On the program there are many firsts, in other words, the first time these various topics have been presented. This morning we have three professors on the program presenting three of these new topics.

Our first speaker this morning, Donald White, is a graduate of the University of Massachusetts in ornamental horticulture, and who now is taking his graduate work at Iowa State. This will be a report of five years work in the development of dwarfing understock for budding and grafting both ornamental and fruit plants.

We are most unfortunate in not having Mr. White with us since he was called back to Massachusetts because of the death of his father We have John Mahlstede who will read his paper, and I am sure will be able to answer any questions regarding this work. John Mahlstede!

DR. JOHN MAHLSTEDE (Iowa State University, Ames, Iowa): Mr. Moderator, President Templeton, and Members of the Plant Propagators Society:

This paper is entitled, "Compatibility in Grafting and Budding Fruit and Ornamental Plants for Adaptation and Dwarfing Purposes." This was the topic we have selected for discussion this morning.

COMPATIBILITY IN GRAFTING AND BUDDING FRUIT AND ORNAMENTAL PLANTS FOR ADAPTATION AND DWARFING PURPOSES[1]

D. B. White and J. P. Mahlstede
Department of Horticulture
Iowa State University
Ames, Iowa

This is the first progress report on a project initiated at Iowa State University in 1956 entitled "Dwarfing of Fruit and Ornamental Plants." One of the primary objectives of this project is the development of techniques for dwarfing and adapting ornamental plants to different soil or climatic conditions. Many select plant materials, normally tall growing, would be well suited for use with modern contemporary building designs if height development could be restricted. Since this project was initiated, several stations have reported on similar work which is either underway or in the planning stage. The number of projects reaffirms the need for an increased inventory of low growing plant materials having acceptable ornamental characteristics, for areas differing in soil and climatic conditions.

One of the most common problems encountered in grafting is that of incompatibility. This inability of two components when grafted together to produce a healthy plant has been known for many centuries. In the third century B.C, Cato (4) observed that the scion used in grafting should always be of a better type than the rootstock, and that certain combinations could not be made successfully. Many other writers of his day reorded similar experiences with the practice of grafting. Francis Bacon, (2), in 1639 stated that a diversity of fruit could be

[1]Journal Paper No. J-4101 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa. Project No 1310

grown on one tree but that all of the scions must be compatible with the stock. Miller, (10) 1759, described double working pear and quince when the pear to be dwarfed was uncongenial with the quince. Thomas Andrew Knight (8), reported some of the symptoms of incompatibility and compared them with the effects caused by girdling.

Work during the past decade with apples, arborvitae, cotoneaster, forsythia, hawthorn, junipers, maples, pyracantha, quince and viburnum (Sax 14, 15, 16, 17, 18; Chadwick 5; Strate and Barker 19; Reisch et al 12) has demonstrated some of the possibilities for the development of dwarf plant materials by the use of selected understocks. However, in all of these studies incompatibility appears to be the one factor restricting the use of dwarfing stocks only to those types which have been tested.

There are many definitions for the term compatibility. In general, compatibility may be considered to be the ability of a grafted combination to survive for the period necessary for its use. This appears to be quite satisfactory since both inherited antagonisms and acquired agents are given consideration. Environmental factors and the techniques used in grafting also are very important to an understanding of compatibility in grafted plants. Recently, workers have found that on certain plants, bud failure can be attributed to virus infection (Milbrath and Zeller 9; Overholzer 11.) Agrios (1) reported virus-like symptoms with combinations of peach on *Prunus tomentosa* and *Prunus besseyi*. However, this work revealed that viruses were not involved, and bud failure was ascribed to incompatibility. Much of the work to date further emphasizes the need for caution in interpreting results of compatibility studies, considering that many factors may influence or result in incompatibility.

Left: Prunus Underwood on P. besseyi, 1½ years from bud, compared to a 12" label.

Right: P. Sacagawea (cherry x plum) on P. besseyi, 1½ years from bud, compared to 12" label.

For the past three years many different combinations have been under trial at Iowa State University. Some of these were not original but were included solely as a means of reference. This work was undertaken mainly as a screening program which might form the basis for further experimentation. After selecting plant materials for testing, the major problem became that of finding compatible combinations. As there is no rule or method of predicting the performance of a graft combination (Bradford and Sitton 3; Roberts 13), the plant materials were selected by separating them according to botanical relationships and chromosome number. The technique of budding was employed in these first screening tests because it is fast and economical of wood. It precludes the problems of purchasing and maintaining large numbers of plants while requiring a minimum of hired labor. Budding is eminently suited for this type of testing, as demonstrated by its use as the basic technique for indexing virus diseases.

One must realize that these tests cover a relatively short period of time. Consequently, final results can be secured only by observation over a number of years. Many of the combinations which were unsuccessful with budding will be repeated using other techniques and different timing of the procedure.

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TABLE I

STOCK	CHROM NO	SCION	CHROM NO	DATE BUDDED	REMARKS
ACERACEAE					
Acer ginnala	26	Acer Crimson King	X=13	7/26/57	No take
Acer ginnala	26	Acer Crimson King	X=13	9/ 4/57	No take
Acer ginnala	26	Acer saccharinum	52	7/26/58	No take
Acer ginnala	26	A ginnala PI69112	26	3/29/57	(root graft) survived summer 1958, winter killed
Acer negundo	26	Acer Crimson King	X=13	7/25/58	Buds failed, plates knitted then died in 1½ months
Acer negundo	26	Acer Crimson King	X=13	7/25/59	Buds failed, plates knitted then died in 1½ months
Acer negundo	26	Acer saccharinum	52	7/25/58	No take
Acer negundo	26	Acer saccharinum	52	8/ 5/58	No take, plate seems to knit then dries up
Acer negundo	26	Acer saccharum	26	9/25/58	No take
Acer negundo	26	Acer saccharum	26	8/18/59	No take, buds too immature before late Aug - early Sept.
Acer saccharinum	52	Acer Crimson King	X=13	7/23/58	Stock overgrew & completely imbedded buds by Fall
Acer saccharinum	52	Acer saccharum	26	8/ 5/58	Stock overgrew & completely imbedded buds by Fall
Acer saccharinum	52	Acer saccharum	26	8/18/59	Buds seems to take, stock overgrew by Fall
Acer saccharinum	52	Acer saccharum	26	9/15/59	Buds seemed to take, failed next spring
ROSACEAE					
Amelanchier canadensis	68	Aronia melanocarpa	34	8/ 3/59	No take, stock not thrifty, hard to work
Amelanchier canadensis	68	Malus, Jonadel	X=17	8/11/58	Shields knitted, buds failed over winter, stock hard to work
Amelanchier canadensis	68	Malus, Jonadel	X=17	9/14/58	Shields knitted, buds failed over winter, stock hard to work
Amelanchier canadensis	68	Malus, Red Delicious	X=17	8/ 4/59	Shields took, buds failed over winter
Amelanchier canadensis	68	Pyrus, De Anjou	X=17	8/ 4/58	Shields took, buds failed over winter
Amelanchier canadensis	68	Pyrus, De Anjou	X=17	7/28/59	Shields took, buds failed over winter
Aronia melanocarpa	34	Amelanchier canadensis	68	8/ 3/59	Some degree of affinity, seem to take, failed over winter
Aronia melanocarpa	34	Malus, Jonadel	X=17	8/14/58	Plate took, buds failed over winter
Aronia melanocarpa	34	Malus, Red Delicious	34, 51	8/ 4/59	Buds take (weak union)
Aronia melanocarpa	34	Pyrus, Bartlett	X=17	8/16/58	1 bud break = 1" growth by 9/25/58
Aronia melanocarpa	34	Pyrus, Bartlett	X=17	8/16/60	½ of buds took, to be tenant grafted on apple

TABLE I (Continued)

STOCK	CHROM NO	SCION	CHROM NO	DATE BUDDED	REMARKS
Aronia melanocarpa	34	Pyrus, De Anjou	X=17	8/16/58	⅓ of buds took, others, shields took
Aronia melanocarpa	34	Pyrus, De Anjou	X=17	7/28/59	⅓ of buds took, others, shields took
Cotoneaster acutifolius	X—17	Amelanchier canadensis	68	8/ 3/59	Plates took and survive, buds dead, some plates later died
Cotoneaster acutifolia	X—17	Malus, Red Delicious	X=17	7/25/58	Plates took and survive, buds dead over winter
Cotoneaster acutifolia	X—17	Malus, Red Delicious	X=17	8/ 4/59	Plates took and survive, buds dead over winter
Cotoneaster acutifolia	X—17	Pyrus, Bartlett	X=17	8/16/58	Plates took, buds go out 1st then bud plates
Cotoneaster acutifolia	X—17	Pyrus DeAnjou	X=17	8/16/58	Plates took, buds dead
Cotoneaster acutifolia	X—17	Pyrus DeAnjou	X=17	7/28/59	Plates took, buds dead, plates raised by heavy callus
Crataegus cordata	72	Malus, Red Delicious	X=17	8/ 4/59	Plate knits, buds dead, stock overgrows plate, stock hard to work
Crataegus crus-galli	68	Malus, Red Delicious	X=17	8/ 4/59	Plate knits, buds dead, stock overgrows plate, stock hard to work
Crataegus oxyacantha	34	Malus, Red Delicious	X=17	8/ 4/59	Plates seem to knit, bud and plates dead, stock overgrown
Cydonia/DeAnjou Pear	X—17	Pyrus, Bartlett	34, 51, 68	9/ 4/59	87 7% take
Malus, seedlings (Wstrn)	X—17	Amelanchier canadensis	68	8/ 3/59	Plates seemed to take, buds & plates died
Malus, seedlings (Wstrn)	X—17	Pyronia veitchi		5/ 1/58	Root grafts, 100% take, tops winter kill badly
Phil coronarius nanus	X=13	Phil. coronarius	26	7/26/57	No take, very hard to work, thin, peeling bark, small stems
Phys opulifolius nanus	X=9	Physocarpus opulifolius	18	7/30/57	No take, very hard to work, thin, peeling, bark small stems
Prunus besseyi	16	Prunus, Chinook Plum	X=8	8/21/57	No take, although seemed to knit
Prunus besseyi	16	Prunus, Gracious Plum	X—28	8/21/57	No take, although seemed to knit
Prunus besseyi	16	Hiawatha (Cherry X Plum)	Unk	8/21/57	No take, although seemed to knit
Prunus besseyi	16	Prunus, Monitor	X=8	8/21/57	Take
Prunus besseyi	16	Prunus armeniaca Apricot	16	8/21/57	No take
Prunus besseyi	16	Prunus persica	16	8/24/59	No take
Prunus besseyi	16	Red Plum Ia No. 10	Unk	7/30/57	No take
Prunus besseyi	16	Sacagawea (Cherry X Plum)	Unk	8/21/57	Take
Prunus besseyi	16	Prunus, Underwood	X=8	7/30/57	Take
Prunus subhirtella pendula	16	Prunus (Red Haven Peach)	16	8/24/59	Seemed to knit, but no survival over winter
Prunus tomentosa	16	Monitor Plum	X=8	7/31/57	No take
Prunus tomentosa	16	Red Plum, Ia No 10	Unk	7/29/57	Buds took, most growth = 3′ in 2 years, all plants of this lot of P tomentosa died in 3d yr

continued on next page

TABLE 1 (continued)

STOCK	CHROM NO	SCION	CHROM NO	DATE BUDDED	REMARKS
Pyrus seedlings	X=17	*Amelanchier canadensis*	68	8/ 3/59	*No take, scion not thrifty*
Rhodotypos scandens	18	Kerria japonica	18	8/10/59	No take, gall-like callus, 3/8" thick around wound, stem breaks easily at point of budding
CAPRIFOLIACEAE					
Viburnum dentatum	54	Kolkwitzia amabilis	32	8/16/58	No take, scion difficult to work
Viburnum lantana	18	Wiegela Vaniceki	36	7/23/58	No take, Wiegela hard to work as bud
V opulus nana	X=9	Viburnum dentatum	54	7/29/57	No take
V opulus nana	X=9	Viburnum lentago	18	7/29/57	No take
V opulus nana	X=9	Viburnum opulus	18	7/26/57	Plate seems to knit, dies overwinter sloughed off the following year
CELASTRACEAE					
Celastrus scandens	46	Euonymus alatus	X=8	7/30/57	No take
Celastrus scandens	46	Euonymus alatus compacta	X=8	7/30/57	No take
Euonymus turkestanica	X=8	Euonymus alatus	X=8	7/26/57	(in greenhouse) seemed to take, then died, stock hard to work (small), suggest grafting
Euonymus turkestanica	X=8	Euonymus alatus compacta	X=8	7/26/57	(in greenhouse) seemed to take, then died, stock hard to work (small), suggest grafting
Euonymus turkestanica	X=8	Euonymus europaeus	64	7/26/57	(in greenhouse) seemed to take, then died, stock hard to work (small), suggest grafting
CORNACEAE					
Cornus stolonifera	X=10, 11	Cornus florida	X=10, 11	3/29/57	(whip & tongue grafts) both were alive but could get no callus to form
FAGACEAE					
Quercus palustris	24	Fagus sylvatica	24	7/23/58	Knitted Buds died over winter
Quercus palustris	24	Fagus sylvatica	24	9/15/59	Hard to work because of long pointed bud
LEGUMINOSAE					
Sophora japonica	X=9, 14	Maackia amurensis	Unk	3/29/57	(root grafts) Passed out during summer of 57
OLEACEAE					
Chionanthus virginicus	46	Fraxinus pennsylvanica	46	7/25/58	Plates took, buds probably too immature
Chionanthus virginicus	46	Fraxinus pennsylvanica	46	8/18/59	Plates took, buds failed by spring, plates still living
Forsythia Arnold's Dwarf	X=14	Forsythia suspensa	28	7/ 2/57	Apparent take, but no survival over winter
Forsythia Arnold's Dwarf	X=14	Forsythia suspensa	28	7/ 2/58	Apparent take, but no survival over winter

continued on next page

TABLE 1 (continued)

STOCK	CHROM NO	SCION	CHROM NO	DATE BUDDED	REMARKS
Forsythia Arnold's Dwarf	X=14	Forsythia suspensa	28	9/15/59	(shield & flute buds) few took, large callus around wounds where no take
Forsythia viridissima	28	F viridissima koreana	28	3/29/57	(root grafts) no take, plants survived a short while in planting bed
F. viridissima Bronxensis	X=14	Forsythia suspensa	26	7/ 2/57	No take
F. viridissima Bronxensis	X=14	Forsythia suspensa	26	7/ 2/58	No take
Fraxinus pennsylvanica	46	Chionanthus virginicus	46	7/24/58	Plates knitted, buds died
Fraxinus pennsylvanica	46	Chionanthus virginicus	46	8/18/59	Stock overgrew, plates the following year
Fraxinus pennsylvanica	46	Syringa villosa	46—48	7/24/58	
Ligustrum densiflora nana	X=23	Ligustrum amurense	46	7/26/57	No take, very hard to work, small stems
Syringa persica alba	44	Chionanthus virginicus	46	8/18/59	Plates took, died over winter
Syringa persica alba	44	Fraxinus pennsylvanica	46	7/25/58	Plates took, died over winter
Syringa persica alba	44	Fraxinus pennsylvanica	46	8/10/59	Take, buds still dormant, on stocks not cut back
Syringa persica alba	44	Syringa amurensis	46	7/30/57	Take buds still dormant. on stocks not cut back
Syringa rothomagensis	X—22	Syringa oblata dilatata	46		
Syringa rothomagensis	X—23			3/29/57	(root grafts), survived until late summer of '57
Syringa rothomagensis	X—24	#8994			
Syringa rothomagensis	X—24	Syringa oblata dilatata #9446	46	3/29/57	(root grafts), survived until late summer of '57
Syringa rothomagensis	X—24	Syringa oblata dilatata #9449	46	3/29/57	(root grafts), survived until late summer of '57
Syringa villosa	46—48	Chionanthus virginicus	46	8/18/59	Plate knitted and surviving buds dead
Syringa villosa	46—48	Fraxinus pennsylvanica	46	7/25/58	Plates took, 1 bud survived, grew to 3½' in '59, acted normal, died during winter of '59, strong union, overgrows stock
Syringa villosa	46—48	Fraxinus pennsylvanica	46	7/25/59	Plates knitted, buds dead
ULMACEAE					
Celtis occidentalis	20, 28	Ulmus americana	28, 56	7/25/58	Plates knit, buds fail by fall, or are overgrown and imbedded
Celtis occidentalis	20, 28	Ulmus americana	28, 56	9/15/59	Plates knit, buds fail by fall, or are overgrown and imbedded

MODERATOR NORDINE: You are to state your name clearly so Mrs Ely can get it, and then state your question Dr. McDaniel.

DR. JOSEPH C. McDANIEL (University of Illinois): My question doesn't deserve all that attention I want to ask what is the material that was grafted on hackberry stock?

DR. MAHLSTEDE *Ulmus americana* and a few buds of *Ulmus fulva.*

DR. McDANIEL: Any compatibility?

DR. MAHLSTEDE: The bud plates seemed to knit with the American elm, but were overgrown by the time growth stopped There was no take by *U fulva.*

MR. CASE HOOGENDOORN. (Newport, Rhode Island): Have you tried de-eyeing some of the shrubs before using them?

DR. MAHLSTEDE. Most of these are budded on seedlings or clumps which have not been dis-budded

MR. HOOGENDOORN: Why don't you start with a new cutting or seedling? If you start with a young seedling or rooted cutting you could pick the eyes out

Years ago we grafted lilacs on *Syringa vulgaris* I always used to de-eye the one-year seedlings which resulted in very little suckering I was interested in knowing if you couldn't apply that same technique.

DR. MAHLSTEDE: First, we were trying to see which ones we can bud in other words we were trying to test for compatibility After this some of these techniques such as the one you mentioned, Case can be used.

DR. STUART H. NELSON (Ottawa, Canada): John, do you have any explanation for the trouble we ran into? Where we bud we run into a lot of incompatibility, the same as you have shown Where we stub graft we don't run into the incompatibility at all and get excellent stands

DR. MAHLSTEDE: I can only venture a guess, Stu Many workers in the past have found that grafting gave better results than budding with some combinations This may be the result of the fact that a single bud has less chance, percentagewise than a scion with more than one bud and a greater area of cambium exposure. Viruses too, may play a greater role than we now realize

MR EDWARD DAVIS (Ozark Nursery Co., Tahlequah, Okla.): Did I understand in giving this paper that Buckholz had better stands with peach on *P. tomentosa* than on *P besseyi?*

DR. MAHLSTEDE· No, not necessarily They lost less trees on *P. tomentosa* after forcing the bud and during the following growing season. However, the initial take was much less.

MR DAVIS: We have tried *Prunus tomentosa* for about four years, and get from two to five per cent bud take On *P. besseyi,* we have a very good stand as high as 95 per cent on bud take However, there is a high per cent of die-back on *P. besseyi* after the bud start They die all summer and fall The question arises in my mind how long will the trees, we accept as being compatible and healthy, live? What are the chances there?

DR. MAHLSTEDE: Buckholz and Agrios had 45 per cent diseased trees on *P. besseyi* One customer sent back some six year old trees to one nursery that were broken at the union. I think our time is up.

MODERATOR NORDINE: Last year we had considerable discussion by a great many speakers in regard to the production of nursery stock or plants in containers. I am sure that a great many members felt that after that they knew all the answers. Fertilization of this material was, of course, stressed, but some way, somehow, someone overlooked the topic of over-fertilization.

We are very happy this morning to have Dr Jim Kelley of the University of Kentucky present this particular topic to you. He has spent a great deal of time and effort on solving some of the problems concerned with the production of nursery stock in cans At this time we present to you Dr. Kelley.

EFFECTS OF OVERFERTILIZATION ON CONTAINER-GROWN PLANTS

JAMES D. KELLEY
Department of Horticulture
University of Kentucky
Lexington, Kentucky

The widespread practice of growing nursery stock in containers has brought about a need for more information in regard to the fertility requirements of woody ornamental plants. Fertilization has always been important in growing quality nursery stock, however, fertilization assumes even greater importance when a plant is grown in a restricted volume of soil such as exists in a container. There are many unanswered questions concerning this type of culture One question that has been of great importance is the fertilization practices necessary for producing quality nursery stock in containers Little is known about the fertility requirements of woody ornamental plants. However, the limited volume of soil that is available for supplying the necessary nutrients of a plant in a container necessitates that for optimum growth, fertilizer be applied to supply the required plant nutrients.

REASON FOR FERTILIZATION

The purpose of fertilization is to provide the plant with a continuous supply and optimum level of plant nutrients for maximum growth of any particular species. Frequent fertilization has aided in providing a constant supply However, information is not available on the optimum levels that should be maintained for woody ornamental plants. Growers are naturally anxious to obtain the maximum growth on a plant whether in a container or in the field. Many times this desire to get rapid growth, particularly on container stock, has led to the application of unusually high amounts of fertilizer. Too much fertilizer, however, can be as bad or even worse than too little. Many times plants are overfertilized, resulting in a reduction in growth instead of more growth.

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FERTILIZATION PROGRAMS

Water soluble fertilizers have been most generally used in the fertilization of container stock and a number of fertilization programs using water soluble fertilizers are being used successfully. However, there is considerable variation in frequency of application, rate of application and fertilizer analyses. Some growers use a one-shot application of a dry fertilizer when the soil mix is prepared, and others fertilize as frequently as every 10 days, while still others feed every third irrigation, using a water soluble fertilizer. In some cases a combination of dry and liquid fertilizers are used. The rate of application also varies Less frequent applications generally mean a higher rate and more frequent applications of a very low concentration or amount of fertilizer

The purpose of our work was to obtain more information in regard to the best rate of fertilization for optimum growth and also at what levels growth would be reduced due to overfertilization.

SYMPTOMS OF OVERFERTILIZATION

What are some of the symptoms of overfertilization and what is its overall effect on the plant? The effects of overfertilization are generally (1) reduction in rate of growth, (2) chlorosis or yellowing of the foliage, (3) wilting of foliage, even though the soil may be moist, (4) tip burn and marginal leaf burn, (5) leaf drop, and (6) death of the entire plant. Now, I would like to take these, one by one, and explain a little more in detail the usual symptoms of overfertilization.

The most common and first symptoms of excess levels of fertilizer salts is a reduction in growth. Generally, this goes unnoticed since the plant does not exhibit any unusual characteristics other than a slow rate of growth. If noticed, it often is attributed to some factor other than overfertilization Many times a grower will notice a reduction in growth and believe that fertilizer is lacking, hence, additional fertilizer is applied. Of course, additional fertilizer on a plant that is already overfertilized will simply reduce growth even further.

Another symptom of overfertilization is chlorsis or yellowing of foliage. Many times this is evident when the specific element in excess is potassium. The leaves will simply turn yellow due to iron chlorosis. This can easily be interpreted as an iron deficiency.

Wilting of foliage is a sign of severe overfertilization, and the wilting is due to the high osmotic pressure of the soil solution making it difficult for the roots of the plants to absorb water, even though the soil is moist.

Numerous experiments have demonstrated the close relationship between plant growth and the osmotic pressure of the soil solution. These relationships indicate that it is the total concentration of soluble salt particles in the soil solution rather than their specific chemical nature which is mainly responsible for the inhibitory effects of excess soluble salts on the growth of plants. It is generally accepted that an increase in the osmotic pressure or soluble salt content of the soil solution results in a decrease in water uptake by plant roots Excess soluble salts can also cause adverse effects on the plant other than the reduction in uptake of water.

Tip burns can be due to either excessive nitrogen or potassium and indicates severe overfertilization.

Plants may be reduced in growth of quality because of excess fertilization or an accumulation of soluble salts and without visual evidence that the problem exists. Once visual symptoms appear on a plant, such as chlorosis, wilting of foliage, tip burn, marginal leaf burn, etc., the damage of reduced growth has already occurred. Hence, a grower cannot depend on visual symptoms as a means of diagnosing slight overfertilization.

SOURCE OF SOLUBLE SALTS AND PREVENTION OF OVERFERTILIZATION

What methods can be used in guarding against overfertilization? The best method of preventing overfertilization is to use a good fertilization program, combined with periodic soil tests for the major elements and a soil test for total soluble salts. The soluble salt test is a very simple one that can be easily made with an instrument known as a solubridge. This instrument is used to determine the total soluble salts or fertilizer salts which exists in the soil, by measuring the electrical conductivity of the soil solution. If a soil, is low in fertilizer salts, the electrical conductivity will also be low, and as the salt level increases, the conductivity of the soil will increase. The most common measure of electrical conductivity in regard to the soil in mhos per centimeter X 10^{-5}. The Model RD-15 solubridge read directly in mhos X 10^{-5}. Generally, it has been found with most soils for florist crops, readings between 50 and 150, using a 1 to 2 soil: water extract, are satisfactory for most crops.

It is important to remember that all inorganic fertilizers are soluble salts. These soluble fertilizer salts are essential for plant growth but when present in the soil in excessive amounts they are harmful to plant growth, primarily because of the high osmotic pressure in the soil solution

FACTORS AFFECTING FERTILITY REQUIREMENTS

As might be expected, plants differ in their fertility requirements. The fertility requirements of ornamental plants appear to depend on (1) the degree of establishment, (2) the plant species, and (3) age of the plant.

Our work has shown that the age of the plant is important in determining its response to rate of fertilization. Young, unestablished plants are generally not able to withstand high levels of soluble salts in the soil. We have found that in general container-stock should be grown the first two or three months, or until established, at slightly lower levels of fertility than usual, and once the plant is established the fertility levels should be raised to the recommended levels.

Our studies have been primarily with five plants: *Pyracantha coccinea* Lalandi, *Ilex crenata rotundifolia, Euonymus alatus compacta, Magnolia soulangeana,* and *Abies concolor* Our first finding was that these five plants did not equally tolerate high levels of fertility. We have rated them as most tolerant, on down to the least tolerant. We found that *Pyracantha coccinea* Lalandi was the most tolerant to high fertility levels: *Ilex crenata rotundifolia* was next in order, *Euonymus alatus compacta* followed third; and *Magnolia soulangeana* was fourth. the least tolerant of high fertility was *Abies concolor*. Plants that had been in the can for at least one year appeared to tolerate higher levels of fertilization than during their first year in a container. Fertilization requirements also appeared to be higher the second year.

FERTILIZER TREATMENTS

In the work I am reporting on, we used seven rates of fertilization in order to determine at which level the most satisfactory growth occurred, and also at which level growth began to be reduced due to excess fertilization The levels of nitrogen and potassium were varied Superphosphate was added to the soil mix at the time of mixing and no additional phosphate fertilizers were applied. The treatments used were: *no fertilization, .68 pounds of 20-0-20, 1.36 pounds of 20-0-20*, and 2.72 pounds of 20-0-20 (Table 1.) The other three treatments were at the same rates — .68 pounds, 1 36 pounds, and 2 72 pounds o fa 20-0-10 instead of the 20-0-20. We were interested in whether the potassium should be equal to or less than the amount of nitrogen. The response of the plants was determined on the basis of total inches of new growth per plant, the average growth per lateral, and the average number of laterals that were produced by each plant.

BEST TREATMENTS AND TOXIC LEVELS

Of the treatments used, we found that in general the 1.36 pounds of either a 20-0-20 or a 20-0-10 gave the best results. When we went as high as the 2 72 pounds of either a 20-0-20 or 20-0-10, there was a reduction not only in total growth but growth per lateral, and also average number of laterals per plant. Also, at the higher rate there was a greater mortality of plants. Of course, we had some mortality of plants in all treatments during the growing season, but at the higher levels of nutrition the plant mortality was considerably higher.

To be more specific in regard to *Pyracantha coccinea* Lalandi, our best growth for this plant occurred when we used .68 pounds of 20-0-10

Table 1.—Effect of fertilization rates on growth of four species of woody plants in one gallon containers. (All measurements in inches)

Pounds of fertilizer/100 gal water, 1 pt./plant every 10 days	Pyracantha coccinea Lalandi	Ilex crenata rotundifolia		Euonymus alatus compacta		Magnolia soulangeana	
	1st yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr
No fertilizer	49.2	31.7	48.6	20.5	52.1	13.3	15.3
.68 lbs 20-0-20	71.0	68.8	216.3	33.4	88.2	29.1	41.9
1.36 lbs 20-0-20	57.9	58.1	245.7	33.3	75.1	27.5	48.4
2.72 lbs 20-0-20	59.6	46.9	267.6	36.5	46.5	21.6	44.1
.68 lbs 20-0-10	69.8	55.4	197.1	35.7	93.2	27.0	43.1
1.36 lbs 20-0-10	60.9	53.3	245.2	38.4	94.9	27.8	43.4
2.72 lbs. 20-0-10	63.9	48.9	249.8	38.0	74.2	28.4	42.1
L.S.D. 5% level	N.S.	7.8	31.0	6.1	15.8	5.2	13.0
L.S.D. 1% level	N.S.	10.4	442.0	8.2	21.3	7.0	17.9

to each 100 gallons of water, applying 1 pint every 10 days throughout the growing season. With *Magnolia soulangeana* we found that the 1.36 pounds of 20-0-20 gave the best growth. At levels above approximately 1½ pounds of fertilizer per 100 gallons of water there was a definite reduction in growth. *Euonymus alatus* responded most satisfactorily to a low level of fertilization and also a 2 to 1 nitrogen-potassium ratio. The 68 pounds of 20-0-10 gave the best growth response on *Euonymus alatus compacta*. At levels higher than this there was a significant reduction in total growth and in average number of laterals per plant. *Ilex crenata rotundifolia* likewise responded best to moderate levels of fertilization with the .68 pound rate of 20-0-20 giving the best growth the first growing season, and the 2.72 pound rate of 20-0-20 the best growth the second growing season.

SOIL NITROGEN AND POTASSIUM

The fertilization program was combined with an intensive program of determination of soil nitrogen and potassium. Results indicate that the soil nitrates should not be allowed to go higher than 100 parts per million on a soil basis, and soil potassium should not go beyond 300 parts per million. As far as safe levels of fertilization are concerned, it appears that for most plants in containers fertilization rates should be between one and two pounds of a 20-0-20 or 20-0-10 per 100 gallons of water and applied approximately 1 pint per plant every 10 days. This rate in general gave the most satisfactoy results with nitrate levels being maintained near 100 parts per million and potassium levels near 300 parts per million on a soil basis.

It also appears based on the solubridge test that soluble salt readings greater than 75 to 100 may result in a reduction in growth of many woody ornamental plants, particularly the more salt sensitive species. More work is needed before definite recommendations can be made in regard to soluble salt levels.

SUMMARY

In summarizing, I would like to say that overfertilization of woody ornamental can result in a reduction of growth, chlorosis, severe stunting or death. The symptoms of slight or moderate overfertilization is a reduction in growth with no unusual leaf characteristics. More severe overfertilization can cause such symptoms as chlorosis or yellowing of the foliage, wilting of the foliage, burning of the tips and margins of the leaf and even death of the plant. Severe overfertilization is probably not too common. Slight overfertilization is believed to be rather common. The best method of preventing overfertilization is to use a sound fertilization program combined with periodic soil testing for nitrogen and potassium as well as testing for soluble salts by using a solu-bridge. Soil nitrates should be maintained at not over 100 parts per million and soil potassium levels should not be greater than 300 parts per million on a soil basis. Tentative results indicate that the solu-bridge reading of a 1:2 soil. water extract should be between 50 and 125 for the woody plants studied. In the work being reported, these levels were most nearly maintained by fertilizing with a dilute fertilizer solution containing 1 5 to 2 pounds of 20-0-10 or a 20-0-20 water soluble fertilizer per 100 gallons of water and applying 1 pint per gallon container every 10 days throughout the growing season

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MODERATOR NORDINE: If we were to open the floor to questions it would be easy to devote the rest of the forenoon to questions. Dr. Kelley will be here on Friday night for the question box session. I feel sure that a great many of you will want to question him at a great length concerning this very, very interesting topic With your permission we'll hold the questions until Friday evening.

The Program Chairman has a great deal of latitude for the selection of his speaker and many times he selects something of a personal nature. Now I am quite sure that you all know the question that Martin brings up every single year at the question box, that is, the dropping of the needles on taxus. He has never been able to get an answer to this problem and I suspect that he brought in the next speaker for that particular purpose. However, I do know, too, that we will all benefit from this next particular topic.

Nearly 30 years ago Richard White, who is now Executive Vice President of the American Association of Nurserymen, made a statement to the former Plant Propagators Society that nurserymen will attribute the death of plants in propagating cases and in the beds to everything under the sun but to plant diseases. Many of us have become acquainted with this important statement in recent years So with this in mind we are very, very happy to introduce the next speaker He is Dr Spencer Davis of Rutgers University where he is Extension Specialist in plant diseases. In other words, he devotes full time to answering questions on plant disease problems With that, Dr. Davis!

DR. SPENCER H. DAVIS (Rutgers University, New Brunswick, New Jersey): Thank you, Sir and Gentlemen.

Apparently Dick White was a good reformer in New Jersey because he got all our nurserymen to think that nothing happens to a plant other than a disease. I wish many of our nurserymen had been here for the first two papers. I think it would have relieved our burden a lot. Incompatibility answers half of our problems and over-fertilization answers the other half.

DISEASES IN PROPAGATING BEDS

Spencer H. Davis
Rutgers University
New Brunswick, New Jersey

I realize that each nursery has its own particular problems If you talk ten minutes about somebody's problems it is not of too much interest to the person who has a different type of problem confronting him.. We are going to talk therefore, a little bit about the general diseases found in propagating beds. We are also going to think about what happens to many of these cuttings after they become plants. You solution containing 1 5 to 2 pounds of 20-0-10 or a 20-0-20 water soluble fertilizer per 100 gallons of water and applying 1 pint per gallon container every 10 days throughout the growing season

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First of all, let's take the non-infectious diseases. They are usually easy to correct. You can get 100 per cent results with them, but you don't have any interest in these because you know the answers to them.

Cankering is common on taxus after it has been lined-out in the field. We find if we have a tall, spindly plant in dry soil we often get girdling or cankering around the base under very warm conditions. This is not a fungus disease but rather a result of injury to the tissue. To my way of thinking, taxus is probably one of the most tender plants we have and one of the ones most readily injured by too much or too little of something. This same plant will suffer from wet feet when you have lots of moisture. As a result browning of the foliage is often a good symptom of this trouble.

We often run into another thing when it is too cold at the wrong time of the year. This happens with many plants including *Ilex spp.* Incidentally, I am not going to give the varietal names of the holly because I had a sad experience in Connecticut. One gentleman said when they grafted on one variety they had failure but had excellent results with another rootstock. One of the men in the auditorium said they had the reverse situation in Oklahoma. We have this type of thing coming up when we talk about susceptibility to cold or heat. Apparently, in different parts of the country you obtain different results.

Another one of these so-called "non-infectious diseases" has been described by Dr. Kelley. You can imagine what happens to plants put in an area where you have opened your fertilizer drill and stood there and talked for a while. Later on in the season you have a "disease" that breaks out down in this area and the plants are completely killed. You call your plant pathologist and ask what fungus has started and spread out. Perhaps you buy a fungicide, apply it and that is the end of the trouble. It doesn't spread any more up and down the bed.

Another type of injury to nursery stock can be caused from the use of certain toxic chemicals. Here you see a wooden fence that was treated with pentachlorophenol, which is sold under the trade name of Wood Life It was put on in June and when we got a hot day when the wind was blowing some of these volatile chemicals that are used in preserving the wood gave off a toxic residue. You may have a screened bed or lath house in which you would like to save those posts or that lath for as many years as possible. You treat it and during a hot day you may get some of this fumigation from it on the plants.

We sometimes find a batch of cuttings that are completely rotten at the base. This usually results from having poor aeration in the medium, overwatering or overfertilizing.

All right, now let's look at some of the infectious diseases. How are we going to combat them? Well, we have soil sterilization and a good sanitation program We can select the propagating stock carefully. If we do all this we will probably end up with 100 per cent results.

Some time ago we collected a batch of holly seedlings from a flat where the plants were dying. Mr. Batchelor isolated a fusarium from it. Having seen these in the flats it was my feeling that in some of the cases it was too wet and the fusarium came in as a secondary organism.

Another organism that can give you trouble is verticillium Those of you from agricultural areas should be cautioned not to pick up top soil from an area which had been planted with tomatoes or peppers or egg plants. If you do you may be bringing in a load of verticillium also. This will effect rooted cuttings, and in fact I don't care whether it is maple, peach, crabapples or any one of 87 plants that we can name for you, they will get the verticillium disease.

In another case we have an example of a disease which occurred when azaleas were brought in from the field in the fall and put in benches too tightly. A fungus got in with these plants that were put so close together that there was no air through them. The same propagator planted some benches with a little more space between them, and these benches had no fungus.

This is one we run into when the soil is heavily manured and then is kept on the wet side. This is slime mold. It is not a disease but rather a type of fungus that runs all through the place even up a telephone pole. If you stood there long enough, it would run up your leg.

This next one is getting into the true diseases, which by proper sanitation or sterilization you can do a lot about. This is crown gall on rhododendron. This particular lot was almost 100 per cent infected because the bacterium was brought in with the soil. Here is a photo of a willow tree infected with crown gall, which is typical of so many Here again, I think proper selection of stock from which the cuttings are taken will help a lot to clear this trouble up.

All right, let's look at another complex, which is a combination of a virus and/or what we might call graft transmissable troubles. Here again, if you select your propagating material correctly and if you control insects, (this applies more to herbaceous plants than to your type of plants), you can have 100 per cent results.

Just this year one of the men picked up a plant of *Ligustrum lucida,* which had what we believed to be a virus. Just within the last six or seven months the Plant Disease Reporter carried a very nice description of this. Taking any cuttings from plants with this virus even though there are no visible symptoms in the leaves will result in propagation of the virus as well as the privet.

There is a disorder on holly which to my knowledge is not a virus. We call it purple blotch Perhaps some day it may be proven to be a virus. To my way of thinking it is just a clonal characteristic. When we get soil too wet, all cuttings from that clone will come down with purple blotch In Clarence Wolf's Nursery in southern New Jersey, where he has 10 or 11 acres of holly, we find that all the same selection will have purple blotch and the row next to it won't have it Here again, proper selection is the way to avoid troubles.

Last night we talked to Bill Flemer about anthracnose. He said that we are not too much interested in anthracnose on the London plane tree in the nursery. Somehow nurserymen get the London plane and the Sycamore mixed up and we are running into some areas in Jersey where there is an awful lot of anthracnose on street trees. These trees were sold to street tree commissions as the London plane. When you start looking for white bark and the small balls, you know they did not buy a London plane tree.

The next disease, phytophthora shows considerable variation with varieties of rhododendron. Some varieties are almost completely knocked out with this fungus while others are untouched. Dick White is probably the one that has done the most work on phytophthora. This was done 25 or 30 years ago Since then, a lot of new varieties have come in. Next summer Professor Nichols of Penn. State University is going through the northern states, trying to run a survey on resistant varieties. I think he will be visiting some of you nurserymen on this trip.

When I said that some of you weren't interested in some of these methods for controlling these troubles, I meant it. However, if we have a high-priced chemical and it is difficult to use and requires special equipment, and if instead of 100 per cent results you can get 25 or 50 per cent results, and maybe it will injure some varieties such as weed killers might do, you might have a lot of interest because they are new chemicals or you heard about it or read about it some place.

In New Jersey they were having a lot of trouble with phomopsis on gardenia. This is a random selection of cuttings which had about 30 per cent rooted beautifully and 70 per cent dead because of the fungus. We tried incorporating a fungicide in the soil. The next slide shows what one and two per cent Ferbam or Fermate actually incorporated in the sand will do the growing results. We controlled the disease 100 per cent with about two pounds of Ferbam in 100 pounds of sand but we had short roots. With 100 pounds we had longer roots. We then dropped down to one-half and one-quarter per cent We now have as our state recommendation for gardenia the use of one pound of *Ferbam* in 400 pounds of sand Occasionally there are problems that come up that just can be answered without further experimentation We had one in a rose greenhouse where the plants just did not grow. A fungus we call Lepiota was responsible for this condition It is a fungus that permeates the soil and may run for four or five feet. We did quite a bit of work on this, using some of the newer materials.

We ran into a flower blight problem on holly this past spring which was very wet. I realize that you are not so much interested in the flowers on these plants but the thing here is that these diseased parts fall down on the leaves or worse yet, on the soil which will give you a soil canker on some of these plants. This is the sort of thing we may have to try to control with chemicals.

Too, on rhododrendron, we have a leaf spot which is caused by a simple type of fungus, but it attacks early in the spring. We have chemicals to control this, but we must get it in at the right time.

There is a potential problem for all azalea growers in this section of the country. This disease is known as petal blight. This slide shows a plant just starting down with the disease in New Jersey. It was on a plant that was brought up from the south apparently with the fungus on it. For those who think they have it, whether you have the southern form or not, we suggest that you put the petals in a polyethylene or glass container and keep them for one week. At the end, of this time if you have these little black structures then you will know that you have this petal blight disease or azaleas. Here again, the disease can be controlled with proper sprays.

Very quickly let's look at soil sterilization. Two chemicals have come out in the last couple of years that looks very promising. Methyl bromide, perhaps sold as MC-2, and Vapam are the two to which I refer. Just within the last two months a paper has come out that states that you can control crown gall by using these materials at the recommended rates. I know a lot of nurserymen use these chemicals for weed control but here is a suggestion for their use to control organisms in your soil also.

One of the worst problems in seedbeds of cabbage and broccoli is damp off and wire stem. These can be controlled by mixing terrachlor with the soil. I must caution you not to use chemicals such as terrachlor and captan on crops until you have first tested them to be sure you will not get any injury or stunted growth.

Now let me conclude by mentioning some of the new chemicals that are showing a lot of promise in vegetables and fruits. As some of you people heard me say, you people are on the sucker list. Every station in the country has somebody working on apples and peaches and when we get to ornamentals, a lot of you people have to pick up the chemical samples and do the research yourself Dyrene, Maneb, Cyprex, and Phaltan are some of the newer ones Incidentally, Phaltan appears to me to be an excellent thing for you folks who are dealing with roses. It is the only thing I know that controls both black spot and powdery mildew. To my knowledge, we have no other chemical that will do this. Dithane A-40 is out for the first time this year. It is a dry material taking the place of the old Dithane D-14, the liquid material. Karathane is still an excellent material, out three or four years, for powdery mildew, and the liquid mercuries are ideal for a lot of sanitation work.

Of course we always have the situation where you sell a well grown tree to some customer who stakes it after planting. Then at the end of the season the tree is dead and the post has six inches of growth on it. In one town, 500 trees were planted like this, and at the end of the summer we had 200 live posts and 200 dead trees. They used swamp maple for stakes. The soil was so soggy wet that it swoshed when you walked on it.

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MODERATOR NORDINE· All right, let's have some questions.

MR. JIM WELLS (Red Bank, New Jersey): I'd like to ask Dr. Davis if there is any general treatment that he would recommend of new or old chemicals for treating the soil before planting to reduce infection in the field?

DR. DAVIS: One would be Ferbam, which is one of the nicest you can get in that there is generally less injury with it than with others. Try it at the rate of one pound for 400 pounds of propagating sand. When you get into soil, you are getting into a different matter. The chemist refer to the soil as being well buffered. When we get a lot of these chemicals in the soil, it ties them up rather quickly Quite a few of our florists, are starting to experiment with Terrachlor and Captan now for use on a number of flowering plants. Here again, use it carefully and try it on a few plants before you hit all of them.

MR. WELLS: We had a discussion either last year or a couple of years ago on this question of sterility. Dr. Waxman made the statement at that time that in the best nursery run in an orthodox manner if you adopt sterile methods and conditions you will increase your efficiency by 20 per cent. Now that is substantial. My point in asking this was, Do you think it is worthwhile for any nurseryman growing any crop to consider using this Terrachlor and Captan as a general preventative measure, and if so, what percentage improvement would he get?

DR. DAVIS: I would *not*, and I underline not, suggest that all nurserymen go out and start using this mixture. Any time you are satisfied with the results you are getting don't try to get another 20 per cent by putting these chemicals in your medium. You will probably get more trouble than benefit. The only place we recommend the use of chemicals are the places where you have had previous experience with disease problems If I were trying something and getting 80 per cent results year after year I would not worry about trying to put a chemical in and getting an extra 20 per cent. Farmers don't do this; they just plant another 20 per cent to feed the bugs

MR. ALBERT LOWENFELS (White Plains, New York): You mentioned purple blotch on holly, *Ilex opaca* You recommend not propagating from these plants. What should one do then, spray for it?

DR. DAVIS. I ran some experiments about 10 or 11 years ago at the Wolf Nursery using about 15 chemicals. We tried to isolate the thing and found that it is not a fungus, or a bacteria. We call it a physiological disturbance and not something tied up with any organism.

MR. TED E. FOULKE (Cleveland, Ohio): Dr. Davis, this past summer I spent some time with Dr. Roberts and they have a purple blotch problem in English holly which apparently is traced to the presence of boron deficiency. In the places where they fed boron at the rate of 25 parts per million they didn't find the blotch. Is there any relationship between this and our American holly?

DR. DAVIS: There is probably a pretty fair relationship. Dan Fenton, who works at Wolf's Nursery ran quite a lot of experimental work on different fractions of potassium and lime on *Ilex opaca,* with added boron Again you have the choice of propagating from a clone or strain that does not have purple blotch in it, or one that has this tendency. I will take the clone that is free from this trouble.

DR. CHARLES HESS (Lafayette, Indiana): You mentioned that purple blotch was somewhat related to soil moisture conditions. In other words, would you say that with wet feet you would have more blotch?

DR. DAVIS: In the years when purple blotch is prevalent we find it is worse on plants that are growing with wet feet. Here again, you can have two seedlings side by side, one can be blotched up and one completely free from the trouble.

PRESIDENT TEMPLETON: I want to ask a question about this purple blotch. Is it possible that iron deficiency is involved?

DR. DAVIS: Iron has been used but it has not given consistently good results.

MR. RALPH SHUGERT (Neosho, Missouri): Have you done any work on phomopsis blight of cedar?

DR. DAVIS: Charley Hess probably has done more work along that line with Pat Pirone, than I have. I think he is using the old copper spray as the best material.

About a week ago I thought Captan, of the new materials was a good answer to juniper blight. In reading the fine print however, they were not referring to phomopsis.

MODERATOR NORDINE We stand recessed until 1:30 this afternoon.

The session recessed at 12:15 o'clock.

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packing cost, there is a limit to the radius beyond which it is not economically feasible to ship these plants. On the other hand, bare root plants, which can be easily and cheaply bundled, thereby holding weight to a minimum, shipping costs are also minimal. Therefore, the radius that the bare root plants can be shipped is greater than those in bands or pots despite Mr. Billerbeck's nifty method of putting them right on his own trucks. That is a solution that sooner or later many of us who are attempting to penetrate the liner market may come to rather than to depend on common carrier.

The other problem is associated with the production of these small plants in their rather restricted soil volume. There are those difficulties that arise over the maintenance of adequate fertility levels, adequate moisture levels and control of temperatures in a small, isolated parcel of soil. Since we have been growing our plants in containers in Illinois we have become much more aware of these problems, recognizing it is easier to grow plants today in one sterile acre rather than a half sterile acre. The smaller the parcel of soil, the more rapidly the moisture level fluctuates, the more rapidly the fertility level fluctuates the more variation you get in temperature.

I just want to stress that potted or banded liner propagation is no substitute for good cultural care. All too frequently in this nursery industry we find an answer promised panacia, becomes a reason for careless growing. The pot and band will not do anything magic for you but if used properly we believe it will produce a better plant almost under any conditions.

MODERATOR MAHLSTEDE: Since we will postpone the question period until we have heard from all the speakers, I would like to call on Mr George Blyth to discuss the subject before the panel.

Mr. Blyth presented his prepared paper, which was followed by a sequence of colored slides.

THE PROS AND CONS OF BANDED VERSUS BARE ROOT MATERIAL

George P. Blyth
McConnell Nursery Company
Port Burwell, Ontario, Canada

We have been growing summer softwood cuttings, in containers for the past thirty years. We had difficulty in transplanting these to the field We have used everything from clay pots, wooden bands, tar paper bands and plastic pots to peat pots. We find the Jiffy peat pots to be very satisfactory and are doing the best job to date. The advantages of banded liners applies to varieties that are difficult to transplant, or summer cuttings that are to be carried over the winter for spring planting or for shipping.

Our present method is to pot all our summer cuttings in Jiffy pots. We hold them during the winter in frames. The potting medium used is one-half sand and one-half peat. We fertilize once a week, using 20-20-20, Rapid Gro, until the end of August. The pots are covered in late November with fine gravel to prevent heaving. The frames are covered with tar paper. This is removed in April and the potted cuttings are watered once a week.

We can begin planting in May. We use two Smallford planters drawn by a Farmall tractor. Four men plant approximately 20,000 per day at 12 inch settings We have a very small loss Types such as forsythia, honeysuckle and weigela are salable material by fall. This method produces a plant suitable for mail order and packaging, which is a major portion of our business.

A large number of our shrubs are grown from hardwood cuttings These are fall planted. Some may be dug the following fall. Plants requiring a two year growing period are cut back in the fall. These trimmings are used as cuttings, and the stock is left for another year to develop a better branch and root system.

Seedlings, of course, are bare root planted, and, if the weather is dry, there are losses. Most of our bare root plantings are shade trees and evergreens. They are freshly dug and planted either fall or spring. Trees are planted by using a plow and spade. We use a Smallford planter with evergreens. This machine plants two rows at a time. Four men will plant 10 to 12,000 a day using a 24 inch spacing. Last spring four men and two planters set in 10,000 *Ulmus pumila* in a nine hour day.

(*Editor's note*: Mr. Blyth concluded his discussion with a series of colored slides illustrating procedures used for handling bare root and potted liners.)

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MODERATOR MAHLSTEDE: Thank you, George Without interrupting the program we will call on Dick Vanderbilt of the Koster Nurseries.

Mr. Richard Vanderbilt presented his prepared discussion on the advantages of banded or potted liners versus bare root material.

ADVANTAGES OF BANDED OR POTTED LINERS VERSUS BARE ROOT MATERIAL

RICHARD VANDERBILT
Koster Nursery
Bridgeton, New Jersey

The usual and generally true arguments for potting are that there is less loss, more rapid establishment, more flexibility in planting times, and a better plant in a given time. But a visit to a good grower who wouldn't pot anything on a bet, shows that good plants may be grown without potting. I have in mind our neighbor Hap Hoogendorn, Case's brother, whose taxus can match or better anything we can do in pots following the U. C. mix and fertilizing every third irrigation. In addition to this, as far as I can tell, he has no loss, has very rapid establishment, and plants most anytime he feels inclined.

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The chief benefit of potting for us is that we have been able to eliminate the planting of any coniferous material into beds, thus saving the tremendous amount of hand labor involved in keeping the beds clean. We are able to plant directly in the field, and to sell the liner directly from the row as a B & B plant.

We have adapted a 20 inch row spacing from the local lettuce farmers that works exceedingly well The potted liners are spaced 16 inches in this row, giving us a population of approximately 20,000 plants per acre With this spacing we are able to grow a taxus, for example, to a small salable B & B plant after three years on the row

Planting is done with a four row mechanical transplanter, made in Holland, Michigan This is the wheel type transplanter with neoprene fingers. It has worked out better than any expectations we had for it The plants are set uniformly at any depth required. There is no root drag and they are firmed in much better than is possible even with the best of hand planters. Cultivation is done with a four-row independent gang cultivator.

The potting itself is now done into peat pots which are not as good as veneer plant bands for speed in potting, but what is lost at potting time is regained at planting time by not having to remove the band.

The mix we use is the U. C. mix C, 50 per cent peat and 50 per cent sand, with a base fertilizer supplemented with a 3-1-1 ratio liquid fertilizer in a concentration of 30 ppm nitrogen every third watering. Planting is done the following spring or early the same autumn We have found that by potting we are able to produce a salable plant more cheaply than by any other means.

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MODERATOR MAHLSTEDE: Now, since Dick summed it all up in about two minutes I think we should pay special attention to him when it comes to the question and answer period.

Gerald, if you will give us your thoughts on this subject, we will conclude our panel discussion

Mr. Verkade presented his talk on the advantages of potted liners in production.

ADVANTAGES OF BANDED OR POTTED LINERS VERSUS BARE ROOT MATERIAL

GERALD VERKADE
Verkade Nurseries
New London, Connecticut

The three advantages to potting liners are (1) to maintain a higher survival with certain plants, (2) to produce a salable plant sooner, and (3) to extend the planting season. The main disadvantages is the added production cost which amounts to four to seven cents for each unit.

We use two types of pots in our operation For our grafting understock we use a 2¼" plastic rose pot, which has to be removed before

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We use two types of pots in our operation For our grafting understock we use a $2\frac{1}{4}''$ plastic rose pot, which has to be removed before planting. For our cuttings we use a 2¼″ or 3″ square peat pot

Cotoneaster horizontalis, and *C. praecox* are potted because of low survival. I have found that leaving these summer cuttings in the rooting medium until spring and transplanting them bare root has often showed a 25 per cent to 50 per cent loss. By potting them after they have rooted and placing them in a frost free frame, usually 95 per cent survive the winter and planting operation in the spring Magnolias, viburnums, Pink dogwoods, and Japanese maples are also potted These items after potting are placed in a controlled warm frame for the winter. I have tried overwintering them in the rooting medium and although most of them are alive in the spring, bareroot transplanting gave us high losses. Therefore to produce a salable plant quicker and to extend our planting season we pot these items

For the past four years we have been growing plants in one and two gallon containers Because of a limited container area we have found that by potting some varieties they can be sold after one growing season Bare root stock did not always make up to size. We therefore pot *Forsythia*, *Weigela*, and *Euonymus*. The potted *Euonymus* cuttings will be about 75 per cent salable in one year In order to get *Forsythia* and *Weigela* to make up in one year we use one year old light hardwood cuttings and can them bare root, or use potted summer cuttings I believe the potted summer cuttings make the nicest finished shrubs.

Cotoneaster horizontalis, *C praecox* and Magnolias are also potted We not only pot these in order to have a higher survival rate, but we have also found that potting enables us to sell close to 50 per cent after the first growing season

Rhododendron cuttings are rooted in the fall and potted in 3 inch peat pots in January. One big reason we pot these is that we sell 30 per cent or more in May of that same year It is much easier to pick out the best if you don't have to cut them out of the flat. Another reason is that we find the root and top growth is far superior the following fall. We grow all our hybrid rhododendrons in containers one year. We grow a few thousand azaleas each year. I have found that potting the summer cuttings and planting them into containers the following spring, we are able to grow them at a profit in two seasons

There is only one variety of *Taxus* that I will pot, ie. *T brevifolia nana*. These are potted because of the low survival rate the first winter in beds They are potted in June from the rooting medium and are kept in a frost free frame the first winter This variety is the only one which stem splits the first winter with us I honestly can not see any good reason to pot other Yew varieties. The benefits are so little that I do not believe it covers the cost I do not recall any serious problems in transplanting cuttings, or 2, 3, or 4 year old bare root liners as long as they have a good healthy root system and it is not too late in the season

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MODERATOR MAHLSTEDE: Thank you, Gerald.

The floor is now open for questions. I didn't know Martin had loaded the panel with men that used banded or potted liners rather than bare root material I think you men in the audience have a few things you might add in regard to bare root transplanting Is Bill Flemer in the room? Bill, last year I remember that you mentioned something about the rooting out of plants in peat pots. Have you anything to add to this discussion?

MR WILLIAM FLEMER (Princeton, New Jersey): Yes, the reason we like to use peat pots, John, is that you don't get that snarl of roots within the pot itself. The old roots come out, start growing and new roots come out from the inside of the ball. These also keep growing so in turn you go to the field with a plant that has a large fibrous root system just going out to the edge of the pot If the same plant is grown in a clay pot, the roots spiral around on the inside of the pot and you get conditions in the field very similar to that of the holly plant that Spence Davis told us about this morning. As a result we have gone over entirely to peat pots except for one or two exceptions.

