in the black or red oak group require two years to ripen. The only known exception is *Quercus agrifolia* (California Live Oak), which, though belonging to the black oak group, ripens the acorns in one year.

The oaks are monoecious. The staminate flowers are borne in slender, pendulous catkins; the pistillate flowers are located in the axils of the young leaves. The flowers are pollinated by the wind, which can carry the pollen for a considerable distance. Oaks hybridize readily, more so when single or scattered trees are among other species belonging to the same large group. There are no known hybrids between plants of the white oak and the black or red oak groups.

The fruit is a one-seeded nut, surrounded at the base or sometimes almost enclosed by a cup-like involucre. The acorns vary widely in size, but all have a hard outer shell that contains an embryo with two large cotyledons.

All the oaks are spring flowering, ripening the acorns in the fall. Among the tree-sized oaks, plants do not become seed-bearing until twenty or more years old. The shrubby oaks can start fruiting when only three or four years old. Seed years through the geographical range of a species may be frequent, while in a local area seed years may be very infrequent, ranging up to ten or more years between good crops. An example of this condition occurred this fall with Northern Red Oak. We had no seed in our extensive woodlands, but thirty miles away there was an abundant crop. Within the species that range over large areas there are undoubtedly geographical races with adaptability to various soils and with varied susceptibility to frost injury.

Acorns are attacked by about ten species of acorn weevils of two genera, at least three species of moths, and several species of gall wasps. The acorn weevils are a common and destructive insect. One or more eggs are deposited in the acorn in late summer. The larva feeds on the kernel until the acorn reaches the ground; then the larva emerges and disappears into the soil. Damage to the seed may range from slight during years of heavy crops to very severe during years of light crops. Acorns can be treated by holding the nuts in 120 °F water for 30 minutes. This treatment is a common practice in our operations, but the White Oak (*Quercus alba* L.), where a root or radicle is already present, this root has been damaged by the treatment. Acorns can also be treated by fumigation with methyl bromide. The dosage is five pounds per 1000 cubic feet of container space, treated for five hours at a maintained temperature of 62°F. Acorns should be treated for weevils as soon as possible after gathering. At the present time there are several research projects under way dealing with the control of acorn weevils. At present the only suggestions for the control of acorn weevils in the soil before their emergence are the products used to control similar insects. Chlordane used as recommended is very effective; also, Aldrin granules at the rate of five pounds per acre provide good control. A more detailed account of a five-year study of acorn weevils will be found in the December, 1962, issue of THE JOURNAL OF ECONOMIC ENTOMOLOGY, by Prof. C. K. Dorsey of West Virginia University.

Since squirrels and other rodents gather large quantities of acorns, it is necessary to gather the acorns as soon as they fall, particularly those in the white oak group.

A variation exists in the germination between the two oak groups. Acorns in the white oak group are not dormant; germination of the root occurs in the fall. The shoot or top appears the following spring. Several species within the large white oak group, namely White Oak (*Quercus alba*), Chestnut Oak (*Q. montana* Willd.), and Chinquapin Oak (*Q. prinoides*), germinate within a few days after the acorn reaches the ground. Acorns can be stored dry for short periods in storage cellars. However, acorns in the white oak group should be sown as soon as possible in the fall. Acorns from the black oak group remain dormant over the winter and germinate the following spring. The latter can be sown in the fall or stored dry in sealed containers just above freezing, or mixed with a moist medium (sand or peat) and stored at cool temperatures. However, better germination occurs when acorns are mixed in a moist medium and kept at low temperatures for 30 to 90 days prior to spring sowing.

Better seedlings are produced when acorns are sown in rows in moist, well aerated humus-filled soil. Acorns will vary greatly in size, and should be covered accordingly, from one to three inches deep. Germination is usually high; it will vary according to the damage done by the weevils. Several kinds of rodents can be very destructive following seeding; hardware cloth over the seed beds provides the most effective control.

The only reported disease of small seedlings is collar rot, which kills seedlings in patches. The disease is soil-borne and can be controlled by treating the patches with 1½ fluid ounces of formaldehyde in two pints of water to each square foot of seed bed. This is an old remedy; some of the newer fungicides should also provide a control of this disease. Additional information can be found in the WOODY PLANT SEED MANUAL, Miscellaneous Publication No 654, U. S. Department of Agriculture.

MODERATOR ROLLER: Thank you, Roy.

We will go right along with our next topic, which is Vegetative Propagation of the Oaks by William Flemer, III, Princeton Nurseries, Princeton, New Jersey.

THE VEGETATIVE PROPAGATION OF OAKS

WILLIAM FLEMER III
Princeton Nursery
Princeton, New Jersey

The vegetative propagation of Oaks is one of the little traveled by-ways of plant propagation, infrequently employed and even then for only a very few horticultural varieties. The reason is that the oaks are difficult to propagate either by layerng or cuttings and if grafted, which is the most successful method, are so badly stunted by the process that several years' culture are necessary before normal growth is resumed. It is a pity that there are not more successful methods known, for an inexpensive, reliable process would be very valuable for the nursery and forestry professions. Everybody who has grown large blocks of oaks for shade trees has observed the considerable variation which even young trees exhibit. Often standing side by side in the nursery row can be seen crooked, stunted specimens and ones which grow with exceptional speed, form a straight trunk and well furnished head without special attention, and are saleable long before the majority of the other trees in the same block. Similarly vastly superior forest types are to be found in the wild. ones which would be far more profitable as timber trees if they could be inexpensively reproduced. Seed selection from superior parents is always good practice, but since oaks are wind pollinated and highly heterozygous as well, this is of limited value. Another interesting phenomenon is the constant succession of natural hybrids which appear in large seedling populations. Many of these hybrids have real horticultural merit. Outstanding have been a *Q. palustris-coccinea* hybrid with superior fall color and a greatly improved branching habit over the Pin Oak, a *phellos* x *borealis* hybrid with leaves like the Willow Oak but somewhat larger and with brilliant scarlet fall color, and a number of *phellos* x *virginiana* hybrids of superior form, deep. Germination is usually high; it will vary according to the damage done by the weevils. Several kinds of rodents can be very destructive following seeding; hardware cloth over the seed beds provides the most effective control.

The only reported disease of small seedlings is collar rot, which kills seedlings in patches. The disease is soil-borne and can be controlled by treating the patches with 1½ fluid ounces of formaldehyde in two pints of water to each square foot of seed bed. This is an old remedy; some of the newer fungicides should also provide a control of this disease. Additional information can be found in the WOODY PLANT SEED MANUAL, Miscellaneous Publication No 654, U. S. Department of Agriculture.

MODERATOR ROLLER: Thank you, Roy.

We will go right along with our next topic, which is Vegetative Propagation of the Oaks by William Flemer, III, Princeton Nurseries, Princeton, New Jersey.

THE VEGETATIVE PROPAGATION OF OAKS

WILLIAM FLEMER III
Princeton Nursery
Princeton, New Jersey

The vegetative propagation of Oaks is one of the little traveled by-ways of plant propagation, infrequently employed and even then for only a very few horticultural varieties. The reason is that the oaks are difficult to propagate either by layerng or cuttings and if grafted, which is the most successful method, are so badly stunted by the process that several years' culture are necessary before normal growth is resumed. It is a pity that there are not more successful methods known, for an inexpensive, reliable process would be very valuable for the nursery and forestry professions. Everybody who has grown large blocks of oaks for shade trees has observed the considerable variation which even young trees exhibit. Often standing side by side in the nursery row can be seen crooked, stunted specimens and ones which grow with exceptional speed, form a straight trunk and well furnished head without special attention, and are saleable long before the majority of the other trees in the same block. Similarly vastly superior forest types are to be found in the wild. ones which would be far more profitable as timber trees if they could be inexpensively reproduced. Seed selection from superior parents is always good practice, but since oaks are wind pollinated and highly heterozygous as well, this is of limited value. Another interesting phenomenon is the constant succession of natural hybrids which appear in large seedling populations. Many of these hybrids have real horticultural merit. Outstanding have been a *Q. palustris-coccinea* hybrid with superior fall color and a greatly improved branching habit over the Pin Oak, a *phellos* x *borealis* hybrid with leaves like the Willow Oak but somewhat larger and with brilliant scarlet fall color, and a number of *phellos* x *virginiana* hybrids of superior form, almost as evergreen as the Live Oak and considerably hardier, grouped under the name "Darlington Oak." The best of these hybrids would merit naming and introduction to the trade if really satisfactory techniques of vegetative propagation could be developed.

Propagation Methods

Pot Grafting. The most reliable method for the vegetative increase of Oaks is the grafting of the desired variety upon potted seedlings of the same species. An economically acceptable percentage of "take" can be readily achieved. The method is somewhat costly but by no means prohibitive. However, as mentioned above the grafted tree which results is severely stunted for several years, and only gradually is normal growth resumed. This stunting results both from the temporarily limited flow of nutrients through the graft union and from the bonsai effect of confining the seedling to a pot for ease and economy in handling during the grafting process.

Small seedlings of the species desired should be potted up in the spring prior to the season when grafting is contemplated. More vigorous understocks are produced by directly sowing acorns in the pot through frequent liquid fertilizing to produce a seedling of sufficient caliper to be grafted. A three inch deep or "rose" pot should be used for establishing the understocks because it will better accommodate the rather long tap root of the normal oak seedling.

The potted seedlings are brought into the greenhouse in February and scions of the past summer's wood about 12 inches in length and up to pencil size, depending on the diameter of the understocks available, are cut and brought in. The scions are grafted onto the understocks using a veneer graft, tied with a budding rubber strip, and the top of the understock is cut back to a length a bit shorter than the scion. The callusing of the union and the eventual percentage of take are greatly improved by leaving on this large portion of the understock's stem. The grafts can be placed on beds of peat under double sash, but comparable stands and greatly reduced problems from fungus attacks can be obtained by setting the potted grafts upright on the open bench of a humid greenhouse and covering the unions with moist peat. Waxing the union does not seem to be of any marked advantage and since it involves still another operation, we have dispensed with it at Princeton. After the graft has callused and the scion has started into active growth (usually by mid-March), the pots are taken up, the understock is cut off at the graft with shears making a slanting cut, and the successful grafts are again set up in a humid greenhouse but without peat about the unions. After a week or so of high humidity, ventilation is gradually given until the new scion growth is well hardened off. Like *Fagus* grafts, the union is very weak for the first season's growth. Therefore, whether the grafts are bedded out or shifted into containers, much loss will be prevented by staking the grafts with a light 18 inch bamboo cane for the first season's culture. Similarly the rubber tie should not be cut until after the graft has been staked up. The dead scion can be removed from unsuccessful grafts and the potted understocks carried on an additional season and grafted on the opposite side the following February. Equally successful grafting can be done in a humid greenhouse in late August, using current season's scion wood and cutting back the scion leaves to ½ their former size. However since this operation occurs at an especially busy point in the soft wood propagation schedule, most propagators prefer the February-March timing.

Field Grafting. A number of Dutch and Belgian nurserymen practice open field grafting of Beech and Oaks. In this method the understocks are first lined out and established in field rows. Vigorous scion wood is gathered in early March, cut in 4 inch lengths and stored, heeled in boxes of peat in cold storage. Just as the buds of the understock begin to swell in April, the tops are cut off squarely, the stubs are split and wedge-grafted with scions cut to a long slender double-edged point. Understocks are normally larger than the scion, so special care is taken to match the cambium of scion and stock on at least one side of the graft union. The graft is tightly tied with string or raffia and the entire scion and graft union is coated with grafting wax. Since the seedling has an abundant established root system prior to grafting, splendid growth during the very first summer after grafting is achieved by this method. However, it is commercially practical only under the cool, moist spring conditions of the low countries or the British Isles and is decidedly not successful in the drying winds and sudden hot spells of our American spring. It is certainly worth a try in extreme coastal Oregon and British Columbia, but is out of the question for most other regions.

Dormant Budding. In an attempt to produce Scarlet Oaks with better root systems and to perpetuate superior clones of other species, a number of nurserymen, ourselves included, have made extensive experiments with dormant field budding of Oaks. In large measure they have been unsuccessful, and commercially practical stands have not been obtained. Both de-wooded and "flat" buds have been used, budded at two-week intervals from early July through to early September. The best stand we ever obtained was about 15% budding *Q. palustris* on *palustris;* and *phellos, coccinea* and *borealis* on *palustris* have averaged less than that, in order of descending success. The shields, especially of de-wooded buds, normally unite successfully, but the bud either dies and drops entirely off prior to the resumption of growth in the spring or else simply does not sprout at the appropriate time. I investigated several reports in England on budding oaks, in one case *Q. cocinea splendens* on *robur*, but even there a 25% stand was considered good and the *cocinea* on *robur* did not make a very preposessing tree. Their somewhat better bud stands may again be a function of the mild, moist British winters and springs.

Understock — Scion Relationships. It has been a long accepted dictum that the two major divisions of the Oak family should only be grafted on members of their own section; ie. White Oaks on White Oaks and Black on Black. This is all very true and might be further refined to state that only members of a section should be grafted on their own section if a permanent tree is to result. Thus *Quercus* *pontica* in England is successful on *Q. robur*, a member of the same section (Robur), but is not so on *Q. alba,* even though both are "White Oaks" in the looser sense. Similarly the evergreen oaks of the section *Ilex* are reasonably compatible. But even within a section cases of marked incompatibility occur. For example *Quercus borealis maxima* is decidedly stunted on *palustris* roots, while it is better on *coccinea*, and *coccinea* is fairly compatible on *palustris* roots. A specimen of *Quercus stellata* on *Q. alba* (both members of the section *Prinus*) grew satisfactorily for many years near Beltsville, Maryland, when it was snapped off clearly at the graft union one year during a violent thunder storm. All of this leads to the conclusion that oak grafting should be confined to putting the species on its own species understock or the hybrid oak on seedlings of one of the parent species, preferably on the parent species with the best and most fibrous root system, for ease in later transplanting.

Soft Wood Cutting Propagation. Some work was done at the Northeast Forestry Experiment Station in New Haven many years ago attempting to root Oaks from soft wood cuttings. The results were disappointing from a commercial point of view but at least it was demonstrated that there was variation in the rooting ability of different clones. *Quercus alba* was the principal species used. More recently Hans Hess of Hess' Nurseries, Wayne, New Jersey, has had some intriguing results rooting *Quercus robur fastigiata* from cuttings. Hans has kindly permitted the inclusion of his work in this paper. The cuttings were made from the current season's growth while it was still in a soft condition in early July. They were treated with 2% I.B.A. and stuck in an open mist bed with no shade. Rooting was about 50%, which while not startling is commercially valuable since cutting propagation is far cheaper than pot grafting with all the preparation and handling involved. The rooted cuttings were stored at about 38° F. and broke dormancy normally in March. The growth of the cuttings was vigorous, many of them making 10 to 12 inches by the first fall.

Further experiments with soft wood cutting propagation seem desirable, using especially desirable clones for cutting wood. Since it is evident that there is variation in the ability of various clones to root from cuttings, it is always possible to stumble upon really superior species or hybrid clones which will also root with commercially feasible percentages of success.

MODERATOR ROLLER: Thank you, Bill.

Now at this time we are going to have time for your questions.

MR. DON HILLENMEYER: This I address to Roy Nordine. How long do you treat your seeds in the 120 degree water?

MR. NORDINE: Thirty minutes at the 120 degree temperature. This is an old practice that has been handed down from mouth to mouth. As far as I can remember and find out, it is not recorded in the literature. It was an old treatment used for treating bulbs for nematodes and things like that. That is the standard treatment and can be used on any of the seeds for treatment whenever we have common insect injury.

MR. McDANIEL: I have a comment on one of the so called hybrids mentioned as the Darlington Oak. I believe the latest opinion is that it actually isn't a hybrid, at least in the phellos and Virginiana. Apparently, it is a select type of the southern evergreen oak. I don't know of any actual hybrid between live oak and members of the red oak or black oak to which it belongs.

On the weevil treatment, that is one of the standard procedures with chestnut seedlings in areas where the chestnut weevil occurs.

MR. INGELS: I would like a little more explanation on treating the acorns when you plant them. For instance, were they treated with arsenate of lead? Would that have any effect on keeping the rodents away? I did that this last year and I don't know.

MR. FLEMER: I would be a little afraid to soak the acorns in arsenate of lead, but we have found it a very effective treatment to control squirrels and field mice. We wet the acorns first and then put them in a box and shake them in regular lead arsenate spray powder around until they get covered with the white spray powder. We had a flight of squirrels and the woods are littered with dead squirrels around our seed. They have to chew through the lead arsenate before they can get into the acorns. It is highly effective.

DR. CHARLES HESS: Bill, do the grafts of oak during the period of adjustment you mentioned, go on their own roots?

MR. FLEMER: It depends upon how compatible the graft is. For instance, it is possible to graft *Quercus robus* and *Quercus alba* and if you plant it deep, the scion will go on its own roots. Then you have a perfectly happy combination, but in our cases of *Quercus phellos* on *palustris* or some of those rather compatible combination or *Quercus coccinea* on *coccinea* seedlings, they do not go on their own roots and it takes some time until you get the graft union mature enough to permit rapid diffusion of nutrients. They are quite stunted but only temporarily.

MR. RALPH SHUGERT: You mentioned chestnut leaf oak listed in Rehder for Zone VII. It will be growing in the southern range of Zone V. I was wondering, Roy, aren't chestnut leaf oaks at your Arboretum? It seems like I saw some.

MR. NORDINE: What do you refer to?

MR. SHUGERT: Castaneaefolia.

MR. NORDINE: No, we do not have this plant.

MR. FORSTER: I believe you can't give the name chestnut leaf oak to a group which do have foliage similar to the chestnut. There are more than several of them, apparently.

MR. FLEMER: I would like to recommend, speaking of unusual oaks, to the southern members of the Plant Propagators Society that they try growing the Japanese live oak, *Quercus myrsinaefolia*. This is, to my mind, one of the handsomest of all evergreen oaks, with long polished green leaves. The seed is available for the writing by the bushel from the Plant Introduction Station just outside of Savannah, Georgia. The people down there are quite kind about making it available. It forms a large majestic rounded tree at maturity and has this thick, heavy polished foliage, one of the most beautiful evergreen trees I have seen.

MR. HILL: In what zone will it grow?

MR. FLEMER: There is a lot at Greenbrier. They have quite a patch at Norfolk. That is Zone VII or VIII. I don't think it will take it to the National Arboretum. Do you know, Ray?

MR. RAY BRUSH: I would like to make a remark about this. Capitol University got hold of it somehow from the South about eight or ten years ago. At the present time we have a tree at the American Bureau College at Temple in Amhurst. It has gone through two winters. Although it loses its foliage, it sprouts out the following spring and grows.

MODERATOR ROLLER: Thank you, gentlemen, for a very interesting discussion.

The next subject on the program for this afternoon was to have been Propagation of Kalmia by Means of Seeds, but John Ravenstein is on a trek to Europe, so we are going to make up a little time right here and call on Jack Hill for a discussion of Propagation of *Juniperus chinensis* in the Greenhouse and Mist Bed.

MR. JOHN B. HILL: I can't let this opportunity go past after the discussion on oaks. A hybridist by the name of Samuel Hovenstein wrote in a spoofing way a little poem and concluded with his theory that oaks were noble and eternal as compared to the wreckage of man's transient nature with these words of counsel: "Before the world goes up in smoke, ladies, get yourself with oak."

Now to get into this subject of the propagation of the chinensis group.

THE PROPAGATION OF JUNIPERUS CHINENSIS IN GREENHOUSE & MISTBED

JOHN B. HILL
D. Hill Nursery Company
Dundee, Illinois

As I approach this group of experienced and knowledgeable propagators, I wish it understood that I do so without any burden of vanity or overconfidence. The broad subject of propagating the various cultivars of *Juniperus chinensis* is, at once, so broad and widespread in its practical application that I feel it most useful to avoid frequent reference to the research of other workers and, rather, confine my remarks so that they apply to our experiences and observations made in Dundee. The published research is readily available to all.

Hasty examination of earliest records finds that there is reference to the rooting of *Juniperus chinensis* by cuttage in the Orient and England during the 18th century. Very little is said of the actual technique and equipment employed, but the strong inference in these it available. It forms a large majestic rounded tree at maturity and has this thick, heavy polished foliage, one of the most beautiful evergreen trees I have seen.

MR. HILL: In what zone will it grow?

MR. FLEMER: There is a lot at Greenbrier. They have quite a patch at Norfolk. That is Zone VII or VIII. I don't think it will take it to the National Arboretum. Do you know, Ray?

MR. RAY BRUSH: I would like to make a remark about this. Capitol University got hold of it somehow from the South about eight or ten years ago. At the present time we have a tree at the American Bureau College at Temple in Amhurst. It has gone through two winters. Although it loses its foliage, it sprouts out the following spring and grows.

MODERATOR ROLLER: Thank you, gentlemen, for a very interesting discussion.

The next subject on the program for this afternoon was to have been Propagation of Kalmia by Means of Seeds, but John Ravenstein is on a trek to Europe, so we are going to make up a little time right here and call on Jack Hill for a discussion of Propagation of *Juniperus chinensis* in the Greenhouse and Mist Bed.

MR. JOHN B. HILL: I can't let this opportunity go past after the discussion on oaks. A hybridist by the name of Samuel Hovenstein wrote in a spoofing way a little poem and concluded with his theory that oaks were noble and eternal as compared to the wreckage of man's transient nature with these words of counsel: "Before the world goes up in smoke, ladies, get yourself with oak."

Now to get into this subject of the propagation of the chinensis group.

THE PROPAGATION OF JUNIPERUS CHINENSIS IN GREENHOUSE & MISTBED

JOHN B. HILL
D. Hill Nursery Company
Dundee, Illinois

As I approach this group of experienced and knowledgeable propagators, I wish it understood that I do so without any burden of vanity or overconfidence. The broad subject of propagating the various cultivars of *Juniperus chinensis* is, at once, so broad and widespread in its practical application that I feel it most useful to avoid frequent reference to the research of other workers and, rather, confine my remarks so that they apply to our experiences and observations made in Dundee. The published research is readily available to all.

Hasty examination of earliest records finds that there is reference to the rooting of *Juniperus chinensis* by cuttage in the Orient and England during the 18th century. Very little is said of the actual technique and equipment employed, but the strong inference in these early reports indicate that even then the idea was considered neither novel nor new.

For the benefit of those in this audience who have not yet encountered the problems typical of rooting the "more difficult" varieties, most of the currently popular cultivars of *Juniperus chinensis* can be effectively reproduced by graftage without unusual difficulties. There is apparently a far greater variation in the willingness of this specie to root as cuttings, than to heal as a grafting scion. Since our operation is entirely commercial in nature, we tend to do very little "pure research," but always seek empirical and practical procedures for handling those varieties which are currently most desirable. Thus, emphasis and the best focused observations are always made relative to the varieties leading the sales list. A good example of the focus, to which I refer, can be found with the familiar cultivar — Sargent's Green Chinese Juniper. It is not difficult to recall a period some ten or fifteen years ago when this variety was nowhere near as popular as today and, therefore, since it was to be propagated in only small quantities, did not receive anything like the attention that it does today, relative to rooting percentages, quickness of rooting and all the other factors that enter into determining the commercial feasibility in a propagation project. We have made attempts in Dundee to correlate the apparent ease of rooting with some cultivars to the difficulties experienced with others on a basis of plant growth characteristics. It quickly becomes apparent that the typically multistemmed and low-growing forms root far more easily than do those displaying a distinct arborescent or tree-like growth habit. Thus, where there appears to be no commercial feasibility in attempting to root *Juniperus chinensis Iowa,* there can be no question at all about the ability of any good propagator to produce the familiar *Juniperus chinensis pfitzer*.

It might be interesting to trace for a moment the evolution of the propagational practices at D. Hill, since our records go back with accuracy to the early years of this century. The first efforts at rooting selections of *Juniperus chinensis* were made with a cold frame facility. In this type of operation, the cuttings were typically stuck in outdoor, glass-covered frame, just before growth commenced in the Spring. In our latitude, this would place the period of taking during the last week of April and the first two weeks in May. No record was made of experiments of various types of cuttings, but simply notes made of the varieties, quantities and time of making. The accepted procedure for that method of propagation was to insert the cuttings during the bracketing dates given above, and their removal from the cold frame was not scheduled until the next year: just before the bed was prepared to receive the next batch of cuttings. No record is given of the time when the first rooting became apparent, but it is inferred that these cuttings were kept under shaded glass, outdoors, for the entire period, with only very casual mention made of "arising and watering." These old records gained back from the years 1902-1910 reveal that percentages were not very good. . . . The record of *Juniperus chinensis* procumbens made in the year 1908 finds that 400 cuttings were inserted into the cold frame on July 14th, and the bed was covered tightly on December 6th, and the cuttings were found to be dead and disposed of on April 24th of the next year.

Percentages improved appreciably when fresh horse manure was included in these outside, glass-covered, rooting frames, for now they were actually hot beds. Records made between 1910 and 1916 frequently find that percentages in excess of 60% were enjoyed with *Juniperus chinensis procumbens* and another variety, simply listed as *Juniperus chinensis*. Time of taking, sticking and removal were all identical with he procedure described previously.

The first pair of actual propagation greenhouses were erected in Dundee in 1914, and the first efforts in rooting cuttings of the *Juniperus chinensis* species were made by "direct benching." This first two or three years were not very successful, and I suspect that these failures trace to the inability of the persons in charge to maintain adequate temperatures and humidities, thus the procedure was developed whereby cuttings were taken during the summer dormant period— late June to early July — and stuck in flats which were then placed in an outdoor hotbed over four to six inches of fresh manure. These flats, with the cuttings intact, were then brought into the greenhouse in the late fall, and actually rooted in the greenhouse itself. It is doubtful whether any rooting took place in the hotbed, but, except for the tremendous amounts of labor involved in moving these flats, this system offered considerable flexibility, in that individual flats of cuttings or even whole lots of cuttings in flats could be "reflatted" and thus the limited space in the greenhouses used to maximum advantage. As a usual thing, the cuttings that rooted over the first winter were "flatted off" sometime during the next growing season for subsequent culture in flats up to two or three years before they were bedded out in the Fall. This method of combining a hotbed preconditioned with a greenhouse was developed fully between 1917 and 1954.

During 1954-55 our method of handling Juniper cuttings was changed once more back to the direct-benching method. This was under the guidance of Mr. Jim Wells, and we are still following this direct-benching method on all but the so called "difficut varieties." At the present time, therefore, we are going direct from the field grown stock plants to the bench with most varieties in the early Fall of each year. Our present program has come to recognize the desirability of rapid handling on all varieties of *chinensis* and we, therefore, actually make the cuttings themselves right in the field, treat them with a chosen hormone, and have them in the greenhouse rooting bench in well under 30 minutes. We try never to let batches of these cuttings accumulate for there seems to be a rather strong correlation between total percentage of rooting and rapid handling.

The method which we are using on those varieties considered to be more difficult to root, and I will use *Juniperus chinensis Maney* as an example, calls for taking short, tip cuttings in late July and "pre-conditioning" in an outdoor mist bed for 8 to 10 weeks. Although this method produces problems in handling, it does appear to enable rooting percentages that are sufficiently high to render the method commercially feasible. This method of pre-conditioning in an outdoor mist bed has evolved after rudimentary trials ranging from allowing the initial superin layer to form in the air, to the familiar system of lifting and re-sticking Fall made cuttings after 4 to 6 weeks in the bench. At the present time, we appear to be getting much better results with Maney Juniper handled in the way described. This cultivar has the decided tendency to develop a large, vigorous callous and then refuse to differentiate this abundant parenchyma into roots. Pre-conditioning these cuttings in the mist bed during the summer and then re-sticking into a greenhouse bench during the month of October gives adequate rooting percentages in a reasonable length of time. It is not at all unusual to find 15 to 20 percent of these tip cuttings lightly rooted after 8 to 10 weeks in the mist frame and those found rooted are potted off immediately. The remainder display none of the heavy callous so typical of the cuttings directly benched in the Fall and thus are easy to handle during the re-sticking process. At the present level of observation and experiment, there appears to be no special advantage to re-applying a chosen hormone nor removing whatever callous has formed in the mist bed. We simply sort out the rooted from the unrooted and handle the latter quickly while re-inserting it into a regular greenhouse bench.

There is strong feeling that the apparent advantages in this system of handling do not trace nearly so much to any magical quality of the mist but rather to the time that these cuttings are taken . . . late June through early August. It is suspected that a good propagating greenhouse, adequately equipped with fan and pad cooling will probably do a better job than the mist, since after 8 or 10 weeks in the mist type facility, there is evidence of severe foliar leeching, which results in partial defoliation and rather unsightly cuttings. Perhaps one day Dr. Hess will have perfected that greatly sought "black box" into which a sample cutting may be inserted and the cofactors determined by a direct read-out scale on the top of the box!!

Since we do not yet have this wonderful device of the future, let me describe quickly several techniques that we have found useful in addition to dispelling several beliefs which we had and are perhaps even now prevalently held elsewhere. . . . .

There appears to be no difference whatsoever in the rooting percentages obtained with cuttings which include "the heel" and those severed with a sharp knife on either an oblique or straight-across cut. All varieties of *Juniperus chinensis* appear to root best when the growing tip is left intact. Thus, what we call "tip cuttings" give us a better percentage than "butt cuttings." It is typical that the cutting including the greenest wood also requires a greater strength of hormone application than older and more mature wood but with an additional variation shown in that identical cuttings taken in July and September, find the former requiring a greater hormone concentration. Thus, the greener and softer the cutting, the stronger hormone required.

Our present method of applying hormone in dry form may be worth commenting upon—because our cuttings are always field made and gathered into oriented bunches, counted and of approximately equal length, we dip the entire bunch of cuttings for "swish treatment" into Morton Chemical's Panogen, diluted one to twenty thousand and then insert the butt end of the bunched cuttings into the top of a small polyethylene bag containing a very small quantity of the dry hormone. When the bottom of this bag is shaken vigorously, we appear to obtain quite an even coating of the hormone powder on the moist ends of these cuttings. The above described method would seem to give us more uniform results than the standard dipping and tapping method, while also enabling the advantage of handling the cuttings in substantial multiples.

In keeping with recent findings by Dr. Chadwick and Dr. Reisch, we are unable to correlate any improvement in rooting with wounding. We are, therefore, not now, practicing the technique of wounding on any cuttings of any kind.

Since our commercial production aim is, of course, to get the *individual* plant *off* and *going* as an *individual* at the earliest possible date, we like to lift each batch of cuttings from the greenhouse rooting bench at the earliest reasonable date. We have discovered that considerable time can be saved by re-sticking those cuttings which were not rooted in bunches rather than singly. We are not sure just why cuttings thus lifted and re-inserted appear to exhibit a *marked tendency to root quickly when gathered in bunches of ten to* twenty; the effect is plainly evident nonetheless. It might be that the factor of bench aeration is contributing to this effect and to this end. I should also like to point out that our present method of sticking all cuttings specifies the use of a peg board rather than the more familiar method of opening a slit and then "pounding" the cuttings in. *The rooting sand currently in use is of medium coarseness* . . . about the consistency of coarse coffee grounds and thus is probably quite well aerated at all times. I presume that most members are familiar with our over-all bench management program, which does not call for the changing of sand but rather for steam sterilizing between each batch of cuttings. If at all possible, we also like to re-steam before any cuttings are re-stuck, thus eliminating the possibility of pathogen carry-over from one bench to another.

In summary, it is felt that the most important factors in the achieving of good Chinese Juniper rooting percentages are:

1. Rapidity of handling from parent plant to bench.
2. Maintenance of cool bench temperatures for the first 4 to 6 weeks — 58 to 62 degrees Fahrenheit.
3. Maintenance of adequate humidity in the rooting environment without excessive wetting of the cutting tops.
4. Willingness to undertake the labor of lifting the cutting batch for pot processing those ready, and re-sticking those cuttings which appear to be in good condition but not yet rooted.
5. Careful selection and maintenance of disease and insect-free stock plants.

Most selections of *Juniperus chinensis* are not truly difficult to propagate, but the task for all of us will be measurably lessened when Charles Hess produces that wonderous "black box."

Thank You.

MODERATOR ROLLER: Are there any questions?

MR. JAMES WELLS: Jack, I am interested in this question of wounding, and whereas, I can agree and did say in my paper that wounding has never actually rooted a plant, I believe, nevertheless, it has a very definite effect upon the quality of the root system and the number of points of attachment now. Do you find, say in taking the standard juniper pfitzer that you are getting the same quality of rooting without wounding as you did with it?

MR. HILL: Jim, I believe yes, and I believe if your tests on wounding were carried out under consistent conditions over a long enough period you would find where wounding might have a particular advantage under a particular set of conditions. Again, I refer to pfitzer and normal conditions. I find wounding is pretty much a waste of time.

MR. HOOGENDOORN: Did I understand you correctly that you use sand for your juniper cuttings?

MR. HILL: Yes, we use sand entirely for junipers.

MR. HOOGENDOORN: Have you ever experimented with peat and perlite?

MR. HILL: Peat and perlite, peat and sand, and peat and Turface — that is the name of the Canadian silt-clay. The sand seems to work best.

MR. HOOGENDOORN: Did I understand you to say you never cut your tips back?

MR. HILL: Not until rooting has taken place. We wish to develop character. After the rooting and growing, then we remove the tip, but not before.

MR. HOOGENDOORN: Don't you get a long cutting then?

MR. HILL: No, on these chinese we tend to use a short tip for we want greener than usual wood. We take the cutting I would say a maximum of five inches, probably averaging something more like four. On the horizontal we take a long branch and cut it up into pieces, but that is just for the chinensis.

MODERATOR ROLLER: At this time we have New Plants: Their Propagation and Adaptation — by A. F. Dodge, Regional Plant Introduction Station, Ames, Iowa. Mr. Dodge.

NORTH CENTRAL REGIONAL PLANTINGS OF WOODY ORNAMENTAL AND SHELTER PLANT INTRODUCTIONS[1]

A. F. DODGE[2]

INTRODUCTION

In an effort to more clearly define the behavior of familiar as well as new introductions of woody ornamentals when planted in the North Central Region, several state ornamental specialists met under the leadership of Prof. S. A. McCrory at South Dakota State College, Brookings, South Dakota, in January 1954. This group organized a regional performance study program within the framework of the state-federal North Central Regional Plant Introduction, New Crops program. In the spring of 1954, the Regional Station began forwarding woody ornamental and shelter plants of mutual interest to cooperating personnel at 21 trial sites in eight states.

This work is recognized by the several participating state agricultural experiment stations of the North Central Region, the Regional Plant Introduction Station, Ames, Iowa, and the New Crops Research Branch, Crops Research Division, of the Agricultural Research Service, U. S. Department of Agriculture, as necessary and contributing to a better understanding of the horticultural performance of new ornamentals introduced to the region. It is felt that the program has widespread implications over and above unrelated testing of plant material. For example, the propagator, the nurseryman, the plant-using public, and the academic horticulturist will derive such valuable information on the adaptation of these plants to the vicissitudes of continental climates and attendant soils. To date, 144 different trees and shrubs have been distributed of 30 cooperating trial planting sites in 12 states.

HISTORICAL BACKGROUND

Since colonial times, nurserymen on both sides of the Atlantic have been the continuing dominant force in the never-ending task of bringing together and testing newly found trees and shrubs for horticultural characteristics and adaptation to local climate, soils, and management. The success of this type of work depends on the plant sense, the technical skill, and the business acumen of the individual nurseryman.

Another means of assaying the trees and shrubs suited for a given locality is observing their performance in arboretum plantings. Carefully planned and maintained living collections offer an ideal opportunity for the evaluation of unusual or newly introduced material in comparison with the commonly used plants. Needless to say, a well developed arboretum offers untold educational and research opportunities.

---

[1]This study was conducted as a work plan under the North Central Regional Plant Introduction state-federal cooperative project NC-7 Title The Introduction, Multiplication, Preservation, and Testing of New and Useful Plants of Potential Value for Agricultural and Industrial Uses. Sub-Title of Work Plan· Woody Ornamental and Shelter Plants for the North Central Region. This work was supported in part by Regional research funds of the United States Department of Agriculture

[2]Horticulturist, Special Crops. Regional Plant Introduction Station, Iowa State University, Ames, Iowa

In an attempt to compile existing information on the behavior of ornamental plants, J. C. Loudon in 1834 sent out about 3000 inquiries or "Return Papers" to plantsmen in many countries, regarding the performance of trees and shrubs. Owners of arboreta or other plantings, nurserymen, gardeners, and foresters were asked to return information on the location, environment, and performance of the important trees and shrubs on their property or under their care. These data were included by location under "Statistics" for each species described by Loudon in his "Trees and Shrubs that Endure the Open Air in Great Britain and Ireland."

"Return papers" were received from cooperators in the British Isles, Western European countries, the Americas, Asia, Australia, and Polynesia. Loudon's monumental eight-volume work resulted in a renewed appreciation of plants and plantings and of the many introductions of that era with respect to ornamental values, hardiness at various locations, and reaction to different soils.

The United States Congress of 1862 strengthened American agriculture with the establishment of the United States Department of Agriculture and aid to the state Land Grant Colleges and Universities through the passage of the Morrill Act. As these institutions undertook their various tasks, it soon became evident that the research facilities and personnel of each organization complemented those of the other.

The Hatch Act, passed in 1887, authorized the federal support of state experiment station projects. Ten years later this support assisted Professor N. E. Hansen, South Dakota Experiment Station horticulturist, to initiate a series of plant explorations to the cold and dry parts of continental Russia and Siberia as an agent of the U.S. Department of Agriculture. He sought out hardy grasses, legumes, fruits, and ornamentals for the rapidly expanding agriculture in the northern prairie states where commonly used crop plants were damaged by the severe climate and alkaline soils. The plant materials collected by Dr. Hansen are listed in Inventory No. 1, Foreign Seeds and Plants, Imported by the Section of Seed and Plant Introduction, Division of Botany, U.S. Department of Agriculture, Washington, D.C., 1898. The Inventory clearly illustrates that vegetables, grasses, legumes, shrub fruits, tree fruits, oil seeds, novelties, and ornamentals were introduced from Eurasia where the climate was similar to that of North American prairies and plains.

Congress continued to support agricultural research, but passage of the Research and Marketing Act of 1946 permitted, for the first time, the organization of truly cooperative state-federal agricultural research activities on a regional basis. Four regional plant introduction stations were established to receive and propagate plant material introduced into the United States. These regional stations serve plant scientists by increasing, maintaining, and supplying viable seed and plants for their research studies. Also, each station is a center for compiling accumulated information on introductions for exchange among plant scientists. The North Central Regional Plant Introduction Station at Iowa State University serves the 12 North Central states plus Alaska.

The United States Department of Agriculture New Crops Research Branch is responsible for the exploration, introduction, propagation, and evaluation of desired ornamental plant materials for research purposes. Recently much of this work has been in cooperation with the Longwood Gardens, Kennett Square, Pennsylvania.

Ornamentals having potential use in the North Central region are forwarded to the Regional Station at Ames and ultimately to experiment station specialists for research purposes. Items which merit regional trial are propagated at the Regional Station and distributed to cooperating trial sites upon request. Plant response to local conditions is ultimately included in the state reports on adaption, merit, disease reaction, use in breeding work, and any acceptance by the nursery industry. These data are compiled by the regional station and distributed to cooperating plant scientists.

In addition to the regional station research program just described, the United States Department of Agriculture has supported research on plant introductions at four United States Plant Introduction Stations. These stations, located at Glenn Dale, Maryland; Savannah, Georgia; Miami, Florida; and Chico, California, have a long record of success in supplying ornamental introductions to cooperating specialists in the nursery industry, at research institutions, and at the various arboreta.