I would like to hear whether Jack Hill is using the peat pots and what he thinks of it at Dundee

MR HILL: Bill's question to me, as I understand it, is what do we think of peat pots in Dundee? We have just begun to experiment with peat pots. I will confess to all of you, as close as we live to George Ball that I looked at it for a long time before I could see where there was any real value for production of conifer liners. It was always my impression that the peat pot broke down rather quickly. We find from experience that plants in peat pots can at least be held as long as they can in clay products with complete alleviation of the problem which Bill describes relative to the circling of the roots. Mr. Wells' understanding is that all roots are oriented by gravity except when they are mechanically constrained in a structure. When a plant is taken out of this clay pot with the roots well circled, placed without disturbing it in the soil, the damage does not come from the root which continues to circle, but rather comes from the cone structure that arises when the already circled root increases in diameter resulting in a girdling, choking effect.

Summing it up quickly, I think we do like the peat pot. I think Bill Flemer really gave me an idea several years ago when he described his method of setting the pots up dry, that is, after the rooted cuttings were placed in the pots and the pots were set for multiple handling, they were not squeezed together. There was a deliberate attempt made to set them carefully so that there was an open space between units. The purpose of the space in there was to allow air to reach all sides. Also, it prevents invasion, that is, the roots in one pot cannot invade the pot of the plant adjacent We are all for peat pots now.

MR. JOHN VERMEULEN (Neshanic Station, New Jersey): We have almost completely gone over to peat pots in all our potting and liner production. We put our peat pots in a container for shipping. We have two sizes, that is a small container for 12, and a large container for 36. It is a big saving.

I also have a question for someone on the panel. We had a big loss of azaleas potted in peat pots last winter. We had it once before and I thought we had overcome it. We potted the cuttings in February and about the middle of March we started to lose these plants. We lost approximately 15 to 20 per cent of our cuttings. We have tried to trace it down and as far as we have gone, it appears that there was too high a soluble salt content in our soil. Also, we think that it may be in the pot itself. This year we have pots imported from Sweden to check on this Can anyone tell us, how to eliminate this and be sure it wouldn't happen again?

MR. GERALD VERKADE: I don't know if I can tell you the exact reason for these losses. I had a very unfortunate experience with the thick peat pot. I try to use the thinnest type peat pot I can I found that especially with our rhododendron cuttings last summer, that once in a while a plant would drop off. The only reason we could see for the loss was that they were too wet. What we do now is to use a very thin pot on our azaleas. When we plant them out in the spring we try to stack them so there isn't a tendency to hold water, especially for three or four days consecutively.

MR. JIM WELLS: I would like to make a couple of comments and ask Gerald a question. First of all, we killed a lot of plants like firethorn with Jiffy pots. They don't over-winter at all in the frames. I think it was my own fault I wouldn't really blame it on the Jiffy pots. I think they just got too dry. I wasn't used to using them I found that under my method of growing that putting the plants into flats was greatly superior. The same is true of *Prunus* Hally jolivette, and so I abandoned the Jiffy pots.

In regard to this pot, we ran a pH test by crumbling up the peat in a pot and running it on a one to two dilution. We came up with a reading of four, under which we consider it to be quite lethal. Now that is not a very good experiment because the soil is immediately put in there and it is diluted before the plant starts to grow. Nevertheless, that pot, in my opinion, was just a plant killer. Perhaps it unfortunately was under the spigot when they turned on the fertilizer, but it wasn't very good.

The question, Gerald, I would like to ask you is, Do you take the pot off your rhododendron when you put them in the can?

MR VERKADE: No, we do not

MR. WELLS: And what medium do you use?

MR VERKADE: I have done it two ways with the rhododendron. I have used straight peat as a medium in the peat pot The following year we used peat and perlite. The medium I root my cuttings in is the medium it is potted in.

Now in our can we use our regular container mix I don't want to go into all the details of the container mix since some other time might be more proper. However, it is the same mix we use for rhododendrons. I take the rhododendron in the spring and crack the pot. This is not the standard peat pot that we use, but rather a thinner one. It is much thinner and has a hole in the bottom. If you squeeze it, it can be broken easily. The roots will grow out of it, but we are still breaking the pot up We drop them in the larger container and put a can mix around them.

MR. WELLS: I have always been an advocate of potting. I brought in some rhododendron liners this past spring from Portland, Oregon, and they arrived in the most perfect condition, beautifully packed and beautifully grown, by Railway Express. The plants had tight balls of roots which had been lifted from a bed of peat. You could throw them about. In fact, I did, without damage. I have always argued that the potting of a plant in an artificial medium and then putting it out into the field created an oasis in which the plant was likely to remain. That hasn't proved out in practice. I have planted these plants from Oregon in my nursery and they are the best plants I have in the nursery I am switching over entirely to a peat medium for growing liners. These will not be in pots.

MR. A. J. RADDER (Bloomfield, Connecticut): I worked for a nursery and we used up to one million peat pots for the potting of tobacco plants for resetting in the field. Last year they found out that a certain number of them in the peat pots were completely stunted while other ones grew very well. After they sent them to our own laboratory we found out that those in the peat pots that came from Denmark were completely stunted The reason was attributed to the type of fertilizer they used and the heavier wall.

(*Editor's note.* This situation has since been corrected.)

MR. MARTIN VAN HOF. I think it would help also to take off the top of your peat pot or tear it before planting.

MODERATOR MAHLSTEDE: That brings up the question of *wicking. The placement of the peat pot in relation to the soil surface* is a very important consideration.

MR. HOOGENDOORN: Two years ago it was a hard winter. The previous spring we had planted out some hollies in peat pots for the first time. I found in the spring they had all heaved out and dried up. Then last year, Bill Flemer had the same trouble in the field. The reason they heaved up is because the pot had wicked, dried and the root didn't go through the walls of the pot There was nothing to hold them in the ground. This past spring we tore off the upper half of the pot and then planted. We still kept the ball intact but got away from the wicking.

MODERATOR MAHLSTEDE: Any further comments on wicking? Dick Vanderbilt.

MR. VANDERBILT: It is not the wicking but rather a comment on the use of pure peat for rhododendrons. Case said that he had no trouble with rooting out once the lip of the pot was removed. That would be true as long as the peat is saturated You can get over this problem if you treat them with a wetting agent like Aqua Gro.

The rhododendron is in a peat ball, pure peat. If you plant that out it won't always root out until the peat ball is 100 per cent soping wet. If you try the Aqua Gro, regardless of whether the peat is ringing wet or not it will root out in a sandy soil.

MR. FRED NISBET (Asheville, North Carolina): I would like to address a question, please to Mr. Verkade. Do your thin pots hold up over the entire season? We start pulling our azaleas, rhododendrons, pieris, and such, from the open mist beds in August, and of course we have a problem that no one else has here, that is we don't have adequate help. Therefore, the process strings out until normally October. We put them in frames. The question then is, "Would these peat pots hold up until we could start putting them into beds in the nursery in late May or June?

Now the pots we have been using have a fairly thick wall. They hold up satisfactorily as long as May and June if we handle them very carefully. However, with any amount of handling at all they go to pieces. Will the thin pots hold up as well?

MR. VERKADE: They will not hold up as well. In fact, I don't think you could use the thin ones On my rhododendrons we pot the cuttings well in November, and can them in the spring. So, actually, we only hold them probably three months in the peat pot, at the most. I never have kept anything all summer.

MR. NISBET· We keep them anywhere from August to October until May or June in trenches.

MR. VERKADE: From October to May I believe they would hold up that long. During the summer I don't think so During the winter months when there isn't so much root action I think they would hold up.

MR. NISBET: I support Dick Vanderbilt's comment on the use of Aqua Gro. If you are using peat pots or anything else hard to wet, it would pay you to get onto this stuff because you can do a wonderful job with it. I think it saved at least 3,000 azaleas for me this year which wouldn't have had a chance without it.

MR. PETER VERMEULEN: We made a test with two year old taxus cuttings, which were either transplanted to a bed or put into three-inch peat trays This past year we had an excessive amount of moisture and we had a lot of loss because of wet feet For the peat pots in the frames we had comparable or better growth and absolutely no loss due to wet feet. We found there was a decided advantage to the use of peat pots.

MR STROOMBEEK (Perry, Ohio). This question is addressed to Mr. Vanderbilt, in relation to the use of Aqua Gro in transplanting. I tried the material out and it seemed to work very well. However, I found out too late in the season that you have to keep repeating the application, otherwise you get serious wilting or stunting. Have you noticed that, too?

MR. VANDERBILT: I never tried it on deciduous stock or on rhododendrons. We give them one treatment after potting and another one before they go out. The root action begins in the soil within seven days, and we feel that once root action has begun in the soil, our problem is over as far as using Aqua Gro. We have not repeated it and felt we haven't needed to.

MR. HERMAN SANDKUHLE (Oakland, California): What is your experience with round pots versus square units?

MR. VERKADE: I like the square mainly because they fit so nicely and there is less chance for the medium to run in between them

MR. SANDKUHLE: What about watering?

MR. VERKADE: Your watering problem is minimized. They occupy the same amount of room but they look neater in the flat.

MR SANDKUHLE: You have had no problem from the lack of air on the sides or rotting out of the bottom of the pot?

MR. VERKADE: I haven't seen too much difference.

MR. SANDKUHLE· John, I'd like to make one comment. We have a fine medium for use in the peat pots on the West Coast. We happen to be a user of the UC Mix. Using Redwood sawdust and sand we find in the small peat pots we create quite an algae problem. If not taken care of, it puts quite a crust on the top of the peat pot and, therefore, slows up the percolation of the water. If you are anticipating changing, you want to watch the algae problem.

MR. JACK HILL: What do you do about this algae problem?

MR. SANDKUHLE: At the present time, Jack, we use a copper spray and we have eliminated some of it. We had not noticed it at first and did not take care of it. As a result we had to go in and actually remove the crust. It puts a membrane on top of the medium, somewhere in the neighborhood of twenty-thousandths of an inch, and it prevents the water from going in.

MODERATOR MAHLSTEDE: I think you will all agree that the panel has done an excellent job, so let's give them a hand. (Applause)

It is a pleasure for me to introduce Donald J. Moore, Reforestation Officer, from Hamilton, Bermuda. He has traveled a long way and probably invested quite a bit of money to be here with us this afternoon. After talking to Don before the meeting, I am certain that he has an interesting message to bring us on the topic, "The More Unusual Aspects of Plant Propagation Methods and Experiences in Mist Propagation in Bermuda." Don Moore!

Mr. Donald J. Moore presented his address.

THE MORE UNUSUAL ASPECTS OF PLANT PROPAGATION METHODS AND EXPERIENCES IN MIST PROPAGATION IN BERMUDA

DONALD J. MOORE
Bermuda Botanical Gardens
Paget East, Bermuda

Before proceeding into the main subject matter of this paper, it is, I feel, essential to aquaint you all with a few statistics relevant to Bermuda's geographical location, climatical data and topography. Whilst these factors may not effect propagation to any great extent in a broad sense, they most certainly do dictate problems to us locally. They do this in no uncertain matter.

Our climate may be described as sub-tropical. Geographically, however, we are located in the Temperate zone. Exact location, relevant to the nearest point of land, is 568 miles from Cape Hatteras. The nearest west indian island is Abaca, some 700 miles to the south west. Contrary, to general belief, we are not part of the West Indies, but are indeed, very much an isolated land mass.

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We owe our congenial climate entirely to our close proximity to the Gulf Stream. Frost is unknown. The lowest recorded temperature is 41.3 degrees F. The average rainfall may vary somewhat, but to quote official figures, in 1959, we recorded 80.74 inches. June, July and August, are normally the driest months. However, this last August was exceptionally wet, and we recorded 11.55 inches of rainfall in that month.

The Islands cover a total area of some twenty-three square miles. This is of course an extremely small area. An illusion of greater area is created however, by the undulating topography of the country. It is hilly with broad valleys throughout. The highest point above sea level is 250 feet. There are no natural fresh water supplies, but brackish marshes occupy many valleys.

This topography gives some variation in soil types, although light, sandy soils predominate. An exception is a relatively rich red clay loam found in one section.

All soils are basically formed from Aeolian limestone and are therefore completely alkaline, with a pH of 8 and up. Generally speaking, they are very shallow, depths ranging on an average of from 1 - 3 feet. Six inches only down to bare rock, being the rule in many instances. This shallow depth of soil creates an immediate problem when planting out, particularly with woody ornamentals. The following common procedure for planting generally has to be adopted. A wooden stake is placed at the site chosen for a specific plant. A hole is then blasted out with dynamite or drilled, and made ready for planting. Planting may then be carried out.

Summarizing this data, I will now assess the climatical factors, deterrent to optimum plant growth.

Periods of strong wind and accompanying salt spray, decide principally our choice of plant material. Salt spray damage to foliage can be as equally damaging to evergreen foliage as can frost.

Minor, but occasional and prolonged periods of drought, may also have their effect to a lesser degree.

Pathogenic organisms in the soil, unless controlled, may have a field day, with our very high average humidity.

Summarizing soil types, deterrent to optimum plant growth, I would make these observations.

The light texture of our soil, makes water retention virtually impossible.

Drying out is relatively quick after periods of even, prolonged or heavy rainfall. Planting times are in fact, dictated by weather conditions prevailing and variations occur in every season.

The high pH has a three-fold effect. It prevents the cultivation of all acid loving ornamentals, and hinders the progress of those falling in the intermediate range. It locks up many major and trace elements, in a form not available to the plant. Iron deficiency is so commonplace, its appearance is accepted as normal, by many laymen. This high pH has an effet on rooting potential of certain species, but more on this later.

At one time, flora of these islands was dominated by one endemic tree, namely, *Juniperus bermudiana,* the Bermuda cedar. Today, 99 per cent of these trees are dead, felled, cleared away and replaced.

The arboreal disaster was brought about the entry of a scale insect on coniferous material from the U.S.A., in the mid 1930's.

The pest in question is the Oyster shell scale, *Lepidosaphes newsteadi.* Because of our isolation, the native cedar had remained unmolested for years, and therefore had no genetical resistance to the ravages of this insect. By 1939 the effects of the infestation were becoming clearly visible. During the intervening war years, very little could be done, and by 1945, it became obvious that the greater percentage of the trees were doomed. Suitable chemical control was not available at that time, and all efforts were centered on biological control, this only met with limited success. Other pests contributed to the enemy camp, namely *Acutaspis perseae,* "Black cedar scale," and *Panimerus juniperi,* "Juniper aphid."

The Department of Agriculture, initiated a programme of clearance and replanting in 1945. This programme was known as the Reafforestation programme, but re-beautification would I think be a term nearer to the description of the actual task.

Prior to this period, nursery production of woody plants, had been very limited, and facilities for large scale propagation were non-existent. Also, due to the former dominance of the juniper, the range of desirable ornamentals was also severely restricted. With the cooperation of the governments of Trinidad and Jamaica, nursery production was commenced on our behalf, in these countries. Material was sent in by sea and air, shipped bare root, and grown on in Bermuda for a short while, prior to planting out. By 1950, we were completely dependent of these nurseries, and were producing all material required, ourselves. In 1959, a total of 33,000 trees and shrubs were distributed from the nursery. As facilities have increased so has our production, and in September of this year, 1,850 plants went out in just that one month.

There are three commercial concerns in the island. The largest is in the florist cut flower trade and also produces a quantity of woody stock. As we distribute a certain amount of free material, and sell the remainder at very low cost, it might be said that our competition to this gentleman is somewhat unique and you may feel, unfair?

The other two concerns are a landscaping company, who will shortly be branching out into the production of house plants, and a rose nursery. The Rose Nursery has found a profitable line of business in the sale of budwood to firms in Europe, principally in Germany.

The greater part of our propagation is carried out under slat house conditions, but glasshouses are used to some extent. We are enlarging this latter concern next year.

We also intend to make greater use of the advantages offered by polyethylene and similar products. Wind will be a governing factor however, when considering the erection of all plastic houses.

Slat houses are used on an extensive scale. We constructed out of native juniper, what we consider to be the only house of commercial proportions in Bermuda, some three years ago. This house is 250′ in length, with 13′ wide plant beds on either side of the 12′ wide through-road. The greatest value of the slat house lays of course in the protection from high light intensity it provides and also in welcome protection from the winter winds.

Frames are of course used extensively for propagation of both seed and cuttings.

Due to the very light nature of our soils it is almost impossible to lift most plant from open beds, with soil attached to the roots. This makes bare root transplanting a hazardous business, particularly with water being a valuable commodity. For this reason, the greater proportion of our stock is grown in cans.

Peat pots are used, for the production of some bedding stock. Clay and plastic pots are used where small quantities of choice exotics are involved.

Many of the methods of plant propagation is relation to cuttings, originated locally, and are typical of those practiced in warmer climates. In some instances, the old way is still the best. However, in most fields, modern methods are to be preferred, and this is the policy I adopted, once having become acclimatized to local conditions. Many plants may be easily grown from relatively thick hardwood internodal cuttings, taken at any time of the year. Subjects propagated in this way, include hibiscus, nerium oleander, aealypha, polyscias and tamarix. When these cuttings are inserted in the open ground, where they are intended to grow and remain permanently, no method of propagation could be more simple or effective.

The common method adopted when propagating such material in containers has been to plant each cutting directly into its container. Experience has shown, however, that a high percentage of losses are recorded this way. Prior to rooting, the cutting is critically vulnerable to the adversity of drought or saturation. We are continually hampered by the lack of skilled help, and the art of correct watering cannot be trusted to novices. An almost 100 per cent take of cuttings is ensured, by simply placing your cuttings in a prepared cutting bed, and initiating callus and root formation, prior to potting. This is the only method we use now.

Semi hard wood cuttings of broad-leaved evergreens and flowering shrubs are planted in glasshouse beds and frames in a manner familiar to you all. Bougainvillea roots readily from internodal cuttings of 5 to 7 inches long, but care must be taken when potting off, and the speedier this transference takes place the better.

A method of propagation which we use and which I have developed upon quite considerably, is that of aerial layering, with the use of polyethylene wraps. The polyethylene we use is sold in special widths and is banded and impregnated with Hormodin No. 3. As in some cases, we have also applied Hormodin directly to the cut surface, and have never used clear polyethylene, I cannot say whether the presence of this root accelerator has actually aided or not. Layering is carried out between April and September and the time for rooting varies from species to species, and to a lesser extent from season to season.

The following are species we have had success with: — Ficus in seven species, *Cassia floribunda, Olea europea, Platanus acerifolia, Par-*

kinsonia aculeata and recently an uncommon *Pachira* species, which rooted 100 per cent in twenty days. With regards to the *Platanus,* it is interesting to note, that this Temperate subject thrives under our conditions and grows into a well shaped large tree upon maturity. Because of the recent dearth of literature on the complexities of the genus, *Platanus,* I will keep an open mind, as to whether or not our collection is correctly named.

After severing from the parent plant and potting up, the layers are usually placed under glass for ten days, then into a slat house, followed by gradual exposure to the sun and hardening off. Provided the ball of roots is lightly broken up prior to potting and good sense is shown in watering, these layers grow rapidly into good sized planting specimens, and never show any check in progress.

We have had partial success when air layering *Magnolia grandiflora, Cassia biflora* and *Hibiscus schizopetalus variegata,* but more study in method is required with these plants. Attempts to root, *Grevillea robusta, Jacaranda mimosaefolia, Juniperus silicicola, virginimia* and *bermudiana, Metrosideros tomentosa, Sabinea carinalis* and *Agathis australis* have ended in complete failure.

Some ten years ago, we found it necessary to place a complete ban on the importation of citrus nursery stock. This step was taken because of the great risk of importing the virus tristezia into Bermuda. This virus generally does not reveal its presence until the tree comes into bearing, yet remains masked on the young stock until that time. There is no effective control and infected stock must be destroyed. After placing the ban, came the problem, where are we to obtain young trees from in the future? Nobody locally showed any desire to take it up as a commercial proposition, so the department added further to its enforced commercial activities. Stock trials revealed the local rough lemon as being the most compatible for budding upon. Conventional 'T" budding, with a "shield" bud was tried at first, but percentage of takes was low. Budding with a naked bud, however gave high takes, so this method is the one used now. Budding is carried out from April through to September. Under normal weather conditions, the dry months of June and July show the poorest results. Stocks are usually ready for budding upon one year from planting out and trees ready for sale one year to eighteen months after budding.

After heading back, sucker growth from the stock is usually prolific, and our much stretched man power is fully extended in keeping them clear. Pests such as Diaprepes esurions, the "Donkey beetle," have to be kept under control constantly. Bermuda's climate makes it ideal for many visiting pests, in ever-increasing life cycles.

A rootstock at present under trial with us is the Cleopatra mandarin. It is alleged to offer some resistance to tristezia infection, and is adaptable for early varieties of orange, such as Parson Brown. The tendency for fruit to reduce in size on this stock is one we cannot establish until the trees come into bearing, unfortunately.

Two interesting points I would like to briefly mention before I overlook them are: The greatest proportion of our garden labor comes from the Azores. These men, whilst extremely hard working, are very set and determined in their ways.

They base their budding ability completely upon the phase of the moon, which determines whether or not they should bud. Despite my successful attempt at one time in budding when the moon's phase is taboo, they cannot be moved from their beliefs. Cosequently, although we bud from April to September, the actual budding time is reduced by half.

The other point of interest, with local flavor is that our budders use the dead leaves of *Pandanus utilis* for budding ties. They would rather work with this material than any other, such as raffia or plastic ties. As their results are satisfactory, there is no gain in us attempting to change things. The leaves are cut into narrow strips and placed in water to soak for one night after gathering. They are then considered ready for use.

Up until two years ago it was our general practice to lift the trees for sale from October through to the end of December. Many people suffered losses when planting in partially exposed sites however. These losses were brought about by persistent salt spray deposit, during prolonged windy periods in January and February. Consequently we now lift, when favorable weather occurs in February, through to early April.

The trees are lifted bare root and pruned as necessary. Fresh top growth is cut back to more mature wood. Whether or not, we would gain any advantage by reducing them harder, as practiced in Florida, we do not know. Practical experiment in this line will be carried out during the coming season.

Last year we sold some 1,700 trees at a cost of $1.40 each. This year some 2,500 are ordered, of which about 1,000 will be ready at an increased cost of a further $1.40 each.

Turning away from economic crops now, and going back into ornamentals, many of the older roses thrive here. Amongst these we are proud to include the rare *Rosa chinesis semperflorens,* which is the parent of a great many of our modern tea roses. This rose was rediscovered here some ten years ago, and I have a slide of it to show you later.

Modern hybrid roses are grown, but cannot be considered as a permanent feature as they should be. These roses, which are imported, are always budded on rootstocks where a period of natural dormancy is essential to provide the very necessary resting period required for perpetuation. Unfortunately our climatical condition is not suitable to the inducement of this resting period. Hence the roses, although profuse in flower, do not live for long. The solution of the problem lays in finding a stock with a natural self-induced period of dormancy. We have found one rose, namely *Rosa odorota major,* which is a strong growing species, having a natural dormancy of some three weeks in July to August.

Up to the present, we have not approached a planned budding programme so we cannot really give any qualified answers. However, a limited amount of budding has been carried out. "Takes" were good but later growth poor, suggesting a possible incompatibility.

It would appear that my allotted time is running out faster than I anticipated, and I still have not mentioned my main subject matter, namely that of mist propagation.

Mist propagation is very new to Bermuda and our work is very much experimental at present. Our unit is of the intermittent mist type, controlled by an electronic leaf. It was designed and manufactured in England to the specifications laid down by The National Institute of Agricultural Engineering.

Whilst we do not experience severe temperatures, it was felt advisable to afford some protection to the unit. Exposure to wind or breeze, however light, would cause serious spray drift and affect coverage. Accordingly, as you will see from slides later, the unit which is in four 6′ x 6′ sections, is placed in frames, fitted with conventional Dutch lights. The site chosen is completely exposed to full sunlight.

The unit was first brought into practical use in September, 1959. A major electrical breakdown occurred in December, however, which necessitated removal of the control box, for a complete replacement. For this reason, proper experiment could not commence until July of this year. Since that date, a great deal of plant material has been tried out, with very encouraging success. We have run into some "bugs" however, which may be of interest to you.

Rooting of conifers, particularly junipers has been a virtual failure, despite very profuse callusing which has resulted in many cases, root initiation has failed to occur. East Malling have assisted us considerably in diagnosing these failures. Two interesting factors emerge. Our completely alkaline sands and water supply will alone inhibit rooting, simply by causing profuse callus. The ideal soil temperature for root initiation appears to be from 70 to 75° F. for most subjects. On occasions our soared to 80° F. and over, despite the fullest of ventilation, and non-use of electrical heating. This excessive temperature can also inhibit rooting by causing excessive callus.

Leaching of nutrients has also provided us with problems. Its effect on the rooting of *Agathis australis,* has been very pronounced. Wider use of nutrient foliar sprays will obviously overcome this problem.

With the exception of "damping-off," which has been a minor concern, the absence of pest and disease problems has betn gratifying pronounced.

Despite assurances that our high light intensity would not affect material, I persisted in keeping heavy shading on the lights. We removed this shading in October last, anticipating the normal drop in light intensity in the Fall. Since then however, the light intensity has been as high as at any other time of the year without having any ill affects on plant material at all. Hence, a complete reversal of my opinion on this matter.

We obviously have an enormous amount more of experimental work to accomplish in this fascinating field of plant propagation.

(*Editor's note*: There followed a short showing of slide material, relevant to the discussion.)

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MODERATOR MAHLSTEDE: We certainly appreciate your giving us a very excellent talk, Don, of your conditions and methods of propagation in Hamilton, Bermuda.

The next paper is entitled, "Evergreen Grafts Under Plastic Covers," and will be presented by Hans Hess. He has driven over very treacherous roads to be with us for the afternoon, and I hope for the rest of the session. Mr. Hans Hess, Hess Nursery, Wayne, New Jersey.

Mr. Hess presented his prepared paper.

EVERGREEN GRAFTS UNDER PLASTIC

C. W. M. HESS, JR.
Hess Nursery
Wayne, New Jersey

For many years there has been little if any change in grafting procedures. The well known pony sash or half sash have constituted the standard enclosure for the Wardian Case. These sash are quite heavy, have an abundance of sharp splinters, and to air the grafted plants they must either be hung or removed to the greenhouse path. This procedure requires about a minute per sash for removal and replacement. This short period of time in itself doesn't mean much until you multiply it by the one hundred and thirty sash in a four bench propagating house, one hundred feet long. Approximately fifteen hours a week are required for the average seven weeks the grafts are in the Wardian Case. You will find that your pocket is lighter by more than one hundred and fifty dollars on this basis.

Realizing this overhead expense, some growers have experimented with mist lines to eliminate the need for using sash. During the summer this has proved very successful in grafting Japanese maples, dogwoods and other deciduous material. Evergreen grafts for the most part do not like this type of treatment. Mist for winter grafting has not been very successful.

In the past five or six years we have seen great advances in the use of plastic, such as for lining greenhouses to conserve heat, building economical greenhouses and even as a substitute for glass. The need for a number of additional sash for a new propagating house and the prohibitive price, prompted us a few years ago to try plastic as a substitute. Light, one by two inch frames, four feet wide were constructed. Four mil plastic was then stapled to this frame. These sash, for labor and material cost less than one dollar and fifty cents, or about twelve cents a square foot compared to seventy five cents a square foot for the conventional pony sash. These sash proved superior to the pony sash, since they were much lighter and easier to handle. The grafts had far more light, since these sash have a narrow frame. There was less moisture loss than with conventional glass sash.

As more and more uses for plastic were found and advertised and from hearing Harvey Gray explain his vapor proof case we decided we might save some more time and money with these plastic sash. We cut our airing of the grafts from a daily operation to once a week and have

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As more and more uses for plastic were found and advertised and from hearing Harvey Gray explain his vapor proof case we decided we might save some more time and money with these plastic sash. We cut our airing of the grafts from a daily operation to once a week and have observed no change in the percentage of good plants. The deciduous material is not aired at all until time for hardening off. We find no mold problem if we apply a spray of Captan before closing the cases. For the outside grafting in early spring, we use a plastic cover over the grafts and sash on top with a twelve inch air space between. The plastic is left intact until the time comes for hardening the grafts.

This past year we have begun to use, on a limited scale, a different method, in our plastic cover, grafting procedure. The grafts are placed upright in the bench, the union plunged and the entire bench covered with a plastic sheet. This is removed each night at sundown and left off until the following morning. On cloudy days the plastic is left off all day. This procedure has given good results and the grafts come into growth naturally making them much stronger for field planting. The understock for this procedure must be spring potted for satisfactory results.

These are the uses of plastic which we have adopted to save time and labor in our propagation program. I sincerely hope that this information may be of use to the members of the Plant Propagator's Society.

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MODERATOR MAHLSTEDE: We now have ample time for any questions from the floor, relative to the use of plastic frames or sash covers on grafting cases or grafting beds.

MR. GERALD VERKADE: What type of understock do you use on your junipers?

MR. HANS HESS: We offer the customer a choice of either *J. chinensis hetzi* or *Juniperus virginiana* understock.

We grow our *J. virginiana* understocks. We take a one-year seedling and transplant it in April and it develops a very fine understock by fall. We have found that if these are then carried over and spring potted, that it is extremely difficult to control the blight because of the closeness of plants in pots.

MR. HOOGENDOORN: I haven't asked you, Hans, did you say summer grafting of maples and dogwoods is very successful under mist? Is that in a greenhouse bench?

MR. HAN HESS: Yes, that would be in a greenhouse bench.

PRESIDENT TEMPLETON: Hans, you said juniper grafts made in the winter under mist were not successful. Would you describe, please, in fair detail the conditions under which those grafts were carried? In cases where they failed, why do you think they failed?

MR. HANS HESS: We have used both peat and sand in which to plunge the union. In either case, with junipers, using mist, it seems that the amount of water necessary to keep the scion in good condition is detrimental to the healing of the union.

PRESIDENT TEMPLETON: How much light did you have on the grafts after they were made and while they were under mist? What was the light intensity?

MR. HANS HESS: This was done in the greenhouse with clean glass.

MR. VERKADE: You talked about propagating dogwood and maples in the summer. How do you winter these?

MR. HANS HESS: They have to be in a temperature controlled, frost free environment.

MR. EDWARD DAVIS: We do not graft a very large number of junipers. I thought ,however, that this might contribute a little something to this discussion. Some three years ago we decided that we could use the polyethylene cover on the grafts. We use about 50 per cent shading on the greenhouse and were very careful with the misting, using a humidistat to control the moisture. We have had good success with this technique.

MR. HENRY C. KIRSCHNER (Fairview, Pennsylvania): Mr. Hess, have you found that the peat moss and your junipers are not compatible? Does the acid peat have a reaction on the growth of the understock or the union?

MR. HANS HESS: In the conventional grafting case we want the union under peat during the period when the graft is growing together. This has proved very satisfactory and we have had no difficulty whatsoever. I might also say, that using sand as a plunging medium has also worked out very satisfactorily without any detrimental effects at all.

MR. WELLS: Hans, have you tried these methods you have just described in the grafting of the fastigiate Scotch pine, *Pinus sylvestris fastigiata?*

MR. HANS HESS: I have not tried them. I have someone who is generously going to send me some scions this winter.

MR. MARTIN VAN HOF: Do you just drape the plastic cover over the grafts and take it off at night?

MR. HANS HESS: Yes, Martin. It is draped over and hangs over the side of the bench. It is not nailed absolutely tight. There would be some very small loss of air out of the case itself.

MODERATOR MAHLSTEDE: Any further questions? All right, if not, we have a little time here and I am going to ask President Harvey Templeton to come forward and make any announcements that might be pertinent at this time. Harvey!

PRESIDENT TEMPLETON: I have just a few announcements. The members of the Resolutions Committee are Jim Scarff and Paul Wilms.

The members of the Audit Committee are: Warren Richards and Ralph Fisher.

The members of the Nominating Committee are: Chairman Hugh Steavenson, Louis Vanderbrook and L. C. Chadwick.

MODERATOR MAHLSTEDE: Although we are running a little ahead of time, I think it would be in order to call on Mr. David Leach, Brooksville, Pennsylvania, who will discuss the general topic of "Outside Green Grafting of Rhododendrons Under Polyethylene." Dave Leach.

Mr. Leach presented his discussion of a procedure for green grafting rhododendrons which was illustrated at various points by colored slides.

OUTSIDE GREEN GRAFTING OF RHODODENDRONS UNDER POLYETHYLENE

David G. Leach
Brooksville, Pennsylvania

I am going to talk this afternoon very briefly about still another method of propagating rhododendrons.

Green grafting of rhododendron is a kind of a special situation, because I think almost anyone agrees today that a rhododendron is better off on its own roots. There are a few situations, however, where it is just about necessary to graft. There are a few rhododendrons that are not vigorous enough on their own roots and there are a few, that will not root from cuttings. Mrs. C. S. Sargent, for example, which is just about universally recognized to be about the finest often is described by the nurserymen as being impossible to root.

Rhododendrons have traditionally been grafted in the winter in the greenhouse. A few years ago I read about topworking old plants by grafting. I then adapted this technique to the propagation of new plants by green grafting, since it seemed to me to be far superior to dormant winter grafting technique.

The understock can be almost any kind of a two or three-year seedling rhododendron. The understock can be potted, although there is a wide variety of ways in which this can be done. The understock can also be dug for making the graft and then replanted in a ground bed. The grafts can be made on seedlings which are growing in flats. If you do this, you grow 18 seedlings to a flat for the specific purpose of grafting. You can even grow your seedling in a ground bed without ever digging it. The saving in labor and convenience is very great, since the grafts are made when vegetative activity is at the year's high. You can do many things with this at a time when it is impractical to do the dormant season grafting. I might say to you fellows that don't grow rhododendrons that I have tried this same method with one or two other plants and it does very well.

In making the graft the top of the understock is first lopped off. After making these grafts during the summer at weekly intervals from mid-June to early September I find the best period is from June 20 to July 10. The scions should be at least half ripe and the leaves should be fully developed and firm after the first flush of growth. It is desirable but not necessary for the understock to be a little bit less mature. I have had perfect results with the understock and the scion at the same degree of maturity. It is apparent *Rhododendron maximum* is ideal for this purpose because it starts a little later than most other species. The new growth of the stock is lopped off just above the lowest leaf leaving a stub.

The next step is to split the understock right down the center of the stem. I suppose some of you old timers of grafting will get a kick out of my using a razor blade. I only make about 50 grafts a year, and I can always find a razor blade around.

The scion when ready for use will have three leaves. It is wedge-shaped at the base for insertion in the split understock.

Now if the scion is slightly larger than the understock there are inevitably four points of union between the cambium of the understock and scion. In my opinion it is better to have the scion a little larger than the stock rather than to have it perfectly matched. Of course, having both units the same size is also a good situation. It is especially important to set the scion firmly in the understock at the bottom of the split, because this is where the healing begins.

The reason I leave a short stub above the leaf on the understock is because it provides a point of anchor for binding up the split with a rubber grafting strip. That little stub above the lower leaf is more for convenience than for anything else.

The next step is to take some damp sphagnum moss and wrap it around the point of union. All of the free moisture should be squeezed out of the moss before it is covered with a polyethylene plastic bag which is tied at the bottom with a "Twist-Em" or rubber grafting strip. These bags are very cheap and have the added advantage of visibility. Each graft is in its own little miniature greenhouse. The damp sphagnum moss provides the moisture and the polyethylene bag acts as a vapor barrier while permitting the interchange of oxygen and carbon dioxide. Further, the sphagnum moss is famous for its antibiotic properties and therefore prevents decay fungi from multiplying at the graft union. From this point on, the sun must not directly strike the grafts in the closed bags, because if it does, the result is fatal. It is therefore necessary to shade the grafts.

These grafts heal very quickly. After several weeks, lay aside the shading, and open the bags at the bottom, at least enough to give them some ventilation and air circulation. A week or ten days later remove the plastic bags and replace the shading but leave the sphagnum tied around the union. In a week or ten days remove the sphagnum. A week after that reduce the shading and start to acclimate the plants to normal exposure.

In my opinion the advantages of summer green grafting over dormant season grafting are these:

(1) A great deal less skill is required. The fitting of the cambium layers between the scion and understock is not nearly so critical when the tissues are inactive, vigorous growth and the wounds heal more quickly.

(2) Some rhododendrons which can't be propagated by dormant winter grafting, succeed very well as green grafts.

(3) Expensive greenhouse facilities and the cost of heating them in winter are eliminated.

(4) There is a great saving in labor by eliminating the endless syringing and ventilation which are costly features of winter greenhouse grafting.

(5) There is almost no disease problem. The oldtimers know that whole crops are sometimes lost in the greenhouse because of *Phytopthora sp.*, especially when *Rhododendron ponticum* is used as the understock.

(6) The percentage of successful grafts is so nearly perfect it is marred only by mechanical errors in aligning scions and understocks which are poorly matched in size.

(7) The cleft growth is faster and easier to make and subsequent growth of summer green grafts outstrips that of winter grafts.

If you want to make grafts lower on understocks, you can do that by cutting back the seedlings the year previous to within ½ inch of the ground. The next spring rub out all but the strongest sprout and make your graft on this. Even using the two-year seedling the graft is only two inches above ground level. I feel myself that is a perfectly satisfactory situation.

I have used this method for hollies and I suspect that it could be used for particular clones of many other plants that are difficult or impossible to root.

Now as a matter of academic interest, green grafts can also be used on mature rhododendrons. The only requirement is that the mature understock plant be in a shaded position, or you must erect a shade over it. In this case, in making the graft on a mature plant, you remove all but the strongest twig produced in the first flush of spring growth and make the graft on this remaining shoot, exactly as you would on the two-year seedling.

Here is a mature plant with six different clones grafted onto it. I suppose there may be some market for these multi-grafted specimens, but to me the result is only bizarre. The reason I do it is because I am a breeder and by grafting the seedling onto a mature stock, they set buds the year following grafts, thereby speeding up the hybridizing work.

Green grafting is cheap, easy, and consistently successful for special situations. I commend it to your consideration for your own purposes. Thank you.

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MODERATOR MAHLSTEDE: I am sure there will be a number of questions on this paper.

PRESIDENT TEMPLETON: Dave, have you ever tried instead of wrapping the union with sphagnum moss, taping it or waxing it?

MR. LEACH: Yes, I have tried that but the sphagnum moss is much better. You really need some moisture, Harvey, inside the enclosed polyethylene bag, and the sphagnum moss provides that moisture and saturated atmosphere inside the bag. Aside from that, I suppose you could sprinkle water inside, because the bag would be closed. This seems to work better than waxing. I have tried spraying with Wilt Pruf but this seems to be the best of the methods I have tried.

PRESIDENT TEMPLETON: The reason I was interested, goes back to the subject of grafting under mist. Apparently with sphagnum moss the union is coated continuously with a film of water. Would you assume they are? Is the moss that wet?

MR. LEACH: No, it isn't that wet. You wring out all the free water so there isn't a film of water around the junction of the understock and scion at all.

PRESIDENT TEMPLETON: Thank you.

MODERATOR MAHLSTEDE: Any other questions or comments?

MR. LOWENFELS: Why should you graft holly? I haven't had any trouble with the ordinary method of propagation.

MR. LEACH: Just as a matter of curiosity.

MR. HANS HESS: Dave, you say that the union of this graft was approximately two inches in the ground. When this is planted, that union remains above the ground at that point. You don't plant that with the union below the surface do you?

MR. LEACH: No, you do not.

MR. HANS HESS: What has been your experience as far as suckers from the understock?

MR. LEACH: I have had no trouble with them but I can't explain why I haven't because with the understock that I use you will always have some. I almost always use *Rhododendron maximum*. Whether that accounts for it, I don't know.

MODERATOR MAHLSTEDE: Any further comments or questions?

MR. JIM WELLS: Dave, how long do these grafts take to unite and when do you remove the bag?

MR. LEACH: I usually ventilate the bags in something less than three weeks when there is a good callus formed.

MR. WELLS: How quickly can you make these grafts?

MR. LEACH: I do them very quickly because I think the cleft graft is the quickest and easiest of all grafts to make.

MR. WELLS: Have you tried any other understock than *R. Maximum?*

MR. LEACH: Yes, I have tried a variety of understocks, but *R. maximum* is the best. It is a little softer as a seedling. I have tried all sorts of miscellaneous rhododendron lines and they all work fine.

MODERATOR MAHLSTEDE: Are there any questions you might have to ask? If not then, we stand adjourned until 8:00 o'clock this evening.

The session recessed at 4:05 o'clock.

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only and I believe all of you now have this sheet upon which appears my talk. In order to save time, I will not go into very much detail.

Professor O'Rourke presented his paper on the "Establishment and Maintenance of Stock Blocks."

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ESTABLISHMENT AND MAINTENANCE OF STOCK BLOCKS

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

It has been shown that stock blocks established for a ready supply of propagative material must be well fertilized, sprayed for pests, given weed control, and irrigation when necessary. Other factors to consider are site selection, economy of space, pruning, and virus-free certification.

The site for stock plants grown for softwood cutting material should be convenient to the greenhouse so that collections may be made frequently when the wood is in just the right condition. On the other hand, plants grown as a source of seed, scionwood, or hardwood cuttings, may be grown wherever space is available. Neither the best nor the worst land should be used for this purpose. Sloping land should be planted on contour in conformity to good soil conservation practices. Fertility and available water are always prime requisites for the production of propagative material.

Nurseries and arboretums often feel compelled to keep propagating material of a large number of different clones, even though the demand may be both sporadic and sparse. Space must necessarily be conserved. One plant of each clone is often sufficient. These may be planted closely together in rows and kept within bounds by close and frequent pruning. Permanent labels are important, but the location of each plant should also be plotted on a map to insure identity if the label becomes lost or illegible.

In England some stock blocks of apple varieties consist of single plants of each variety planted three feet apart in rows that are six feet apart. The size of the scion variety tree is controlled by grafting on a Malling IX rootstock. They are also pruned heavily both in summer and winter which not only limits the size but also stimulates the production of vegetative shoots for budwood purposes. This system is not only economical with space, but also guards against mixtures when scionwood is collected as only one variety is on one tree. When two or more scions are grafted in the limbs of a large tree, identity is often lost and the wrong variety of budwood may be collected.

Severe pruning not only keeps the plant in a vegetative state, but also induces sprouting from near the base of the tree. Cuttings and scion from these shoots usually root or unite to a greater degree than from wood taken from the upper branches. This physiological condition of the tissues is generally termed "juvenility" as it responds similarly to that of young seedling trees. The juvenile condition may be maintained for many years by drastic and frequent pruning.

It is highly desirable everywhere, and in some states legally necessary, to maintain propagative wood in a virus-free condition. Although viruses are spread in several ways, the most common ones are by insect vectors or through propagative methods. Thus isolated plantings, frequent spraying, and even screened houses are sometimes used to protect the stock plants.

Propagators should consult with plant pathologists before they bring plant material into their stock blocks from outside sources. Many varieties of plants do not show visible symptoms, but still carry the viruses latent in their tissues. Fortunately, there are some plants, both woody and herbaceous, which are susceptible enough to certain viruses that they show symptoms very quickly after a bud or scion from an infected plant is inserted into their tissues. This method, known as "indexing," is reasonably reliable and should be used frequently as a check on the status of the propagative material. Seeds and rootstocks, as well as scionwood, may carry viruses and the source of each should be carefully scrutinized before purchase.

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MODERATOR HILL: Thank you very much, Steve. I believe again in the interest of cohesiveness of this program it would be well if we note as we go along the points over which we wish to raise questions and bring them all up at the end of the program.

Next I am going to call on Louis Vanderbrook, who is going to talk to us about his particular method of managing stock blocks and particularly about his fertility maintenance program. Louie, I would like to stress each time that you give us the "why" you have chosen a particular method. Here is a method you are using, obviously, you have developed it. Describe the method and then tell us as well as you can why you have chosen this method over the obvious alternative. Louis Vanderbrook!

Mr. Vanderbrook presented his paper on the techniques he has used to manage the stock block.

ESTABLISHMENT AND MAINTENANCE OF STOCK BLOCKS FOR PROPAGATION

LOUIS VANDERBROOK
Manchester, Connecticut

In the establishment and maintenance of a stock block for cutting purposes, layering, stooling or whatever method of reproduction you plan to use, we first have to consider the advantages and disadvantages of such a venture.

Let us first consider the advantages of a stock block. The establishment of such a planting will enable us to:

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ESTABLISHMENT AND MAINTENANCE OF STOCK BLOCKS FOR PROPAGATION

Louis Vanderbrook
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In the establishment and maintenance of a stock block for cutting purposes, layering, stooling or whatever method of reproduction you plan to use, we first have to consider the advantages and disadvantages of such a venture.

Let us first consider the advantages of a stock block. The establishment of such a planting will enable us to:

1. Have our source of supply close at hand.
2. Give strong healthy cuttings as a result of controlled fertilization and cultivation.
3. Enable us to secure our cutting material when we want it with a minimum of time.
4. Be sure our materials are disease free by use of proper controls.
5. Help preserve juvenility.

Now the disadvantages of planting and maintaining a stock block are as follows:

1. We will have to invest some capital to set aside an adequate amount of good land
2. We will have to manure, fertilize, and cover crop it to put it in good condition and keep it high in fertility.
3. We will have to take sufficient plants of each variety out of salable inventory to produce a given number of cuttings yearly.
4. We will have to fortify our will power to hold these plants for reproduction only and not give in to offers of purchase.

Now after having weighed all the advantages against the disadvantages we decide to establish the block. We then select a fertile area of the best land we own, manure it heavily, about 40 or 50 cords per acre, plow and harrow it in the spring of the year and sow it to sweet corn, using a lime sower and putting on corn enough to get a good even stand

When the corn is knee high, in late June, sow 300 pounds of ammonium nitrate (33%N) on the corn with the fertilizer or lime spreader and plow under and harrow. After harrowing sow Austrian or Japanese millet with the lime spreader, again using enough seed to get an even stand Leave the millet until August 15th and then again spread on 300 pounds of ammonium nitrate before plowing. After plowing let the land lie for three or four weeks and then harrow and fit for planting.

For evergreen stock plants use strong, 15/18 inch plants, either spread or height, depending upon the type selected and for the flowering shrubs use strong 12/18 inch or 18/24 inch plants cut back for planting.

During the growing season fertilize the stock blocks with a 10-10-10 fertilizer at the rate of one ton per acre every year. and you will get plenty of strong, healthy cuttings

In fitting land for yew stock blocks also harrow in ground limestone, after spreading at the rate of one ton per acre. A note of caution here. Do not use lime on Canadian yews but it is alright on all others.

The usual spray controls will have to be used on the blocks for insect and disease control each year. The evergreen stock block will take about three years to reach a heavy yield of cuttings although you should cut whatever yield is produced the first and second year. The flowering shrub block will produce good quantities from the first year on. The great time saver here is that you can go in and cut the plants right down and get a large number of cuttings in one or two hours and keep the cutting crew supplied for an entire day. This is much faster than taking cuttings here and there from fields which will be sold the same or the following year.

By having such stock blocks the time and dollar cost of taking the cuttings is reduced by 60 to 80 per cent and this is certainly a sizable saving. The blocks should receive the same constant cultivation. hoeing and weeding as the balance of the nursery. This continued practice will result in healthy increased numbers of cuttings.

The main objective in all propagation, naturally, is to use cuttings that are large in size and bursting with health and vigor. This will result in a percentage of rooted plants that will be in the highest ratings.

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MR. VANDERBROOK: I would like to comment further on some of the points I brought up in my talk. As for the selection of plants for stock blocks, I have always felt that Dr. Chadwick in a statement he made a few years ago at one of the New England meetings put his finger on a very important point. Dr. Chadwick said, if you are going to use a liner, use a strong one If you want to raise husky human beings you have to have husky children. For evergreen stock plants we use strong 15/18 inch plants, either spread or height, depending upon the type selected For the flowering shrubs we use strong 12/18 inch or 18/24 inch plants cut back for planting Evergreens are not cut back for stock block planting.

During the growing season fertilize the stock blocks with a 10-10-10 fertilizer at the rate of one ton per acre every year, and you will get plenty of strong, healthy cuttings Most yews will require limestone, except the Canadian variety You don't want to use lime on these or you will get into trouble. Another point is that it is necessary to maintain the stock blocks as you would your nursery. They have to be constantly cultivated since you can't let stock blocks stand and be healthy and produce. The healthiest liner you can get comes from a healthy cutting in the beginning. If you put in a healthy cutting as a liner, you are going to maintain this right through your finished plant, if you keep up your fertilizing program

I will be glad to answer any of the questions if you have any later on.

MODERATOR HILL: Thank you very much, Louie. I have noted a number of pointed questions I intend to ask you later.

I am now going to call on Dick Vanderbilt, who is going to describe a method of handling rhododendron stock blocks.

Mr. Vanderbilt presented his paper on the establishment and maintenance of rhododendron stock blocks which was supplemented with colored slides.

THE ESTABLISHMENT AND MAINTENANCE OF A STOCK BLOCK OF HARDY HYBRID RHODODENDRONS

RICHARD VANDERBILT
Koster Nursery
Bridgeton, New Jersey

REASON FOR A RHODODENDRON STOCK BLOCK

A good stock block enables one's entire production to be taken from plants that are true to name. It is possible to produce more cuttings of better quality than when cutting plants which are destined to be sold. In working over material to be sold there is always the conflict of wanting to take the best propagating material and simultaneously doing whatever is best for the plant being cut. A stock block allows more flexibility. We may treat salable aged plants, or those being grown to be sold, to produce the maximum amount of body and to encourage flower bud development, while treating mother plants to produce the maximum amount of vegetative growth and to hinder or halt reproductive activity.

In addition a stock block provides a more reliable source of cuttings year after year.

THE ESTABLISHMENT PROCESS

The obvious prerequisite is to procure the plants in the varieties and quantities deemed necessary. One of the most important factors to success is a satisfactory site. If the soil is basically a fast-draining one, it can be fitted to grow rhododendrons if the pH is 5.6 or under. The addition of peat moss alone would lower this to 5.1 to 5.2. Some of our rhododendron soils have a pH as low as 3.8 on which the plants do very nicely.

A moderate amount of shade is a very decided asset when working with rhododendron stock plants, especially the more touchy red varieties. Cuttings strike more readily from a plant that is shaded than from one fully exposed, all other things being equal. Shade may be provided by a lath house or portable shades erected on pipe runners.

We have hit upon using a modified woodland which fulfills these requirements well. The most difficult thing was to determine the amount of thinning needed to produce an abundance of cuttings having a high rooting potential.

Insufficient light is not necessarily detrimental to the health of the plants, but one side effect is that a second growth is rarely produced. Instead, plants become drawn and have greatly enlarged leaves. The presence or absence of this second growth is the determining factor as to what per cent of the cuttings may be safely removed. If a stock plant makes two growths a year, one may remove 100 per cent of the second growth for propagating wood. If, however, one removes all the cuttings from plants producing only one growth a year, the plants will soon die. These plants should have only half the cuttings removed.

We prepare the soil for our stock plants as we prepare all our soil used for growing rhododendrons. The area selected is subsoiled, then spread with peat to a depth of 2 inches which is then rototilled. We use a raised bed that is 5½ feet wide with a 2½ foot aisle. Actually we raise the bed by removing the soil from the aisle area to a depth of 12-14 inches and putting it on the bed. We use a middlebuster plow that takes much of the hand labor out of this operation. The beds are fertilized with: 1 ton gypsum per acre and ½ ton each of: 20 per cent superphosphate, magnesium sulfate, and tankage. This is equivalent in pounds per plowed acre to: 80 pounds of nitrogen, 200 pounds of phosphoric acid, 200 pounds of potassium sulphate, 200 pounds of magnesium sulphate and 1000 pounds of calcium sulphate and oxides This dose is applied annually as a follow up treatment. The area is then ready to be planted. The plants are mulched immediately after planting with either hay, pine needles or what have you, and renewed as needed. Plants are spaced usually for two or more years of growing and moved as they become crowded. Available area ultimately determines how distant the plants are set. Young plants are never spaced further than the room needed for two years growth as they exhibit a definite preference for close company

The plants are hand weeded as necessary and sprayed for insect control and leaf diseases 5 to 6 times a year. We use DDT, Kelthane and Parzate for this purpose.

Very often the plants will tend to make only one growth and in July begin to develop flower buds. This can be reversed by pinching out the bud and/or spraying with chelated iron and liquid fertilizer in a concentration of 30 ppm nitrogen.

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CHAIRMAN HILL: Thank you very much, Dick Now, since we have quite a lot of time remaining, despite our late start, I would like to just impose upon all of you and frame two or three questions for each of you.

Steve, I would like to ask you, No 1, for a specific definition of juvenility. Just exactly, what is juvenility? How can we insure it? Why, for example, is the growth produced in 1960 on the tip of a ten-year old plant any different than the growth produced in 1960 at the growing end of a two-year old plant?

Next, will you go over once more an evaluation of the importance of this proximity of the stock plant to the propagating facility? You stressed that early in your discussion and I just wonder really how truly important that is Should be allowed to override numerous other factors?

PROFESSOR O'ROURKE. Juvenility is probably the hardest thing there is to explain in plant growth. We really only guess at most of the causes. We know this, however, that if we take a one-year old plant of almost any kind we can take cuttings from it and they root very, very quickly We can take cuttings from a two-year plant, but it won't be quite as good. From thereon it depends on the age of the plant as to when this easy rooting stops. In apple, it stops after the second year. In white pine, it stops at about the eighth year, and various other plants at various other times. Now this condition of the young plant grown from a seedling we call juvenility. It is rather difficult to try to take this particular condition and transfer it over to an old plant where we may get the same phenomenon. We sometimes call ths a reversion to juvenility. Whether it reverts or whether it is just an expression of something that is already there, we don't really know, although I think it is the latter.

As an illustration, if we cut down a tree close to ground level we will get sprouts coming up from near the base. Those sprouts will react, perhaps they will even have leaf characteristics, of the juvenile condition Now we term that juvenility, even though these sprouts come from a very old plant. Now the juvenile condition has nothing to do with the chronolgical age in the way I am expressing it now, because a tree can be very old sometimes and still give out these shoots near the base that are juvenile in so far as rooting is concerned.

A couple of years ago I gave a talk here on how they kept their apples in the juvenile stage in England. They use hedges and they keep those hedges pruned very, very closely so that no flower buds ever came out on them. They keep the hedges in a vegetative condition. They take hardwood cuttings from these and then root quite well.

I have taken a little longer than I wanted to, but I hope I have expressed it.

MODERATOR HILL: Now, Steve, I hope you will defend yourself and defend this proximity of the stock plants to the propagating facility, recognizing this is 1960 and we all have these things called trucks How important do you think it is to have the stock plants located near the propagating facility?

PROFESSOR O'ROURKE: As I stated, the stock plants from which you take softwood cuttings should be located close to the propagating facilities. It is only human not to go out to the back woods to see that the cuttings are just in the exact condition for collection. You know how important it is especially with something like lilacs. It is so important in many softwood cuttings that you take them when it is right. It doesn't make much difference about stock blocks for budwood, scionwood or hardwood cuttings, but the ones which bear softwood cuttings, even though it might cost more to use the land up near the greenhouse are worth the effort.

MODERATOR HILL: That is very good. I thought most of us in this room were interested in pure science, therefore, we were not subject to this thing we call human nature. If the stock plants were located quite a distance from the plants we would go back to that place and get them. I am sure we tend to do best those things which are easiest and if it is closer, it is sure enough easier.

Louie, I would like to move over to you where I noticed that you stressed the importance of this pre-plant management of the area you had chosen for the establishment of the stock block. I wonder if the pre-plant treatment you describe is different from that which you would provide for sale plants only for an economic reason or if there is anther specific reason, particularly with reference to what would appear to me as the application of excess quantities of available nitrogen.

Next, I wonder if you would defend this matter of what you call large cuttings. Large is a relative term, and therefore, should probably be qualified a little bit. To use one example, let's take a spreading yew. The aspect ratio is, let's say, one inch wide and ten inches high, whereas, the aspect ratio of the plants which we sell, produced from that cutting, are quite the other way It is perhaps in the ratio of three to two. When the plant is three feet wide, it will be two feet high Somewhere between the tmie that cutting strikes root and during its formative growing years, it has to change that aspect ratio. Therefore, I wonder if perhaps it would be better to start with a smaller, shorter cutting than the typically large one. Start out with this factor of weight of wood and tell us how important that is, and why.

Last, Louie, I would like to have you kind of define the whole principle of the stock block.

We are fortunate to have as our Program Chairman this year an outstanding proponent of that second system, which is not the actual establishment of stock blocks but rather, taking a portion of a block of sale plants which are in the process of production. Perhaps, these are not scheduled for sale for a year or so, but the cuttings are annually taken from a select group of these sale plants in the process of belng made up. There is obviously quite a lot of difference risk-wise. If we put all our stock blocks in one basket geographically, there is quite a risk. There could be fire. Some careless technician could make a careless application of chemical or fertilizer, whereas, with Martin's program he has his risk distributed over a large area. The likelihood of someone making a mistake, that penalizes his department is much less Therefore, Louis, will you defend the principle of putting them in one place as opposed to the principle of having them scattered on the premise? Those three things: No. 1 is the specifics of the pre-plant; No. 2 is the size of the cuttings; and No 3 is the whole stock block principle.

MR. VANDERBROOK: To answer your questions, Jack, I will admit that the pre-planting preparation of this stock block area to the average nurseryman here will perhaps seem to be using an excessive amount of organic as well as chemical material. The reason for that, and it is a good reason which we have found by practical experience, is that those plants that you put in that stock block are going to stand there for a long time. If you continue to cut them back hard, as we have always done, you can leave those plants there for as long as 10 or 15 years. As long as you maintain your fertility you can still get results.

I know that I can't paint a word picture to you fellows to show you what our stock block looks like, but I will attempt to describe it. The manager who purchased our nursery is here, and can verify that many of the stock blocks which we had and which he has used for the first time this year were plantd in 42-inch rows. This summer as a result of the fertilizer that had been poured into that stock block the plants were so big that the branches met in the middle of the row. You could hardly see the ground. You could make four or five cuttings from one of the branches.

One of the advantages, I will admit, to the process of fitting the land for salable plants is that we used the cover crop method of preparing the land. On stock block establishment you have to pour on a terrific amount of organic matter, because you are going to have it there for a long time. That is why we add the 40 to 50 cords of cow manure to the acre.

Now to defend the size of the cutting. I don't have to tell the average person here that a man who is perhaps average size, five foot six to eight, is going to be a lot more powerful and have a lot more endurance in doing physical activity than a man who might be four foot two or four foot five, and hasn't got as much body area and muscle area. They say a small man is as good as a big one but the question comes down to endurance. We have found it takes twice as long to get a salable plant or twice as long to get a fit liner if you take two or two and a half inch cuttings than if you take six inch cuttings. There is something about the bigger cutting, the same as the bigger man that has more vigor or more reserve vitality connected with it. Therefore, we lean to the larger cutting In fact, we used to always put them in, sometimes ten inches long and we didn't cut them back.

Now to defend the stock block as to having all the plants in one location as contrasted to having the spread over the nursery. All of us are not in a situation such as Martin is in Newport, where he has 200 to 300 acres of nursery and can afford to go out and get cuttings from all the plants in that way. Yet he cannot match the speed of gathering that you can get from a stock block where you go in and cut them right down He doesn't save that time but he perhaps is willing to write that off as a hedge against risk of injury to his plants.

We have never had anything happen to these stock blocks, either chemical or natural They have always been healthy and produced for us every year.

MODERATOR HILL: I thank you very much, Louie.

Dick, I would like to have you go a little further along this matter of reliability of production. It was a phrase you used in reference to the stock block. It is like a man who grows nothing but carrots. Along comes the carrot knife and he is out of business. On the other hand, a man whose crops are diversified may lose his carrots but he doesn't lose his whole operation. This risk of having all our propagating plants in one location, therefore, subject to the vagaries of that limited environment are obviously more risky than the ones out in the field. Can you think of a couple of good reasons why stock blocks rather than gathering the vegetative material from sale plants should be used in the process?

Next, can you give us the reasons why this stock plant grown in shade produces a toughening which as you say strikes more readily?

The last part of the question I want to ask you is to go over once more this reason for gathering only one-half of the cuttings each time you collect cuttings.

MR. VANDERBILT: Before I get into the rhodos, I would like to comment on the size of the cuttings Louie mentioned. It is not the length of the cuttings but the diameter.

MR. VANDERBROOK: In order to be a good cutting it should have the girth there, too, in order to have viability.

MR. VANDERBILT: We strive to sell two-year old and three-year old plants of rhododendron We don't deliver any bigger plants. We have four-year olds because they were culled as a three-year old, not because we deliberately start out to grow a four-year old plant.

I would say we probably wouldn't need a stock plant at all. All we would have to cut would be our one-year olds which have been pinched to make a good body. The actual cuttings are extremely small. You cannot take any cuttings from those plants without hurting the body, and the cutting in my mind will take two to three times as long to get a salable plant. They are too small and too thin. We would rather collect from plants that are a little larger.

The second thing comes about if you continually take your cuttings of rhododendron from young, one and two-year old plants. If you do this each year your leaves will tend to get smaller and smaller and eventually you will get down to a two-year old leaf which is about a half inch long. It will look like a real dwarf The longer it remains the more it tends to behave like the mother plant.

On this reliability thing, if for some reason your one-year olds up and die, this can be a real calamity. If you are depending on these you are out of business If you have a mother block, you have no one-year olds but at least you have something to start over with.

On this matter of shade, I can't say why this happens but the cuttings we took from shaded plants tended to root up more easily than those collected out in the open field

On this question of taking half the cuttings, I would say that if the stock plant produces two growths a year, you may remove that entire second growth for cuttings If you take more than half consistently year after year, you will kill the plant since the rhododendron grows in flushes. When you take the cuttings you remove all the eyes, with that cutting If it has made only one growth bud and you take the entire growth then the plant has to fall back on buds from a previous season If you do this year after year it is going to run out of eyes and you are going to kill the plant That is why I use only one-half the wood on the first flush. However, if they make two, then I don't mind losing all the second one.

MODERATOR HILL: I think that is very good. Dick. I think the reason you have given for taking one-half of the cutting, especially the handling, is different from our familiar juniper and taxus which more or less grow continuously. The taxus have the facility to grow from adventitious buds. That is why they are chosen for topiary work in the West and in Europe

If I can kind of serve here as an unbiased anchor man on this, I would like to tell you what our thinking has been at Dundee, and what we have done that may be different from anything described here.

As late as two or three years ago we were spacing our stock plants at a deliberate wide spacing. Let's take a plant like spreading yew, for example If it is to be used continuously as a stock plant over 12, 15 or more years, it is going to ultimately come up to immense size, even with the persistent annual reduction of twig length. Therefore, we space them at an 8′ x 8′ spacing and it takes a lot of acres On the other hand, when that plant is large, it produces an awful lot of cuttings.

At the time we thought this through, it appeared that we wanted this space right around the plant for we are believers in Chadwick's theory of using stock plants in sod rather than in clean culture That can be traced back to the type of planting where we may easily have one of those warm and relatively nice fall periods where the wood does not harden off as rapidly as we would like When winter comes, it frequently catches that material in a state that is too soft to withstand this sharp drop in temperature. Therefore, any propagating wood taken after that shows considerable deterioration Frequently they do not root at all. Therefore, the sod is a balancer as far as maintaining good vigorus hardened growth. It is only necessary to supply sufficient fertility to care for the requirements of the sod plus whatever additional you may need for the crop The sod serves as a balancer during these fall periods where the plant is changed to the point where it is warmer and wetter than average. Our cutting wood in these blocks inside tends to harden up a good bit earlier Therefore, we can get into the blocks earlier in the season than would be possible otherwise We like the idea of mowing rather than cultivating I think it is a toss-up as far as cost goes, providing the plants are arranged at the time of planting so they can be mowed.

I said orginally we had planted our stock plants eight feet apart. Now we have switched around and said we are going to leave our rows between these plants eight feet apart and we are going to somewhat crowd those plants in the row The reason for that being that we find we can get a great many more cuttings per square foot of allocated area if we squeeze these plants until finally we come up with a thing almost like a hedge We are finding in this way it results in mature multi-stem plants that are completely interlaced. Therefore, you may take a cutting off here, which is in effect attached to a root system well down the row. We do not think that is deleterious in any way Being in hedge form it facilitates the application of insecticides and fungicides It lends itself specifically to the banding method of fertilizer application along the base of the stock plants. This sod enables us to get in there in the winter months since it is cleaner and easier to walk upon than a cleanly cultivated place would be

One of the factors that has not been covered on this stock block proposition versus the taking of cuttings from the sale plant, is this matter of genetic stability. We all know some plants are relatively stable while others like euonymous are unstable They mutate while you are watching them Therefore, the forms don't tend to stay the same. Certainly in that case it would be an advantage to selectively take your cuttings from your tiny plants which are in the sale blocks in order to achieve uniformity. *Taxus densiformis,* which we regard as an entirely stable plant, will lend itself to stock block culture in order to achieve this unformity.

Before I conclude and open this session up for questions, I would like to add that personally I feel there is a great need for basic research in this general area of timing. Research is needed to find out a method of determining when the physiological condition of the plant is right that the cutting material from it will root readily. I have always felt there is a great misconception in this ocult art of propagation which says it is the administration of the individual propagator that makes that cutting root. Yet, all of us have had the experience of dropping a cutting under the bench where the condition is surely not one that we would deliberately provide, and that cutting rooted handsomely We have also seen crops that despite our effort to maintain an optimum bench and house environment that have failed Therefore, I can't help but think that perhaps the success or failure of an individual propagation lot is dependent far more upon the physiological condition of that plant right at the time the cutting is taken than it is by the handling we give it afterward, within relatively broad limits. I don't know how that can be sorted out.

I understand there have been papers that attempted to relate this basic "rootability" to the carbohydrate-nitrogen ratio. There was just no way that a straight-line relationship could be plotted Perhaps it is in this X factor that Charlie Hess talked about last year and I hope before this meeting is over he will give us a little more on these hidden factors, which I am sure are nowhere near sufficiently understood Are there any questions?

MR. HOOGENDOORN: I would like to direct my question to Dick Vanderbilt. Do you find that you get quicker rooting and better rooting out of second flush than first flush growth?

MR VANDERBILT· It doesn't seem to make too much difference, Case.

MR DON HARTMAN: My question is to Steve O'Rourke. You made reference to viruses. Were you speaking of this just in regard to fruit trees or are you doing some work also in ornamntals?

PROFESSOR O'ROURKE: We know more about viruses in fruit trees because indexing procedures have been carried out to a much greater degree. However, viruses are breaking out in all types of plants, including ornamentals The determination of the symptoms and indexing techniques are not advanced to a stage, however, as it is with fruit trees.

MR. HARTMAN Are they doing any work to find which ornamentals are virus infected?

PROFESSOR O'ROURKE: I believe there are some pathologists working with ornamentals but I am not familiar with the exact ones.

MR. VERKADE· On your rhododendron stock blocks of such difficult to root varieties as C. S. Sargent and Dr. Dresselhuys, are you going to be able to root cuttings off, say seven, eight or nine year old plants?

MR. VANDERBILT: On this juvenility factor, I don't go along with some of it as it applies to rhododendrons. I have taken cuttings from one-year old plants and have had much worse luck than with cuttings from seven or eight-year old plants They seem to do just as well. I don't see any effect of juvenility, but this is just my own opinion.

DR SIDNEY WAXMAN (Storrs, Connecticut): This is directed to Dick Vanderbilt Please give us in a little more detail on how you prevent flower formation in the rhododendron

MR VANDERBILT: It can't always be prevented If it does develop, pinch it out. Very often when the first root is formed, if caught early enough, this could be prevented by spraying with Sequestrene iron chelate, or with Peters fertilizer at a concentration of 30 parts per million nitrogen. If this doesn't work you could also pinch out any flower bud that did develop and this would usually start to grow again provided that the plants were fertilized early.

MODERATOR HILL: If I understand his response it is, concerned with upsetting the C-N ratio which would prevent flower bud formation.

MR RICHARD FILLMORE: Mr. Moderator, first of all, I would like to make a comment. You may recall that some years ago we had a banquet speaker who mentioned the work of Dr. Van Slogteren in Holland, who has worked out serological techniques for the determination of viruses in bulbous plant materials Now, very briefly, they inoculate horses for certain types of plant virus organisms and subsequently remove blood from the horse, purify it in some sort of serum and by introducing this serum into a certain reactive plant, they can tell immediately whether or not that particular bulb is diseased by virus Now the plant indexing technique of picking up these things by plant responses, in particularly susceptible plants is exceedingly slow and laborious. I think this line of Van Slogteren's if it could be more widely supplied and more broadly supported, although it might take three scientists and ten technicians a long time, and cost a lot of money, holds much for the future

I want to ask Richard Vanderbilt this question. Do I understand that if one repeatedly takes small leaf cuttings from a well-recognized clone of rhododendron, such as *Rhododendron roseum elegans*, that the size of leaves on a finished plant will be reduced so the plant is almost unrecognizable, let's say after five or ten vegetative generations of this sort of procedure?

MR VANDERBILT: Not quite. With a small leaf cutting from a mature plant you shouldn't have any trouble. It should go on and develop normally

MR. WILLIAM COLE (Painesville, Ohio): A question to Louie Vanderbrook On the economics of the stock block, I wondered about your argument of being able to take more cuttings more quickly to supply your needs Do you think that the extra time it would take to collect your cuttings from the nursery rows would offset the initial cost and capital outlay for the stock block?

MR. VANDERBROOK: There are two angles It isn't just the capital or cost alone. Sometimes the blocks you are growing on for sale do not produce as many cuttings as are produced off the stock block. That is one of the reasons for the stock blocks. For instance, in one block we set up we had approximately three hundred *Taxus densiformis* plants set out From those three hundred plants we got an average of 20,000 cuttings. You are not going to get that from the finished block containing the same number because you are going to sell them.

MR COLE: Unless you are selling a rooted cutting you are not going to be growing that many plants anyway. Say, for a two-year old plant, if you take one cutting, you can still match your number.

MR VANDERBROOK: You gain in cutting material and make room for expansion. You can get into the lining-out stock market

MODERATOR HILL: I don't think there is time for more questions. I think the panel members have done an excellent job.

Our next discussion is going to be on "Mulching Materials and Methods of Application." Dave Dugan is the Moderator for this group, and I am going to turn it over to him.

Mr. David R Dugan, Dugan Nursery Company, Perry, Ohio. took the chair

MODERATOR DUGAN: Thank you, Jack The panel, as you see by your program, consists of Harvey Gray, Case Hoogendoorn, and Dr. Miller.

We will start with Harvey Gray who will give us the basic facts on just what mulching is We will then let the other two members fill in, both with practical and research facts, to build this subject up If they don't answer the questions, I am going to take the liberty of calling on the audience for some of their experiences so we can have this thing pretty well thrashed out in an hour's time. Harvey, if you will start the discussion, please

MR. HARVEY GRAY (Farmingdale, New York): Anything I have to say relative to mulches will be geared to the plantsman as a propagator and will cover such areas as seed in the seed bed, seedlings, transplants, rooted cuttings, grafts, and comparable material that will be in the bed for one to three years and maybe a little longer. My thinking does not include at this time the areas of stock blocks, if you will, or material in the field that may or may not be mulched. I believe our Society is and should concern itself primarily with plant propagation rather than nursery operations and management, and so I will confine my remarks to the plant propagator rather than to the nurseryman.

Mulches, what are they? I think if we would check on a good source of printed information, the Brooklyn Botanical Garden a few years ago did an excellent job on a publication in which a dozen or maybe two dozen authorities presented their ideas relative to mulches I note that mulches may include a dust mulch for those who are interested in rock gardens for rock plantings. There are pebbles and stone mulches. In the mineral type of mulch, then, we jump a considerable distance from the dust and pebbles and stones, to aluminum foil. As long as we are on the sheet material such as aluminum foil we go to plastic films and paper sheets, such as the pineapple grower uses. There are mulches of shredded paper, paper mache, all sorts and kinds of paper scrap, organics, waste products of agriculture or agricultural processing, corn cobs, brush, wheat hulls, wood chips from the chipper of the tree operator to the wood chips of industry in the mills and millworking, sawdust, and you go on and on to name as many more as I have already named. As a result we have a terrific variation and number of materials that could be used as mulches.

Now with that in mind, let's jump to the next point I have in mind, and that is, what can we expect these mulches to do? Well, I would say they will control weeds when properly and timely applied. They will control water when this is a factor or feature that we need to concentrate on, and they have a controlling action on soil temperatures. All of these things we find are important as far as transplant beds, and seed beds are concerned

Now we will move on to the location of our beds in relation to the soil. Whatever our objective may be as far as weed control, water control, and temperature control is concerned we have a decision here as to whether we should or should not use a mulch, because there may be certain detrimental effects connected with its use. Take, for instance, if you would mulch on a heavy clay soil, right away you are pretty apt to be in difficulty. I can recall a young chap who was advised to mulch with crushed corn cobs on an area because his rhododendrons were doing poorly. He made this application of crushed corn cobs to a bottomland clay soil. Well he had more problems after he applied the mulch than before he applied it. In fact. what he should have done, was lifted the plants out and gotten them out of that area because they were drowning.

On the other hand, we have soils which are light in texture. Here we find that mulching can be helpful, and we may or may not make an application So we have, then, these different kinds of materials that we could work with. We recognize what they are used for, ie, weed control, soil water control and soil temperature control We recognize that soil type has an important part to play here

Then we have another point, and that is the location of these beds in relation to the light intensity. When we have our beds in full sun we have a different situation than when we have it in the shade. When they are in the full sun I raise the question as to whether we should or should not make an application of a mulch. Reasoning this through I would say we ought to take a look at the top and root portions of the plant. Are the plants small leaved or possibly narrow leaved? Do the plants have a deep penetrating root or do they have a very shallow, fibrous root system? Now if the plant has a small or narrow leaf and the root system tends to go down, I believe the place for your plants is in the full sun, as soon as you can get them there. Why? Because in full sun, photosynthetic action has a great part to play in affecting the C-N ratio. The C-N ratio has to do with the amount of combined carbon, that is your cellulose and comparable or allied materials, proportioned against that of the combined nitrogen, with the interplay of proteins and amino acids Now in the full sun, the plant through photosynthesis will manufacture an abundance of carbohydrate, as Dick Vanderbilt pointed out, with all other things being equal But they will produce a large amount of energizing food, that is, the carbon end of the C-N ratio business. So in the full sun we are going to get a large amount of food manufactured where if we were to cut the light we would also cut the amount of food that is produced, bearing in mind that we must have a favorable balance of phosphorus, nitrogen and phosphoric acid Minor and trace elements also should be given due consideration and adjusted in the full sun.

Why is it, then, that we are making this application of a mulch? Are we putting it on for weed control, water control, or temperature control? Quite likely it is for weed control to an extent If it is in beds of the sort I have described then aren't we failing to consider the use of materials such as methyl bromide. Vapam, and comparable materials? I am not including in this particular area materials such as Simazine or CIPC but those materials that will serve as a nematocide when applied in the proper amounts. I think that we can make use of this type of material rather than controlling our weeds with mulches.

But if it is a temperature control such as was pointed out yesterday in relation to that physiological breakdown at the soil line with taxus cuttings, might not mulches be the answer to that problem?

If it is water, that is your problem, how in the world can you grow a good crop of plants without irrigation, so what do you need the mulch for?

If, however, you do lean toward the use of mulches, let's take a closer look at some of these materials that have already been suggested. I believe that we should recognize resiliency in our material so that it will not mat down. I believe that we should recognize in material that we choose to use a non-water absorbing material. This will rule out such materials as sawdust and peat moss, because they surely will pick up a terrific amount of water. This invites the roots to grow in the mulch where it is your intention they grow in the medium which has been prepared below for them. So rather than using such materials as peat moss and sawdust, I would suggest the consideration of salt marsh hay, wood chips and shredded sugarcane. These materials possibly should be used over some of the other materials that have been suggested I think it is most important in the case where the plants are in the sun that we should avoid soil-like materials, such as peat and sawdust, because it does invite the roots to go into the mulch rather than into the medium below.

I prefer to put my plants, and I ask you to consider putting your plants in migrating shade, where one minute the shade is in such a spot and a few minutes later the sun creeps in and the shade moves on. This, I believe, gives your plants a better chance to manufacture this food than they would if they were in full sun, but still you are getting the benefit of reduced water losses and a better control of temperatures. Here are the type of plants I would put in such a migrating shade. It would be those that suffer for the sake of a better term, "cook-out." "Cook-out" sounds like a Boy Scout or Girl Scout phrase. That is not what I am talking about. I am talking about plants that are large leafed with fibrous roots If you place a large leafed fibrous rooted cutting or seedling in the full sun you are going to have "cook-out." The temperatures are going to raise havoc with the water loss, both by transpiration and evaporation. So we should see to it that our plants are protected from this rapid loss of water. Migrating shade will do the job better than mulching in the full sun We also get good control over temperature with migrating shade We get good control over water. Our beds would be sterilized with methyl bromide or Vapam rather than mulched. However, if you were to mulch, because you failed to practice weed control, a lighter mulch will do the job, if it were in the full sun. I don't know why, but this is my observation over a number of years. I find when I use wood chips I can get away with not much more than a half inch layer of wood chips. These wood chips, of course, come from a mill rather than from the chipper that the brush clean-up fellow use These chips are of a size like nickels, dimes and quarters, laid down just like so many little plates. This will do a wonderful job of weed control

MODERATOR DUGAN. Thank you, Harvey. We will pass now to Mr. Case Hoogendoorn for his comments

MR. CASE HOOGENDOORN: Now you just heard the technical side of mulching What I am going to give you is just my own experience, which of course is purely commercial. I have already found out that Harvey and I are on opposite sides of the fence

Mr. Hoogendoorn presented his paper on mulching materials and methods of application. He supplemented his discussion with demonstrations of plant materials grown under this system of culture.

USE OF MULCHES IN THE NURSERY

CASE HOOGENDOORN
Hoogendoorn Nurseries
Newport, Rhode Island

Since we do a lot of propagating, we had the same trouble everyone else has and that is to keep ahead of the weeds in the beds. This is usually all handwork, which is costly and consumes a lot of time.

Before we began to use a mulch, the soil in these beds, consisting of a heavy loam, was very hard in the spring, after the heavy winter rains and quick drying spring winds. Trying to break up that soil in the spring with a scratcher was slow work and was hard on the wrist, which has bothered me for years. So I started to look around for a better method to control these weeds and the hard soil condition After looking around I started to eliminate various mulch materials for one reason or another.

I had seen the sawdust used, which I thought had disastrous results. It broke down too fast, robbing the soil of nitrate nitrogen As a result the plants turned yellow and needed constant feeding with nitrat. For that same reason I did not dare to use wood chips, chopped straw or hay. Then we come to peat moss. That looked alright to me at first, but after analyzing the results, I eliminated that also, for these ting or seedling in the full sun you are going to have "cook-out." The temperatures are going to raise havoc with the water loss, both by transpiration and evaporation. So we should see to it that our plants are protected from this rapid loss of water. Migrating shade will do the job better than mulching in the full sun We also get good control over temperature with migrating shade We get good control over water. Our beds would be sterilized with methyl bromide or Vapam rather than mulched. However, if you were to mulch, because you failed to practice weed control, a lighter mulch will do the job, if it were in the full sun. I don't know why, but this is my observation over a number of years. I find when I use wood chips I can get away with not much more than a half inch layer of wood chips. These wood chips, of course, come from a mill rather than from the chipper that the brush clean-up fellow use These chips are of a size like nickels, dimes and quarters, laid down just like so many little plates. This will do a wonderful job of weed control

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I had seen the sawdust used, which I thought had disastrous results. It broke down too fast, robbing the soil of nitrate nitrogen As a result the plants turned yellow and needed constant feeding with nitrat. For that same reason I did not dare to use wood chips, chopped straw or hay. Then we come to peat moss. That looked alright to me at first, but after analyzing the results, I eliminated that also, for these reasons: in the first place, it is rather expensive, and in the second place, just as soon as you get some wind or dry weather it dries out and blows around to a certain extent. A bed, which has been planted to cuttings or seedlings is never perfectly level. Now what happens? If you water these beds with overhead irrigation sprinklers, or you get heavy rains, your peat moss will float to the lowest places in the bed The result of this is that the higher areas in your bed have no peat moss, while in the lower areas the peat moss will bury the seedlings or cuttings. I also found that when the peat moss gets dry, it does not help to maintain the desired moisture content in the soil. This eliminated peat moss for me.

Then I started experimenting with sugar cane (also called Servall) This appealed to me since cane is pressed flat and would have no tendency to roll or blow around Not knowing what this material would do to the plants, we started to experiment and used it under two shades of every item we had in the beds, in other words, two shades of yews, two shades of junipers, etc. Our beds are 5¾ feet wide and we use lath shades which are 4 feet wide and 6 feet long. We then watched it for a year, especially since small rhododendrons, azaleas and pieris are very sensitive. If there was anything wrong with this sugar cane, these items would be the first to show it

Everytime we examined this sugar cane, we noticed that the soil never baked but remained nice and loose, and, at the same time, there was always moisture in the soil and only a few weeds. Every item had a good color, even the rhododendrons and azaleas After a year we examined the sugar cane. It looked darker than it did originally, it was weather beaten, and it had settled some, but it had not deteriorated to any extent. As far as I was concerned, the results were very satisfactory. Ever since then we have used sugar cane on everything we planted in beds.

Now to the application of the sugar cane mulch, which I think is important. This sugar cane comes in bales 24 x 24 x 20 inches and is hard, machine pressed being held together by 3 wires much like a bale or peat moss. We take a hatchet to snap the wires and break up the bale with a spade or hatchet into 3 or 4 lumps and throw it in a corn cutter with a blower, which is belt driven from the power take off a tractor. We generally chop up 100 or 150 bales at a time which takes only a few hours with 4 or 5 men. After it is passed through the corn cutter and blower in a big pile, it is thoroughly broken up, fluffy and ready for use. All we have to do now is back a truck up, load it and take it to wherever we are planting.

If we are mulching evergreen cuttings we put it on about 1 or 1¼ inches deep. In larger cuttings, like Magnolias or cherries, and Red Japanese maple grafts, beech grafts, etc we put it on about 1½ inch deep. In small cuttings and seedlings we use maybe one half inch or even less. Now, of course, this does not eliminate weeds 100 per cent, but we get from 50 to 75 per cent control, depending on how thick or thin we can apply it. We feel that we save a tremendous amount of hand weeding as we have 8 or 9 acres in beds alone. In fact, I just counted the beds and came up with 195 beds, 6 feet wide and averaging 200 feet long, which requires a lot of handwork to keep free of weeds. Weeding these sugar cane beds is much easier on the fingers and scratchers as well as being much faster.

When we plant small cuttings and seedlings in the early summer, and can only apply a small amount of sugar cane, we add to it in the fall after they have made some growth and the plants are a little larger. When we put this sugar cane in the beds, we take it off the truck in wheelbarrows, big planting boxes, or bushel baskets and just throw it around on the beds by big double handfuls. It naturally falls very uneven. Then we cut some wild cherry branches with the leaves on and use these as brooms to brush out the sugar cane evenly. Another important factor about sugar cane is that it does not mat like chopped straw or hay and therefore gives you excellent aeration, as it allows water through very easily.

Now a word of caution, don't try to go after 100 per cent weed control by putting the mulch on three or four inches thick or more as that will have disastrous results. We also discovered since we used a mulch that we have a better root system. By having a looser soil which has a better moisture content, we produce a lot of white, soft feeder roots near the surface of the soil giving us a plant which responds quicker after transplanting. We have also learned another advantage about the use of a mulch. Years ago we used to transplant seedlings in September, but it never was advisable to transplant seedlings later than that. If we planted later, the plants would partly heave or heave out altogether, resulting in poor stands. Of course, you realize that I am talking about our New England conditions.

Since we started to use this sugar cane mulch, we can plant anytime during the fall, even in November, as long as the ground is in good shape. We use eight inch boards around the beds and then mulch the cuttings or seedlings. We then put lath shades over the frame and our heaving troubles are eliminated.

Now to sum up the advantages of using a mulch. We control 50 to 75 per cent of the weeds. We maintain a higher moisture content in the soil, and consequently have to do less irrigating. We are getting a better root system. We are getting much better growth as our beds are never buried under weeds. Being able to do a lot of bedding out in the fall, takes that much pressure off the spring planting season. At the same time, fall planted seedlings and cuttings will produce much better growth than spring planted stock.

Now I would like to add one more thing about a mulch we used 25 and 30 years ago, that is, rotted cow manure. We used to plant our beds in the spring and early summer and then top dress them in the late fall with one year old cow manure. That was a wonderful mulch as that would give you excellent growth, beautiful color on the stock and it acted as a fertilizer at the same time. But it too created a weed problem since it resulted in the production of a lot of clover, which is hard to pull, plus the usual chickweed and pigweed, etc. The weeds, being well fed would grow very fast and gave us a battle all summer long. Therefore we eliminated the use of cow manure as a mulching material.

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CHAIRMAN DUGAN: Thank you, Case.

Next we have Dr. Bob Miller from Ohio Agricultural Experiment Station. I don't believe he has as big a bag of tricks as Case has, but as you will see, he has a lot of good practical information.

DR. R. O. MILLER (Wooster, Ohio): Thank you, Dave. What I would like to do is to discuss one point I think touched upon by both of these gentlemen, that is, the fact that mulch materials vary. Not only do they vary in composition, but the effects also vary. I think it is important to put these two considerations together. We have summer mulches and we have winter mulches. The objectives of using a summer mulch are different from the objectives of using a winter mulch. Summer objectives, going over it briefly, are weed control, moisture control, and temperature control.

Research in the nine-year experiments on mulching have shown fairly conclusively that Wooster silt-loam was a heavy soil which contained a great amount of moisture and that mulching has had an effect on that moisture. In dry years the mulched plots yielded better than the unmulched. In years when there was adequate rainfall, the mulched plots were still as good or better than unmulched plots. In years when we had heavy rainfall the yield on the mulched plots might have been down considerably. This shows that over a nine-year period the primary effect on plant growth was an effect on the moisture content of the soil and the amount of moisture available to the plant. Moisture control then is one primary objective of a summer mulch.

Let us look at temperature control since there has been considerable research to show that mulches do affect soil temperatures. Unfortunately, no one is really able as far as I know to say exactly what the effect is. High soil temperatures are temperatures that are bad. but how bad are they? I don't think we know for sure. It certainly is likely to vary with the type of material produced. Lower soil temperatures may contribute to the beneficial effects derived from summer mulches. Summer mulches also add considerably more organic material to the soil which in turn improves soil structure and improves soil fertility. Assuming that we add enough nitrogen to correct this carbon-nitrogen unbalance that we sometimes get by adding easily decompoesd inorganic matter, such as straw, sawdust, and so forth, the net long-term effect of any mulch material will be an increase in soil fertility. This comes about even though the organic material initially ties up nitrogen. This nitrogen, however, does become available in later years. During the first years of the experiment on mulching it was found necessary to add additional nitrogen to mulched grapes. However, in later years, as the accumulated nitrogen and bacteria broke down and became available to the plant, there was a net increase in nitrogen as well as in phosphorus and potassium.

Another thing to think about is the fact that mulching improves soil structure. This was touched on by Mr. Hoogendoorn when he said that the soil is loose. Why is it loose? One reason conceivably is that the mulching materials provide food for bacteria in the soil which acts to aggregate the soil. They build up quite rapidly and the net effect is a gross improvement in soil structure.

I would also like to point out one other possible advantage of a summer mulching, something that I think is generally neglected. It seems to me quite conceivable that summer mulches could also improve soil aeration. How? Certainly, they prevent packing of the surface of the soil, which might increase the amount of oxygen which goes into the soil. They also very definitely could keep the roots in the upper layers of soil which are looser. This might be very definitely an improvement as far as aeration is concerned. Soil aeration is important, and as I say, we don't know just what the effects of mulched material are on this important subject.

Now let's take a look at winter mulches. We have said we need to control weeds, to control moisture, to control soil temperature, perhaps to increase organic matter, to increase fertility and to improve soil structure and increase aeration. The soil, as I see it should have a winter mulch as insulation to protect the soil from alternately freezing and thawing and to prevent plant losses by this process of heaving out.

In plants that have underground storage structures or herbaceous plants which have no above-ground parts during winter, the idea is very definitely to apply a mulch to insulate the soil. This keeps the soil from freezing and thawing, by keeping it in a frozen condition from the time the mulch is applied until the time it is removed.

Now there is only one major objective, as I see it, for a winter mulch, namely for insulation. What materials give you good insulation? First of all, the ideal insulation material is snow. Again, as far as the mulch is concerned, many plants can be grown in containers on top of the ground in other parts of the country that are not as hardy as this part in Ohio. The main reason for this is the fact that snow covers them all winter. This protects them from freezing and thawing and prevents losses in this particular plant. We can't all have snow when we want it. What other materials are good? Let's keep in mind what we want in an insulation material that aren't wet and soggy since they tend to insulate better than materials which are easily wet. The sugar cane as Case pointed out, did not pack, or become wet, and this apparently provided good winter protection. Those who live along the East Coast know that salt hay is available and this also, does not pack and become soggy.

When you get into this part of the country, the good mulching materials available locally are not quite so numerous. Certainly, straw, corn cobs to a lesser extent, and sawdust materials, do become packed during the wintertime. So perhaps this sugar cane might be a pretty good material for this purpose. Personally, I have had no experience with it. Remember, in the wintertime the thing we are after is insulation. For those of you who are thinking about liners, and so forth, in beds, maybe the insulation is a disadvantage, because we are holding the soil heat in the soil and it is not getting above the beds. By the same token, we are keeping the cold air temperature up above the plants and the cold is not penetrating the soil. It is an insulation layer we are providing. I can see where insulation of this type might not be desirable since it might contribute to the winter killing of the above ground parts just above the mulch. Perhaps there may be some questions on that later.

I would like to emphasize the point that I feel quite definitely that the choice of materials is going to depend on whether we are talking about the application of a summer mulch or a winter mulch. Both of these uses have different objectives in mind. Thank you very much.

MODERATOR DUGAN: Thank you, Bob. I was afraid the panel members wouldn't mention our favorite mulch here in Ohio, known as snow. All of you had a demonstration of how that is applied the other day.

I now call for questions from the floor.

MR. LOWENFELS: I think, Mr. Gray, you mentioned one point about erosion. I have a place in our area where we mulch with leaves and it stops soil erosion. I don't think leaves were mentioned, but I am wondering what Mr. Gray thinks about oak leaves?

MR. GRAY: There are some leaves, because they tend to stick and shingle, are objectionable. However, because of the resiliency of oak leaves you have a perfect mulch.

MR. FRED NISBET: I wrote an article for Flower and Garden Magazine a while back on mulches, and I have been flooded with objections, requests, and so forth, from mulch manufacturers ever since. The one that was furthest off-base as far as I was concerned was a cork manufacturing outfit, who wanted to know if I had ever used cork for a mulch, and wanted to know if I would try it. I said I would. They wanted to know the specifications the material should have. I said a quarter to three-quarters of an inch for particle size and less than two per cent fines. Has anyone here ever used cork for mulch and do you agree with the sizes I set up? Would this be about right, or should I change the specifications?

MR. GRAY: Just a comment. I would say your three-quarter inch is a little bit large, maybe a quarter to a half inch would be better.

DR. CHARLES HESS: The only problem I can see, is that the cork might tend to float away.

To enlarge a little bit on the point Bob Miller made, John Creech did some work with azaleas and mulching. He measured the temperature above the ground and at six feet and definitely found that there was an insulating effect from the mulch. As Bob pointed out, the air temperature above the mulched plots was actually colder than the air temperature above the unmulched plots. In other words, the insulation held the cold out from the soil, but it also held the heat that is released from the soil from the top of these plants. In plants which are borderline he actually incurred greater loss from mulched plots than from plots not mulched. As Dick said, there was about five degrees difference.

DR. MILLER: One comment I would like to make along that line. It again depends on your objectives. For perennials growing in the spring, they are interested in getting the plants up and in flower, so they can be dug and sold in a fairly attractive condition. Now early removal of a mulch at that time of the year will let the soil warm up considerably whereas it would stay frozen for a longer period of time if it were mulched.

MR. ROLAND DE WILDE (Bridgeton, New Jersey): As Charlie brought out, we found out 20 years ago that if you use salt hay for azaleas you run into the problem of early frost hazard because the hay insulates the soil and keep the heat from going up around the plant. I am talking now about the type where buds are formed fairly late in the fall, and you can take an awful licking in getting your buds set. If a frost or cold sets in and it gets down to 25, it might even kill the plants and we have had that happen, too. So we don't mulch azaleas any more with that type of material. We do mulch rhododendron. They form their buds much earlier. They stop growing sooner, and the danger of damage to that particular plant is not as great. Otherwise, I think mulches are ideal, as Case said, for weed control.

There is one thing I wanted to ask him. Some years ago when we first got a load of sugar cane we got a brand called Staydry, which is used on Paul Tryon's in South Jersey. I used it also in some areas and I think it was put on sometime in May, without any shade over the azaleas. It promptly killed the whole shooting match and we haven't used it since. I don't know whether or not they were putting some preservative in the stuff at that time. Have you ever run into that? I don't suppose you have or you would have said something about it.

MR. HOOGENDOORN: No, I have been using this material for about ten years. First, I used it on an experimental basis, as I pointed out. I have never had any damaging effect. You may have put it on too thick, trying to get 100 per cent weed control. As I said, that is a very important point.

MR. DE WILDE: Maybe that was too thick, and I was two weeks late in applying it. I used it mostly because it is easier to put on and easier to get comparative results with the material.

CHAIRMAN DUGAN: I am sorry, we have to cut this off, but our time is up. Thank you very much, panel.

Mr. Hill resumed the chair.

MODERATOR HILL: Thank you very much, Dave, and the entire panel for your discussion on mulches.

I am sure none of us want to miss one word of this talk we now have coming up. Your inimitable Dr. Charles Hess is going to talk to us here about this "X" factor that I named earlier. We can certainly depend upon Charlie to be searching, provocative and erudite. Charlie!

Dr. Charles Hess discussed the work he is doing on the identification of auxin systems responsible for rooting of cuttings.

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RESEARCH IN ROOT INITIATION — A Progress Report

Charles E. Hess
Purdue University
Lafayette, Indiana

As many of you will remember from last year's talk (2), we are attempting to establish chemical differences between easy-to-root and difficult-to-root cuttings. One of the plants we are working with is *Hibiscus Rosa-sinensis.* The red flowering form of this plant is easy to root and the white form is difficult to root. In addition we have a third variety which is intermediate in its ability to root. By extracting the tissue of the three forms of *Hibiscus* we find four separate root promoting substances in the red *Hibiscus,* three root promoting substances in the *Hibiscus* which is intermediate in its rooting ability, and two in the difficult-to-root *Hibiscus.* In other words, a correlation exists between the number and the amount of root promoting substances we can extract and the rooting ability of the cutting — the easier a cutting is to root, the more root promoting substances can be extracted. The root promoting substances are not related to indoleacetic acid (IAA), the natural plant auxin, but interestingly enough, they require the presence of IAA for maximum activity.

The major effort in the present *Hibiscus* research is to isolate the root promoting substances in pure form and identify them. This is a very formidable problem because plant tissues contain many thousands of substances and at times I feel our extracts must contain all of them. However, progress is being made and we now know some of the physical characteristics of the root promoting substances. They are soluble in water and in methyl and ethyl alcohol. They appear to be insoluble, as a group, in chloroform and ether. The root promoting substances are thermostable; that is, they can be exposed to high temperatures (in this case 250° F. at 15 p.s.i. for 20 min.) and still remain active. The thermostability information provides an indication that the substances are quite stable, at least in a semi-purified condition. This is encouraging information because it means that we can work with the rooting substances at room temperature without the fear that they will break down into other substances which probably would not be active. Finally, the root promoting substances are nondiolytic. This property is determined by placing the substances in a cellophane bag which is sealed. The bag is next surrounded with a solvent such as water. Substances of small molecular size pass through cellophane membrane into the surrounding water. Substances of large molecular size stay within the cellophane bag. It turns out that the root promoting substances all stayed within the bag. Although this indicates the substances are of large molecular size, the possibility exists that the root promoting substances are attached to a large molecule and this prevented their escape from the bag or that the substances absorbed to the inside surface of the bag. You can see from this example that in research you very seldom get clear cut answers. Instead you find indications which lead to other experiments which in turn provide more indications and other experiments and so it goes until you finally have enough evidence accumulated to make a valid conclusion.

Now I would like to describe some of the work we have been doing with *Hedera helix,* the English Ivy. *Hedera* is an ideal species for studying root initiation. Both the easy-to-root juvenile form and the difficut-to-root mature form can be found on the same plant. The juvenile condition is characterized by a horizontal growth, and as you know, is used as a ground cover. The leaves are lobed, the stems are often reddish, and grow rapidly. The mature form, in contrast, grows upright, has entire leaves, the stems are usually green, and growth is slow. The best indication of maturity is that when plants reach this stage of growth, they are capable of flowering. However, the particular difference in which we are interested is rooting ability. The juvenile form, which will initiate aerial roots, can be rooted at almost any time of the year with nearly 100% success. The best we have been able to do with the mature cuttings, up to this year, has been 16% rooting with an average of 2 roots per cutting. So you can see there is a tremendous difference in the rooting ability of the 2 forms, and yet we are sure that the tissues are genetically similar, if not identical.

Many other, if not all plants have a juvenile phase of growth. The juvenile form of *Euonymus coloratus,* for example, has leaves which color to a dark purple-red in the winter. The leaves on the mature form, which will develop if the plant is allowed to grow up a support, do not "color" nearly as well as the juvenile form. The best way to detect the male form, as with the *Hedera,* is to check for evidences of flowering.

The beech expresses its juvenility in a little different way. Young seedlings in the juvenile stage of growth retain their leaves well into winter. Mature plants lose most of their leaves early in the season. However, in many cases, the base of a mature tree will retain its leaves. The reason is that this portion of the tree remains physiologically juvenile. If scions are taken from this area, the plants will be juvenile. If scions are taken from the upper portions of the tree they will be mature and will lose their leaves early in the season.

Mature apple trees also are physiologically juvenile at the base. If an apple tree is girdled or heavily pruned, shoots will arise from or near the base of the plant. These shoots are physiologically juvenile and because of their rapid growth are called water sprouts. Conifers also go through a juvenile phase of growth. In the juniper the young seedlings have needles, and as the plants become mature, the needles are reduced to scale-like leaves. Conifers provide a particularly good example of the relationship between juvenility and rooting ability. If cuttings are taken from young seedlings of pine or spruce, they are relatively easy to root. As the plants mature, propagation by cuttings becomes increasingly more difficult, until finally, they are classified as being "impossible to root."

You can see, therefore, from the few examples that I have given, the phenomenon of juvenility can be found in a wide range of plant material, and that when plants are in the juvenile stage of growth they are easier to root. As I reported last year, we found that the juvenile *Hedera helix* contains more root promoting substances than does the mature *Hedera*. Since then we have found that the juvenile *Hedera* extracts contain four individual root promoting substances which are similar to, but not exactly the same as those extracted from the *Hibiscus*.

With this background, the widespread phenomenon of juvenility, the association of juvenility with rooting ability, and the fact that the juvenile tissue contains more root promoting substances than does the mature, we became interested in the possibility of rejuvenating a mature plant. If this were possible we could obtain a better understanding of the mechanisms which control the expression of juvenility and maturity. With this knowledge it might be possible to prolong the period of juvenility for the benefit of the propagator or hasten maturity for the benefit of the plant breeder. The experiment was conducted by grafting scions of mature *Hedera* on established juvenile understock. Scions bearing fruit were selected so as to be sure the scions were physiologically mature. The fruit was cut off prior to grafting. Grafting was done in March, 1960. The sequence of growth following union formation is shown diagramatically in figure 1. After the union had formed, all juvenile growth was removed. The first new growth from the scion was morphologically mature — i.e. the leaves were entire and the shoots were upright. This first spurt of growth was probably already differentiated in the bud at the time the scion was taken. Shortly after the first spurt of growth was completed, new growth developed which was morphologically juvenile. The leaves were lobed and the shoot was horizontal. The mature tissue therefore had been rejuvenated. Doorenbos (1) and Stoutemyer (4) have reported that cuttings taken from the rejuvenated growth was easy-to-root. However, our grafts did not stop at the rejuvenated stage. After a period of approxi-

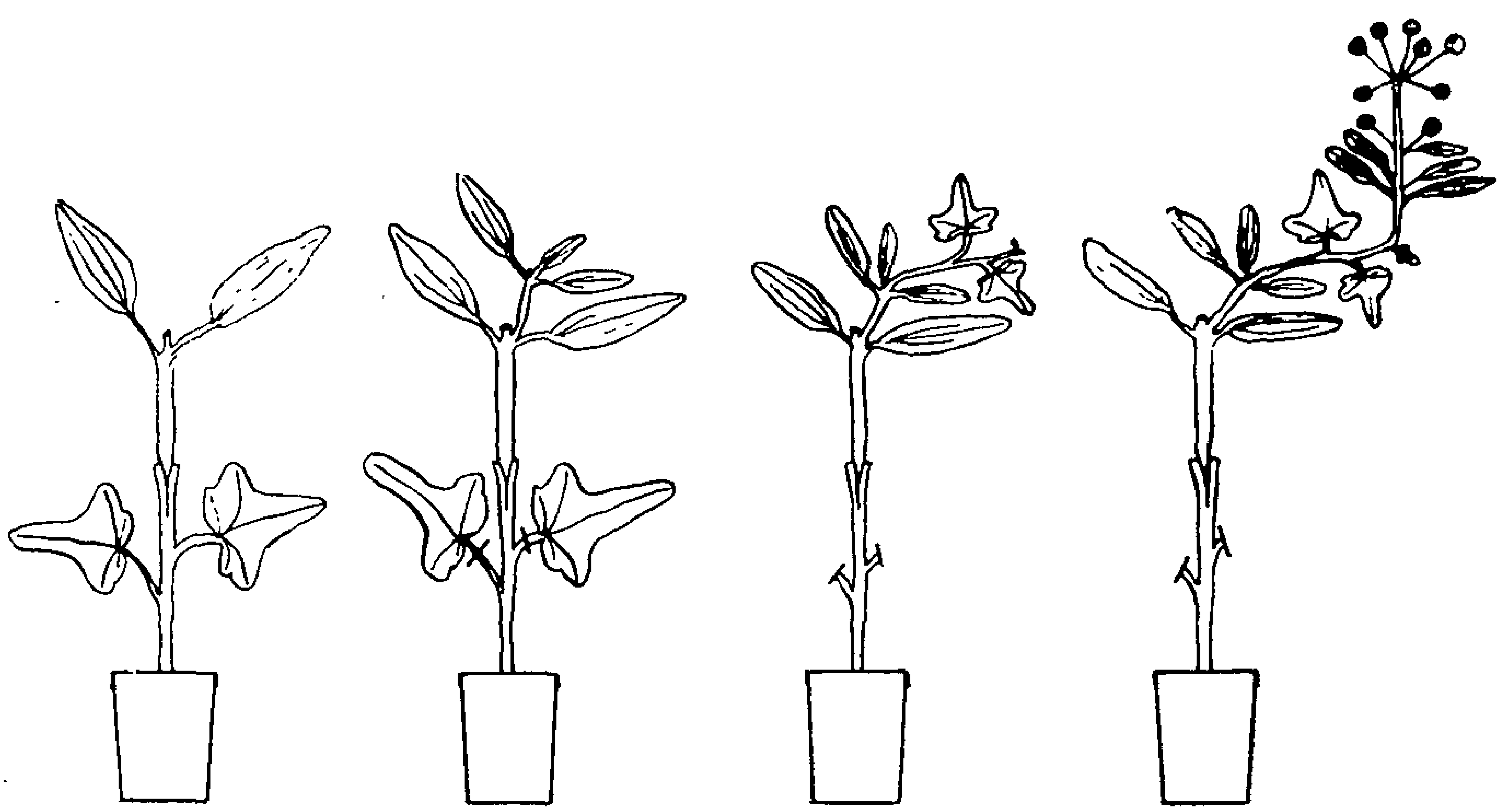

Figure 1.—Induction Of Juvenility And Reversal To The Mature State

mately 4 weeks of juvenile growth the shoots reverted back to a morphologically mature condition. Not only did the leaves become entire and the shoots grow upright, but they also flowered and produced fruit. There was no question about the maturity of the new growth.

Now that our scions had produced growth that went the full cycle from mature to juvenile, back to mature, we wanted to see how the final mature growth would root. We took cuttings and also tissue samples for extraction. The original mature growth, if used as cuttings rather than scions, rooted at 16% with an average of 2 roots per cutting. When cuttings were taken from the "reverted" mature shoots we obtained 96% rooting with an average of 17 roots per cutting. So, although the tissue was morphologically mature, the cuttings rooted nearly as well as juvenile cuttings (juvenile cuttings taken at the same time rooted 100% with an average of 30 roots per cuttings). When we analyzed the extracts from the "easy-to-root" manure shoots, we found four cofactors, identical with those present in juvenile tissue. However, the amount of each cofactor present in the "reverted" mature tissue was less

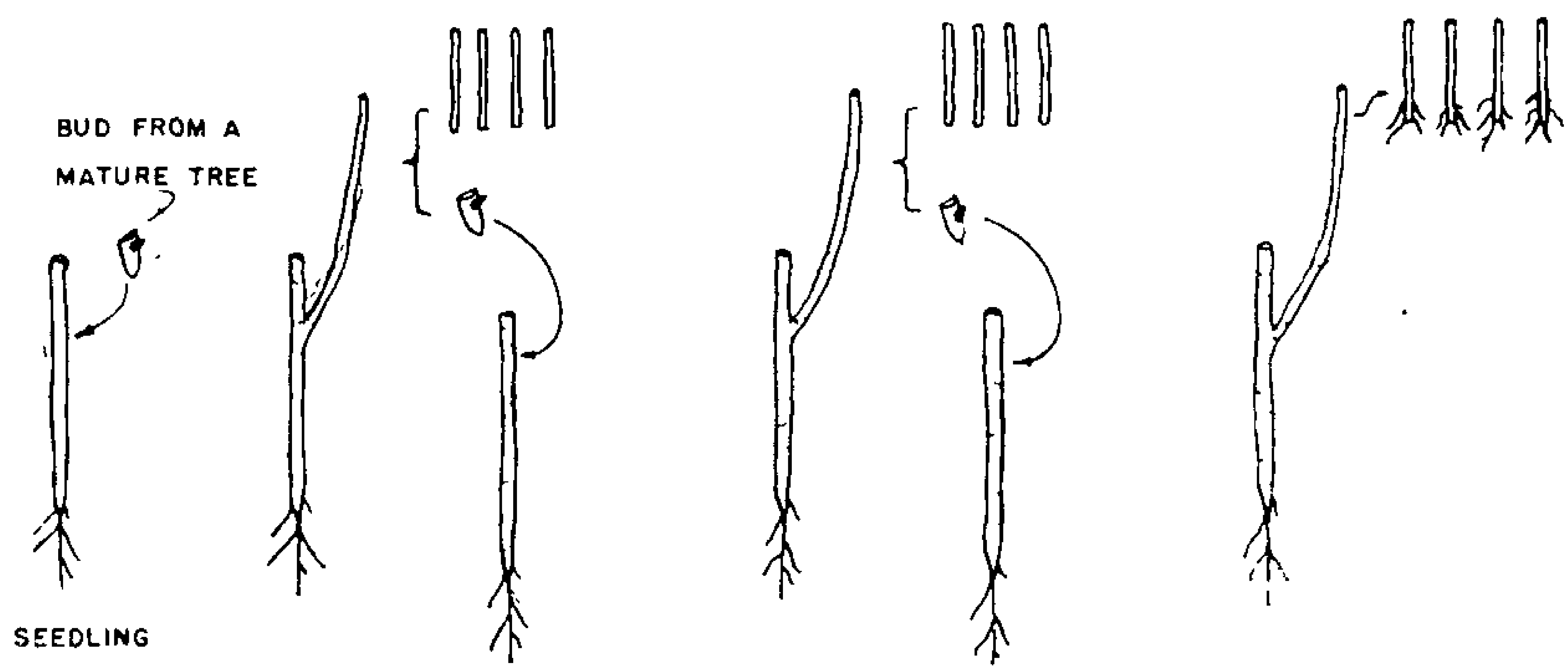

Figure 2.—Accumulation Of Rooting Abiilty By Budding On Seedlings

than that in the juvenile tissue. So, once again, we have a correlation between rooting ability and the presence of root promoting substances. The mature cuttings before grafting were difficult-to-root and contained little or no root promoting substance, after grafting the "reverted" mature tissue was relatively easy-to-root and contained all 4 root promoting substances although in a reduced amount when compared to juvenile tissue. Another conclusion can be drawn from these experiments — although juvenility and rooting are very closely associated, they are not necessarily controlled by the same mechanisms, since the morphologically and physiologically mature, flowering shoots were easy-to-root. If the same substances are involved in the rooting and juvenility, then the assumption may be made that a higher level of these substances is required for the expression of juvenility as compared to rooting ability.

Figure 2 shows that the transfer of rooting ability from a juvenile stock to a mature scion or bud does not necessarily occur in one operation as it did with *Hedera*. In this case Muzik (3) budded mature form of *Hevea*, rubber tree, on *Hevea* seedlings. When new growth was produced by the mature bud, cuttings were taken and also a bud was taken from the new growth and was budded on another seedling. The cuttings taken from the first budding operation failed to root. When the second budding produced growth, cuttings were taken and again a bud was budded onto a third seedling. The cuttings from the second budding operation also failed to root. When the third budding produced growth, cuttings and buds were taken again. The cuttings still did not root. But when cuttings were taken from the fourth budding operation 30% rooting was obtained. The results of this experiment indicate a gradual accumulation of root promoting substances and that it was not until the fourth budding that the level was high enough to stimulate rooting. In this case there was no apparent morphological change to the juvenile condition. The *Hevea* experiment is similar, in a sense, to the example I gave previously about conifers. Of course, with conifers the rooting ability gradually decreases as the plant matures. I bring this point up again for consideration when deciding to establish a stock block. Careful records should be maintained so that any trends in rooting ability would be immediately apparent. If there is an apparent "maturation effect," the stock block may be rejuvenated by severe pruning which forces shoots from or near the base of the plant, which as I have pointed out, often remains physiologically juvenile.

In summary, we are continuing to work on the identification of the four root promoting substances extracted from *Hibiscus* and *Hedera*. Realizing that as many plants grow from the juvenile, seedling stage to maturity, there is a gradual decrease in rooting ability, we attempted to rejuvenate mature scions of *Hedera* by grafting on juvenile understock. Rejuvenation was obtained, but the shoots reverted back to the mature form. However, the "reverted" mature growth was now almost as easy to root as juvenile cuttings. Analysis of the extracts from the juvenile and mature tissues showed that the "reverted" mature tissue contained almost the same amount of root promoting substances as did the juvenile tissue.