METHODS AND MATERIALS

A woody ornamental subcommittee made up of cooperating state ornamental specialists guides the regional trial program by making periodic reviews of objectives and recommendations for additional materials to be included for trial. Each winter the Regional Station supplies state leaders with a list of available planting stock. Requests for planting material are made by state according to local needs. The planting, care, measurement, records, interpretation of plant behavior, and the reporting of results are major phases of regional trial work undertaken at each trial location by state cooperators.

For the most part, deciduous trees and shrubs have been included in these regional trials. A few broad-leaved evergreens have also been selected for study. Some of these plants were obtained as stock plants or liners for propagation, growing and distribution by the Regional Station. Other plants were donated by arboreta, by interested nurserymen, or by state experiment station horticultural departments. Still others were distributed as plant introductions obtained through the New Crops Research Branch, Beltsville, Maryland.

The members of the woody ornamental subcommittee, the regional trial state leaders, and state cooperators, as well as their locations (Table 1) are presentd by state.

These men have carried the burden of this testing program. Without their interest and continued effort there would be no regional testing program for ornamentals.

Table 1. **Cooperating personnel[1] and location of trial sites for the North Central Region woody plant trials.**

Alaska	No regional trials.
Illinois	H. R. Kemmerer★, Univ. of Ill., Dept. of Hort., Urbana J C. McDaniel†. Univ. of Ill., Dept of Hort., Urbana
Indiana	★, Temporarily not assigned †, Temporarily not assigned H. B. Weyland‡, Purdue Univ., Dept. of Hort., Lafayette
Iowa	J. P. Mahlstede★, †, ‡, Dept. of Hort , Iowa State Univ., Ames
Kansas	R. A. Keen,★, †, Dept. of Hort., Kansas State Univ., Manhattan C. E Banbury‡, Branch Station, Colby W. W. Duitsman‡, Fort Hays Branch Station, Hays A. B. Erhart‡, Branch Station, Garden City T. B. Stinson‡, Branch Station, Tribune
Michigan	C. E Lewis★, †, Dept. of Hort., Mich. State Univ., East Lansing G. W. Parmelee‡, Beal-Garfield Bot. Garden, Mich. State Univ., East Lansing C. T. Black‡, Mich Conservation Dept., Rose Lake D. A. Carroll‡, Soil Consev. Serv., Plant Materials Center, Rose Lake
Minnesota	L. C. Snyder ★, †, Dept. of Hort., Univ. of Minn., St. Paul Deane A. Turner‡. Southern School of Agriculture, Waseca Wes H. Gray‡, West Central School and Expt. Statoin, Morris B. C. Beresford‡, Northwest Exp. Sta., Crookston N. H. Grimsbo‡, North Central Exp. Sta., Grand Rapids Herbert Hopen‡, Northeast Exp. Sta., Duluth
Missouri	R. E. Taven★, †, ‡, Dept. of Hort., Univ. of Missouri, Columbia
Nebraska	Glenn Viehmeyer★, †, North Platte Exp. Sta., North Platte Paul Ehlers‡. Box Butte Exp. Sta., Alliance Lionel Harris‡, Scottsbluff Exp. Sta., Mitchell J. H. Agar‡, Park Dept., Lincoln J. A. Churchich‡, Parks and Recreation Dept., Omaha C. A. Hutchison‡, Park Dept., Scottsbluff
North Dakota	D. G. Hoag★, †, Dept. of Hort., N. Dak. State Univ., Fargo T. S. Conlon‡, Dickinson Exp. Sta. Dickinson
Ohio	L. C. Chadwick★, †, ‡, Dept. of Hort., Ohio State Univ., Columbus
South Dakota	S. A. McCrory, Chairman★, Dept. of Hort., S. Dak. State College, Brookings W. G. Macksam†, ‡, Dept. of Hort., S. Dak. State College, Brookings W. R. Pringle‡, Central Substation, Highmore
Wisconsin	E. R. Hasselkus★, †, Dept. of Hort., Univ. of Wis., Madison G. Wm. Longenecker‡, University Arboretum, Madison

[1]Sub-committee members(★), state leader(†), and cooperators(‡) with their locations.

Reporting of plant performance was unified by the preparation of a Species-Planting Site Report Form.[1] This Report Form provides for the survival record, performance record, recommendations for use based on the behavior of the trial plants, general opinion of the plant at the test site, and any factors which might govern the use of the plant in the area served by the trial. The Species-Planting Site Report Forms serve as the basis for five-year summaries for each accession. (This form is presented as Table 2).

REGIONAL TRIAL DATA

To date, five-year reports have been prepared on 40 accessions included in the early regional trial plantings. An examination of

[1]J. P Mahlestede, Iowa State University and L C Snyder, University of Minnesota assisted the author in preparation of this form and in organizing the content of the five-year reports derived from these data sheets.

these reports with respect to survival, plant losses, fifth-year shoot growth, condition of growth, plant size after five years on trial site, and suggested limits of planting in the region was undertaken for this meeting of the Plant Propagator's Society.

Survival

Survival data for a given accession are based on an inventory taken after the fifth winter at each trial site. The number of live plants is expressed as a percent of those planted. Grouping of the plantings having the same survival percent proved to be an effective way to summarize the regional survival performance of each accession on trial. For example, the survival data for 22 *Spiraea* x *vanhouttei* (Briot) Zabel (Van Houtte spirea) plantings clearly show (Figure 1) the success which attended the trial plantings of this species.

Table 2. SPECIES - PLANTING SITE REPORT FORM

NC Regional Woody Ornamental Trials

Cooperator .... Planting Site .... State ....

Species ....

A. SURVIVAL RECORD

No. of Plants Received .... Date .... No. of Plants Planted .... Date ....

No. of Live Plants 1st Fall .... No. of Live Plants after 1st Winter........

No. of Live Plants after 2nd Winter .... No. of Live Plants after 5th Winter........

No. of Replants Received .... Date........ No. of Replants Planted .... Date........

No. of Live Replants 1st Fall .... No. of Live Replants after 1st Winter........

No. of Live Replants after 2nd Winter .... No. of Live Replants after 5th Winter........

B. PERFORMANCE RECORD

(1) Average of 5th year Apical Growth (inches) ....

(2) Average plant height end of 5th year (feet) ....

Variation: Tallest plant .... Shortest plant ....

(3) Average plant spread end of 5th year (feet) ....

Variation: Broadest .... Narrowest ....

C. RECOMMENDATIONS: (For the area represented by this planting site)

(1) Indicate A, B or C for each of the following whichever is applicable.
A-Recommended B-Recommended for trial only C-Unsatisfactory

.... Border Planting .... Highway Planting .... Ground Cover

.... Screen Planting .... Shelterbelt Planting .... Wild Life Planting

.... Specimen Planting .... Windbreak Planting .... Hedge Planting

.... Foundation Planting

(2) Statement regarding general opinion of plant performance on test site.

(3) Discuss good qualities and objections which might govern its use in the area represented by test site.

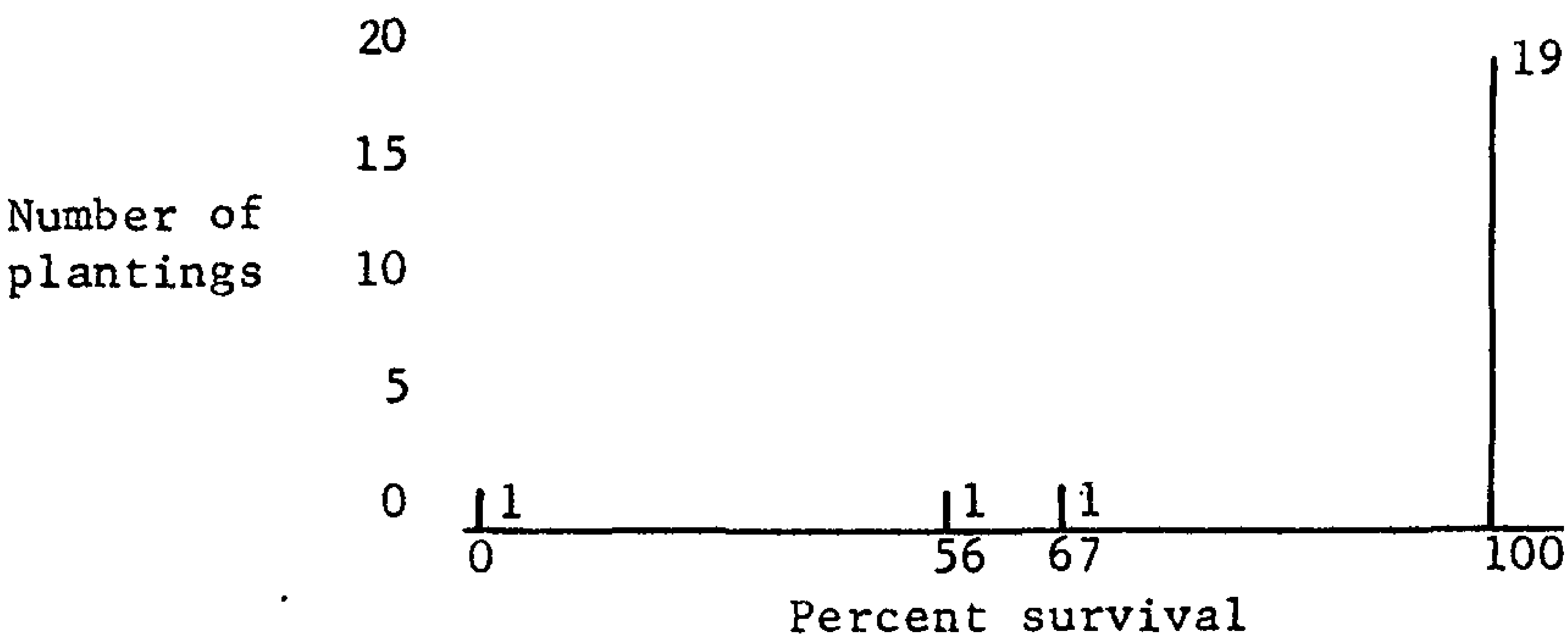

Fig. 1. Number of Van Houtte spirea plantings grouped by five-year survival percentage, North Central Regional woody plant trials.

Figure 1 indicates that only one planting failed completely. Half the plants at another site and one-third of the plants at a third trial had failed in five years. Nineteen plantings were reported with 100-percent survival. The five-year survival record of the Van Houtte spirea trial plantings was successful.

When the survival data for the regional trial plantings of *Styrax japonica* Sieb. & Zucc. (Japanese snowbell) seedlings are arrayed in the same manner, (Fig. 2) the general failure of this species in trial plantings is apparent.

Species-planting site report forms showed that 19 plantings were devoid of all Japanese snowbell plants. Only three widely scattered plantings were reported to have live shrubs.

In the use of this method for summarizing survival data for each of the 40 accessions, three distinct groups of species were apparent. More than half the trial accessions had survival records similar to

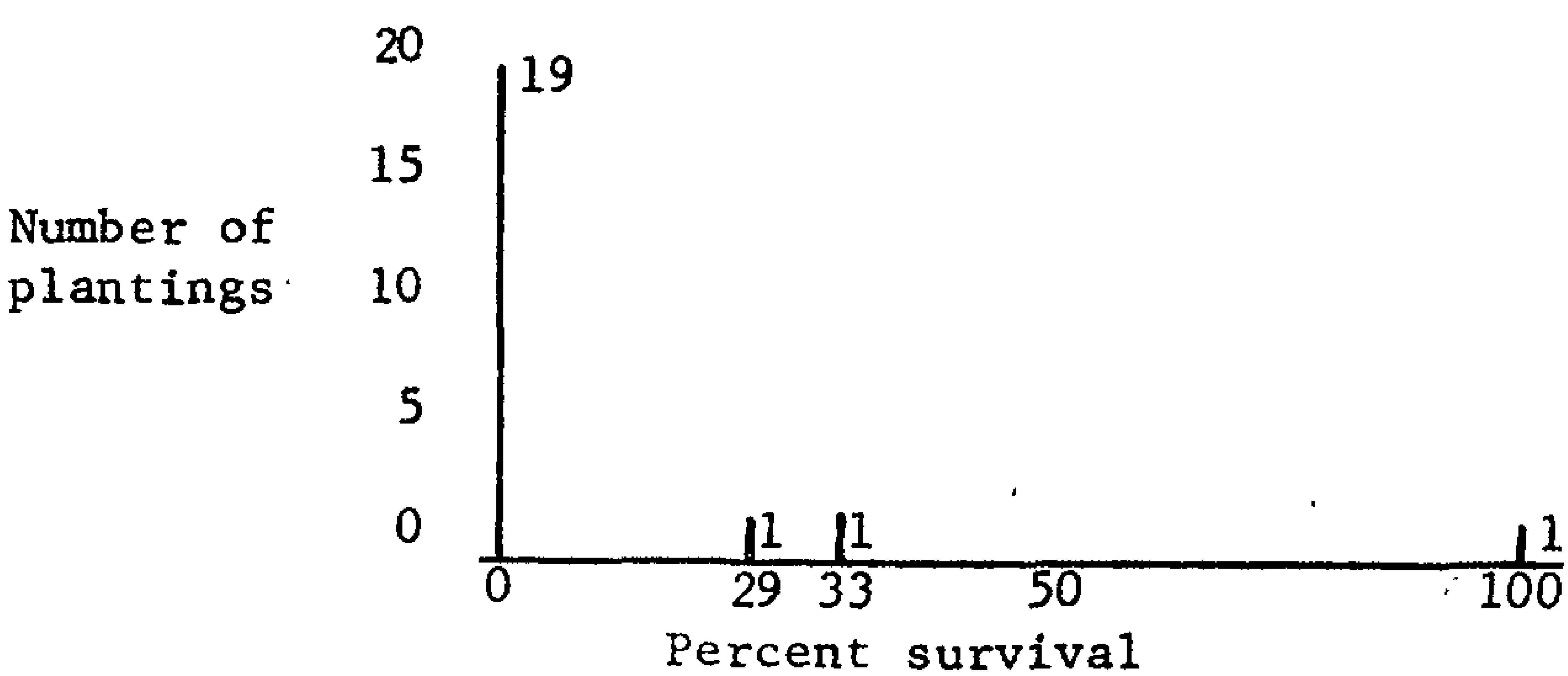

Fig. 2. Number of Japanese snowbell seedling plantings grouped by five-year survival percentage, North Central Regional woody plant trials.

that of Van Houtte spirea. This was termed the successful survival group. A small group with survival resembling that of Japanese snowbell was considered to be unsuccessful. A third, or intermediate survival group, had plantings with perfect survival and complete failure in approximately equal numbers.

For each of these three survival groups — successful, intermediate, and unsuccessful — the average number of plantings with perfect five-year survival, the average number of plantings which failed, the ratio of plantings with perfect survival to those which failed, and the number of accessions per group are presented in Figure 3.

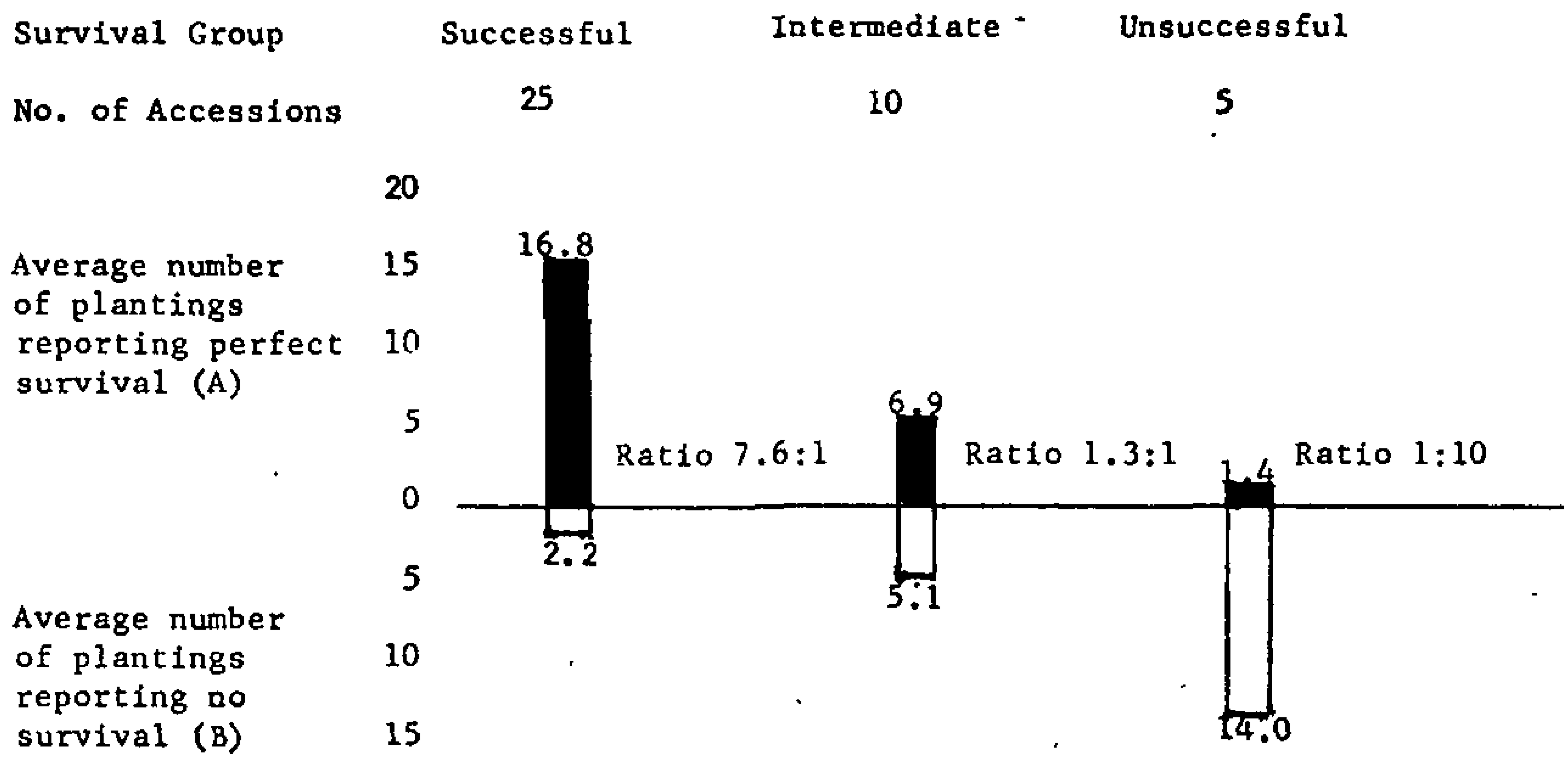

Fig 3. Forty North Central Regional trial accessions divided into three survival groups. Included for each group are the number of accessions, the average number of plantings with perfect five-year survival (A), the average number of plantings with no five-year survival (B), and the ratio of A:B.

The names of the various trees and shrubs comprising each of the three survival groups (Fig. 3) are as follows:

Group I. Successful (25)
- Caragana pygmaea (L.) DC.
- Cornus racemosa Lam.
- Cornus stolonifera var. coloradensis (Koehne) Schneid.
- Cotoneaster lucida Schlecht.
- Euonymus bungeanus Maxim.
- Euonymus nana var. turkestanica (Dieck) Krisht.
- Forsythia ovata Nakai
- Forsythia x 'Arnold Dwarf'
- Gleditsia triacanthos fma. inermis (L.) Zabel 'Beatrice'
- Gleditsia triacanthos fma. inermis (L.) Zabel 'Moraine'
- Gleditsia triacanthos fma. inermis (L.) Zabel 'Sunburst'
- Ligustrum amurense Carr. 'Amur River North'
- Ligustrum vulgare L. P.I. 107630
- Lonicera x bella 'Albida' Zabel
- Physocarpus opulifolius var. nanus (Kirchn.) Zabel
- Populus x robusta (Simon-Louis) Schneid.

Rhus trilobata Nutt. ex Torr. & Gray
Ribes diacanthum Pall.
Rosa rugosa 'Hansa' Thunb.
Rosa spinosissima var. altaica (Willd.) Bean
Rubus deliciosus Torr.
Spiraea x vanhouttei (Briot) Zabel
Ulmus x 'Fremont'
Ulmus pumila L. (Chinkota)
Viburnum lentago L.

Group II. Intermediate (10)
Acer ginnala Maxim.
Cercis canadensis L. (Minn. Seedlings)
Cotoneaster apiculata Rehd. & Wils.
Deutzia x lemoinei ex Bois
Euonymus nana Bieb.
Ligustrum vulgare L. P.I. 26767
Pyrus ussuriensis Maxim.
Ulmus carpinifolia Gled. 'Christine Buisman'
Ulmus pumila L. (common)
Ulmus pumila L. (Dropmore)

Group III. Unsuccessful (5)
Berberis julianae Schneid.
Euonymus kiautschovica Loes.
Hypericum prolificum L.
Platanus acerifolia (Ait.) Willd.
Styrax japonica Sieb. & Zucc.

Plant Losses

In addition to the survival count taken after the fifth winter. trial plantings were inventoried three other times: i.e., at the end of the first growing season, after the first winter, and after the second winter. From these stand counts the cumulative losses were obtained for these intervals after planting. Representative species taken from the three categories outlined under Survival (Fig. 3) are presented as the cumulative number of plants lost in relation to time after planting.

The losses sustained by trial plantings of *Ligustrum amurense* 'Amur River North' and *Ligustrum vulgare* P.I. 107630 are charted (Fig. 4) as typical of the group having successful survival.

Ligustrum vulgare P.I. 107630 was introduced from Yugoslavia in 1934 by Edgar Anderson while on the Arnold Arboretum Balkan Expedition. It was thought to possess considerable cold and drought hardiness which apparently is an attribute of this plant introduction.

The 'Amur River North' privet has been extensively used as a hedge material in the west central states of the North Central Region. It is used as far north as the Twin Cities, Minnesota, but has not proved satisfactory at Brookings, South Dakota.

Obviously the significant difference in the losses which these two accessions sustained in regional trials occurred during the first grow-

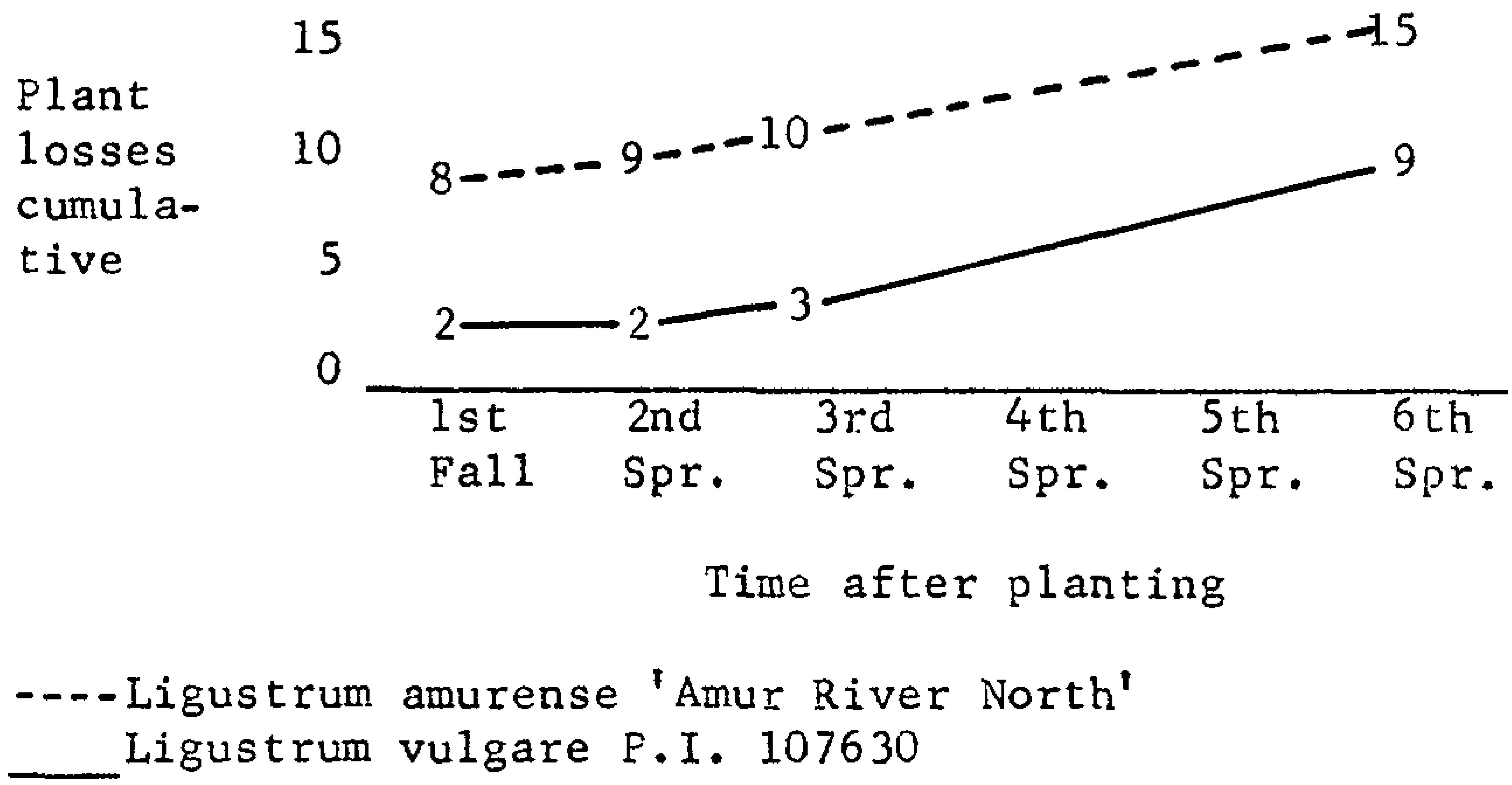

Fig. 4. Cumulative plant losses for two privet accessions (high survival group), North Central Regional Woody Plant Trials.

ing season. Subsequent losses for both are similar. Whether the first season losses of 'Amur River North' reflect an abnormal condition of the planting stock, rough handling, or the response to adverse site conditions is not known. Some of these plantings were made in locations outside the area where privet is usually planted.

The plant losses for representative accessions in the intermediate survival group are shown in Figure 5. Ligustrum vulgare P.I. 26767

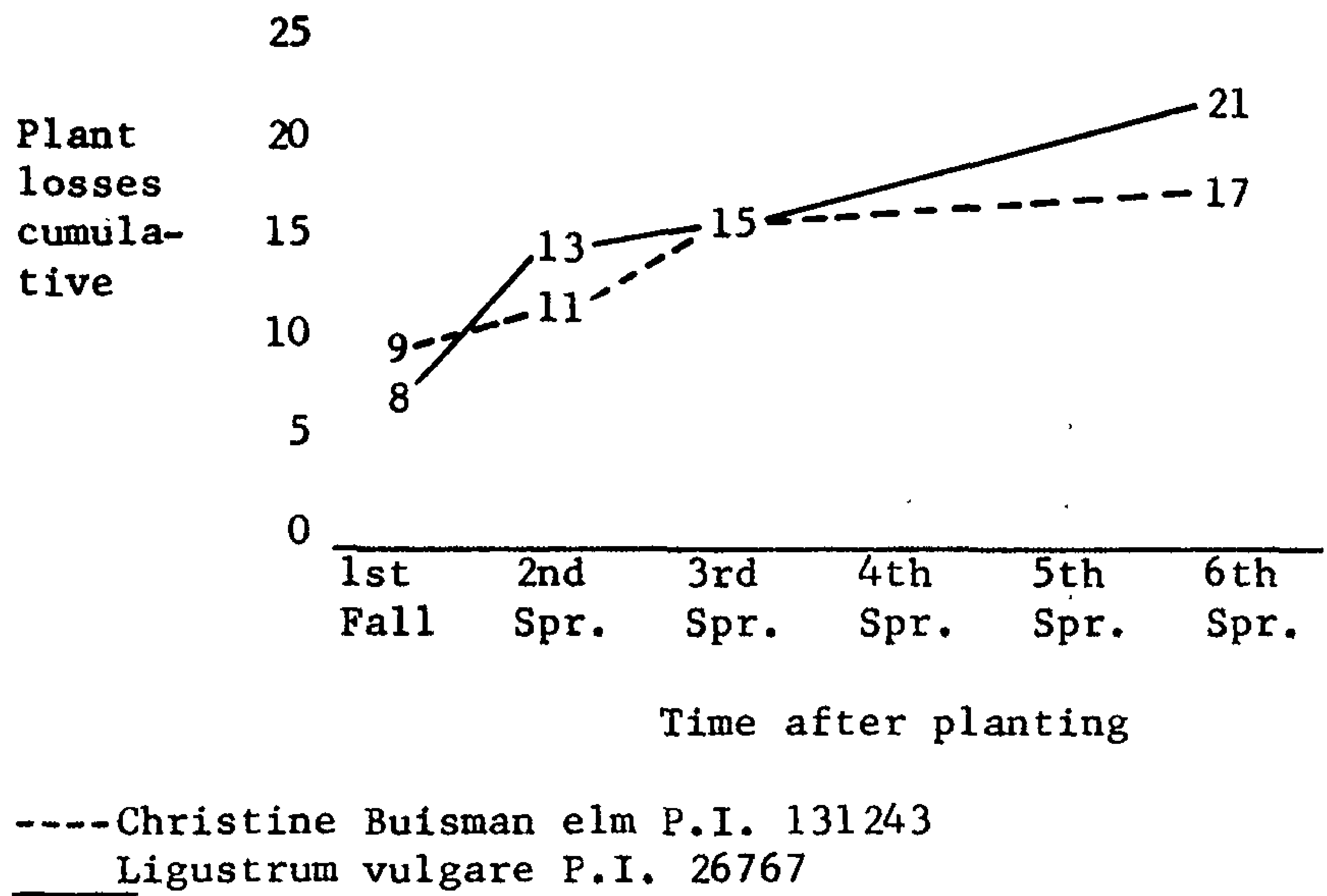

Fig. 5. Cumulative plant losses for two accessions (Intermediate Survival group), North Central Regional Woody Plant Trials.

and *Ulmus carpinifolia* Gled. 'Christine Buisman' P.I. 131243 were chosen from this group of 10 trial species.

Ligustrum vulgare P.I. 26767 was introduced by F. N. Meyer, U.S.D.A. plant explorer, in 1910 from a dry rocky mountainside near Sebastopol in the Crimea. Thirteen of the 21 plants of this accession reported lost on regional trial sites failed to survive the first year. In other words, more than half these losses resulted in the year immediately following planting.

The loss pattern for the 'Christine Buisman' elm was similar. More than half the plants reported dead were observed to fail during the first year after planting. The 'Christine Buisman' elm was introduced as P.I. 131243 in December 1938. All propagators in the Region are still concerned as to just how far north and west this disease-tolerant shade tree will prove satisfactory.

Seedling Japanese snowbell plantings referred to in Figure 2 were chosen to represent the third group, the unsuccessful survival group. The regional trial losses of this Asian shrub are plotted against time after planting in Figure 6.

First-season losses, 18 plants, were heavy. Thirty-four plants failed to survive the first winter. Thus, fifty-two Japanese snowbell seedlings were lost by the end of the first full year of trial. During the second 12-month trial period, eight more plants died. At the end of the fifth year, 66 plants of the original 71 were dead.

Fifth Year Shoot Growth

Fifth-year shoot growth measurements for *Cornus stolonifera* var. *coloradensis* (Koehne) Schneid., Colorado redosier dogwood, repre-

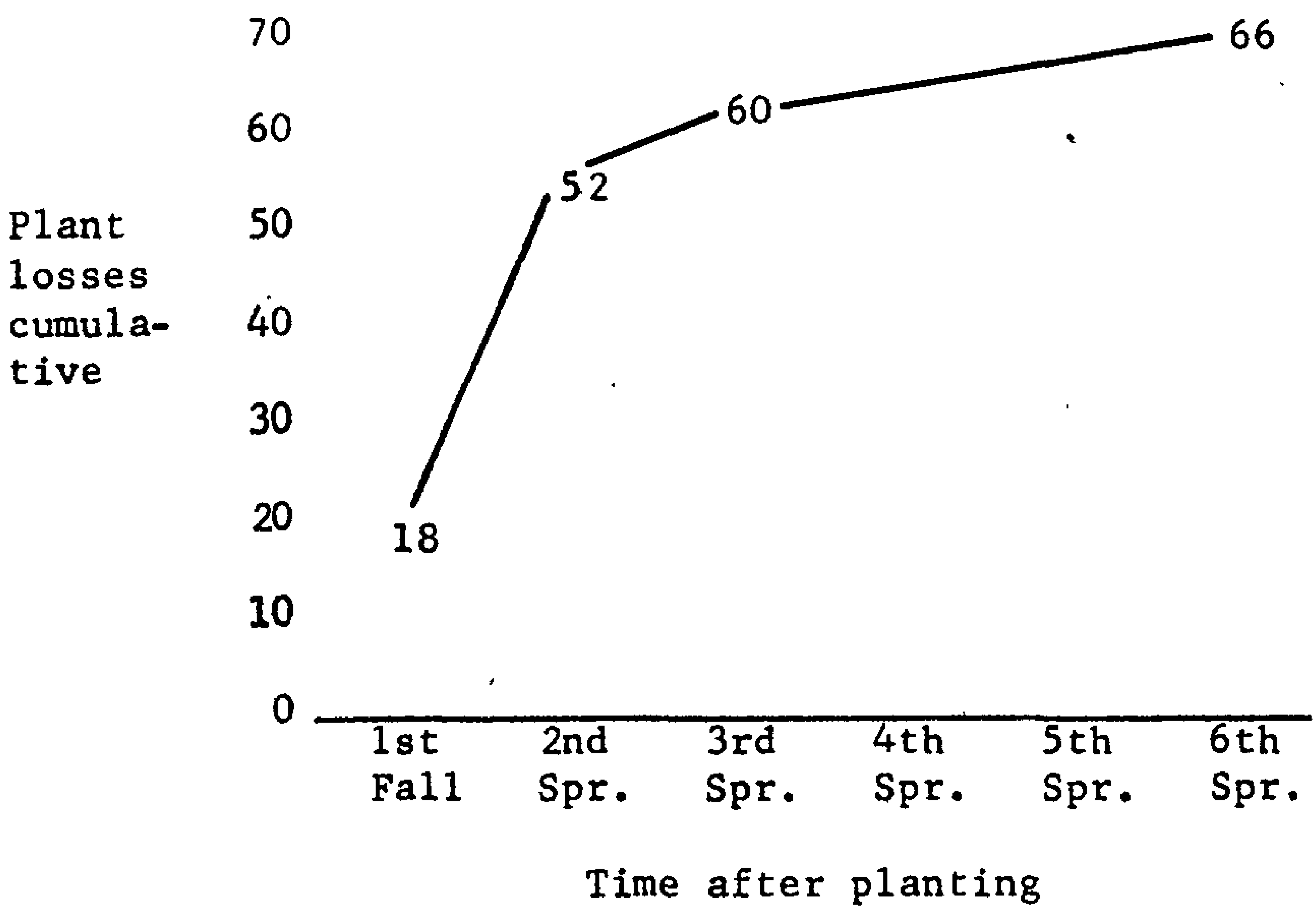

Fig. 6. Cumulative plant loss for Japanese snowbell seedlings (unsuccessful survival group), North Central Regional Woody Plant Trials.

senting the successful survival group were made by cooperators. There was no indication that any tender plants existed among the plantings of this native shrub. Average shoot growth reports summarized in Table 3 came from 13 locations.

Table 3. Average fifth-year shoot growth of Colorado redosier dogwood regional trial plants.

Location	Growth (in.)	Location	Growth (in.)
Ames, Iowa	5	Morris, Minn.	7
Grand Rapids, Minn.	5	Madison, Wis.	7
Rose Lake, Mich.	5	Waseca, Minn.	8
Fargo, North Dakota	6	Dickinson, N. Dak.	8
North Platte, Nebr.	6	Excelsior, Minn.	12
Brookings, S. Dak.	7	Crookston, Minn.	13
Highmore, S. Dak.	7		

Not only does the Colorado redosier dogwood appear to have many fine attributes, including good survival, region-wide hardiness, attractive bark color, moderate leaf size, recurring flowers, foliage to the ground, and no suckers, but regional trial data for this shrub (Table 3) suggest that stem growth is confined or moderate in amount.

The fifth-year shoot growth data for the Lemoine deutzia should also be considered. This shrub represents the intermediate group with respect to survival. Cooperator fifth-year shoot growth reports for this shrub have been grouped (Table 4) as to whether or not the plants were adapted to the planting site. Plants at a given location which proved to be tender, chlorotic, or both, were considered unadapted.

Table 4. Average fifth-year shoot growth of adapted and unadapted plantings of Lemoine deutzia by trial lcoation, together with notes on plant condition.

Location	Growth (in.)	Notes on Plant Condition
Adapted		
Columbia, Mo.	4	Does very well
Madison, Wis	5	Hardy, vigorous growth
Brookings, S. Dak.	7	Has done well
Twin Cities, Minn.	8	Hardy
Lincoln, Nebr.	10	Slight dieback at tips
Ames, Iowa	10	Grows well
Manhattan, Kansas	10	Some leaf scorch
Unadapted		
Hays, Kansas	3	Chlorosis — dry
Scottsbluff, Mitchell, Nebr.	4	Chlorosis — winter kill (dry)
North Platte, Nebr.	12	Not winter hardy
Crookston, Minn.	24	Severe chlorosis — not hardy
Grand Rapids, Minn.	25	Killed back 2 winters

The Lemoine deutzia is an example of a shrub which fails to perform successfully in western and northern trial locations in the region.

The plantings of Japanese snowbell seedlings, representing the unsuccessful-survival group, resulted in finding only two hardy plants among 23 trial plantings. One of these plants is located at East Lansing, Michigan, while the other seemingly hardy shrub is one of three planted at Lincoln, Nebraska. All three plants of this planting are alive. Two are tender (Fig. 7) and suffer cold damage each year. The third plant flowers, fruits, and maintains live twigs without evident dieback (Fig. 8). Fifth-year shoot growth of the two normal plants averaged 9½ inches.

Through arrangements with the Department of Horticulture, University of Nebraska, the hardy seedling at Lincoln Nebraska, is being propagated for future regional trial planting.