I would like to mention one other area of research that was stimulated by last year's question box, relative to the identity of Chloromone. After a comprehensive study using paper chromatography, *Avena* coleoptile straight growth and mung bean rooting assays, and ultraviolet spectral analysis, we concluded that the principal auxin in Chloromone was naphthaleneacetic acid. It was present in our sample at a concentration of at least 3 mg/cc (3,000 p.p.m) in an aqueous solution at a pH of 8.2. Thank you very much.

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MODERATOR HILL: That was certainly outstanding, Charlie. I am sure everybody in the audience was impressed with the depth and detail of this type of truly scientific investigation.

We must also recognize that investigations of this kind are best left in the hands of those capable of undertaking them, analyzing them, and we look forward to the day, Charlie, that you will give us a small black box that is readily portable, that we can take with us and take a small piece of juniper cutting, close the door and it will light up either green or red ,saying now or wait another week. Thank you very much.

The session recessed at 12:00 o'clock.

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FRIDAY AFTERNOON SESSION

December 2, 1960

The session convened at 1:30 o'clock, Mr. Hugh Steavenson, Forrest Keeling Nursery, Elsberry, Missouri. presiding.

CHAIRMAN STEAVENSON: Will you panel members please come forward? Constant DeGroot, John Vermeulen, Richard Van Heiningen, Thor Bergh and Rodney Bailey.

Ladies and Gentlemen, we have a program this afternoon composed of very distinguished speakers on the subject of propagation. It is my particular pleasure to give you as our first speaker of the afternoon Mr. Constant DeGroot of Sheridan Nurseries, at Oakville, Ontario, Canada. I know that many of you have had the pleasure and opportunity of seeing Constant's propagation layout at Oakville. He certainly has a nice assortment of plants and he certainly is doing a beautiful job with them.

This afternoon he is going to discuss "Successful Winter Grafting of *Juniperus* varieties on Unrooted Cuttings" — Constant DeGroot.

MR. CONSTANT DE GROOT: Thank you, Hugh. Good afternoon, Fellow Propagators. I would like to report on the small trial which involved the grafting of *Juniperus* on unrooted cuttings, a technique which is not new.

Mr. DeGroot presented his paper on techniques of propagating junipers by means of cutting grafts.

SUCCESSFUL WINTER GRAFTING OF JUNIPER VARIETIES ON UNROOTED CUTTINGS

CONSTANT DEGROOT
Sheridan Nurseries
Oakville, Ontario, Canada

Grafting the genus, *Juniperus* on unrooted cuttings is not new. Some will remember when James Wells talked about it at one of our earlier meetings. It has been tried before on *Juniperus virginiana plumosa* and *hetzi*. I have tried it also, but the results were not very encouraging, perhaps because the know-how was missing.

The most common practice is to graft on potted seedlings of *J. virginiana,* since they are easy to get in large quantities. The result, however, can be very alarming. You may have the misfortune of having the entire crop hit by blight, which results in very heavy losses in the potted understock. Last winter we did not have 50 per cent of our stock fit to graft on. For all the time and land it takes to produce a two year seedling, I have never seen a good ball dug on a juniper that was grafted on *J. virginiana*. Taking these four points into consideration for a ten year period I doubt if the overall stand in the field would be over 50 per cent.

Those varieties grafted on *J. virginiana hetzi* seem to have a better root system, but show some signs of dwarfing, which is not serious. This actually favors the production of a more compact plant. With all these problems and poor luck, it makes one think a little to see if there are any corners that could be cut. As a result we ran a trial grafting on unrooted cuttings of *Juniperus pseudocupressus* which is a fast and tall growing variety. I know from experience it is far easier to root than *J. virginiana hetzi* and has a more fibrous root system than any other variety that I know.

The grafts were made in December, using the common veneer type, which was made in two and three year old wood. One year old wood was not used because it does not root as well as the older wood. These were treated with Seradix powder #3, and stuck in pure sand so that the scion was at a depth of 1/2 inches. They were spaced at a distance of 2 x 1 1/2 inches (which was a little too close; they should have a spacing of 2 x 2 inches which would give them more air). There was a greater percentage rooted on the outside rows than in the center.

When grafting on unrooted understock the scions should be smaller than those used on rooted understock and therefore none of the scions used were over 7 inches long. Since very little sap or nutrients are available, they were covered with polyethylene for thirty days. I don't know if this was beneficial to them or not. Perhaps mist would be of greater advantage. The scions were healthy looking, after removal of the polyethylene, but the understock showed signs of yellowing. All the rooted cutting grafts were potted after 120 days and when planted in the field (table 1), had as much or more roots than those grafted on *Juniperus virginiana*.

Table 1.—Success of cutting grafts of various varities and species of Junipers.

No. Grafts	Species or Variety	No. Planted
26	Canaert	5
26	Sky Rocket	11
26	Silver	12
26	Fairview	12
26	Pyramidal	13
26	Keteleer	15
26	Blauw	16
26	Olympia	16
26	Burk	17
26	Mountbatten	17
26	Blue Mountain	18
26	Hills Dundee	23

*All cuttings were treated #3 Seradix

CHAIRMAN STEAVENSON: Thank you, Constant. We now have time for questions on this subject of grafting on unrooted understock. Bill Flemer.

MR. FLEMER: What is *Juniperus pseudocupressus?*

MR. DE GROOT: I don't know. The original was obtained in 1924 from Henri den Ouden of the Old Farm Nurseries at Boskoop. I asked him if it was *Juniperus virginiana* but he could not tell me the true species at that time.

MR. HOOGENDOORN: Is it something like an Andorra?

MR. DE GROOT: No, if you look at the sample in the exhibit, it is a very tall, fast-growing variety.

MR. DE WILDE: I was going to ask Constant if he ever tried any other varieties for understock, such as *Juniperus horizontalis plumosa* or *Juniperus excelsa stricta?*

MR. DE GROOT: No, I have been making cutting grafts on just this one variety. The root formation is different for other junipers. You can make a good ball on *Juniperus virginiana pseudocupressus.*

MR. ROY NORDINE: This question again is in regard to this understock. We have *Juniperus virginiana pseudocupressus.* Being a *J. virginiana,* I know it won't root very easily. Where did you get the *Juniperus pseudocupressus* and how does it differ from the species, *J. virginiana?* Where did you find this plant?

MR. DE GROOT: We brought it in from Holland originally. If you want to, you can compare this one with the species, *J. virginiana,* and see if it is the same.

MR. MARTIN VAN HOF: Could it be *Junperus virginiana cupressifolia?*

MR. DE GROOT: I don't know *T. v. cupressifolia.*

CHAIRMAN STEAVENSON: Constant, I wasn't clear how much better you thought this understock was than *J. chinensis hetzi.*

MR. DE GROOT: To my knowledge it roots easier than *J. hetzi* or any other variety I know.

CHAIRMAN STEAVENSON: Would *J. hetzi* be as satisfactory otherwise?

MR. DE GROOT: Why I prefer this understock to *J. hetzi* is because of better root formation and resultant ball. *Juniperus chinensis hetzi* has very heavy roots similar to *J. virginiana.*

MR. HOOGENDOORN: One more question, please. Does this plant have a tendency to blight like the red cedar?

MR. DE GROOT: No, we have *Juniperus virginiana canaerti* and *burki* and all the other varieties next to it. Both *canaerti* and *burki* will be destroyed but this variety will stay.

MR. HOOGENDOORN: Does it have seed? If it does, have you tried growing seedlings?

MR. DE GROOT: Yes it does, but we have never collected any.

(*Editor's Note*: Letters from Henk den Ouden of Old Farm Nurseries, Boskoop and Roy Nordine, establish this evergreen to be *Juniperus virginiana pseudocupressus.* Apparently the evergreen is of hybrid origin, which may explain its ability to root easily from cuttings. The exact origin of the plant is unknown, although it was believed to have been importd by Old Farm Nurseries from H. A. Hesse, Baumschulen — Weener, Ems, Germany many years ago.)

CHAIRMAN STEAVENSON: It hasn't been my privilege and pleasure to have had the opportunity of visiting our next speaker's place, but I have always been very impressed with his plant list and his obvious skill as a propagator with many difficult subjects. Now may I present Mr. John Vermeulen, John Vermeulen and Son, Inc., Neshanic Station, New Jersey, who will address us on "Propagation of *Ginkgo biloba* by Cuttings." Mr. Vermeulen!

MR. JOHN VERMEULEN (Neshanic Station, New Jersey): I will start by saying that I don't have much to say and I won't talk very long. This is a new subject and I do think that there are people on the floor that maybe know more about it than I do. I hope we can open the floor up for discussion after I introduce the subject.

Mr. Vermeulen presented his paper on the techniques used at his nursery to propagate ginkgo from cuttings.

PROPAGATION OF GINKGO BILOBA BY CUTTINGS

JOHN VERMEULEN
John Vermeulen and Son
Neshanic Station, New Jersey

When Martin Van Hof asked me last Fall if I could fill in with a paper about the propagation of ginkgos I told him that I would try and explain our experience with this plant. We started with the propagation of male ginkgos about ten years ago, but due to several more important things we were trying out we did not take a serious interest in it until the summer of 1957.

As you all know the ginkgos are readily propagated from seed. In this seedling population you get both female and male trees. These female ginkgos produce a lot of seeds which, when they do drop off in the early fall and are stepped upon, leave a very unpleasant odor. To eliminate this serious problem many nurseries have been grafting or budding the male ginkgo. However, as with many other plants, the question of ease and expense of production arose. If there was an easy method of propagation the male ginkgo could be sold at a more reasonable price and produced in larger quantities.

We, as propagators of small plants, could not think of planting out stock for budding or going to the added expense of grafting. The rooting of cuttings was therefore the solution to this problem. As we only had a very limited access to propagating material, our trials were only on a very small scale the first year. As we had been checking on many more trees in order to determine their sex we increased our trials as we went on. It takes several years for the ginkgo to mature and to bear seed so we had to check older trees for several years to be sure that they were the male form.

In propagating the ginkgos there is also the consideration of the type of tree from which the cutting wood is cut as well as its location and the type of soil in which it is growing. As far as we have been able to find out we think it is the type of tree which makes the difference in the rooting.

This, I think is as far as I can go in telling you about our results. I hope that through questions we all can learn a little more. There are ous skill as a propagator with many difficult subjects. Now may I present Mr. John Vermeulen, John Vermeulen and Son, Inc., Neshanic Station, New Jersey, who will address us on "Propagation of *Ginkgo biloba* by Cuttings." Mr. Vermeulen!

MR. JOHN VERMEULEN (Neshanic Station, New Jersey): I will start by saying that I don't have much to say and I won't talk very long. This is a new subject and I do think that there are people on the floor that maybe know more about it than I do. I hope we can open the floor up for discussion after I introduce the subject.

Mr. Vermeulen presented his paper on the techniques used at his nursery to propagate ginkgo from cuttings.

PROPAGATION OF GINKGO BILOBA BY CUTTINGS

JOHN VERMEULEN
John Vermeulen and Son
Neshanic Station, New Jersey

When Martin Van Hof asked me last Fall if I could fill in with a paper about the propagation of ginkgos I told him that I would try and explain our experience with this plant. We started with the propagation of male ginkgos about ten years ago, but due to several more important things we were trying out we did not take a serious interest in it until the summer of 1957.

As you all know the ginkgos are readily propagated from seed. In this seedling population you get both female and male trees. These female ginkgos produce a lot of seeds which, when they do drop off in the early fall and are stepped upon, leave a very unpleasant odor. To eliminate this serious problem many nurseries have been grafting or budding the male ginkgo. However, as with many other plants, the question of ease and expense of production arose. If there was an easy method of propagation the male ginkgo could be sold at a more reasonable price and produced in larger quantities.

We, as propagators of small plants, could not think of planting out stock for budding or going to the added expense of grafting. The rooting of cuttings was therefore the solution to this problem. As we only had a very limited access to propagating material, our trials were only on a very small scale the first year. As we had been checking on many more trees in order to determine their sex we increased our trials as we went on. It takes several years for the ginkgo to mature and to bear seed so we had to check older trees for several years to be sure that they were the male form.

In propagating the ginkgos there is also the consideration of the type of tree from which the cutting wood is cut as well as its location and the type of soil in which it is growing. As far as we have been able to find out we think it is the type of tree which makes the difference in the rooting.

This, I think is as far as I can go in telling you about our results. I hope that through questions we all can learn a little more. There are many things I would like to find out from others who have been working on this particular plant. Following is a completed record of our results from 1957 through 1960 (tables 1 and 2).

Table 1.—Effect of various rooting compounds on the rooting of male, Ginkgo cuttings.

Number	Treatment	No. Rooted September 4
13*	Hormodin #3	11**
13	IBA 1%	10
13	IBA 2%	10
13	Cut start 7	0
13	Cut start 9	1
13	Cut start 11	8
13	Cut start 13	8

* Cuttings stuck July, 1957
** All cuttings were rooted lightly.

Table 2.—Effect of year, variety and rooting treatment on the rooting of Ginkgo biloba cuttings.

Date Stuck	No Stuck	Type	Treatment	No Rooted	Days	Degree of Rooting
7/29/58	150	Male	Hormodin #3	75	58	Fair
7/21/59	150	*G. Fastigiata*	Hormodin #3	122	55	Fair
7/21/59	80	*G. pyramidalis*	Hormodin #3	7	55	Fair
7/21/59	150	Male	Hormodin #3	69	55	Fair
7/21/59	50	2 yr. wood	Germain	21	55	Fair
7/13/60	315	*G. fastigiata*	Hormodin #3	216	52	Fair
7/13/60	65	*G. pyramidalis*	Hormodin #3	17	52	Fair
7/13/60	16	*G. pyramidalis #2*	Hormodin #3	9	52	Fair
7/13/60	85	Male	Hormodin #3	46	52	Fair
7/13/60	225	Male	Hormodin #3	131	52	Fair

All cuttings which were not rooted in 1958, 1959, and 1960 were put back in the bench and left there until the following summer. All these rooted well. The rank of light means each cutting had two to four roots and those which were ranked as fair had four to seven roots per cutting. One more remark, I think if we would leave all cuttings in the bench until late spring we would get a near perfect stand. However, as we like to turn our stock over as soon as possible, we still take up the stock in September and pot what is rooted and restick the others.

All cuttings were made from the current year's growth which is taken as close to last year's wood as possible. Cuttings were then placed in a mixture of 80 per cent stand and 20 per cent styrofoam which was firmly packed down. This was kept under intermittent mist until the cuttings were rooted.

* * * * * *

CHAIRMAN STEAVENSON: Thank you very much, John. Now do you have questions for John, or would anyone care to comment on the rooting of ginkgo? If so, we would be very happy to have them.

We know some of our West Coast friends are apparently doing a lot along this line on the coast. Maybe they would like to comment on this subject Harvey, John said you might have a few comments on the rooting of the ginkgo.

PRESIDENT TEMPLETON: Yes, we have tried rooting male ginkgo, for the first time about four years ago. We found it was extremely difficult to accumulate any quantity of cuttings. If you go to a big tree and it looks like it has plenty of cuttings on it, when you start looking there are only a darn few there. The only usable cuttings are the terminals. All the rest are borne on little short spurs. If they do root they are not going to grow long. It is a matter of going over the whole tree, which might be 75 feet high and getting a few here and there. To get any quantity from an established tree you would have to cut it back and let it make a lot of new shoots

One year we put in about 6,000 cuttings, one bed of them. We got a good stand. I would guess 4,000 out of the 6,000 rooted. As we do with all our cuttings, we left them there over the winter They rooted in the soil. The next year they didn't grow one bit. The second summer after they had been rooted they grew reasonably well and wound up between 6 and 24 inches in height.

Now that is a little discouraging and I want to ask John what his experience has been with the growth of these rooted cuttings after he gets them rooted. Do they make a satisfactory tree?

MR. VERMEULEN: Whatever we potted did very poorly the first year, as you said. The second year they made fairly good growth. What we potted early last summer did much better than what we potted later in the summer. Those potted six months later are bigger plants than ones potted from summer cuttings.

There was one more thing we have tried The first year we used five different rooting powders We found, however that Hormodin #3 has given us the best results, and we think it is better for everything.

CHAIRMAN STEAVENSON: Are there any more questions?

PRESIDENT TEMPLETON: Yes. I might make another comment on the use of rooting hormones on ginkgo cuttings. We see no beneficial effect, at least if we put on too strong a hormone, such as two per cent indolebutyric acid in alcohol, it simply kills the end of it. If we put Hormodin #3 under our conditions, it often kills the base so we get no rooting. We also made tests with Hormodin #2, which is not too detrimental but certainly showed no benefit. We get just as much rooting from no Hormodin at all.

MR. FRED NISBET: I think the reason we haven't used more ginkgos is the fact that there aren't enough males. Another thing, don't plant them if you have any deer in the vicinity. Whether or not they really brouse on the buds and foliage I am not sure yet. I suspect it, but that makes little difference inasmuch as by rubbing their antlers on the stems they are rubbing right through the cambium and girdling the tree.

CHAIRMAN STEAVENSON: Thank you for your observation. They are propagating a lot of ginkgos out there on the West Coast. Somebody ought to be able to tell us how they are propagating these.

PRESIDENT TEMPLETON: I suppose this is subject to correction by those people on the West Coast who are actually doing it. This is my impression of what they told me. They are grafting ginkgo seedlings in containers, usually in January. That isn't too critical, but they simply make an inverted cleft graft above the soil surface and put them back in the greenhouse. They can also be put out where they can be covered with polyethylene or under shade so the scion doesn't dry up too rapidly. It is easy to get a high percentage with no trouble at all.

MR VERMEULEN: Have you found there is any difference in the type of tree you get your cuttings from? We get different results from different plants. I was wondering if anybody else did

MR. RALPH ZIMMERMAN (Cincinnati, Ohio): We bought some Autumn Gold from the West Coast and also some ginkgo from the Princeton Nurseries. The Autumn Gold roots real well but the Princeton won't root at all. I don't know why, because we used the same kind of cuttings and everything.

CHAIRMAN STEAVENSON: Thank you, Mr. Zimmerman. Autumn Gold is a clone they are working with on the West Coast which has been developed by the Saratoga Horticultural Foundation. It is supposed to be a particularly nice male type, with good yellow autumn foliage and other desirable characteristics. It is available, by the way, in the West Coast nurseries.

.Our next speaker I think is well known to all of you and to nurserymen and nursery groups over the country. I know he supplies a good deal of stock to other nurserymen for redistribution, and it is my particular pleasure to give you Richard Van Heiningen of Van Heiningen Nurseries, Deep River, Connecticut. He will speak on "Winter Propagation in Outside Frames with Electric Cables." Dick Van Heiningen!

Mr. Van Heiningen discussed the procedure he uses to root cuttings in outdoor frames equipped with electric cables.

PROPAGATION IN FRAMES USING ELECTRIC CABLES FOR BOTTOM HEAT

RICHARD VAN HEININGEN
Van Heiningen Nurseries
Deep River, Connecticut

I would like to give you a little history of our propagation method so that you can see how we sort of walked into the electric cable method of propagation

My father, who ran the Evergreen Nursery Company in Wilton, used frames exclusively for the propagation of evergreen cuttings. He was supplied in the wintertime with horse manure, until Bordens and Sheffield Farms turned from horses to trucks. When there was no man-

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My father, who ran the Evergreen Nursery Company in Wilton, used frames exclusively for the propagation of evergreen cuttings. He was supplied in the wintertime with horse manure, until Bordens and Sheffield Farms turned from horses to trucks. When there was no manure available, they continued to propagate in frames but with inadequate bottom heat It was their procedure to make cuttings in the summertime, starting about July

Now this encompassed all sorts of evergreen cuttings that are familiar to you, such as arborvitae, chamaecyparis, taxus, and the junipers. They had rather good success. I think it was to some extent similar to mist propagation, because when the cuttings were once in the frame they were kept nearly airtight by bags placed underneath the sash. The frames were not opened unless it was necessary to syringe them, which was done on a sunny day as many as three times. Cuttings usually did not root, however, until the following spring. They callused nicely before winter, stood still in the winter, and in the spring they would start off usually with roots first, and top growth later. This technique of summer propagation took men away from other work that was very important, and so we tried to do it during the winter with some form of bottom heat, which, as I mentioned before was with manure. When that wasn't available, we tried early spring cuttings in March. When this was done we got top growth and very little root growth until late in the season which usually was not good enough to carry the cuttings over winter.

When I went into business for myself up in Deep River, I started the same procedure of making cuttings in the summertime but it was also difficult for me It took us away from work such as weeding, that was necessary during July and August. We had to devise some method of furnishing bottom heat. I had been receiving a publication from the Connecticut Light and Power Company and one issue mentioned electric cables. I know some of you fellows had used it already, and it had been used on the floors of chicken houses to keep them warm It occurred to me this might be an excellent way to heat the sand in the frame, giving us exactly what we wanted.

We first tried one frame. This first experience with this cable heat in our frame was very successful and was very encouraging. We use it only on *Taxus* *Taxus* for the most part is not difficult to root, but we hadn't had too much success with our summer propagation techniques. We weren't able to hit it like my father had been able to do back in the twenties and thirties. When we did get what might be termed a 90 to 95 per cent stand, using electric cables, we were absolutely enthused because we felt it wasn't necessary to go to a great expense to install this equipment or to construct a greenhouse. We could just continue with the frames we already had by simply adding this electric cable to the bottom of the frame.

The cost of one frame's operation for this period of about four months ran somewhere around fifty dollars and we felt it as well worth it because the actual cost per cutting was around .8 of a cent. We felt that was certainly well worth doing. So the following year we went into three frames with electricity Now we had about eight frames, but we put three frames into electricity to check it once more. We had an overflow of cuttings, so we rented a small greenhouse for a year with no heat in it other than these electric cables. Again the frame proposition was successful but the experience in the greenhouse, although successful, cost us a tremendous amount of money. Without heat in the greenhouse to aid the electric cables, the electric cables continued to run even though we had a thermostat controlling the bed temperature. The temperature never got high enough to shut off the juice It was the constant running of this very high electricity consuming piece of equipment that we had that cost the money. As a result we discontinued that, although the results from the propagation were fairly good.

The following year we went into eight frames, all equipped with electric cables This time we had almost complete failure because we got an infestation of *Rhizoctonia* that was devastating. We also changed our medium in our frames, but we never did any fumigation. We either brought it in with the cuttings or it had begun to form in the frames during the first two years of use with electric cables We lost out of 120,000 cuttings all but 5,000, and when we planted those 5,000 we lost more still. We hadn't paid any attention to this fungus problem that we might suddenly get and that was a blow when we lost all our cuttings that particular year. From that time on, we have thoroughly fumigated all our frames with formaldehyde We have also tried pouring on Dithane and that has worked satisfactorily We feel, too, that we have gotten some hormone action from this chemical. No hormone has been isolated from Dithane, yet when it breaks down it aids in the rooting. We use Dithane as a thorough cleanup and follow it by spraying on Dithane about a week before we stick the cuttings We have used Vapam as a drench on the walls and sand surface and that also seems to work.

Now I might mention that we have rooted about everything in these frames that we can grow. We have rooted all varieties of *Taxus* up to 90 per cent. With junipers we have great variation in rooting, anywhere from zero to say 90 per cent, depending on the variety. *Juniperus chinensis sargenti* we just can't get to root. Myers columnar we can't root very well. However, we have had good luck with such types as the variety that is sometimes sold as the Blue Sargent, and good luck with *Juniperus scopulorum viridifolia,* which looks like *J. excelsa stricta* but it is a columnar type and is not subject to the difficulties you have with *J. e. stricta.* The Sargent hemlocks have been rooting since we listened to Harvey Gray. We do that following his directions for use of a plastic covered case within the frame. The plastic completely encircles the medium underneath and over the top We have had good luck rooting anywhere from 50 to 75 per cent of the Sargent weeping with the cuttings in sand, peat and Styrofoam and with the aid of two per cent indolebutyric acid. We have rooted some dwarf hemlock, and some *Tsuga canadensis microphylla* but not as successfully as arborvitae. Some of the spruces have been rooting rather well, such as *Picea abies n. nidiformis* and *compacta*

We root azaleas too, but not with bottom heat. We put our azalea cuttings in August and enclose them in a plastic case, much like we do with the Sargent hemlocks. We get very good rooting on such varieties as *Azalea yedoensis, poukhanensis,* one called John Cairns and *Azalea y poukhanensis compacta.*

We also root rhododendron in an enclosed case within the frame. This time we do it in October with bottom heat, using the cables We have had some variation in our results The easier varieties, such as America, seem to do well, but the more difficult ones, like *R. atrosanguineum,* and Mrs. C. S. Sargent, we haven't been able to do too much with them. We can root them probably as well as you can root them anywhere but we can't keep them growing. So in frames of this type I think we are probably limited to doing just about as well as we can, which is not up to that which you can do in a greenhouse. With *Ilex* we have no trouble. *Ilex opaca* and *crenata* can be rooted fairly easily.

Now the construction of our frame is from cinder block The high side has four tiers of block, the low side three. About two rows of the blocks are underground. The surface of the sand when it is placed in the frame comes to about half way up on the second row. In other words, it is about 12 inches from the bottom of the frame which is about eight inches from the surface outside. The surface of our sand is about eight inches down from the outside of the surface. That, we feel, gives us good insulation from the cold on the outside. When the frame is completed we first put in a good drainage bed consisting of three inches of stone, followed by an inch of fine sand upon which the cable is laid. Then a four-inch cover of sand is placed over the cable. Our cables are all hitched to a main line which in turn has a thermostat which controls the temperature. We try to keep our heat at about 70 degrees F, although it varies from 68 to 72° F. It is very close to being accurate and I think that is probably as close as you can keep heat under most conditions with most types of equipment

We use glass sashes over the frames. Last winter for the first time we put plastic over the top of the sashes to help insulate the beds. We have been afraid to seal all the frames very tightly since we had fungus trouble that one time and we felt a little aeration might be good. Because of this we have not sealed the sashes to the frame itself but rather have draped the plastic over the sashes. It did keep a good bit of wind out.

Coming back once more to the cost of operation, you might ask if this isn't a very expensive means of propagation? Well, I don't know. I don't have an accurate figure on what it costs to propagate in the greenhouse. Each of our frames is 180 square feet inside. In *Taxus* cuttings we can stick about 15,000 in that area, and with good results it costs eight-tenths of a cent per cutting. With poor results, of course, the price immediately goes up. It costs $12 per month per frame for that number of cuttings. In other words, 15,000 cuttings costs $12 a month for a four-month period. That is $48 to root 15,000 cuttings That can vary, but say the average is $12. Two winters ago we had very cold weather in January and the thermostat called for heat even during the day when the sun was out. Because of the extreme cold, the cost of electricity ran up to $15.00 or a total of $60.00 for a four-month period. But let's remember this, that the cost of construction is very low. To build a 30 by 6 foot frame of this type, it takes 190 blocks at 75 cents a block, which includes the block, the mortar and the labor of construction which means $150 per frame. Then, of course, you must have the usual sash, which are about $12 apiece, or maybe more now. The wiring in the frames themselves, the cable, and the thermostats will cost $70 per frame. The switchboard, and incidentally, the size of the switchboard will depend on the number of frames you have, can be rather expensive. W have 10 frames, each one draws 10 amps, so we needed more than 100 amp service. The next service was 200 amp service, which costs a little better than $200 to install.

Now compare this to the cost of installing heat of another form, such as steam heat or hot water heat underground in frames It would be necessary to construct a building for the burner and it would be necessary to put in the pipes which probably would have to be done by a professional It might add considerably to the cost. Over the years, however, there is a possibility it might be cheaper.

I would like to give you some of the advantages that I feel we have in the use of this type of heat I have mentioned one, that is the initial low cost of construction and the need for little professional help. You can do all this yourself with the exception of possibly the switchboard. The maintenance cost is low. In fact, there is no maintenance whatsoever in this equipment. There is no painting, of course, to do except on the sashes. The excellent results that can be obtained by the use of cable heat is another advantage. The frames themselves are very convenient for the purposes of changing your medium and for general access. You can back a truck up to the frames and empty the frames or you can bring the sand in, in the same manner. The convenience of irrigation, too, is an advantage. We have installed irrigation in these frames by the use of tobacco nozzles on a pipe which runs lengthwise over the frame. We cannot only water the frames without opening the sashes but we can also fumigate these frames initially by pouring the formaldehyde or whatever material we are using through the pipes, cleaning them very thoroughly and keeping in all the gases. You can also harden-off your cuttings very well in frames, once the cuttings are rooted. When the weather is right the sashes can come off and screens can go on Your cuttings go out in the open and before you have a chance to move them they acclimate themselves to the conditions under which they have to grow.

Here are some of the disadvantages. Snowfall of any great amount is a nuisance because you have to shovel it off before it can get into your frames The inspection of frames during cold weather is difficult. It is not easy to raise or open the frames. It raises the amount of heat necessary to keep them warm and gives the cuttings a cold blast of air which we feel is not advantageous. The growing of rhododendrons is difficult because once you have them rooted you can't keep them growing, since the air above the sand is always very cool and possibly is the cause of the high cost of heating. I think we are in a very cold area because we get cold air draining into our frame area. We don't get sun probably as long as if we were on the crest of a hill. Our day is a little shorter in the winter time and it makes for a long night and a higher heat requirement. If you were on top of a hill in a very sunny location I think you would find the cost dropping considerably, especially when you have bright, sunny days.

I would just like to run over the equipment we have been using. For a thermostat we use a G.E. Model HSC 5 with a 30-inch capillary tube which is a very simple thing, costing about $10 It has a cover on it which keep water out. We run our equipment on 220 volts. We use cables that are 120 feet long. You can use shorter 60 foot cable, but you need more outlets over a given area. These thermostats are rated for 20 amps We are using lead cable instead of plastic I would say this, the plastic cable would last longer in the soil in the sand, but it is a hard thing to put down. It just doesn't seem to want to stay put. The lead cable once it is bent and laid down, stays in place. If it is not removed too often for frame cleaning it will last indefinitely. The lead covering on the lead cable does crack and that will cause a short circuit. We like the Rockbesto heating cable and it costs us seven cents a foot, which is a special price It usually runs about 13 cents a foot.

Now there is one other thing I might mention before I close and that is that there may be another means of heating with electric heat, although I have nothing but a very small amount of information on it. This is an electric ground warming with the help of wire netting. In the pictures that are shown in this booklet it appears to be a two-inch mesh chicken wire, but evidently it is not exactly the same because they claim you must buy this particular wire because the other type won't work It is being used in various Dutch nurseries and has the advantage of distributing the heat very evenly throughout the bed without drying the medium. It operates on 42 volts and therefore is harmless, even though the wires are not insulated. We are now looking into this possibility for supplying bottom heat to our cuttings

If there are any questions I will try to answer them.

* * * * * *

MR. RADDER: Would you tell us a little about your establishment?

(*Editor's note*: Mr. Van Heiningen then reviewed the major points of his talk by means of colored slides.)

DR. CHARLES HESS: Dick, did you ever try to put hardware cloth over your cables to get a better distribution of heat or don't you think it is practical enough or beneficial enough to warrant the extra work?

MR. VAN HEININGEN: We have tried it and we didn't think it helped too much. We had some drying out although that was our own fault. We didn't have quite enough sand over the top of that wire and the cuttings got rather close to the cable. We had drying throughout the entire frame, and so we decided to discontinue it because it adds quite a bit to the cost. It would save us, however, from having to remove the cable every time we changed the medium We have done that because we are afraid of hitting the cable with the shovel when they are digging the sand out.

DR. HESS. We are just about ready to install a heating setup at Purdue. We got ours from a person by the name of Peterson who was at Cornell from Denmark. He brought this idea with him. We used the Allis-Chalmers transformer to drop the voltage down from 110 to around 30 volts Now the saving comes from the fact that you don't have the lead-covered cable expense. You can use just plain 10-gauge fencing wire. The total outlay of funds are the same but you eliminated the replacement cost of the cables which, as you pointed out, do crack if they are moved around a lot

MR. VAN HEININGEN: It is necessary to handle the lead-covered cable when it is warm. Usually we plug it in and bend it to whatever shape it has to be.

PRESIDENT TEMPLETON: On this subject of bare wire electric heating cable, I might say that it has been used in England for many, many years. It is usually bare, galvanized wire operated at six, eight or ten volts. It isn't as attractive as it sounds, because the transformer is quite expensive There is no danger of shock with the low voltage wire

As pointed out, it is a heated, single wire. If you are interested, it is no trouble to get all sorts of information on it from England. Write to NIAE in England and they will send you cost figures on the installation, diagrams of installations, as well as electrical consumption as it varies with the temperature during the year. They have all the data.

MR. LOWENFELS: I am using electric cable in a greenhouse and the instruction sheet said to put wire over the lead cable. I took old window screening and put it on over the cable. Have you tried that, and is there any advantage or disadvantage to its use?

MR. VAN HEININGEN: I just mentioned that I had tried it and it would appear to me that there should be an advantage to its use. However, we had some trouble with drying out simply because we did not have enough sand cover over the wire screening. I think we should try it again and be sure we have enough sand cover.

DR. STUART NELSON: Seemingly Charlie has found a source for a transformer, which has always been the problem. I would like to ask Charlie if he knows what it would cost.

DR. HESS: There are several sizes, depending on how large a bed you want to heat. We got the medium-sized one, which runs about $95 for the transformer.

MR A. D. SLAVIN (Elbridge, New York): Actually, we are up in pretty cold country and what we actually do, without going into details, is use one of Hugh Steavenson's polyethylene houses inside of which we have electrically heated trays We use plastic covered cable, which as has been mentioned is tough to tie down. What we do is simply take a 2″ x 4″, soaked in copper napthanate and stick it at the end of each frame in this house The cable is tacked down with staples. We put about an inch of good gritty sand on top of this and then we stretch hardware over this. If a clumsy person digs down in the frame he wouldn't ruin the plastic cable. That cable has now been in over five years. It is still giving us the same response in temperature.

The plastic wire has become brittle. I could take it out but you couldn't handle it easily. I chose plastic cable because the wire itself does not reach the temperature that lead cable does, although there is a lot more per unit. Ours is laid in the same fashion as the lead cable, but because there are so many more feet per unit, it is laid two inches apart in order to get a better distribution of heat. I don't think that is necessary, but it is working all right and it is cheaper than the lead cable After five years it has been pretty well amortized Each unit is 25 feet long and four feet wide. We use two sections of this plastic cable Each one draws 800 watts for each 100 square feet when we have the current on. This is usually all winter in our country The thermostat used is essentially the one that has been described.

I may say something about our results in polyethylene covered frames. Under our conditions when winter really sets in, the highest we can get the soil temperature in these frames in the polyethylene house, is 54 degrees. As a result, we don't try to heat the unit any longer than we have to That is one reason, and the other reason why we don't make *Taxus* cuttings in August, is that we have one of the longest growing seasons in the country and our *Taxus* aren't hardened up by this time. We wait until they are hardened up and start taking cuttings Now that we have good dormant wood, we pay no attention to a heel because we can see no difference in the rooting between those that have a heel and those without one We are getting 82 per cent take on yews We get 90 to 93 per cent on arborvitae On *Ilex crenata,* which we propagate later in the winter because it doesn't take so long to root. we get about 100 per cent. On the desirable species of juniper we average about 30 per cent For that reason we have actually gone down and rented space in a greenhouse and done our juniper propagation under the electric heating technique that I mentioned

We have kept very careful tract of costs because it was one of the first plastic houses around our part of the country. The building costs are amortized over a five-year period. These costs include cleaning up the place, putting the new polyethylene on, the cost of electricity, and also for the last two years this figure includes the cost of cleaning, making and placing the cuttings. It costs four and six-tenths cents a cutting. Don't ask me how that corresponds with somebody else's cost. We are quite happy Incidentally, we have as much as 18 inches of snow for a two-week period in the winter, and in the frames we limit the frames to yew. We put them in and we never look at them again in the winter time. As winter comes on, and we are through with our open mist season, we move the lines into the greenhouse along with the timer. All during the winter we just merely use the mist nozzles instead of manually watering the cuttings. As spring comes on we will put on the timer when we feel it is desirable.

Another thing I like particularly with yews is that with this type of propagation, my experience is that we get no top growth until there are roots on the cuttings.

MR. VAN HEININGEN: That is very true. The frames are very cold except for the sand, consequently, there is not much top growth until root formation has taken place. This is a very good point.

MR. ROLAND DE WILDE: We use hardware cloth over cables because I find when we don't use it the boys cut the cables. I used plastic one year and the first thing that happened was that the temperature was 102 degrees, which nicely cooked everything in the frame. Since that I have stayed with the lead cables which I think are a little more satisfactory.

MR. VAN HEININGEN: One advantage with the plastic cable is that it is longer. I think the 220 volt system has 160 feet instead of 120 for the lead cable and for this reason you can cover a little more area and distribute your heat more evenly. If you use hardware cloth with lead cables you can probably get the same distribution. The wattage is the same. I think it is 800 watts per cable and that is true for the plastic as well.

MODERATOR STEAVENSON. Thank you very much, Dick. I would like to ask if you know what your kilowatt hour cost is for your electricity?

MR. VAN HEININGEN: Yes, it runs about three and a half cents. We are on demand meter and the more we use the more we pay. I don't know exactly how they figure it out.

MODERATOR STEAVENSON: We are up against the same thing. I had a house about 100 feet long with electric cables and our electricity cost is about the same. It was simpler for me to put in hot water, which I did because of the cost. However, I can see for your frames where it would be much more convenient to use cables than it would be to use hot water. What is your rate on your formaldehyde fumigation?

MR VAN HEININGEN: The formaldehyde is a two per cent solution. It is used at the rate of three gallons in 150 gallons, or 147 gallons of water, and three gallons of formaldehyde. That is a two per cent solution if my figures are correct, and we use 150 gallons per frame. That is an awful lot of liquid but with the irrigation system it works fine. We put it through the pump from a barrel and it is a simple matter to do all the frames at one time.

MR. RADDER: How long, Dick, do you wait before you stick cuttings?

MR. VAN HEININGEN: We have to wait two weeks and if we smell formaldehyde we wait longer. If we haven't got time to wait we will use Dithane, because you only have to wait seven days for that. Vapam is even quicker, but if you us formaldehyde you have to wait at least two weeks and you can smell it if it is there.

MODERATOR STEAVENSON: Do you cover your frame with sash after you put formaldehyde on?

MR VAN HEININGEN: Our irrigation is inside the frame. The sashes are put on the frames after application. After two weeks we open it up and air it out.

DR. CHARLES HESS: Just one comment, on why we are personally intersted in low voltage heating. We do on occasion like to run heating cables in our mist beds even in the summertime and particularly if you are in a cold area, or have a cool summer, as we did have this year If you have ever had lead heating cables with a few cracks, under mist, you can really get set on your ear. That is why we want to try out this low voltage idea to see if we can't overcome this hazard.

MR. VAN HEININGEN: We had trouble with one of our cables last winter and you couldn't even take a plant out to check it without getting a shock.

MR. RALPH SHUGERT (Neosho, Missouri): There is a question relative to what temperature you keep your frames?

MR. VAN HEININGEN: About 70 degrees We keep it at 70 degrees for everything.

MR. A D. SLAVIN: We can't maintain the temperature at 70, but it hasn't been any great disadvantage in our experience You are only going to get one crop over the winter and you can save some money in two ways. One is to take your *Taxus* cuttings and get them callused Under our temperature condition, they will callus up pretty well in six or seven weeks. After that for the rest of the winter you might as well turn off the heat. In our case we would turn it on about the 20th of March. In other words, we could have six full weeks with the current off on *Taxus,* and I think we are going to for arborvitae also. It is a waste of time to put them in before Washington's Birthday. You get no better results with December, January and early February placement under these conditions In the frames that we are going to use for arborvitae, the current doesn't have to be turned on until that time Of course, it won't work for juniper.

MR. VAN HEININGEN: May I follow that through for a moment? We had a faulty thermostat on one occasion and when I opened this frame up the temperature was actually 90 degrees You can get it up there if you keep the heat on

We don't stick all our cuttings at the same time. We do that for two reasons, ie, it isn't necessary, and it is a saving if you don't run your frames all the time. We stick juniper cuttings in November We stick our hemlock cuttings earlier if we can do it, in October These are already rooted by the first of the year, and we can actually take those out and store them. We did this last winter and put in another crop, because we can't keep the temperature up there *Taxus* cuttings we do not bother with until after the first of the year unless we have bad weather before and we have nothing else to do Arborvitae are the very last thing we take and they will root in a matter of a month. *Taxus* will take anywhere from four to six weeks to start making roots Our men can work all winter long because the heat can be kept up to 70 degrees.

MR. SLAVIN: Another thing I would like to mention, except for the matter of safety and cost of installation I don't think it makes a darn bit of difference what type of heating you use I am not an electrical engineer, but are going to get so many thermal units out of every watt There is probably nothing that can be measured more accurately in transferring one type of energy to another than electricity. The two most imoprtant points is the safety factor and the cost of installation. If you put the watts in, you will get the watts out, providing you have a well-designed electrical unit or some other type of system

Incidentally, when we go to frames we can keep a higher temperature than in the greenhouse because we have less air to heat.

MR. HARVEY GRAY: Have you time for two questions? One, what depth do you place your thermal tube to give you most efficient control of your heat?

Number 2, in your use of a two per cent formaldehyde solution, do you make this application prior to the placement of your fresh medium or after the medium has been put in place?

MR. VAN HEININGEN: To answer your first question, the capillary tube is placed about one inch above the wire and we place it cross-wire over the wire so that it is directly above the cable. We have found by experience you get a closer temperature by having part of the tube over part of the cable.

To answer your second question, we clean the frame completely, add the new medium, and then we put on the formaldehyde so that we treat the fresh sand as well as the walls and the base of the frame.

MR. SLAVIN: We put our tube about two and a half inches below the surface, which means the tubes are three to three and a half inches above the wire. My idea is to put the tube about where the base of the average cutting would be located, or within an inch.

MODERATOR STEAVENSON: Thank you, gentlemen. We have time for two more questions.

MR. AART VUYK (Indiana, Penn.): Dick, do you have an trouble with the cables when you change the sand?

MR VAN HEININGEN: That is one of the good reasons for having it covered with a wire of some sort to protect it. We always pull the wire out after we are through.

MR. WELLS: Hugh, I just wanted to make a couple of comments regarding the use of these plastic cables and about arborvitae cuttings. We have used two kinds of plastic cable. One is a stiffer, single wire made by a company in Chicago, which comes in long lengths and which has been quite satisfactory The other is a much more flexible type of plastic-covered cable made by Cox and Company in New York. That comes in 120 foot lengths only and also works well

The cost of using these cables to heat a frame made up of 10 standard sash, using the current from a power source which cuts off from 4:00 o'clock in the afternoon until 11:00 o'clock at night was $25 a month.

Now in regard to the arborvitae, we have rooted a number of these varieties successfully in this following manner. Make the cuttings about the middle of February, treat them with hormones, pack them in deep flats in moist sphagnum moss and put them in the cellar where the temperature is 55 or 60 degrees. Place a couple of electric lights in there so they have a little light during the day and leave them there for six weeks They will callus in the moss and even begin to initiate roots Six weeks from the middle of February brings you to the end of March. At that time, take them out in the ordinary frame and set them upright in sandy soil, shut the frame down tight and water them often. Give them a little shade and they will root practically 100 per cent without any heat.

MODERATOR STEAVENSON: Thank you, Jim, for your comments.

About the nicest thing that happened to me when I got Martin's program was to pick it up and notice that my old sidekick was going to be on this panel here this afternoon. Our next speaker, two other men in the audience and I started out together. I hate to say the date, but it was exactly 25 years ago in the Conservation Service. I would like to introduce the third man who is here, who started with Thor and I, Al Dodge, please stand up The fourth culprit, who I am mighty happy and proud to see here is Art Slavin. To me, and to all of us it is like old home week after these 25 years to get back together again.

Our next speaker, as I mentioned has the fancy title of "Woodland Conservationist." He tells me that is a fancy title for forestry. Thor Bergh has operated a large seedling nursery for many years. He has been in commercial nursery work and he has been engaged in various types of forestry and woodland practice, principally in the colder lake states area. He is exceedingly well qualified for the topic that he is going to discuss, namely, will seed from Northern plants produce hardier plants than those produced from seed collected in Southern regions? Thor Bergh!

MR. THOR K BERGH. As you said, this is very much like old home week with the four of us back, and not only that but I have met several other fellows here that have made my stay so far a lot of fun. I expect to have a lot more pleasant experiences before I leave here.

Mr. Bergh presented his paper on the affect of seed source on hardiness of plant material

WILL SEED FROM NORTHERN PLANTS PRODUCE PLANTS HARDIER THAN THOSE FROM SOUTHERN REGIONS

THOR K. BERGH
Woodland Conservationist
U. S. Soil Conservation Service
Saint Cloud, Minnesota

Mr. President, Mr Chairman, members of the Society and guests. It is a real challenge to present a talk on a subject that, I am quite certain, is very familiar to some of you, probably most of you Not only is this a challenge but also a distinct honor for me and for the Soil Conservation Service, the agency that I represent, to have the privilege of talking to you today.

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The title that was assigned to me is "Will Seed From Northern Plants Produce Plants Hardier Than Those From Southern Regions?".

This may be a controversial subject. I am sure that some of you feel that you have an answer to that question.

Many of my comments will stem from my own experience, some from work of colleagues, and some from work of others about which I have read or heard.

With your permission, I may deviate a little now and then from the subject of hardiness and swing occasionally into the subject of adaptability. They seem to go together, and it is often difficult to discuss one without also mentioning the other.

As you know, the use of seed is only one way of many ways to propagate plants. To some of you, it may be a minor part of your propagation program. Many of you are in the field of ornamental plant propagation. My work takes me primarily into the field of soil and water conservation, in which field we have greater interest in plants of utilitarian value, rather than ornamental.

If you are in the field of ornamentals, you are actively engaged in propagation by budding, grafting, layering, and rooting, as well as seeding. As a matter of fact, many plants that you grow may require that you first make a seeding to produce root stocks to which you will later plant a bud, or graft a piece of scion wood.

Many plants used for ornamental purposes are also propagated and grown to saleable size, direct from seed. Concolor fir, noble fir, several spruces, notably Colorado Blue, the pines, some *Taxus,* junipers, cedars, to name a few of the evergreens can and are propagated from seed.

The list of deciduous trees and shrubs that are grown from seed is long and very important.

Certainly every man here has a vital concern in using good seed — seed that will produce a plant that will be hardy and adapted to the site and be completely adapted to the conditions it will encounter when it is planted in its ultimate location.

To us in the north country, one of the characteristics a plant must have, of course, is hardiness. But, in addition to that, it must be adapted to other factors. These factors may be such thing as soil texture and pH, conditions of wetness and drought, competition, insects and diseases.

In growing plants from seed, th most important consideration the propagator must keep in mind — once he has decided what species to grow — is the source of his seed.

Even for the propagator who makes a conscientious effort to obtain good seed, it is often difficult to obtain seed of known origin, true botanical identity, or of known age, purity and viability. The propagator who does not require proof of origin is gambling, and the consequence may be costly, not only in money expended for poor seed, but in time lost.

Europe has gone through the evolution. After bitter experiences many European countries have enacted rather strict laws regarding the use of forest tree seed. German seed dealers voluntarily submitted to regulations of seed import as far back as 1906. Later, German law required certification — by appointed forest officers — of stands of trees and even individual trees, before seed could be collected. Additional measures which have been adopted or brought into being by law are, the adequate labeling of all seed as to origin, restrictions of the movement of seed within the country, and heavy import duty on foreign seed. America has lagged behind in this matter of seed certification of trees and shrubs.

The United States Department of Agriculture has adopted a policy regarding forest tree seed. This policy could well be adopted for all seed, including those used by the propagator of ornamentals and fruits.

It may be well to make it clear that this policy applies only to seed and nursery stock used within the U. S. Department of Agriculture, and is in no way to be construed as federal legislation regarding these matters.

This policy, if followed by all propagators, however, would go far toward promoting the proper use of seed of known origin. The pertinent parts of this policy read as follows:

"Recognizing that trees and shrubs, in common with other food and fiber plants, vary in branching habit, rate of growth, strength and stiffness of wood, resistance to cold, drought, insect attack, and disease and in other attributes which influence their usefulness and local adaptation, and that such differences are largely of a genetic nature, it shall be the policy of the United States Department of Agriculture, insofar as practicable, to require for all forest, shelterbelt, and erosion-control plantings, stocks propagated from segregated strains or individual clones of proven superiority for the particular locality or objective concerned.

Furthermore, since the above attributes are associated in part with the climate and to some extent with other factors of environment of the locality or origin, it shall be the policy of the United States Department of Agriculture:

1. To use only seed of known locality of origin and nursery stock grown from such seed.
2. To require from the vendor, adequate evidence verifying place and year of origin for all lots of seed or nursery stock purchased.
3. To require an accurate record of the origin of all lots of seed and nursery stock used in forest, shelterbelt, and erosion-control plantings, such records to include the following minimum standard requirements to be furnished with each shipment:
    - (1) Lot number
    - (2) Year of seed crop
    - (3) Species
    - (4) Seed Origin:
        - a. State
        - b. County
        - c. Locality
        - d. Range of elevation
    - (5) Proof of origin
4. To use local seed from natural stands whenever available unless it has been demonstrated that seed from another specific source produces desirable plants for the locality and uses involved. Lo-

cal seed means seed from an area subject to similar climatic influences and may usually be considered as that collected within 100 miles of the planting site and differing from it in elvation by less than 1,000 feet.

5. When local seed is not available, to use seed from a region having as nearly as possible the same length of growing season, the same mean temperature of the growing season, the same frequencies of summer droughts, with other similar environment so far as possible, and the same latitude.
6. To continue experimentation with indigenous and exotic species, races, and clones to determine their possible usefulness, and to delimit as early as practicable climatic zones within which seed or planting stock of species and their strains may be safely used for forest, shelterbelts, and erosion control.
7. To urge that states, counties, cities, corporations, other organizations and individuals producing and planting trees for forest, shelterbelt, and erosion-control purposes, the expense of which is borne wholly or in part by the Federal Government, adhere to the policy herein outlined."

A similar policy on all seed could become a reality if the buyer of the seed would demand that his seed dealer provide adequate data as to origin of seed.

To summarize this policy, you will recall that it recognizes the fact that trees and shrubs, as well as all other forms of plant life, vary in many ways. Although my topic has primarily to do with hardiness, we can hardly talk about the ability of a plant to resist cold, without also bringing into the discussion these other items of adaptability that influence their usefulness and value to those of us who propagate them and use them.

It is well known to all of us that a single species of plant may include a great diversity of unique varieties, forms, races and strains. Considerable research has been carried on in recent years to try and determine the reasons for the development of these variations within a species Basically, however, the greatest influences in the development of these variations are climate, soil conditions and site factors.

There is a great deal of work that still needs to be done to determine the existence of these variations within species, and also to learn the range of these plants.

At the present time, we do know a few things about these variations or races within a species

First of all, we know that, in all likelihood, most species of plants that grow under a variety of climatic and soil conditions have developed variations in one or more of the items we listed earlier, such as branching habit, rate of growth, hardiness and resistance to drought, insect and diseases.

We know also that as the climate of the place of seed origin increases in warmth and mildness, susceptibility to frost and snow damage increases; resistance to certain fungi increases and rate of growth increases. There is a tendency to form thicker stems and larger, more well developed crowns Fruit and seed size increases.

As an example, we can point out a few species that have developed definite variations with the range of the plant because of differences in climate, soil and site.

In the case of our native Minnesota red pine, we know of a least three races that differ in frost hardiness. Siberian elm has several variations. In the case of this particular tree, the lack of knowledge regarding seed source on the part of nurserymen, caused a great deal of trouble some 20-25 years ago. Millions of plants were produced and sold as "Chinese elm." Actually, this was Siberian elm, *Ulmus pumila,* but the seed was gathered from trees in the southern portion of its natural range in the country of its origin They proved to lack in hardiness in our northern areas. The tree developed a bad name, and to this day, we still suffer from the old prejudices. Today, we still have available to us, from nursery sources, several races of Siberian elm. The difference is that they are now largely from northern hardy seed sources, and the plants are perfectly hardy. It will take years, probably a new generation of Americans, to completely forget the bad taste for the old so-called Chinese elm Even among our northern hardy races of Siberian elm we have variations in growth rate and size. Some of the northerly strains are named Chinkota, Manchu, Harbin, Dropmore, and there are others.

Another example is Scotch pine Here we know of at least five races. In the seed catalog of one of the better known seed dealers, there are listed no less than eleven seed sources of Scotch pine, all of them supposedly different in one respect or another. Each of the five recognized races differs in their degree of hardiness, growth rate, growth form and habit Some other common plants where more than one race exists and where there is a difference in hardiness are western hemlock, southern slash pine, Engelman spruce, Sitka spruce (which, incidentally, has five recognized races), white spruce and many others, as well as several common deciduous species, both of native and foreign origin.

For example, I notice three so-called races of European larch listed. The dealer describes the first one as coming from the Eastern Alps at elevations of 3,000 - 4,200 feet, the second one from the foothills of the Eastern Alps at 1,200 - 2,100 foot elevations.

The third European larch listed is from the Western Alps at 6,000 foot elevation. The description goes on to inform the buyer that this particular larch has a late starting and early terminating growth, is cold and wind resistant, and grows tall, straight and very fast. Here we have a recognition on the part of this seedsman that there are variations within a species, and he has gone to considerable effort to tell his customers about them

This is commendable, and it is only hoped that in years to come, we can be provided with reliable data on all variations of all species of plants, in order to make the propagator's job easier and the ultimate user more satisfied and happy

Norway spruce is another interesting item in this particular catalog. This catalog describes eleven sources of seed and provides a great deal of information to help the buyer to decide which one is best for his use and locality.

This is all very good, and a move in the right direction because, as of today, there is no exact way of determining racial origin of a plant on the basis of seeds or young seedlings.

The purchaser of seed or stock must depend chiefly on the certification of the collector or dealer.

Another interesting subject regarding seed, the seedling and the adult plant has to do with variations in seed size, seedling development, stem form and general structure of plants growing in the same area For example, two plants of the same species and similar age growing side by side may show considerable difference in the size and weight of the seed they produce. Seeds from the same tree may vary a great deal There may also be considerable variation in resistance to rust, mildew, insect damage, etc.

Some of these variations may have to do with resistance to frost damage. There is very little experimental data to support it, but observations seem to indicate that this is true.

Suffice to say that in regard to plants of the same species growing together in the same area, it is important that even here the seedsman pick his seed plants and gather seed only from individual plants having the most desirable characteristics of branching, foliage, growth, resistance to frost, drought, insect and disease.

How many of us have taken a bundle of tags and gone out to a nursery block or to a scion block or a group of plants anywhere to tag plants that show superior attributes regarding good foliage color, good growth form, beautiful flowering habits, heavy fruiting of large individual fruits and for other desirable characteristics. I can recall such things as a shrub having heavy leaf mildew, and its next door neighbor having little or none at all; the caragana bush that is completely defoliated by blister beetles, and its immediate neighbor untouched by the beetle.

At this point, we may start to ask some questions as to "why." Just why is it that the plant grown from seeds of the same species growing at opposite ends of its range are so different in respect to hardiness Why is it that we cannot take white pine seed from Illinois, for example, and expect the seedlings to be hardy in Northern Minnesota? Why can't we take seed of Siberian elm from its southern most range in Southern China and expect the seedling to be hardy in the northern portion of its range — Northern Siberia?

This brings us quite naturally into the physical and chemical makeup of seed.

A seed is a rudimentary plant or embryo — a young plant. It is composed of seed-leaves, a bud, a stem and roots. It is a plant in miniature.

Usually associated with this embryonic plant is some stored food and a protective coating.

From the standpoint of handling seed, three types should be considered. First, there is the true seed which can be readily extracted from dry fruits or cones. This includes most conifers, the pod bearing plants such as locust, and the capsule producing plants such as the poplar.

Second, we have the dry fruits such as the nuts of oak and chestnut and the fruits of maple and elm.

And third, we have the fleshy fruits such as honeysuckle, plum, walnut, mulberry and apple. These seeds can be used without cleaning, altho, in most cases, the fleshy portions are removed to leave the inner seed for easier handling.

None of these seeds can be used to propagate new plants, of course, until they are ripe. As the seed ripens on the plant, a series of physical and chemical changes take place. These changes, especially the chemical changes, are very complicated and little understood. Fortunately, the chemical changes are usually accompanied by readily observed physical changes such as changes in color, taste, odor and texture. Thus, unripe seed that is green, dry, sour and bitter becomes yellow or reddish, juicy, sweet and many times edible.

Other seed such as those dispersed by the wind change from green to tan or brown; the seed coat bcomes darker and harder, and the meat of the seed becomes less milky and more firm. The seed is then fully developed.

To the layman or the inexperienced, one could now assume that this fully developed ripe seed is ready and able to germinate. However, this is not necessarily true. A substantial majority of seed will not germinate immediately, even tho the conditions may seem ideal.

Before germination can take place, two conditions are necessary.

First — The seed must be ready to germinate.

Second — The external factors must be favorable.

Some ripe seeds will germinate and grow at any time, providing these two conditions are provided. They are not many in number of species, but do include some of the legumes, some species of alder, some of the poplar, willow, and even some of the pine, as well as others.

In the cooler regions of the world, however, most of our seeds become dormant immediately after they become fully developed and ripe. This is especially true of those that ripen in the fall of the year.

In order to survive, all living creatures must adapt themselves to their environment. With winter and killing cold weather coming on in late fall, it certainly is not to the best interest of a species of tree or shrub to permit its seed to germinate soon after it falls to the ground.

What would happen if seeds did not go dormant. The young plants, sprouting from the germinating seed, would succumb to frost, and there would be no progeny.

Seed of willow, poplar, some elm, and others are fully developed and become ripe early enough in the season so that they have ample time to germinate and develop into a fully mature seedling before the first frost, so we have no problem here.

In this business of plants adapting themselves to their environment, there also are degrees of adaptability. Coming back to white pine we can illustrate this degree of adaptability. It isn't necessary for white pine seed produced from a native white pine tree in Illinois to go dormant for so long a period of time as a white pine seed produced in northern Minnesota.

Why? Because the winter is of shorter duration in Illinois and, in this case, the white pine has adapted itself to the shorter winter, and thus a shorter dormancy period for the seed.

If a Minnesota white pine seed and an Illinois white pine seed were sown side by side in the forest litter of northern Minnesota, the Illinois seed would probably die, because it would germinate during the first intermittent warm spell of the spring. The Minnesota seed would wait and not permit germination until later on when the weather became favorable for seedling survival.

A little later on, I want to go one step further and consider the plant that may be produced by these seeds of northern and southern sources, but before we get into that, let's explore this business of seed dormancy a little further.

As we stated earlier, seed dormancy is common, and frequently very important in the survival of the species. It is most common in northern climates and is very closely related to the climate of the area where the species in question is native. Generally speaking, seed of the same species from southern portions of its range may, and usually do, have a shorter period of dormancy as already illustrated in the case of the white pine seed. During this period of dormancy, the phenomena of what we call "after-ripening" takes place. "After-ripening" is a process largely of chemical change in the seed. Conditions of proper temperature and moisture must prevail in order that after-ripening progresses satisfactorily.

There are variations here too. Some seed require a period of warm temperatures, followed by a period of cold temperatures, before its after-ripening processes are completed and the seed permitted to germinate. In addition to this, some seeds may have an impervious seed coat which prevents moisture from entering the inner portion of the seed. There are many other complicated combinations of conditions that are necessary before the seed in question will germinate at the wanted time. or, for that matter, germinate at all. For example, no one has satisfactorily solved the seed dormancy problem and the conditions that are necessary to bring about germination of Basswood seed. Let us consider, however, the most common and most easily overcome of seed dormancy problems. Once we have discussed these more complicated aspects of dormancy, after-ripening and germination can be reviewed

One of our most common problems of dormancy and after-ripening is found with most of our northern conifers. Many other plants have much the same problem. Essentially, we can say that after-ripening takes place during a period of cool temperature and in the presence of moisture.

In nature, this need is satisfied by the parent plant dropping the seed to the ground in the fall, where, if it is lucky, it finds a favorable seed bed. The seed lies dormant until spring when thawing warm weather arrives. Then, and not until then, the seed germinates. The conditions, in this case cold temperatures in late fall and winter, along with moisture in the seed bed provided by fall rains and winter snows — have been met

Now, if we, as nurserymen and propagators, do not or cannot seed in the fall but for some reason find it necessary to make our seeding in the spring, these conditions of temperatures and moisture must be supplied artifically. In this business, we call that "stratification" This is a tricky business, however. It is relatively easy to provide these conditions, but the degree of temperature, the amount of moisture, the media in which we stratify, and the length of time required before after-ripening is completed is a big question and a major headache.

Now, seed source comes into the picture again. Unless we know the source of our seed, we cannot possibly know how long a period of time the seed will lie dormant in stratification before the after-ripening process is complete, and the seed is ready to sprout

Many of you, no doubt, have had the experience of having seed sprout in stratification long before you expected it to sprout, and long before you were ready to use it. This may be due to the fact that you got a batch of seed from a source more to the south than you had anticipated.

In using southern seed, therefore, we are running a risk of seed germinating too soon in the spring.

The next consideration is the seedling or plant produced from this southern seed. Let's assume we are lucky and successful in producing a seedling from this seed It grows vigorously all summer and goes into the fall season. Through generations of growth, the ancestors of this plant have adapted themselves to southern conditions. Now for the first time, this one year old seedling finds himself in the colder north country. The growing season may be 25 days shorter, and the first killing frost comes 15 days earlier than he and his ancestors had adapted themselves to endure. He is not ready for frost. He has not "hardened off" as we call it. The growth on this plant is still soft and succulent. He suffers frost damage, freeze-back. He is said to lack in hardiness. There are other characteristics by which a plant may display a lack of hardiness during the winter months and during periods of extremely low temperatures, but this fall period, with the early killing frosts, is one of the most critical periods of all What happens in the fall that cause us to say that a plant lacks hardiness? It is rather a simple story.

At this particular time of year, a plant lacking in hardiness, a southerner, continues to grow. The tissue remains soft. Plant cells remain filled with cell fluid. The first heavy frost freezes this fluid; the fluid expands as does frozen water in a bottle, and the plant cell is ruptured as is the glass bottle when it is full of water and frozen.

In contrast to this, a hardy plant of the same species but of northern parentage has adapted itself to slowing its growth in the fall, hardening the tissue, reducing the moisture in the plant cell, and thus is ready for the fall frost. It survives because it is not injured. This adaptability to freezing conditions in the fall is one characteristic of hardiness. Native seed from your own local native plants are adapted to your conditions Seed of the same species from more southern sources are not.

There are many other complicated factors regarding the many species of seeds and plants which I do not have time to discuss today. Suffice to say at this time, almost every species of seed has its own peculiarities and characteristics of dormancy, periods of after-ripening and necessary conditions to bring about germination at the wanted time.

For the successful propagator, these characteristics and treatments must be familiar to him

I once produced some plants of Norway spruce of central Indiana seed source The after-ripening period required was several weeks shorter than that of Norway spruce seed from old trees in southeastern Minnesota By growing them in a protected spot, using a minimum of nitrogen fertilizer, and eliminating irrigation in late summer on the droughty sand site, we were able to bring them thru as four year old transplants. It's risky. We shipped them back to their home state for planting.

We once produced American elm from southeastern Minnesota seed and planted some of the stock in northwestern Minnesota. It proved to lack in hardiness and killed back in varying degrees every year, largely because of early fall frost damage For plantings in northwestern Minnesota, we now advocate the harvest of northwestern Minnesota seed. These are common but typical examples.

And now to get back to the original question. "Will seed from northern plants produce plants hardier than those from southern regions?" The answer is, of course, "Yes."

The hazards encountered everyday by every propagator are too numerous anyhow, without asking for more trouble, especially those troubles that we can avoid I think it is of prime interest to all of us in this business to insist that seed sources be made known to us, and further, that we use only those seeds that will produce the finest stock, perfectly hardy in the area where they are to be ultimately used, and adapted to the conditions they will find there

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MODERATOR STEAVENSON: Very fine, Thor.

Who has a question for Thor Bergh?

MR. BEN DAVIS: We have quite a problem with our seed in that we get it in the fall, clean it, put it in cold storage for stratification and they sprout sometime before the weather is favorable for planting.

MR. BERGH: Well, I suggest that the way to solve that problem is to stratify your seed at different times of the year. Eventually you will find what the satisfactory time of stratification is. It may be 90 days, or it may be 120 You won't know until you actually try it out. It may be that you could seed them in the fall and then you wouldn't have to worry about them.

Your experiment station in our own state may also have information that will help you

MR. DAVIS: Well, sometimes we have had things sprout as quickly as 30 days after we had stratified them. We don't know how to prevent it. If we could store them dry, it would solve our problem. You can't let pear seed dry out, as I understand.

MODERATOR STEAVENSON: Do you have a 32 degree storage?

MR. DAVIS: No, not too close to 32 degrees. We have cold storage in which we stratify our seed but we also keep bare root stock there, too, and it usually runs about 35 to 40 degrees.

MODERATOR STEAVENSON: If you can get some temperature pretty close to freezing when you see evidences of sprouting, you could put your seed in at that temperature and hold it almost indefinitely.

MR. DAVIS: I might add, last year we tried putting some in quick freeze, and we didn't get one single seed to come out.

MR. DAVIS: That quick freeze thing worked on *Rosa multiflora* and we thought it might work on *Pieris,* although it didn't

MR. HOOGENDOORN: What is wrong with seed when all of it doesn't sprout the same year? Some magnolias will come up the first year and you may even find some coming up the third year. You also will find that some of the seed of *Juniperus virginiana* will come up the first year and some the second. What happened there?

MR. BERGH: I haven't had much experience with magnolia but there are some seeds that may have a protective coating on them, and the degree of thickness of that coating may vary with the seed. As a result you may have seeds coming up the first year and you may have some seeds coming the second year In the case of *Juniperus virginiana,* one of the things that we do to assure germination of the seed, after fall seeding is to clean them very thoroughly and get that waxy coat off the seed. Not only that, but we have collected the seed early in the fall before it actually became dead ripe and with early fall seeding we have obtained 100 per cent germination the following spring.

MR HOOGENDOORN: What about magnolia?

MODERATOR STEAVENSON: Thor, I would like to comment on Case's question. Nature doesn't form these seeds for the convenience of the nurserymen but rather she builds them for the preservation of the plant. For example, a batch of seeds will be sprouting for 20 years. This is nature's way of spreading out the progeny so the species has a better chance of germinating and reproducing its kind during a favorable season. There are many plants such as holly, cedar, and hawthorn which react just as you describe. All you can do is hope to germinate the greatest number.

MR. HOOGENDOORN: One way I have tried to overcome it with *Juniperus virginiana* is to keep it in a bag until the beginning of August. This is then stratified until the spring. By holding it over and stratifying it in August you get all the seed germinating

MR. HANS HESS: I have a comment to supplement what Case Hoogendoorn has just brought out. We, like Case and many others, have had the same experience with seed of juniper and of American holly, that is, partial germination the first year with the bulk of the seed coming up the second year. We have found that by holding this seed over and stratifying it around February or March, that if there is a small amount of germination the first season we just forget about it. When we sow the seed the following season we get the bulk of our germination the following spring.

I would like to ask one question of the speaker. Have you had any experience on the results of bringing northern seed into southern areas?

MR. BERGH: Of course, that is the opposite of bringing southern seed to the north, but I think it would be a poor policy to bring any species too far south out of its range. For example, take the case of Northern Red pine. I think possibly it would not be advisable to take plants of Norway pine too far south out of its natural range, although there are places in the south, like Missouri, where some Red pine has been planted and it looks all right. However, as this U.S.D.A. policy states they feel that you should stay close to the natural range of the species that you are considering.

DR NELSON: May I comment on pear seed germination? I might say that at Ottawa we don't keep our pear seed moist. We let it dry out and put in dry storage. The greatest influence on the effectiveness of stratification on pear seed will be entirely dependent upon the moisture content of the stratification medium. There is a further complication here in that there is a difference in performance of seed produced in good seed years and poor seed years, which is dependent on the weather at blossom time. If you have unfavorable weather at blossom time you will have to add at least two weeks to the stratification period and about 25 per cent more moisture. That sounds like a lot. Where in one case we use an even weight of moisture and peat moss we would have to go to say 120 grams of water to 100 grams of peat moss under another set of conditions.

MODERATOR STEAVENSON: Thank you, Stu.

PROF. J. C. McDANIEL (Urbana, Illinois): I have a comment on the matter of holly seed germination. The technique has not been worked out completely but it sounds promising and I thought worth mentioning to this convention. In our department someone brought in some trees of *Ilex cornuta*. He harvested some seed last September and soaked it approximately ten days in a weak solution of household lye. When the seed was softened he washed it with vinegar, sowed it outdoors and it came up. Ordinarily *Ilex cornuta* won't come up for nine or ten months at the earliest. In this treatment he got uniform germination the first spring.

MODERATOR STEAVENSON: Thank you, Mac. I believe Bill Flemer has a question.

MR. FLEMER: In answer to Hans Hess' question, I would say as far as shade trees are concerned we at Princeton Nurseries like to get northern seed sources rather than seed sources farther south, from New

Jersey This gives us a much longer digging season. For example, if we plant sugar cane seed from Vermont the trees go into dormancy about two weeks earlier in the fall and they are sometimes three weeks later in coming out into growth again in the spring. This gives us a much longer time when we can handle the trees in the dormant condition as compared with seed from locally grown maples. If we get seed from Tennessee sugar maples the situation is disastrous, since they never stop growing They pop out on the first warm spell in the spring. From a nurseryman's point of view, it is more advantageous if you can do so, to get seeds from further north than the location of the nursery.

MR. FRED NISBET: How do your customers like that for the next 50 years?

MR. FLEMER: They don't care because we have to sell all over the country and we can't very well sell New Jersey sugar maples in Vermont and we certainly don't want to sell New Jersey sugar maples from Tennessee. The trees are just as nice but they do have the shorter spurt growth in a shorter period of time.

MODERATOR STEAVENSON: We have time for perhaps one more question.

MR. HARVEY GRAY: I wonder if the speaker would make a comment on stratification in polyethylene bags where the seed has been moistened and then put into bags at a favorable temperature.

MR. BERGH: We tried stratification in polyethylene bags, as you say, and we can't say whether it was good or bad We had fair germination with some species On some we got no germination We felt that probably stratification with some medium such as we have always used was a little better in some cases because of these coatings on the seed which may be eaten away by the action of the acid in the medium or something of that kind I don't think I can say as far as my experience is concerned as to whether or not it can be substituted for the old-fashioned method of stratification

MODERATOR STEAVENSON: We use polyethylene bags almost entirely for stratification. However, we use a medium with the seed before putting it in the polyethylene bag. The big advantage is that you don't have to be watering your box all the time.

MR. GRAY: The reason for that question, Hugh, I believe it was in Forestry Planting Notes that this has been cited as a practice for Loblolly pine, which would indicate it was quite a successful manner of treatment I was wondering if this might be carried over to other types of coniferous material.

DR. NELSON. I haven't had a great deal of experience with coniferous material but with apple, germination is reduced to about one-half. When we wet the seed itself and set it under high humidity, cool temperature conditions we got roughly 40 per cent germination However, with peat moss at a one to one peat moss-water mixture before we sealed it up, we had up to 80 to 85 per cent germination.

MODERATOR STEAVENSON: Al Dodge, would you take just two minutes to make some remarks? Al is in charge of the U S D.A., Plant Introduction ornamental work in the North Central Region.

MR. A. F. DODGE (Ames, Iowa): Out lots of cedar are quite small, and I will go along with the use of polyethylene bags with a moderate amount of medium with the seed.

MODERATOR STEAVENSON: The last speaker of the afternoon is Mr. Rodney Bailey, Vince Bailey's nephew, and Gordon Bailey's son. He has been handling the nursery propagation the last couple of years. We are fortunate that we have Rod here with us to discuss "Over-Wintering of Softwood Cuttings under Controlled Temperature," which I know they have been doing a great deal of work on. Rodney Bailey!

Mr. Rodney Bailey presented the discussion on the procedures used to overwinter softwood cuttings in a controlled temperature, nursery storage.

OVERWINTERING OF SOFTWOOD CUTTINGS UNDER CONTROLLED TEMPERATURES

VINCENT K. BAILEY
J. V. Bailey Nurseries
Dayton's Bluff Station
Saint Paul 6, Minnesota

The present day propagator has been given the knowledge, through recent research, of how to root softwood deciduous cuttings at a low cost This know-how has been spread by our universities and such organizations as the Plant Propagator's Society We have all cut our costs tremendously by adopting these new methods.

I feel that the propagators work does not stop at putting roots on a cutting. If he can not produce a finished plant economically, he is soon in financial trouble in this very competitive world. The transfer of this rooted cutting into the field has been a challenge to all of us. Many are getting good stands by placing them in bands or pots for a time and then transferring them to a field. There are a number of variations of this procedure but it is very costly in time and labor.

In order to reduce this high labor cost, we started six or eight years ago to transfer these rooted cuttings directly into the field. We were well satisfied with the results in all ways The stands were good and growth was surprisingly vigorous. The storage over winter was in trays packed in peat. Several years ago we tried storing in polyethylene in a modern refrigerated and humidified cooler. I give you this background for our experience to point out our reasons for searching for a better method of getting the finished plant at low cost.

Following is our procedure that we have found to be most economical for producing quality stock. The plants are allowed to mature naturally in the mist beds or the greenhouse benches. Probably one of the reasons for our success with this method is the attention we give to the proper hardening off of this rooted cutting. In my estimation, nothing will take the place of this natural process. The chemical defoliants or mechanical means of leaf removal reduce the vigor of the plant to some

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During the month of November they are removed and placed on a sheet of polyethylene with, of course, the leaves all removed and straightened out as if ready for bunching. The sheet of poly is rolled up with one edge folded ove rthe roots. Use a large enough sheet to completely enclose the plants. The bundles are tied with string or rubber binders. We place 300 to 500 per bundle which makes a convenient size to handle. There is no packing of any sort placed around the roots This is another saving of labor as there is absoluetly no need of any moisture holding material inside these bales. The very small amount of moist sand clinging to the roots and the moist plant itself is sufficient to prevent any desiccation

These bales or bundles are then placed in a room with temperatures of 33 to 34 degrees F The relative humidity is held at 96 per cent This controlled humidity of the storage room is further insurance against any drying of the bales. One might ask how we prevent fungus growth on these plants. There has never been any fungicide used and we have not seen any evidence of growth at any time on these plants. This is, I am sure, due to the low constant temperature of 33 to 34 degrees F. held at all times Most parasitic types of fungus require a much higher range of temperature. The usual labeling and records of location are kept. It is just as simple as that — there is nothing complicated about it.

At planting time in the spring these bales are taken to the field and handled in the usual manner. The medium and larger growing varieties are placed in 44 inch rows while the dwarf varieties are put in two foot rows. As you can see the handling costs are very low. Enough plants can be put in a pickup truck to keep a rather large crew busy all day. Our production is between three hundred and four hundred thousand annually The resulting stands are very satisfactory.

I have here a small bundle of plants to show the method of wrapping and the size of the cuttings used They will be on the table for you to examine at your leisure This method of storing rooted deciduous cuttings is way past the experimental stage with us We have had consistently satisfactory results for the past four years and we are very happy with it

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MODERATOR STEAVENSON: Thank you, Rod. We have time for some questions for Rod.

MR. HANS HESS: In your test with this method of storage, do you confine it entirely to deciduous material or have you done it also with evergreen material?

MR. BAILEY: So far it has just been with deciduous material. One thing I might add here, on our evergreen cuttings, which we take about the 10th of November, we will go through and take all varieties and store them in our cooler We can then take them out when needed in the greenhouse We don't put them in polyethylene. We merely put them in wet moss and at a controlled temperature and humidity

MR. FRED NISBET. Do you have any light in that cold room or is it entirely in the dark?

MR. BAILEY: It is in the dark pretty much except once in a while during the working hours when the lights are turned on. This cooler is also used for storing shrubs and other types of material.

MR. PHILIP M. FISHER (Chicago, Illinois): We only root one type of softwood cutting and that is blueberry stock. At the present time we leave them right in the ground bed. We have already put on about an inch of sod sprinkled all over the cuttings. We use the wire arch of about six inch mesh netting in the summer to support the polyethylene and Saran cloth is added in the winter We cover that whole arch with pine bows. The whole thing freezes solidly and there is still some frost in the ground when we shake them out in the spring. As of the last two years we have had no loss and find it very satisfactory and a very cheap method. We just set the cuttings out in the nursery in the spring.

MR. BOB DE WILDE: You mentioned 33 and 34 as your temperatures Is this extremely critical? Would 40 degrees do?

MR BAILEY: Well, I wouldn't say that it is absolutely necessary to have 33 or 34 degree temperatures but we have had very good results at that temperature.

MR. DE WILDE: Have you had bad results at 40 degrees?

DR. CHARLES HESS: Bill Stoddard and I actually worked with this experiment. This 34 to 38 degree temperature was really essential because of the fact that when you got to higher temperatures you got into trouble with fungus growth I think you mentioned this before at a lower temperature. This low temperature was not high enough to allow growth of the fungi that would cause trouble. The lower temperature, the closer it is to freezing, the slower all the plant processes are, and therefore, the longer they can be stored without changing the plant's internal condition significantly.

MR HOOGENDOORN: Do you roll those cuttings in sheets or do you place those in polyethylene bags?

MR. BAILEY: We use just sheets of polyethylene, which are rolled, overlapped, and tied.

DR. MAHLSTEDE: We have had cuttings of the Maney juniper in polyethylene bags in groups of 15 up to 100, for as long as a year. As of this time we are just starting to take them out now at intervals of 60 days, and potting them to see how they will perform. We intend holding some of these for as long as two years.

Another thing we are doing with this storage technique is to take *Taxus* cuttings in December, flush them, and hardening them in a similar method to what Rod has described, by putting them in storage two or three months. We then store them another two months and put them out in beds We are interested in seeing if we can get a little extra growth by this conditioning sequence.

MODERATOR STEAVENSON. We have time for one more question if somebody has one.

MR. HOOGENDOORN. Has anybody experimented with carrying over evergreens, like arborvitae, juniperus or any evergreen? What I mean, like evergreens we propagate in summer under mist. Have you taken those up in the fall and carried them over. If so under what temperatures or humidity conditions?

MR. HANS HESS: I carried out one experiment a year ago last fall, taking samples of a number of evergreen seedlings and also *Taxus* cuttings, arborvitae, and some of the deciduous material. These were placed in polyethylene bags, tied shut with an elastic band, and were put in ordinary refrigerator in which the temperature held at approximately 34 degrees. They were in there from November until the frost went out in April and were planted outside. All of the evergreens which I tried came through 100 per cent. The varieties of the deciduous materia, that is, deciduous seedlings which did not respond satisfactorily were Pin oak, which was a complete loss, Mountain ash, which gave us a 50 per cent stand, and hawthorn, which also gave us about a 50 per cent stand Viburnums responded very well.

MODERATOR STEAVENSON. We will stand adjourned until 8.00 o'clock p.m., at which time Dick Van Heiningen will be moderator for the Plant Propagators question box.

Let me remind you again that Roy Nordine wants to meet with the arboretum people at 5:30 for a supper meeting.

The session recessed at 4:40 o'clock.

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PLANT PROPAGATION QUESTION BOX

FRIDAY EVENING SESSION

December 2, 1960

The Plant Propagation Question Box Session of the Ninth Annual Meeting convened at 8:00 P.M. in the Mather Room of the Manger Hotel. Mr. Richard Van Heiningen, of Van Heiningen Nurseries, Deep River, Connecticut, presided over the informative session.

This portion of the meeting was not transcribed.

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SATURDAY MORNING SESSION

December 3, 1960

The session convened at 9.00 o'clock, Dr. L. C. Chadwick, Ohio State University, Columbus, Ohio, presiding.

MODERATOR CHADWICK: As usual, in sessions of this type it is a little difficult to get people assembled in the morning. We are glad to see so many of you here.

I am not A. R. Buckley, as the program states, but I have been asked to moderate this morning's program.

We are particularly fortunate in having this first speaker on the program this morning, as all of us are interested in good plant material. I think that most of us would agree that viburnums are among the better shrubs that we have. Dr. R. R. Egolf has had a considerable amount of experience and devoted much study to this genus of plants. I am sure that he will have some very worthwhile information for you this morning. Dr Egolf.

Dr. Roland R. Egolf, U.S. National Arboretum, Washington, D.C. presented his paper on "Noteworthy Viburnums."

NOTEWORTHY VIBURNUMS

Ronald R. Egolf
Cytogeneticist
U.S. National Arboretum
Washington 25, D.C.

The genus *Viburnum*, of approximately 175 species, does not require an introduction to this Society; as it is one of the staples of the nursery trade. You are familiar with one or another of the snowballs, guelder roses, or blackhaws. There are few ornamental groups of plants which display such diversity of form and are adaptable to as wide a range of conditions as *Viburnum*.

The group is widely represented in the north temperature zones of both the eastern and western hemispheres. The native species of this country may not equal their asiatic cousins in spetacular flowering and fruiting characteristics, but they include several of the most adaptable forms The species widely cultivated are natives of Asia, Europe or North America. In addition to the few forms known to most nurserymen there are innumerable choice species that are practically unknown. As seen on the map of the distribution of *Viburnum* the major centers of concentration are in Asia, Eastern U.S. and Central and South America. Unfortunately, none of the species from Central and South America and only a portion of the asiatic species have been introduced into cultivation in this country. When conditions permit, noteworthy additions to horticulture are certain to come from these areas. Likewise, I am confident that many of the so-called "species" of the nursery trade are inferior types to those that could be selected from native populations.

The chromosome complements of *Viburnum* fall into several basic genome groups with the basic number, or n = 8, n =9, or n =10. The greatest number of species, including those native to the U.S., are in the n = 9 group which composes a polyploid series with the diploid chromosome numbers of 18, 36, and 72 The species with n = 8, or Zn, the diploid chromosome number of 16 or multiple thereof, are restricted to one section of the genus that is represented in Asia Among this group of species with a basic chromosome number of 8 are those that have a panicle inflorescence, such as found in *V. fragrans* and *V. sieboldi*. The chematic diagram illustrates a possible interrelationship of the low basic numbers to the higher basic numbers and polyploid species in a range of chromosome numbers from 2n = 16 and 2n = 18 to 2n = 72.

Propagation of most species and cultivars can be readily achieved by one or the other of the cutting, division, grafting, layering, or seed techniques. As with any diverse group not all species will respond to the same treatment In the past, seed, layerage, graftage, and hardwood cuttings were the basic propagation procedures adopted. With the advent of mist propagation the shift has been toward softwood cuttings. Cuttings taken in early June and July can be well rooted in three weeks or less, depending on the species. Such early rooted cuttings will be well established by fall and will be less susceptible to winter injury.

Germination of *Viburnum* seed is complicated by epicotyl and hypocotyl dormancy and or inhibitors. The intensive study made by Giersbach in 1937 indicates that a warm pretreatment at 40°C will induce development of the root. If after a prescribed time lapse, the seed is exposed to 5°C the epicotyl, or shoot, will develop. The length of temperature treatment is not constant for all species and many problems remain before the differences can be fully interpreted. The procedure followed by many propagators of sowing the seed in outdoor beds in early summer and allowing the seed to freeze during the winter, will stimulate the warm period followed by a cold period, that initiates germination. If the seed cannot be sown until late summer the length of warm period may be insufficient and germination will not be achieved until after the second exposure, that is, after the second winter.

Since the topic for discussion is noteworthy viburnums, and not a review of propagation, the major discussion will deal with the diversity and adaptability of the genus However, it is necessary to emphasize the confused complex of species that is grown in many of the American nurseries. What is often offered for sale as a particular species is a complex hybrid of mongrel parentage that has been fathered, reared, and sold by the nurseryman not aware of the confusion and misrepresentation he was creating Viburnums are self- and cross- compatible in varying degrees. The result is that pollen from a poor ornamental specimen may be blown by the wind, or carried by an insect, to a flower on the select clon from which seed is harvested. As a consequence, the propagator, who selects seed in good faith, grows the plant and thus continues the cycle for a number of generations, is not maintaining the species, but is evolving a new race of mongrels that probably warrants little space in any back yard.

It is not to be inferred that certain species cannot be grown from seed with a resultant population of reasonable uniformity in the characteristics of growth, flower and fruit There will always be the odd segregates that are inferior plants. With the ease of vegetative propagation by softwood cuttings greater stress should be placed on select clons which insure the man on the street who purchases the plant, that he has obtained something worthy of his devoted attention. There has been emphasis on seedling plants to insure fruiting; but this cannot be substantiated, as many of the select clons when isolated will be interfertile and fruit abundantly Possibly a few of the species that are shy fruiting do require a higher degree of cross-pollination, but why not utilize several select clons rather than a heterogenous seedling population which in all probability will include a high percentage of discard plants that would prove a sad disappointment to any consumer.

Grafting does provide for the asexual perpetuation of a select clon, but it does not always please the consumer. It is a common practice to use seedling *V. dentatum, V. rhytidophyllum,* and *V. lantana* for grafting or budding understock. Such techniques may produce a salable plant in a shorter period of time, but with softwood cutting propagation the advantages of growth differential are to a large degree minimized. The major objection to grafted plants is the competition that develops between stock and scion. The keen plantsman may recognize the difference between stock and scion and be on the constant vigil with the pruning shears: but the amateur, unaware of such growth from the understock may realize after a few years that he has a plant of *V. lantana* and not *V. carlesi,* or one of the other hybrids. In addition to the competition between stock and scion there is always the matter of compatibility and growth rate of the stock and scion as the plant matures.

The majority of the species are not particular as to soil, but will thrive somewhat better on heavy loams soils with a pH of 6.0 - 6.5

There is always the exception, as with *V. acerifolium, V. furcatum,* and *V. lantanoides,* that prefer a moist, organic soil with a more acid reaction that is in the range of 4.5 - 5.0. *V. cassinoides, V. dentatum, V. lentago,* and *V. scabrellum* are well adapted to moist areas. Whereas, *V. acerifolium, F. lantana, V. opulus, V. prunifolium,* and *V. rafinesquianum* are adaptable to both shade and dry conditions, an environment in which few ornamentals will thrive. Many of the species will benefit by partial shade, but in general, the fruiting forms will produce best if exposed to sun during much of the day.

Once properly established, the Viburnums demand little maintenance, being practically free of insects and diseases. Should sulfur or sprays containing sulfur come in contact with the foliage, it will cause rapid defoliation. The *V. lantana*-type plants will be seriously injured by lead arsenate. Many will recognize *V. opulus* and its cultivars by the distorted leaves and branchlets that have resulted from extensive aphid infestations. Sprays of lindane and malathion applied before the leaves are curled will readily control aphids. Mildew which may be troublesome in late summer, can be controlled with Karathane (Mildex) spray. A bordeaux mixture or other copper fungicide spray will prevent the spread of bacterial leaf spot on certain species of the *V lantana* section. However, this disease rarely is serious enough to disfigure the foliage.

The landscape architect may choose from an array of growth habit forms such as the picturesque, gnarled branches and trunk of *V. sieboldi,* the horizontal tier branches of *V. plicatum tomentosum* and *V. prunifolium,* the globose, compact shrub as *V. carlesi* and *V. dilatatum,* or the dwarf cushion forms of *V. opulus nanum* and *V. fragrans nanum.* Viburnums have many characteristics which make them well adapted for use as specimens, as trimmed or informal hedges, for mass planting, or as small trees with single or multiple stems. The plasticity of form combined with flower, fruit and foliage characteristics will explain the significant position Viburnum holds for the northern landscape architect and nurseryman.

The chart you have is an attempt to summarize the ornamental characteristics of the cultivated Viburnums. No attempt has been made to list all the new introductions since they may not have been released, require further testing, or may be an inferior ornamental. Because the chart is rather comprehensive only a representative sample can be briefly discussed

Attention will be first directed, to the species outstanding in flower. Inflorescence composed of all fertile, all sterile, or a combination of fertile and sterile florets occur in Viburnum.

Viburnum fragrans, the fragrant Viburnum, is the first to flower in the spring. The abundant fragrant, pale pink tubular florets are borne at the end of short spurs. In the North these early buds, which are formed the previous summer, may be injured by freezing. This Farrer's introduction from China is cultivated far too little. *V. fragrans alba* has somewhat larger white flowers; while 'Roseum' is a darker pink selection. The dwarf compact *V. fragrans nanum,* that seldom exceeds two feet in height, tends to flower less freely; but it is a superior plant to *V. opulus nanum,* which never flowers or fruits and is susceptible to aphid injury.

V. grandiflorum is a plant of more robust growth than *V. fragrans* and is nearly unknown in cultivation in this country. This Himalayan plant has a larger flower truss, composed of medium to dark rose florets. Unfortunately, the plant is less hardy than *V. fragrans.* The hybridization of *V. fragrans* and *V. grandiflorum* has produced *V.* x *bodnantense* which is of intermediate flower habit between the parents. In areas where *V.* x *bodnantense* will thrive it is one of the finest for flower. The two cultivars 'Dawn' and 'Deben' are both excellent.

The plant which probably rates near the top of any list is *V. carlesi,* the Fragrant or Koreanspice Viburnum. The buds open from pale pink to white flower clusters at the same time the velvety, pale green leaves are unfolding. *V bitchiuense* is very similar in flower to *V. carlesi,* but more spreading in habit of growth. Several selections of this species are worthy of extensive cultivation. The hybrid *V.* x *juddi* is intermediate between its parents *V. carlesi* and *V. bitchiuense,* and a noteworthy addition to any garden. *V. carlesi* was crossed with *V. utile* to produce the semi-evergreen *V.* x *burkwoodi,* 'Park Farm Hybrid' and *V. chenaulti.* None of these are as heavily scented as *V. carlesi.* The foliage of *V. chenaulti* is slightly smaller and somewhat more compact than *V.* x *burkwoodi,* but in general the plants have much in common. In northern areas these cultivars will be deciduous, but further south they will remain evergreen until midwinter. *V.* x 'Carlotta' and *V.* x 'Anne Russell' are seedlings of *V.* x *burkwoodi* which probably are not significantly different from the parents. *V.* x *carlcephalum* is a relatively recent introduction from England,) but the plant is now more than a quarter century old. *V.* x *carlcephalum* is a robust growing plant with a larger and coarser inflorescence than *V. carlesi.* The attractive white flowers of the evergreen *V. utile,* the Service Viburnum, are not well known. *V. utile* is hardy as far north as Philadelphia and deserves cultivation in many more nurseries.

The greatest number of species have the inflorescences composed of innumerable small white to cream-white fertile florets. These provide a display for only a few days. However, in such species as *V. dilatatum, V. prunifolium, V. rufidulum* and *V. sieboldi* the mass of airy white flower clusters can be a feature of the landscape.

The snowballs are probably the most widely known group since the European Snowball, *V. opulus roseum,* and lilac were plants commonly transported by our ancestors across the frontiers as they moved West. The grotesque pattern created by aphid injury on the branches is a fairly reliable identification characteristic. *V. opulus roseum* is the hardiest of the snowballs. *V. macrocephalum,* the Chinese Snowball, is the least hardy and cannot be grown successfully north of Baltimore unless trained to a wall or planted in a protected patio corner. The Japanese Snowball, *V. plicatum,* is generally known in the commercial trade as *V. tomentosum sterile. V. tomentosum* is not a valid name and the plant with the ring of sterile marginal florets around the cluster of fertile florets should properly be identified as *V. plicatum tomentosum.* The Japanese Snowball is a choice ornamental, but less hardy than *V. opulus*. However, aphids are no serious problem on the plant. *V. plicatum* 'Rosace' is a new pink introduction which is not yet well known. Since none of the snowballs fruit they are only showy when in flower.

The mixed type inflorescence composed of a cluster of fertile florets surrounded by a marginal row of enlarged sterile florets includes some of the most ornamental flowering Viburnums A plant contending for the top position is *V. plicatum tomentosum,* the Doublefile Viburnum, with its architecturally tiered branches of white to cream flowers in mid-to-late May. The plant develops into a specimen nine feet high and often wider. The cultivars 'Lanarth' and 'Mariesii' differ little from each other but are more showy than the species. The cultivar 'Rowallane' is a fine textured specimen that has smaller leaves, flowers freely and fruits abundantly. 'Rowallane' is not widely cultivated in this country. *V. plicatum tomentosum 'Roseum'* is a plant of variable performance. If the season is cool and the soil slightly acid, a pale pink coloration will develop on the sterile florets. The response will vary from year to year depending on the climatic conditions.

The inflorescence of *V. opulus, V. trilobum,* and *V. sargenti* are the same type as those of *V plicatum tomentosum.* Although these species and their cultivars are more spectacular in fruit, the flower display increases the effective usefulness of the species. *V. lantanoides,* the *Hobble Bush,* and *V. furcatum* its Japanese counterpart, will enlighten any woodland trail with their cream-white floral display.

It is the fruiting characteristics for which many species are cherished. The blue and blue-black fruits are the leat spectacular but those like *V. cassinoides* and *V prunifolium,* often display remarkable contrast as the clusters of green fruit pass through the multiple color changes. Nearly all the native species of this country have black to blue-black fruit that provide a source of food for wildlife in winter. The evergreen Chinese *V. davidi* and the European *V. tinus* display some of the most vivid metallic blue fruits However, these must be viewed close-up as blue is not a strong contrast color with green.

With few yellow-fruited shrubs the four yellow fruited Viburnums can be highly recommended. The fruit passes from a pale yellow to a rich orange-to-brown with freezing weather as it matures on *V. opulus xanthocarpum, V. sargenti flavum,* and *V. setigerum aurantiacum.* The light yellow fruit of *V. dilatatum xanthocarpum* is not seriously damaged by freezing and will remain on the plant until early winter.

A few species present a spectacular fruit display for a few weeks in late summer or early fall when the fruit changes from green to orange or red and finally to black. One of the most striking is *V. plicatum tomentosum* which displays its abundant small red fruit above the horizontal branches Unfortunately, as the fruit matures on this species, as well as that of *V. sieboldi,* it is rapidly devoured by birds. The fruit of *V. sieboldi* provides a striking contrast in mid-summer between the bright red fruit on red pedicels and the deep rugose leaves. Even after this fruit has completed its color change to black and has been eaten by birds, the prominent red pedicels remain to enhance this fine specimen plant. *V. lantana* probably affords the best display for the shortest period of time in mid-August when the fruit clusters contain the brilliant orange fruit in various stages of maturity. Depending on climatic conditions the duration of this display may be a few days to a few weeks. The large fruit clusters of *V. rhytidophyllum* are not as brilliantly colored but add interest to this evergreen plant in late summer.

Of all the fruiting viburnums the most highly prized are the persistent red fruit types. With the exception of *V. opulus* from Europe, *V. edule,* and *V. trilobum* from North America, these are all of Asiatic origin. *V. dilatatum*, which is well known, or should I say too well known to you, is also marketed by many nurseries under the name *V. wrightii.* This compact, bushy shrub is adaptable to many landscape uses. The flower display, the form of growth, the russet-red autumn foliage, and, last but not least, the abundant red fruit, place this plant near the top of the list of select species. *V. wrightii,* a misnomer to most nurserymen, is an equally valuable plant with a superior fruit display. *V. wrightii* has ovate glabrous leaves, shoots and a terminal bud enclosed by red bud scales. This plant is distinct from *V. dilatatum* which has soft pubescent leaves, densely villous branches and gray-brown pubescent bud scales. The fruit of *V. wrightii* is larger, glossy scarlet early in the season and persists on the plant. Many nurseries offer a more pubescent form of *V. dilatatum* as *V. wrightii.* The nurseryman is not wholly responsible for this misrepresentation as the majority of Japanese seed firms supply *V. dilatatum* seed rather than V. wrightii. With select plants of each of these species available, they should be asexually propagated. From seedling populations of either of these will result many inferior seedlings.

V. lobophyllum and *V. betulifolium* comprise an even more confused lot. These Chinese red-fruited species are not easily separated. The leaves of *V. lobophyllum* are broadly ovate, abruptly narrowed at apex, rounded at base and with shallow teeth. Those of *V. betulifolium* are ovate to diamond-shaped, broadly wedge-shaped at base, the terminal part more gradually tapered and coarsely toothed. Probably the best distinguishing characteristic is the stone which in *V. betulifolium* is smaller and nearly circular in outline, in *V. lobophyllum* ovate, tapering to a point at one end and more deeply grooved. Young plants of *V. betulifolium* are sparse to fruit but older specimens are masses of pendulous scarlet red fruit. *V. hupenhense* is sometimes confused with *V. betulifolium* and *V. lobophyllum* but can be distinguished by the dense stellate pubescence on both leaf surfaces. This shrub is shy to fruit every year, but a fine specimen is outstanding.

Another taxonomical complex exists between *V. setigerum* and *V. phlebotrichum. V. setigerum,* or *V. theiferum,* the tea viburnum, is an erect shrub which often has the branches arched under the weight of the fruit clusters. Upon exposure to freezing the fruit becomes translucent. *V. setigerum* is distinguished from the lower growing *V. phlebotrichum* by its larger and longer-stalked, thicker denticulateserrate leaves by the longer stamens, and by the outermost scales of the winter buds being more than half as long as the whole bud. It is a much more vigorous shrub and larger in every part. This plant will fruit freely if given sunlight and good drainage.

A few other red-fruited Asiatic species worthy of extensive cultivation are *V. ichangense, V. foetidum, V. wilsoni,* and *V. japonicum.* The cream-colored florets in large cymes, brilliant red fruit and waxy evergreen foliage of *V. japonicum* are combined in one of the best plants for areas south of Washington.

Many more plants of *V. opulus, the European Cranberrybush,* are grown than of *V. trilobum,* the American Cranberrybush. In warmer zones it will perform slightly better than our native cranberrybush, but for northern areas *V. trilobum* cannot be equaled. Since it grows far north into Canada, it can withstand the severest winters. *V. opulus* and its cultivars are annually disfigured by aphids, whereas *V. trilobum* is immune to this distortion. Again, a plant complex has resulted between these two species. Few nurseries are growing and marketing a true *V. trilobum* which has three distinct broad lobes, small glands at the petiole base, a narrow grooved petiole, branches smooth light gray-brown, and an overall wide spreading habit of growth The fruit of *V. opulus* is bitter, but that of *V. trilobum* is edible and makes fine jelly. The cultivars of *V. trilobum* are not readily obtainable and would be notable additions to any nursery list. The cultivars 'Hans,' 'Andrews' and 'Wentworth' were selected for their fruit characteristics. 'Andrews' has stout stems which hold the large, late-ripening fruit erect 'Hans' has medium-size fruit clusters that ripen in September 'Wentworth' is a vigorous, spreading bush that has large drooping clusters of large fruit that ripens in mid-August. The lower growing 'Compactum' which produces many thin stems and fruits well can be highly recommended. The cultivars 'Manito' and 'Phillips' are recent large fruit selections. A pink flowering form has been located in British Columbia.

The more vigorous, large fruited *V. opulus* 'Notcutt' may well provide a good replacement for *V. opulus* The intermediate *V. opulus compactum* is free fruiting and a plant more adaptable to modern landscape usage than the tall, coarse growing *V. opulus.*

V. sargenti is a third species with deeply lobed leaves that can be distinguished by the elongated central lobe of many leaves, especially on young vigorous growth; the dark corky bark of the older branches, and the purple anthers. The Sargent viburnum is a plant of imposing upright stature with heavy textured leaves. The fruit, which is less abundant than on *V. opulus* or *V. trilobum,* persists on the plant until late winter.

The *Viburnum* autumn foliage display will vary from clear yellow, orange, red, to purplish reds and maroon, with many species being very nondescript and blending with the neutral tones of the surrounding scene. *V. sargenti flavum* and *V. opulus xanthocarpum* put forth some fine yellow hues at the same time that *V. opulus, V. trilobum* and *V. sargenti* are decked out in orange-reds. *V acerifolium* provides some of the best red foliage in the autumn woodland. The darker reds of *V prunifolium, V. lentago, V. rufidulum, V. nudum* and *V. cassinoides* provide accent points to any landsape. *V. dilatatum, V lantanoides, V. plicatum,* and *V sieboldi* are noteworthy for their display of dark reds to purplish reds

Among this diverse genus are many that are evergreen. Of course, the majority of these are restricted to southern areas. *V. rhytidophyllum,* the Leatherleaf viburnum, with its deeply fissured long narrow leaves, is a familiar sight in the north. Unless this plant is in a sheltered corner the windswept foliage will become severely burnt and possibly the plant defoliated during the winter The pink flower form, *V rhytidophyllum roseum,* is only pink in the early bud stages and opens to a creamy-white. The hybrid *V.* x *rhytidophylloides, V rhytidophyllum* x *V. lantana,* is a hardier large shrub that will tend to be semi-evergreen. *V.* x *rhytidocarpum,* a cross between *V. rhytidophyllum* x *V. buddleifolium,* is semi-evergreen and has few points to recommend its use.

V. japonicum and *V. utile* have already been referred to, but I would emphasize that these evergreens are worthy of more extensive cultivation. In the warmer zones *V. cinnamomifolium, V. davidi, V odoratissimum, V suspensum* and *V. tinus* are grown. *V. suspensum* is a medium sized shrub with glossy oval leaves supported by slender warty stems which develop into an arched mound-like specimen. *V. odoratissimum* has panicles of fragrant white flowers that are followed by brilliant red fruit that finally turns black. Few species express the extreme variability of *V. tinus.* In late autumn and again in the winter and early spring, the abundant flower buds will open after a few warm days to a white mass of bloom. The flower buds that were formed the previous season are often winter injured and the flowers turned brown by frosts The dark green foliage will be severely injured in areas north of Washington. The low growing *V. davidi* with its deeply veined, handsome evergreen leaves, rates a top spot on any list of select species The white flowers are superseded by brilliant metallic blue fruits that persist for months. Here is a plant useful for many situations and ideal for planters. *V. cinnamomifolium* has the same deeply three-veined leaves as *V. davidi* but is a tall growing shrub or small tree.

Such species as *V. propinquum, V atrocyaneum, V. calvum, V henryi* and *V. cylindricum* after further evaluation will undoubtedly extend the list of recommended evergreen species Further selection and hybridization among such a diversified genus is certain to yield even more select cultivars. In the meantime, more of the select forms now available should be asexually propagated.

TABLE 1.—THE CULTIVATED VIBURNUMS

Viburnum	Habitat	Height	Flw Date	Color Fruit	Fruit Season	Zone	Special Comments
acerifolium	NE U S	3'-6'	early June	black	S,F	4	Useful in dry, acid woodlands; *red autumn foliage.
X 'Ann Russell'	Hybrid	5'	*early May	black	S	6?	Cross of *V carlesi* x *V. burkwoodi;* heavy textured glossy green foliage; pink buds open to sweetly-scented white flowers.
atrocyaneum (E)	China, India	10'	late May	blue-black	F	8	*Finely branched evergreen shrub; red-bronze in winter.
betulifolium	C & W	12'	late May	*bright red	F,W	6	Young plants fruit sparsely, wide arching plant with abundant fruit.
bitchiuense	Japan	10'	*early May	black	S	6	Open, thinly branched; pink form excellent ornamental; flowers fragrant; foliage maroon to red in autumn.
X *bodnantense*	Hybrid	10'	*March-April	black	S	5b	Cross of *V. fragrans* X *V, grandiflorum;* flowers rose in bud open white, 'Dawn' and 'Deben' select cultivars; flower buds may be winter-injured.
buddleifolium	C China	8'	mid-May	red to black	S,F	6	Leaves up to 8" long, pale green, soft, velvety-textured; semi-evergreen.
burejaeticum	Manchuria, China	15'	May	bluish-black	F	5	Twigs glabrous and nearly white the second season.
X *burkwoodi*	Hybrid	6'-8'	*early-mid-May	black	S	5b	Cross of *V utile* X *V. carlesi;* *glossy, semi-persistent foliage; 'Park Farm Hybrid' form attains breadth rather than height; flowers pinkish to white, fragrant

(Continued on next page)

E — Following species indicates evergreen
* — Outstanding for characteristic.
Fruit Season — S = summer, F = fall, W = winter.
Zone — Suffix b used with hardiness zone number indicates that the plant is hardy only in the warmer parts of a zone According to Plant Hardiness Zone Map, U. S Dept. of Agr , Misc Publication #814.

Table 1 (Continued)

Viburnum	Habitat	Height	Flw Date	Color Fruit	Fruit Season	Zone	Special Comments
calvum (E)	W China	4′	early May	blue-black	F	7b	*Fine textured, compact growth
X *carlcephalum*	Hybrid	6′	*1 April, early May	black	S	5b	Large clusters of clove-scented, white flowers; tends to be somewhat coarse in habit of growth; good autumn color
carlesi	Korea	5′	*1 April, e May	black	S	5b	Pink buds open to fragrant white, waxy blooms, plant in semi-shady position; *reddish-purple autumn foliage, 'Compacta' a dwarf form
X'Carlotta'	Hybrid	5′	*1 April, e May	black	S	5b	Seedling of V. burkwoodi which is little different from *V. carlesi*.
cassinoides	E US	6′	early June	*red to blue-black	F	4	Prefers acid, moist soil; symmetrical plant with glossy green foliage; multicolored fruit clusters spectacular in Aug. and Sept., var *nanum* a distorted, compact plant with crinkled leaves
X *chenaulti*	Hybrid	6′	*1 April, e May	black	S	5	More compact form than *V burkwoodi;* autumn foliage reddish-bronze, pale pink to white, fragrant flowers
cinnamomifolium (E)	China	18′	May	blue-black	F	7b	*Large dome-shaped evergreen with deeply veined leaves
cordifolium	China, Himalaya	10′	*April	red to black	F	6?	Snowball type inflorescence, plant not known in cultivation, but worthy of introduction
corylifolium	India, China	10′	1 May	scarlet	F,W	6	Inferior to *V dilatatum* in fruit
cotinifolium	Himalaya	12′	mid-May	red to black	F	5b	Leggy, coarse plant; less hardy than *V lantana;* foliage reddish-bronze in autumn
cylindricum (E)	India, China	15′	early June	black	F	7b	Leaf dull green and covered with thin layer of wax which cracks or shows gray when leaf is bent

(Continued on next page)

Table 1 (Continued)

Viburnum	Habitat	Height	Flw Date	Color Fruit	Fruit Season	Zone	Special Comments
dasyanthum	China	8′	mid-June	*red	F	6b	Glabrous branchlets become purplish brown second year; choice fruiting species, not widely cultivated
davidi (E)	W China	2′-3′	June	*metallic blue	F W	7b	*Handsome, low spreading, compact shrub with dark, leathery, evergreen foliage; certain plants tend to have sexes separate, a choice plant for planters
dentatum	NE US	15′	mid-June	blue-black	S F	3	Multiple stem plant, shade tolerant, moist areas; *red to purplish-red autumn foliage, var *pubescens* similar in habit of growth
dilatatum	China, Japan	10′	*l May, e June	*red	F,W	5b	Compact shrub, one of th ebest for persistent fruit; 'Improved' and 'Moraine' selected cultivars
dilatatum xanthocarpum	Hort form	10′	*l May e June	*yellow	F,W	5b	Yellow fruit form will not come true from seed
ellipticum	NW US	8′	l May, e June	black	F	6	Slender shrub of mountainous regions; rarely cultivated
edule	N US	5′	May-July	*red	F,W	2	Rarely cultivated; succeeds best in half shady, moist, cool situation
erosum	Japan, China	6′	mid-May	red	F	6	Slender, much-forked branches; flower and fruit clusters long stalked, plant somewhat straggly in appearance
erubescens	Himalaya, W China	15′	early June	red to black	S	6	Fragrant, pale pink flowers in drooping panicles; plant in cultivation is a poor form which often suffers winter injury
foetens	Himalaya	5′	early winter & spring	red to black	S	7	Leaves pungent odor when crushed or while decaying; one of earliest species to flower; plant in protected location

(Continued on next page)

Table 1 (Continued)

Viburnum	Habitat	Height	Flw Date	Color Fruit	Fruit Season	Zone	Special Comments
foetidum	Himalaya, China	8′	June	*bright red	F	8	Semi-evergreen; excellent fruiting plant; leaves produce an unpleasant odor when crushed or removed from plant.
fragrans	N China	9′	*late March, early April	red to black	S	5b	Blush-pink, sweetly scented flowers appear at end of short spurs after the first few warm days of spring; flowers often killed by winter freezing; plant in sheltered, sunny spot; 'Roseum', and 'Bowles' selected clones
fragrans alba	N China	9′	*1 March, e April	cream to black	S	5b	Free flowering form with slightly larger individual blooms; more susceptible to winter injury.
fragrans nanum	Hort. form	2′	*1 March, e April	red to black	S	5b	Dwarf, compact plant which does not flower as freely as the species
furcatum	Japan	10′	*early May	scarlet to black	S	6	Similar to *V. lantanoides,* more upright; requires humid, shaded situation; *brilliant scarlet to reddish-purple autumn foliage.
grandiflorum	Himalaya	10′	*early March, April	red to black	S	6	Rose-colored flowers will not endure as much frost as *V. fragrans;* young plants tend to be leggy and sparse flowering.
harryanum (E)	W. China	6′	mid-May	black	F	8	Very distinct small leaves which may be in a whorl or opposite, *compact evergreen with a privet-like appearance
henryi (E)	C. China	9′	early May	*coral red to black	S	7	Shrub or small tree spectacular with fruit in late summer, may become defoliated in severe cold weather
X *hillieri* 'Winton'	Hybrid	6′	June	red changing to black	S	7	Natural cross of *V. henryi* X *V. erubescens;* wide spreading shrub with dark green, glossy foliage

(continued on next page)

Table 1 (continued)

Viburnum	Habitat	Height	Flw Date	Fruit Color	Fruit Season	Zone	Special Comments
hupehense	C China	6′-8′	late May	*red	F	6	Presence of stipuled leaf stalks and orbicular ovate leaves distinguish it from *V. dilatatum*. Dense pubescence of leaves distinguishes it from *V. betulifolium*.
ichangense	C & W. China	6′	mid-May	*red	F	7	Slender-branched shrub; leaves pubescent beneath; ovary and inflorescence densely villous
X *jacki*	Hybrid	12′	mid-May	black	F	4	Cross of *V lentago* X *V. prunifolium;* intermediate between parents.
japonicum (macrophyllum) (E)	Japan	6′	late May	*red	F	7	*Sturdy shrub with glabrous young shoots and leathery ovate leaves; a fine plant for woodland conditions
X *juddi*	Hybrid	15′	*early May	black	S	6	Cross of *V carlesi* X *V. bitchiuense;* flowers fragrant pinkish-white; more spreading than *V bitchiuense*
kansuense	W China	4′-8′	May	red	F	6	A species of the *Opulus* group that lacks showy sterile flowers, leaves deeply lobed, flowers purplish-white.
lantanoides (alnifolium)	NE U S.	12′	*late April	red to black	S	4	Will only thrive in moist, acid woodland, *leaves a dull brick-red in autumn
lantana	W Asia & Europe	15′	mid-May	*orange-red to black	S	4	Striking contrast in late summer between strong foliage and half-ripe fruit; tolerates dry situations; dense rounded form, dark, heavy foliage; red autumn coloration.
lantana rugosum	Europe	15′	mid-May	*orange-red to black	S	4	*Leaves larger, darker green and more wrinkled than the species
lantana variegatum	Hort form	10′	mid-May	orange-red to black	S	4	Leaves variegated yellow, unless planted in partial shade will burn in summer.