Average Plant Size after Five Years (Height-Spread in Feet)

The five-year North Central regional trial reports of the Colorado redosier dogwood indicate a range in size of plants from 3.3 x 4 feet on eroded sandy soil to 6-8 x 6.5-10 feet on more fertile sites. This

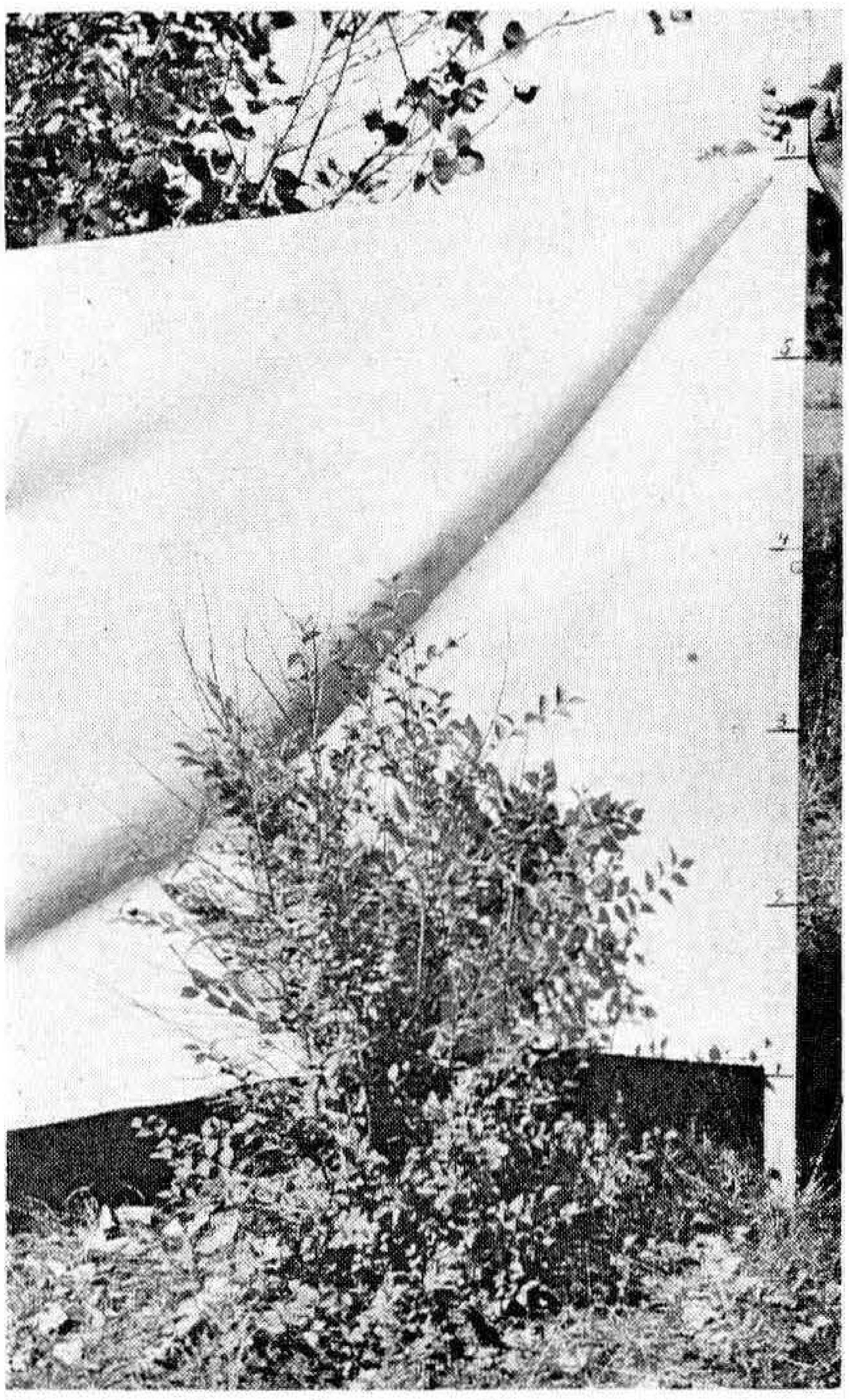

Fig. 7. One of two *Styrax japonica* **seedlings showing poor stature and extensive dead tissue associated with tenderness. University of Nebraska, Dept. of Horticulture, photo.**

Fig. 8. Hardy *Styrax japonica* **seedling with good stature, little or no injury. Univ. of Nebraska, Dept. of Horticulture, photo.**

medium-large shrub has horticultural merit and superior regional trial performance which recommend it to the propagator for increased ornamental use throughout the region.

The Lemoine deutzia trial plantings apparently were adversely affected by several site factors, such as drought, heat, various dormant season conditions, and chlorosis associated with alkali accumulations in certain soils. The resulting size of plants at various trial sites are presented in Table 5 for comparison. The locations of these plantings are grouped as adapted and unadapted.

Table 5. Average five-year height-spread measurements (feet) of Lemoine deutzia in adapted and unadapted trial locations.

Location	Size (feet)
Adapted	
Columbia, Missouri	4 x 5
Madison, Wisconsin	3 x 3.5
Brookings, South Dakota	3.5 x 3
Twin Cities, Minnesota	3 x 3
Lincoln, Nebraska	3.5 x 4
Ames, Iowa	3.6 x 3
Manhattan, Kansas	4.2 x 3
Unadapted	
Hays, Kansas	4 x 3
Mitchell, Nebraska	2 x 2
North Platte, Nebraska	3 x 3
Crookston, Minnesota	2 x 2
Grand Rapids, Minnesota	4.1 x 3.6
Duluth, Minnesota	1.75 x 1

Trial plant size information on the Japanese snowbell is limited. Only two hardy plants were measured. These plants averaged 5.5 feet in height and 4.5 feet in spread after five years on the trial site.

Suggested Northern and Western Limits of Planting

By taking into account the survival reports, the fifth-year reports on shoot growth, the condition of the plant on each site, and the plant development after five years, it is possible to estimate where the plant might be successfully used in the region. Such estimates are indicative, but of necessity, tentative. A longer period will be required for an adequate trial of most species, particularly trees, to determine accurately the limits for successful use. The five-year regional trial data suggest that the Colorado redosier dogwood (Fig. 9) may be used to illustrate a species which apparently can be planted with success throughout the region. Other species with good five-year adaptation reports include *Lonicera* x *bella 'Albida'* Zabel (Fig. 10) and *Ribes diacanthum* Pall. Plantings of these species could be expected to show good survival and virtually no winter damage. Their growth would be moderate to good on most sites with little drought injury or damage from moderate alkali soils.

The majority of the species in the successful survival group were found to perform satisfactorily over less of the region than the three shrubs just noted. Certain rosaceous plants, such as the two shrub roses tested, the Boulder raspberry (Fig. 11) and the Hedge cotoneaster (*Cotoneaster lucida* Schlecht) were noticeably affected by alkali soil areas and by the conditions in the southwestern part of the region. Another trial plant, Nannyberry (*Viburnum lentago* L.), also reacted unfavorably to alkali and drought. (See Fig. 12.) Still others, the budded thornless honeylocusts for instance, are more tolerant to alkali soils, but may be more subject to winter injury (Fig. 13.) Thus within the successful survival group considerable differences were noted among species in the suggested limits of recommended planting.

The Lemoine deutzia trial reports indicate a lack of hardiness to drought and winter conditions. Furthermore, this species was observed to be subject to chlorosis due to the presence of alkali soils on certain trial sites. The detrimental factors indicated will apparently limit the use of this floriferous shrub in the region (Figure 14).

Other trial accessions in this intermediate-survival group might be expected to be used with varying success, depending on the inherent ability of the species to react to local environmental factors.

Plants which appear in the unsuccessful survival group may be expected to perform satisfactorily over a relatively small part of the region. Plants of this group are of particular interest to the ornamental specialist. New introductions of a species under trial are a potential source of hardiness. Needed hardiness may also be found in exceptional individuals of a seedling population. In either case, the actual worth of any new material can only be properly assessed through propagation and inclusion in a regional trial planting program similar to that underway in the North Central Region.

SUMMARY

1. In 1954, state experiment station ornamental horticulturists of the North Central Region organized a tree and shrub trial planting program in cooperation with the North Central Regional Plant Introduction Station and the New Crops Research Branch, Agricultural Research Service, U.S. Department of Agriculture.

2. Since 1959, five-year reports on each succeeding year's regional trial planting have been prepared. More than five years will be needed to evaluate completely trials of most trees and shrubs.

3. Forty tree and shrub accessions, for which five-year reports had been prepared, were grouped according to survival as successful, intermediate, and unsuccessful. The average number of trial plantings with 100-percent survival was used as a basis for this grouping.

4. Performances of several regional trial items with respect to survival, plant losses, shoot growth, height and spread, and suggested

limits of successful planting in the region are presented.

5. Two introductions of the common privet, P.I. 26767 and P.I. 107630, were noted to differ with respect to survival and first-season losses. The trial response of the commercial 'Amur River North' privet was compared with the two common privet introductions.

6. The Japanese snowbell seedling trial reports revealed a general failure to survive. The trial planting at Lincoln, Nebraska contained one hardy plant and two tender plants. The hardy shrub is being propagated for further regional trial planting.

7. Regional trial planting of new ornamental and shelter plants is a practical approach to the age-old problem of adaptation evaluation. This technique is one step in an orderly sequence of processes through which the performance of each accession is observed and documented.

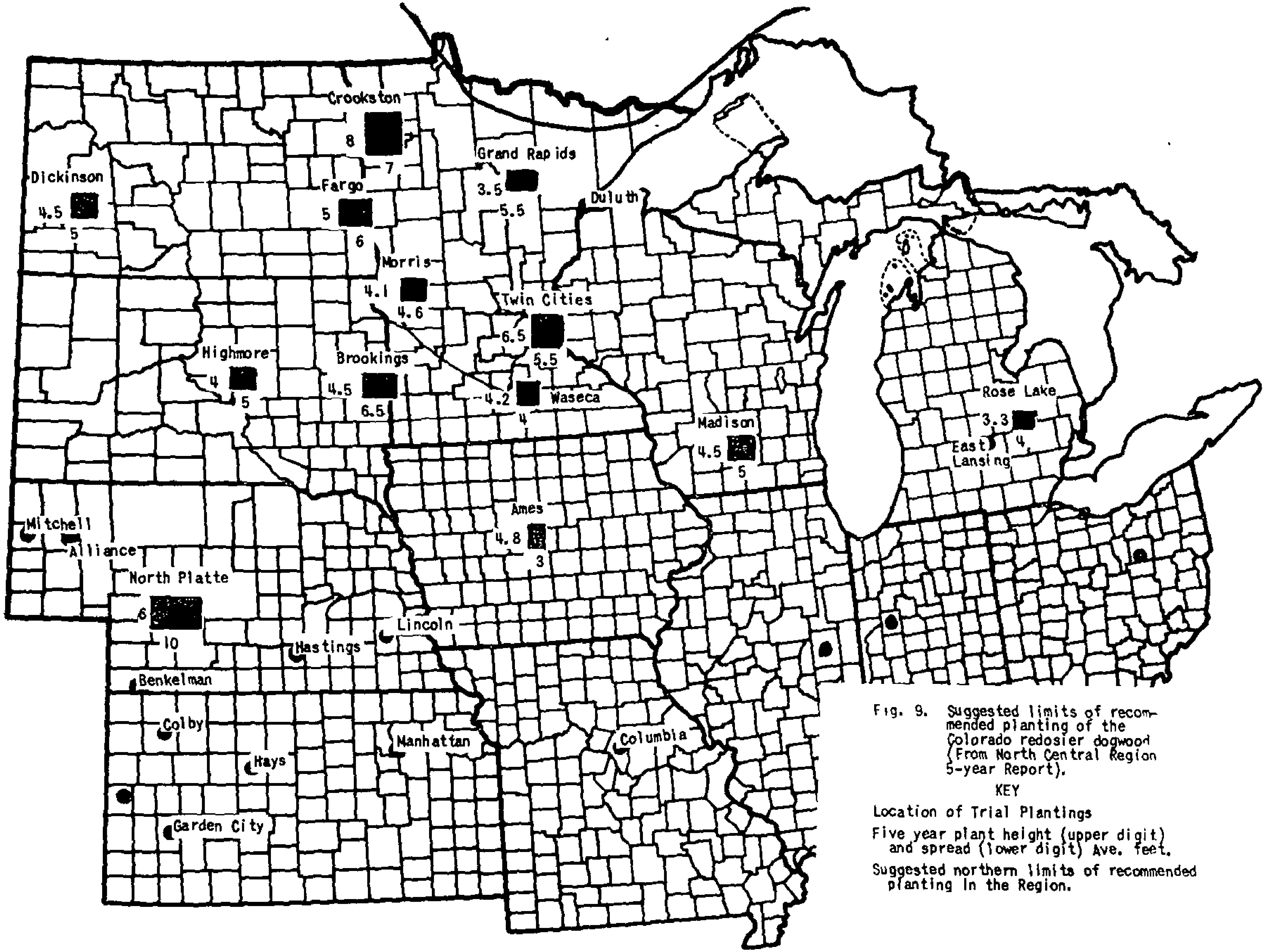

Fig. 9. Suggested limits of recommended planting of the Colorado redosier dogwood (From North Central Region 5-year Report).

KEY

Location of Trial Plantings

Five year plant height (upper digit) and spread (lower digit) Ave. feet.

Suggested northern limits of recommended planting in the Region.

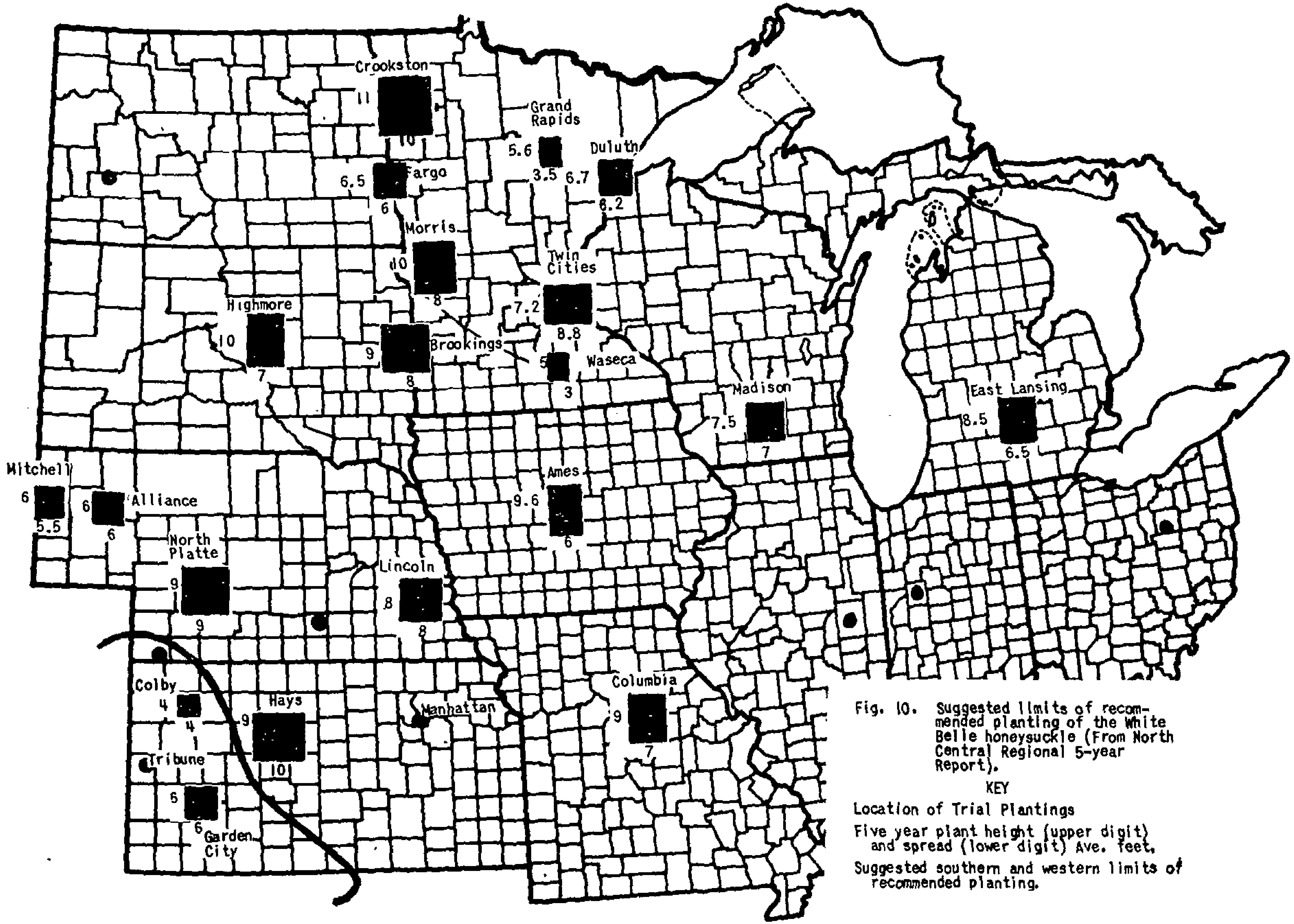

Fig. 10. Suggested limits of recommended planting of the White Belle honeysuckle (From North Central Regional 5-year Report).

KEY

Location of Trial Plantings

Five year plant height (upper digit) and spread (lower digit) Ave. feet.

Suggested southern and western limits of recommended planting.

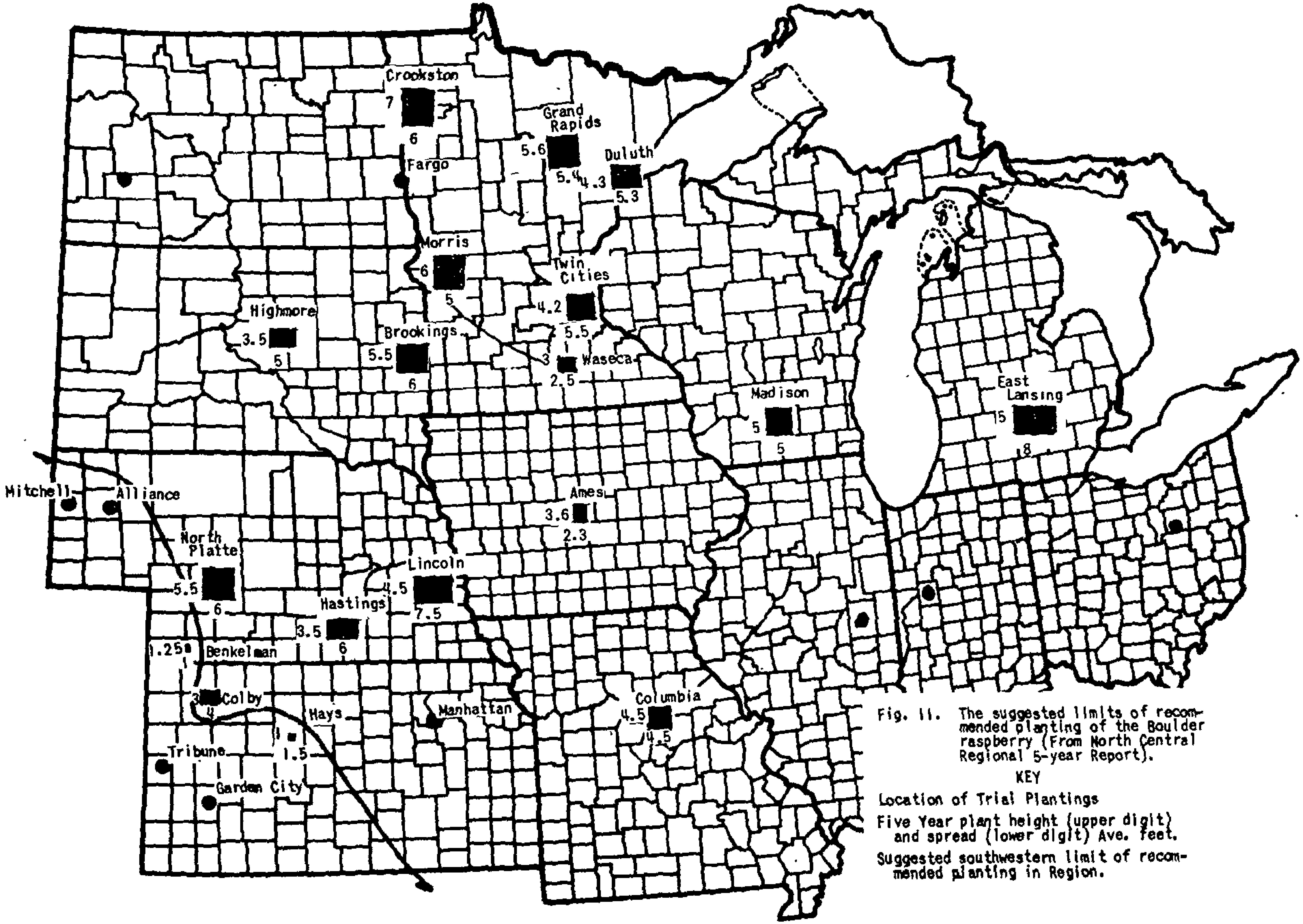

Fig. 11. The suggested limits of recommended planting of the Boulder raspberry (From North Central Regional 5-year Report).

KEY

Location of Trial Plantings

Five Year plant height (upper digit) and spread (lower digit) Ave. feet.

Suggested southwestern limit of recommended planting in Region.

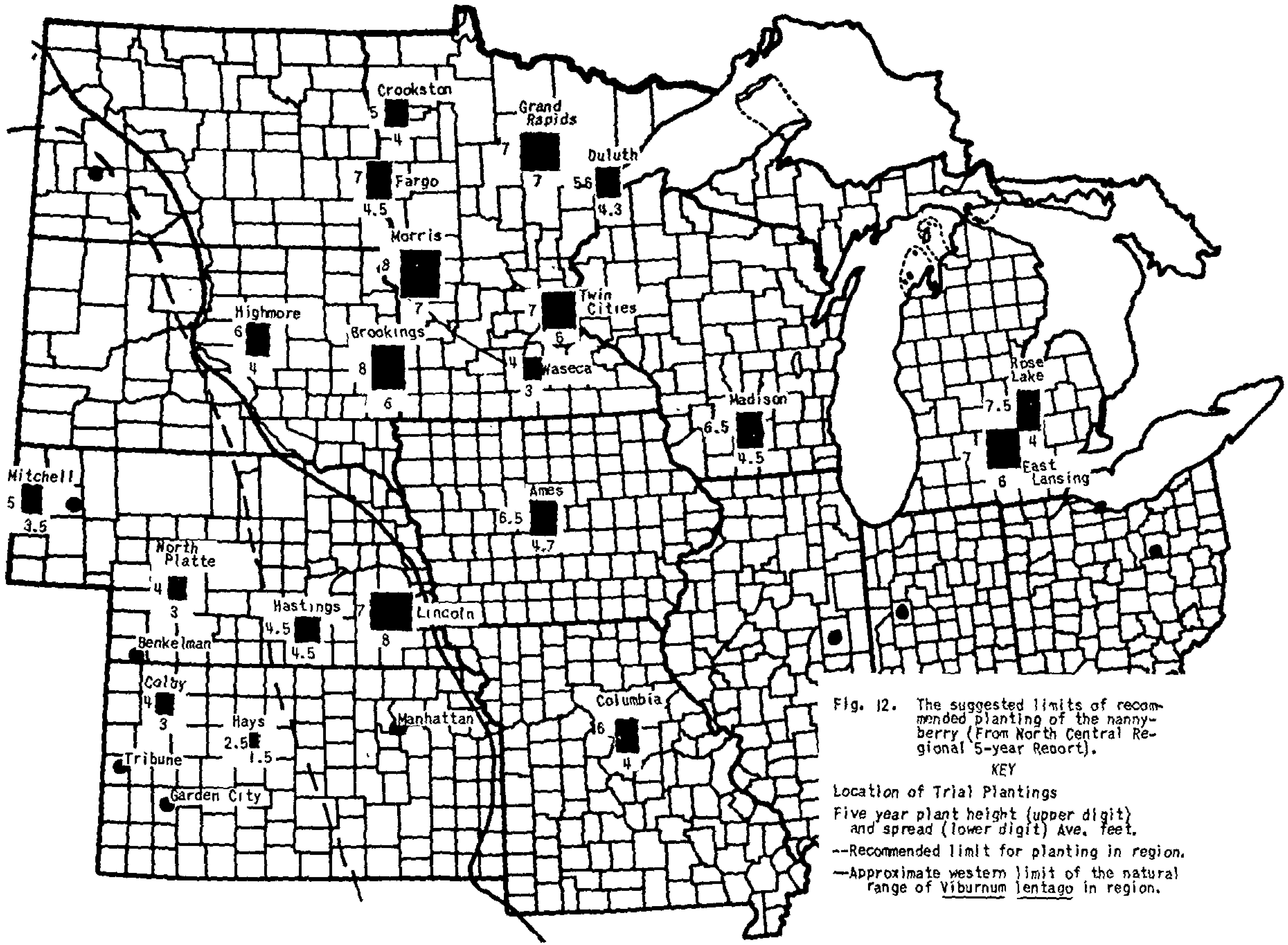

Fig. 12. The suggested limits of recommended planting of the nannyberry (From North Central Regional 5-year Report).

KEY

Location of Trial Plantings

Five year plant height (upper digit) and spread (lower digit) Ave. feet.

--Recommended limit for planting in region.

—Approximate western limit of the natural range of Viburnum lentago in region.

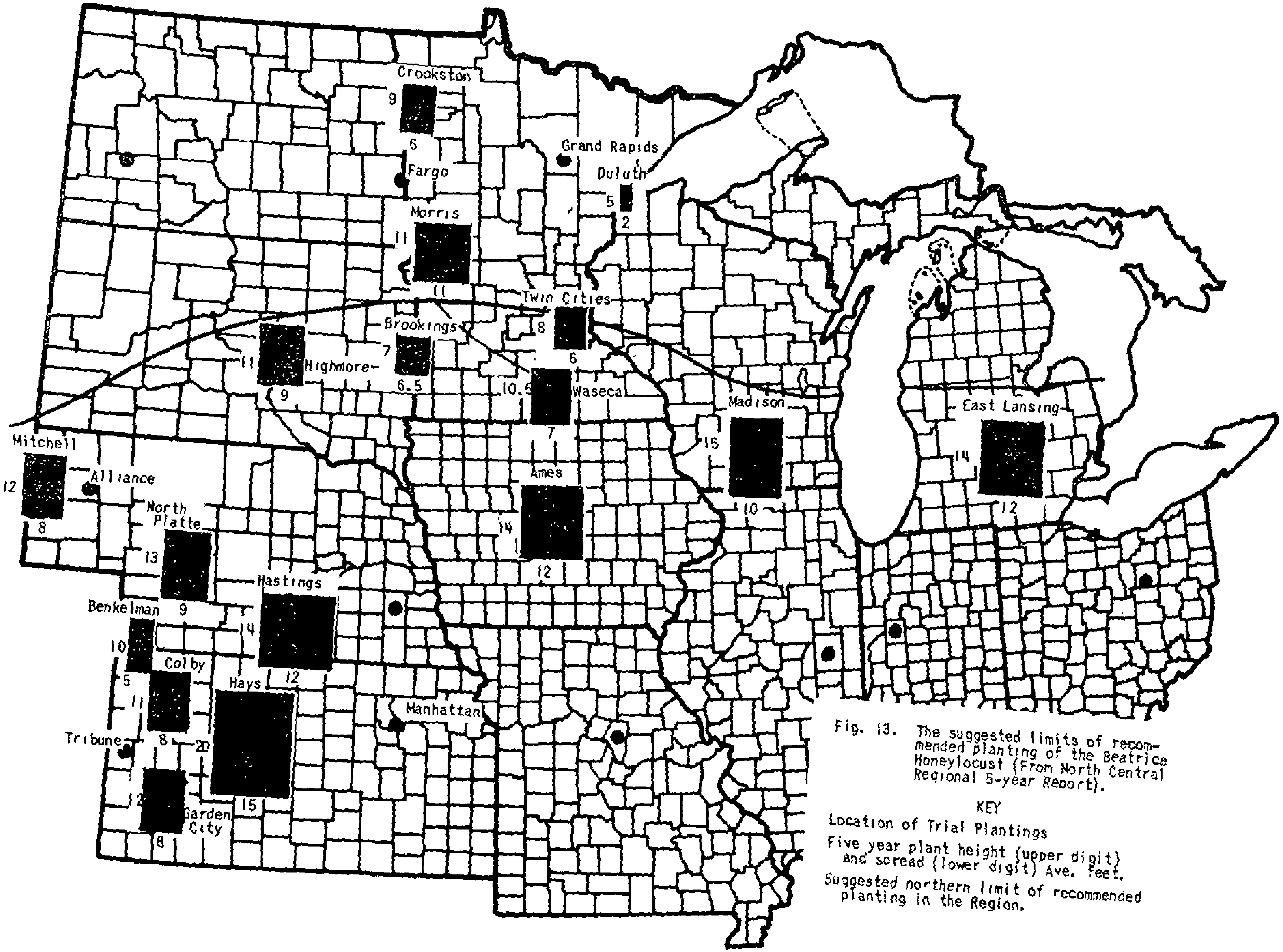

Fig. 13. The suggested limits of recommended planting of the Beatrice Honeylocust (From North Central Regional 5-year Report).

KEY

Location of Trial Plantings

Five year plant height (upper digit) and spread (lower digit) Ave. feet.

Suggested northern limit of recommended planting in the Region.

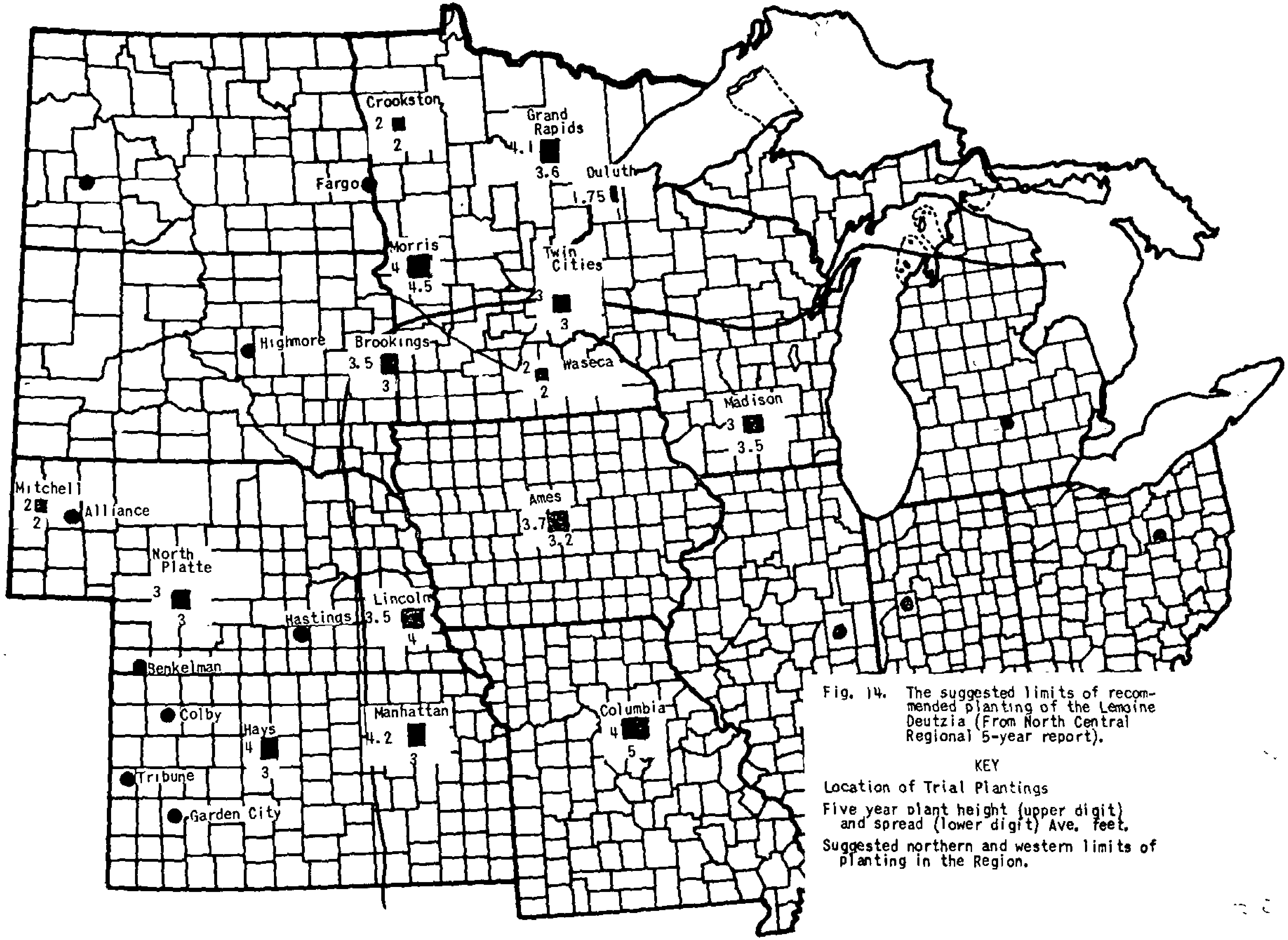

Fig. 14. The suggested limits of recommended planting of the Lemoine Deutzia (From North Central Regional 5-year report).

KEY

Location of Trial Plantings

Five year plant height (upper digit) and spread (lower digit) Ave. feet.

Suggested northern and western limits of planting in the Region.

MODERATOR ROLLER: Thank you, Mr. Dodge, for an informative and interesting presentation.

Now we have come to the end of our time and this concludes the technique sessions of the program. I would like to thank the gentlemen on this afternoon program for the kind cooperation and very worthy efforts.

Meeting adjourned for business session.

SATURDAY EVENING SESSION

Twelfth Annual Banquet. Mr. Carl E. Kern, Wyoming Nursery, Cincinnati 15, Ohio was presented the Plant Propagators Award. The evening was concluded with an excellent speech by Mr. Fred Smith, Management Consultant, Cincinnati, Ohio. His topic was "The Best Is Yet To Be."

TECHNICAL SESSIONS

THURSDAY EVENING SESSION

October 18, 1962

The Third Annual Meeting of the Plant Propagators' Society — Western Region, opened at 7:45 P.M. at the Educational Center, California State Polytechnic College, San Dimas, California, with remarks of welcome by Herman J. Sandkuhle, Jr., President, Western Region. This was followed by a brief report from Don Hartman, President, International Plant Propagators Society. Program Chairman, Percy Everett, introduced the Moderator for the evening Symposium, O. A. Batcheller, Head, Department of Ornamental Horticulture, California State Polytechnic College, Pomona, California.

SEEDS AND THEIR ROLE IN MODERN PROPAGATION

MODERATOR BATCHELLER: Seeds have always played an important role in the history and development of countries, as food, as articles of commerce, for religious rites, and for decoration.

If anything, the seed in the 20th Century has become more important, and today represents the most costly of all agricultural crops produced, with some F_1 hybrid seed selling for over $1000 per ounce. Despite the cost of planning, development, processing, packaging and care, the modern day seed is still a better buy than it's predecessor, as rated by yield and returns.

Unlike most products sold today in easily observed plastic packages, the seed is "an unknown." "a picture or description in a catalog that should come to life," "the promise of a seed company." This built-in future, as developed by the great seed companies, needs all the protection and care possible so that the embryo may develop to its greatest potential. To assist us this evening in our discussion on 'Seeds In Their Role in Modern Propagation" we have a well-known panel of experts:

Dr. Walter Lammerts, Horticulture Research Division, Germain's, Livermore, California.

Mr. J. C. Eden, Forest Technician, State Forestry Nursery, Davis, California.

Mr. Dara E. Emery, Horticulturist, Santa Barbara Botanic Garden, Santa Barbara, California.

Our first speaker tonight will be Dr. Walter Lammerts, who will discuss the subject of embryo culture. Dr. Lammerts.

PRACTICAL VALUE OF EMBRYO CULTURE IN NURSERY PRACTICE

WALTER E. LAMMERTS
Horticultural Research Division of Germain's
Livermore, California

INTRODUCTION

If, by practical value, we mean the germination of seed for rouine growth of nursery stock, I might as well say right now that embryo culture has none. However, most larger nurseries by now realize the value of at least some plant selection as a means of improving their general line of nursery items and finding varieties better adapted to specific localities. The very fine work of the Saratoga Horticultural Foundation, Saratoga, California, is an outstanding example.

Also, many nurseries are realizing the need of breeding work involving actual cross pollination in order to combine a desirable trait such as unusually lovely foliage with exceptional flower or fruit quality. Unfortunately, in many genera the percentage of germination obtainable by routine methods is rather low, varying from 10 per cent to 65 per cent. Also, and even more important, the really desirable combination of characteristics is often found in that percentage of seeds which do not germinate!

Finally, in most shrubs and trees such as the camellia, peach, nectarine, and cherry a number of years elapse from the time a seed is harvested until fruit is produced, if one follows routine nursery practice. The question then is: Granted that it does pay nurseries to carry on at least modest research programs, just what are the advantages of embryo culture?

A brief resume of the history of this technique and some examples of its successful application is probably the best way to answer this question. Also, suggestions for research leading to simplification and large scale adaptation will be made.

HISTORY OF PRACTICAL APPLICATION

H. B. Tukey, working at Geneva, New York Agricultural Experiment Station, was one of the pioneers in this technique. His paper, "Artificial Culture Methods For Isolated Embryos of Deciduous Fruits," (1) is a classic and should be read by everyone contemplating this sort of research. He quite correctly credits O. W. Davidson and Florence Flemion of the Boyce Thompson Institute as also being pioneers. The basic formulas described by Tukey are the ones which we still use. I have found them applicable for use with cherry, peach, nectarine, plum and camellia. Tukey also reports successful use of embryo culture with pear and apple seed. Undoubtedly many other types of shrubs in various genera which have embryos encased in thick-walled seed coats, taking three to six months to germinate in the usual manner, would also respond. My own work which made it possible for me to make such rapid headway in rose, peach and nectarine breeding at Armstrong Nurseries from 1935 to 1940 was reported in the American Journal of Botany under the title of "Embryo

Culture, an Effective Technique for Shortening the Breeding Cycle of Deciduous Trees and Increasing Germination of Hybrid Seed." (2)

In describing the material and methods, I recommended several improvements over the Tukey technique, such as sterilization of the peach pits with mercuric chloride at 1 to 1000, use of hot water to make the calcium hypochlorite disinfecting solution, and disinfection at 110 to 115° F. The use of a good surface tension reducer, at the rate of one gram per liter, was most helpful if the coats or testas were badly infected. By use of this technique a much higher percentage of germination resulted from my very extensive apricot, peach and nectarine crosses made in 1937. About 10,500 flowers were emasculated and pollinated which resulted in 2536 fruits, an average of 24 per cent; 69 percent of these were successfully embryo-cultured. Many were from crosses involving very early fruiting parents, seeds of which do not germinate at all following usual stratification methods. The very successful Robin variety of peach was from one of these 1937 crosses, that is, a cross of Babcock peach with the early-fruiting Mayflower. From the 1938 cross pollinations, 76 per cent of the seed were germinated. A comparison of normal stratification with embryo culture involving four different crosses, gave the following comparative percentage:

Stratified Seed	Embryo Cultured Seed
44%	67%
26	100
50	80
23	95
44	78

The culturing technique was particularly satisfactory and helpful with crosses involving early types, such as Early Imperial or Mayflower, which characteristically have many abortive embryos which do not respond to stratification.

In 1939, 81 per cent of the 1092 embryos from 1114 fruits were successfully cultured.

Similarly, I found in my work at Descanso Gardens that a very great increase in germination of camellia seeds was effected by this technique. This was particularly true when crosses were made involving species such as *Camellia japonica* x *C. reticulata* and *C. cuspidata*. Seeds of these crosses planted in the usual manner simply do not germinate because the embryos are partially aborted. Embryo culture readily effected their germination, though considerable extra care was necessary until the very young seedlings became established.

The most important part of this work involves a combination of the use of embryo culture with the proper photoperiod, as shown in my article, "Effect of Photoperiod and Temperature on Growth of Embryo Cultured Seedlings," (3) published in 1943 in the American Journal of Botany. Many of the late fruiting varieties, such as Muir, usually remain very dwarf-like, even following germination by embryo-culturing. When exposed to a continuous 24-hour photoperiod, they could be grown to 3-3 ½ feet in height during the winter and spring following germination in the fall. When transplanted to the field in April, following hardening-off and exposure to six weeks cold storage in a dark room at 40° F., these seedlings made rapid growth and flowered abundantly the second spring after pollinations were made. Peach, nectarine, cherry and other deciduous tree hybrids, having a shorter chilling requirement, responded even better. A combination of embryo-culture immediately in the fall after harvest, followed by continuous-light treatment and transplanting to the field in the spring was most effective.