Continued on next page

Table I (continued)

Viburnum	Habitat	Height	Flw Date	Fruit Color	Fruit Season	Zone	Special Comments
lentago	E US	30′	mid-May	*blue	F,W	3	Much branched, round topped, large shrub or small tree, *autumn color red to purplish red
lobophyllum	C & W China	15′	late May	*red	F,W	6b	Leaves broadly obovate abruptly narrowed at apex; rounded at base; much confused with *V. betulifolium* and *V hupehense*
macrocephalum (*macrocephalum sterile*)	Garden form from China	12′	*early-mid-May	--	--	7	Largest of the snowballs with inflorescences as much as 8″ diameter; in colder areas can be trained to a protected wall, semi-evergreen in south
macrocephalum keteleeri	China	12′	*early-mid-May	black	F	7	Only the marginal flowers are sterile showy type; somewhat hardier than the wholly sterile plant
molle	C & S US	12′	late May	blue-black	F	6	Interesting bark peeling revealing shiny under surface, dense, bushy shrub for naturalistic plantings
mongolicum	Siberia & China	6′	mid-May	black	F	5	Species in cultivation rarely properly identified; plant chiefly of botanical interest
nudum	E US	10′	early-mid-June	blue-black	F W	6	*Lustrous large leaves assuming brilliant red fall color, grows best in moist areas
obovatum	E US	10′-30′	late April	black	F	8	Dense, low shrub with small oblanceolate leaves that turn bright-red in autumn
odoratissimum (E)	India to Japan	10′-25′	*late May	*red changing to black	S	8	*Large shrub or small tree with handsome evergreen foliage; small white flowers in pyramidal clusters 4″-8″ long
opulus	Europe, N Africa, N Asia	12′	late May	*red	F,W	3b	Persistent, decorative, scarlet fruit, tolerant of dry situations, foliage and branches nearly always distorted by aphid injury
opulus compactum	Hort. form	4′	late May	*red	F,W	3b	Compact form that fruits freely, orange-red autumn foliage

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Table I (continued)

Viburnum	Habitat	Height	Flw Date	Fruit Color	Fruit Season	Zone	Special Comments
opulus nanum	Hort form	2′		- -	- - -	3b	*Dwarf form adaptable for hedges; seldom flowers
opulus 'Notcutts	Hort form	12′	late May	*red	F,W	3b	Larger fruit selection which may be slightly more vigorous
opulus roseum (*opulus sterile*)	Hort form	12′	*mid-May	- -	- -	3b	European snowball; globose clusters of sterile flowers, subject to serious aphid injury
opulus variegatum	Hort form	12′	*late May	red	F,W	3b	Yellow variegated foliage burns in the heat of summer
opulus xanthocarpum	Hort form	12′	*late May	*yellow	F,W	3b	Golden yellow fruit becomes translucent yellow during winter, clear yellow fall color, compact, round-headed shrub
orientale	W Asia W Caucasus	10′	late May	*red	F	6	Large, ornamental fruit, type plant not known in cultivation
phlebotrichum	Japan	8′	early May	*red	F	7	Smooth, yellowish-gray branches, small leaves with short petiole, fruit clusters nodding
plicatum (*tomentosum sterile*)	Garden form	9′	*late May	- -	- -	5b	Japanese snowball, graceful shaped shrub, tender during severe winters, *red to purplish-red autumn foliage, 'Rosace' recent pink cultivar selection
plicatum grandiflorum	Hort form	9′	*late May	- -	- -	5	Hardy, more vigorous than *V plicatum*, pure white flowers clusters
plicatum tomentosum (*tomentosum*)	Japan, China	9′	*late May	*red to black	S	5	Twin rows of inflorescences with marginal sterile flowers, horizontal branches, less hardy European snowball, *purplish-red autumn foliage
plicatum tomentosum 'Mariesii'	Hort form	9′	*late May, early June	*red to black	S	5	Larger trusses and sterile florets, than the species; variety 'Lanarth' similar

Continued on next page

Table I (continued)

Viburnum	Habitat	Height	Flw Date	Fruit Color	Fruit Season	Zone	Special Comments
plicatum tomentosum 'Roseum'	Hort form	6′-8′	*late May	*red to black	S	5	Under certain soil and climatic conditions the flowers are soft, pale pink; intensity of flower color will vary with years
plicatum tomentosum 'Rowallane'	Hort form	8′	*late May	*red to black	S	5	A refined form with smaller leaves; flowers and fruits abundantly.
propinquum (E)	C & W. China	6′	early May	blue-black	F	8	*Bushy, evergreen shrub; variety *parvifolium* has narrow leaves which present a finer texture.
prunifolium	E US	15′	*mid-May	*blue-black	F,W	4	Large shrub or small tree with horizontal branches; pendant black fruits persist often until March; *autumn foliage rich, wine-red; select cultivars 'Holden', a weeping form; and 'Gladwyne', large fruit form
rafinesquianum	E US	3′-6′	*late June	blue-black	F	3	Compact shrub, very floriferous; foliage with fine texture; grows naturally in dry, rocky soils
X *rhytidocarpum*	Hybrid	8′	late May	red to black	F	6b	Cross of *V. rhytidophyllum* X *V. buddleifolium;* leaves intermediate between parents; semi-evergreen.
X *rhytidophylloides*	Hybrid	15′	late May	red to black	F	6	Cross of *rhytidophyllum* X *V. lantana;* semi-evergreen, deeply-veined foliage persists well into winter; hardier than *V. rhytidophyllum;* 'Willow Wood' and 'Holland' select clones.
rhytidophyllum (E)	C. & W China	10′	mid-May	red to black	F	6	Stiff, ascending branches; leaves wrinkled and very tomentose beneath; bold-textured, dark foliage, droops in cold weather; avoid planting in windswept areas; a species of much variation; 'Aldenham' select clone.
rhytidophyllum roseum (E)	Hort. form	10′	*mid-May	red to black	F	6	Flower buds bright pink but color fades as florets open.

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Table I (continued)

Viburnum	Habitat	Height	Flw Date	Fruit Color	Fruit Season	Zone	Special Comments
rigidum (*rugosum*) (E)	Canary Island	8′	April-May	blue-black	F,W	9	More robust growth than *V. tinus;* larger leaves, densely pubescent; less hardy than *V. tinus.*
rufidulum	SE U S	30′	mid-May	blue-black	F	6	Velvety, dark brown winter buds; *dark glossy green foliage becomes dark blood red in autumn; horizontal branching
sargenti	NE Asia	12′	*late May	*red	S,F	5	Leaves thick textured; many with elongated center lobe; corky bark, vigorous growth; resistant to aphid injury; plant with imposing stature.
sargenti flavum	Hort form	10′	*late May	*yellow	S,F	5	Similar to species but with golden yellow fruit; must be propagated asexually as will not come true from seed
scabrellum	SE. U S	10′	June	blue-black	F	6	Reddish-brown branches; suitable plant for naturalizing in moist woodlands
schensianum	China	8′	mid-May	red to black	F	5b	Shrub with slender branches which are stellate pubescent when young; plant seldom cultivated under proper name
setigerum (theiferum)	C. & W. China	12′	mid-May	*red	F	6	Leggy plant often arched under weight of fruit; plant often injured by late spring frosts, leaves larger and longer stalked than on *V phlebotrichum*
setigerum aurantiacum	Hort form	12′	mid-May	*yellow orange	F	6	Fruit changes from pale yellow to intense orange as it matures, good plant for contrast
sieboldi	Japan	30′	*late May	*red to black	S	5	*Shrub or small tree; large, dark green rugose leaves; red fruit pedicels ornamental; a fine specimen plant
sympodiale	C China	8′	April	red to black	F	6	Sympodial growth, leaves elliptic-ovate, sub-cordate at base
suspensum (E)	S Japan	4′-6′	April-May	coral red to black	S	8b	Evergreen shrub with large, oval, shiny green leaves on slender, warty stems; fragrant, rose-tinted white flowers

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Table I (continued)

Viburnum	Habitat	Height	Flw Date	Fruit Color	Fruit Season	Zone	Special Comments
tinus (E)	S Europe, N Africa	10′	*March April, autumn	*metallic blue	S,F W	7b	Variable species with many selections; compact glossy foliage; in northern areas may winter burn and injure flower buds
tinus variegatum (E)	Hort form	6′	April, autumn	metallic blue	F,W	7b	Leaves variegated white, yellow, green; will burn in full sun
trilobum	N E U S	12′	*late May	*red	S,F, W	2	American cranberry bush, hardier than V opulus; large fruits in drooping clusters remain on plant until late spring; less satisfactory in south; grows best in slightly acid, moist soils; fruit edible; deep red fall color Select cultivars include 'Hans', 'Andrews', 'Wentworth', 'Phillip', 'Manito' and pink flower form
trilobum compactum	Hort form	5′	late May	red	F,W	2	Much-branched shrub, adaptable for hedges, freely flowers and fruits
urceolatum	Japan	3′	May	black	F	6	Straggling shrub with procumbent rooting stems; plant in general cultivation under this name is *V opulus*
utile (E)	C China	5′	*late April early May	red to black	F	6	*Graceful shrub of distinct open habit; producing cluster of flowers similar to *V carlesi*
veitchi	C China	6′	mid-May	red to black	F	6	Shrub similar to *V lantana* but more ornamental; under surface of gray green leaves densely clothed with stellate pubescence
X-*vetteleri*	Hybrid	10′	late May	blue black	F	5	Cross of *V lentago* X *V. nudum,* plant probably not in cultivation in this country, dense foliage, plant of globose form
wilsoni	C China	8′	mid-May	*red	F	6	Firm red fruit rapidly eaten by birds; type plant seldom cultivated
wrighti	Japan	9′	*late May	*red	F,W	5b	Abundant, handsome red fruit is well displayed against the dark green leaves; young shoots and leaves nearly glabrous Plant grown under this name in most nurseries is V dilatatum
wrighti hessei	Hort form	3′	*late May	*red	F,W	5b	Dwarf form that fruits freely.

MODERATOR CHADWICK: Thank you, Dr. Egolf, for this very interesting discussion of the viburnums.

We have about five minutes if there are any questions.

MR. ROLAND DE WILDE. I would like to ask if *Viburnum davidi* is being disseminated by your arboretum.

DR. EGOLF: I knew this question would sooner or later come up for some of these selections. My collection now consists of 1900 selections which are under trial. The arboretum will not distribute these direct. The stock will be turned over to the Glendale Station from which it will be distributed to commercial nurseries. At present I do not anticipate releasing any viburnums during the coming year.

MR. RALPH SHUGERT: Would you comment, please sir, on the merits of *Viburnum carlesi* as against *Viburnum juddi*, let's say in southwest Missouri. We find *V. juddi* performing a little better in the field than *V. carlesi*.

DR. EGOLF. In general *V. carlesi* is better than *V. juddi*. The true *V. carlesi* from China is a superior plant to what is grown by most nurseries since it is much more hardy.

I noticed you mentioned *Viburnum fragrans* as compact. My experience with this plant is that it is loose and lacy.

DR EGOLF: That is typical of many of the forms of fragrans which were brought from China by Bowles. It is also pink and tends to have the lacy character of *V. fragrans* grown in the nursery.

MR. JIM WELLS: The nurserymen seem to be taking a beating here for maintaining poor plants. I would like to ask how soon do you expect to release these better forms? When can we get something good?

DR. EGOLF: There are some good things in the trade now that are propagated asexually by certain nurseries. It is not particularly proper for me, being a representative of the Government, to promote any particular plant, and I refrained from listing specific plants. *Viburnum dilatatum* is asexually propagated in the nursery trade now

Two names which I can give you offhand are: Improved and Moraine, both are excellent.

MR. MARTIN VAN HOF: What about *Viburnum trilobum* and *americanum?*

DR. EGOLF: *Viburnum trilobum* and *americanum* are synonymus.

MODERATOR CHADWICK: Any further questions? Bill Flemer.

MR. FLEMER: Do you think that *Viburnum opulus* and *trilobum* hybridize in the field?

DR EGOLF. They do.

MR. FLEMER Will they hybridize naturally?

DR. EGOLF: They aren't natural but I have crossed the two and have seedling populations coming on which are intermediate between the two parents. I don't know if either of the parents, can equal some of the select forms of *V. trilobum* now available.

MR. FLEMER: On this same subject again, how would you differentiate between *V. opulus* and *trilobum?*

DR. EGOLF: *Viburnum trilobum* has three very prominent lobes, with the upper two lobes being nearly at right angles to the center. The petiole has very small glands and is narrow-grooved. The overall growth of *Viburnum trilobum* is widespreading while *Viburnum opulus* is more upright with a urn-shaped lobe.

MODERATOR CHADWICK: The next subject we have for discussion this morning is on the propagation of *Sciadopitys verticillata,* a plant that perhaps isn't as well known as it should be. I believe it has certain characteristics that warrants its use in landscape work a lot more than it has been used in the past. Probably the reason why it hasn't been used more is the difficulty experienced in propagating this plant.

Dr. Waxman of the University of Connecticut has been working on this problem for sometime, and I am sure that he has an interesting report for us this morning. Sid!

DR. SIDNEY WAXMAN: Thank you, Chad. I am glad you did not say for just how long a time.

Dr. Waxman then presented his paper on the results of experiments with various techniques used to propagate the Japanese umbrella pine.

PROPAGATION OF SCIADOPITYS VERTICILLATA

Sidney Waxman

Department of Horticulture
University of Connecticut
Storrs, Connecticut

The Japanese umbrella pine is certainly a highly desirable tree. It is a pyramidal, closelv compact tree with glossy foliage. It is almost entirely free from insect and disease injury, and on the whole is a plant we should use more.

It is an interesting tree from several aspects, ie, it belongs to a genus that is composed of only one species, and no other evergreen resembles it, in fact, no fossil records of it have ever been found. It is thought by some people to be a remnant of an age long past.

There is a natural stand of these trees in the mountains of Japan, (Mount Kojasnin), where they have attained a height of from 79 to 90 feet. Specimens are only rarely seen in this country. However, more people are now becoming quite interested in this plant and there are several nurseries in the New England area that are growing them. The umbrella pine is fairly hardy, growing as far north as Portland, Maine. Most umbrella pine are found in the East. Also, I understand that there are some on the west coast. This tree was first brought into this country by Dr. G. R. Hall of Bristol, Rhode Island as far back as 1862.

There are several reasons why there are so few umbrella pine being propagated. One of these is the slow rate of growth of the seedlings. To give you an example, after the first season's growth from seed, they

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There are several reasons why there are so few umbrella pine being propagated. One of these is the slow rate of growth of the seedlings. To give you an example, after the first season's growth from seed, they will have only two leaves. At the end of the third year, they will have approximately 18 leaves but will have attained a height of only two inches. After about 50 years they may grow to a height of 25 to 30 feet. This, of course, depends greatly on the conditions under which they are grown. The slowest rate of growth occurs during the first four years. Beyond that point, the annual shoot growth may average from 2 to 6 inches.

In view of the slow rate of growth of seedlings, attempts have been made to propagate it by other means. These includes layering, grafting and cuttings. The various techniques and the results that have been obtained with each are discussed in the following sections.

LAYERING

Liberty Hyde Bailey in his well known reference book, entitled the Standard Cyclopedia of Horticulture, reported that in addition to being propagated by seed they can also be propagated by layering. Although I haven't been able to find any further information in the literature concerning the layering of the umbrella pine, it certainly is reasonable to assume that it could be accomplished without too much difficulty. However, since the number of trees available is so limited, the layering method for the present would be out of the question if one were interested in obtaining large numbers of them. The limited numbers of plants available for layering would then also be a reason why so few are being propagated.

GRAFTING

A thesis problem concerning the propagation of the umbrella pine was carried out and published by W. J. Lowry in 1931. In his experiments, Mr. Lowry grafted umbrella pine scions on *Thuja occidentalis*, *Chamaecyparis pisifera* and *Cryptomeria japonica elegans* with no success. He was, however, able to graft onto *Cryptomeria japonica* stock with apparent success. However the eventual growth and survival of these were not discussed.

CUTTINGS

The next approach to this problem is the rooting of cuttings. Lowry reported, in his thesis, the results of the experiments he carried out in 1930. He did not use such hormones as IAA or IBA, since their beneficial effects on root initiation were not known until several years later. However, his rooting environment was not too different from a plastic tent. He attempted to root the cuttings under double glass in a peat-sand mixture. His results after 14 months showed that out of over a thousand cuttings taken, only 14 had rooted.

This should serve as another good reason why this plant has not been propagated to any great extent. Not only are cuttings hard to get in quantity, but they are also extremely difficult to root. The rooting results obtained by Lowry, although they were quite low, were better than those I obtained when I first tried to root them under mist about six years ago. At that time, I took about 100 cuttings during July. I applied various hormones to some and placed them under intermittent mist. After nine months, all cuttings were alive, well callused, but not a single one had rooted The following year, again, in July I repeated this and included both one year and two year wood. The results remained consistent, in that not a single one rooted.

On March 31st, 1957, I obtained some cuttings from the Arnold Arboretum while on a tour. I placed them in flats of peat and perlite under mist, fully expecting to discard them sooner or later. However, after approximately six months they rooted 40 per cent without the benefits of a hormone.

The following year, one of our students, Mr. Larry Demars, wanted to carry out an experiment on his own and asked me how to root these cuttings. All that I could suggest at that time, was to take them at the end of March He did this and, in addition, treated the cuttings with the following hormones: Hormodin #1, #2, #3, Chloromone 1/3rd, 2/3rds, and full strength, Hormo-root A and B, and two untreated groups. This made a total of 100 cuttings for the experiment. Five months later they were rooted 100 per cent.

In order to explain the reason why he obtained 100 per cent rooting, two facts could be considered: (1) The cuttings may have been taken from a tree that had an inherent ability to root easily, or: (2) It may be that it is the time of the year that determines the rooting response of the cuttings, or to state it more accurately, it might be the stage of growth.

In analyzing my rooting results as well as those of others I found that there were certain periods of the year when the percentage of rooting was very low and other periods when rooting was considerably better. For example, in the thesis by Lowry, I found that even though he took his cuttings during the months of June, July, August, October and November, in 1930 and in 1931 that he had experienced poor rooting on cuttings regardless of the month of collection. In another report, by Dr. J. DeFrance, it was reported that he was able to root 12 cuttings out of the 25 taken. This would be approximately 50 per cent rooting. In this case, the cuttings were taken at the end of January. It appeared then, in these early experiments that greater percentages of rooting were obtained in the periods of January and March, whereas rooting was extremely poor on cuttings taken June through November. It may be that the ideal time to take these cuttings is after the breaking of the winter dormancy but before the new growth develops.

In an effort to answer these two questions, two experiments were set up. In the first one, I wanted to determine whether the tree from which the student obtained his cuttings had a greater potential for rooting then other umbrella pines. In this experiment I managed to obtain cuttings from three different trees, including the one he used. Altogether, 96 cuttings were taken. The results after five months showed that apparently there were no differences in the rooting ability of these three trees. The first tree rooted 93 per cent, the second 72 per cent and the third 84 per cent. In the second phase of this experiment, an attempt was made to determine when cuttings should be taken to obtain maximum rooting. In this case, having only two trees available from which to collect cuttings I took small groups of cuttings at various intervals starting on February 11 through July 8, of this year.

The results of these experiments which are somewhat variable are as follows: Cuttings taken February 11th rooted 83 per cent, February 25th, 50 percent, March 25th, 66 per cent, March 31st 91 per cent; April 14, 83 per cent, April 21st, 41 per cent, and April 28th, 25 per cent. Later, a group of 40 cuttings were taken on July 8th and although sufficient time had elapsed for rooting to occur, not one cutting had rooted. *These results show fairly good rooting had occurred on cuttings* taken from February 11th through April 14th. The percentage of rooting of cuttings taken after the middle of April declined, so that we may assume that within this period of February through the middle of April cuttings may be taken with some success. The date that has given the highest percentage of rooting during the experiments carried out the past three years was March 31. The cuttings in most cases were of current year's growth There were some differences between those treated with Hormodin 3 and those not treated. Those treated had more roots as well as a slightly higher percentage that rooted. Cuttings were all wounded by running the point of a knife longitudinally down to the base of the stem on three sides. The medium used was a mixture of 60 per cent German peat moss and 40 per cent coarse perlite. Cuttings in flats containing this mixture were placed under intermittent mist.

In dealing with large numbers of plants I would suggest that propagation from seed would be the ideal thing rather than from cuttings. The only difficulty lies in over-wintering them.

If you are to propagate large numbers, then the first thing is to germinate them from seed. If you want to get a more rapid growth, then use cuttings, but again, be sure the plants you take these cuttings from are of good types.

* * * * * *

MODERATOR CHADWICK: Thanks, Sid, for this report.

Are there any questions?

MR. JIM WELLS: Dr. Waxman, from what position on the plant did you remove the cuttings?

DR. WAXMAN: These cuttings came entirely from lateral growth which could be reached from the ground.

MR. WELLS: Did you notice any difference between height of sampling and rooting?

DR. WAXMAN: No, we have too few cuttings to be able to try this. However, one plant was about ten years old and the other thirty, but there were no differences in rooting

MODERATOR CHADWICK: Are there other questions? Bill Flemer.

MR. FLEMER: Would you very briefly review what you think is the best seed practice with the *Sciadopitys?*

DR. WAXMAN: Ordinarily you can obtain the seed from your dealer during March or April. Frankly, all seeds come from Japan. When the seeds first come, I put them in a gallon jug of water, and bubble air through it Now the purpose of this is merely to get the seed wet However, I do change the water twice during a one week period. If I didn't bubble air, there wouldn't be enough oxygen. After that, I sow the seed in flats containing a mixture of about 50 per cent peat and 50 per cent perlite. Now if you recall the talk I gave two years ago showing that the length of day affects the germination of seed, you will remember that if the seed gets light at any time it will not germinate.

In germinating seed, they prefer a temperature of 65 degrees, that is not much higher or lower. What I do is to saturate the mixture after the seeds are covered, let it drain and enclose the flats in plastic and put them in an area where I know the temperature doesn't vary too far from 65 degrees. Ordinarily it takes 100 days to germinate, and with this method we find it occurs in 40 to 50 days

These plants are quite small. What I do is leave them in the flat that first year and they make a little growth. I don't think it matters whether you move them out or not. We fertilize them in that mixture and leave them in the flat in the greenhouse. It is not necessary. We have tried putting them out in the frost-free frame, and that works out quite well Perhaps the second year they could go to the frost-free frame for the winter.

MR HANS HESS: Do you have any information as to the length of viability of the seed? Does it have to be current seasons seed or can it be held over?

DR. WAXMAN: I have germinated seeds that were five years old, and the per cent of germination does decrease. The germination after five years was about 50 per cent. Ordinarily when you buy new seeds you might get 60 to 75 per cent germination.

MR VERKADE: Do you get the same results with your light treatment? You said this light would give you practically a year's extra growth. Can you do the same with interrupted light?

DR. WAXMAN: I haven't tried this, but I suspect it will. By interrupted light Pete means that we give them a light for one second out of each minute during the entire night. It takes quite a while to get this response from them.

MR. HARVEY GRAY: Sid, I think you might be interested in the observation which was made by Willard Titus, in that the date you are having your best rooting percentages is the date when the cones are naturally falling from the mature plants.

MR. WELLS: Have you tried a heavy wound, that is, removing a slice from the side of the cutting?

DR WAXMAN: I would be afraid to. I found in the earliest experiment that if we had the slightest wet condition we found rot. I was afraid to give it a heavy wound. A slight wound won't rot and would tend to heal easier So much depends on how wet the medium is.

MODERATOR CHADWICK: Sid, I would like to know what difference you expect from rooting on March 31st and April 1st. Seriously, is there any explanation for this curve you showed?

DR WAXMAN: It is certainly an unlikely time of year for taking evergreen cuttings. Many evergreens taken at this time of year would shoot out top growth before producing roots. The umbrella pine, however, is very slow to start growth. Perhaps there may be a high production of hormones, at this very critical time of the year It is known that just before new growth begins that you get a rise in the level of auxins in the plant and perhaps that is what is needed for rooting cuttings of this plant.

MODERATOR CHADWICK: You will have the answer on that next year?

DR. WAXMAN: We are still working on it, and before I forget, I would gladly accept any contribution of cuttings preferably on March 31st.

MODERATOR CHADWICK: The rest of the morning session is devoted to weed control or the use of herbicides on various types of nursery stock We are going to modify the program a little bit from what is printed in your program, since we feel that perhaps it would be better to get some of the background material or fundamental material, before going on to some of the more practical applications of the problem.

To start with, I would like to introduce the members of the panel: Dr. Kenneth Alban, Department of Horticulture, Ohio State University, John Newhouse, Bagatelle Nurseries, and Dr. Chappell of the Virginia Agricultural Experiment Station.

Dr. Alban is going to lead off the discussion this morning on some of the more fundamental aspects of chemical weed control. Ken!

DR. E. K. ALBAN (Columbus, Ohio): Thanks a lot, Chad.

I thought that starting off today we might just take a look at where we have been and then perhaps see where we might be going.

Having had a little experience with pulling weeds of various kinds in ornamental seedlings, I know this is a real task. We have been just as anxious as Chad and all of you to find a satisfactory method of solving more of our weed problems.

Through the years we have used oil in oil burners and flamers of various sorts to try to control, particularly surface weeds. Then another method that the tobacco seedsman has used, which many of you have perhaps heard about and are familiar with, is the use of a fire. It is rather interesting to watch some of these fellows use a pile of wood, set it afire and keep it moving along the tobacco bed just to the point where they are not burning up the organic matter but are killing a lot of weed seeds. It has been a good method for partial weed control but I think we still come back to one of the best methods we have and that is steam. Whenever you can possibly get a portable steamer in I would recommend it.

The difficulty with the various chemicals is the susceptibility of different crop plants and the tolerance of many of the weed species. You encounter all of these things which causes a lot more trouble as compared to the use of steam

I think we might just take a brief look at some of the chemical sterilants and fumigants, with which many of you are familiar and evaluate them in relation to their weed control effectiveness.

One oldtimer is formaldehydate, and many of you are familiar with this compound, not only for weed killing ability but more important, for its fungicidal capacity. We would have to say as far as weed control goes, formaldehyde is only a fair to poor chemical.

Now another one that you are not perhaps as familiar with is allyl alcohol, which is a fairly effective herbicide, particularly on soft weed seeds that will be germinating in four or five weeks after treatment. One major objection to allyl alcohol is the large volume of water you have to use with it Quite frequently several hundred gallons of water are necessary in 100 square foot area for the proper functioning of this compound

Another compound that I first ran into trouble with but have learned to live with is Chloropicrin or tear gas. We treated a quarter of an acre with the wind right when we started but not so right when we finished and it is a rather mean material to handle. On the other hand, it will give you fair weed control.

Vapam, a fairly new compound, gives us good weed control if we set up the right conditions. I will discuss this in a little more detail after I complete this list of chemicals.

Mylone is a compound you have heard about and our experience with it has been that it results in only fair weed control.

Eptam is a fairly new one, perhaps not used so much in the nurseries yet but used particularly in potatoes in our vegetable crop work. This compound is rather interesting Incorporated in the soil, we have had very good success in the killing of the weed seeds. This past season on a potato field where we had used Eptam right after planting the potatos we had no weeds in there during the entire season. Even though we continued to cultivate we did a very good job of killing the weeds in the top four or five inches of the soil This is one that perhaps might bear watching and I would say that good and excellent weed control has been obtained.

Another compound you have used and know, is Methyl Bromide or Dowfume. This will give you good weed control. In fact, we can have excellent results if we go to the two pounds per 100 square foot treatment.

Now some of you have used these, some of you have seen them used Some of you have seen some very poor results and perhaps if you are lucky you have seen some good results. I would like to briefly go over the factors that are, we feel, influencing the effectiveness of soil fumigants and soil sterilants The first one that I think is often ignored the most is the physical condition of the soil at the time of treatment. In general, we would say that we would want the soil to be ideal moisturewise as it would for plowing, discing or rototilling. We would like a soil that did not compact, or fall apart too easily. It needs to be worked up fairly fine allowing at least a six inch area for any of these chemicals to be effective.

Another important factor would be whether or not the chemical is either lighter or heavier than air. This is a decision you must make. Will the chemical seep downward or do we need some kind of cover or seal to prevent escape of the chemical. It is surprising the number of times this is ignored, except with Methyl Bromide The moisture, which I have already mentioned, is very critical. Temperature is very critical. Most of our seedbed work and plant propagation bed work does seem to come in the early spring and this is the poorest time in the world to use any of these chemicals to prepare a seed bed or plant bed The best time is in the fall when you have high enough temperatures to get maximum effectiveness of the chemical. I would say practically none of these I have mentioned will work well when the temperature is below 60 degrees. Preferably the temperature should be in the 70 to 75 degree range, which means late September or early October would probably be a good time for using some of these treatments.

Then another factor, particularly with the granular materials, is distribution Getting these materials mixed thoroughly into the soil is very important. I am sure that the lack of this consideration has resulted in very poor weed control at times. You have some spots with sufficient amounts of the chemical and others with only a trace of the chemical where you get no weed control. Cross discing, cross rototilling after using many of these would help a great deal.

One other area I would like to mention would be that of eliminating noxious perennial weeds ahead of putting any nursery stock on the area. There are certain grasses such as quackgrass, and Johnsongrass that we should take out before we put any nursery stock in the field. We have a lot of good chemicals to do this, and most of them have a minimum residual activity Dalapon does a beautiful job on plant grass as a fall treatment and you could go back on there with most any crop the following spring In cases where you would like to go on the land a little quicker, you would use amino triazole It has been our experience with a wide range of other horticultural plants that we can safely use it within a two-week period, which is necessary for the amino triazole to act on the grass plant. Certain other broad-leaf weeds, such as Canada thistle and dandelion can also be eliminated with amino triazole. This solves a perennial problem which is usually one of your most severe ones after you have a planting established.

Another important thing that is often ignored is eliminating potential weed seed from fence rows and from adjacent areas Our good conservation friends have indicated to me, at least that eliminating some of this cover in fence rows makes sense in our business There are a lot of other areas where they would disagree with this viewpoint I think that if we can take care of some of our weed seeds in the fence rows, in the walkways, and in our roadways, we can help reduce the seed for some of the chemicals that will be discussed later on this program. I have briefly talked about pre-plant treatments

An additional method would be pre-emergence treatments The term means that prior to the time the crop comes up we apply a chemical which will effectively control weeds, we hope, and not damage the crop. Then we have post-emergence treatment. Here we use directed sprays ordinarily with selective herbicides where we have a crop plant that will tolerate the chemical and a weed species that are susceptible to the chemical. You will hear more about these later two methods of weed control from the other members of the panel

I think one of the important things to remember, from my experience with herbicides, is that you cannot guess on any of these things. You cannot guess on susceptibility of crop plants Everyone of these crop plants is going to be a little bit different and you are dealing with thousands of them and what may work on taxus will not necessarily work on viburnum. I am sure you all realize this, but I think it is worth an additional word of warning that just because you have had success with one particular species don't assume the chemical is safe on others. Thank you very much.

MODERATOR CHADWICK: Thank you, Ken. There will be an opportunity to ask questions after the other members of the panel have presented their material.

We will now turn to a few comments on pre-emergence materials by Dr Chappell, Department of Plant Physiology, Virginia Agricultural Station, Blacksburg, Virginia

DR. W. E. CHAPPELL: When Mr. Van Hof wrote me back in the summer asking me to participate in this program, he suggested that I confine my remarks to pre-emergence weed control. This is what I have done.

Dr. Chappell presented his paper covering the aspects of pre-emergence weed control

PRE-EMERGENCE WEED CONTROL IN NURSERY CROPS

W. E. Chappell

Virginia Agricultural Experiment Station
Blacksburg, Virginia

INTRODUCTION

The term "pre-emergence" when used in reference to weed control usually means an application of chemicals after planting, but before the emergence of the crop or weeds. In the case of transplants or liners, however, it would be pre-emergence to the weeds only. The selection of the chemicals to be used for pre-emergence weed control will depend on whether it is being used on direct seeded crops or whether it is to be applied as a directed spray on lining out stock and also whether a liquid or granular application is being made. Certain sprays cannot be used on liners even when it is directed at the base of the plants without taking some chance of producing some injury The same chemical might be applied as a granular formulation without any injury.

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PRINCIPLES INVOLVED IN PRE-EMERGENCE WEED CONTROL

Most weeds are much easier to kill about the time they germinate and wherever possible, it is desirable to kill them before they become established. In pre-emergence applications a thin film of chemical is applied on the surface of the soil which will prevent growth of young weed seedlings and they are usually killed before they ever become visible above the ground.

In the case of direct seeded crops, such as dogwoods, pin oaks, etc., these seeds are planted fairly deep and germinate slowly in comparison with most weed seeds. This being the case, a fairly high concentration of a very toxic chemical can be applied to the surface and kill the weed seedlings without endangering the desirable seedlings which come up later. In some instances as in the case of seeded crops that do not germinate for a long period, a delayed pre-emergence application can be made even after the weeds are up. In such cases it is necessary to use a chemical that has both contact killing properties as well as leaving a residue in the soil that will keep other weeds from growing. An example of this type of application is the amine salts of dinitro-o-sec-butylphenol oil (DNBP).

Selectivity of herbicides may be physical or chemical. A chemical may be very toxic to established nursery stock when applied as a spray. but if the same chemical is applied in the granular form, it may be safe to use on a variety of plants as a pre-emergence application for the control of weeds. This is known as physical selectivity. A truly chemically selective herbicide can be applied safely as a spray on certain species of nursery crops. Unfortunately very few herbicides are available that possess this property

In general pre-emergence herbicides may be classified as (1) non-selective (2) selective residual Since most herbicides are non-selective in so far as nursery crops are concerned, they must be applied either in the granular form or as a directed spray so as to avoid contact injury. The principle involved in granular applications is that the particles do not adhere to the plants and fall to the ground where they act as a residual pre-emergence chemical and in some cases will kill small weed seedlings by contact With directed sprays the principle is merely to physically keep the chemical off the leaves and stems of nursery stock.

Many chemicals are more effective pre-emergence herbicides when applied in the granular form Some exceptions to this are simazine and atrazine. The principle involved here is that granular forms remain on the surface and are not leached as readily as sprays.

A good example of a selective residual treatment is dacthal, a chemical for pre-emergence control of crabgrass in lawns. Most established lawn grasses are resistant to dacthal, but it is very toxic to germinating crabgrass seed.

APPLICATION TECHNIQUES INVOLVED

Pre-emergence herbicides are applied as a spray or in the dry or granular form. The application of an overall spray to seeded crops is relatively simple and can be accomplished with little difficulty. All that is needed is to determine the amount of liquid that a sprayer is delivering per unit area and then add the desired amount of chemical to make that volume For applying directed sprays, however, the procedure is more difficult In order to keep the spray off the nursery stock the nozzle must be correctly spaced and be set at a proper angle. Also the rows must be uniform in width if more than one row is to be sprayed at a time. Unless large acreage are to be sprayed, it would probably be safer to apply the chemical with a single nozzle that is controlled by the applicator.

Table 1.—Summary of herbicides used for control of weeds in nursery stock.

Situation	Herbicide	Formulation	Rate lbs/A (active)	Known Intolerant Species	Effective Control
Winter weeds in·					
Directed seeded crops peach, walnut. dogwood, oaks, etc	DNBP	Spray or granular	8-10	All small seeded crops	3-4 months
	Simazine	Spray	2-3	All small seeded crops	4-6 months
	Naburon	Spray or granular	5	All small seeded crops	4-6 months
	CIPC	Granular	8-10	None	3-4 months
Summer weeds in					
Bare Rooted Stock	None	—	—	All	—
Rooted Transplants					
In Field or Cans	DNBP	Granular	8-10	Barberry	4-6 weeks
	CIPC	Granular		None	3-5 weeks
Liners — one month or more after planting	DNBP	Granular	8-10	None	4-6 weeks
	CIPC	Granular	8-10	None	3-5 weeks
	Neburon	Direct spray or granular	5	Azaleas	4-6 weeks
Established Liners					
(two annual applications only)	DNBP	Granular	8-10		4-6 weeks
	CIPC	Granular	8-10		3-5 weeks
	Simazine	Direct spray or granular	2-3	Azaleas	6-8 weeks
	Neburon	Spray or granular	5	Azaleas	6-8 weeks
Field Stock					
(two annual applications only	DNBP	Granular or direct spray	6-8		4-6 weeks
	Simazine 3 lbs + Amitrol 1 lb (Amizine)	Direct spray Fall or early spring only. Keep 12"away from plants-	7	Azaleas Barberry	8-12 weeks
	CIPC	Granular	8-10		3-5 weeks
	Simazine	Granular or direct spray	3	Azaleas	6-8 weeks
	Neburon	Granular or direct spray	5	Azaleas	6-8 weeks
Crabgrass in Lawns	Dacthal	Granular	10	None	Season
	Zytron	Granular	15	None	Season

Granular herbicides can be applied with modified fertilizer drills, certain seeders or dusters. The greatest difficulty in applying granular materials is proper calibration. Most granular applicators are equipped with gravity flow control devices which are very difficult to properly set. The most satisfactory type of applicator for large scale use is a tractor mounted Cyclone seeder, but it has several disadvantage the major one being a reduction in out put as the hopper becomes empty. For general usage it would be best to weigh or measure the amount of material needed for a given area and apply it with a small applicator, going over the area two or three times if necessary.

Both spray and granular applications should be applied shortly after planting or cultivating before the weeds get started. In general only annual weeds are satisfactorily controlled by a pre-emergence application. Granular applications should not be applied when the nursery stock foliage is wet.

RESIDUAL PROPERTIES AND USES OF SOME PRE-EMERGENCE HERBICIDES

The action of pre-emergence herbicides effected greatly by environmental conditions such as soil moisture, subsequent rainfall, temperature, soil type, weed species present and many other factors. It would therefore, be impossible to suggest weed control treatments that could be safely and effectively used in various sections of the country. The following herbicides (table 1) have been used with success in Virginia, but they should be used with caution until the grower becomes familiar with their performance in his own nursery.

MODERATOR CHADWICK: Thank you, Dr Chappell. I am sure there will be some questions for you later on.

We will now turn to John Newhouse, Bagatelle Nursery, for his comments. John!

Mr. Newhouse presented his paper on weed control in the nursery.

CHEMICAL WEED CONTROL IN THE NURSERY

John Newhouse
Bagatelle Nursery, Inc
Huntington Station, New York

Chemical weed control, properly used, is one of the best money-savers that has been introduced to the nursery business in many years. The days of planting material by hand and hand weeding or hoeing are fast disappearing.

Any material that will kill certain types of plant growth while allowing others to grow is dangerous if indiscriminately used When using any of the materials on the market today, it will certainly pay to follow the manufacturer's recommendations and try the material to be used on a small scale to ascertain how it will act under local conditions.

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In our case, the young stock planted in beds was the most expensive area of the nursery to keep clean. The material planted in field rows is planted so that mechanical cultivation is possible, leaving very little hand work to be done Labor in our section of the country is probably quite a bit higher than it is in most, making it nearly economically impossible to grow our own liners.

Our area of bedded stock consists of about 2½ acres. In an area planted for two years, on heavily manured soil, and irrigated during the entire growing season, the weed population was just too expensive to keep under control. This led us to try chemical weed control. Crag herbicide, while doing a fairly good job without damage, did not last long enough, and chloro IPC damaged some material severely. While we have heard of good results with both of these materials, neither of them solved our problem.

Our next trial was with simazine. We have had such good results with this material that now we are using it exclusively. As you all know, this is not a new material, having been on the market for two or more years It has been used in nearly all sections of the country with equally good results.

The Geigy Chemical Corporation, like all other herbicide manufacturers, give recommendations for use of their product, but assume no responsibility for damage resulting from its use Geigy's recommendations include its use on a wide variety of plants such as arborvita, barberry, boxwood, junipers, yews, and others. Elsewhere in the recommendations it states . . . "unless otherwise stated, do not apply simazine to land planted to any other crop, or damage to the crop may result ." They also recommend it be used on established stock only.

We have not followed these recommendations to the letter. We decided on a solution of five ounces of simazine 80 to 30 gallons of water. We have used this mixture on newly transplanted cuttings, with excellent results. Applied within a few days after transplanting, after irrigating the beds and loosening the soil when it was dry enough to work, we had good control with a minimum of damage. When I use the term "good control," I do not mean a complete elimination of weeds, but rather control to the point where it is possible to weed an acre of liners in a very short time Strengthening the mixture to the point where all weeds are eliminated for a year in newly transplanted stock would, in my opinion, bring the concentration too close to the danger point.

In addition to the list of material contained in the manufacturer's recommendations, we have used it on several other varieties of plants with success Rhododendron, *Pieris japonica* and azalea cuttings and grafts of *Acer palmatum atropurpureum, Fagus sylvatica riversi* and *Tsuga canadensis sargenti* were treated with good results.

We have had some damage from the use of simazine in only one case. This was an area of approximately 150 square feet planted with yew. A check of the records for this particular area showed that it had received five applications of the material in a space of eleven months. This was nearly three times the dosage the other areas had received.

Although the damage was slight, it did show that care should be taken in the use of this chemical.

The problem of any possible buildup of the material in the soil has been a topic of discussion ever since this material was put on the market. I am not able to offer much along this line After using it for two years, at the strength mentioned earlier, we did sow one of the areas to rye after the liners were removed. As far as we could see, it did not make any difference in the germination of this seed.

* * * * * *

MODERATOR CHADWICK. Thank you, John, for those comments, and I am sure again there will be some questions relative to the use of chemicals for weed control. I hope that we might have approximately half an hour so we can get out some of the problems that are of interest to you Because of this I am only going to take a very few minutes as far as my part of the program is concerned I was going to make some general remarks, but I think we will turn directly to the slides and I will make some comments while we are going through them.

(Dr. Chadwick presented slides and remarked on the research being done on nursery weed control at the Ohio Agricultural Experiment Station.)

We will continue with this panel discussion by opening the floor up for questions.

DR. MAHLSTEDE: How does the temperature of the soil in the can in the greenhouse compare with the temperature in the field? I am thinking here about the rate of breakdown of simazine in those cans as compared to that under field conditions.

MODERATOR CHADWICK: I will have to admit, John, we did not take soil temperatures on these. These cans were in a relatively cool greenhouse during the spring of the year, maintained at roughly 60 to 64 degrees. My guess is that the soil temperature in those cans would not be greatly different from what we would find in the field at the time we normally would sow oats.

MR MARTIN VAN HOF: I would like to ask John Newhouse if the application he makes is over the course of a year or do you apply it at several times of the year?

MR NEWHOUSE: The material I use is sprayed on just once a year.

MR VAN HOF· Is there any build-up of the material in the soil? If you use it more than once a year would it retard final growth?

MR. NEWHOUSE.I don't think it would retard growth, although you might get some burning. I haven't found a case where I can say that it retarded growth. I did have a few cases of burning resulting from over-application.

MR. DE WILDE. We tried simazine under the direction of the agricultural representative of Geigy, putting it on azaleas and on artemisia. We used as much as four times the recommended strength and we got no damage to the azaleas. It did quite a bit of harm to the artemesia, however. This was put in in May and during that summer the artemesia was retarded but not killed. The interesting thing was that the following spring we got much more kill on the artemesia. This is the thing that scared me for field crops. The stuff doesn't work down nearly as fast as the manufacturers think or I wouldn't have got more kill the second year with no more application

MR. JIM WELLS. I want to direct the question to John Newhouse, but before I do this I would say that we have been testing simazine on azaleas and rhododendrons and we have had no damage whatsoever. We took azalea liners, made up our beds in the normal manner with the addition of the peat, rototilled and put simazine on the top. There was a virtual elimination of weeds We used the granular at about the rate of three pounds to the acre. There was no noticeable effect at all on the growth of the plants The following year the small area treated was clear of weeds It was again rototilled, planted and again treated with simazine. There was no noticeable effect on the azaleas and there were no weeds. We have, therefore, come in two years in the same area without damage so far.

Now, John, I was interested in your statement that you had sprayed young plants of rhododendron and azalea in beds and had no damage. Was this immediately after planting and at the rate you mentioned?

MR NEWHOUSE: That was within four days after they were planted, on about the 10th of June. We applied the chemical at the rate of five ounces to thirty gallons of water.

MR. WELLS: The question here is what area did you cover, John, with that spray?

MR. NEWHOUSE: Well, to answer that one, maybe I better tell you how I do it We plow under a cover crop of rye, then we rototill in about two inches of a mixture of peat and manure. We still do things the old-fashioned way. We bed our horses with peat moss. It sounds expensive but it makes wonderful manure. Naturally, you get a few more weeds that way After it is planted we irrigate it As soon as it is dry enough so it will work up and on a good drying day so the color of the soil will change after it is worked, we spray on just enough to change the color. Now how many pounds you end up with to the acre, it is hard to figure out. I found that is a pretty foolproof method.

MR. GEORGE HOYSIC (Rochester, New York): We have quite loose soil with plenty of organic matter. We have used the 4-W granular simazine on *Euonymus vegetus, alatus* and *alatus compacta,* and observed that we got quite a bit of defoliation on the *E. vegetus,* and quite a bit of yellowing on the *E. alatus.* We discussed this with a number of the members who have some knowledge of chemicals. One of these men stated that simazine lowers the pH of the soil and if we would apply lime to the soil it would compensate for it. Well, we went along and did it, and our soil is roughly around pH 6.3. This was done in May and again in July. We noticed the coloring was coming back to the plants. The new foliage on the *Euonymus vegetus* was coming along in fairly good shape, also, in fact, some looked so good that we used some on landscape jobs.

What do you have on that condition?

MODERATOR CHADWICK: Any comments over here on pH change caused by simazine?

DR CHAPPELL: I have no data on the effect of the chemical on soil pH I don't think two to four pounds per acre is going to change the soil pH very much, regardless of how acid alkaline it is.

On the general subjct of granular simazine, we have had considerable injury in some instances where we put on an application as low as two pounds per acre on azaleas. Now in spray form we have had some temporary damage on some species, especially on the younger liners. In those cases, they recovered. I would like to point out under certain conditions you may get some injury. Most of these gentlemen have indicated they haven't had any injury, and I am sure they haven't had it However, I would just like to throw that in because there is this possibility.

MODERATOR CHADWICK: I want to throw this question in here, if you will pardon me. I think one of the interesting aspects of this problem is the correlation between the granular material and a spray application The gentleman over at the end of the table here, down at Ohio, is known as "no granular Alban." so I would like to have him make a few comments on this phase of the problem. Ken!

DR. ALBAN: I am not so much against granulars as I am against the method we have to apply them. We do not at the present time have adequate equipment to get a good even distribution of granules at the two to three pounds distribution rate that we need The performance of these chemicals, indicated by the abstracts which I just received from the North Central Weed Control Conference indicate that, in general, you can expect about the same results whether you spray or whether you use the granules. I think this has been holding up right along. On this simazine question, I would just like to point out Chad, that we are dealing with a fairly insoluble material and as long as you don't have very much rain and if you don't irrigate very much, you can put a lot of simazine in and not get any damage. I did put two and four pounds on potatoes and I never hurt the potatoes until one year I got 11 inches of rain in nine days. The two pounds of simazine knocked out all the potatoes. I have just recently, this summer, completed an evaluation of 90 varieties of sweet corn. Simazine is recommended on sweet corn Seventeen out of the 90 had a 10-pound rate per acre which we might compute from putting on two to three pound applications. Seven of these varieties had a significant reduction in yield. Now this is with sweet corn, a crop that very definitely simazine is recommended. for.

I think we have to move very carefully in incorporating simazine in some of these soil beds, because we may end up having to pull some of this soil up and throwing it away.

MR DICK VANDERBILT: I would like to make a statement about simazine on azaleas. I believe one of the most important things why Jim didn't get injury and why we didn't, is the high level of organic matter in our beds. We have gone up to 16 pounds actual of simazine on all varieties of azaleas that we grow and the same with rhododendron. Not one rhododendron was injured at the 16 pound level. I would say there is at last 25 per cent organic matter in our soil. In the field, on *Ilex rotunda* one year we used 2.2 pounds of simazine and got no injury. The organic matter was approximately 1.97. The following year the organic matter dropped to 1.2. There was quite some injury with the same rate.

Dr. Chadwick, do you know of any correlation between organic mattr and injury?

MODERATOR CHADWICK: We have made no observations on the use of simazine under various amounts of organic matter in the soil. I wonder if there are any comments from the panel on that.

DR. CHAPPELL: I think that is generally true with any chemical. The higher the organic matter the more chemical it will stand, including fertilizer. If you have enough organic matter there to absorb the chemical you are not as likely to have trouble with injury.

MR NEWHOUSE: It all goes back to what I said a while ago. I recommend that it be tried out locally under your own conditions. What works well for me may not work so good for you. Now if I were to move out to Illinois and start growing out there, I would start experimenting out there. I have hit on a mixture that works fine for me under my conditions.

MR. BEN DAVIS (Oklahoma): We have just recently tested simazine on our orchard nursery We used two pounds actual per acre on a band spray. We run on a four and a half foot middle, and we sprayed a foot on each side of our row with two nozzles, using a John Bean type sprayer. We calculated our sprayer very carefully so we maintained the same two pounds actual per acre during every tankful of spray. We sprayed several different varieties of both evergreens and deciduous stock and got no injury. We also got only about two-thirds control of the weeds.

MODERATOR CHADWICK: Thank you. I might comment that this banding method of application is being used fairly extensively in nurseries at the present time.

MR TOM PINNEY, JR (Evergreen Nursery, Sturgeon Bay, Wisconsin): Simazine I would like to say, is something I would be real concerned about. We have had a lot of experience or we feel we have. We have about five million liners and a lot of these are conifers that are spruces and pines. Most of them are under this program. We have injured conifers with as low as half a pound per acre, actual. This we know. Our records are pretty accurate, and I think we have set up a long-term plot. We are working on the residual for five years. We are applying as high as 20 pounds per acre of simazine, seeing what we get, and you would be amazed. I would just like to suggest that you take it a little bit easy. We have had a lot of injury to 50.000 fir

MODERATOR CHADWICK: Tom, can I ask what other types of conifers have you had injury on at low rates?

MR. PINNEY: Chad, it depends a great deal on the time. I am not getting it on Concolor fir if applied before they start to grow. If you apply it after they start to grow, in other words, let's say in August when you feel they have hardened up a little bit, it will stop the buds right in their tracks and defoliate the plants. However, the roots looked in good shape because there were some that were direct sprayed but we didn't direct it good enough. Also, Scotch pine and Ponderosa pine behaved in the same way. If you apply it in the late winter months, before the plants start to grow in the spring, all these are pretty tolerant. You have to learn when to apply it.

MR. DICK BOSLEY (Bosley Nurseries, Mentor, Ohio): Chad, there were a couple of other chemicals discussed and I would like to pose a question to the panel on amino triazole. There was quite a fuss a year ago on this at Thanksgiving. Is this amino triazole the same amino triazole we are using and have been using for years on grass? What justification is there for us to use it? Is it safe or isn't it safe?

MODERATOR CHADWICK: Any comment on it? Ken?

DR. ALBAN: As long as we don't eat nursery stock we are all right.

MR. BOSLEY: *The men are handling it.*

DR. ALBAN: Any time we handle herbicides we have to be careful. I think in normal handling you would have no trouble. I try to give all our workers instructions to be careful and wash their hands and not get a lot of this material on them. I would not worry about amino triazole if I were you and normally use it.

MODERATOR CHADWICK: We have time for about one more question.

MR ART VUYK: We started to use simazine last year for the first time on Japanese yew in established field plantings. We treated only a small area in June, and in September when we planted our oat cover crop we had definite signs of chlorosis in the oats but no injury on the Japanese yew. This year we treated that whole block with simazine in June and we planted the oat crop again in September. In the particular spot in the plot which had the second application, the chlorosis in the oats was very severe. The oats in the rest of the field, which was treated only once, are eight to ten inches high and considered a good stand. In the particular block that was treated twice now, at the rate of two and a half pounds to the acre, the oats are not any bigger than three to four inches and as yellow as yellow can be.

It might be interesting to you fellows that the Experiment Station in Boskop has been using simazine for a few years now. They are consistently watching not to use it any later than the end of June. They are afraid of a buildup of the chemical, especially when it is applied later than June. They are warning about this in practically every paper they send out.

MODERATOR CHADWICK: We are going to call a halt to the questions. I know some of you have other questions. I think we should give the panel members a good round of applause.

I think Hugh Steavenson has an announcement.

MR STEAVENSON: I would like to see the Awards Committee right after we break up, at the back of the room. That consists of Roy Nordine, Harvey Templeton, Joe McDaniel, and Zophar Warner We also have to get the West Coast representatives on it so Don Hartman and Herman Sandkuhle are also invited.

The session recessed at 12:00 o'clock.

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SATURDAY AFTERNOON SESSION

December 3, 1960

The final technical session convened at 1:50 o'clock, Mr. A M. Shammarello, A. M. Shammarello & Son Nursery, Cleveland, Ohio, presiding.

MODERATOR SHAMMARELLO: Let's call this meeting to order, please We are running a little behind time.

The following speakers will conclude the meeting for this year. We have a variety of speakers who will discuss many topics.

Let me present to you, Dr. John Mahlstede, Iowa State University, Department of Horticulture.

DR. JOHN MAHLSTEDE: Thank you. I would like to discuss with you for a few moments the peat container that is displayed in the exhibit area. It is presented strictly on an experimental basis. It is a large peat pot, if you like, with a polyethylene skin on it. We have tried different plant materials, using it as a growing container and also using it as a forcing container to see where it might have some application in the field of plant propagation and nursery management.

At the conclusion of the talk I would also like to say a few words about this Dyfoam pot which is also displayed in the same area

I would like to discuss, first, the use of the large six by nine inch peat container, as a forcing unit for hybrid tea roses and then consider its merits and faults as a growing container.

Dr. Mahlstede presented his papers which were supplemented by colored slides

USE OF THE PEAT POT AS A FORCING CONTAINER FOR HYBRID TEA ROSES*

J. P. Mahlstede

Department of Horticulture
Iowa State University
Ames, Iowa

INTRODUCTION

With increased production and sales of ornamental plants grown in containers, both the producer and merchandiser would like to find a substitute for the Number 10, black asphalted can that has been used to produce much of the stock grown in the "one gallon" size of container. Emphasis on packaging has called the attention of nurserymen to the need for a dual purpose growing and selling container for the smaller sizes of landscape ornamentals Functional, colorful, plantable, cheap pots would have an increasing, expanding market in the years ahead.

*Pots and funds for this study supplied through the courtesy of the Willis Reynolds Corporation, Lebanon, Indiana
Journal Paper No J—4117 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa Project No 1214

It was therefore the purpose of this study to determine if the 6″ x 9″ experimental peat pot* fitted with a polyethylene jacket might serve as a forcing container for hybrid tea roses, which are usually potted early in the spring, forced, and sold during the summer months.

METHODS AND MATERIALS

In order to determine the effect of different potting procedures on the performance of both the plant and the container, two mediums, two plant root treatments, and two medium treatments were utilized in this experiment Number 1, Chrysler Imperial roses, were pruned to three, 6 to 8 inch canes in order to insure uniformity between the various treatments applied The root systems were pruned to a length varying between four and five inches prior to potting. Sterilized soil, composed of one third pea gravel, one third peat, and one third Webster type soil, and a mixture of 50-50 peat and perlite by volume were used as the mediums. Five single plant replications in a completely randomized design constituted the experimental design for the study.

After pruning the roots of one series of plants was dipped in Rutex, an anti-desiccant which has had limited use a substitute for packing materials in nursery storages. After potting another series of plants were watered with Aqua-Gro, which was applied at the rate of one ounce per gallon of water. Control treatments with and without Rutex and Aqua-Gro completed the treatments applied to the roses.

After potting on June 3, 1960 all plants were removed to a shade area and the cane systems capped with 1½ mil. polyethylene bags. This was done in order to maintain a high relative humidity in the environment immediately adjacent to the canes, which in turn would insure the maximum amount of bud break and prevent undue loss of moisture during the time the plants were becoming established. Two weeks after potting, the polyethylene bags were remved and the plants fertilized with a 10-6-4, slow release fertilizer at the rate of one teaspoonful per container

Plant performance in terms of bud break, and total growth was evaluated on September 28, 117 days after the plants had been placed in the containers. In addition, pots were classified as acceptable, or unacceptable, depending on the condition of the container and polyethylene jacket.

RESULTS AND CONCLUSIONS

The use of a soil wetting agent greatly facilitated watering during the initial phases of the experiment. In addition, the peat container also was readily wet evenly to the juncture of the jacket.

In handling, it was noted that the heavier soil medium necessitated careful handling in order to prevent splitting of the container as it was set in place. Although the lighter peat-perlite medium was easier to handle, plants had to be spaced quite close together, or supported towards the end of the experiment to prevent the plants from blowing over. The polyethylene jacket housing the peat container although quite thick before extrusion is relatively thin over most of the soil surface, and for this reason was quite subject to puncture. The lip of the peat pot above the medium line generally disintegrated towards the end of the experiment, which necessitated handling the plant by the "soil ball."

Representative samples of each container were field planted in mid-August. The plants suffered no setback and rooted out well by the end of the growing season.

In general, there was little difference between the performance of the plants contained in any of the mediums, root dips or medium treatments. However, from table I, it is quite apparent that a medium of peat and perlite, together with a Rutex root dip, and an Aqua-Gro watering amendment resulted in roses which had more breaks per plant and a resultant greater total growth. Averaging the percentage of acceptable pots at the end of the growing season, it is also quite apparent that the lighter soil mix resulted in a higher percentage of acceptable pots.

Table I.—The effect of medium, plant treatment, and watering on the performance of Chrysler Imperial roses in peat pots.

Medium	Treat	Treat	Ave No Breaks per Plant	Ave Total Growth per Plant	Ave Length of Breaks	Pots 9 28 % Accept
Soil	None	None	8 52	37 75	4 58	75%
Soil	None	Aqua	6 25	36.13	5 78	75
Soil	Rutex	None	7.75	42 5	5.48	80
Soil	Rutex	Aqua	5.75	41.0	7 13	60
Peat-Perlite	None	None	7 0	40.12	5.73	100%
Peat-Perlite	None	Aqua	7.4	42.4	5 73	75
Peat-Perlite	Rutex	None	8.6	40	4.65	100
Peat-Perlite	Rutex	Aqua	12 0	64.7	5.30	100

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USE OF THE PEAT POT AS A GROWING CONTAINER FOR ORNAMENTAL PLANTS*

J. P. Mahlstede

Department of Horticulture
Iowa State University
Ames, Iowa

INTRODUCTION

It is a common nursery practice to grow ornamental plants in various sized containers for periods of time varying with the type of plant and size desired for marketing. It is possible with plant types which make up quickly, to start in the early spring with a well rooted cutting and

*Pots and funds for this study furnished through the courtesy of the Willis Reynolds Corp , Lebanon, Indiana..
Journal Paper No. J—4120 of the Iowa Agricultural and Home Economics Experimnt Station, Ames, Iowa. Project No. 1214.

pot above the medium line generally disintegrated towards the end of the experiment, which necessitated handling the plant by the "soil ball."

Representative samples of each container were field planted in mid-August. The plants suffered no setback and rooted out well by the end of the growing season.

In general, there was little difference between the performance of the plants contained in any of the mediums, root dips or medium treatments. However, from table I, it is quite apparent that a medium of peat and perlite, together with a Rutex root dip, and an Aqua-Gro watering amendment resulted in roses which had more breaks per plant and a resultant greater total growth. Averaging the percentage of acceptable pots at the end of the growing season, it is also quite apparent that the lighter soil mix resulted in a higher percentage of acceptable pots.

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Soil	None	Aqua	6 25	36.13	5 78	75
Soil	Rutex	None	7.75	42 5	5.48	80
Soil	Rutex	Aqua	5.75	41.0	7 13	60
Peat-Perlite	None	None	7 0	40.12	5.73	100%
Peat-Perlite	None	Aqua	7.4	42.4	5 73	75
Peat-Perlite	Rutex	None	8.6	40	4.65	100
Peat-Perlite	Rutex	Aqua	12 0	64.7	5.30	100

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produce a finished, landscape sized plant in one gallon container in one growing season Slower growig plants, which includes many of the evergreens take much longer to reach marketable size, and for this reason are often shifted up from smaller containers before they are sold.

The purpose of this study was twofold, first to determine the feasibility of using a peat pot having a polyethylene jacket as a growing container for a rapidly growing and a relatively slow growing plant, and second to establish the response of these two types of plant materials to different mediums.

METHODS AND MATERIALS

The plant materials selected for this experiment included cuttings of *Cornus stolonifera*, the Red-osier dogwood, which had been rooted from hardwood cuttings during the winter of 1959-60, and one year old rooted cuttings of *Juniperus chinensis Maneyi*, the Maney Juniper, which had been grown in three inch peat pots for one year. These plants were placed in 6″ x 9″ polyethylene jacketed peat pots* on June 3, 1960 Five single plant replications were placed in each of three mediums, including 50-50 mixture of peat and perlite, a 50-50 mixture of sand and peat, and a soil mixture composed of one third soil, one third pea gravel, and one third peat. After potting, replicates were either watered with 800 ml water or with an equivalent amount of water containing 1 ounce of Aqua-Gro per gallon of water. The plants were then removed to a shaded growing area where they were fertilized with a 10-6-4 fertilizer in the amount of one teaspoonful per pot.

RESULTS AND CONDITIONS

The condition of the peat containers and final growth measurements were recorded on September 28th, 1960, 117 days after the plant materials had been potted. Although pots containing the dogwood

Table I.—The effect of medium and a wetting agent on the performance of dogwoods and junipers in peat pots.

Medium	Medium Treat	Ave No Breaks per Plant	Ave Total Growth per Plant	Ave Length Break per Plant	Per cent Containers Accept
Cornus stolonifera					
Sand-peat	None	2 2	12.7″	5 8″	80%
Sand-peat	Aqua	2 6	22 4	8 6	100
Peat-perlite	None	3 0	29 6	9 9	100
Peat-perlite	Aqua	3 0	28.6	9 5	40
Soil	None	2.4	22 6	9 4	60
Soil	Aqua	3.0	27 0	9 0	100
Juniperus chinensis Maneyi					
Sand-peat	None	2 0	16 0″	8 0″	100%
Sand-peat	Aqua	2 0	17 6	8 8	100
Peat-perlite	None	2 0	16 6	8 3	100
Peat-perlite	Aqua	2 0	17 2	8 6	100
Soil	None	2 0	18 6	9 3	100
Soil	Aqua	2 0	16 6	8 3	100

liners were generally in poorer condition than those containing the junipers, the percentage of acceptable pots ranged from a low, of 40 per cent acceptable, to a high of 100 per cent. The use of a soil wetting agent did not appear to affect the longevity of the peat container (table 1) It would appear from these results that the shape of the container makes it improbable that this experimental pot can be used for extended growing periods A pot with tapered sides, a wider base, a reinforced lip and a slightly thicker polyethylene jacket might make this container more applicable to a growing operation.

A medium composed of peat and perlite resulted in plants of dogwood which had more growth and a greater number of breaks than those contained in either a sand-peat or a soil mixture The addition of a soil wetting agent appeared to result in a greater amount of growth in the heavier soil and sand and peat mediums

The slower growing junipers showed little effect as concerns number of breaks or total growth from either the medium or soil wetting agent treatments.

* * * * * *

I mentioned the Dyfoam pot. This is a bonus from the California meeting. Ken and I saw a representative from the Dyfoam Corporation while we were out there. The fellow's name is Frank Dever, Dantoy Products, Burlingame, California. This Dyfoam is a material used as an insulating material. The container in this 6 inch size sells for about ten cents.

We are interested in its use as an over-wintering container. Take a No. 10 can, invert it over a half inch Styrofoam sheet and you can make this cover that will fit over the top of the pot to hold the medium in. It is held in place by four or five finishing nails. It might have a lot of application as a growing container.

Also, the temperature changes within this unit are very slow, which means we might be able to circumvent winter injury during the winter months and might also use it as a growing container during the summer to minimize temperature fluctuations I think the fellows in Oregon have noted that the temperature inside this container is almost equivalent to field soil. In our area with a black container growing taxus, we have no roots on the hot side at all. With this type of container we might be able to put roots on the entire row of plants growing in the south and west rows of our container blocks

MODERATOR SHAMMARELLO, Thank you. Dr. Mahlstede, for your excellent talk

Now we have to limit the questions because we are running way behind time.

MR. ARIE JAN RADDER: I have two questions. One, do you feel that the roots will go through the polyethylene cover? We have been offered this little poly peat pot for taxus liners and I was afraid to use it. I was afraid I would have to cut the polyethylene off before I put it out

DR. MAHLSTEDE: I certainly would advise you to take the polyethylene off. Also, when you plant a peat pot, I would advise you to break out the base, or if you have more time, take the entire peat pot off if it is not rooted through. If you have a lot of roots through, you might as well leave it in place and take off the upper lip before planting. We have noticed with certain types that the roots like to stay in that medium. This will be influenced by the soil moisture, the type of soil you have, and so forth. In a moist medium, if the medium in the pot is peat and perlite, we noticed that the roots did puncture through on the older evergreens. However, I certainly wouldn't advise planting the peat pots with the polyethylene jacket on

MR ARIE JAN RADDER: As for the other question, I would like to have the name of the company that makes the plastic pot.

DR. MAHLSTEDE: The same company that is handling the plantainer, Nursery Metal Pots, Inc is also handling the Dyfoam pot The name of the company manufacturing the pot is Dantoy Products, 1315 Marsten Road, Burlingame, California. Are there any other questions? Thank you

MODERATOR SHAMMARELLO: Our next speaker is Gary Wilms, of the Department of Horticulture, Michigan State University. He is going to talk to us on "The Effect of Nodules on the Rooting of Cuttings of *Juniperus* and *Thuja*" Gary Wilms!

MR. GARY WILMS: Thank you, Mr. Shammarello. It is indeed an honor for me to speak to you today because I hold with great respect the work that has been done by this organization. Also when you are not old enough to vote, it is often hard to express yourself as an individual. Nobody wants your opinion on any subject at any time about anything. But I hope to share with you a few of my experiences that I have had concerning the effect of nodules on the rooting of cuttings of *Juniperus* and *Thuja*.

This paper will give you the basic information that I have found in my studies at Michigan State and also some information that has been obtained at home at the Gary Nursery, Columbiana, Ohio. with my father.

Mr. Gary Wilms presented his paper entitled "The Effect of Nodules on the Rooting of Cuttings of *Juniperus* and *Thuja*." He supplemented his discussion with colored slides.

THE EFFECT OF NODULES ON THE ROOTING OF CUTTINGS OF JUNIPERUS AND THUJA

GARY L. WILMS AND F. L. S. O'ROURKE

Department of Horticulture
Michigan State University
East Lansing, Michigan

Journal Article No. 2722 of the Michigan Agricultural Experiment Station

The side branches of certain species of *Juniperus* and *Thuja*, particularly those on the lower portions of the tree, often have swellings or tissue protuberances along the stem There are termed "nodules" in this report. The cause for the development of these nodules is not known and has been variously attributed to environmental conditions, to genetic factors, and to the physiological condition of the tissues known as juvenility.

Past experience and observations made at the Gwenn-Gary Nursery, Columbiana, Ohio, in large-scale production of cuttings has shown that those cuttings with nodules on the stems rooted more quickly and produced more roots than those without nodules The differences were particularly noticeable with cuttings of Spiny Greek juniper (*Juniperus excelsa* 'Spiny') as those with nodules rooted 70 to 80 percent, while tip cuttings without nodules rooted as low as 10 to 15 per cent A study was therefore made at Michigan State University during the winter of 1960 to compare the degree of rooting between cuttings of several species with and without nodules.

Cutting wood was taken from plants in the Gwenn-Gary Nursery in January, shipped to East Lansing and made into cuttings 7 to 8 inches in length. Lots of 100 cuttings each with and without nodules of three different species were treated with indolebutyric acid and set on January 20. 1960, in a greenhouse bench under mist humidification They were removed on April 10, 1960, and graded into three classes according to the degree of rooting. Arbitrary values of "5", "3", and "I" were assigned to each cutting in the classes "heavy". "medium", and "light", respectively, to use as an index for comparison.

The following table shows the results of the test.

Table 1.—The effect of nodules on the rooting of cuttings of clones of Juniperus and Thuja.

Species and Clones	With Nodules	Total Rooted	Dgree of Rooting: Heavy	Medium	Light	Alive Not Rooted	Dead	Index
*Juniperus chinensis**								
'Hetz'	Yes	65	29	22	14	35	0	225
'Hetz'	No	13	5	2	6	88	0	37
Juniperus horizontalis								
'plumosa' 'Andorra'	Yes	72	40	23	9	23	6	278
'plumosa'	No	50	18	18	14	43	7	158
Thuja occidentalis								
'Woodward'	Yes	98	73	17	8	1	1	424
'Woodward'	No	100	66	25	9	0	0	414

* Nomenclature according to "Standardized Plant Names". 1942

This test indicates that rooting of both the 'Hetz' and the 'Andorra' clones of juniper was markedly increased by the presence of nodules on the cuttings while the 'Woodward' clone of arborvitae was not affected. The effect of nodules, therefore, varies with the species of evergreen from which cuttings are taken

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DR CHARLES HESS: Gary, are these nodules actually root initials or are these just young tissue which has to go through the process of developing into root initial?

MR. GARY WILMS. That I don't know for sure. I made some cross sections and it showed that these definitely were initials, but I couldn't tell whether they came from inside this nodule or not.

DR. HESS: As I understand it you made your cross sections at the time you collected your cuttings. The sections showed root initials, is this not right?

MR. WILMS· Not distinctly They showed the cell formation. I might add that it has been stated that these nodules, when placed in water or in moist sand will continue to grow. They will remain dormant indefinitely if they remain on the plant

MR. HOOGENDOORN: I would just like to add this for your information. Years ago when we were making evergreen cuttings, we found that the Spiny Greek juniper could root, but that it would take two years. If they didn't die, they would root We used to look for bubble cuttings on one and two year old plants. It seems they are most prevalent on the younger rather than the older stock. We generally took cuttings from two-year transplants. That is where we found most of the bubbles

MR. GARY WILMS: Mr. Hoogendoorn were these bubbles distributed all over the plant or mostly on the portion of the plant that you could use as cutting wood?

MR. HOOGENDOORN: Some years they would be all over the plant and other years there may not be so many. They were always on the side branches and sometimes on the main branch.

MODERATOR SHAMMARELLO: That was a very interesting talk.

Our next speaker is Mr. Albert Lowenfels. He has been a pioneer with mist gadgets and I think he has both the first one and the last one on the market. Mr. Lowenfels, will now come up here and tell you about those mist gadgets. Mr Albert Lowenfels!

MR. ALBERT LOWENFELS: One of my first experiences with mist propagation was inspired by Jim Wells One hot summer day I went down to Kosters, and watched Jim's mist system. This was in August. It was the hottest day I ever saw and he didn't know me from Adam, but he showed us around a little bit I went home and put in some nozzles and quickly got mist going and kept it going all day We rooted some cuttings.

The next year I read about a time clock, so I put in a clock operating four seconds out of every minute Nobody was there to turn it off when it was raining or when it was cloudy, and for my money you can forget about time clocks unless somebody is in the greenhouse or the field watching them all day. I think the new devices which have been invented since then are much better.

I have here the first electronic leaf that Charlie Hess sold me. I don't know what year it was, but it wore out. I also know Harvey Templeton invented this unit The one that is now being used is put out by White Showers They are in Detroit and I got this unit from them. In fact, it worked so well that I have two of them. This is attached to what you might say is an amplifier, which is a radio tube When the electronic leaf dries it turns on the current which is relayed through the amplifier to a solenoid value operating the line of mist nozzles. Once in a while you have to change the tube, but I have been using it with good success.

The next device I got was from a man named Geiger in Pennsylvania which consisted of two rods. These are connected to a mercury tube sort of system, which turns the current on and off to the solenoid value. There is a minute distance between these two parallel rods. When the rods get wet the current goes off and when it gets dry the current goes on, giving you mist

The last device I have was brought out, I think last year by this same Mr. Geiger It works on the principle of the weight of water, and is self-contained Everything is in the unit, including a small mercury switch. All you do is to attach this to your electric light system, and to a solenoid value and you are in business. There is a leveling device on this so you can keep it absolutely level

Of these various devices, I am inclined to like this last the best because the two rods have to be cleaned frequently If your water is high in salts you might have problems with the electronic leaf

I think that about describes these various mechanisms I will be glad to answer questions on them. I don't see why anybody should use a time clock when these systems are available.

I have one more word I happen to have another line of business in which I make what people consider a pretty good living. I have received several honors as a result of this business and have made a little money. I have also won a number of boat races. However, I am more honored by having been elected as a member of this Society and to speak here today than anything I have done in my long, long life. I think I am the second oldest man at this meeting. Thank you.

MODERATOR SHAMMARELLO. Thank you, Mr. Lowenfels, for your very interesting talk.

Now our next and last speaker will be Mr. Alfred Fordham. Arnold Arboretum. He will talk to us on "Germination of Double-Dormant Seeds" Mr. Fordham!

MR. ALFRED FORDHAM (Jamaica Plain, Massachusetts): This discussion will deal with seeds having dormancies. The reasons for these natural safeguards were amply covered by Mr. Bergh in his talk yesterday afternoon and need not further be discussed or mentioned.

Mr. Fordham presented his paper and sequence of colored slides.

GERMINATION OF DOUBLE—DORMANT SEEDS

ALFRED FORDHAM
Arnold Arboretum
Jamaica Plain, Massachusetts

The discussion will deal with the two stages of pretreatment necessary for seeds with epicotyl or shoot-bud dormancy, together with the method of shortening the usual time needed for germination. Due to the length of time normally required to germinate them they are in the category of so-called two-year seeds.

CHIONANTHUS RETUSUS

Collection of *Chionanthus retusus* seeds was made in mid-October of 1959. After cleaning they were stored dry until January 18, 1960. This lot was then given five months warm stratification. In this period roots emerged, developed to some extent, and were then ready for cold stratification. If cold is not provided to ripen the shoot-bud the roots will continue to grow until the food stored in the seed is expended. Five months of warm stratification in this case proved to be more than was necessary.

The second lot from the same seed batch was given a three-month warm period followed by three months at 41° F. When sown after these pretreatments a general germination occurred in seven days.

As concerns the method of pretreatment, the seeds are distributed throughout a stratifying medium, which in this case was composed of half sand and half peat moss contained in a polyethylene bag. It is important that the bulk be kept small since at planting time the entire contents of the bag are sown. In proportion, the medium would be two or three times the volume of the seed. It is moistened but is not wet.

Where two stages of treatment are necessary to overcome double dormancy, the bags are first placed on a greenhouse bench to provide the warm stratification requirement In this particular location the temperature ranged between 60 and 101° F. A maximum and minimum thermometer placed in a bag of medium and set on the bench registered this fluctuation. As routine procedure we check seeds with epicotyl dormancy about once a week to see whether or not radicles have emerged. When they do and it becomes a general condition, the bag is moved to the refrigerator to ripen the epicotyl. In the refrigerator a temperature of 41° F. is maintained Wire baskets labeled by months simplify locating bags of seed due to be processed.

VIBURNUM SARGENTI FLAVUM

Viburnum sargenti flavum has been exposed to five months warm stratification. As with *Chionanthus retuses* this length of time was these natural safeguards were amply covered by Mr. Bergh in his talk yesterday afternoon and need not further be discussed or mentioned.

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VIBURNUM SARGENTI FLAVUM

Viburnum sargenti flavum has been exposed to five months warm stratification. As with *Chionanthus retuses* this length of time was more than necessary as the radicles emerged and the seed was ready for cold treatment in three months.

DAVIDIA INVOLUCRATA

The fruit of *Davidia involucrata* is an extremely hard, two to five seeded stone. It, too has epicotyl dormancy. Following four or five months of warm stratification these seams decompose and weaken to the point where the developing radicle forces out this segment. As a matter of interest *Nyssa* and *Davidia* are both in the family *Nyssaceae*. The fruit of *Nyssa* is a one seeded bony stone with single dormancy requiring two to three months of cold stratification to ripen the embryo. The structure of the seed coat is a modification of that found in *Davidia*. As the radicle develops the weakened section is forced out, but unlike the *Davidia* is hinged and remains attached.

We now have the stages of germination in *Davidia*. After four or five months of warm stratification, the weakened segment is pushed away and radicles develop partially. The seeds are then ready for cold stratification. After three months of cold have conditioned the epicotyl, the seedling starts to grow and withdraw from the stone.

HAMAMELIS MOLLIS

Hamamelis mollis responded best when given three months of warm stratification followed by three months at 41° F. This does not have epicotyl dormancy but requires two stages of pretreatment for germination.

Incidentally, we keep our records right on our accession cards. All entries are made on four by six cards and each is assigned an accession number. The origin of the material together with any other information that might be pertinent is recorded. In this instance seeds were received from the University of Washington Arboretum and treatment was started on the fifteenth of February, 1960. Thirty-six seeds were involved. Lot #1 was given three months of warm stratification followed by three months at 41° F. On being sown, 88 per cent germination occurred in seven days. Lot #2 provided the same percentage of germination but required two months longer to do so owing to the longer period of warm stratification. As each movement of the seed is accomplished a note is entered on the card.

KOELREUTERIA PANICULATA

A *Koelreuteria paniculata* seed lot was soaked in concentrated sulphuric acid for one hour. It was then divided into three groups. Lot #1 was sown at once, lot #2 was provided with cold stratification for one month and lot #3 was stratified for two months. Although *Koelreuteria* is supposed to be doubly dormant, a general germination occurred in 13 days when lot #1 was sown without a secondary treatment. In 1958, when this was tried, we found that after a one hour acid soak, the seed germinated in the refrigerator. So, in 1960, the same treatment was tried using seed from a difference source. *Koelreuteria paniculata* seed, when collected in separate years from two different sources, showed the inhibiting condition to be only in the seed coat.

CEDRUS LIBANI

Cedrus libani responded best with two months cold stratification Lot #1 was sown without pretreatment, and germinated poorly and erratically. In fact, after two and one-half months some are now in the hat stage. Lot #2 germinated in 13 days after one month of cold treatment Lot #3 produced a uniform germination in five days when stratified for two months at 41° F. Lot #3 would be the best treatment as Cedar of Lebanon is extremely susceptible to damping-off diseases. When induced to germinate quickly and in unison, they can be potted or boxed in a matter of days By quickly separating them the spread of diseases is minimized.

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MODERATOR SHAMMARELLO. Thank you, Mr Fordham, for your very informative talk. I am sure you will have a lot of questions from the audience.

MR. HOOGENDOORN: I would like to ask a question. Do you treat all seeds which have a dormant period first with a cold, and then with a warm period, or the reverse, or do you vary it with the type of seed?

MR. FORDHAM: It will vary with the type of seed that you have

MR. HOOGENDOORN: How is *Davidia,* the Dove Tree, handled?

MR. FORDHAM: Four or five months of warm stratification followed by three months of cold.

MR. HOOGENDOORN: One other question. I see you have *Hamamelis mollis.* Do you think it is going to come true to type from seed?

MR. FORDHAM: I don't know We just germinated it to get the information on germination.

MR. HANS HESS: How do you handle *Nyssa sylvatica?*

MR. FORDHAM: Give it two months of cold at 41 degrees.

MR HANS HESS. Suppose, for example, you got seed in the fall, as most nurserymen do. We would like to stratify it in the fall and sow them in the spring. Generally, this seed comes in after the period when you can sow it outside. If it went beyond the two months cold treatment would that have any effect on germination?

MR. FORDHAM: No, it perhaps wouldn't. You could extend the period since there is quite a bit of latitude.

MR HANS HESS: Do you have any record as to the percentage of good seed that you normallly get from *Nyssa sylvatica?*

MR. FORDHAM: Yes. With us it generally comes as summer seed and is perhaps 100 per cent good.

MR. HOOGENDOORN: Have you treated *Pinus cembra* the same way?

MR. FORDHAM: We tried *Pinus cembra* this past summer 16 different ways. Some of these ways germinated better than others, but in such a pattern that it didn't make sense We couldn't conclude anything.

MR. C. MAHLSTEDE (Cleveland, Ohio): How do you handle the seed after it has sprouted during stratification? This would be in regard to those that have double dormancy in which the root requires one period, and the shoot requires another period of stratification.

MR. FORDHAM: I am sorry, I don't understand the question.

DR. CHARLES HESS. In other words, when you have a seed with double dormancy and you allow the radicle to emerge, then you return it to the cold to give it the cold treatment to ripen the epicotyl. Can you still broadcast seed of this type that has its radicle already emerged? ?

MR. FORDHAM: Oh, yes, certainly you could. You would have to be very careful. The seeds would naturally orient themselves after they were put out.

MR. JIM WELLS. I would like to ask you if you have tried less than three months warm treatment on any of these seeds and whether you do need the full three months?

MR FORDHAM: Yes, we have done this with some things but generally we treat it three months or more. I expect with many things a shorter period might work.

MR. WELLS: You don't know for sure but you believe shorter periods would be successful. Incidentally, *Hamamelis mollis* doesn't come true to type from seed.

MR. GEORGE HOYSIC. I find that tree peony seeds work this way. We used to use peat moss and we found out that we lost quite a few of them. We now just put sand over them.

MR. FORDHAM: They have the same type of dormancy that the *Davidia* has. They put the radicles out first.

MR. LOWENFELS: Have you done any work on holly?

MR FORDHAM: Yes, some. We worked with *Ilex yunnanensis* and found you could germinate it very readily in high percentages by giving them a five months warm period followed by three months of cold.

MR. LOWENFELS: Now I intend to try *Ilex opaca* and *I. aquifolium this way.*

MR. FORDHAM. We tried those two They are just as unpredictable with us as with everybody else. We can't seem to get uniform germination.

MR. HARVEY GRAY: Al, to go back to the *Davidia,* one of the problems, of course, is in getting the plant into existence because it is good. I tried it several times, not being too successful. You have pointed out the way now, so I look forward to getting a batch of plants by this particular treatment

The question I have in mind relates to cleaning The seeds I have at the moment are still in the fruit. In other words, the pulp has not been taken off and the fruits are in a polyethylene bag. Do you think this would satisfy the stratification period or would you suggest cleaning the seed first?

MR. FORDHAM: No, they should be in the stratifying medium in order to do this.

MODERATOR SHAMMARELLO: Are there any more questions? If not, I wish to thank you again, Mr. Fordham.

The final scientific session adjourned, and the meeting continued in the annual business session.

ADJOURNMENT

TENTH ANNUAL BANQUET

Past President, Harvey Templeton, Jr. and the newly elected President, Mr. Martin Van Hof, presided at the annual banquet held in the Ballroom of the Manger Hotel.

The evening gathering was thrilled when it was announced that Harvey Templeton was the recipient of the Plant Propagators Award. The award was presented as a tribute to his ingenuity which led to the development and perfection of the electronic leaf and control unit for mist propagation. As a faithful servant of the Society, for his willingness to share information, and for his expert leadership in executing the goals and aims of the Society, Harvey Templeton has rightfully been so honored.

The Annual Banquet was privileged to hear an address by Frederick G. Meyer, of the United States Department of Agriculture, who discussed, "Ornamentals in Italy, Southern France, Spain, and Portugal." Dr. Meyer drew on his keen knowledge of ecotypes in developing the flora found in these various Mediterranean areas.

KEYNOTE ADDRESS

SATURDAY MORNING

October 15, 1960

General Chairman Don Hartmann introduced Mr James S. Wells, James S Wells Nursery, Inc, Red Bank, New Jersey, to give the keynote address of the conference.

THE PLANT PROPAGATOR — THE BASIS OF OUR INDUSTRY

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

MR. CHAIRMAN. Fellow growers

It is customary for the speaker to begin by saying how pleased he is to be here, but I do so on rather a different level because it is not often that a speaker has the opportunity to give essentially the same speech under the same title twice in ten years

It was in 1951 that the Plant Propagators Society came into being, and quite by chance it fell to my lot at that time to put forward some ideas as to how our society should be organized. Last week, as I read through the proceedings of this first meeting, I realized that I could hardly improve on what I had said ten years ago. It might be simpler if I suggested you read the first three or four pages of proceedings Number I and sat down. However I feel you expect a little more of me than that.

I am deeply conscious of the importance of this meeting to you and of my responsibility to it Fortunately my position is rather an impregnable one, because events have proven that the ideas of ten years ago have developed into what by any count can be considered a very successful organization

I would like to hark back to the first meeting and briefly describe some of the thoughts that passed through our minds and over which we ranged our discussions at that time. We were conscious of the fact that there had been a Plant Propagators Society in existance in this country way back in the early thirties which had failed partly because of the depression, but mostly because there was a wide discrepancy between the number of people who had knowledge to impart and those who did not. When the neophytes outnumbered the experts things began to dry up. We realized that unless we could re-organize the society on a different basis, adjusting and controlling the level and the quality of our members it could not and would not last.

Most of you know that plant propagation has been a somewhat secretive business This I am ashamed to admit comes largely from Europe and to some extent it still exists there. In it's most extreme form a grower will lock his propagating houses and not allow anyone in. Other growers are not quite so blunt but many may be most uncommunicative and not at all ready to give information away. I am glad to say that this archaic position is slowly dying out, and it was the purpose of our Society when it began to eliminate it entirely from the ranks of it's members.

In my original thinking it seemed to me that the plant propagator was one of the last strongholds of the real craftsman. Here may I quote directly from the first proceedings; —

"It is well for us to consider that the craftsmanship and skill of the plant propagator is the beginning of a long chain of events running through every phase of our industry. It is upon this skill, and upon nothing else quite so much, that all other parts of our great industry ultimately depend. Of what use would the landscape architect or the garden contractor be to the home owner if no plants of any kind were available? Where would the florist obtain his flowers, his bulbs and seeds, and what would be the value of fertilizers, barrows, garden centers and garden magazines without plants? Horticulture in its widest sense is the art of growing fruits, vegetables and ornamental plants. All of these, everything growing which is covered by the term horticulture has to originate with the plant propagator He is, in very fact, the basis of our industry. Holding such a position as this it says much for the character and integrity of this man that he has not wished to take advantage of the situation in any way. Many other groups of workers have thought it right to hold the rest of the community or other members of their business fraternity to ransom in what they like to call their own best interests. Without going into the pro's and con's of labour relations we can look at the record with justifiable pride for I believe there can hardly be another section of the nation which has such a clean record. The true plantsman has little time for such "goings on," he has more important things to do. Just as long as he can make a reasonable living and see that his family is well provided for, then by far the most important thing to him is his work. In this day of machines and mass production the plant propagator is one of the last and as yet unassailed strongholds of the true craftsman. This I suggest is the pivot upon which this meeting (— and indeed the meeting we are having today) should depend and upon which we should base our plans for the future existence of the organization" This was my thinking ten years ago and I would not wish to change a word of it today.

We then moved on to discuss what the requirements of membership should be, and it is here that I would like to emphasize something very clearly and strongly The requirements for membership should be stringent and should reflect an extremely high standard of ethics, skill and experience. If there is any criticism I have to make of our Society it is that the requirements for membership and the manner in which they have been applied have not been stringent enough. Our society has been so successful that people have joined it and are continuing to join it from all parts of the world. As we become larger the problem of retaining and maintaining the high level with which we undoubtedly started is becoming more difficult. Guests can come to our meetings and of course they are warmly welcomed but when you have a membership of some 250 people, all of whom may bring two guests if they wish, it is possible for us to have a meeting of well over 500. The intimacy and vigorous direction of our earlier meetings would then be lost. You may say "well why shouldn't we have 500 people if they are all keen and eligible"? and I suppose there is an argument for it, but whether we like it or not it is impossible for some people to get up in front of a crowd and say what they want to say and the bigger the crowd the worse the problem becomes. There is no question in my mind that we have to keep the size of our society within bounds and that as the quantity of people who want to join becomes greater then we must raise our standards so that we may continue to cull the cream of the crop. This selectiveness, whereby those with superior knowledge and skill are chosen for membership in our society is, in my opinion, essential to it's success

It was my desire to call the original organization the Plant Propagators Guild but apparently the word guild has a connotation in this country which it does not have in Europe. To me it means a group of highly skilled technicians and craftsmen who get together as a fraternal organization to help each other, to discuss the day by day problems of their work and to pass on useful knowledge one to the other What are the essentials for the establishment of a guild? The first and most vital necessity is the collection of a group of people with a high degree of knowledge and skill. The second essential is that this group must be willing to share what they know with others of a similar calibre, and that both must be willing in turn to help the novice attain proficiency in the craft. To quote again from the first proceedings, —" What then should the requirements of full membership be? I would like to suggest these

1. At least 10 years active and practical experience in the art of plant propagation.
2. A high standard of integrity in the community and the trade. This should be vouched for by not less than four people of similar standing.
3. Already willingness to freely share his knowledge and skills with other members.

It is hard to assess which of these three would be considered the most important, but a willingness to share with others would quickly show whether knowledge and experience were there, and the very act of sharing would suggest integrity. I think therefore, that this last a ready willingness to freely share his knowledge and skills with other members should be considered of paramount importance." With these ideas in mind, our society was organized.

We now have before us two clear pictures of different phases of the Plant Propagators Society. The first phase was back in the 30's when we had a simple society to which people paid so many dollars a year to become a member and came to the meetings when they were called. People with knowledge grew less and less in number, people without knowledge increased. This imbalance, further accentuated by the problems of the depression finally eliminated the society. In 1951 it was re-organized, but this time we made sure that virtually all the original members were knowledgeable and that they would plan the distribution of their knowledge in an orderly manner to help those less well trained or less skilled in this profession. The last phase has, I think you will agree, been quite successful. Although the controlled nature of our organization may go against the grain with some, I think our harshest critics must accept the fact that we have a formula which is successful

Before passing on I feel that I should discuss this question of sharing very briefly, because it is a fundamental part of our organization, yet now that I am operating a business for myself I can see perhaps a little more clearly some of the arguments which people put forth in which they say "Why should I go out of my way to help my competitors?" I have come to the belief that it is only wise to be a little discriminating. Let me give you an explanation. I have a competitor in my area who is growing many of the plants which I grow He is selling them at cut-throat prices and he is a disturbing influence because he is upsetting the proper balance of trade. He is not a member of our society and were his name to come up and I had the opportunity, I would veto his application. He has been to my nursery and I have shown him around in a casual manner. When he wanted to buy hormone powders of a special type we were just out He is treated with courtesy but not with detailed co-operation

What is the other side of the picture? Four years ago when I began my business I went to my many nurseryman friends and said "Can I have some cuttings" and without exception I was handed a pair of clippers and told to help myself. I found the most warm and generous openhandedness on the part of everyone It was generous enough to set me up in business growing plants which they are selling Now when any one of them appears on my nursery, or writes and asks for advice I respond immediately I have received tremendous help from all of these people and I like to think that in some small measure I have been able to help them too.

Coming now to the actual meetings of our society, those of you who have attended will know that you have never taken part without coming away with more knowledge than you gave. This is a unique situation! We have a society of keen and knowledgable people all of whom trust and like each other. They know that their neighbour is not trying to steel a "march" on them: they know that this country is big enough and the opportunities are sufficiently great to justify anyone getting into the production of any plant that interests him, for we have not yet scratched the surface of the horticultural potential in the United States. They know that if they help this man today, tomorrow they will come to a discussion which will help them to do their job more efficiently. Time and time again members have come to me and said "I heard so and so at the last meeting. We tried it last winter and it works to perfection" This atmosphere, this quality of knowledge plus a desire to share one with the other has not come about by chance. Therefore I cannot urge you too strongly to organize on a similar basis and to organize not at all on the basis of quantity but solely on that of quality.

We are surrounded today with quantity — millions of units, billions of dollars. We talk glibly in these figures and in many respects quantity is the criterion by which success is judged. I would not decry this completely because it does indicate a general vigour and aggressiveness which is an integral part of a growing economy. But it won't suffice for us, for quantity is not what we want. If we want quantity· if we are interested in joining societies then just look in the horticultural Who's Who and slap down a couple of hundred dollars and join 50 societies There is practically no limit to the number you can join. You will pay your $5, receive your bulletin and thats about it. I believe that we want something more from our society, and in order to achieve it we have to be selective.

Therefore, to sum up, I would urge you to organize on a very high level Let membership in your chapter of our society be something to be prized above all other membership that might be available to the person concerned. Let it be something that he has to strive to attain, and once attained, has to maintain at a high level in order to keep. Let there be stringent requirements of him not only to get in but to keep in. Let him be required to contribute regularly to the meetings or to the News Letter or to some aspect of your corporate activities, so that he remains an active contributing member. It is far better that you have a modest number of such people actively working together, than that you have a large number with but few contributors The atmosphere generated and the pleasure each will receive from your meetings in the limited group will be far greater than in the wide unrestricted one.

One final point. We who were in at the beginning of the society are delighted to be here also for the first meeting of the first chapter. We realize that geography and climate will dictate your interests which may well be different from those of the parent society. But we hope that you will plan and develop in such a way that you can maintain the closest possible contact with the central organization. The "WESTERN CHAPTER" is our first born, and as such must always hold a special and most high place in our regard. We shall follow your development with keen attention, wishing you well in every way, and hoping that your activities can further enhance our mutual desire to establish and maintain the plant propagator as a craftsman of the highest order

PRESENTATION OF OFFICERS AND COMMITTEE MEMBERS OF THE PLANT PROPAGATORS SOCIETY

Chairman Don Hartman convened the session which took place Saturday evening, October 15 and turned the meeting over to Mr. Philip Barker, Department of Landscape Horticulture, Davis, to introduce the officers and committee members of the Plant Propagators Society.

MR. BARKER: The first person that I would like to introduce is the President of the Plant Propagators Society. He attended Georgia Tech University and spent some time at Yale and the University of the South. For 20 years, he was a cotton merchant in the South As he in-

FRIDAY EVENING SESSION

October 14, 1960

Dr. Lloyd A. Lider, Department of Viticulture and Enology, University of California, Davis, moderated the symposium. Chairman Lider opened the symposium with the following remarks.

MECHANIZATION OF GRAFTING METHODS

LLOYD A. LIDER
University of California, Davis

The panel discussion of machine grafting techniques which has been placed on the program this evening exemplifies the basic reasons for desiring to establish this society and for its meeting together this evening. The vegetative propagation and grafting of perennial plants has been an important phase of commercial nursery operations for many years. Several specific horticultural industries in California are based upon the use of scion varieties grafted on special rootstocks designed for certain environmental conditions or because they are resistent to soil borne pests or diseases.

Techniques of propagation which insure the successful production of a dependable number of strong grafted plants for nursery sale are essential to the program of providing the planting stock for the expanding horticultural industries of this state.

Various types of mechanized grafting techniques have been used for several decades in the European grape industry. Many hundreds of thousands of bench-grafted vines are produced each year and an increasingly greater proportion of them are being produced using techniques designed to reduce or eliminate hand labor. Several commercial nurserymen in California have adopted some of these modernized practices and for at least the last 25 years, mechanical grafting tools have been used for producing bench-grafted grapevines.

The California grape industry is an excellent example of the growing demand for grafted planting stock This huge industry — comprising over 450,000 acres of vines — currently has approximately 30% of its acreage planted upon resistant rootstocks. The industry is currently replacing — or adding new — about 15,000 acres of vines each year. This means, then, that 5,000 acres are put upon rootstocks — at 500 vines to the acres, we are planting each year, an additional 2½ million grafted vines. Obviously, this is a big operation in which new labor-saving techniques have a definite place.

The current crisis in the California pear industry is a second example of the importance that grafted rootstocks can play in a large agricultural industry. It appears likely that this industry will be saved by the use of certain specific stock-scion combinations. It is estimated to date that the state has lost between 150,000 and 170,000 bearing pear trees and is threatened with the loss of about ⅓ of the total acreage existing in the state. The state's total bearing acreage is approximately 37,000 acres, thus something like 12,000 acres or a total of about 1½ million trees have a shadow hanging over them. If this dire prediction comes about, it will be the obligation of the nursery industry to make available a comparable number of nursery grafted trees, upon which to rebuild this industry.

It is obvious from these examples, as well as from many others which could be cited, that the nurseries of California hold a key position in the fruit industries of this state. The nursery business will continue to play a major role in helping solve the problems that come to face California horticulture, and as well will be instrumental in insuring its future progress.

In order to insure the success of the nurseries in fulfilling their obligations to these fruit industries, they must be capable of providing a continuing supply of strong and healthy grafted replanting stock. In order to do this, the use of modern techniques of propagation and the adopting of new ideas of mechanized grafting as they are brought to light are obviously important.

The expansion of new plantings of horticultural crops is going on continually. Many old areas in California are going out, and new areas are being developed to take their place. Research has pointed the way to an understanding of the old and some new disease and pest problems and in some cases, has offered new types of graft combinations as their solution. Many of these new types will be tested and adopted by the industries. On the other hand labor costs are continually climbing The production of hand-whipped bench grafts is slow and expensive. It requires great skill in the hands of the individual. We all know that the finding and training of new grafters is increasingly difficult.

For these reasons, and many others, the progress in the development and use of mechanized grafting tools is of great interest to nurserymen today. A panel of three speakers has been brought together here to discuss for you several types of mechanical grafting tools and how they have been adapted to specific situations in commercial operations.

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Chairman Lider introduced Dr. Curtis Alley of the Department of Viticulture and Enology, University of California, Davis.

MACHINE GRAFTING AND PREPLANTING TECHNIQUES FOR GRAPE BENCHGRAFTS

Curtis J. Alley

University of California, Davis

Before the introduction of phylloxera into France around 1868, and into California about the same time, there was little need for grafted or budded grapevines. Most grapevines were developed on their own roots, generally by rooted cuttings grown in the nursery the previous year.

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Phylloxera, however, made it imperative to grow desired fruiting varieties on phylloxera-resistant stocks. The same was true of sandy areas where nematodes were a troublesome pest. When resistant rootstocks were first used, hand labor was the chief method of making the benchgrafted vines. Where labor costs are low, such is the common practice even today.

Present economic conditions in the U.S. prohibit such an operation. It wasn't long after benchgrafting became a reality that enterprising nurserymen and growers began to develop machines to do the job for them. Not only could the workers be semi-skilled, but the machines could work faster and without tiring.

There are three methods of producing nursery grafted grapevines: (1) the scion may be grafted on the resistant cutting, rooted in the nursery, and planted in the vineyard a year later; (2) the resistant cutting may be rooted in the nursery, dug the following spring, benchgrafted, returned to the nursery for a year, and planted in the vineyard the third year; (3) the resistant cutting may be rooted in the nursery for one year, grafted or budded in place without removal the following fall (budding) or spring (grafting) and planted in the vineyard the third spring. The first method is fastest and cheapest, and therefore preferred. The second method is recommended for rootstocks that root with difficulty or for cuttings of resistant stocks that are too small to graft as cuttings. The third method eliminates digging and replanting, but produces very large vines, difficult to dig and handle.

BENCH GRAFTING MACHINES — The machines to be discussed are used either commercially or experimentally in making benchgrafts of grapevines.

TONGUE and GROOVE MACHINE — The tongue and groove type, a very successful machine, uses the basic ideas of a tongue and groove type cut contained in an Austrian patent, issued about 1928 to

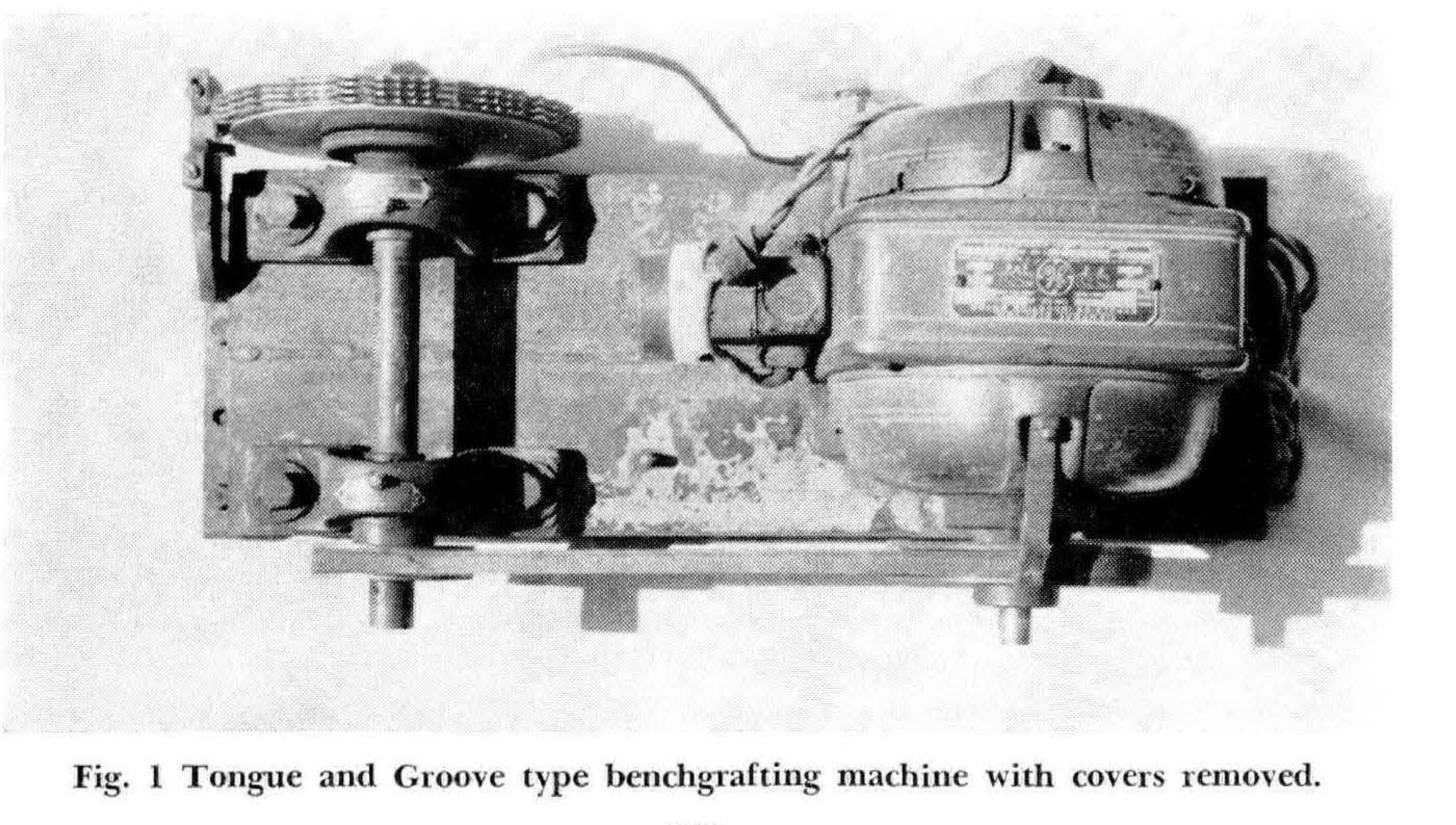

Fig. 1 Tongue and Groove type benchgrafting machine with covers removed.

Albert Hengel, Limberg, Austria A modified version, built by H. E. Jacob, University of California, (Fig. 1) consists of a ½-HP 110 V. electric motor with a 5¼″ pulley that runs at 3,500 RPM.

The motor drives a saw mandrel by V belt at 5,250 RPM. The saw mandrel consists of a 3¼″ pulley, a 1″ shaft supported by two bal-bearing supports, and a series of saw blades (separated by aluminum discs or spacers), all purpose blades 1/16″ thick 8″ in diameter, with very little set to the teeth — 1/32″. Water is sprayed on the saw blades through the top of the saw guard by a ⅛″ copper tube flared on the end to give a fine spray. This prevents burning or drying out of grape tissue in cutting the series of grooves

For benchgrafting, the saw head is four blades, separated by aluminum spacers, ⅛″ thick and 7″ in diameter. The combination of blades and spacers is such that it cuts a series of grooves, each 3/32″ thick and ½″ deep The entire saw unit is covered with a sheet metal guard, except the cutting guide opening for insertion of the scions and stocks, and the bottom, which permits the water and sawdust to drain into a barrel. The cutting guides are so adjusted that the fit between rootstock and scion is even along the sides when the rootstock cutting or rooting is cut against one guide and the scion against the other guide, providing both are of the same diameter and the ends of both are cut squarely across before the grooves are cut When scion and stocks are ½″ thick or more, tying at the union with a rubber budding strip or raffia is unnecessary

Good, straight, well-matured wood, accurately size graded, is necessary for fastest work. In careful tests, a number of grafts made with the machine were comparable to short whip grafts made by hand by a skilled grafter. Three reasonably fast men can make 2,000 to 3,000 grafts per day with the machine. The completed benchgrafts are generally tied with a rubber budding strip or with raffia. With a similar machine, the pulley that drives the saw mandrel is located in the center of the shaft. One end of the shaft turns the saw blades for cutting the grooves, and the other end turns a wire brush, for disbudding, or turns another set of saw blades. With one head for cutting the scion and the other head for cutting the stock, two men working at the same machine can obtain a high output.

A large version of this type of machine is used commercially. A seven-man crew, making 5,000 to 6,000 benchgrafts in an 8-hour day, consists of one man cutting rootstocks, one cutting scions, three joining stocks and scions, and two tying the benchgrafts Excluded, of course, are the time and labor required to make the cuttings and scions, disbud the rootstock cuttings, and grade. Raffia is the preferred tying material. Rubber budding strips have been used in the past, but this requires their cutting in mid-summer. This machine cuts a single groove, ⅛″ thick. The advantage of this machine is the speed and ease of operation. Output is high, and it works very well with large and medium size material. The finished grafts can be handled roughly without disturbing the union (especially when tied with rubber budding strips). A disadvantage is a tendency to give a rougher cut than machines that use knife blades

Another machine of this type cuts a single groove, $1/8''$ thick and $3/4''$ deep instead of $1/2''$. A very long staple inserted at right angles through the entire graft union is very satisfactory, though the grafts cannot be handled quite as roughly as grafts tied with a rubber budding strip.

FRENCH-TYPE MACHINES — Modified Long Whip Graft: This machine can be hand or foot operated (see Fig. 2). The operating lever moves two knife blades, fastened to a V-shaped bracket at an angle, on machined runners through a base, slotted to permit just the blades

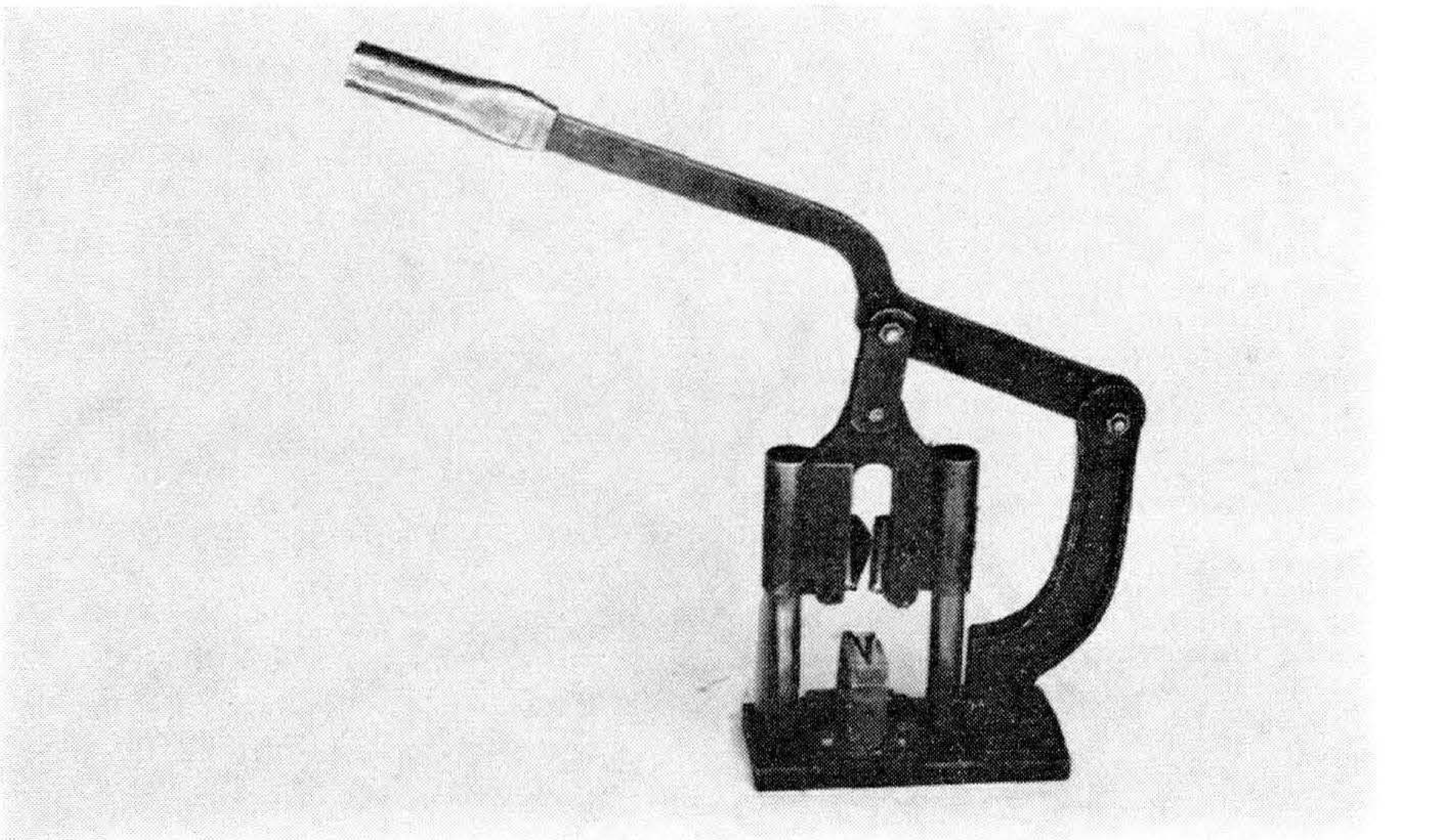

Fig. 2 Modified long whip graft French machine.

to pass through. This machine cuts a long V-shaped notch in the top of the rootstock cuttings and a corresponding tapered point on the scion. The taper is equivalent to two to four times the diameter of the stock (long whip). A five-man operating crew can make about 4,000 benchgrafts in an eight-hour day — one man cutting stocks and scions, two men matching stocks and scions, and two men tying with rubber budding strips. This is exclusive of preparation of cuttings, grading, and sizing. The completed graft after tying is very strong and can be handled rather roughly without breaking. The machine does a very good job on large and medium-size stocks. Since the machine uses knife-type blades, the cut is much smoother than that obtained with the tongue and groove machine. A disadvantage is the difficulty of obtaining cutting blades that have a good steel and can hold their edge. There is one report that when the scion and stock grow together, there is a tendency for the scion to cause a splitting of the stock down the center. The machine retails for about $45.

Modified Short Whip — A. Lozevis, Agen, France, sells grafting machines that make short whip type of benchgrafts. Several types of such machines are available. All the machines use three knife-type cutting blades. The machines are operated electrically or by hand or foot. The types demonstrated here are the hand and foot operated models.