In camellias, as reported in the 1949 Camellia Yearbook, under the title, "The Effect of Continuous Light, High Nutrient Level, and Temperature on Flowering of Camellia Hybrids," (4) it was possible to grow seedlings from embryos cultured in October, 1946, to a height of over six feet and have them set flower buds by January of 1948. Thus, these hybrid camellia seedlings were brought into flower one year and four months after germination! The hybrids which grew the fastest tended to be the slowest in flowering. Even with the handicap of nine months under normal day-length prior to continuous light treatment, seedlings were all in flower by April of 1949. It is then possible to shorten the breeding cycle of the camellia from a period of four to eight years to about one and one-half years.

The flowers resulting were typical enough to be indexed for color, petal number, and size. I might add that a weekly feeding with a high nutrient level, balanced plant food, containing 420 ppm of nitrogen, 120 ppm of phosphorus and 120 ppm of potash was used. This nutrient solution also contained a small amount of sulfur, calcium, iron and traces of manganese and magnesium and other minor elements.

Embryo culture technique was usually employed by me only when moving from one breeding location to another. It was most useful when I began the plant breeding program at Armstrong Nurseries and again when I started my general ornamental shrub and fruit tree breeding work at the University of California at Los Angeles in 1940. It was of particular value when I transferred my work to what was then known as Rancho del Descanso in 1945. Here time was certainly the essence since Mr. Howard Asper and I had the problem of making our general nursery operation pay for the cost of the breeding work. My successful development of the Daily News Series of double flowering peaches would not have been possible without the use of this technique at that time.

In my rose breeding I use this technique only when I am beginning some unusually new line of work where genetic considerations make it quite clear that there is no hope of any commercially desirable hybrid until at least two or three generations of cross pollinations, or back crosses, have been grown.

POSSIBLE FUTURE DEVELOPMENTS

At present we are working on the use of various antibiotics in the hope that they may greatly reduce the possibility of contamination. This has always been a limiting factor in the use of embryo culture since transfer of the embryos after they have been sterilized in the calcium hypochlorite solution always involves considerable risk of contamination even under the most careful and clean laboratory conditions. A high concentration of penicillin used in the form of Crysticillin & Mycostatin does not harm the embryos of roses or peaches. The percentage of infection is considerably reduced. It is hoped that by the proper combinations of antibiotics we may eventually be able to use less tedious methods of embryo culture, which, of course, would tremendously increase its practicality.

Thus, if we could use large Stender dishes and transfer embryos at the rate of 100 or so per dish, insuring them against contamination by the use of a high concentration of antibiotics, it might well be possible to use this technique even in general nursery practice for the production of seedlings otherwise difficult to obtain by use of germination methods.

LITERATURE CITED

1. Tukey, H. B., 1934. "Artificial Culture Methods for Isolated Embryos of Deciduous Fruits." Proceedings of the American Society for Horticultural Science. 32:313-322.
2. Lammerts, Walter E., 1942. "Embryo Culture, An Effective Technique for Shortening the Breeding Cycle of Deciduous Trees and Increasing Germination of Hybrid Seed." American Journal of Botany. 29:166-171.
3. Lammerts, Walter E., 1943. "Efeect of Photoperiod and Temperature on Growth of Embryo-cultured Seedlings." American Journal of Botany. 30:707-711.
4. Lammerts, Walter E., 1949. "The Effect of Continuous Light, High Nutrient Level and Temperature on Flowering of Camellia Hybrids." American Camellia Society Yearbook. 1949:53-56.

MODERATOR BATCHELLER: Are there any questions for Dr. Lammerts?

VOICE: What type of disinfectant do you use in your embryo culture work?

DR. LAMMERTS: First, place the embryos in 8 hydroxy-quiniline sulphate solution, 1-20,000, for botrytis and bacteria control.

Then transfer to ortho-phenyl-phenol sodium salt (1-2000). This is very important for control of parasitic fungi. The latter treatment is quite important since otherwise, if only the first disinfectant is used, unusual parasitic fungi which are not killed by the first disinfectant will become established and kill the embryos.

VOICE: What type of lights were used for increasing the growth of your peach seedlings and at what distance were they placed above the plants?

DR. LAMMERTS: In the 16-hour photoperiod experiments, 200-watt type C Mazda lamps placed about three feet above the plants were used to supplement the normal day length, i.e. they automatically went on during the winter at about 5:00 p.m. and were turned off by the clock at 10:00 p.m.

Experiments now going on indicate that the recently developed Gro-Lux lamps, developed by Sylvania, are even more effective than 200-watt C Mazda lamps.

MODERATOR BATCHELLER: Thank you, Dr. Lammerts. Our next speaker on the program, Mr. C. J. Eden, will talk to us on the subject of conifer seeds. Mr. Eden.

CONIFER SEED — FROM CONE TO SEED BED

C. J. Eden
California State Division of Forestry
Davis, California

CONE COLLECTION

The first process in the propagation of conifers by seed is the collection of the cone containing the seed. Cones are collected mainly during the months of September and October. Collection may be from standing or felled trees, from the ground, or from squirrel caches.

Cones should be checked for seed maturity and seed quality before full scale picking. Various tests for determining maturity can be made: cone flotation, color of cone or seed, character of seed endosperm and embryo. Seed quality can be checked by cutting the cone and examining for blank or damaged seed.

The Pacific Southwest Forest & Range Experiment Station has delineated fourteen seed collection zones in California. All the area with a zone is considered to have the same climatic and edaphic conditions. Therefore, planting stock propagated from seed collected any place in the zone may be planted at any place within the zone and be considered as being planted into the same environment as that in which the seed was produced.

When the cones are collected they are kept separate by species, differences in elevation, and area. A "Report of Cone Collection" is filled out by the person supervising the collection for each distinct lot of cones. Information entered is: species; location — i.e. county, township, range, section, and elevation; dates of collection; number of sacks of cones collected; number sacks rough-cleaned seed processed; condition of crop — Good, Fair, or Poor; special remarks; and identification of collector. Each "Report of Cone Collection" is prenumbered, and for the moment, the lot of cones defined by the information on the report is assigned this number. Every sack of cones in the lot is tagged inside and out with this number for identification and then sent to the Division of Forestry nursery at Davis, California, for processing. The "Reports of Collection," when completed, are also sent to Davis.

Information given on the "Report of Collection" is transferred to another card called the Production Record. This card is then used to keep a case history on the seed processed from the cones, as it is used. When the collection information is placed on the Production Record the lot of cones is assigned a Code Number. The Code Number is made up from the initials of the scientific name of the species, the collection zone source, the elevation, and the year of collection. For instance, sugar pine seed collected in Zone III at 4000 feet elevation, in 1962, would be assigned the Code Number PL III 4 2. PL is the initials for *Pinus lambertiana,* Roman numeral III is the zone, the number 4 is for 4000 feet elevation, and the number 2 is for the year 1962. Separate lots of cones similar in species, collection zone, elevation, and year of collection all have the same Code

Number and are, therefore, combined into one lot. The number(s) of the lot(s) making up one Code Number is listed on the Production Record card.

EXTRACTION AND CLEANING

As the cones are received at the extraction plant they are placed under one of two different drying treatments. Cones of most species are spread in the sun on cement slabs or heavy paper. The heating and drying, due to the action of the sun, causes the cones to open in a period of one to two weeks. The broken cones of the true firs are hand-processed over a screen to remove the seed from the cone scales and other large matter. A portable shaker made of expanded metal is used to remove the seed of other species from the cone.

Cones of a few species do not respond readily to air drying. Various types of kilns may be used to open the cones. A small extraction drum, 4′ x 10′, which will hold 30 to 40 bushels of cones, is used by the Division of Forestry. Warm air at a temperate of 110-140°F. is blown into the closed drum. Periodically the drum is turned to shake the seeds from the opened cones. Eight to twenty-four hours of heat are required to open most cones. A forced air kiln, with a daily capacity of 800 bushels of cones, is being planned for construction in the near future. The extracted seed is passed over a scalper which removes the bulk of the debris. After the scalping operation pine seeds are de-winged, using a small cylinder lined inside with corrugated rubber and having a rubber-tipped paddle wheel which rubs the seed against the lining. A two-screen cleaner with a rough air separation is used to remove the remainder of the debris. The seed may be upgraded by means of a pneumatic separator which blows off the poor quality, light seed.

During the entire processing of the seed, the various lots are kept separate according to the Code Number. Certain information is transferred to the Production Record card after the seed is cleaned. This information is: the pounds of clean seed obtained, and the number of pounds of clean seed per sack of cones collected.

CONE STORAGE

Seed of a number of species of conifers require storage at quite low temperatures. Species which should be stored at, or near, 0° F. are white fir, red fir, sugar pine, Douglas-fir, Sierra redwood, and Coast redwood Species such as ponderosa and Jeffrey pine can be stored at higher temperatures, up to 35° F., if the moisture content of the seed is below about 10%. However to insure increased periods of storage with high viability, all conifer seeds should be held at or near 0° F. and below a moisture content of 10% of oven-dry weight.

At the Division of Forestry nursery near Davis, seed is stored in 5-gallons cans, which hold approximately 25 pounds of seed. It is planned to place polyethylene bags inside the cans to further reduce possible accumulation of moisture. The cans are marked with the Code Number assigned to the seed.

SEED TESTING

The first phase of seed testing should be the running of purity tests. Seed purity is the percentage by weight of clean seeds, true to species, in a sample containing seeds and other materials. However, because the California Division of Forestry processes seed only for its own use, and because the seed cleaning process gives seed of good purity, by ocular estimates the purity percent is recorded as 100 percent. If a particularly dirty lot of seed is obtained after the compete cleaning process, a purity test is run and the purity percent recorded.

The second phase of testing is computing the number of seed per pound. For determining this figure, a vacuum seed counter can be a valuable aid. A plate with a certain number of holes, such as 50 or 100, is connected to a vacuum line. The vacuum holds one seed at each hole, giving a known number of seed. For Division of Forestry purposes, samples of 100 seed are measured out with the counter and weighed on an analytical balance. Using ratio's, the number of seed per pound is then computed. Larger samples should probably be taken for smaller seed and for seed earmarked for sale.

Germination tests can be conducted by a number of techniques. Some of these are: tetrazolium, which is a dye which stains the embryo according to the apparent maturity of the seed; hydrogen peroxide, which promotes a rapid root radical growth; and direct germination.

The California Division of Forestry uses all three of the above methods, but the first two, tetrazolium and hydrogen peroxide, are used only when a quick approximation of the germination percent is desired. Tetrazolium and hydrogen peroxide tests generally do not give as reliable results as direct germination tests.

Direct germination tests are run in a small germinator using plastic dishes containing a perlite medium. At the present time the Division has one germinator in which 30 tests of three 50-seed samples can be run at one time. Another germinator of similar type is on order, and a third being requested in a future budget. With three germinators 90 tests of 150 lot samples or 45 tests of 300 lot samples can be made. When the third germinator is obtained 300 lot samples will be used to increase the reliability of the tests.

The germinators are maintained at a constant temperature of about 72° F. Although the larger seed laboratories run tests in germinators with alternating light and dark, and alternating temperatures, the Division of Forestry does not have this type of equipment. Tests are run for a period of about six weeks. Germination is checked weekly for the first four weeks with a final check at the end of the sixth week.

The Production Record card is used to record the results of the germination tests. As always in the processing of the seed, it is kept separated into different lots according to the Code Number.

A new method of obtaining germination figures has just recently been given some study. This is through the use of X-rays. In several European countries this method has been in use for several years, but in the United States we are still only in the experimental stage.

A sample of seed is X-rayed and a X-ray plate developed. Very good plates clearly showing the endosperm, the seed coat, and the embryo, including the cotyledons, can be obtained. When checked by a trained viewer it is quite possible that seeds having the capacity to germinate can be distinguished from seed not havng this capacity. If this method is workable, much time in obtaining germination figures can be saved.

STRATIFICATION

Seeds of many conifer species possess or acquire an internal dormancy which may delay germination or prevent it completely. Internal dormancy can be broken by exposing the seeds to abundant moisture and oxygen at temperatures of between 32° and 41° F. The above method of breaking dormancy is called cold stratification.

Stratification, as done by the California Division of Forestry, is carried out in the following manner; the seeds are mixed uniformly with an equal volume of vermiculite, moistened with a solution of 1¼ oz. of Captan 50W per gallon of water, placed in vegetable crates lined with burlap, and then stored in a walk-in refrigerator controlled to about 35° F.

A process is being considered in which small lots of seed can be soaked in water, placed in plastic bags, and then held in the refrigerator for the proper period of time. The advantage of this method is that no separation of seed and verimiculite is required after stratification and before sowing.

Seeds of conifer species require different periods of stratification. The following chart lists these periods:

STRATIFICATION PERIODS OF CONIFER SEEDS

SPECIES	TIME
Aleppo pine, *Pinus halepensis*	None
Canary Island pine, *Pinus canariensis*	None
Coast redwood, *Sequoia sempervirens*	None
Coulter pine, *Pinus coulteri*	None
Monterey pine, *Pinus radiata*	None
Arizona cypress, *Cupressus arizonica*	4 weeks
Lowland white fir, *Abies grandis*	4 weeks
Ponderosa pine, *Pinus ponderosa*	4 weeks
Beach pine, *Pinus contorta*	6 weeks
Bishop pine, *Pinus muricata*	6 weeks
Douglas-fir, *Pseudotsuga menziesii*	6 weeks
Jeffrey pine, *Pinus jeffreyi*	6 weeks
Red fir, *Abies magnifica*	6 weeks
Scots pine, *Pinus sylvestris*	6 weeks
White fir, *Abies concolor*	6 weeks
Incense cedar, *Libocedrus decurrens*	8 weeks
Sierra redwood, *Sequoia gigantea*	9 weeks
Sugar pine, *Pinus lambertiana*	12 weeks

SOWING

A number of operations are performed to the nursery seedbed areas prior to sowing.

The first operation is the ground preparation with various pieces of equipment. If a cover crop has been grown on the area, the crop is first plowed under and then the ground disked. On fallow areas, the plowing operation is generally omitted.

Every two years, in the fall or early spring, after the ground has first been worked, liquid fertilizer is injected into the soil. The fertilizer used is 8-25-0 and is applied at the rate of about 800 pounds per acre, unless sawdust has been added; then it is applied at the rate of 4000 pounds. It is injected into the soil at the five to seven inch depth.

Periodically the nursery seedbed areas are fumigated for the control of root pathogens and weeds. Approximately two weeks prior to the desired sowing date, which is in April or May in the Division of Forestry nurseries, a mixture of methyl bromide (58%) and chloropicrin (42%) is injected at the rate of 300 pounds per acre. Immediately after injection, the ground is covered with polyethylene tarping. The tarping is left on the beds for a period of about 24 hours. After the tarping is removed, the soil is tilled to a shallow depth. allowed to air out for about 10 days, and then leveled.

To attain a density of a certain number of seedlings per square foot, it is necessary to determine the number of seeds to sow per square foot. This figure is computed by the following formula: number of seeds per square foot=

$$\frac{\text{planned density / square foot}}{\text{germination \% x purity \% x survival factor\%}}$$

The "survival factor %" is the percentage of germinated seed expected to grow to trees. A density of 30 seedlings per square foot is desired for one year stock, and a density of 40 per square foot for two year stock.

The computations for the number of seeds per square foot are worked out on a Sowing Schedule form by the nurseryman in charge of each nursery. Other information to be shown on this form for each lot of seed to be sown includes: seed/lb., seedlings/lb., lbs. sown, planned production, seed drill settings, bed number, and bed space, both calculated and actually sown. Data from the Sowing Schedule is then transferred to the separate Production Records kept for each different lot of seed. Each year, as a particular lot of seed is sown again, the data is added to the Production Record. Therefore a complete record of a particular lot of seed can be kept on one source from collection to complete use.

After the calculated bed space required for each lot of seed is determined on the sowing schedule, a seed bed layout is completed. On the layout, the nurseryman maps out the planned location and space of the lots of seed to be sown.

At the time of sowing, the seed is separated from the vermiculite stratification medium. Because seed of all the pines and of Arizona cypress is disturbed by a number of bird species, it is necessary to treat the seed prior to sowing with a bird repellent. Various repellents, such as anthraquinones and thiram materials, are used. Arasan 75, a thiram powder, is used by the Division of Forestry.

Seed to be treated with a bird repellent is handled in the following manner: A sticker of one part Dow Latex 512R, or Rhoplex AC-33, to nine parts of water is mixed thoroughly and placed in a small cement mixer; seed is added and the seed coat thoroughly covered with sticker; then Arasan 75 powder is added at the rate of 10% by weight of the seed to be treated; the mixer is turned until all seed coat surfaces are covered with the powder; the seed is finally spread out to dry.

Sowing is accomplished by means of a shop-made seed drill. The basic parts of the drill are two Oliver belt-type fertilizer spreaders, and eight Planet-Junior seeding units. Seed is sown in rows, although occasionally some seeds have been broadcast, sown by removing the Planet Jr. units. The rows are spaced six inches apart with eight rows to a seed bed. Each bed is therefore about forty-two inches wide.

Watering of the seedbeds is done by a Skinner oscillating system. The water lines are spaced 52 feet apart and are from 300 to 500 feet long. Each line is rotated by an oscillator driven by water pressure and can be adjusted for various widths of coverage. The lines operate on 40 to 60 pounds pressure and apply water at the rate of about 45 gallons per minute for a 500 foot line.

During and immediately after germination, watering is done primarily to reduce ground temperatures. Soil temperatures are checked at intervals throughout the day. When temperatures reach about 95° F. water is applied until the ground surface is moistened thoroughly, usually 30 to 45 minutes. Watering is done throughout the day in this manner. No water is applied after about 3:30 P.M. to permit the ground surface to dry out before night fall. As the plants increase in size, the watering is continued over a longer period of time at less frequent intervals. After about four months, water is applied for periods of three to four hours several times a week.

In certain areas, additional shading may be necessary for species such as Douglas-fir, the true firs, and sugar pine. Lath frames or saran netting are used.

Every two years, after the seedlings are about 12 weeks old, they are given a top dressing of 32-0-0 liquid fertilizer applied through the sprinkler system. Enough fertilizer is applied to bring the available nitrogen level to 200 pounds per acre, if no sawdust was added earlier, and to 1000 pounds per acre if sawdust was added. This 200 or 1000 pounds includes the amount added by the 8-25-0 injected prior to sowing.

Most species are raised for 1-0 seedlings; however white fir, red fir, Scots pine, Sierra redwood, Douglas-fir, and sugar pine should be 2-0 stock when released for field planting.

One of the most thorough books covering the propagation of conifers from seed is the Woody Plant Seed Manual,[1] prepared by the

[1]U.S D A Misc. Pub. No. 654.

United States Forest Service. However in many areas it is outdated. The California Division of Forestry each year prepares a list of commercial seed dealers of plants native to California. This list is available from either the office of the State Forester, State Office Building No. 1, Sacramento, or the Davis Forest Nursery, California Division of Forestry, Route 1, Box 1410, Davis, California.

MODERATOR BATCHELLER: Thank you, Mr. Eden. We will now hear from our last speaker this evening, Mr. Dara Emery, who will discuss seed propagation of some of the native California plants. Mr. Emery.

SEED CULTURE OF CALIFORNIA NATIVE PLANTS

DARA E. EMERY
Santa Barbara Botanic Garden
Santa Barbara, California

This is a discussion of problems likely to be encountered in the seed propagation of California species of *Ceanothus, Fremontia,* and *Rhus.* Seed dormancy of one or more types is common to all these species. When the hot water treatment is used to break the seed coat dormancy, the seeds are added to about four times their volume of water at a temperature of 180° to 190° F., left to cool for 12 to 24 hours, and then sown before drying. Depending on the quality of the local tap water with its additives such as chlorine, iodine or fluorine, significantly better results may be obtained with the hot water treatment by using bottled drinking water, distilled water or rain water, and their use is recommended. The concentrated sulfuric acid treatment may also be used on hard seed. In this treatment it is important that the seeds be thoroughly and repeatedly washed in running water immediately following the prescribed soaking period in order to remove all the excess acid which may still be present in the charred part of the seed coats. For the type of internal dormancy that is sometimes present in seed of these species, the seeds should be put in a tightly sealed polyethylene bag with a small amount of moist peatmoss, placed in a refrigerator at a temperature of 35° to 41° F. for the prescribed period and then sown.

Ceanothus and *Fremontia* seedlings are particularly susceptible to damping-off, and it is extremely important that all soil mixes be sterilized and clean or sanitary cultural practices, such as those presented in the University of California Extension Service's Manual #23 on the U.C. System, be followed. No special soil mixes are required for these species but a very well-drained mix is desirable. The sequence in containers is from seed flat to liners to gallon cans. In some cases the seed flat is omitted and the seed is sown directly into liners.

Ceanothus Species, California Wild Lilac.

The seeds of most California species of *Ceanothus* are long-lived. Seeds ranging in age from seven to sixteen years have given good

United States Forest Service. However in many areas it is outdated. The California Division of Forestry each year prepares a list of commercial seed dealers of plants native to California. This list is available from either the office of the State Forester, State Office Building No. 1, Sacramento, or the Davis Forest Nursery, California Division of Forestry, Route 1, Box 1410, Davis, California.

MODERATOR BATCHELLER: Thank you, Mr. Eden. We will now hear from our last speaker this evening, Mr. Dara Emery, who will discuss seed propagation of some of the native California plants. Mr. Emery.

SEED CULTURE OF CALIFORNIA NATIVE PLANTS

DARA E. EMERY
Santa Barbara Botanic Garden
Santa Barbara, California

This is a discussion of problems likely to be encountered in the seed propagation of California species of *Ceanothus, Fremontia,* and *Rhus.* Seed dormancy of one or more types is common to all these species. When the hot water treatment is used to break the seed coat dormancy, the seeds are added to about four times their volume of water at a temperature of 180° to 190° F., left to cool for 12 to 24 hours, and then sown before drying. Depending on the quality of the local tap water with its additives such as chlorine, iodine or fluorine, significantly better results may be obtained with the hot water treatment by using bottled drinking water, distilled water or rain water, and their use is recommended. The concentrated sulfuric acid treatment may also be used on hard seed. In this treatment it is important that the seeds be thoroughly and repeatedly washed in running water immediately following the prescribed soaking period in order to remove all the excess acid which may still be present in the charred part of the seed coats. For the type of internal dormancy that is sometimes present in seed of these species, the seeds should be put in a tightly sealed polyethylene bag with a small amount of moist peatmoss, placed in a refrigerator at a temperature of 35° to 41° F. for the prescribed period and then sown.

Ceanothus and *Fremontia* seedlings are particularly susceptible to damping-off, and it is extremely important that all soil mixes be sterilized and clean or sanitary cultural practices, such as those presented in the University of California Extension Service's Manual #23 on the U.C. System, be followed. No special soil mixes are required for these species but a very well-drained mix is desirable. The sequence in containers is from seed flat to liners to gallon cans. In some cases the seed flat is omitted and the seed is sown directly into liners.

Ceanothus Species, California Wild Lilac.

The seeds of most California species of *Ceanothus* are long-lived. Seeds ranging in age from seven to sixteen years have given good results in germination tests at the Botanic Garden. Regardless of age, *Ceanothus* seed is quite variable as to the percentage of viable seed. Some species are also variable as to the presence or absence of internal dormancy. Seeds of nearly all the species have hard or impermeable seed coats which can be softened with the hot water treatment. Internal dormancy, when present, is of the type that is broken by cold stratification. See the accompanying chart for specific seed treatment recommendations.

Pre-treated seed starts to germinate in one to five weeks (average two and one half weeks) depending on the species. Eighty or ninety percent germination is not unusual.

Ceanothus seedlings are very subject to damping-off, and this is the most important single problem encountered in seed propagation of this genus. Seedlings seem to suffer less shock when spotted-off at the four- to six-leaf stage than at the two-leaf stage, even though this entails more root damage and often root pruning. Many species are very rapid growing and the use of some type of peat pots is recommended for liners to prevent coiled root systems. Rather severe losses among liners may be experienced two to four weeks after spotting-off, especially if the weather turns cool or if the plants are not kept on the dry side. Spotting-off losses can be avoided by sowing the seed in small peat pots at the rate of one or two seeds per pot.

In summer, during occasional hot spells, losses may occur among gallon can plants that are grown in full sun, even though they are kept adequately moist. Growing the plants under light shade helps to reduce this loss. Another loss may occur among container plants in the fall when summer temperatures drop. This is especially true when they are ready, or nearly ready, to plant out and are grown in full sun. Light shade also helps to reduce this loss.

A fungus disease that is a constant threat to *Ceanothus* of all ages is caused by a species of *Phoma*. This disease, common in the chaparral of certain areas, is spread by air-borne spores which require warmth and moisture to germinate. The disease is therefore most acute during spring and summer, in areas with lots of fog or early-morning dew. The first symptom of this non-systemic disease on container plants is usually the appearance of scattered necrotic leaves which do not drop. It may never go beyond this stage. However, infections that develop on the trunk near the soil-level soon girdle and kill the plant. The control is a preventive spray of parzate or fermate, two pounds per 100 gallons of water plus a little spreader, applied every seven to ten days. Among the *Ceanothus* species and hybrids growing in the Santa Barbara Botanic Garden, *Ceanothus griseus* and its clonal forms seem particularly susceptible to this disease, and the alternate-leaved *Ceanothus,* which are the most popular in cultivation, seem to be more susceptible than the opposite-leaved types.

Recommended Seed Treatment for *Ceanothus* Species

Ceanothus arboreus (Catalina Ceanothus)	Hot water. Two months stratification may further improve germination.

Ceanothus cordulatus (Hoaryleaf Ceanothus; Whitethorn)	Hot water and 3½ months stratification
Ceanothus crassifolius (Hoaryleaf Ceanothus)	Hot water. Three months stratification may further improve germination.
Ceanothus cuneatus (Buckbrush)	Hot water.
Ceanothus cyaneus (San Diego Ceanothus)	Hot water. Three months stratification may further improve germination.
Ceanothus dentatus (Cropleaf Ceanothus)	Hot water and 3 months stratification.
Ceanothus divaricatus (Whitebark Ceanothus)	ditto
Ceanothus diversifolius (Trailing Ceanothus)	ditto
Ceanothus foliosus (Wavyleaf Ceanothus)	Hot water. Three months stratification may further improve germination.
Ceanothus fresnensis (Fresno Mat)	Three months stratification.
Ceanothus greggii var. perplexans (Cupleaf Ceanothus)	Hot water and 3 months stratification.
Ceanothus griseus (Carmel Ceanothus)	Boil in water 1 minute, then cool immediately to room temperature.
Ceanothus impressus (Santa Barbara Ceanothus)	Hot water and 3 months stratification.
Ceanothus incanus (Coast Whitethorn)	Hot water and 2 to 3 months stratification.
Ceanothus integerrimus (Deerbrush)	Hot water and 3 months stratification.
Ceanothus jepsonii (Jepson Ceanothus)	Hot water.
Ceanothus lemmonii (Lemmon Ceanothus)	Hot water and 3 months stratification.
Ceanothus leucodermis (Chaparral Whitehorn)	ditto
Ceanothus megacarpus (Bigpod Ceanothus)	Hot water.
Ceanothus oliganthus (Hairy Ceanothus)	Hot water. Three months stratification may further improve germination.
Ceanothus palmeri (Palmer Ceanothus)	Hot water and 3 months stratification.
Ceanothus papillosus (Wartleaf Ceanothus)	ditto
Ceanothus papillosus var. roweanus (Rowe Ceanothus)	ditto
Ceanothus parryi (Parry Ceanothus)	ditto

Ceanothus parvifolius (Littleaf Ceanothus)	ditto
Ceanothus prostratus (Squaw carpet)	ditto
Ceanothus purpureus (Hollyleaf Ceanothus)	Hot water and 2 to 3 months stratification.
Ceanothus ramulosus var. fascicularis (Coast Ceanothus)	Hot water. Three months stratification may further improve germination.
Ceanothus rigidus & var. alba (Monterey Ceanothus)	Hot water.
Ceanothus sorediatus (Jim Brush)	Hot water. Three months stratification may further improve germination.
Ceanothus spinosus (Greenbark Ceanothus)	ditto
Ceanothus thyrsiflorus (Blue Blossom)	Hot water.
Ceanothus tomentosus var. olivaceus (Woollyleaf Ceanothus)	Hot water. Two to 3 months stratification may further improve germination.
Ceanothus velutinus (Tobacco Brush)	Hot water and 3 months stratification.
Ceanothus verrucosus (Wartystem Ceanothus)	Hot water. Three months stratification may further improve germination.

Fremontia Mexicana, Southern Fremontia and
F. Californica, Flannel Bush.

The problems most apt to occur in seed propagation of *Fremontia mexicana* and *F. californica* are seed dormancy, spotting-off losses, and damping-off of gallon can stock in the early fall. The seeds of both species have hard or impermeable seed coats which yield to the hot water treatment. Pre-treated seeds of *F. mexicana* start to germinate about two weeks after sowing *F. californica* seeds may also have internal dormancy which can be broken by 30 to 60 days of cold stratification. This seed, pre-treated for hard seed coat but not for possible internal dormancy, starts to germinate six to seven weeks after sowing, and germination may be sporadic. Total germination of 65 to 100 percent may be expected for both species. The easiest way to avoid possible spotting-off losses is to sow the seeds singly in 2¼″ or 3″ peat pots. Using a sterilized, well-drained soil mix, following clean cultural practices, keeping the plants on the dry side, and growing gallon stock in light shade helps to avoid possible root rot losses as the weather turns cool in the fall.

Rhus integrifolia, Lemonade Berry and *R. ovata,* Sugar Bush.

Seed dormancy is a problem in *Rhus ovata* and *R. integrifolia.* Both species have tough, impermeable seed coats. This dormancy condition may yield satisfactorily to the hot water treatment, but at the Santa Barbara Botanic Garden the sulfuric acid treatment is preferred. *R. ovata* seed requires soaking in concentrated sulfuric acid for a period of one to several hours. One germination test on freshly-collected garden seed using replicates of 100 seeds each and soaking periods of 1, 2, 3 and 4 hours gave total germination of 35%, 62%, 60% and 24% respectively, with the first germination occurring in eight days on all replicates. In another case, using one-year-old garden seed, 250 seeds soaked 3½ hours gave a total germination of 67%.

Rhus integrifolia seed requires soaking in concentrated sulfuric acid for four hours or longer, depending on the age of the seed. No germination test, such as was made on *R. ovata* seed, has been made on this species at the Garden, and our germination results over the past five years as seen below have not been consistent.

Botanic Garden seed - Year collected —	Date Sown	Treatment period in Conc. Sulfuric Acid	Total germination	Days before first germination
1957	July, 1958	5 hrs.	40%	14
" (same seed lot)	Feb., 1962	4 hrs.	72%	11
1959	June, 1959	4 hrs.	81%	9
" (Same seed lot)	Sept. 3, 1960	4 hrs.	34%	9
" (Same seed lot)	Sept. 24, 1960	5 hrs.	12%	12

To obtain optimum germination with any particular lot of seed, a germination test similar to that mentioned above for *R. ovata* is suggested.

Spotting-off for both species is best done at the two plus leaf stage, and even then the tap roots may be four to six inches long or more. Root pruning does not seem to be detrimental to the seedlings.

FRIDAY MORNING SESSION

October 19, 1962

The second session convened at 8:45 a.m. with Moderator Hudson Hartmann, University of California at Davis, presiding.

THE MODERN ROLE OF MIST PROPAGATION

MODERATOR HARTMANN: Major milestones in the history of plant propagation are rare — especially in the field of propagation by cuttings. In recent years, however we have experienced two such events. One is the development of the auxin concept in plants and the knowledge of the effects of synthetic plant growth regulators, and the discovery that one of these effects is the stimulation of adventitious roots on stem cuttings. This development started about 1935, and the mass of knowledge accumulated since then has been tremendous, leading now to routine applications of auxins, as IBA, to cuttings.

The second development we have witnessed in recent years has been the discovery, starting in the 1940's, that rooting of leafy cuttings is greatly enhanced by keeping the leaves wet by means of mist sprays. This has greatly increased the scope of plant materials we are able to propagate by cuttings. Just why this is so will be explained by our first speaker, Dr. Hess. Following this, Peter Mordigan will discuss how these new techniques of mist propagation have influenced the economics of plant production.

There are many plant species, which in the past have been so difficult to start from cuttings that we have been resigned to using seed propagation for them, and accepting the seed variability and dormancy problems. This has been particularly true for some of the native plant types. Don Sexton, at the University of California Arboretum at Davis, has been doing considerable work in trying to get many such plants started by using mist. During his trials he has accumulated much information which he is going to discuss today.

Finally we will hear a talk by Floyd Dillon, Fred Real, and Don Dillon on one of the most interesting applications of mist I have seen — producing a grafted plant by healing the graft union and getting roots started on the rootstock — all in one simultaneous operation under mist. The Dillons are working with citrus, but I am sure this technique could be applied to many other plant types.

To start our Symposium this morning, we will have a discussion by Dr. Charles Hess, Associate Professor of Horticulture, Purdue University, on the Theory of Mist Propagation. Dr. Hess:

THE THEORY OF MIST PROPAGATION

CHARLES E. HESS
Department of Horticulture
Purdue University
Lafayette, Indiana

Mist propagation is a form of automated syringing which has proven itself in both experimental and commercial use. A number of plants are now being propagated from cuttings which formerly were grafted, and plants which are easy-to-root can be propagated in a shorter time. Also the time in which a cutting can be taken and successfully rooted has been extended by the use of mist. Although timing is still very important, it is not quite as critical as it is for other types of propagation practices.

The question may now be asked, if mist is really automated syringing, why is there such a difference in the results obtained with mist as compared to the standard double glass technique? Why is it, for example, that with *Prunus serrulata* 87% rooting is obtained in 32 days under mist where as only 37% is realized under double glass, or similarly with *Cornus florida rubra,* 96% rooting is obtained under mist compared with 22% under double glass?

To find the answers to these questions, we started by studying the environment under the two conditions — mist and double glass. First we measured temperature. Using very fine thermocouples and a Minneapolis Honeywell multiple recording potentiometer we continuously recorded leaf, air, and rooting medium temperatures. The results from a typical 24 hour period are shown in Figure 1. It can be seen that the leaf tissue temperature under double glass was consistantly higher. This was particularly true during the day, when there was as much as a 30° F. difference. On the average, during a 24 hour period, the leaf tissue temperature was 11° F. higher under double glass. This large and consistant difference in temperature can affect a cutting in many ways.

First, let us consider water relations. As you know leaves contain thousands of pores which are essential for the exchange of carbon dioxide and oxygen. These pores also provide an outlet for the loss of water vapor. Whether or not the loss of water vapor (transpiration) is beneficial to a plant is problematical. In an intact plant the loss of water from the leaves is compensated by water taken up by the roots. But the propagator, as his first step in preparation of a cutting, is to severe the shoot from its water supply. Now, the loss of water vapor becomes a very serious problem, since if it is not reduced, the cutting will wilt and die.

Of all the differences noticed between mist and double glass propagation, perhaps the most pronounced is the ability of the cuttings to maintain turgidity, even when extremely soft cuttings are used. The ability to maintain turgidity under mist is not explained by the presence of more water vapor in the air. In fact the vapor pressure under the two conditions is approximately the same. However, the difference in leaf temperature as described above can cause the difference. Using the data given in Figure 1 we can calculate on a theoretical basis the tendency of a leaf to lose water. In Table 1 you can see with the 11° F differential in temperature between mist and double glass that the vapor pressure gradient under double glass is over twice that under mist. In other words cuttings under double glass can potentially lose twice as much water as a cutting under mist.

Experimental results bear out the theoretical conclusions. Figure 2 shows a comparison of fresh and dry weights under mist with those under double glass. Fresh weight under mist increases significantly as does dry weight. But under double glass the cuttings actually lose fresh and dry weight. Under mist an average cutting gained 4.14 grams of water during the propagating period while an average cutting under double glass lost 1.88 grams of water.

A second way a large temperature differential can affect a cutting is by speeding up respiration or food utilization. Within the normal range of temperatures used for growing plants, a 10° F. increase in temperature will double the rate of respiration. Therefore, cuttings under double glass are using the products of photosynthesis at twice the rate of the cuttings under mist. This in itself is a serious problem since the soft cuttings, which are ideal for mist propagation, contain low carbohydrate reserves. But the problem is greatly magnified by another environmental difference between mist and double glass. This is the difference in light intensity.

The confined air space under double glass acts as a heat trap. If not heavily shaded, the air and tissue temperatures of the cuttings

Table 1. A Comparison of Vapor Pressure in Leaves Under Mist and Double Glass

	Mist	Double Glass
Leaf temperature	75°F	86°F
Vapor pressure within leaf (mm Hg)	23.76	31.82
Vapor pressure of surrounding air (mm Hg)	17.50	17.50
Vapor pressure gradient (mm Hg)	6.26	14.32

reach a point where the cuttings are killed or are severely "burned." But as a consequence of the shading, the average light intensity under double glass was 240 foot candles. In contrast under mist, where no shade was used, the average light intensity was 7000 foot candles.

The processes of respiration and photosynthesis under mist and double glass are compared in Table 2. In this experiment with *Cornus florida* the percentage rooting in 21 days was 96% under mist and 22% under double glass. In the mist bed, with an average temperaure of 75° F and a light intensity of 7000 foot candles, the rate of photosynthesis was equivalent to 6.93 mg of CO_2 taken up each hour by each square centimeter of leaf area. The cuttings under double glass exposed to 80° F. and 240 foot candles of light were ac-

Table 2. **Comparison of Rooting, Photosynthesis and Respiration Under Mist and Double Glass**

	Mist	Double Glass
Percent Rooting (*Cornus florida*)	96%	22%
Average Leaf Temperature	75°F	86°F
Respiration (mg CO_2/hr/cm^2)	- - -	5.26
Photosynthesis (mg Co_2/hr/cm^2)	6.93	- - -
Increase in carbohydrates (mg per cutting)	138.0	17.2

tually respiring rather than manufacturing carbohydrates. The rate of respiration was equivalent to 5.26 mg of CO_2 given off every hour by each square centimeter of leaf. The cuttings under double glass were utilizing carbohydrates almost as fast as they were being manufactured under mist. As a result the cuttings under mist gained 138 mg of carbohydrate per cutting while under double glass there was an increase of only 17.2 mg per cutting. The increase was 8 times greater under mist. The rooting potential of a cutting, and particularly a soft-wood cutting, is very closely related to its carbohydrates supply and the substances which can be synthesized from this starting material. A cutting under mist with 8 times more carbohydrates will have a much better chance of rooting than a cutting under double glass.

The reasons, therefore, that cuttings under mist root better than cuttings under double glass can be attributed to a few main factors. One, the reduced leaf temperature under mist reduces the transpiration rate without the necessity of having a confined air space. The reduced leaf temperature is probably due to a combination of cooling by the water itself, if it is indeed at a lower temperature, and by the evaporation of the water from the leaf surfaces during the "off mist" periods.

Since a confined air space is not necessary with mist, shading or

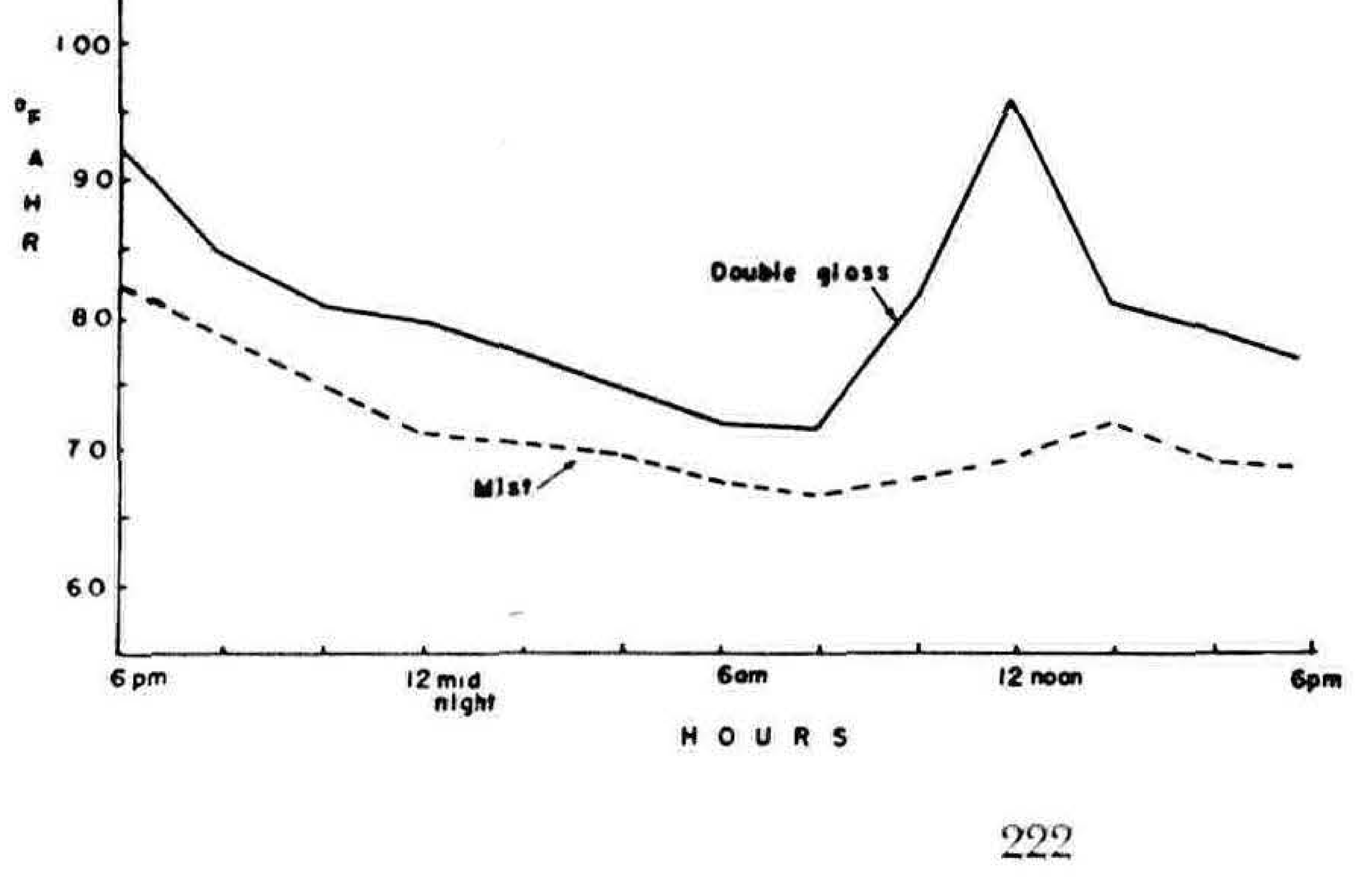

FIG. 1. Leaf tissue temperature under mist and under double glass during a 24 hour period

at least heavy shading is not required. Therefore, much higher light intensities can be used.

The combination of high light intensity and reduced tissue temperature results in situation where the products of photosynthesis can actually accumulate and be utilized in the process of root initiation. Cuttings under the low light, high temperature environment of double glass actually utilize carbohydrates at rate greater than they are manufactured during most of the propagating period.

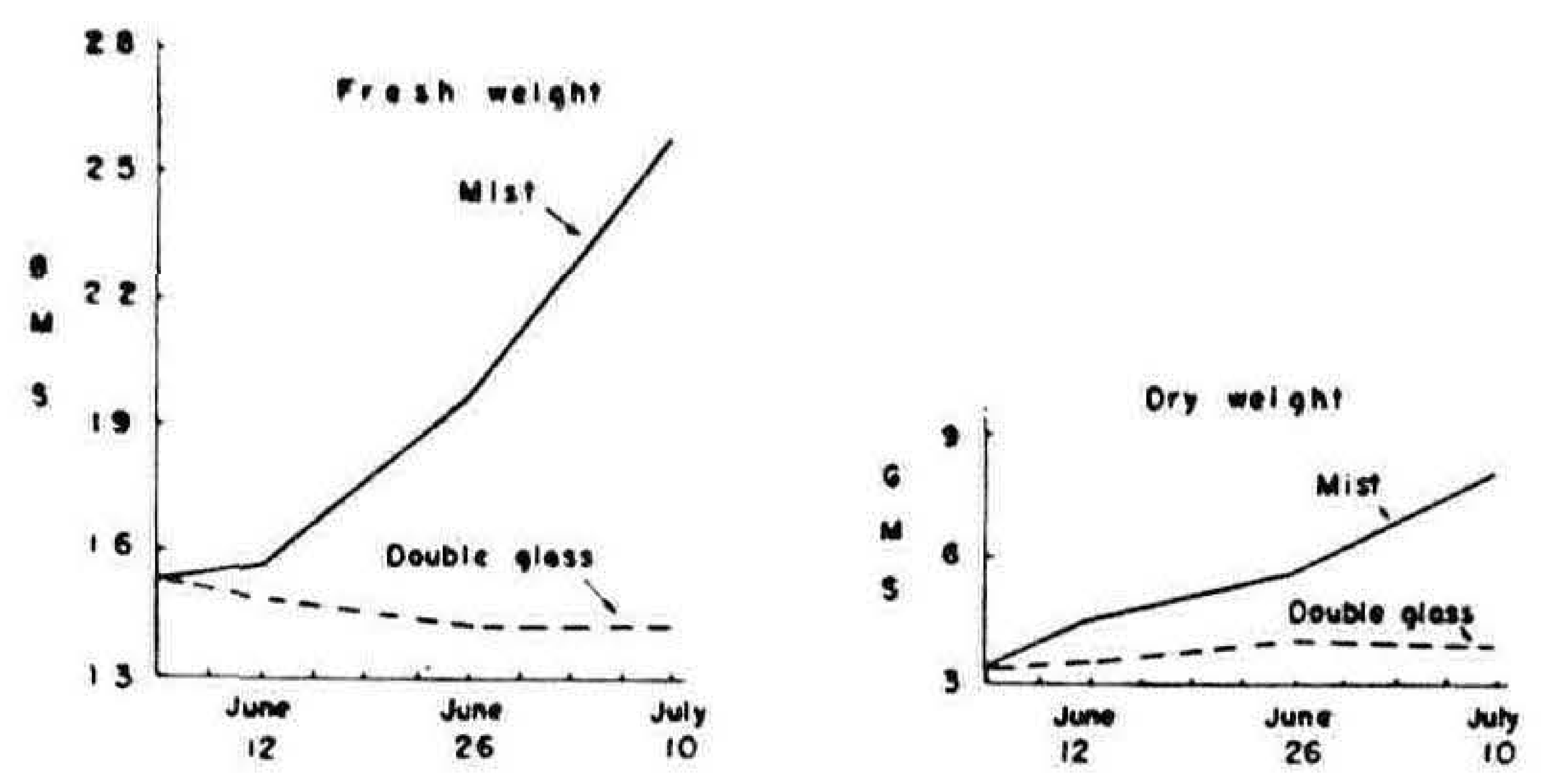

FIG. 2. Comparison of fresh and dry weight of cuttings under mist and double glass

	Gain in fresh weight	Gain in dryweight	Water increase x loss
Mist	8.85 gm	4.17 gm	4.14 gm
Double glass	− 1.22 gm	0.66 gm	− 1.88 gm

MODERATOR HARTMANN: Thank you, Charles, for a most enlightening discussion. I think we can see now that the better results we have been obtaining with mist is not just a matter of good luck, but it is based on sound physiological principles, which are not difficult to understand.

We will now hear from Mr. Peter Mordigan, of Mordigan's Evergreen Nurseries, Sylmar, California, who will discuss the Economics of Mist Propagation. Mr. Mordigan.

THE ECONOMICS OF MIST PROPAGATION

PETER MORDIGAN
Mordigan Evergreen Nurseries
Sylmar, California

The increased use of mist propagation throughout the country has necessitated that progressive propagating nurseries experiment and energetically use their findings for the sole purpose of a more efficient operation. The cost of production has become such a serious problem that thoughtful propagators should stop and analyze their particular situation. There are those who are already satisfied with their results. However, there are many who are interested in new methods of propagation. Perhaps this discussion on "The Economics of Mist Propagation" will give hope and comfort to the new adventurer and give reassurance to the "Old Timer" that he is on the right track. To best illustrate this, a quick analysis of our own operation, should throw a new light on the subject.

at least heavy shading is not required. Therefore, much higher light intensities can be used.

The combination of high light intensity and reduced tissue temperature results in situation where the products of photosynthesis can actually accumulate and be utilized in the process of root initiation. Cuttings under the low light, high temperature environment of double glass actually utilize carbohydrates at rate greater than they are manufactured during most of the propagating period.

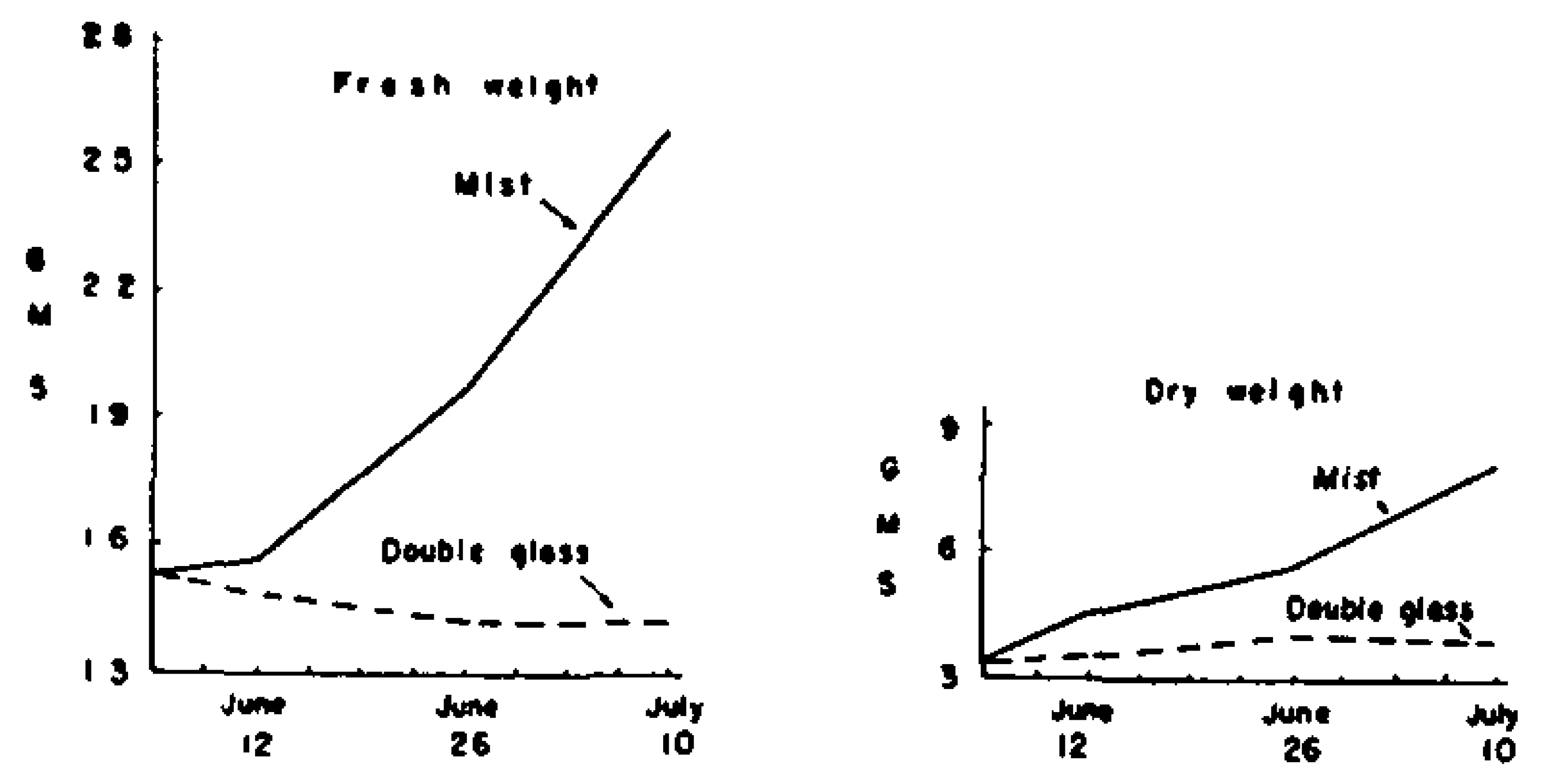

FIG. 2. Comparison of fresh and dry weight of cuttings under mist and double glass

	Gain in fresh weight	Gain in dryweight	Water increase x loss
Mist	8.85 gm	4.17 gm	4.14 gm
Double glass	− 1.22 gm	0.66 gm	− 1.88 gm

MODERATOR HARTMANN: Thank you, Charles, for a most enlightening discussion. I think we can see now that the better results we have been obtaining with mist is not just a matter of good luck, but it is based on sound physiological principles, which are not difficult to understand.

We will now hear from Mr. Peter Mordigan, of Mordigan's Evergreen Nurseries, Sylmar, California, who will discuss the Economics of Mist Propagation. Mr. Mordigan.

THE ECONOMICS OF MIST PROPAGATION

PETER MORDIGAN
Mordigan Evergreen Nurseries
Sylmar, California

The increased use of mist propagation throughout the country has necessitated that progressive propagating nurseries experiment and energetically use their findings for the sole purpose of a more efficient operation. The cost of production has become such a serious problem that thoughtful propagators should stop and analyze their particular situation. There are those who are already satisfied with their results. However, there are many who are interested in new methods of propagation. Perhaps this discussion on "The Economics of Mist Propagation" will give hope and comfort to the new adventurer and give reassurance to the "Old Timer" that he is on the right track. To best illustrate this, a quick analysis of our own operation, should throw a new light on the subject.

Our operation is in the Sylmar area of the San Fernando Valley in Southern California. It is an area 1160 ft. above sea level with extremes of 105° F to 29° F; windy from October to May; sunny days, 300 plus when there is no smog. Any similarity to other places is co-incidental.

We have three areas in which mist propagation is in operation. One has electric cables for heating, the other two have circulating hot water.

Number 1 Mist House, (and by the way — the first in California), has dimensions of 34′ x 36′ with solid redwood sides up to 24″ then 1 x 2 redwood slats to enclose the area. Thirty percent saran cloth was used to cover the top. This saran coverage was necessary because leaves from a deciduous tree adjacent to the mist house fall continuously.

Our observations point out that the haze of water mist gives a blanketed effect on the cuttings, which in turn eliminates the cost of lath or saran covering. Besides, the higher light intensity on these plants, especially on short winter days was most beneficial. The mist system was installed 6′ above the cutting beds and consists of nine lines of 3/8″ copper tubing with ten Monarch 160 mist nozzles spaced at 4′ centers on each line. This has resulted in an ideal coverage condition.

Each of these lines can be operated independently or all as a unit. This was done by installing a manually-operated valve on each line, which is used as conditions require. For example; first, controlled watering of rooted cuttings for hardening purpose; second, on our many, many windy days, we can shut off, by manual operation, all but one line on the windward side. As the continuous gust of wind hits this line of mist, the whole propagating area is blanketed with a swirling, floating fog-like mist. This is an important saving of water when it is realized that this condition can be constant for several weeks at a time. Also, it is a big factor in lessening salinity problems. Further, by the use of by-pass valves, the whole system is operated intermittently by a clock which can be switched off. We wish to emphasize that we disagree with the theory that mist areas should be protected from winds to prevent water loss from cuttings. The proof is in our own operation.

Our flats are placed on raised beds 8″ high, enclosed on all sides to ensure uniform heat from electrical cables stretched upon a surface of gravel. This creates an area in which the hot, moist air is confined close to the base of the cuttings in the flats. The cool mist from the top and the warm moist air from the bottom creates an ideal environment for rapid rooting and slow top growth We have not as yet encountered *Rhizoctonia* or any other diseases under these conditions. Due to compactness and efficient use of space it is interesting to note that this house has a capacity of 460 flats; the aisles will hold an additional 84 flats. Averaging 300 to 500 cuttings to a flat, the potential capacity of this house is 200,000 plus cuttings. The capital output of $1200 to construct this house is small compared to the low operational cost and highly efficient performance.

In contrast to this low cost propagation house, we had previously constructed an 18′ x 36′ greenhouse for a total sum of $4,000. This house included mist, fans, coolers and hot water heating. We had an idea that we would speed up production. However, we were due for a disappointment. In the first year of operation over 50% of the cuttings had to be thrown out due to *Rhizoctonia* infestation. It was not long before we realized that something had to be done. We cut down the benches to 16″ and enclosed the sides to prevent heat loss. We utilized the heating line adjacent to the outside walls of the greenhouse and built two enclosed benches for additional space flanking the greenhouse to hold 86 more flats. We redesigned the mist system. We opened the sides of the greenhouse below bench level to allow heat to reach these new areas. The mist operation is controlled both by a clock and a humidistat. However, we still feel that manual operation is necessary for complete control. All roof vents in this house are kept open at all times with the exception of hot, dry, windy days. To insure efficiency of operation, high percentage of rooting, and elimination of *Rhizoctonia,* we installed on each hot water line a mist line which operates at night or on cold days when the hot water is circulating. The hot, moist air created filters through the flats, keeping the cuttings in a turgid condition, thus elminating the necessity of overhead misting geared to the humidistat. The over-all capacity of this house is now 276 flats or 100,000 plus cuttings.

In the construction of a third house we capitalized on our experience from the two previous constructions. However, in this case we left all sides and top open. The capacity of this house is 296 flats or 118,000 plus cuttings. By these figures you can readily see that economical production of cuttings under mist is not only probable but very much possible. Bear in mind, however, that the solution of the problem is not the same in any two given areas.

To sum up this discussion, our pattern of economy has been the maintenance of a certain sense of uniformity in all three of our mist propagation houses with continuity in compactness, in design, and in operation. Our results are most gratifying. We have had our failures but they have come from our over-anxiousness. We let caution go to the wind when hot items were in demand. That is a human failure, not a mechanical one.

We have observed in this mist propagation a factor that often may not be recognized. That is, the ease with which plants propagate, given the ideal conditions. This success gives the propagator a sense of confidence in what he is doing, which in turn spurns him to greater success both economically and spiritually.

MODERATOR HARTMANN: Thank you, Mr. Mordigan. We will now hear from Mr. Don Sexton in regard to his work in rooting cuttings of California native plant species under mist. Don.

MIST PROPAGATION OF CUTTINGS FROM NATIVE CALIFORNIA PLANTS

Don K. Sexton
Botanical Garden Botanist
University of California, Davis, California

During the past 6 years the author has propagated native California plants from cuttings, under mist spray, for use in the University of California Arboretum on the Davis Campus. In many instances only a limited number of plants has been desired, and propagation of a particular species has been attempted on only one or two occasions. In other instances, especially with ground-cover plants, a number of lots involving many cuttings have been grown. Records have been kept of each lot of cuttings.

In general, California native plants respond to attempts at cutting propagation under mist in much the same manner as do other plants. However, many species require better drainage, both in the rooting medium and after potting, than do most plants.

Several factors must be taken into account in this type of propagation. First, the condition of the stock plant from which the cuttings are to be taken must be considered. Rather soft, leafy cuttings with a firm or even mature base are best, although very soft tips may dry or wilt before callusing. Most species produce suitable cutting wood in early summer or after fall rains under natural conditions in our area. Deciduous plants should be propagated early enough in summer to allow a flush of new growth before dormancy sets in. Propagation from relatively young seedlings or cutting-grown stock plants is more often successful, even when these plants are still in the nursery, than propagation from older plants.

Another factor is the freshness of the cuttings. They must not dry out. If held in transit, the cut material should be stored in polyethylene bags in the shade. Cuttings should, however, be planted as soon as possible or at least placed under the mist.

The rooting medium we use generally is a coarse sand or granite grit. Sometimes a mixture of perlite and vermiculite is used. Cuttings are soaked in Panogen soil drench and, after drying a few minutes, the bases dipped for 10 seconds in a 4,000 ppm solution of indolebutyric acid.

During the first week, the cuttings must be covered thoroughly by the mist, especially when the sun is shining on them. Available sunlight is an important factor in callus and root initiation, which are greatly delayed by prolonged cloudy or foggy weather. In Davis, October is a good month for taking cuttings of most species; the work should be completed by mid-November for best results. Our spray is not heated nor do we have bottom heat; in winter this is an undesirable factor. Too much water in the rooting medium is also undesirable; therefore it is important to have the best possible drainage, especially in winter. The 3¾-inch deep flats have holes drilled in the bottom and are set above the bench on ½-inch stakes. Once the cuttings are fairly well rooted, with several 1-inch roots, the cuttings should be potted. The longer they remain in the rooting medium under the mist, the more likely they are to rot. This is especially important in the case of slow-rooting species which take 8 weeks or longer to root.

We plant the cuttings into 3-inch peat pots. Potting soil is one part sand to two parts rich clay loam containing humus. The proportion of sand may be increased in winter. Hardening-off the cuttings is a problem. The roots and stem bases are subject to rotting, and the tips easily dry. The potted plants are left under the mist for several days and then are removed to a humid environment and shaded. After a few days, the newspaper shading is removed. As soon as roots appear through the pots or the tops begin to push out new growth, the pots are moved to a less humid area. Here they are kept until the plants have hardened sufficiently to be placed under lath.

It is important to remember that most native plants must never be over-potted, over-watered, or over-fertilized. We keep them for some time in peat pots, then in 4-inch pots before moving to gallon cans. They are given water only when the peat pots or soil appears dry. Distilled water is used in the greenhouse to avoid serious salt and boron injury caused by use of the local well water. No fertilizer is used as the potting soil is sufficently fertile.

Records of results may be summarized by placing the species in three groups:

1) Species rooting readily — more than 50% potted up and usually established.
2) Species and varieties in which approximately half the cuttings have rooted. In many instances, however, only a few of the cuttings have been successfully carried on to established plants.
3) Those difficult to root, or which have failed to root under the conditions of the tests.

Propagation under mist of cuttings from native California plants
University of California Arboretum, Davis, California. 1956-1962

1) Easily Rooted and Established
   - *Arctostaphylos densiflora* 'James West'
   - *A. hookeri*
   - *A. insularis*
   - *A. uva-ursi*
   - *Baccharis pilularis*
   - *Ceanothus arboreus*
   - *C. gloriosus*
   - *C. griseus*
   - *C.* var. *horizontalis*
   - *C. maritimus*
   - *C.* x 'Ray Hartmann'
   - *C.* x 'Sierra Blue'
   - *Diplacus* hybrids (firm wood)
   - *Encelia* spp.
   - *Eriophyllum* spp.

Eriogonum arborescens
E. x *blissianum*
Lepechinia calycina
Malvastrum spp.
Monardella spp.
Penstemon spp. (most)
Ribes sanguineum
Salvia spp.
Solanum spp.
Trichostema lanatum
Zauschneria spp.

2) Approximately 50% Rooted and Established

Arctostaphylos densiflora 'Sentinel'
A. *edmundsii*
A. *pajaroensis*
Artemisia spp.
Ceanothus purpureus
C. x 'Mountain Haze'
Eriogonum fasciculatum
E. (prostrate)
E. *grande*
E. *rubescens*

3) Failed or Very Few Rooted and Established

**Arctostaphylos manzanita*
A. *viridissima*
A. *viscida*
Carpenteria californica
**Ceanothus impressus*
C. *integerrimus*
**C.* *lemmonii*
**C.* *megacarpus*
C. *papillosus*
C. *papillosus* var. *roweanus*
C. *thyrsiflorus* var. *repens*
C. *tomentosus*
C. x 'Julia Phelps'
Eriodictyon spp.
Eriogonum crocatum
E. *giganteum*
Fremontia mexicana
Garrya spp.
**Lupinus* spp.
**Rhamnus californica*
R. *crocea*
R. *crocea* var. *ilicifolia*
**Rhus integrifolia*
R. *ovata*
Ribes speciosum

---

*Asterisk indicates species in which a very few cuttings were rooted and became established.

MODERATOR HARTMANN: Thank you, Don. We will hear a series of three talks from the Four Winds Nursery at Mission San Jose, California, dealing with a most interesting operation of rooting cuttings and healing a graft union simultaneously under mist. The speakers will be Mr. Floyd Dillon, Mr. Fred Real, and Mr. Don Dillon. Floyd Dillon will start. Floyd.

SIMULTANEOUS GRAFTING AND ROOTING OF CITRUS UNDER MIST

Part One—"Environment and Mother Plants"

FLOYD DILLON
Four Winds Growers
Mission San Jose, Fremont, California

Optimum citrus environment is the reason for the location of our growing grounds at historical Mission San Jose, Alameda County, California. We are now a part of the new City of Fremont.

Here, in 1797, the 14th Mission of the ultimate 21 Mission chain, was established. It proved to be an ideal climatic location.

In the 1840's Captain Fremont, after exploring most of the West, selected Mission San Jose as the place for his future permanent home, "Casa Fremontia."

I quote a portion of a letter, now in the Bancroft Library, University of California, from Fremont, written at Mission of San Jose in September, 1846.

"This is a pretty place — this Mission. The gardens or orchards might be made handsome places, but to render them valuable, possession of the water which comes from a ravine in the hills is essential. A handsome plain of good lands extends from the hills towards San Francisco Bay and could be well watered."

I will add — he didn't get this land — but Fremont is a rightful name for our city. Our 6-acre growing grounds are on Mission land, on the foothill bench, sloping to the west.

The drainage of cold air is ideal. The Mission elevation is 300 feet, ours about 200 feet, while Niles, about 3 miles from us has an elevation of 45 feet.

This is a thermal belt, relatively frost free (but we had snow last winter!) Orange trees are common here in the dooryard gardens of the older homes. The sun gives ample heat. The area is free of noxious weeds, difficult scales, and free of the lethal virus, Tristeza — commonly called "Quick Decline." We ship pinto tag. Our water is from Hetch Hetchy reservoir (San Francisco water supply), and of exceptionally good quality. The right climatic environment is basic because all of our propagation is from mother-plant twigs. These mother plants are grown in the open air, without shelter from the elements. Having the right wood to propagate is essential. However, the propagation of these twigs and their simultaneous healing and rooting is done under controlled hot house conditions.

MODERATOR HARTMANN: Thank you, Don. We will hear a series of three talks from the Four Winds Nursery at Mission San Jose, California, dealing with a most interesting operation of rooting cuttings and healing a graft union simultaneously under mist. The speakers will be Mr. Floyd Dillon, Mr. Fred Real, and Mr. Don Dillon. Floyd Dillon will start. Floyd.

SIMULTANEOUS GRAFTING AND ROOTING OF CITRUS UNDER MIST

Part One—"Environment and Mother Plants"

FLOYD DILLON
Four Winds Growers
Mission San Jose, Fremont, California

Optimum citrus environment is the reason for the location of our growing grounds at historical Mission San Jose, Alameda County, California. We are now a part of the new City of Fremont.

Here, in 1797, the 14th Mission of the ultimate 21 Mission chain, was established. It proved to be an ideal climatic location.

In the 1840's Captain Fremont, after exploring most of the West, selected Mission San Jose as the place for his future permanent home, "Casa Fremontia."

I quote a portion of a letter, now in the Bancroft Library, University of California, from Fremont, written at Mission of San Jose in September, 1846.

"This is a pretty place — this Mission. The gardens or orchards might be made handsome places, but to render them valuable, possession of the water which comes from a ravine in the hills is essential. A handsome plain of good lands extends from the hills towards San Francisco Bay and could be well watered."

I will add — he didn't get this land — but Fremont is a rightful name for our city. Our 6-acre growing grounds are on Mission land, on the foothill bench, sloping to the west.

The drainage of cold air is ideal. The Mission elevation is 300 feet, ours about 200 feet, while Niles, about 3 miles from us has an elevation of 45 feet.

This is a thermal belt, relatively frost free (but we had snow last winter!) Orange trees are common here in the dooryard gardens of the older homes. The sun gives ample heat. The area is free of noxious weeds, difficult scales, and free of the lethal virus, Tristeza — commonly called "Quick Decline." We ship pinto tag. Our water is from Hetch Hetchy reservoir (San Francisco water supply), and of exceptionally good quality. The right climatic environment is basic because all of our propagation is from mother-plant twigs. These mother plants are grown in the open air, without shelter from the elements. Having the right wood to propagate is essential. However, the propagation of these twigs and their simultaneous healing and rooting is done under controlled hot house conditions.

We grow our own original mother plants, both rootstocks and scions. Our selections and methods are based on "research," if you will pardon our usage of this word with this definition — "If one appropriates another man's idea, that is stealing; but if you combine the ideas of many experts along with your own, that is research." We should confess plagarism in "twig-grafting.' Dr. Halma and fellow member Ted Frolich of UCLA really taught us their methods. Ted not only grafts two twigs, he often sandwiches them 3 or 4 high in his researching at UCLA. We hold to this belief — to secure identical results and keep on producing identical results, we must use identicals, both rootstock and scion. While the specific scion strains are generally well known and recognized, this does not hold true with rootstocks. Citrus seedling rootstocks are quite variable. That is why we use twigs of rootstock mother plants, not seedlings, in our propagation. Most of our scion varieties are progeny of one mother tree of the variety. To a lesser degree this is true of our rootstocks. Our objective is to have every twig-graft, both rootstock and scion, the progeny of a specific mother plant. Conditions change, however; nucellar strains are causing the abandonment of old-line strains. The California citrus industry now is committed to a long range program of producing an indexed, disease-free planting at Lind Cove, in Tulare County. This is being ably developed by Dr. William Bitters and associated horticulturists of the University of California at Riverside. It takes a long time to draw conclusions. When such new, indexed, budwood is available, our mother plants will be replaced with new mother plants which will grow from Lind Cove buds.

An ample supply of the right hardened-off twigs of new growth are a must to successful twig grafting. Both scionwood and rootstock wood must be simultaneously available at the right time.

SIMULTANEOUS GRAFTING AND ROOTING OF CITRUS UNDER MIST

Part Two—"Propagation"

FRED REAL
Four Winds Growers
Mission San Jose, Fremont, California

In grafting and rooting citrus simultaneously, our propagators go out into our mother blocks and cut twigs of scion wood and understock, using the last growth cycle. When the twigs are grafted and ready to be flatted, they are on the average 12 inches long. Our propagators gather their own wood each morning and never is the wood allowed to get dry. The twigs are always kept moist and when they are brought into our propagating room they are dipped into a fungicide solution containing ½ cup P.C.N.B. and 2½ cups of Captan (40 percent wettable powder) in 20 gallons of water.

When the preceeding preparations have been made, our propagators start making their grafts. The cut for the graft is ½ to ¾ inches long at about a 30° angle. After the graft has been made, it

We grow our own original mother plants, both rootstocks and scions. Our selections and methods are based on "research," if you will pardon our usage of this word with this definition — "If one appropriates another man's idea, that is stealing; but if you combine the ideas of many experts along with your own, that is research." We should confess plagarism in "twig-grafting.' Dr. Halma and fellow member Ted Frolich of UCLA really taught us their methods. Ted not only grafts two twigs, he often sandwiches them 3 or 4 high in his researching at UCLA. We hold to this belief — to secure identical results and keep on producing identical results, we must use identicals, both rootstock and scion. While the specific scion strains are generally well known and recognized, this does not hold true with rootstocks. Citrus seedling rootstocks are quite variable. That is why we use twigs of rootstock mother plants, not seedlings, in our propagation. Most of our scion varieties are progeny of one mother tree of the variety. To a lesser degree this is true of our rootstocks. Our objective is to have every twig-graft, both rootstock and scion, the progeny of a specific mother plant. Conditions change, however; nucellar strains are causing the abandonment of old-line strains. The California citrus industry now is committed to a long range program of producing an indexed, disease-free planting at Lind Cove, in Tulare County. This is being ably developed by Dr. William Bitters and associated horticulturists of the University of California at Riverside. It takes a long time to draw conclusions. When such new, indexed, budwood is available, our mother plants will be replaced with new mother plants which will grow from Lind Cove buds.

An ample supply of the right hardened-off twigs of new growth are a must to successful twig grafting. Both scionwood and rootstock wood must be simultaneously available at the right time.

SIMULTANEOUS GRAFTING AND ROOTING OF CITRUS UNDER MIST

Part Two—"Propagation"

FRED REAL
Four Winds Growers
Mission San Jose, Fremont, California

In grafting and rooting citrus simultaneously, our propagators go out into our mother blocks and cut twigs of scion wood and understock, using the last growth cycle. When the twigs are grafted and ready to be flatted, they are on the average 12 inches long. Our propagators gather their own wood each morning and never is the wood allowed to get dry. The twigs are always kept moist and when they are brought into our propagating room they are dipped into a fungicide solution containing ½ cup P.C.N.B. and 2½ cups of Captan (40 percent wettable powder) in 20 gallons of water.

When the preceeding preparations have been made, our propagators start making their grafts. The cut for the graft is ½ to ¾ inches long at about a 30° angle. After the graft has been made, it is tied with a rubber band. The grafted twigs are put back under mist. After making twig grafts, our propagators dip the plants into the fungicide again before "stumping" them. The cut on the base of the plant is made square, dipped in hormone and flatted up.

The hormone we use is a formula given to us by O. A. Matkin, head of the Soil and Plant Laboratory, Inc., Orange, California. At one time we used Hormodin No. 3, and indolebutyric Acid in a liquid. The hormone we are now using consists of:

1.0	grams indolebutyric acid
25.0	grams fermate
99.0	grams talc
125.00	grams

We find it cheaper and it works just as well, if not better than, the hormone previously used.

During the course of the day if any twig is dropped or has fallen to the floor, it is always put back through the fungicide before it is returned to the working bench. Flats used to carry or hold plants while flatting, or when grafting, and containers used for the hormone are dipped in fungicide before being put away for the day. All excess hormone is thrown away every day.

Our grafting room is maintained in a state of "kitchen cleanliness." Access is limited to people who work there. At the end of each day's work, it is thoroughly cleaned. All prunings and left-over wood are discarded. The mist case in which twigs and completed twig-grafts are held during the day is scrubbed, using 16 ounces of 25 per cent Clorox in 2½ gallons of water. The table and counter tops, which are covered with vinyl linoleum, are scrubbed with the same solution. All tools are cleaned and stored in lined drawers. The floor is scrubbed, even the windows are washed daily. When completed we can go home.

SIMULTANEOUS GRAFTING AND ROOTING OF CITRUS UNDER MIST

Part Three—"Hot House Operation"

DON DILLON
Four Winds Growers
Mission San Jose, Fremont, California

We have adopted the U. C. System for container-grown plants, as discussed in University of California Manual 23, as the foundation of our growing operation. We are convinced that mother blocks of clean planting stock are essential for a sound growing operation. This is the first principle to support the production of quality nursery stock. The second principle is proper soil treatment. We use a modified U. C. soil mix, in that we use redwood sawdust instead of peat moss. The soil mix is an essential part of our operation. The last principle is proper sanitary practices. We make a real effort here also. All of these practices are necessary. They are goals. We recis tied with a rubber band. The grafted twigs are put back under mist. After making twig grafts, our propagators dip the plants into the fungicide again before "stumping" them. The cut on the base of the plant is made square, dipped in hormone and flatted up.

The hormone we use is a formula given to us by O. A. Matkin, head of the Soil and Plant Laboratory, Inc., Orange, California. At one time we used Hormodin No. 3, and indolebutyric Acid in a liquid. The hormone we are now using consists of:

1.0	grams indolebutyric acid
25.0	grams fermate
99.0	grams talc
125.00	grams

We find it cheaper and it works just as well, if not better than, the hormone previously used.

During the course of the day if any twig is dropped or has fallen to the floor, it is always put back through the fungicide before it is returned to the working bench. Flats used to carry or hold plants while flatting, or when grafting, and containers used for the hormone are dipped in fungicide before being put away for the day. All excess hormone is thrown away every day.

Our grafting room is maintained in a state of "kitchen cleanliness." Access is limited to people who work there. At the end of each day's work, it is thoroughly cleaned. All prunings and left-over wood are discarded. The mist case in which twigs and completed twig-grafts are held during the day is scrubbed, using 16 ounces of 25 per cent Clorox in 2½ gallons of water. The table and counter tops, which are covered with vinyl linoleum, are scrubbed with the same solution. All tools are cleaned and stored in lined drawers. The floor is scrubbed, even the windows are washed daily. When completed we can go home.

SIMULTANEOUS GRAFTING AND ROOTING OF CITRUS UNDER MIST

Part Three—"Hot House Operation"

Don Dillon
Four Winds Growers
Mission San Jose, Fremont, California

We have adopted the U. C. System for container-grown plants, as discussed in University of California Manual 23, as the foundation of our growing operation. We are convinced that mother blocks of clean planting stock are essential for a sound growing operation. This is the first principle to support the production of quality nursery stock. The second principle is proper soil treatment. We use a modified U. C. soil mix, in that we use redwood sawdust instead of peat moss. The soil mix is an essential part of our operation. The last principle is proper sanitary practices. We make a real effort here also. All of these practices are necessary. They are goals. We recognize that in some of our practices we are a little short and that constant improvement is necessary. In this work we are regularly assisted by Mr. O. A. Matkin of the Soil and Plant Laboratory, Orange, California, one of the authors of Manual 23.

Incoming water, either clear or fertilized, passes through Monarch, 100 mesh, strainers. We use normally-open solenoid valves since we have found it is better to have continuous water on the twig-grafts than none at all in the event of a power failure. We use General Electric silicone cables for bottom heat. Each bench has it's own HSC-5 thermostat, pilot light, and circuit breaker.

Our timer was inspired by discussions and papers we heard at the first Western Section, Plant Propagators meeting at Asilomar in 1960. We use a 24-hour clock to control two six-minute timers. The pins on the 24-hour clock can be set for 15-minute intervals, and the 6-minute clocks at any 5-second intervals. By proper placing of the pins, any combination of mist duration and interval can be programed. Like other propagators, our controls must allow great flexibility yet provide a high degree of reliability. By the use of relays, the 24-hour clock prevents the chance of continuous misting in the event that the 6-minute clock were to stop for the night in an open (misting) position.

We have recently added a 1½ H.P. 3600 R.P.M. motor and pump to increase our mist line pressure to 140 P.S.I. A 120-gallon tank under air pressure maintains even pressure. This increases nozzle velocity and creates smaller droplets. These absorb more heat and tend to hang in the air longer. This allows us to reduce the mist duration and increase the mist intervals. We use a Monarch 3.0 120° oil-burner type nozzle. These would produce 3 gallons of water per hour if allowed to run continuously. These are also fitted with 100 mesh screens. Our lines are ⅜-inch copper tubing. We use Imperial fittings. Our ten benches have individually controlled water lines which are mounted on the ceiling rafters. The lines are located along the front edge of the bench with the nozzles pointing down. Any drip falls in the aisle. Benches are raised, 36 feet long, 3 feet wide. Heating cables are buried in 3 inches of gravel, covered with hardware cloth. After treating the wire mesh and wood benches with copper naphthenate, empty 18 x 18 inch flats are placed on the bench and filled with rooting media. We use coarse grind vermiculite of the type used for insulation fill. The twig-grafts are dipped in hormone and stuck.

When the mist is on it is impossible to see the other end of the greenhouse 40 feet away. Small droplets will still be in the air when the next cycle begins. While this seems like an excessive amount of water, please keep in mind that until the graft has healed, the scion has no contact with the moisture in the rooting media. It is suspended in mid-air, supported by the understock and has no other contact except the atmosphere around it.

When both scion and understock are fully healed and rooted, the bottom heat and the mist line are turned off. Sometimes, though the plants are rooted, we must wait until the graft has healed. The flats are left to harden off for a period of several days to two weeks, depending on variety.

Please note that we do not use peat or other types of pots. The roots are straight and uncoiled. Trees are planted directly into one-gallon cans, bare-root.

It is our aim to produce good-tasting, full-sized fruit on a dwarf tree whose ultimate size has been controlled by the interaction of root-stock and scion. These trees are produced from carefully selected twigs, grafted under kitchen-clean sanitary conditions, then rooted and healed simultaneously under conditions of intermittent mist.

FRIDAY AFTERNOON SESSION

October 19, 1962

The third session convened at 1:30 P.M. with Moderator Richard Maire, University of California Agricultural Extension Service, Los Angeles, presiding.

MODERN SANITATION IN PROPAGATION

MODERATOR MAIRE: *Automation* — a word that has fast become a by-word in our world of modern industry. The ever-present effort to cut corners, mechanize, reduce labor cost and production cost, to compete for their share of the dollar in a fast moving market, has stimulated this transition to automation.

Agriculture, like the other industries, has followed suit. So have the nursery and floriculture industries as a segment of agriculture, but not as fast, and they are not as far advanced as many other industries.

The importance of automation to the nursery industry is well stated in the first paragraph in the first section of University of California Manual 23, "The UC System for Producing Healthy Container-Grown Plants," with which most nurserymen are very familiar. It reads as follows:

> "The most urgent need of the California nursery industry, within the limits of its present market, is for lowered costs of production. This is best achieved by reducing plant losses and by lowering labor cost through mechanization. These in turn require modification of many existing practices. Production must be dependable, uniform, and largely free from unpredictable failures due to diseases, salinity, insects, or weather."

Our session this afternon, as you know, is to cover the topic of modern sanitation in propagation. A good motto to adopt, and is applicable to the control of diseases, is one used by the fire-fighters:

"Hit 'em while they're small."

Or you may be familiar with the slogan in Manual 23:

"Don't fight 'em, eliminate 'em."

Prevention is still the best cure. It is desirable to eliminate disease organisms from soil before prevention is used, but treatment of the soil alone will not control plant disease; recontamination must be prevented.

A surgeon today would not think of placing his sterilized scalpels and knives in a container that had just been used to hold the implements of a previous operation. So, this should be true for the nurseryman or plant propagator. Treated soil will not remain sterile long if flats or benches are not sterile, if propagating stock is not disease free, or if equipment and utensils are not treated.

It can't be a half-way job; it must be all the way, or your efforts may even backfire and result in more problems than you had at the start.

The magnitude of the nursery and cut flower industries here on the West Coast gives us an idea of the tremendous size of the over-all problem. In the nursery industry in California it is estimated that 350,000 cubic yards of soil are used each year — this is equivalent to the top foot of soil from 217 acres of land. This much soil fills many 1-gallon cans and flats, and the volume has been on the increase.

The presentations to follow approach these problems from a practical way, with practical procedures, to insure the nurseryman that he is doing a thorough job of maintaining a clean, sanitary production process.

The first speaker this afternoon will be Dr. Robert D. Raabe, Department of Plant Pathology, University of California at Berkeley. Dr. Raabe.

THE DETERMINATION OF DISEASE-FREE PROPAGATING MATERIAL

ROBERT D. RAABE
Department of Plant Pathology
University of California, Berkeley

The title of this paper should probably be "The Determination of Pathogen-Free Propagating Material." The distinction between "pathogen-free" and "disease-free" is one which is technical and yet, it is important enough so that it should be mentioned here. Disease is a complex resulting from the interaction of a susceptible plant (called a *suspect* or a *host*), a causal agent (called a *pathogen* in infectious diseases) and an *environment favorable for disease development*. 'Disease-free' would mean the absence of disease as a result of the absence of any one or more of the three factors necessary for disease. Thus it would be possible to have plant material with a pathogen present but because of environmental conditions not favorable for disease development, there would be no disease. Later should favorable environmental conditions occur, disease would then result. If, however, the plant material is pathogen-free, disease would not result even though the plant might be placed in an environment favorable for disease development. This is not to say that once plant material is pathogen-free that it will remain so indefinitely. This aspect, however, is to be discussed by Dr. Wilhelm and Dr. McCain in the following papers.

Although the term 'propagation' includes both propagation by seed and by vegetative means, the number of seed-borne diseases is not extremely large. One of the advantages in propagating plants from seed is that many diseases are eliminated this way. Because of this and the fact that the presence of seed-borne pathogens is determined by culturing technique similar to those used in determining the presence of pathogens in vegetative propagation material, the remarks here will be confined almost entirely to the vegetative reproduction of plants.

It can't be a half-way job; it must be all the way, or your efforts may even backfire and result in more problems than you had at the start.

The magnitude of the nursery and cut flower industries here on the West Coast gives us an idea of the tremendous size of the over-all problem. In the nursery industry in California it is estimated that 350,000 cubic yards of soil are used each year — this is equivalent to the top foot of soil from 217 acres of land. This much soil fills many 1-gallon cans and flats, and the volume has been on the increase.

The presentations to follow approach these problems from a practical way, with practical procedures, to insure the nurseryman that he is doing a thorough job of maintaining a clean, sanitary production process.

The first speaker this afternoon will be Dr. Robert D. Raabe, Department of Plant Pathology, University of California at Berkeley. Dr. Raabe.

THE DETERMINATION OF DISEASE-FREE PROPAGATING MATERIAL

ROBERT D. RAABE
Department of Plant Pathology
University of California, Berkeley

The title of this paper should probably be "The Determination of Pathogen-Free Propagating Material." The distinction between "pathogen-free" and "disease-free" is one which is technical and yet, it is important enough so that it should be mentioned here. Disease is a complex resulting from the interaction of a susceptible plant (called a *suspect* or a *host*), a causal agent (called a *pathogen* in infectious diseases) and an *environment favorable for disease development*. 'Disease-free' would mean the absence of disease as a result of the absence of any one or more of the three factors necessary for disease. Thus it would be possible to have plant material with a pathogen present but because of environmental conditions not favorable for disease development, there would be no disease. Later should favorable environmental conditions occur, disease would then result. If, however, the plant material is pathogen-free, disease would not result even though the plant might be placed in an environment favorable for disease development. This is not to say that once plant material is pathogen-free that it will remain so indefinitely. This aspect, however, is to be discussed by Dr. Wilhelm and Dr. McCain in the following papers.

Although the term 'propagation' includes both propagation by seed and by vegetative means, the number of seed-borne diseases is not extremely large. One of the advantages in propagating plants from seed is that many diseases are eliminated this way. Because of this and the fact that the presence of seed-borne pathogens is determined by culturing technique similar to those used in determining the presence of pathogens in vegetative propagation material, the remarks here will be confined almost entirely to the vegetative reproduction of plants.

Inherent with the many advantages of asexual propagation is the disadvantage that if disease is present in any clone or selection, not only will there be a continuation of the disease, but there will be an increase in the amount of it. For this reason, there is a primary interest in obtaining pathogen-free plant material for this type of propagation. The purpose of this discussion is to focus attention on the methods used to determine if plant propagation material is pathogen-free. Actually, nearly all of the means used are for the determination of the *presence* of pathogens and it is by the absence of pathogens in such tests that pathogen-free material is found.

In order to discuss the determination of disease in plants, there should be an understanding of what disease is. Although there are many definitions of disease, one which might be used is "*disease is an injurious disturbance in the form or function of a plant resulting from a continuous irritation.*" The last clause "continuous irritation" is put in so as to exclude certain types of injuries such as those resulting from wind, insect attack, etc. The symptoms of these are usually diagnostic so that the cause is obvious and the trouble can be eliminated.

In general, diseases are usually divided into two groups — non-infectious (non-parasitic), and infectious (parasitic). In the first group are found such diseases as those resulting from an unfavorable environment and include such troubles as nutrient excesses, nutrient deficiencies, air-pollution damage, etc. Since they are not infectious, they are not directly important in the selection of disease-free propagating material. They are indirectly important in that in selection of propagating material, healthy, vigorous plants will give the best results. They are also important in that the symptoms of such diseases might be similar to the symptoms of infectious diseases and when this is true, the actual cause of the trouble needs to be determined.

The first step in diagnosing a plant disease is usually the observation of symptoms. Symptoms may be defined as "*the visible manifestation of the diseased plant.*" Symptoms are of many types and in clude the following: *Chlorosis* (yellowing) and other discolorations, *necrosis* (killing of tissue), *wilting*, and alternations in growth habit such as *stunting, overgrowths, proliferations, etiolation* and other growth abnormalities.

Obviously symptom expression plays an important part, not only in the diagnosis of plant disease, but also in the selection of plant propagating material, since plants obviously diseased as recognized by the symptoms, are usually avoided, and sometimes are rogued or destroyed, as they should be.

Symptoms alone, however, can not be relied upon as the only means of determining disease in plants for several reasons. One is that sometimes symptoms of different diseases might be similar and further tests are needed to determine the actual causes of the diseases. The other and more important reason is that many plants may be infected with a pathogen and the symptoms have not yet appeared. With some diseases, symptoms may not appear, especially in certain varieties. This is particularly true with virus diseases of plants such as dahlia and chrysanthemum though certain fungus infections such as Verticillium wilt may be carried in varieties of some plants which act as 'Typhoid Marys.'

Since symptoms alone cannot usually be relied upon for diagnosis, additional procedures are followed. The first of these is the use of a hand lens or a microscope. The magnifications resulting from the use of these frequently make identification of the causal organism possible. Sometimes, however, further diagnosis is necessary. The symptoms frequently indicate the type of disease present and if so, the correct diagnosis procedures can be followed. For example, if a bacterial or fungus pathogen is suspected, an attempt is made to isolate the causal organism. This is usually done by surface sterilizing small pieces of infected tissue and incubating them on or in some type of culture media until the organism develops enough so that it can be identified. Diseases commonly detected in this way include Verticillium wilt, water-mold root rots, damping-off, the Fusarium wilts, bacterial wilt of carnation and other plants, and bacterial leaf and stem blight of pelargonium.

Since viruses have not been cultured, their presence is detected by trying to transmit them by means of juice inoculation, or grafting on budding to healthy plants, which will act as indicators. At present, much research is directed toward finding reliable indicator plants for many virus diseases. Such plants have been found for viruses which occur in carnations, stone fruits, chrysanthemums, roses, gladiolus, dahlias, and strawberries, to mention a few. One of the problems is that many of the virus diseases are complexes, i.e., they are the result of infection by more than one virus. This complicates the finding of an indicator plant. Frequently indicators can be found for certain components of a complex, and a series of indicators may be needed to show all the viruses present. This is also complicated by the presence of naturally-occurring inhibitors which prevent the transmission of some viruses.

Another means by which viruses may be detected is by the use of serology. This is done by injecting the purified sap of a virus-infected plant into an animal such as a chicken, rabbit or horse. After allowing sufficient time for the animal to produce antibodies specific for that virus, blood is taken from the animal and the blood serum extracted. In a laboratory test, a small amount of purified sap from a plant suspected of having the same virus is added to a small amount of the serum. If the virus is the same as that originally injected into the animal, there will be a positive reaction, usually a precipitate, giving proof of the presence of that particular virus in the suspected host. This technique, though used only experimentally in the United States, is used for large scale detection of the presence of viruses in commercial crops, such as flower bulbs and potatoes in European countries, particularly in Holland.

In conclusion, it should be stated that although no method will work for all diseases, by using a combination of the symptoms, culturing and/or transmission tests, a trained person can usually diagnose most diseases. Such diseased plants should be discarded and only those free of disease should be used for propagation of plants.

MODERATOR MAIRE: Thank you, Dr. Raabe. We will now continue with our discussion of this subject with a talk by Dr. Stephen Wilhelm and Dr. Arthur McCain on how to produce clean propagating materials.

PRACTICAL TECHNIQUES FOR THE PRODUCTION OF CLEAN PROPAGATING MATERIALS

STEPHEN WILHELM
Department of Plant Pathology
University of California, Berkeley

Practical techniques for the production of clean propagating materials involve three basic operations, and these lie at the heart of the subject matter of the fields of plant pathology and horticulture. The raising of superior plants through advances in horticultural science and the control of plant disease are our common objectives and no longer should anyone just assume that plant diseases are inevitable and crop losses to be expected. The three basic operations referred to above are: (1) getting rid of the pathogen at the source (2) geting rid of pathogen carry-over in the soil or from other growing or propagating media (3) getting rid of all sources of contamination by which the pathogen can be reintroduced into growing operations. The first operation — getting rid of the pathogen at the source — means obtaining pathogen-free planting stock, and the full meaning of "clean stock" as used in this talk is stock that is not carrying any known injurious organisms, fungi, bacteria, nematodes or viruses. The second operation — getting rid of pathogen carry-over in the growing media — involves methods of disinfecting, fumigating, or steaming, soils and other growing media, and for this subject matter area, I wish to direct your attention to University of California Manual 23, entitled the U. C. System for Producting Healthy Container-Grown Plants, Chapter 8-13 inclusive, edited by Dr. K. F. Baker. The third operation — getting rid of all sources of contamination — includes maintaining stocks pathogen-free by preventing the reintroduction of pathogens with tools, containers, tractors, water, worker, or insects, etc. This important subject matter area will be discussed by Dr. McCain, and in a practical way was illustrated by the high standards of hospital cleanliness depicted in the talk of Fred Real of the Four Winds Nurseries, San Jose.

Much of our past thinking in plant pathology, perhaps forced upon us by expediency and at the bottom, of our own wishes to serve agriculture, was to provide controls for plant diseases. This we have done, and recommendations involving plant sprays, dusts, drenches, with timing of application that coincides with vulnerable stages in the life cycles of the causal organisms, are readily available. Essential as these measures are to agriculture and horticulture, this approach to control by "fighting" the diseases never got us to the bottom of most diseases. Such diseased plants should be discarded and only those free of disease should be used for propagation of plants.

MODERATOR MAIRE: Thank you, Dr. Raabe. We will now continue with our discussion of this subject with a talk by Dr. Stephen Wilhelm and Dr. Arthur McCain on how to produce clean propagating materials.

PRACTICAL TECHNIQUES FOR THE PRODUCTION OF CLEAN PROPAGATING MATERIALS

STEPHEN WILHELM
Department of Plant Pathology
University of California, Berkeley

Practical techniques for the production of clean propagating materials involve three basic operations, and these lie at the heart of the subject matter of the fields of plant pathology and horticulture. The raising of superior plants through advances in horticultural science and the control of plant disease are our common objectives and no longer should anyone just assume that plant diseases are inevitable and crop losses to be expected. The three basic operations referred to above are: (1) getting rid of the pathogen at the source (2) geting rid of pathogen carry-over in the soil or from other growing or propagating media (3) getting rid of all sources of contamination by which the pathogen can be reintroduced into growing operations. The first operation — getting rid of the pathogen at the source — means obtaining pathogen-free planting stock, and the full meaning of "clean stock" as used in this talk is stock that is not carrying any known injurious organisms, fungi, bacteria, nematodes or viruses. The second operation — getting rid of pathogen carry-over in the growing media — involves methods of disinfecting, fumigating, or steaming, soils and other growing media, and for this subject matter area, I wish to direct your attention to University of California Manual 23, entitled the U. C. System for Producting Healthy Container-Grown Plants, Chapter 8-13 inclusive, edited by Dr. K. F. Baker. The third operation — getting rid of all sources of contamination — includes maintaining stocks pathogen-free by preventing the reintroduction of pathogens with tools, containers, tractors, water, worker, or insects, etc. This important subject matter area will be discussed by Dr. McCain, and in a practical way was illustrated by the high standards of hospital cleanliness depicted in the talk of Fred Real of the Four Winds Nurseries, San Jose.

Much of our past thinking in plant pathology, perhaps forced upon us by expediency and at the bottom, of our own wishes to serve agriculture, was to provide controls for plant diseases. This we have done, and recommendations involving plant sprays, dusts, drenches, with timing of application that coincides with vulnerable stages in the life cycles of the causal organisms, are readily available. Essential as these measures are to agriculture and horticulture, this approach to control by "fighting" the diseases never got us to the bottom of disease problems. Also, working along the lines of control by "fighting" diseases only, tended to compartmentalize our own subject matter and we often looked at plant disease control as if it involved separate and distinct operations from those of growing the crop. The common question is "how do you control this or that disease?" In many instances we now know that if the disease, or properly speaking, the *causal agent or pathogen* of the disease were eliminated from the planting stock at the outset, "fighting" the disease becomes unnecessary. To effectively eliminate a disease at the outset may require considerable change in old esablished growing routines, and if this is so, only those who change reap the advantages available through plant disease control.

Only a relatively few years ago it was the established practice among San Francisco Bay Area chrysanthemum growers to take cuttings in the winter from the old, spent flower beds. Under pathogen-free conditions, there is nothing wrong with this practice, but studies showed that the following diseases: Verticillium wilt, Deuterophoma stunt, Rhizoctonia and Sclerotinia foot rots, Pythium and Pyrenochaeta root rots were carried latent with these healthy-looking cuttings. In addition, such cuttings also could carry two different kinds of serious nematode parasites, several kinds of leaf-infecting fungi and the debilitating virus disease called "stunt." Any one of these diseases if serious enough, can stifle successful chrysanthemum production, and when propagative stock carries the disease-causing organisms, the chances for serious outbreaks are excellent. The reasons why chances for serious disease outbreaks are excellent if planting stock — no matter how healthy its appearance — is carrying pathogens, are these: (1) the causal organism and the crops are transported and planted simultaneously (2) the causal organism is either already in the planting stock or closely associated with susceptible tissues and (3) the particular strain of the pathogen virulent for the crop is the one being spread. Thus, to get back to the Verticillium wilt disease of chrysanthemum, the causal fungus is within the cutting and the strain of the fungus spread by the cutting is the one virulent for chrysanthemum. There are many strains of this fungus and on land never previously planted to chrysanthemum, for instance. such as old brussel sprout land, you may encounter heavy infestations of Verticillium but the particular strains may not attack chrysanthemums. If infected cuttings, however, are planted on this land, outbreaks of the disease are assured.

Thus far we have presented the principles involved in disease control by planting only clean (pathogen-free) stock. Now, how do we go about obtaining such clean stock? The first requirement is separation of planting stock production from crop production. Whether the crop is fruit, shrubs, flower seed, or bulbs, the plant propagative and crop productive operations which in themselves are distinct, must be separated. You nurserymen may tell me, and correctly so, that plant nurseries existed long before even the science of plant pathology and that thus intuitively long ago this separation of operations was made. Separation today, however, means more than just producing planting stocks in the nursery, because nurserymen have been known to depend often on commercial growers for seed, budwood, scions, for land and equipment. Verticillium wilt of rose, a fungus disease, for instance, can be transmitted through bud wood, as well as can the *Coniothyrium* fungus by budding, as of course, can all of the virus diseases. Where insects that spread diseases such as virus disease may be involved, the idea of separation may mean many miles of isolation of nurseries from the crop-producing areas, and even mechanical barriers such as screen houses and disinfecting troughs for workmen's shoes. In the strawberry industry, with which I am most familiar, the nurseries are some hundreds of miles from the production areas, and foundation stocks there are often kept in isolation in screen houses. No strawberry grower any longer would think of stripping old commercial fields for runner plants to obtain stock for planting new fields.

The nurseryman has a responsibility, often deeper than moral, to supply the growers with clean stock, but unless his stocks are clean to begin with, his propagation techniques carry infections with them. Though some progress has been made in methods of mass cleaning up of diseased planting stocks, especially by use of hot water, generally it cannot be done. It is better to spend a lot of time and care on a few selected individuals that have been ridded of pathogens, and tested out as "pathogen-free" and to propagate only from them. Three basic methods are used today to rid planting stocks from infestations, but by no means have the practical potentials of these methods been fully explored. These methods are *heat treatments, culturing cuttings,* and *apical meristem cultures.*

Heat Treatments

Heat treatment of plant materials to control diseases is one of the oldest methods of disease control. Dr. K. F. Baker, Dept. of Plant Pathology at UCLA, who is a foremost authority on this subject, has estimated that annually about 75,000 tons of sugar cane planting stock are treated to control virus diseases in Hawaii, 15,000 tons in Australia, 15,000 tons in Louisiana. About 1,000 tons of narcissus bulbs are treated annually in Washington against nematodes and anywhere from 500,000 to 1,000,000 strawberry plants treated annually in California.

Living organisms vary widely in their tolerance of high temperatures. Most parasitic fungi for instance, are killed by moist heat, which includes hot water, in 30 minutes at 120 to 135° F. Though many dormant seeds and other propagules, such as bulbs and corms, will tolerate this heat, most actively-growing shoots and twigs will not. Actually, the higher the moisture content of plant materials or of organisms, the greater the susceptibility to destruction by heat.

A recent modification in the use of heat is to grow plants at temperatures of 100 to 105° F. for periods of 2 to 30 weeks. Several virus diseases of strawberry, raspberry, rose, and stone fruits, have been eliminated in this way and basic stocks have been built up from these. Plants must be hardened before subjecting them to these high temperatures, allowed to adjust to the temperatures gradually, and provided with high light intensities.

Culturing Cuttings

Over 20 years ago, Dr. W. Dimock, Professor of Plant Pathology, Cornell University, a foremost authority in diseases of ornamental plants, studying the Verticillium wilt disease of chrysanthemums showed that the infection does not reside in the tips of the cuttings. This important discovery has enabled informed nurserymen to specialize in the production of stocks whose parents have a "cultured" pedigree. This pedigree distinguishes them as pathogen-free. Yoder Brothers, Salinas, California, is such a nursery. The idea of detecting latent bacterial and fungal infections in tip cuttings, applied first practically to chrysanthemum, is now widely used in carnation and geranium propagation, and to a limited extent in rose. The details as to just how this culturing is done, which varies with both the crop and the pathogens involved, are available to anyone interested, but are too involved to discuss here.

Apical Meristem Cultures

A general principle which developed out of Dr. Dimock's idea of culturing chrysanthemum cuttings to detect Verticillium, is that *infections of all kinds, fungal, bacterial, viral, diminish and tend to peter out in* the direction of the growing tip of a shoot. By carefully dissecting out the actual growing tips (apical meristems) of some plants and growing them aseptically in a manner similar to the embryo culture techniques described yesterday by Dr. Lammerts, pathogen-free individuals have been obtained. Obviously, a highly specialized technique, and one not adapted to any kind of mass procedures, nevertheless important stocks of important crops have been ridded of *virus* infections in this way. Strawberry, potato, carnation, dahlia, and lily are a few. Frequently, techniques involve a combination of the use of heat and apical meristem culturing. Valuable stocks may be subjected first to long periods of high temperatures, during which they may make some growth. This growth, or the first to appear when the stocks are returned to normal temperatures, is used for the apical meristem cultures. Details as to just how the apical meristem culturing is done are also available but will not be considered here.

As Dr. W. Dimock has pointed out in his articles, an inevitable tendency that attends crop specialization is the concentration of propagation into ever fewer, and larger-scale propagators. Such specialization, though possessed of obvious economic advantages of production and distribution, holds the potential of either promoting horticultural uniformity and excellence or of spreading disease. Diseases developing in parent stocks of large propagators are speedily spread throughout the clientele and this may involve many of the growers of one or of several countries. On the other hand, elimination of diseases in the parent stocks of these same large propagators and by guarding against their ever reappearing, may eliminate or greatly reduce the disease problems for this same entire clientele.

SANITATION IN PROPAGATION

ARTHUR M. McCAIN
Extension Plant Pathologist
University of California, Berkeley

The major sources of plant disease organisms are infected plants, plant debris, soil and rooting media. Disease organisms are disseminated by the transportation of infected plants or plant parts, by air currents, water, insects, nematodes, and mechanically by man. Based on his knowledge, and on experience in controlling diseases, the following sanitary practices will help maintain plants in a disease-free or healthy condition.

Obtain cuttings from selected, disease-free stock plants isolated from production areas.

Take cuttings from high up on the plants.

Break cuttings from stock plants where possible or disinfest tools between cuts.

Do not overhead irrigate stock plants

Keep stock plants sprayed with protective fungicides to reduce the danger from infection by air-borne spores.

Eliminate weeds.

Control insects.

Keep all plant debris cleaned-up.

Do not dip cuttings in water, dust rooting hormones onto cut ends.

Treat all propagating and growing media with steam or chemical fumigants.

Treat containers or use new ones.

Disinfest tools and smooth working surfaces with formalin solution (1 part 37-40% formalin to 18 parts water).

Disinfest benches and other wooden surfaces with copper naphthenate 10% (2% copper).

Do not place treated soil, containers, etc. on untreated surfaces or directly on the ground.

Do not introduce plant disease organisms into treated soil.

Keep feet off treated soil.

Keep hose nozzles off the ground.

Wash hands after working with untreated soil.

Avoid splashing soil particles with irrigation water.

Do not expose treated soil to blowing soil or debris.

Dispose of all diseased plants.

MODERATOR MAIRE: Now we will hear from three speakers who are using these sanitation practices in producing nursery stock. The first is Carl Zangger.

CLEAN CULTURE OF BEDDING PLANTS

CARL ZANGGER
Perry's Plants Inc.
Montebello, California

Basically the production of bedding plants would fall into three categories:

1. The preparation of the soil or planting media.
2. The planting of the seed and production of the seedlings.
3. The transplanting and care of the seedling to the marketing stage.

Everything must start with the soil, as this phase of our operation is very important. We use the University of California system of growing, in which we utilize a mixture of fine sand and peat plus the necessary fertilizer elements. All the elements of our soil mixture are loaded into a permanently-mounted, ready-mixed cement mixer. We have found this does an excellent job of mixing the soil. We have contrived a lid for the mixer, through which we inject live steam directly into the mixer. As the soil is tumbling within the mixer it is exposed to the steam which, we feel, gives us a thorough and reliable sterilization process. All soil mixed in the nursery goes through this sterilization process, by being brought to a temperature of 180 degrees.

From the mixer the soil is run out onto a conveyor belt and brought into our flat filling machine, from which it is distributed into the containers in which we will be planting our seedlings. Of course, prior to placing the sterilized soil into containers, care must be taken to see that the containers themselves are properly sterilized. All of our flats or containers which might be contaminated in any way are placed in a steam chamber and subjected to steam sterilization for a period of approximately one hour.

The temperature within the steam chamber is raised to the vicinity of 200 degrees F. Subjecting the flats or containers to this temperature for a one hour period seems to be adequate to prevent the carry over of any diseases.

After the containers are filled with soil, they are then distributed to the various planting areas throughout the nursery. Care must be exercised to see that the soil is not recontaminated by placing it where dirt or other harmful organisms might be blown into it.

At this point I would now like to discuss step number two, which is the planting of the seed and the production of the seedlings.

Our seed soil is prepared in the same manner as we prepare the soil for our general planting throughout thhe nursery. The flats of soil in which the seed is to be planted are placed in the seed house, leveled, and prepared for the planting of the seed. Care is taken to see that the benches on which the flats are placed are kept clean, and free of all harmful organisms. We attempt to follow good growing practices by seeing that the seed itself is clean and free of disease.

Those varieties which we have found to be particularly bothered by seed-borne fungi are either subjected to dusting with Arasan, drenched with Panogen, or subjected to hot water treatments. We have found these methods to be quite adequate in most situations. After the seed is sown it is watered again. It is important, of course, to see that no contamination takes place after the seed is planted. We try to limit the people who have access to the seed house and, like most growers, we leave the care of the seed flats in the hands of one capable person.

After the seed has germinated and the seedlings have reached the desired size, the flats of seedlings are moved to special areas out of the seed house where they are grown to the desired stage for transplanting. Care is taken here to see that the flats are not subjected to any contamination. Most seed flats are kept on raised benches. Less sensitive varieties may be placed on boards set on the ground, but in no case are seed flats ever placed directly on the open ground. Again care should be taken to see that seed flats are not placed in positions where there is a great deal of traffic or possibility of outside contaminates, such as dust, settling on them.

Periodically we make it a practice to treat all benches and boards on which seed flats may be placed with a solution of copper naphthenate to prevent any carry-over of fungi on the benches. I might add that we treat all of our greenhouse benches in this manner.

In the event that any fungus should appear in a seed flat we treat the affected flat with a drench of Panogen which we have found to be quite effective in controlling most cases. Flats of seedlings which are badly affected by fungi are discarded in most instances, as we have found the transplanting of seedlings from these flats to be very uneconomical. The cost of preparing soil and labor of transplanting are too costly to risk the planting of contaminated seedlings.

After we have prepared our soil and grown our seedlings we have arrived at step number three in the production of bedding plants. This step involves the actual transplanting and growing up to the marketing stage.

The flats of soil and the flats containing the seedlings are brought together to the various planting areas where the seedlings are to be grown. Again care is taken to see that no contamination takes place while these components are being moved about the nursery. The people who are doing the transplanting are indoctrinated so that they are familiar with the reasons why precautions must be taken to prevent possible contamination. Again care is taken with all tools to see that they are clean and free of disease. This, of course, is one of the more difficult aspects to control. If a person should drop one of their tools on the ground the temptation to pick it up and continue using it is great, and of course, this is one of the easiest ways to introduce disease to a flat of transplants.

After the seedlings are transplanted, good housekeeping practices are followed to prevent any contamination of the transplanted seedlings. Hoses are kept off the ground. No one is allowed to get up on the benches or walk over the flats. Animals are kept out, etc. All of the above are possible sources of disease to the seedlings.

When the transplants have reached the desired stage of growth, they are moved from the greenhouses to beds outside, where they are grown to the finished stage for marketing. We have covered most of the beds in the nursery with coarse gravel, upon which we set the flats of transplants. This seems to be adequate in most cases in preventing the transmission of disease from the soil, and allows good drainage through the flats. Naturally, after the plants have been moved from the greenhouse, the opportunities of becoming infected are greater. However, by this time, the plants have reached a stage of growth in which they are better able to ward off the effects of disease organisms. Should disease be prevalent, we have found that the application of Panogen as a soil drench is quite effective.

Now I do not want to give the impression that everything we do is absolutely aseptic. This simply is not practical in any volume production. However, just plain good housekeeping practices should be followed. You wouldn't eat from a dirty table with dirty utensils. The same degree of cleanliness your wife uses in the conduct of your household will usually be adequate for the conduct of your bedding plant nursery, in so far as the cleanliness of the plants you produce are concerned.

MODERATOR MAIRE: Thank you, Carl. Next we will hear from Henry and Fumio Satow, who will describe their methods of producing carnation plants by these clean culture practices.

CLEAN CULTURE OF CARNATIONS

Henry and Fumio Satow
Satow's Floral
Hawthorne, California

The events that led us up to the system of clean cultural practices are as follows:

(a) In 1955, cuttings were taken in the usual manner from *flowering areas* where no sanitary procedures were practiced. These cuttings were misted in steam sterilized sand; rooted cuttings were planted in steam-sterilized *ground beds.* Analysis at the end of 18 months of the blooming period showed that out of an original 125,000 plants planted, only 50% of the plants survived. The other 50% was lost to Fusarium stem rot, Fusarium wilt, and bacterial wilt of carnation. *Reason* for loss of plants:uncultured cuttings were planted into steam sterilized soil. A mass inoculation of harmful carnation pathogens into a soil which has lost its bacterial balance due to sterilization. *Solution*: Use of cuttings entirely from cultured mother-block plants. This resulted in the construction of a double-range, fan-padded glass house, with completely asphalted floor and raised benches housing 6,000 cultured mother-block plants.

(b) In 1957, rooted cuttings from cultured mother-block plants were planted in sterilized ground beds. (Same area as in 1955.) Analysis at the end of 18 months blooming cycle again showed that

When the transplants have reached the desired stage of growth, they are moved from the greenhouses to beds outside, where they are grown to the finished stage for marketing. We have covered most of the beds in the nursery with coarse gravel, upon which we set the flats of transplants. This seems to be adequate in most cases in preventing the transmission of disease from the soil, and allows good drainage through the flats. Naturally, after the plants have been moved from the greenhouse, the opportunities of becoming infected are greater. However, by this time, the plants have reached a stage of growth in which they are better able to ward off the effects of disease organisms. Should disease be prevalent, we have found that the application of Panogen as a soil drench is quite effective.

Now I do not want to give the impression that everything we do is absolutely aseptic. This simply is not practical in any volume production. However, just plain good housekeeping practices should be followed. You wouldn't eat from a dirty table with dirty utensils. The same degree of cleanliness your wife uses in the conduct of your household will usually be adequate for the conduct of your bedding plant nursery, in so far as the cleanliness of the plants you produce are concerned.

MODERATOR MAIRE: Thank you, Carl. Next we will hear from Henry and Fumio Satow, who will describe their methods of producing carnation plants by these clean culture practices.

CLEAN CULTURE OF CARNATIONS

HENRY AND FUMIO SATOW
Satow's Floral
Hawthorne, California

The events that led us up to the system of clean cultural practices are as follows:

(a) In 1955, cuttings were taken in the usual manner from *flowering areas* where no sanitary procedures were practiced. These cuttings were misted in steam sterilized sand; rooted cuttings were planted in steam-sterilized *ground beds.* Analysis at the end of 18 months of the blooming period showed that out of an original 125,000 plants planted, only 50% of the plants survived. The other 50% was lost to Fusarium stem rot, Fusarium wilt, and bacterial wilt of carnation. *Reason* for loss of plants: uncultured cuttings were planted into steam sterilized soil. A mass inoculation of harmful carnation pathogens into a soil which has lost its bacterial balance due to sterilization. *Solution*: Use of cuttings entirely from cultured mother-block plants. This resulted in the construction of a double-range, fan-padded glass house, with completely asphalted floor and raised benches housing 6,000 cultured mother-block plants.

(b) In 1957, rooted cuttings from cultured mother-block plants were planted in sterilized ground beds. (Same area as in 1955.) Analysis at the end of 18 months blooming cycle again showed that

30 to 50% of the original plants were lost to the same pathogens.

Reason: Recontamination of sterilized areas in the soil from contaminated areas that steam could not reach.

Solution: Use of raised beds in place of ground beds, where steam can completely sterilize all the soil in the bed. This resulted in construction of 8 miles of raised beds.

(c) In 1959 with the use of cultured cuttings from mother-block plants, planted in raised steam-sterilized beds, analysis at the end of 18 months blooming cycle showed that a very minute percent was lost to pathogens.

Today, the following procedure is followed to maintain clean cultural practice in raising carnations:

(1) All original cuttings procured from outside sources are cultured, even if they are from a cultured mother-block source. Mother-block plants are re-cultured. Culturing procedure described by James Tammen, R. R. Baker, and W. D. Holley, "Control of Carnation Disease Through the Cultured-Cutting Technique," 1956 Plant Disease Reporter Supplement #238: 72-76, is followed to obtain cultured cuttings for our mother-block plants.

(2) Mother-block plants are planted in August and discarded in July of the following year. Cuttings for our entire field plantings are taken from these mother-plants. Therefore, mother-block plants are handled separately and with the greatest precaution, not overlooking any detail which will re-contaminate the mother plants.

A very strict enforcement of the U. C. System of growing as described in University of California Manual 23 is used.

Once the plants are planted in the raised beds a good common sense sanitation is practiced to maintain the growing carnation plants for two years.

Never get over-confident and become sloppy once you have good clean culture practice. The minute you do, disease will spring up here and there to let you know. We know, because this has happened to us, more than once.

MODERATOR MAIRE: Thank you. Our final presentation in this section will be by Mr. Henry Ishida, who will discuss clean culture of foliage plants. Mr. Ishida.

PRODUCTION OF CLEAN CULTURED FOLIAGE PLANTS

HENRY ISHIDA
Union Nursery Company
Gardena, California

Perhaps the advantage of using clean culture, or better yet the U. C. System, in the production of foliage plants can be better shown by a relative newcomer in the foliage business such as myself, since I feel that we breezed into it without too many headaches or difficulties. I say the U. C. system, since it not only includes clean culture, that is, clean plant material and sterilization, but it also includes soil mixes, nutrition, mechanization and efficient practices.

30 to 50% of the original plants were lost to the same pathogens.

Reason: Recontamination of sterilized areas in the soil from contaminated areas that steam could not reach.

Solution: Use of raised beds in place of ground beds, where steam can completely sterilize all the soil in the bed. This resulted in construction of 8 miles of raised beds.

(c) In 1959 with the use of cultured cuttings from mother-block plants, planted in raised steam-sterilized beds, analysis at the end of 18 months blooming cycle showed that a very minute percent was lost to pathogens.

Today, the following procedure is followed to maintain clean cultural practice in raising carnations:

(1) All original cuttings procured from outside sources are cultured, even if they are from a cultured mother-block source. Mother-block plants are re-cultured. Culturing procedure described by James Tammen, R. R. Baker, and W. D. Holley, "Control of Carnation Disease Through the Cultured-Cutting Technique," 1956 Plant Disease Reporter Supplement #238: 72-76, is followed to obtain cultured cuttings for our mother-block plants.

(2) Mother-block plants are planted in August and discarded in July of the following year. Cuttings for our entire field plantings are taken from these mother-plants. Therefore, mother-block plants are handled separately and with the greatest precaution, not overlooking any detail which will re-contaminate the mother plants.

A very strict enforcement of the U. C. System of growing as described in University of California Manual 23 is used.

Once the plants are planted in the raised beds a good common sense sanitation is practiced to maintain the growing carnation plants for two years.

Never get over-confident and become sloppy once you have good clean culture practice. The minute you do, disease will spring up here and there to let you know. We know, because this has happened to us, more than once.

MODERATOR MAIRE: Thank you. Our final presentation in this section will be by Mr. Henry Ishida, who will discuss clean culture of foliage plants. Mr. Ishida.

PRODUCTION OF CLEAN CULTURED FOLIAGE PLANTS

HENRY ISHIDA
Union Nursery Company
Gardena, California

Perhaps the advantage of using clean culture, or better yet the U. C. System, in the production of foliage plants can be better shown by a relative newcomer in the foliage business such as myself, since I feel that we breezed into it without too many headaches or difficulties. I say the U. C. system, since it not only includes clean culture, that is, clean plant material and sterilization, but it also includes soil mixes, nutrition, mechanization and efficient practices.

I have been, and still am, primarily one of the larger bedding plant growers in this area. However, about two years ago with diversification in mind, we began the production of a limited variety of foliage plants. They are namely, pothos, grape ivy, other ivies, dracaenas, Chinese evergreen, palms, different varieties of philodendrons, varieties of ficus, and some dieffenbachias. Even before going into the foliage plant business, I had the opportunity of visiting many of the local growers on Farm Advisor tours and on other occasions. After deciding to go into this new line, I visited growers in Florida, Puerto Rico, and Texas with a few of my nursery friends and observed their different production methods. The growers there were all sizes, from extremely large operators to relatively small, and they used as many different methods as there were nurseries. In trying to evaluate the most practical, efficient, sanitary and economical methods, I discussed it at length with my friends, and finally decided to follow the method of a relatively small but very efficient local grower. It was necessary, to some extent, that this production system fit into our existing bedding plant facilities.

The bedding plant producers in Southern California are among the most progressive in the nation from the standpoint of clean production, mechanization and marketing. My nursery being as progressive as most, and having had the opportunity to work with the U. C. system since its inception in the early 1950s, this change-over of my greenhouse from bedding plants to foliage plants was not too drastic.

General sanitation practice in growing foliage plants is about the same as with our bedding plant operation. The soil mix is the same U. C. type "cake mix," except for the addition of 50% more humus, mixing and sterilizing in the same transit-type cement mixer, with the soil laboratory checking it out for nutrition. To fertilize, the existing constant-feed system is used with occasional supplemental feeding as with the bedding plants, following the recommendation of the soil laboratory. Pest control is taken care of by the commercial pest control operator who has been spraying our nursery for years. So, our main problem was the adjustment to the amount of water, humidity and the necessary shade. With the main headache of soil, nutrition and disease out of the way, it wasn't too difficult to learn the rest.

By using one of our main foliage plant item, Pothos (*Scindapsus aureus*), as an example, I'll take you through our production method. The cycle is from the propagating vine, cutting, rooting, potting, repotting for finishing, back to the propagating vine. Single leaf cuttings are graded very heavily for overall quality and color, since we feel that this is the cheapest stage to cull plants if it has to be culled at anytime. Cuttings are dipped in a solution of Panogen (or Morton's Soil Drench C) at the recommended dosage and rooted in a steam sterilized flat of a 60% perlite and 40% peat moss mix and placed on a copper naphthenated-treated bench in a steam-heated greenhouse. The plants are drenched periodically with a solution of Panogen through our ¾-inch Smith injector for protective disease control. After rooting, the plants are again graded, then potted in sterilized 2½″ clay pots filled with a mix of 75% humus U. C. type steam-sterilized soil, and placed in a sterilized flat on a copper naphthenated bench. The plants are constantly fed at every irrigation; a 2-inch Smith injector is connected to our water system. The soil laboratory checks the soil and plants at least once a month, with the fertilizer level altered according to their recommendation. All plants are protective sprayed for pests each week. A periodic drench of Panogen is applied for protective disease control, regardless of visible symptoms.

If for any reason, such as — by contamination — some plants are found to be diseased, the whole flat of plants is destroyed and the bench treated before any more plants are placed on it. The advantage of growing in flats is that it not only acts as a barrier against the spread of some diseases, but it also is easier to handle large quantity of plants at one time, when compared to growing plants individually on or in benches.

When the plants become ready for sale, they are again graded and sorted into different flats according to the length of the vine and the use of the plants. Pothos is sold as a single plant in the 2½″ pot, repotted into a 3″ pot as a double plant, triple in a 4″ pot, four plants on a 16″ pole in a 4½″ pot, six plants on a 18″ pole in a 5″ pot, and eight plants on a 24″ pole in a 6″ pot, each plant fitting the size of the pot. Plants that are not salable, but have good characteristics, (but perhaps with a scratch or overgrown), are placed in a separate flat to be grown on as propagation material. These are moved to a separate house and grown in the flat on a clean bench in the original 2½″ pot until they have from twelve to twenty-four or more leaves, depending entirely on the demand for the cutting. When cuttings are to be made, the whole vine from the base of the plant is cut off, the stub and the soil dumped, and the pots stacked in a flat for steam sterilizing and reuse.

By turning over our stock with each cycle instead of leaving a portion of the plants to regrow new vines, we feel that not only better quality plants can be grown, since older plants tend to weaken, but it is also an easier method to control disease, salinity, etc., not to mention the ease in handling. The propagating material is a continuation of our production, not requiring the repotting of plants into larger container or the need to grow plants in beds to be grown solely for propagating purposes. However, all plants grown under this system must be handled under sanitary condition, as if it were all going into propagation. In some nurseries, propagating material is grown in grounds bed or benches where contamination is a problem, then lifted up on to clean benches and into sterile medias, whereas with our system, the propagating material never leaves a clean bench.

The advantages of a production method such as the U. C. system can be applied to different types of plants with little modification. It is a simple, sanitary, efficient, practical and economical system.

Friday Evening Session

October 19, 1962

The fourth session convened at 8:00 P.M. with Moderator Denison Morey, Director of Research, Jackson & Perkins, Pleasanton, California, presiding.

PROPAGATION OF SELECTED PLANTS

MODERATOR MOREY: Our evening program will start with a talk by Mr. W .J. Curtis, Sherwood, Oregon, on some of his experiences in grafting ornamentals. Mr. Curtis.

THE GAFTING OF KOSTER SPRUCE CEDRUS ATLANTICA GLAUCA, COPPER BEECH, PINK AND VARIEGATED DOGWOODS

W. J. Curtis
Wil-Chris Acres
Sherwood, Oregon

We in the Pacific Northwest who graft conifers are somewhat unorthodox in the method and procedure we follow. This came about several years ago, when the late Frank Speybrock of Beaver Creek Nursery, filled his greenhouse benches with freshly potted Norway Spruce understock and immediately began to graft. His percentage was in the high nineties, while those who grafted spruce understock that had been potted in the early spring, had from 50-75%. Was this blind luck? It was later proved not. Frank's success gave all who grafted conifers food for thought. Since that time, 15 years ago, there have been some changes in procedure, at least on my part.

I will try and give you, step by step, the method I use for grafting Koster spruce, *Cedrus atlantica glauca*, copper beech, pink and variegated dogwood.

We either use Norway Spruce of pencil size or collected Sitka spruce. In November we get the understock and trim the roots so they will fit easily into a 3 or 4" pot without bunching. We also trim off a number of the lower branches, which gives us a clean trunk for grafting later. This potted understock is set out in a ground bench of 55-60 degrees F., night temperature, being treated as any other transplanted conifers. We do use a soil mixture of about 50% peat.

In 60 days or less, new feeder roots will be showing around the edge of the pots. You can start to graft now, but I prefer to wait until there is a heavy showing of roots. Your understock is easy to work with, the root system is such that you will not damage the new roots by a great deal of handling.

We always attempt to graft a heavy scion on a heavy understock; when possible to get branched scions, we do so. It has been proven that you get a better take with a scion of two-year, or three-year wood. A two- or three-year wood scion gives a heavy, branched plant ready for the field in one year.

Using a sharp knife, remove the needles from the scion for about 2½ inches. Cut a long, slanting cut one-third the way through the scion at the base. On the opposite side, the side away from the understock, the cut is long and slanting, but just under the cambium layer. Cut off the lower end at about 45 degrees to get away from the bruise caused by the pruning shears. Take your understock and cut a thin slice just below the cambium layer. Set your scion into the understock, bringing this thin layer up over the scion, matching both sides, if possible. Bind with a 4″ rubber budding strip, coat the whole area with grafting wax, paraffin, or as I prefer, Treheal. Set in a bench this time, for a little more heat will help your graft to callus in. Too much overhead heat will bring your understock along too fast. Watch your watering, for such a dense mass of foliage is an ideal environment for fungus growth.

In 30 days or so, the bud will begin to swell and break on the graft. At this time, spread out your pots, leaving a space of 2 to 4 inches between each pot. This depends upon the size of your scion. Cut off ½ of your understock and watch for fungus. You must have good circulation of air for this tender growth is most susceptible to damping-off fungi.

By now your Koster spruce grafts have reached the extremity of this season's growth. You can set them out into beds or shift them to gallon containers, which I prefer. Trim off more of the understock, but leave a single branch for a nurse, and leave this on until the following spring. You will lose fewer grafts during the summer, if any.

Cedrus atlantica glauca are grafted on pencil size or smaller *Cedrus deodara.* We have always handled this understock the same as we have the spruce, until last fall. We had several *Cedrus deodara* that were too small to graft, left over from the year before. These were potted in 4″ clay pots with a nice peaty mixture. By fall they had increased in caliber and had filled the 4″ pots with roots. It was a mild fall so in 30 days they began to show new growth. They were grafted and in two weeks the buds began to swell on the *Cedrus atlantica* scions, with no needle drop. Not one dropped a needle. You, who have grafted *Cedrus atlantica glauca,* and especially those of you who grafted it for the first time, have looked upon those naked scions and wondered whether to throw them out or not. In a short time for some, longer for others, they start to grow and your percentage is quite good. Those same *Cedrus atlantica glauca* put on such growth that they were lined out in the field the last week in September with the majority 18″ tall.

This year all my *Cedrus deodara* understock is well established in 4″ clay pots. Will let you know if this was a freak happening.

We use the same long slim cut on the scion both front and back as on the Koster. This type of cut exposes more of the cambium. A nurse branch is left on the *Cedrus atlantica glauca* until they go into the field. A two-foot bamboo stake is tied in at least three places to prevent breakage.

Let us review. We use a scion that has a large area of cambium exposed. Our understock is cut in such a way that we have an extremely large area of cambium to lay against the cambium of the scion. This will give a stronger and a quicker union with a greater percentage of grafts. We feel very bad if we lose a half dozen out of 500 grafts. The third thing we do differently is to leave a nurse branch to keep the sap flowing until there is an excellent union.

The dogwoods and the beech are handled a little differently, for both must be established in their pots. As we pot them a year before we use them, they also go into 4″ clay pots in the same peaty mixture.

The dogwood, both pink and variegated, are grafted high on 18-24 inch seedlings of pencil thickness. Scions are selected of 3/16-¼″ diameter of this season's growth. The understock is cut off at a height to match the caliber of the scion. A whip graft is used, which is bound with a budding rubber and painted with Treheal. The lower side buds are allowed to grow and develop until the graft is almost leafed-out. The side buds are then rubbed off. By June, the new growth has developed enough so that the plants can be shifted to gallon containers and put outside under lath. By fall they can go into the field. A large number of the pink will be branched and have flower buds. The variegated dogwood should be in a shade house another year, before setting out in the field.

European beech, *Sylvatica,* of ¼-5/16 caliber, established for one year in 4″ clay pots, is the ideal understock for grafting copper beech. Again we use the whip graft, cutting off the understock as close to the pot as is convenient for working. I match scion and understock for size, for the greater the area of matching cambium, the better percentage of your take. The graft union is bound with a budding rubber and sealed with Treheal. In a relatively short time your new growth will burst forth. The same care in watering and ventilating, as with all other grafts, must be followed. When the new growth has fully developed, the new graft can be shifted to gallon containers and set in the shade house to harden up. They also can go into the field in the fall or early spring.

There are a number of operations in common to all four of the grafted plants we have just covered:

All the understock should be moved into a cool greenhouse by mid-November and allowed to begin growth slowly.

The greatest of care must be taken to match the cambium layers on all grafts. A rubber budding strip is used to hold all grafts firmly. Treheal, or a hot wax, is used to seal all grafts. If hot wax is used, great care must be taken to keep the wax the right temperature —if too cold, it will not do a good job of sealing, and if too hot, the cambium will be injured and your graft will not take.

Free air circulation around the grafts is a must, and especially so, on the Koster and *Cedrus atlantica glauca,* for the new foliage is subject to damping off or molding. By watering early in the morning, or on sunny days, you can keep your losses down.

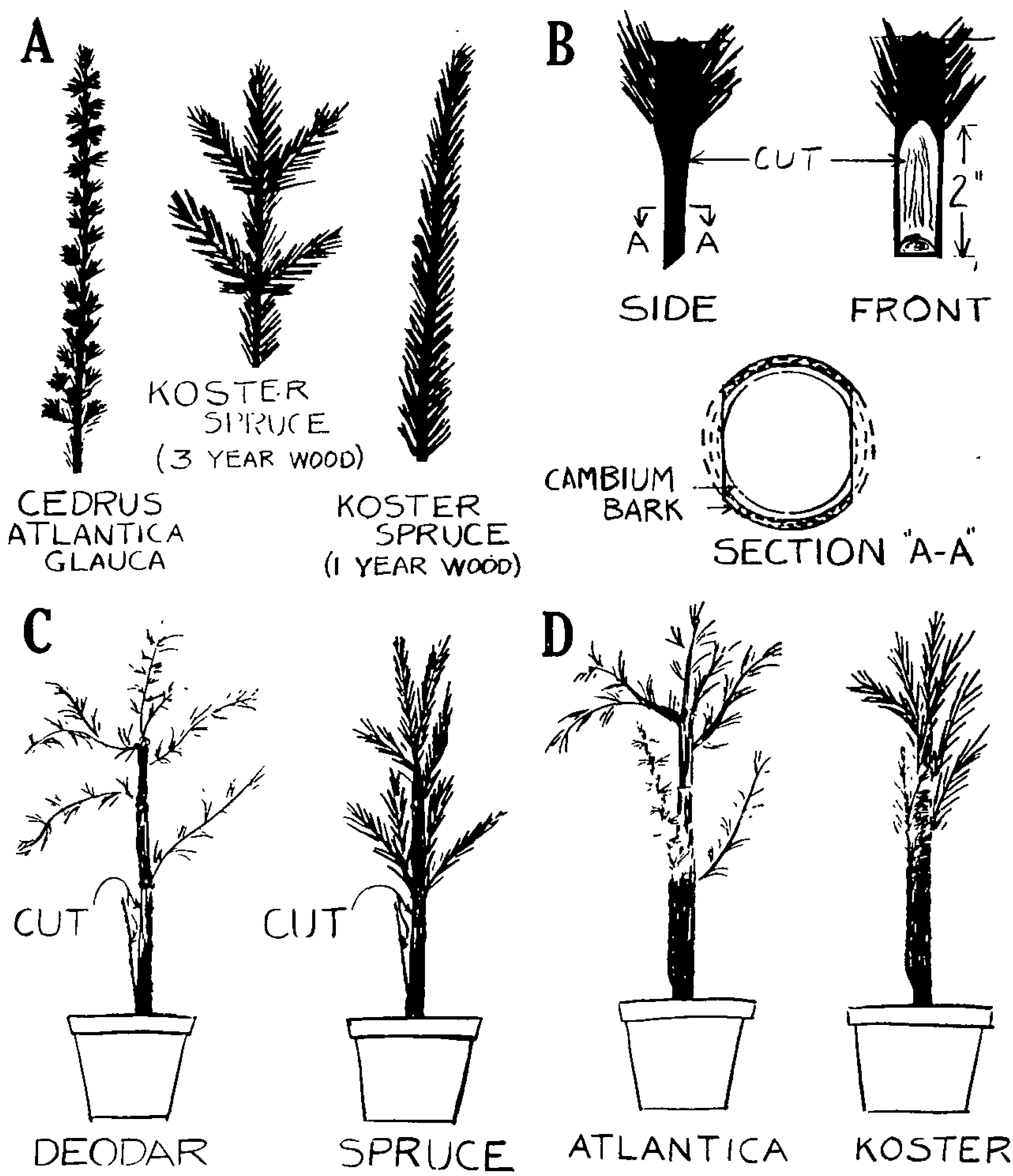

Figure 1. Grafting *Cedrus atlantica glauca* on *Cedrus deodara* and Koster spruce on Norway or Sitka spruce. (A). Materail for the scions. (B). Preparing the scions. (C). Stock plants after cutting. (D) Completed grafts before tying.

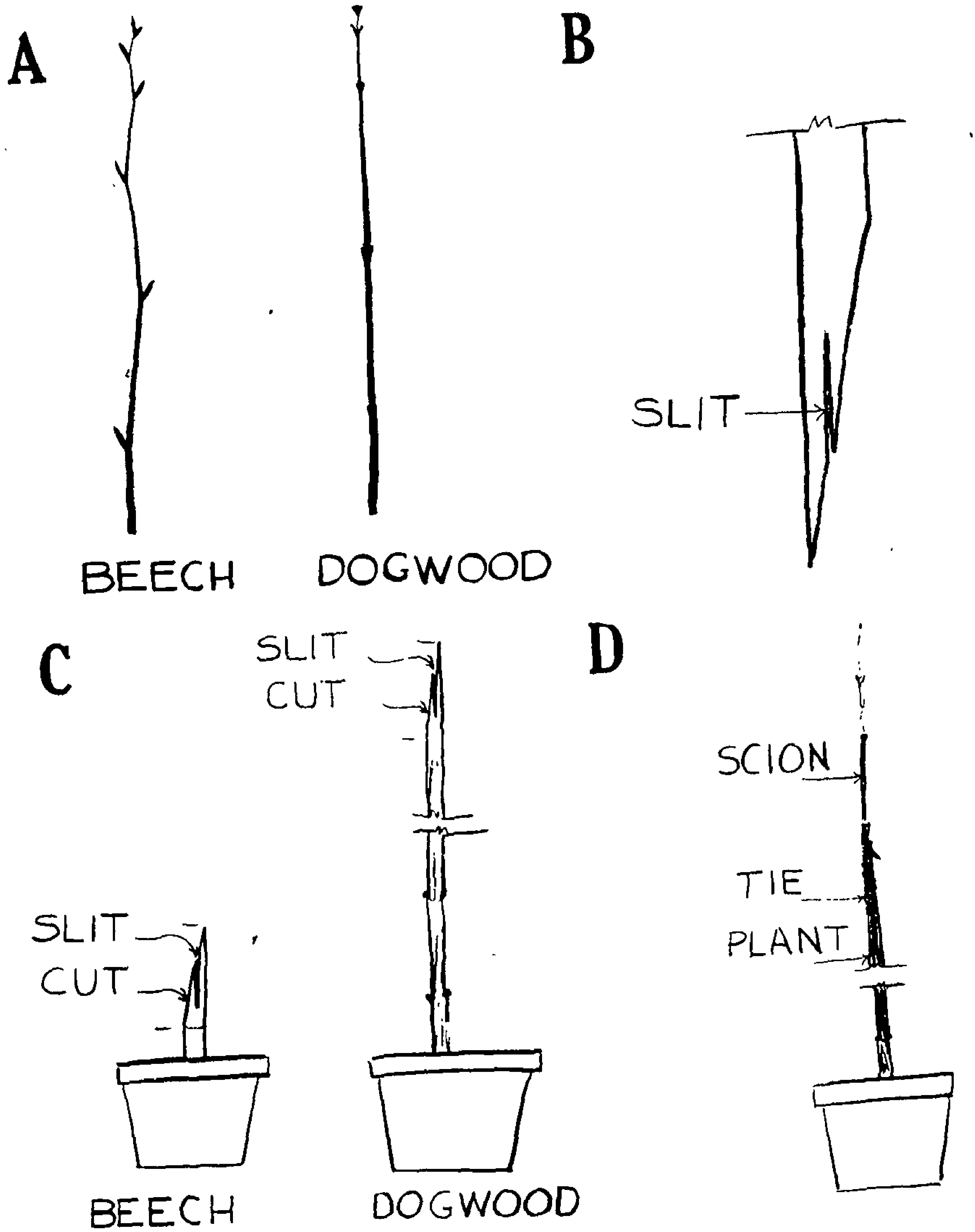

Figure 2. Whip grafting method used for beech and dogwood. (A). Material used for scions. (B) Type of cut made at base of scion. (C). Cuts prepared in stock plants. (D). Completed graft after tying.

MODERATOR MOREY: Thank you, Bill. We will go on now to a discussion by Robert Boddy of Descanso Nurseries, Chino, California, on the propagation of lilacs. Mr. Boddy.

THE PROPAGATION OF LILACS (SYRINGA)

ROBERT BODDY
Descanso Nurseries
Chino, California

Reproduction of lilacs from cuttings has been practiced at the Descanso Nurseries for a period of approximately ten years with varying success. Sometimes rooting will be as high as 25%, sometimes only 1%. Generally, the average is about 10%. The percentage of take would probably be much higher if we were working with many types of lilacs or with an abundance of named varieties. But our work has generally been restricted to one named hybrid, "Lavender Lady." This report concerns our work with this special plant.

'Lavender Lady" is unique because of its ability to consistently produce fine spikes of flowers year after year with an absolute minimum of winter chilling. Thus our nursery, with sales only in the local area, is primarily interested in this single variety, for many of the finest named varieties of lilacs that perform so well in the East and Middle West will never bloom in warm-wintered Southern California.

We have other hybrid lilacs with virtues similar to Lavender Lady under test at our nursery that appear to be easier to root. However, cuttings of these plants have been limited to only a few hundred, so we can not yet compare relative successes.

We prepare to take cuttings of lilacs from blocks of field-grown mother stock as soon as the growth from the first flush of buds is firm. In our limited operation, we will make up to 30,000 cuttings each year but have success with only from 1500 to 5000. The successful cuttings root readily, on schedule, and grow on to make fine plants. In order to insure even this limited success, we perhaps take cuttings too early and too late. That is; the wood is initially perhaps too green and then within a few weeks it is too old. Our "shotgun approach" is to take about 2000 to 3000 cuttings at a time spaced over about a four-week period. At one time during this interval we get a pretty good strike on one or two days' cutting efforts. In analyzing our very limited success we have concluded that all other things being favorable and equal, the selection of wood is of prime importance.

The cuttings that ultimately do best are not quite the greenest and they are not the most mature. They are firm green. They are not soft that they will snap and yet they are sufficiently soft that they will wilt readily if not attended to properly. Length of cuttings is from 3″ to 4″ and caliper is about matchstick size. Cuttings are taken from tips that have just reached terminal growth.

The ultimate in sanitation must be practiced in handling the cuttings. The University of California Manual 23 is our guide in this procedure. A separate small greenhouse, 10′ x 60′, is devoted to the exclusive propagation of lilacs. One week prior to the propagation, the interior of the house is drenched with a Clorox solution under pressure. All parts of the house are exposed to this drench.

A propagation medium consisting of granulated pumice and peat moss is prepared and placed in nursery flats for steam sterilization each day before use.

Cuttings are taken in the morning and prepared and inserted in the medium generally before noon. A light shading is given the greenhouse and initially the house is maintained nearly airtight. Recently we have air-conditioned our greenhouses so that interior temperatures are not excessive. Night temperature is maintained at approximately 65 degrees F. and day temperatures might go as high as 85 degrees F. on a warm day.

We have two types of humidity systems. One operates constantly and sprays a mist under the benches and over the center walk area. The other mist is overheard and is operated at about 75 lb. pressure intermittently. For the first two weeks we attempt to never allow the foliage of the cuttings to get dry. We will hand fog during the day to be sure that no dry spots develop on the benches. After about two weeks the first casualties appear.

Several years ago we used to pinch out the terminal bud of the cuttings. We tried this in an attempt to do away with foliage that was too soft before it fell away. But in nearly all cases, an infection of some sort developed at the point of the pinch and the cutting started rotting from the tip downward. We no longer pinch out terminals. Now our initial trouble seems to come from weak wood that allows the foliage of the cuttings to start falling off at the base of the cutting until nearly all the leaves have dropped; then a black rot starts up the stem. We prick these casualties off daily and continue our sanitation program of drenching and dusting, as suggested in U. C. Manual 23.

The remaining cuttings, and there are precious few, will now commence to callus and the stronger cuttings will develop a light root system. We feel that at long last we have mastered nature but results do not bear out our wishful thinking. For after the cuttings callus, they appear to go dormant. The old leaves get hard and appear to want to drop off. Heat and moisture seem to keep them on, but all growth appears to terminate. Then, on some of the plants, we will notice a swelling of the terminal bud as if it is going to start a cycle of growth. Some root action will develop but it is generally light. Our tests have not indicated that hormone powers make a difference in root growth at this stage..

The development described above takes place about 4 to 5 weeks after a cutting is inserted. From this time on it is a question of watching and waiting. The cuttings appear to be completely dormant, the old foliage deteriorates, and root development is slow.

We start potting off cuttings with roots after about 8 weeks and continue for nearly three months, after which time we will dump all of the remaining cuttings. Most of the material we dump will be callused but our experience is that it will eventually decay and it is not worth our while to nurse them along.

Cuttings that we pot off, while possessing a good root system, are nevertheless dormant and we will not get top growth on these potted cuttings unless it is an occasional break from a previously dormant growth bud. Such breaks occur in late summer and early in the fall. We do not anticipate growth on the liners until the following spring. Our practice now is to take the established potted liners in peat pots and line them out in raised beds of prepared soil mix and grow them under the shade of Saran cloth. The extra shade provided by the Saran allows the plant to grow a little taller with better foliage. We also are planning to take cuttings from the shade grown plants and test their ability to root, as compared with field grown wood. Limited tests made previously with shade grown wood indicate that we will have better success in harvesting a better grade of cutting wood.

Soon we will be starting another lilac season. This year we are going to experiment with lights to determine if this might influence the plant to remain active and not go dormant. We are also going to place some cuttings under a plastic bench shelter and will continue to work with propagation medium of different types that will provide better packing around the inserted stems. We feel perhaps that our medium is too coarse and too much air is allowed to get to the rooting area of the cutting stem.

We are looking forward to our work and hope that someday we will able to provide more lilacs on their own roots for use in the southern California area.

MODERATOR MOREY: Thank you, Bob. Our next paper is on the grafting of *Acer palmatum* by Bill Omar of Doty & Doerner, Tigard, Oregon. However, Bill was unable to make the trip to southern California so his talk will be given by Bill (Omar) Curtis, Bill.

THE GRAFTING OF ACER PALMATUM[1]

WILLIAM OMAR
Doty & Doerner
Tigard, Oregon

I take one-year seedlings from beds and line them out in field rows, planted one-half inch apart in the row. After two years in the field they are ready for understocks and can be dug when dormant around November 1st to 15th and then graded for size, root pruned and cut back some. The seedlings are then potted in 2½", 3" or 4" pots.

After potting, they are bedded down on a greenhouse bench in damp peat moss to a level just over the top of the pot. This submerging in peat holds moisture for a long period of time and makes an ideal medium for producing a rapid, well developed root system. Greenhouse temperature should be 55-60 degrees F. top heat. I do not use bottom heat — just let them come along slowly. This seems to work best for me, as I don't want to force bud action too soon. On February 1st, or shortly thereafter, depending on the winter, they

[1]Paper presented by Mr. William Curtis, Sherwood, Oregon.

cuttings unless it is an occasional break from a previously dormant growth bud. Such breaks occur in late summer and early in the fall. We do not anticipate growth on the liners until the following spring. Our practice now is to take the established potted liners in peat pots and line them out in raised beds of prepared soil mix and grow them under the shade of Saran cloth. The extra shade provided by the Saran allows the plant to grow a little taller with better foliage. We also are planning to take cuttings from the shade grown plants and test their ability to root, as compared with field grown wood. Limited tests made previously with shade grown wood indicate that we will have better success in harvesting a better grade of cutting wood.

Soon we will be starting another lilac season. This year we are going to experiment with lights to determine if this might influence the plant to remain active and not go dormant. We are also going to place some cuttings under a plastic bench shelter and will continue to work with propagation medium of different types that will provide better packing around the inserted stems. We feel perhaps that our medium is too coarse and too much air is allowed to get to the rooting area of the cutting stem.

We are looking forward to our work and hope that someday we will able to provide more lilacs on their own roots for use in the southern California area.

MODERATOR MOREY: Thank you, Bob. Our next paper is on the grafting of *Acer palmatum* by Bill Omar of Doty & Doerner, Tigard, Oregon. However, Bill was unable to make the trip to southern California so his talk will be given by Bill (Omar) Curtis, Bill.

THE GRAFTING OF ACER PALMATUM[1]

WILLIAM OMAR
Doty & Doerner
Tigard, Oregon

I take one-year seedlings from beds and line them out in field rows, planted one-half inch apart in the row. After two years in the field they are ready for understocks and can be dug when dormant around November 1st to 15th and then graded for size, root pruned and cut back some. The seedlings are then potted in 2½", 3" or 4" pots.

After potting, they are bedded down on a greenhouse bench in damp peat moss to a level just over the top of the pot. This submerging in peat holds moisture for a long period of time and makes an ideal medium for producing a rapid, well developed root system. Greenhouse temperature should be 55-60 degrees F. top heat. I do not use bottom heat — just let them come along slowly. This seems to work best for me, as I don't want to force bud action too soon. On February 1st, or shortly thereafter, depending on the winter, they

[1]Paper presented by Mr. William Curtis, Sherwood, Oregon.

will be ready for grafting. This is gauged by root action, and when the buds begin to break, I know they are ready for grafting.

I use a low side graft. By so doing, one does not lose his understock. I have tried other types of grafts, but my best results have been with the use of this low side graft. Care must be taken in matching the cambium, for it is very thin in *Acer palmatum.*

The graft is then tied with a rubber budding strip, and it *must be tight.* It can be waxed if so desired. I have had good results without waxing. Howevei, this method necessitates much greater care of the graft. I would advise a cold wax, such as Treheal. If a hot wax is used, great care must be taken not to injure the cambium and lose the graft by burning. Last year I got a 97% take on *Acer palmatum* varieties.

I grafted *Acer palmatum dissectum, dissectum nigra,* and Burgunly Lace. Some of the understocks were quite large and well-branched, so I put them in gallon cans instead of pots and put on three to four grafts on each understock. A perfect take usually results on these heavier plants. When the grafting operation is completed, I again return the plants to the bench, cover with damp peat moss, and let nature take its course.

In about four weeks, I cut back all new growth from the understock only, and in three or four weeks I will cut back again. This second time I cut back some of the old wood, especially if the understock is branched.

By the time of the second cut back, the graft should show some action and should have started to callus. If waxed, the wax should start cracking which is a good indication that the graft has taken. The scion should be in full leaf and making growth.

In about 90 days the grafted plant will be ready for cutting back of all understocks just above the graft. I then take the young Japanese Maples from the bench and can these in gallon containers. They should be placed under partial shade during the first summer, since the plants are very tender and won't take full sun.

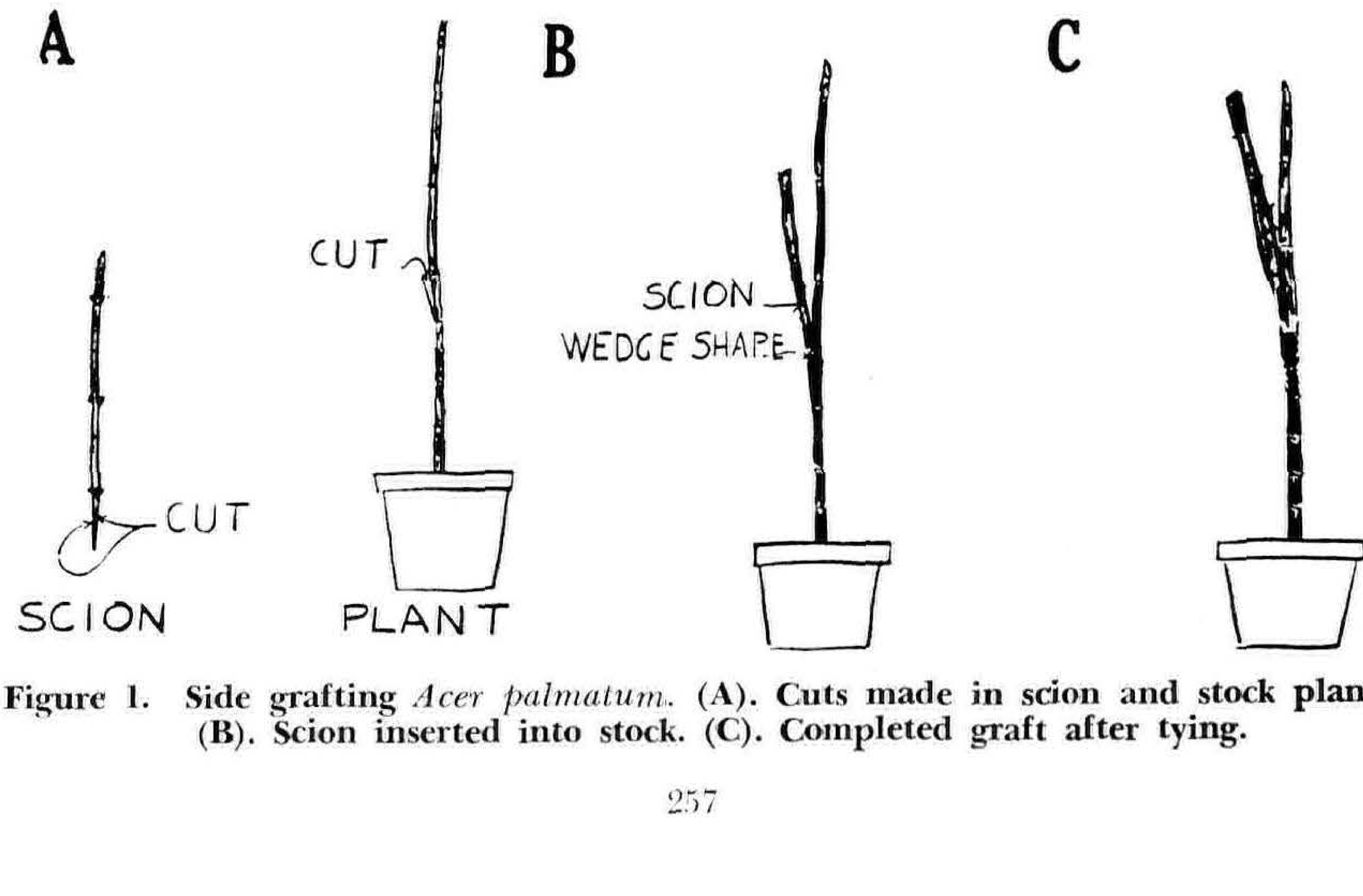

Figure 1. Side grafting *Acer palmatum*. (A). Cuts made in scion and stock plant. (B). Scion inserted into stock. (C). Completed graft after tying.

MODERATOR MOREY: Our last talk in this section is by Mr. Bill Armstrong, Highway Landscape Supervisor of the California State Division of Highways. Bill Armstrong.

ROOT CONSTRICTION OF CONTAINER-GROWN NURSERY STOCK

WILLIAM ARMSTRONG
Highway Landscape Supervisor
California State Division of Highways
Sacramento, California

Any operation by a public agency which requires increased expenditure of public funds is reflected on down to the individual taxpayer. We, therefore, are attempting to eliminate a costly problem which belongs to all of us. If you wanted to assume a selfish attitude, the reverse is also true, inasmuch as any savings by a public agency is reflected in a savings passed on to the taxpayer. From your standpoint, funds spent to replace and maintain defective plant material cannot be used for planting new areas.

The problem which we are attempting to overcome is that of defective nursery stock which is "pot-bound" or "root-bound." Definitions may differ with individuals so let me suggest this: A "pot-bound" plant is a plant which has remained in a pot until the roots have become constricted, usually circling the pot a number of times. The pot is usually 2 to 3 inches in diameter. A "root-bound" plant is one which has remained in any container until the natural root growth has become constricted, usually resulting in a retarded plant.

"Root-bound" plants as just defined may recover from this condition if encircling roots are cut around the outer portion and across the bottom of the ball. "Pot-bound" plants from our experience, will not recover from this condition. Although plants may recover from being "rootbound" after proper plantings, the recovery period delays attaining the desired effects by as much as several years. The cost of this delay amounts to considerable money due to this additional period of intensive maintenance.

In an attempt to reduce the high cost of continuous maintenance, native or drought-resistant plants are used wherever possible. This type of plant is especially sensitive to "pot-bound" root since it is their nature to send roots deep into the earth as rapidly as possible. Once their roots have become constricted and remain in a shallow coil, they die before becoming established, or require care equal to the more domesticated varieties.

Certain varieties respond favorably perhaps for several years or until our plantings normally mature. At this time, plants die of strangulation or snap off at ground level in high winds. Plants like the *Leptospermum* tend to "unscrew" from the ground during windy weather when "pot-bound." Recently an eleven-year-old *Eucalyptus ficifolia* was shoved over with ease while trying to analyze its ailment. The root had never recovered from being "pot-bound." In one area, 100% of all the *Eucalyptus lehmanii* died during the first hot summer after planting because they had not recovered adequately from being "pot-bound" before the stress period of the year.

Losses such as these result in a costly replacement program. Once replacements have been made, the plant must again receive intense maintenance, just as it did when the original planting was made.

As most of you know, contracts are let or orders are placed in advance for commercial nurseries to propagate and deliver most of the plant material which is used for highway planting. Assume that these plants are delivered to us in a "pot-bound" condition. Once they have been accepted at one of our holding areas, they become state-furnished plants on a landscape contract. Let us further assume that the contractor has a number of "pot-bound" plants which he intends to furnish for the contract. Even though we are permitted to reject the contractor's plants, it is extremely difficult to do so when the state is furnishing the same defective plants.

Experience in growing nursery stock has proven to us that plants can be planted directly into gallon cans, thus eliminating the pot stage. Of course, to do this requires the protection of lath for a period after transplanting. If the potting operation could be eliminated, so would the most serious of our problems in root constriction. We appreciate your effort in the use of peat pots, tarpaper pots, square pots, etc. But to date we have not found the pot which will not constrict root growth.

It is understood that surplus potted material is sold as "liners," affording a market for most of the material raised. Since orders with the state specifies a definite number, it is recommended that plants be placed directly into gallon cans, thus eliminating costly replacements at a later date.

The following is a list of plants which are most frequently lost due to being "pot-bound."

Eucalyptus — all varieties
Melaleuca armillaris
Cistus — all varieties
Photinia arbutifolia
Leptospermum laevigatum
Schinus terebinthifolia
Ceanothus — all varieties
Cinnamomum camphora
Pittosporum undulatum
Prunus lyoni
Ceratonia siliqua
Fremontia Californica
Lagerstroemia indica

SATURDAY MORNING SESSION

October 20, 1962

The final session convened at 8:30 A.M. with Dr. Vernon T. Stoutemyer, Chairman, Dept. of Floriculture and Ornamental Horticulture, University of California at Los Angeles, presiding. The program started with an introductory presentation by Dr. Stoutemyer..

THE CONTROL OF GROWTH PHASES AND ITS RELATION TO PLANT PROPAGATION

V. T. Stoutemyer
Department of Floriculture & Ornamental Horticulture
University of California, Los Angeles, California

Much modern plant research is directed toward the control of plant growth either by regulation of the environment, or by the application of chemicals. The progress already made along this line has been encouraging and, in some cases, spectacular. Our florist shops now offer chrysanthemums every day in the year. Powerful new selective herbicides, often spread by plane or helicopter, kill certain plants in a field, pasture or forest while leaving others. The use of chemicals to aid rooting of cuttings is another example. In some of the eastern states, sprayers dispensing maleic hydrazide are used along highways in place of mechanical mowers. Such instances can be multiplied. We shall discuss an aspect of this problem which is little understood and that is the question of control of juvenility and of readiness to flower and fruit in woody plants.

If we could overcome juvenile characteristics in woody plants as quickly as possible, the breeders of tree fruits would be very happy. On the other hand, vegetative propagation would often be greatly simplified if we could cause reversions to juvenile growth at will. In a limited way, these objectives are now possible.

Both woody and herbaceous plants commonly progress through a series of changes in morphology as they go from the seedling to the mature fruiting stage. Sometimes the differences are so slight and gradual that they are not apparent to the casual observer. In other cases they are striking. Some Australian acacias have pinnate leaves in the seedling stage, but after a few months or years lose them and produce only phyllodes in place of the leaves. On the other hand, in some conifers, the change to mature foliage may require many years, even a substantial part of a century in some New Zealand species. In some plants a whole series of transitional leaf types appear. Sometimes two different binomials were given to the same species by taxonomists who were deceived by the varied expressions of growth.

In general, a plant showing juvenile leaf characters will reproduce much more easily vegetatively, and will not produce flowers and fruit, but there are exceptions. Some conifers, olives, and eucalyptus have ben observed to fruit on shoots showing juvenile characters. Citrus seedlings sometimes flower exceedingly early in life and then do not flower again for a number of years.

There are some horticulturists who largely ignore the subject, *since they interpret the leaf dimorphism to be an expression of* different types of growth due to some incidental environmental conditions. However, most horticultural experimenters at the present time recognize the phenomenon and are giving it increasing attention. There are today research centers in England, Holland, Germany, Austria, Russia, and Italy which are studying juvenility in plants.

The speaker has devoted attention to methods of prolonging or reestablishing the juvenile form of growth, because of a long interest in plant propagation. Probably the most progress has been made on this part of the problem. Since breeders of fruit or forest trees are interested in eliminating juvenile expressions of growth as quickly as possible, we shall first mention in outline the treatments which have been reported sometimes to promote this objective.

The late N. P. Krenke, an able and productive Russian worker, put forward a theory of cycle ageing and rejuvenation which he derived from an interpretation of his experiments by means of the Marxian dialectical materialism. Some recent Soviet horticulturists have not accepted his theories. Krenke derived some of his ideas from Michurin, whose theory of mentor grafting is widely held and practiced by Soviet fruit breeders. According to this view, a young seedling in the juvenile stage is very plastic and if deprived of all of its leaves for a period and grown entirely by the photosynthesis of the mature stem as a mentor or trainer scion, it will take on permanently some of the desirable characters of the mentor scion. Many breeding projects in Soviet Experiment Stations still apparently use this technique, probably because of the strong political support of the Lysenko group of geneticists. The idea is found also in pomological literature from the various Iron Curtain countries, but we do not know of any reputable Western scientists who have supported this view. Personally, we regret that a carefully controlled experiment to examine the whole theory has not been conducted in Western countries. *In Western Europe there are now two very distinct viewpoints* regarding juvenility in woody plants among pomologists. One group expresses the traditional viewpoints perhaps first clearly expressed by the German botanist, Goebel, in which the two stages are regarded as quite distinct and to some extent permanent in the lower portion of the tree. On the other hand, others minimize the differences between the two stages and regard their manisfestations as dependent on changes in the nutritional and hormonal balances wihin the tree. To support this viewpoint, they cite observations that the base of a tree may not remain permanently juvenile but may bear flowers and fruit. On the other hand, the so-called juvenile shoots may appear high in mature trees.

Over a dozen different treatments have been claimed to accelerate flowering and fruiting in seedlings of woody plants, but the evidence for many of these treatments is very confusing and contradictory. The present evidence seems to indicate that the efficacy of the treatments apparently depends on the species. There are effective means of speeding the flowering of woody plants of mature, established clones. Caution should be used in interpreting the results of many experiments since in some cases the seedling had often made considerable progress toward the production of flowers before the treatments were applied.

The following are the most important treatments for which favorable claims have been made.

1. *Use of extra or prolonged growth periods.*
   The use of extra growth cycles made possible by artificial environmental control has given contradictory results. However, by the use of artificial lights to provide continuous illumination, Lammerts produced flowering of camellia seedlings at the end of the first year. Similar success has also been reported with birch and rhododendron.
2. *Transplanting and root pruning.*
   This is a standard treatment with wistaria and some success has been claimed with fruit tree seedlings.
3. *Fertilizer applications.*
   Although heavy application of nitrogen may cause heavy vegetative growth which will delay flowering, sometimes with conifers this hastens the appearance of cones, especially when applied in combination with root pruning.
4. *Geotropic responses.*
   Bending stems to a horizontal or descending position sometimes accelerates flowering.
5. *Mound layering.*
   This treatment has been claimed to accelerate the fruiting of grape seedlings from the fifth to eighth year to the third or fourth year.
6. *Bark inversion, ringing and notching, or tying.*
   Possibly these have had some value, but often have temporary effects. A variant has been to tie young seedling plants into knots.
7. *Grafting or budding in crowns of mature trees.*
   This technique has been successful with *Hevea* rubber seedlings and with pines, but has been of uncertain value with many species of fruits.
8. *Grafting on related species.*
   A few striking illustrations of success are known and the technique has been useful with a herbaceous plant, the sweet potato.
9. *Grafting on dwarfing stocks.*
   This technique is useful on old established clones, but it has a problematical value on young seedlings of fruit trees.

10. *Growth regulators.*
Growth retardants have been used to produce bud setting on azaleas.

11. *Grafting mature scions into seedlings.*
The Russian "Burbank," Michurin, claimed to be able to hasten the first flowering of fruit tree seedlings by grafting scions of mature clones in the tops.

12. *Climatic factors.*
Seedling fruit trees have been observed to bear earlier in localities having the most favorable climate. High summer temperatures have been observed to promote cone formation on certain conifers.

The reverse situation, the production of juvenile types of growth at will, is probably of more general interest to plant propagators. Some progress has been made along this line, although there are some controversies relating to the interpretation of certain observed phenomena. The following are treatments which have been observed either to produce reversions or at least to favor the prolongation of juvenility.

1. *Growth from root sprouts or sphaeroblasts.*
Most experimenters agree that juvenile tendencies are prolonged in the roots and crown of the tree. Root sprouts often thus show juvenile characters and root easily. Sphaeroblasts are concretations of wood and meristem which arise on some tree trunks and branches. Adventitious buds are formed on some of them and shoots from them may show juvenile characters.

2. *Severe pruning or heading back.*
This treatment sometimes causes reversions, especially if done near the base of the tree. Reversions are less common in the top of trees with most species.

3. *Reproduction by seed.*
Normal seedlings show juvenile characters and this is true also of nucellar seedlings of citrus which reproduce the variety but in a rejuvenated form. These seedlings are often prized in citrus as they are ordinarily free of viruses and are often exceptionally vigorous.

4. *X-ray treatments.*
This has been reported by one group for English ivy.

5. *Cold treatments.*
This has been reported by one group for English ivy. This and the previous treatment have not yet been substantiated by other experimenters.

6. *Reduced light.*
This is generally considered to prolong the juvenile stage of growth or to promote juvenility.

8. *Grafting on juvenile stocks.*
Grafting of adult ivies on juvenile understocks will promote

reversions, but only if the temperatures are above a certain minimum.

9. *Treatments with gibberellin.*
Spraying mature shoots of ivy with gibberellin produces reversions, if the temperature is above a certain minimum. The range of applicability of this treatment is not known.

At the present time some theories have been advanced regarding the nature of juvenile and adult growth phases in plants, but there is yet little in the way of well-documented, fresh information.

In our laboratory we have attempted to analyze the nature of the phenomenon by means of tissue cultures taken from juvenile reversion shots on adult flowering plants of English ivy. These often occur spontaneously at the bases of mature plants. They can be produced at will by certain treatments, but only the naturally-occurring reversion shoots were used in these experiments.

Both the English and the Algerian ivies in the juvenile stage are true vines having flattened stems, dorsi-ventral leaf arrangement with palmate leaves and frequently produce aerial roots and red pigments. The adult fruiting shoots appear after a period of years and are shrubby and have entire leaves. Root formation is rare on the stems. Transitional forms are common.

The sterile cultures of English ivy were started by pulling off the epidermis and taking pieces from the subepidermal layers about 2 mm square with a scalpel.

These were grown or placed on White's medium (1943) modified as follows:

KNO_3, reduced to 47.0 mg/l (from 80 mg/l)
NH_4 Cl added, 60.0 mg/l
Coconut milk, 100 ml/l
Casein hydrolysate (enzymatic), 200 mg/l
Inositol, 100 mg/l
Napthaleneacetic acid, 1 mg/l
Difco Bacto Agar, 6 gms/l

The medium was prepared with glass distilled water and the pH of the media was adjusted using 0.1 N NaOH to 5.8 before autoclaving at 18 lbs. for 30 minutes.

Small flint glass vials with plastic caps were convenient and saved space. This medium permitted the successful subculturing of callus tissues of English ivy and was found after a prolonged study of methods by my laboratory technician, Mr. O. K. Britt.

The significant finding of these studies is that the tissue cultures from the juvenile tissues have a considerably higher growth rate than those from the mature tissues. Also, the juvenile cultures form roots much more freely. These differences have persisted through seven subcultures. We believe that this shows that the differences between juvenile and adult growth are profound and are apparently on a cellular basis.

MODERATOR STOUTEMYER: We will now hear from Dr. Charles E. Hess, Associate Professor of Horticulture, Purdue University, Lafayette, Indiana, who will discuss his work on the physiology of rooting. We will also be privileged to see the excellent movie film he has prepared, showing step-by-step the methods used and results obtained during his studies. Dr. Charles Hess.

A PHYSIOLOGICAL COMPARISON OF ROOTING IN EASY AND DIFFICULT-TO ROOT CUTTINGS

CHARLES E. HESS
Department of Horticulture
Purdue University

In order to obtain an understanding of the substances involved in the processes of root initiation, a comparative study of rooting has been made in the juvenile and mature forms of *Hedera helix* L. *Hedera* was selected as the experimental material because as shown in Figure 1 both the juvenile and the mature form may be found on the same plant. However, the rooting ability of the two forms is very different. The juvenile form roots very easily; 100% rooting is not uncommon. The mature form of *Hedera*, on the other hand, is very difficult to root, 16% rooting being the maximum under our conditions. Therefore we have plants which should be genetically identical and are grown under the same environment, and yet are very different in their rooting ability.

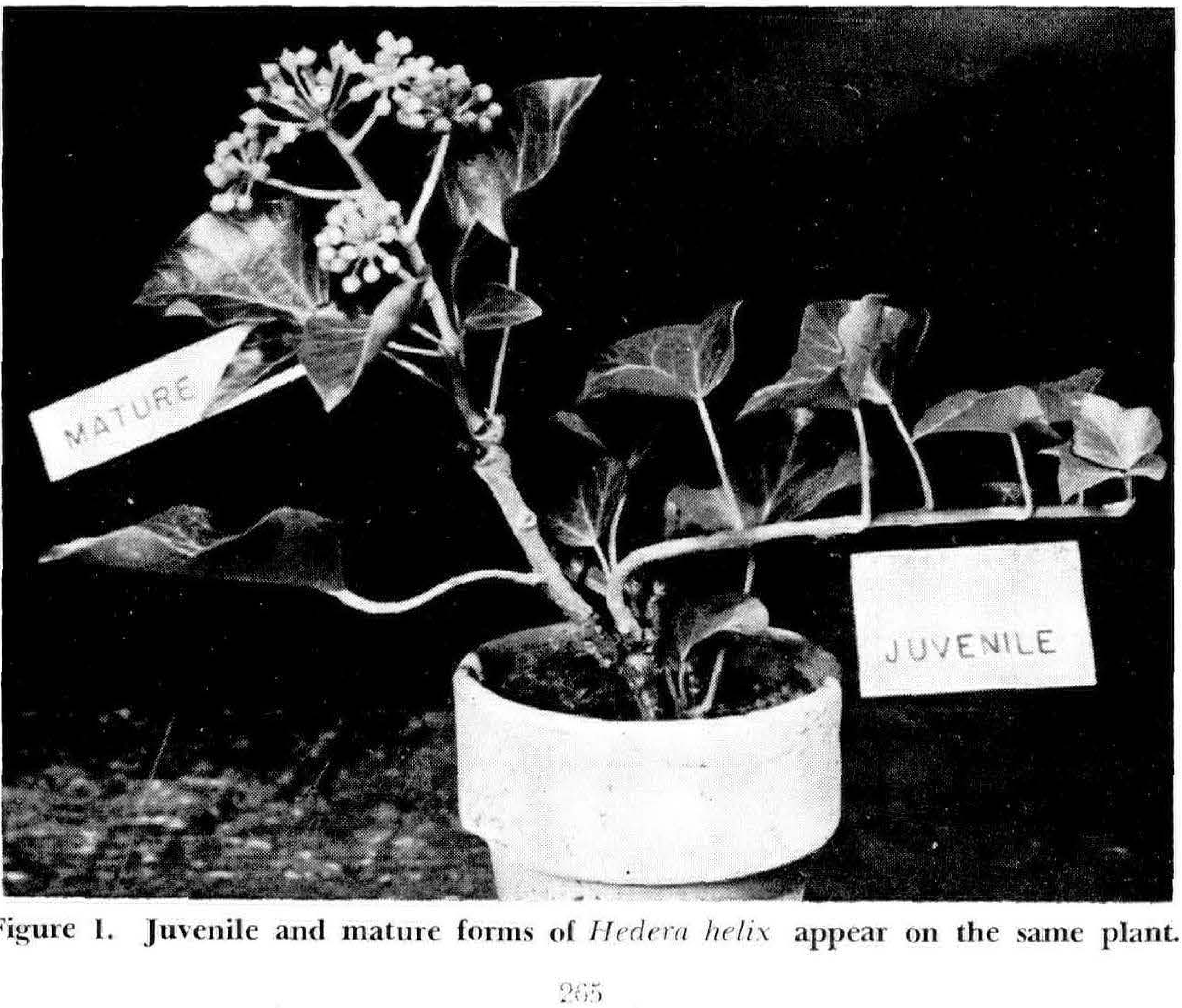

Figure 1. Juvenile and mature forms of *Hedera helix* appear on the same plant.

The first approach in the study was to determine the auxin and inhibitor content of the two growth forms. The purpose was to see if the easy-to-root juvenile form contained an auxin which was lacking in the mature form, or if the mature tissue contained an inhibitor which blocked root initiation. The former possibility did not seem likely since the application of known auxins did not alter substantially the rooting response of the mature cuttings. However the latter possibility, that is the presence of an inhibitor, has been described by Spiegel (3) in difficult-to-root grape cuttings.

Methyl alcohol extracts were made of dried tissue from juvenile and mature cuttings. The extracts were fractionated by paper chromatography. The presence of auxins and inhibitors was determined by use of the *Avena* coleoptile straight growth test as described by Nitsch and Nitsch (2).

The results of such an experiment is shown in figure 2. The bars above the horizontal line represent areas of growth promotion or auxins, and the bars below the line represent inhibitors. IAA, IAN, and IAE represent indoleacetic acid, indoleacetonitrile, and ethyl-3-indoleacetate. The three substances are known auxins which have been found in plant tissues and were co-chromatographed with the tissue extracts for the purpose of comparison.

The important things to see in Figure 2 are (1) that there are several auxins and inhibitors present in the juvenile and mature tissues, and (2) the auxins and inhibitors are present in approximately the same amounts in the juvenile and mature tissues. Therefore, it did not seem possible that the great difference in rooting abili-

Histograms Showing Biological Activity of

Chromatograms of GROWING Hedera helix L. Tissue

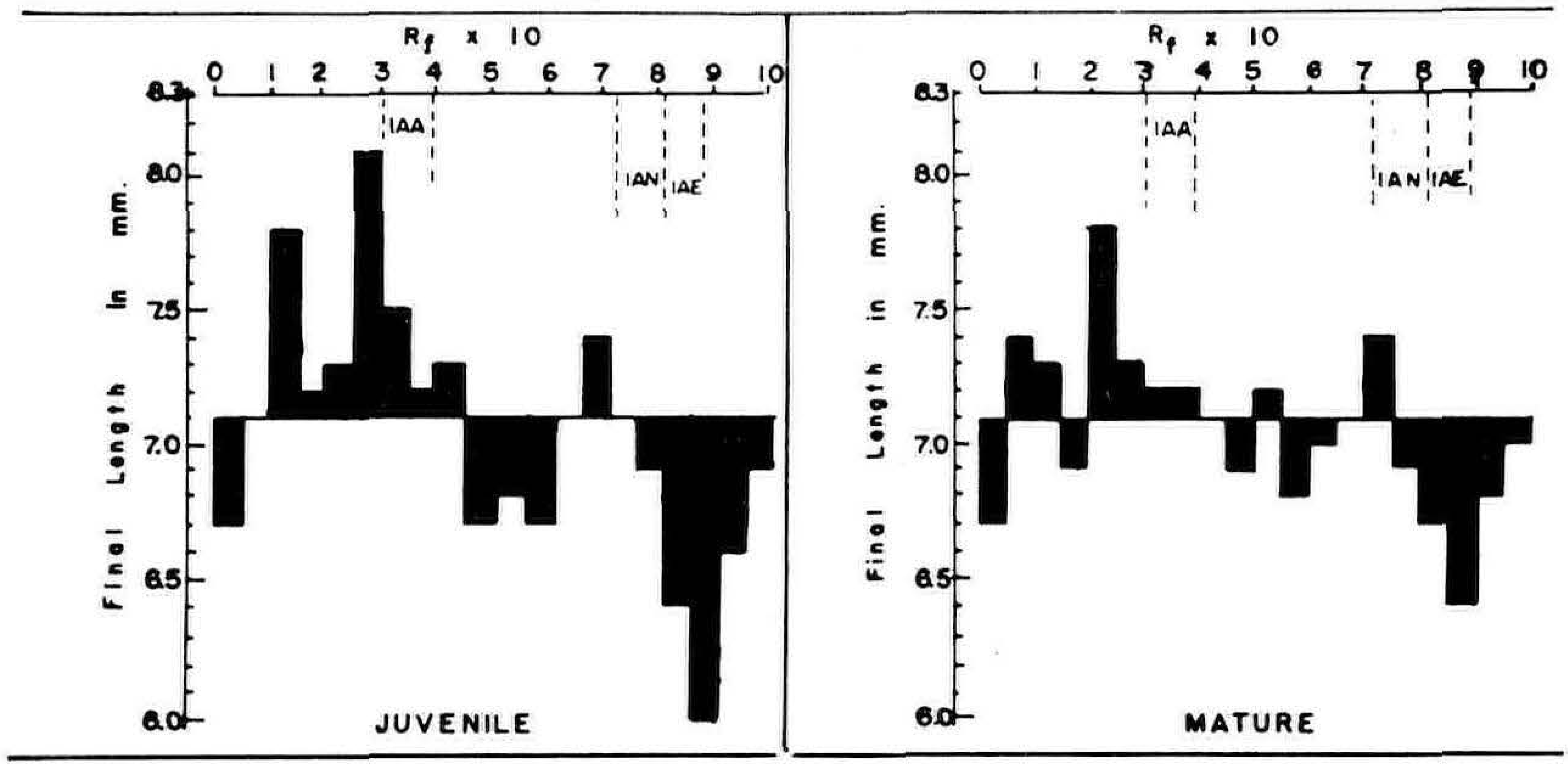

Figure 2.

50mg lyophilized tissue, extracted with methanol for 2 hours at 0°C. Extract chromatographed in isopropanol - ammonia - water (8,1,1). Bioassay - *Avena* coleoptiles 4mm. long, taken 3mm. below tip.

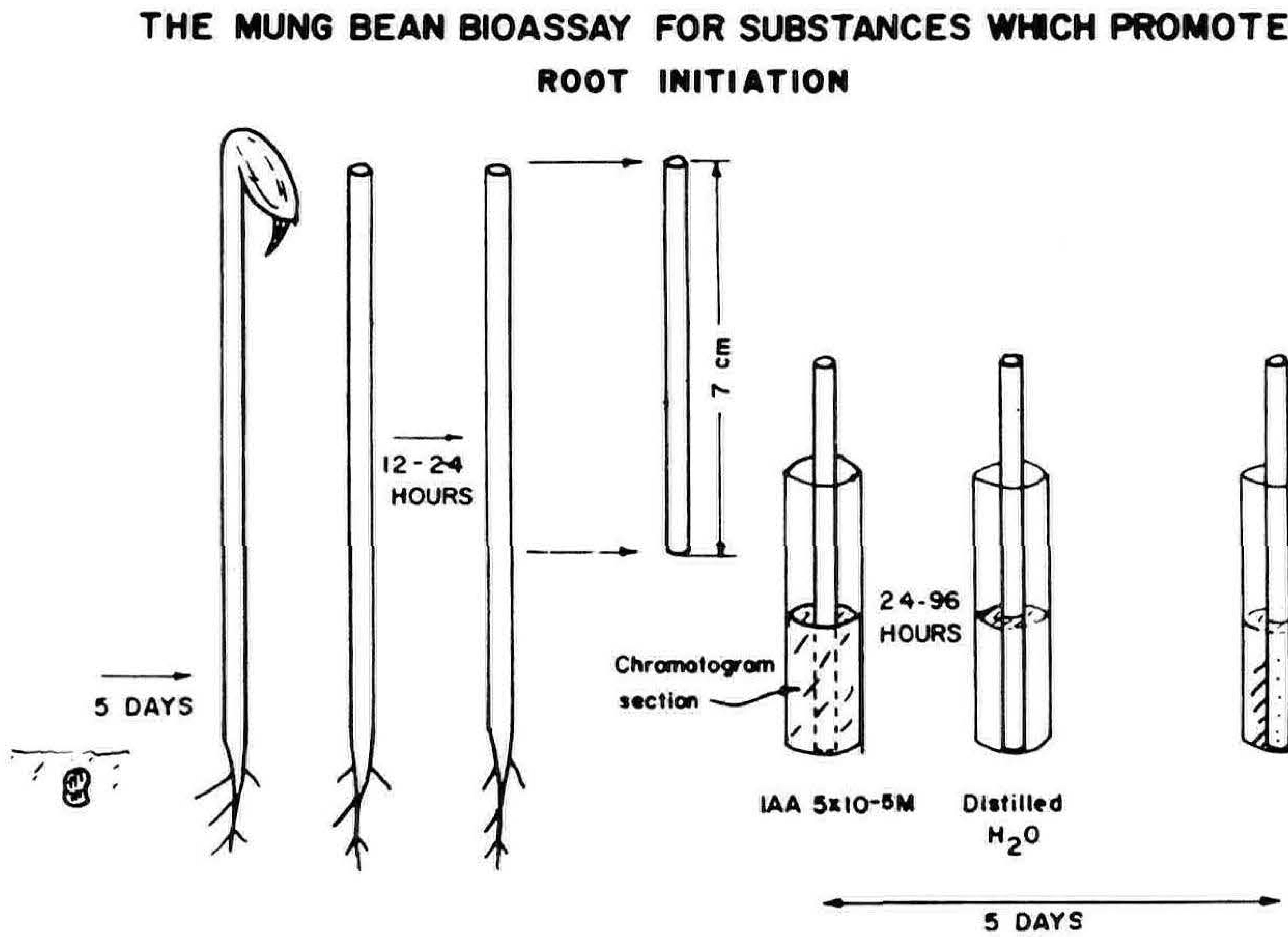

Figure 3.

ty between the juvenile and mature *Hedera* could be explained on the basis of a difference in auxin or inhibitor content.

The next approach was to analyze methyl alcohol extracts of the juvenile and mature *Hedera* with a test based on rooting. Figure 3 shows one of the rooting tests that was used.

Seeds of the mung bean (*Phaseolus aureus*, Roxb.) are planted in vermiculite and are placed in a dark room with a temperature of approximately 27°C and 85% relative humidity. In 5 days the etiolated seedlings are ready for use. The cotyledons are cut off and the remainder of the seedling is allowed to stand for 24 hours. During this time the internal root promoting substances dissipate, leaving the cuttings more sensitive. At the end of the 24 hour period, 7 cm cuttings are taken. Ten cuttings are placed in each vial which contains an extract or piece of chromatogram. After 24 to 96 hours the cuttings are transferred to distilled water. The roots on the cutting are ready to count in 5 days from the time the cuttings were first made. The average number of roots per cutting in each vial is used to determine the presence of a root promoting substance.

Figure 4 shows the results of an experiment using the mung bean test. The juvenile extract, when supplied to the cuttings in the presence of indoleacetic acid (IAA at 5×10^{-5}M), substantially increased the amount of root initiation. The mature extract did not stimulate rooting.

When the juvenile extract is fractionated by paper chromatography and the chromatogram is assayed with the mung-bean rooting test, it is found that the root-promoting activity is due to at least four substances. Figure 5 shows such a chromatogram and each of the peaks above the horizontal line (average number of roots per cutting on the controls) represents an individual root promoting substance.

Although the third (RF0.6) and fourth RF0.8) peaks are quite close in this chromatogram, it has been possible to separate them using other solvents.

On the basis of this and similar experiments with *Hibiscus Rosa-sinensis* L., our present concept is that the differences in the rooting ability of cuttings is due to the presence of at least four substances in the easy-to-root cuttings. The difficult-to-root cuttings either lack these substances or contain smaller amounts of them.

The next step in this study is the purification and identification of the root-promoting substances found in the juvenile *Hedera*. With this information it will be possible to test our hypothesis and also find out how the substances actually work in stimuating root initiation. The techniques used for partial purification and some effects of chemical structure upon the activity of a root promoting substance are presented in a previous issue of the Proceedings (1) and will not be included here.

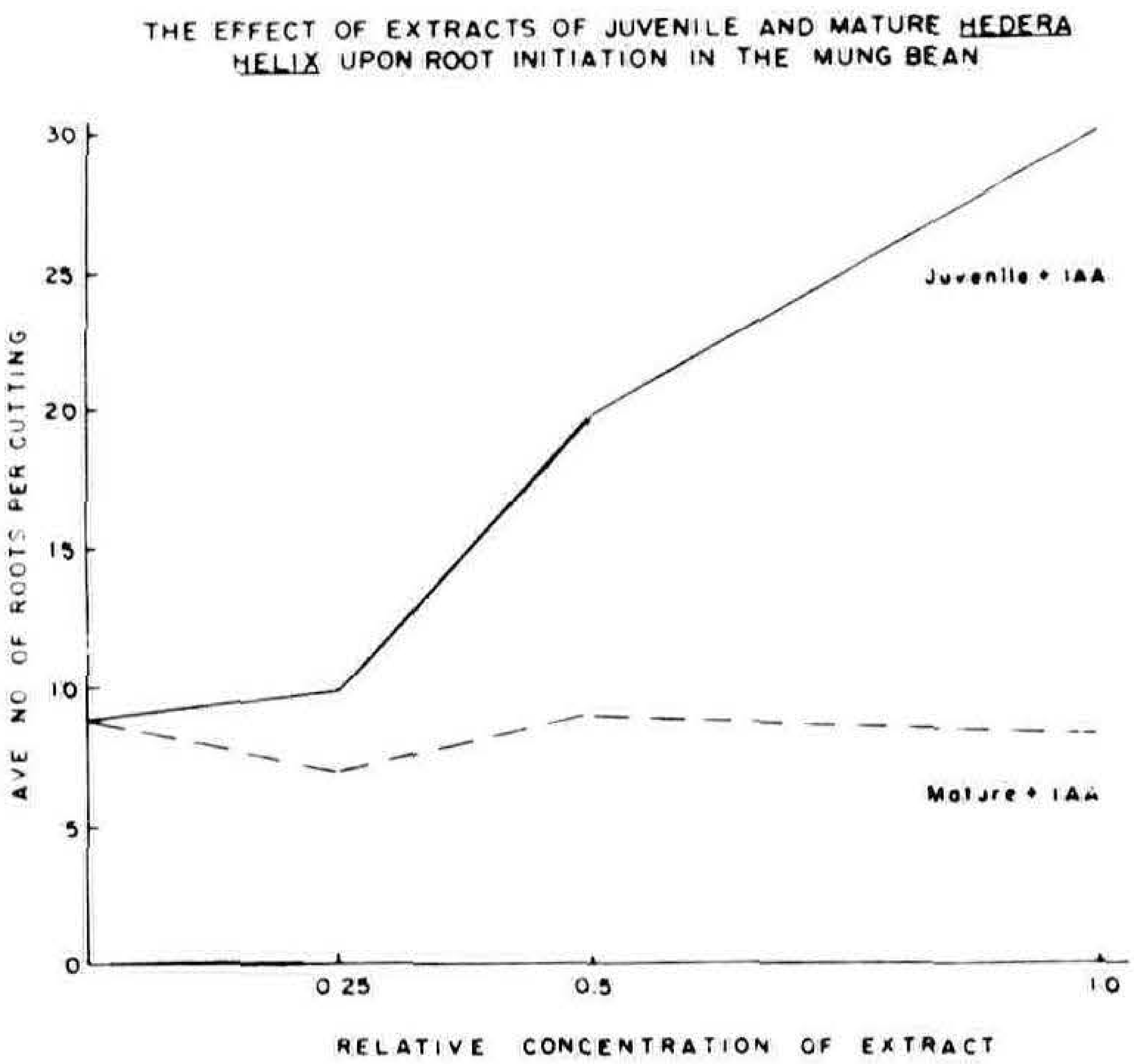

Figure 4.

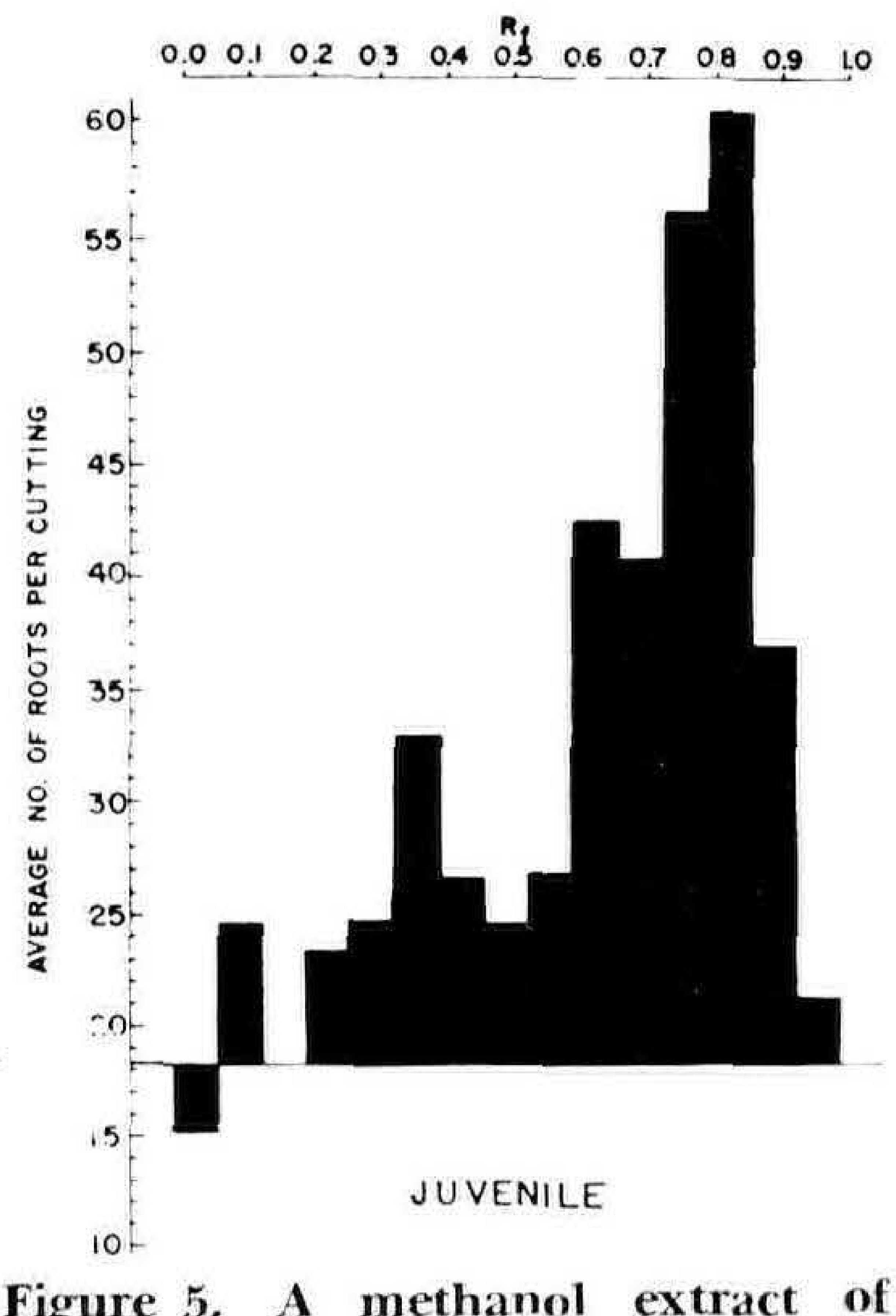

Figure 5. A methanol extract of juvenile *Hedera helix* tissue. water (8.2 v/v). Bioassay: Mung Chromatogram with isopropanol: Bean Cuttings.

LITERATURE CITED

1. Hess, Charles E. 1961. Characterization of the rooting cofactors extracted from *Hedera helix* L. and *Hibiscus Rosasinensis* L. Proceedings Plant Propagators Soc. 1961: 51-57.
2. Nitsch, J. P. and C. Nitsch. 1956. Studies on the growth of coleoptile and first internode sections. A new, sensitive, straight growth test for auxins. Plant Physiol. 31:94-111.
3. Spiegel, P. 1954. Auxin and inhibitors in canes of Vitis. Bull. Research Council of Israel 4:176-183.

MODERATOR STOUTEMYER: Thank you, Charley, for a most interesting talk. Our final presentation in this session will be given by Dr. Harry Kohl, Jr., who will speak to us on the control of plant height; Dr. Kohl.

CONTROL OF PLANT HEIGHT

HARRY C. KOHL, JR.
Department of Floriculture & Ornamental Horticulture
University of California
Los Angeles, California

It should be understood from the outset that this paper is not a review paper in the sense that it attempts to bring together the literature pertaining to plant height control. Instead it is hoped that what is presented here will be a discussion which will stimulate new practical methods of control based on noting and understanding older methods and exploitation of little-recognized possibilities such as photoperiod control.

Genetic Control

Although the majority of this discussion will be concerned with physiological control methods, it should be understood that genetic control of plant height is not only practical but in many instances is the preferred way to solve a problem in height control. Examples are numerous. Zinnias come in a wide variety of height classes from petites to giant, as do other garden flowers such as marigolds, asters, and stocks. The desire here for plants differing in height from the normal, usually towards shorter forms, has been met by judicious breeding and selection. Shorter forms of food crops such as bush beans, non-lodging wheat, and corn more suitable for machine harvesting, likewise have been attained through breeding programs rather than by treatment of existing varieties.

Likewise many dwarf and pyramidal forms of woody ornamentals are obtained by selection of progeny genetically different from the parent. However, in this instance the genetic difference is only that of a single gene and the new form is found as a bud sport or mutation rather than as a seedling from a breeding program.

A particularly interesting mutation is that of a bush rose to a climbing type. The mutation occurs frequently enough so that rose breeders need not concern themselves with breeding climbing roses. They can depend upon bush rose mutations to supply the demand.

The above should not be interpreted to mean that dwarf, woody plants can not be obtained as seedlings. To the contrary, beds of forest tree seedlings frequently contain dwarf forms and the progeny from almost any azalea cross where a forcing-type azalea is a parent will result in a rather high frequency of dwarfs.

Chemical Control

Next let us turn our attention to chemicals used to control height, restricting our discussion to those chemicals which need only be used in small amounts and which might therefore be considered to have hormonal action. These height-promoting and reducing chemicals are relatively new, having been recognized and studied within only the last few years.

The first of these chemicals was gibberellic acid and its many close relatives, collectively called the gibberellins. This group of chemicals among other things, such as influencing flowering, dormancy, and growth rate, tends to elongate plants. Since elongation of the stem alone is usually not horticulturally attractive, the gibberellins have not found a practical application for this purpose.

On the heels of the general announcement of the finding of the gibberellins, the first of the growth retardants, Amo 1618, was discovered at the U.S.D.A. in Beltsville by Mitchel and Marth. This is a dwarfing compound and is one of a rapidly enlarging number of compounds that have been found to have similar effects. Two of these compounds, phosphon and cyclocel, are commercially available, as is Amo 1618.

In general these compounds are remarkable in that they dwarf the plant by shortening the internodes without affecting the leaf or flower size. Plants usually have a darker green color and tend to grow at a slightly slower rate than do untreated plants. These compounds also show remarkable specificity. All growth retardants do not work well on all plants. Amo 1618, for instance, which dwarfs chrysanthemums, is not effective on poinsettias. Phosphon has been found to be effective on both chrysanthemums and poinsettias as well as other species, both woody and herbaceous. Cyclocel also affects a rather broad spectrum of plant species. It is not possible, however, to predict that any of the growth retardants will be effective on an untried species.

Several other points are interesting. One is that the rate of effective application on the same species may change with the season. Such a situation has been reported by Stuart on azaleas. The other point of interest is that carry-over effects have been noted in the seedlings from seed of a treated crop. This might lead to an interesting application by seed producers as, for that matter, might an inclusion of dwarfing compound with the seeds in a packet. So far as I know this has not been tried.

Almost every conceivable way of applying growth retardants has been tried, including dipping rooted and unrooted cuttings, dipping pots, inclusion in the soil mix, spraying on the plant tops and drenching the soil, after the plant is established. Of these methods, the soil drench after the plant is established is perhaps the most useful. At least this is the procedure for the use of phosphon on chrysanthemum which is the only established commercial program of chemical dwarfing with which this author is acquainted.

Notably missing here is a discussion of maleic hydrazide which was discovered and used as a growth retardant even previous to the discovery of the gibberellins. The reason is that maleic hydrazide is a general metabolic inhibitor rather than being specifically hormonal. Also over-treatment with maleic hydrazide is too easy for its use to be practical.

Cultural Dwarfing

The glamorous way to dwarf plants, at present, is chemically, but in any discussion of height control, the older cultural methods should be touched upon. The most easily understood of these methods is top pruning. In some instances, as with hedges and lemon trees, top shearing is used to keep the plants low but with other orchard species such as apples and peaches, a much less severe and more skillful pruning job is necessary if the tree is to be strong, bear fruit in quantity and not prone to wild suckering.

Root pruning can also be used to successfully reduce the height of and even severely dwarf some species. It is a procedure which is used in the art of bonsai. However, it should be noted that root pruning should be done gradually with all species so that the plant can adjust its top growth slowly. Also root pruning must be a continued process. Some plants, roses being notable, respond poorly to tampering with the roots. Roses typically respond by dropping their leaves and by showing iron chlorosis on the new growth.

Still another cultural gambit which can be used to dwarf plants is limiting the water and mineral nutrient supply. In this respect the mineral nutrient which can best be restricted is phosphorus. Using any other element to retard plant growth usually leads to leaf drop or unsightly deficiency symptoms. However, if growth is restricted by low phosphorus it will be found advantageous to reduce the other mineral nutrients to avoid salinity injury to the leaves.

There is a fundamental difference between the restriction of water and mineral nutrients as a dwarfing method and either top or root pruning. That difference is one of balance. Pruning either roots or tops results in a readjustment of the other to a balanced top-root ratio. Restriction of growth by restricting water and nutrients results in an imbalance in that the roots tend to outgrow the tops.

Finally, there are many ways in which the conducting system in a tree trunk may be manipulated to result in dwarfing. In most instances the manipulation might be classified as a root pruning method in that restriction of the root system results from the manipulation. However, more subtle hormonal balance could be involved. Some of these methods include grafting onto a dwarfing rootstock, using a dwarfing interstock, girdling, reversing a section of the bark, upside-down scions, or buds and tying a knot in the trunk of a young sapling. It is notable that almost all of these methods result in a swelling on the upper side of the manipulation indicating a low rate of carbohydrate and/or hormone transport to the roots which might be expected to result in a reduced root system. Likewise it should be noted that most of these methods do not result in permanent dwarfing since later growth tends to rectify the inhibiting situation.

Temperature and Photoperiod Control

The quantitative effects of photoperiod on plant growth are not often emphasized in plant physiology courses and yet photoperiod can have a rather large effect on height and habit of plants. In general, plants tend to be shorter and branched under short photoperiods, and more elongate with less branching under long photoperiods. This height difference at long and short photoperiods is easily seen with forced Easter lilies. The height of plants finished under a long photoperiod may be half again as great as that of those forced under short photoperiods. Since Easter lilies do not branch, this factor does not complicate the effect of photoperiod on plant height. Quite aside from the purposes of this discussion, but to complete the story, those lilies under long photoperiods bloom somewhat sooner.

It should be noted that short photoperiods may not only restrict growth but may actually cause plants to become dormant which, of course, indicates a no-growth situation.

That temperature can be used to keep plants short is not so well known except in the sense that plants grow less per unit of time at temperatures below optimum. Yet the author has devised a system of variable temperature forcing which has proven effective on poinsettias and Easter lilies. The idea of variable temperature is based on subjecting the plant to lower than optimum forcing temperatures during the period immediately following flower bud formation. The date of flower bud formation is relatively easy to ascertain for poinsettias which are a short day plant for which the critical photoperiod is about October 3. Lowering day and night forcing temperatures by 10°F during the month following bud initiation has been found to reduce height by some 40% without reducing the number of leaves or bract size or causing late bloom.

How many plants will respond to variable temperature growing conditions and photoperiod is unknown and presents a wide field for research. It is hoped that some of the audience here might find this research field of interest.