The Nova Rapide is reported by the manufacturer to be portable, permitting grafting in the field. Consequently, it is not a production machine. It can also be mounted on a table and used for benchgrafting. Although not tested commercially, what use has been made of this machine indicates that it will be slower than the modified long whip machine. This machine is hand-operated, but could be easily altered to foot operation. It costs about $25 delivered.

The Ultra Rapide is a foot-operated production machine (Fig. 3), costs about $40 delivered. The carriage, holding the three cutting blades, slides forward horizontally on machined guides. The scion is cut with the left hand, and the stock with the right hand, the two parts are joined together, and passed to the next person for tying or dipping in wax. The manufacturer claims 5,000 to 6,000 benchgrafts per day.

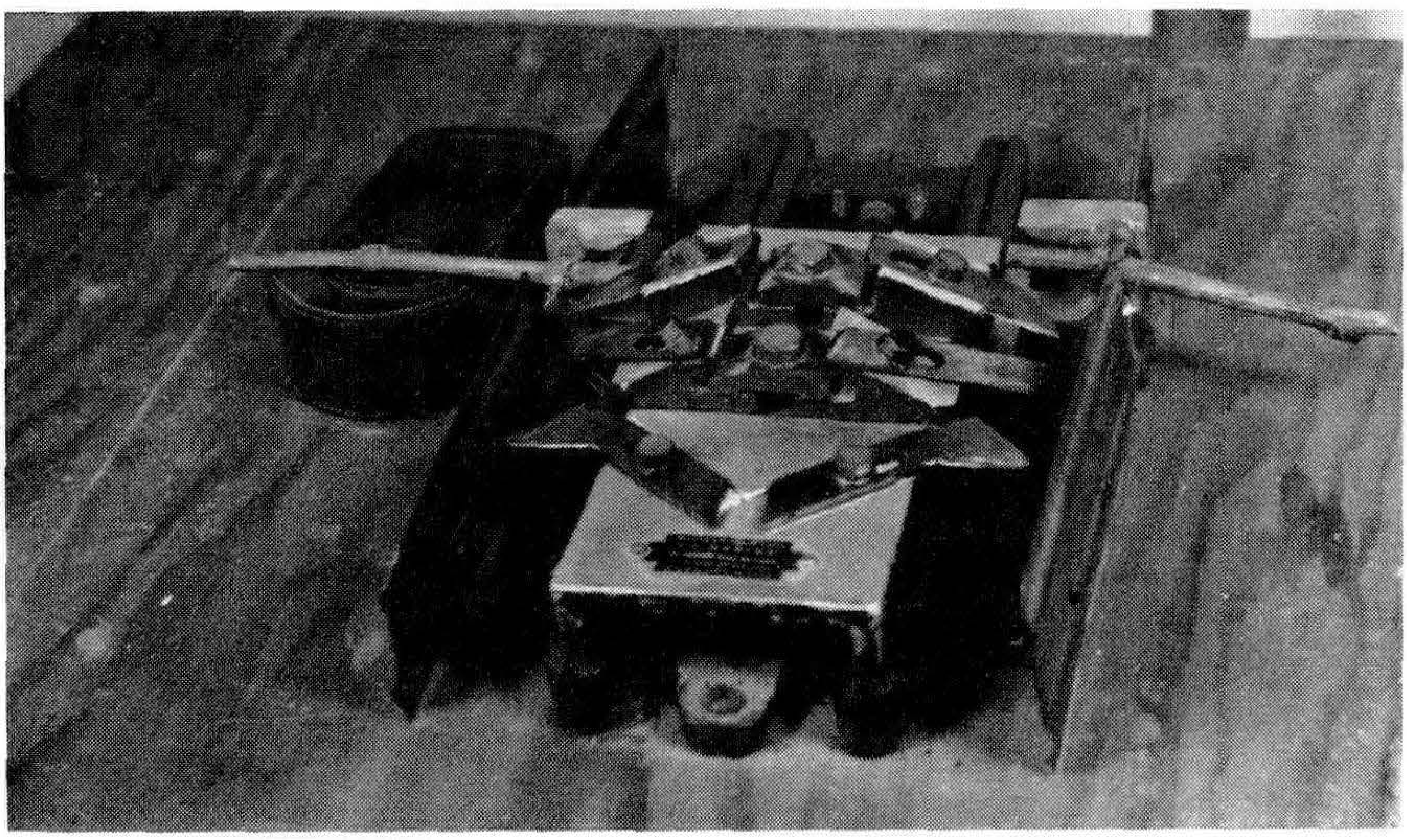

Fig. 3 Ultra Rapide benchgrafting machine

The two types of machines made by A. Lozevis that we have used make a much finer cut than does the tongue and groove type machine. *However, the short-whip type of graft does not lend itself to a union* that can be handled roughly in the nursery. The cut is so short that it cannot be easily tied.

If the benchgrafts are completely dipped to about 3/4" below the graft union with a very hard type of grafting wax, a fairly strong joint can be obtained. It is not necessary to tie waxed grafts, but they must be handled more carefully than a tied graft made by the tongue and groove type machine or the modified long-whip machine. Waxing is a faster operation than tying with raffia or budding strips.

All the machines of A. Lozevis make a type of short-whip graft that must be handled carefully. These types of machines do excellent work on medium and small diameter wood. On large diameter wood or wood that is rather hard, the cut may tend to be wavy, since types of wood cause the somewhat flexible blades to bend when passing through the material. The advantage of the machine is that the cut on small or medium size wood is very clean. Also, the machines are more readily available and some are cheaper than the tongue and groove type or modified long-whip type.

LILIPUT BUD-GRAFTING TOOL — This type of benchgrafting machine (Fig. 4) is in reality a Yema grafting tool manufactured by Leon Brendel of St. Helena. It is an improvement of the original machine, developed by Ulysse Fabre, Vaison (Vaucluse) France. This machine uses three knife-like blades and cuts out a dovetail bud (Yema) that fits snuggly into a corresponding notch cut out of the rootstock cutting or rooting. The machine can be used in the field or on the bench . With sharp blades and correct adjustment, the machine gives a very clean, smooth cut. Tying is not necessary, but nevertheless is recommended, using raffia, staple or budding rubber. The machine is not as fast as a skilled budder, but does a satisfactory job in semi-skilled hands. On the bench the machine would be about equal in output to the Nova Rapide. The main advantage to this machine is that the

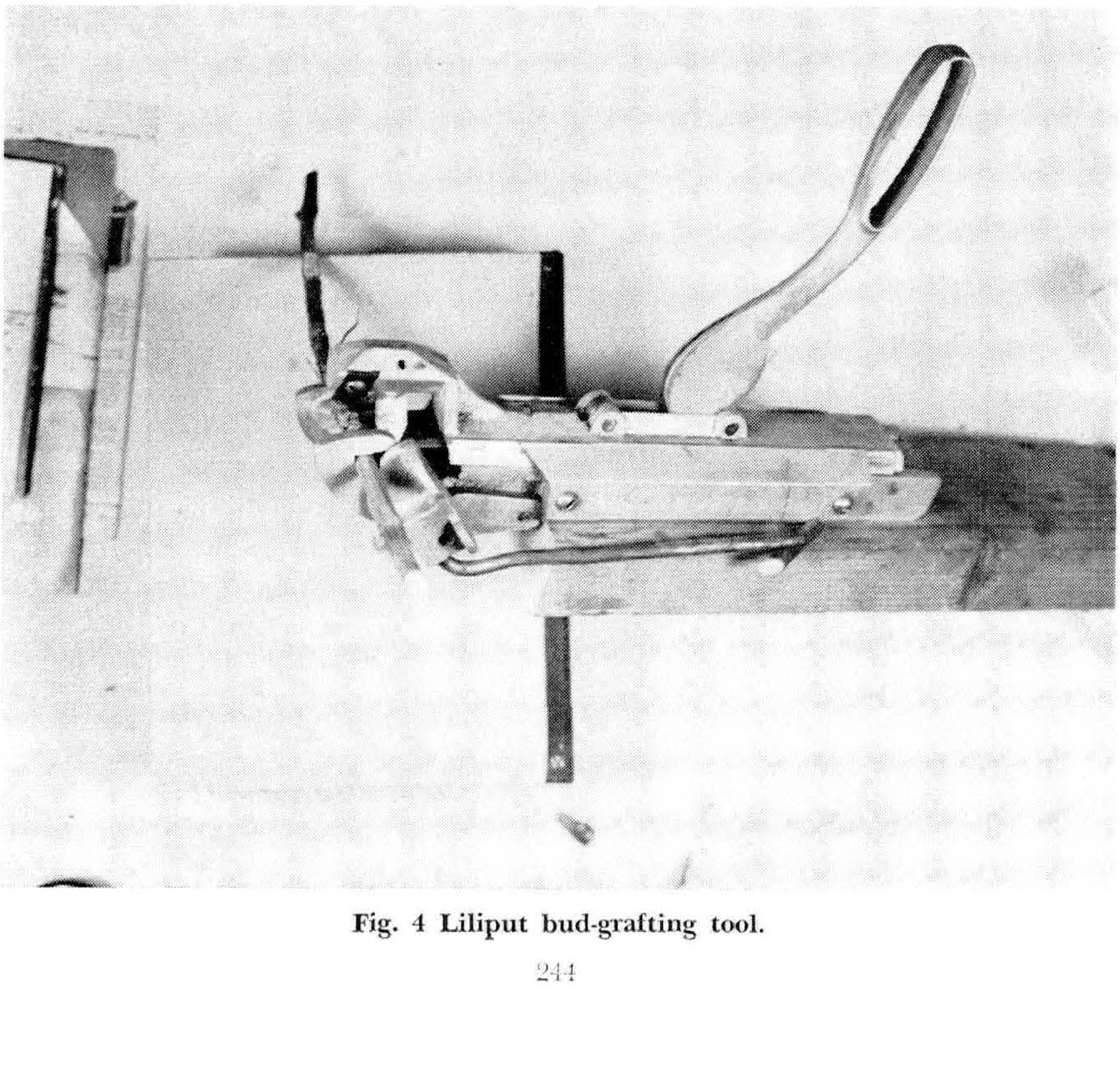

Fig. 4 Liliput bud-grafting tool.

stock is not lost should the bud fail to grow. The top bud of the rootstock cutting or rooting is not removed The Yema graft is made below this bud. Should this Yema bud fail to grow, a nurseryman or grower can make another attempt on the same stock.

The machines discussed above have been used chiefly for grapevines.

In addition, A Lozevis manufactures a machine for benchgrafting roses It seems very possible that such machines could be adapted for woody ornamentals as well as trees. One should remember that these machines work only on hard wood, such as would be found with woody plants in a dormant condition.

PREPLANTING TECHNIQUES FOR GRAPE BENCHGRAFTS

Rootstock cuttings and scionwood cuttings are collected in the winter when the vines are pruned. The cuttings may be made in lengths of 30″ or more. Just before grafting these long cuttings are made into the desired lengths. Benchgrafting can start as early as January and continue until the middle of April The rootstock cuttings should be as straight as possible. The length of the rootstock cutting depends on the locality where grown For coastal regions, a 10 to 11″ cutting is best, for loamy or sandy regions of the interior valleys, a 12 to 14″ cutting is preferred. After cuttings are made, they should be completely disbudded with a sharp knife, pruning shears, or disbudding machine. The stock cuttings are cut off at the base just below the basal bud, and not less than one inch above the top bud.

GRADING — For greater ease and speed in making benchgrafts by machine, the stock and scions should be graded. The best location for grading is where the cut on the stock or scion will be made by the machine. Grading is easy with a slot grader. This consists of a "V" slot, marked across with 5 or 6 horizontal guide lines, cut in the head of the lug box or a brass plate 7″ long with a width of ¾″ at the top, tapering down to ¼″ at the bottom. The ends of the slot are widened into circles, 1¼″ and ½″ respectively at top and bottom. Five or six grades are generally sufficient.

PREPARATION — Scion cuttings generally consist of one bud, cut 1¼″ above each bud and with 1½″ to 2½″ of internode below. Stocks and scions soaked in water for 12 to 24 hours just before cutting are, thereby softened, permitting a smoother cut.

One-year-old rootings to be benchgrafted must first be washed clean. The rootings are shortened to a uniform length of about 12″ and completely disbudded; the roots are cut back to very short stubs no more than 1″ long.

BENCHGRAFTING — After the scions and stocks are graded, they are cut, using one of the machines described earlier. Then they are put together and tied or fastened by staples

CALLUSING — The stocks and scions are nearly or completely dormant. Under favorable conditions, they begin growth processes that bring about the rooting of the stock, the sprouting of the scion bud and the union of one with the other. However, conditions in the nursery are not usually favorable at the time of benchgrafting, so many will dry or be injured by cold or excess moisture if planted then. For this reason, the newly-made grafts should always be placed where moisture, temperature, and aeration can be controlled. Benchgrafts made late in the spring (end of April), when conditions for growth are favorable, may be planted out directly in the nursery. They will callus in the nursery row.

Benchgrafts made with a long hand whip or long machine-type graft are suitable for sand-callusing. For the short or modified short whip graft, the hot-room callus method is recommended as more gentle handling is necessary.

SAND-CALLUSING — First, benchgrafts are tied in bundles for convenient handling

Fine sand, free of pebbles, clay, and organic matter is best; fine, clean building sand is ideal. It must be moist enough to support plant growth, but not too wet to work easily between the bundles of grafts.

The callusing bed may be a pie of sand in an open shed or on the south side of a building. The shed, if used, should be in a warm location. A callusing bed in the open must have a cover of glass, canvas, board. etc., for protection during rainy or cold weather, and open during dry, warm weather The bundles of grafts are placed in the sand in a nearly vertical position, one row at a time, scions up, and sand worked in between the bundles. A layer of sand 2 or 3″ deep is laid on the bottom of the bed before the grafts are placed in position, and the tops of the grafts are covered with a uniform layer of sand 3 or 4″ deep. All the unions should be at the same level. The top of the sand must be slightly moistened every day or two to replace the water lost by surface evaporation. Care must be used to wet only the sand that has dried out and to cover the bed during rainy weather and cold nights.

If the temperature of the sand is about 75° F., the union will callus over and the buds and roots begin to grow in 3 to 4 weeks This period will be shorter with higher temperatures Temperatures above 85° F. cause a profuse, soft callus tissue that may die or be severely injured by unfavorable conditions during or after planting in the nursery. Below 70°, callus formation is very slow, and below 60° it practically ceases. The grafts should be planted in the nursery as soon as the unions are well-callused and before the shoots and roots have made excessive growth.

Sand-callusing or a modification is used by some nurseries that benchgraft grapevines in California The completed benchgrafts are placed either indoors in moist or semi-moist sand or outdoors in an open sand bed. Temperature is more variable outdoors than indoors. Benchgrafts are stored for 4 to 8 weeks and then are planted in the nursery row about the middle or end of April in the coastal areas and around the middle to end of March in the San Joaquin Valley

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Chairman Lider introduced Dr. Thomas D Terry, S. J., Novitiate of Los Gatos, Los Gatos, Califonia.

MACHINE GRAFTING FOR GRAPEVINES

THOMAS D. TERRY

Novitiate of Los Gatos, Los Gatos, California

This report relates the use of machines in grafting grapevines in a small California vineyard in Santa Clara County. It is a general non-scientific view of why this particular vineyard adopted machine grafting and how these machines were used and modified.

Before the use of machines, vines were budded in the field. A good budder, working with two assistants, would bud from 300 to 400 vines in an 8-hour day. There were other disadvantages besides this relatively slow rate. To find mature budwood before the rootstocks run out of water and cease growing is difficult in non-irrigated vineyards. This relatively short period, when field budding is possible, occurs in late August and early September, at the beginning of the vintage, the busiest season of the year. If the bud-graft does not take, that portion of the vineyard is idle for another year

In the winter of 1951-1952, the Novitiate purchased a grafting machine from Mr. Leon Brendel of St. Helena, California. This machine makes identical long triangular cuts in the rootstock and scion. The pointed cut scion is inserted into the V-notched rootstock and held in place by various methods At the time of purchase, we had thought that a man could make 1,000 grafts a day with this machine. The normal rate for three men still was from 400 to 500 grafts for an 8-hour day However, other advantages over field budding were apparent:

1. The grafting is done inside on rainy days in the winter time when workmen would otherwise be idle.
2. Somewhat less skill is required.
3. The grafts are first planted in a nursery, where they can easily get the needed extra water and care for the first year.
4. Only grafts that take and grow well in the nursery are replanted in the vineyard: consequently, vineyard space is not idle.

In the winter of 1952 - 1953, Dr. Curtis Alley introduced us to a type of grafting machine, developed at the University by H. E Jacob This machine cuts a tongue and groove pattern in rootstock and scion wood with circular saws. The scion wood and rootstocks cuttings are fitted together, and the grafts are made stable with raffia or budding rubbers.

The main advantage of this machine is speed. With this machine, our men easily turn out 2,000 grafts in an 8-hour day. One man operates the machine and fits the stock and scion. One man ties the graft with budding strips. And one man provides wood for the saw operator and packs the finished grafts in damp sawdust. Thus, three semi-skilled vineyard men, working inside on a rainy winter day, turn out 5 times as many grafts as three men working in that critically short and busy season when field grafting is possible. And none of the men on the benchgrafting crew must be as skilled as the actual field budder.

Benchgrafting in our vineyard is usually done between February 1 and March 15 The grafts are stored in damp sawdust in an unheated barn, where the temperature range would be from 45 to 60° F. The grafts are usually planted in the nursery between April 1 and 15. Sometimes the buds are beginning to push when the grafts are planted, and one must be careful not to knock them off

Before planting, deep, narrow furrows are cut in the nursery about 4 feet apart, using a chisel tooth The grafts are set in place with the scion at normal ground level Above the scion, between the mounds of dirt on either side, is placed ¾ to 1 inch of sawdust. The sawdust layer may be covered with a very thin layer of soil. The young shoots cannot break through a very thick crust of our clay soil. The dirt for heaping up along the sides of the planted row is taken from between the rows. This hollowed out area provides the furrow for irrigation.

The grafts are brought to the nursery in damp sawdust in grape boxes, and the grafts remain in the damp sawdust until they are actually planted.

As you know, many factors can affect the percentage of grafts that take — water, rodents, insects, soil fertility, etc. If difficulties from these sources are eliminated, we get about 85% to 90% of our grafts to grow.

Over the years, we have made two useful modifications. The original machine cut a 3-finger and 2-slot pattern. If the cuttings were narrow, and not properly softened with water, the machine would tend to shred the ends while making the cuts. Our second machine cuts a 2-finger - 1-slot pattern. On smaller cuttings, the shredding has been minimized.

Another modification is in tying the graft. We formerly used raffia. This is effective, but quite time-consuming. For the past two years, we have simply stapled the grafts together. So far, we think it is just as effective as raffia and more rapid.

We made both of the circular-saw grafting machines. Comparable machines could be made for $75 to $85. The stapler is a large, heavy stapler (Acme No. 1). I am not aware of anyone who sells circular-saw grafting machines

We are very well-satisfied with our present grafting methods as compared with our earlier methods. We are still interested in any new methods that will increase the rate of grafting or the percentage of grafts that take.

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Chairman Lider introduced Mr. Gordon Kershaw of Medford, Oregon, who presented the following paper.

MACHINE GRAFTING OF FRUIT TREES

GORDON KERSHAW
Medford, Oregon

Dr. Lider and Plant Propagators: It was an honor to be asked to give my experiences in grafting fruit trees Dr Alley has asked me to relate some of my experiences in developing several types of grafting machines.

About 1951, we planned to graft some of our pear trees to the variety Red Bartlett. Since the wood was very scarce, we decided to make a bark graft using one bud, set in the stock. This would provide a better take.

We used a 5 kilowatt electric generator and an electric chain saw to remove the tree tops. A band saw was used to cut the scions, always leaving one or two buds on the top of the scion and making sure that one of the buds was facing the outside of the graft This method was successful in producing take as high as 98%. When this method was used on apple trees, the results were nowhere as satisfactory. The cambium seemed to be injured by the saw.

About 1953, we started growing Malling rootstock for dwarfing apple trees. We grafted apple root below Malling 7 and 9, using the circular saw machine as commonly used in California on grapevines. Our first saw speed was 750 rpm, but we found that the bark was torn and left a ragged edge. Increasing the saw speed to 3,500 rpm still produced a rather rough cut on the scion and stock. After joining stock and scion, the grafts were allowed to callus. Most of them remained without any callus development and eventually developed blue mold and died. "Just like the doctor who performed a successful operation, but the patient died"

Approximately 2,000 benchgrafts were made using this method Dr Higden examined them under the microscope and found that the cambium was damaged on the edge and failed to heal. In the process of grafting, the problem of sanitation is very important. The mechanics of grafting is only one step or phase in the operation to develop a grafted plant. Any step along the line can cause failure if not properly handled. Our most effective process is to clean the stock to be grafted and dip the entire plant in a solution of aerosan using 2 tablespoons per gallon of water Scions are also dipped in this same solution and allowed to dry before grafting. The saw blades are painted with a solution of 7½ grams of $HgCL_2$ (citric acid base), 7½ grams of $Hg(CN)_2$ in a pint of water. This is extremely poisonous and should be handled with great care. It is excellent for sterilizing knives and scions. Incidentally, this solution is also Prof. Reimer's "blight solution" for pear trees.

The first grafting machine that we used was the La Rapide built by A. Lozevis of Argen, France. This type machine makes a short whip-graft cut, but it is very hard to adapt to woody plants that have hard and brittle wood. Dr. Alley stated this machine is supposed to make two cuts at the same time, one to cut the scion and the other to cut the rootstock, but it is impossible to make both cuts at once. The writer has tried this and all that he has succeeded in doing was to bite his tongue.

By setting the machine in a vertical position and using compressed air, 12 to 15 cuts a minute could be made. However; the cuts were never smooth, only on one side, and so short that we had trouble in tying them together About 10,000 benchgrafts of apple (using double benchgrafts) were made. The grafts callused well, but were difficult to put in the field without breaking. Even with all these hazards, we still obtained about a 50% take.

Our next machine was a chip budder which we developed ourselves. It makes a clean cut, beveled on both sides, so that the chip bud is held in place by the stock and is covered by wax or budding tape, and heals very quickly Again sanitation cannot be over-emphasized. The machine should be cleaned every 50 to 100 cuts with blight disinfectant solution. Do not forget to dip the stock and scions in aerosan $Hg(CN)_2$ solution

The chip budder makes a clean cut. However, the human element is the most troublesome. Upon sending benchgrafts to friends, they soon call back and report that the benchgrafts are smooth, but that about a third of the scions are upside down. This caused no end of headaches until two changes were made. Where the cut is beveled on both sides of the bud, we moved the bud from the center of the chip to the lowest point of the chip, leaving a long blank space above the bud Also we changed the shape of the chip bud by making the top cut vertical instead of beveled. This produces a chip bud having a bevel cut below the bud and a square cut above the bud. It is impossible to put in a chip bud upside down. When cutting scions for benchgrafting, the cut above the bud is made at an angle and below the bud is cut squarely across (or a bevel cut on the lower side of the scion and square across the top). The speed of the chip budder is between 30 to 60 cuts a minute The slow part of the operation is assembling the scion and the stock, placing the chip bud in the stock, and then wrapping or tying.

To make some of the dwarf combinations, such as a fast growing rootstock, a dwarfing inter-stock, and the scion variety would necessitate all to be accomplished at the same time; for example, with apples Malling #16 rootstock, a Clark Dwarf or Malling #9 inter-stock and the scion. This would require a machine of high flexibility. It should be able to make several different cuts. It should be powered by air and controlled by electric solenoid valves. By changing the various jigs, it should be possible to make the following cuts for grafting and chip budding: (1) Whip grafting (2) Side grafting (3) Scoop grafting (4) Chip budding (5) Saddle grafting and (6) Double side grafting. The machine should make clean smooth cuts at all times. We have developed such a machine and are able to make these cuts at the rate of 60 or more per minute — chip bud, whip graft, and side graft After this machine has had a few of the bugs worked out of it, as all new gadgets do, I will be glad to give an additional progress report. In addition, the machine makes cuts on stock and scion from the size of a matchstick to 3/4″ in diameter.

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SATURDAY MORNING SESSION
October 15, 1960

Dr. Vernon T. Stoutemyer, Chairman of the Department of Floriculture and Ornamental Horticulture, University of California, Los Angeles, moderated the symposium. Chairman Stoutemyer submitted the following paper as an introduction for the symposium

SEED PROPAGATION AS A NURSERY TECHNIQUE

VERNON T. STOUTEMEYER
University of California
Los Angeles, California

Seeds often offer the simplest and most practical method of propagation, both for commercial production and for the person interested in the introduction and trial of unusual plants. Seeds are easy to bring from foreign countries, and they are much less apt to be damaged in fumigation than cuttings or scions. Seed minimizes, but does not entirely prevent, the chance of introducing some new foreign insect or disease. Few seeds carry any viruses

Many of the fine horticultural collections of the world have been built on the importation or exchange of seeds A good seed list of a reliable dealer is a kind of magic carpet which brings the plants of the world to us regardless of where we live.

Most of the seeds which we use in our nurseries present no particular germination problems for a reasonably skillful propagator or even the rankest amateur If, on the other hand, we consider the whole field of plants we may fairly state that seed germination is indeed a complex problem.

The existing information on seed collection, handling, storage and processing has never been well organized in most areas. A few exceptions which might be pointed out would probably be in the fields of forestry and agronomy where the industries concerned have been large and important, with well financed research institutions, adequately staffed.

When we turn to the field of ornamental plants, we find rather meager and scattered information in many areas. Perhaps some of this is due to the relatively small economic importance of many of the plants with which we are concerned. Also, many details of the flower seed business in particular have been closely guarded trade secrets

A number of outstanding general books on plant propagation are available but all of them list comparatively few ornamental plants and present only meager information regarding their propagation. What is needed is the detailed "cook book" type of manual on ornamentals or at least on certain general groups of ornamentals.

There have been a few good European books on propagation of alpine plants Mr. Percy Everett of the Rancho Santa Ana Botanic Garden at Claremont a few years ago published a compilation of years of results in the propagation of California native plants, entitled "A Summary of the Culture of California Plants at the Rancho Santa Ana Botanic Garden. 1927 - 1950"

Some excellent compilations of information on flower seeds, according to those who read the languages, have been published in Sweden and Holland.

The Woody-Plant Seed Manual, Miscellaneous Publication No 654, of the U.S Department of Agriculture was prepared by the Forest Service. It contains much information on seed treatments and stratification. Much of the detailed information on this subject was developed at the Boyce Thompson Institute for Plant Research at Yonkers, New York.

One general compilation of recommended procedures for seed germination in mimeographed form which has been most useful in answering inquiries was prepared by Dr Charles F. Swingle, formerly of the U.S Department of Agriculture, when he was with the Soil Conservation Service. This is very scarce but grants of assistance are being sought to amplify this and publish it in more permanent form. If this project can be completed, a much needed addition to the literature of propagation can be made.

Many supposed problems of seed germination are due to the commercial handling and storage methods of seed collectors and firms The seeds may have been immature when collected A surprising number of seeds, especially from the tropics but also many woody plants of temperate regions lose viability quickly if stored up dry. Fortunately, air transport has solved many problems related to seeds having a short period of viability. In the days of sailing vessels, the problem of introduction of many plants was solved by permitting the seeds to germinate and grow while in transit. The Wardian case was developed to facilitate long distance transport of tender plants.

Much has been learned about the means of prolonging the viability of seeds. Under the urgent need in World War II for carrying over stocks of vegetable seed, such as onions, for an additional year, scientists of the U.S. Department of Agriculture developed effective methods of prolonging storage life The moisture content of the seeds was reduced and stabilized and the seeds were stored at low temperatures. Carbon dioxide atmospheres will prolong the storage life of such difficult seeds as the South Africa composites, as for instance, gerberas.

Much more is known about prolonging the life of seeds than about their behavior after they are removed from such treatments. One vegetable seed buyer for a large seed firm stated that he would never buy a lot of seeds which had been in cold storage.

Several pressures will doubtless force a reevaluation of these treatments. The development of hybrid seeds is creating a demand for longer carry-overs of seeds in order to avoid the organization and expense of producing the seeds every year. At the present time we do not know what will happen to these seeds in the hands of the customers.

Another movement which is creating a demand for more knowledge regarding prolongation of seed viability is interest in the creation of seed banks for the use of plant breeders Plant materials of no apparent immediate use can thus be made available for use at any time when a certain type of genic material is needed, without the great expense of growing it each year. The rapid destruction of much of the natural vegetation of the world is creating a serious problem for the plant breeder, and our own U S. Department of Agriculture is struggling with the problem of creating a gene bank for the breeders of economic crops.

We could doubtless use seed propagation much more than we do in producing distinct varieties of woody plants We would need to have pedigreed, tested seed sources, sometimes properly isolated Foresters have long known about the importance of seed selection in order to get properly adapted forest tree populations.

For instance, European nurseries of the last century often grew the following horticultural varieties by seed

Red leaved Norway maple
Red leaved common barberry
Red leaved beech (some strains variable)
Weeping European larch (variable)
Wier's cut leaved maple
Weeping Scotch pine
Weeping peach
Chinese peaches with red and white flowers
Weeping black locust
Laciniate elderberry (variable)
Variegated pelargoniums

Some varieties of *Ligustrum vulgare* were observed to come true from seeds while others did not. They were not able to reproduce certain varieties of lindens, alders, beeches, variegated hollies, ornamental double flowered varieties of *Prunus* from seeds. The literature reveals a lack of agreement on this subject, doubtless because of the great genetic variability of the material Plants which appear to be closely similar may be vastly different in genetic make up or genotype.

Some years before the writer arrived at UCLA, Dr Walter E. Lammerts devoted some attention to improving the foliage and flowering qualities of jacarandas. He grew progenies from various superior trees which he selected on the basis of certain desirable characteristics. A number of distinct types were clearly apparent, some retaining much more foliage in some winters than others Practically all of the progenies were remarkably uniform in character. Lack of space and changes of personnel prevented growing these trees to maturity, but the possibility of improving woody plant populations by selection was clearly shown. The writer is convinced that selected seed from isolated superior jacaranda trees would have definite advantages.

Seed of flame eucalyptus — available in California invariably produces many off types — dwarfs and undesired colors. Older seedsmen and nurserymen agree that years ago, seeds imported from Australia produced fine uniform trees with deep, rich red flowers Apparently, Australian seed does not now guarantee uniform stock. The explanation is simple and has been given by Dr. William S. Stewart and Mr. George Spalding of the Los Angeles State and County Arboretum, who have visited the locality of the species in West Australia. The native grove is small and is surrounded by *E. calophylla*. Seed collected from the edge of the grove will probably be contaminated and will contain many hybrids. That collected in the middle of the grove will be more apt to breed true. The difficulties of seed propagation has led to inarch grafting of this species on the Riviera of France and Italy. Dr George Ryan of the Department of Horticultural Science at UCLA has worked out simpler grafting methods.

One very desirable flowering tree, the Cape Chestnut, *Calodendrum capensis* of South Africa is so variable in appearance and performance that vegetative propagation is suggested The writer has noticed great and consistent yearly differences in blooming dates in several trees in Elysian Park, Los Angeles, and at the Stephen Vavra Estate in Bel Air, there was a tree which regularly bloomed in the winter. It might be worthwhile to determine if selected seed sources of this tree would solve the problem of numerous trees which never thrive and make good specimens

The following lectures will treat many of the phases of technology relating to seeds with much more detail. In conclusion, the writer would like to mention two objectives which a society of propagators could foster. First of all is the exchange of information on reliable dealers in seeds The knowledge of sources of unusual plant materials is one of the assets of a good landscape architect. May we not similarly say that a similar knowledge of seed collectors and dealers is part of the equipment of a good propagator. This information is not easy to come by and seed collectors living on the frontiers of civilization are not al-

Table I Sources of California Native Plants

1 O Kenneth Smith, P O Box 100, Magalia, California
2 L L Edmunds, Danville, California
3 Calmers California Wild Flower Nursery Dos Rios California
4 Herman Seyforth, Padua Hills Gardens, 555 West 8th St, Claremont Calif
5. Ted Hutchinson, Greasewood Nursery, Barstow, California (desert plants)
6 Eustace Rush, Seedsman, 1014 W Olive Ave, Burbank California
7 S S Lawrence, Seedsman, P O 408, Las Vegas, Nevada
8 Mrs E W Cisler, Route 2 — Box 89A, Hemet, California
9 LaTuna Nursery, 10459 Tuxford, Sun Valley, California
10 Roy Carter P O Box 551 or 14950 Mission Blvd., San Fernando, California
11 Gregg's Nursery Service, 407 E 165th St, Gardena, California
12 Clyde Robin, Collector of Wild Flower Seeds, Carmel Valley, California

Most of the large retail nurseries are selling an increasing variety of native plants

Not commercial sources for the trade, but sources of rare plants for propagation purpose and introduction

a Santa Barbara Botanic Gardens, Santa Barbara, California
b Rancho Santa Ana Botanic Gardens, Claremont, California

ways as reliable as one might desire. A really good directory of specialized seed sources could be a worthwhile activity of an organized group.

Another possible area in which a group might function is in the salvaging of information which would otherwise perish — perhaps forever. We have not conserved our harvests too well. Some very able horticulturists of an older generation have died leaving very little of their hard earned knowledge behind them. Having, in many cases, very little literary skill, they have left few records of their immense knowledge.

Chairman Stoutemeyer introduced Dr. Dale E. Kester of the Department of Pomology, University of California, Davis. Dr. Kester discussed seed dormancy as it is related to certain nursery practices.

Table 2. SEED SUPPLIERS

	NAMES	ADDRESSES
1	S. S. Lawrence	P. O. Box 408, Las Vegas, Nevada
2	Theodore Payne	2969 Los Feliz Blvd., Los Angeles, Calif.
3	Eustace Rush	1014 West Olive Ave., Burbank, Calif.
4	Morris & Snow	776 Wall Street, Los Angeles 14, Calif.
5	Herbst Brothers	92 Warren Street, New York 7, New York
6	Edwin A. Menninger ("The Flowering Tree Man")	Stuart, Florida
7	Conyers B. Fleu, Jr.	Ross and Montana Streets, Germantown, Philadelphia, Pa.
8	Harry E. Saier	Diamondale, Michigan
9	F. W. Schumacher, Horticulturist	Sandwich, Massachusetts
10	Albert Wilson (tropical plants & seeds from South & Central America, and Mexico)	9127 Juniper Avenue, Fontana, Calif.
11.	Central Nursery Company (Exotic Subtropicals)	2675 Johnson Avenue, San Luis Obispo, Calif.
12	Evergreen Farms (Conifers)	P. O. Box 497, Palo Alto, Calif.
13	Roy Carter (Palms, shrubs, trees)	Box 551, 14950 Mission Blvd., San Fernanado, Calif.
14	Willard Hagen (Tree Seeds)	135 Las Tunas Drive, Arcadia, Calif.

Forest Service, U. S. Department of Agriculture, Washington 25, D. C. maintains a list of Tree Seed Dealers.

SEED DORMANCY AND ITS RELATIONSHIP TO NURSERY PRACTICES

DALE E. KESTER
University of California, Davis

A seed may fail to germinate for three basic reasons First, it may be non-viable and thus incapable of development. Secondly, it may be subjected to environmental conditions which are unsuitable for germination. Thirdly, the seed may be affected by specific internal conditions — either in the seed coverings or in the embryo itself — which prevent germination from taking place until such time as these conditions are removed. The latter cause of non-germination will be the subject of this paper.

CONCEPT OF DORMANCY

Dormancy refers to failure to grow or to germinate. It may be due to either environmental conditions outside the plant or seed or to conditions inside the plant or seed itself To separate environmental and internal factors arbitrarily is difficult because the end result usually depends upon an interaction between both That is, the effects of a specific internal condition within the seed which prevents germination may differ depending upon the environment in which the seed is placed.

On the other hand, the distinction between external and internal factors is usually made and dormancy in seeds has usually been used only in reference to conditions within the seed that prevent germination. Thus, the "normal" environmental requirements for germination are recognized as being a supply of moisture, a moderately warm temperature and a supply of oxygen. Failure of a viable seed to germinate because of the effect of some condition within the seed covering, the endosperm or in the embryo itself is considered to be seed dormancy It has generally been recognized that such conditions have arisen through the evolutionary development of the particular plants because such characteristics have assisted survival during adverse periods of their natural environment.

CAUSES OF SEED DORMANCY

There are various conditions within seeds which cause dormancy and considerable information is available as to suitable methods of treatment. Much work concerning the problem has been carried out by the Boyce Thompson Institute of Yonkers, New York. Reviews of the work on seeds are available (3, 5, 17, 11). Attention should be called to the recent review by Dr Lela Barton at the 6th annual meeting of the Plant Propagators Society (2)

An outline of the various causes of dormancy and the general methods by which they can be overcome follow.

A CLASSIFICATION OF SEED IN RELATION TO TYPES OF DORMANCY WITH EXAMPLES

Seeds which have seed coats that are hard or impermeable to water

Species: *Acacia, Albizzia,* Amorpha, camellia, carob, *Ceanothus* (some species) chamise (*Adenostoma*), *Cytisus,* goldenrain tree

(*Koelreuteria*), honeylocust (*Gleditsia*), locust (*Robinia*), olive, *Parkinsonia, Rhus* (some species), *Sophora*.

Treatments: (1) Scarification: file or rub individual seeds with sandpaper, for large lots use mechanical scarifier.

(2) Sulfuric acid: place seeds in concentrated sulfuric acid for fifteen minutes to six hours depending upon species, follow by washing to remove the acid.

(3) Hot water: drop the seeds into hot water (180 to 212°F). Remove heat immediately and leave in gradually cooling water for six to twelve hours.

(4) Warm stratification: place seeds in warm, moist conditions to allow microorganisms to soften coats, may require several months.

Seeds which have a dormant embryo that responds to chilling

A. Those which require a single stratification period.

Species: a) fruit and nut trees. almond, apple, cherry, chestnut, grape, peach, pear, plum, walnut.

b) ornamental and forest plants: *Arborvitae*, alder (*Alnus*), *Amelanchier*, ash, barberry (*Berberis*), beech, birch, boxwood, *Chamaecyparis, Clematis* (some species), *Ceanothus* (some species), *Cercocarpus*, cypress, dogwood, Douglas fir, *Exochorda*, fir (*Abies*), *Garrya, Gaultheria*, hemlock (*Tsuga*), honeysuckle, larch, liquidamber, madrone, magnolia, *Mahonia*, maple (some species), *Myrica, Osmaronia, Photinia*, pine (some species), *Prunus*, pyracantha, *Rhamnus*, rose, spruce, sycamore, *Styrax, Viburnum* (some species), tulip tree.

Treatment: Stratify by holding the moist seeds at 32 to 50° F for one to as long as three to four months or more. May be fall planted or the pre-soaked seeds may be mixed in a moisture retaining material and stored out of doors in stratification pits or placed in metal (or plastic) containers and stored in commercial storage units.

B. Those requiring a warm period for root or embryo development prior to the chilling period.

Species: Some lilies, peony, a number of *Viburnum* species, wild ginger (*Asarum canadense*). Holly, fringe tree (*Chionanthus*), *Nandina* and ginkgo possibly should be listed here.

Treatment: Stratify at a warm temperature for several months followed by cold stratification for several months

C. Those requiring two consecutive chilling periods separated by a warm period.

Species: A few natives of temperate zone — *Trillium*, blue cohosh, lily-of-the-valley, solomon's seal, bloodroot, and false solomon's seal.

Treatment: Cold stratification for several months, followed by warm stratification of several months, followed by a second cold stratification.

Seeds which combine an impermeable seed coat with a dormant embryo

Species: *Arctostaphylos, Ceanothus* (some species). *Cotoneaster*, Dogwood (some species), elder (*Sambucus*), hawthorn (*Crataegus*), Halesia, holly (*Ilex*), honeysuckle (some species), juniper, linden (*Tilia*) mountain ash (*Sorbus*), *Rhus* (some species), *Symphoricarpus*.

Treatment: (1) Treat by softening the seed coat followed by a cold stratification period.
(2) Give a warm stratification period of several months followed by a cold stratification period.
(3) Harvest the seeds when immature and do not allow them to dry before stratification

Seeds which contain inhibitors that prevent germination

Examples: A number of inhibitors have been identified in fruits and possibly may affect germination whenever a fruit part such as a hull, etc. is still retained on the seed. Presence of inhibitor affects germination in beet, pistache, guavule, a number of desert plants.

Treatment: Prolonged soaking in water to wash out the inhibitor.

Seeds which are dormant when freshly harvested but become germinable upon dry storage

Examples: Most grains, grasses, vegetables, many flower seeds

Treatments. This type of dormancy is difficult to classify since it is interrelated to specific environmental requirements. It is principally a problem of seed testers rather than propagators except in specific cases. Principal means of treatment include exposure to light, alternating temperatures, chilling and potassium nitrate. A number of such seeds germinate at 70-75° or less and become dormant at higher temperatures.

STRATIFICATION OF SEEDS

The group of seeds to be discussed in most detail are those which have a dormant embryo and which respond to stratification. *Stratification* refers to the procedure of mixing seeds with a moisture retaining medium, and holding them cold and moist for a prescribed length of time. During stratification certain internal changes take place which allow germination to proceed without hindrance. These changes have been referred to as "after-ripening" and, for want of a better term, it will be used here.

This pre-germination treatment is the commonest germination requirement for species of trees and shrubs found in the temperate zone. Of 444 species of plants listed in the Woody Plant Seed Manual 43 per cent have this requirement and an additional 17 per cent have dormant embryos combined with a hard seed coat, 60 per cent of the total species described (17). Seeds of practically all deciduous fruit tree species require stratification.

The general procedure for handling such seeds is reasonably well-known and probably has been recognized for centuries. On the other hand, the basic reason why such seeds are dormant is largely unknown although some of the biological changes that take place have been described (9).

After-ripening is a gradual, progressive change under proper environmental conditions of stratification. The seed becomes less and less dormant and more and more ready to germinate. Germination may then begin even at the low temperature of stratification. What may not be recognized as equally important is that the after-ripening reaction is reversible. If environmental conditions during stratification should change to that which will be discussed later, the degree of dormancy in the seed may increase rather than decrease.

Environmental Influences on Stratification

The four environmental factors which are necessary for the after-ripening reaction to be completed are moisture, low temperature, aeration, and a certain amount of time. The four factors will be considered in some detail.

Water. After-ripening does not take place in a dry seed but only after a certain amount of water has been absorbed. Thus, pre-soaking seeds in preparation for stratification is desirable, if not essential, to insure that sufficient moisture is in the seed at the beginning of the

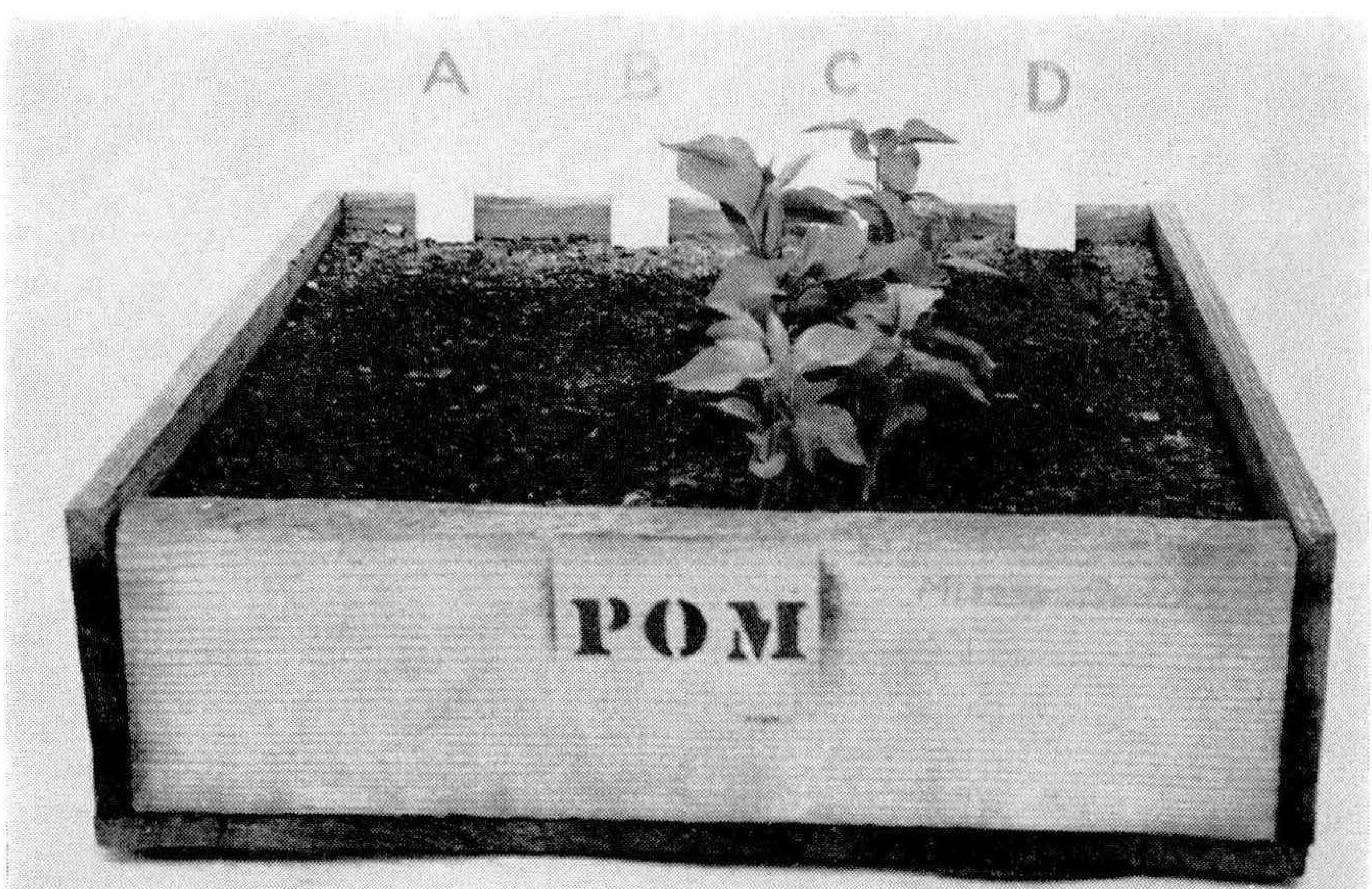

Figure 1.—Effect of environmental factors during stratification on germination of *apple seeds, A. unstratified seed, B. dry, 37° F, C. moist, 37° F, D. moist, 37° F, sealed container. Stratification time approximately 3 months.*

stratification period. Secondly, the seeds should not be allowed to become dry during stratification If drying does occur, after-ripening ceases and, it is generally believed, will be reversed (12) On the other hand, some studies have indicated that reversal of after-ripening may not necessarily occur with drying (4, 13, 14, 16). This point should be clarified. If stratified seeds could be dried (under proper conditions) prior to sprouting, it would greatly facilitate planting.

Once the stratified seed begins to sprout, rapid absorption of moisture takes place and drying out at this point is decidedly injurious to the seedling.

Aeration. After-ripening requires air, presumably oxygen. That poor aeration can retard or stop the process can be easily demonstrated (see Fig. 1). Many years ago workers at the Boyce Thompson Institute showed that nondormant seed subjected to a carbon dioxide atmosphere become dormant and respond to stratification (6, 15). The principal point as regards stratification practices is to be sure that there is good aeration in the stratification containers.

Temperature Temperature response is the most important difference between after-ripening and germination. A comparison of the temperature relationship of the two processes is shown in Fig. 2

After-ripening takes place at cool temperatures from about freezing or slightly below to around 55 to 60 degrees F and ceases, and, at least in some cases, is reversed at higher temperatures The temperature requirement for after-ripening has narrow limits for some kinds of seed For instance, Barton (2) reports that *Rosa rubiginosa* seeds stratified for six months at a series of different temperatures germinated only after being stratifed at 41° F On the other hand, seed of most species respond to a range of low temperatures although some temperatures are more favorable than others.

The range of favorable stratification temperatures has been established for many seeds (3). The effectiveness of different temperatures for after-ripening shown in Figure 2 is based upon detailed experimental work carried out recently in Europe on apple seed (1, 8, 14). Although comparable data of this detail is not available on other species, the relationship shown fits closely with present concepts of the phenomenon and should be expected to hold approximately for many, if not most seeds, requiring stratification.

Optimum temperatures for after-ripening in the case of apple are shown to be in the range of 37° F to 41° F At temperatures lower than optimum, effectiveness becomes less but is still quite good at 32° F. It ceases somewhere around 5 to 7° F below freezing. As temperatures go higher than the optimum their effectiveness becomes less and less until a point is reached where the after-ripening process ceases As temperatures go still higher than this point, after-ripening actually reverses itself and the seed becomes more and more dormant. In the experiment cited the "compensation temperature" (where after-ripening neither proceeded nor was reversed) was 17° C., slightly over 60° F.

Figure 2 also shows the effect of temperature on germination in the case of *nondormant* seeds of apple and radish. Both show basically

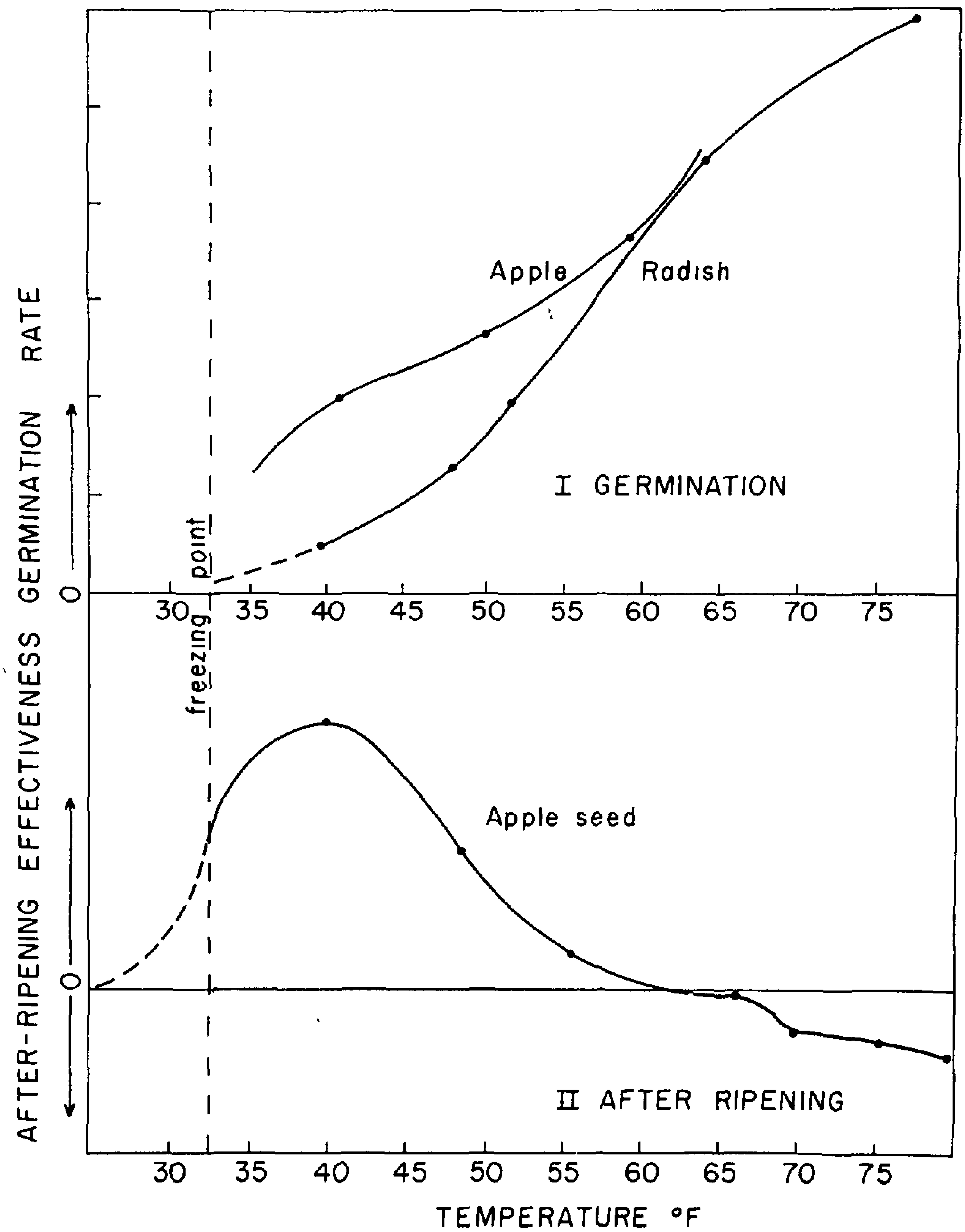

Figure 2.—Effectiveness of temperature of after-ripening (below) compared to its effectiveness on germination (above). Apple Data from Abbott (1) and Schander (14). Radish data from Figure 6-2 in Hartmann and Kester (11).

similar responses. The graph shows that at or near freezing temperatures, germination is either non-existent or very slow. As the temperature increases, the germination rate also increases. Optimum temperatures are somewhere around 70 to 80° F or higher depending upon the kind of seed.

In actual practice temperature does not affect the two processes — after-ripening and germination — separately as shown in Figure 2 but involves the two processes simultaneously Figure 3 shows experimental germination data which parallels conditions that can exist in nursery practice. The seed — again apple — were stratified at 37° F for 65 days and then germinated at the temperatures indicated in the graph (8).

Germination occurred most rapidly at 60° F but only a portion of the seeds germinated. In other words, at the higher temperature where germination was most favored, some of the seeds remained dormant Such seeds may not only fail to germinate but may develop secondary dormancy and require a second stratification period. Thus, if relatively high soil temperatures occur after planting — for instance, if planting is delayed or if unseasonably warm temperatures prevail early in the season — poor stands may result. This situation has apparently occurred some years in our nursery at Davis Such unsprouted seeds remain in the soil all summer and sometimes have been observed to sprout in large numbers the folowing year. Also, in breeding programs for stone fruits at Davis, California, seeds are stratified in controlled cold storage at 36° F and germinated in the greenhouse where relatively high daytime temperatures can occur. It has generally been observed that unless a seed is actually sprouting at the time of planting, it will probably not germinate in the greenhouse even though it is viable, has been stratified for the prescribed length of time and others of the lot are sprouting

Germination of stratified seed of Eastern Hemlock (*Tsuga canadensis*) has also been shown to be inhibited by warm temperature (13). The optimum temperature was 62° F

Seeds planted at 50° F took slightly longer to germinate but higher percentage of germination resulted although not enough to produce a complete stand. At temperatures of 45° F the germination was still more delayed but complete germination of all of the seeds took place. In other words, the temperature was cool enough for after-ripening and warm enough for germination to take place with no inhibition. This situation probably occurs in the open when seeds either are planted in the fall or are planted early in the spring when temperatures are cool. Good stands can result even though the seeds are not completely stratified at the time of planting.

At temperatures approaching freezing after-ripening continues but the germination is much delayed Thus as stratified seed nears the stage where sprouting will begin and if planting is to be delayed, the seeds can be shifted to colder temperatures and held for some time to delay sprouting. Work in Germany (7) indicated that the seeds can be held effectively at temperatures as low as 28° F. They also report that if apple seeds are air dried at this low temperature they can be held for a long period of time without losing their readiness to germinate

Time Time is closely related to temperature. The after-ripening reaction requires a certain amount of time to complete (as already indicated) but the requirement varies with temperature. The shortest time is required at optimum temperatures. As the temperature deviates from optimum the stratification requirement becomes longer and longer

An important aspect of the stratification problem is that individual seeds within a given lot have different time requirements. Figure 4 illustrates this fact with cherry seed in that the percentage capable of germinating increases with time. Similar results are shown with *Abies* in Figure 5 which shows germination at warm temperatures following different periods of stratification time. In this species, as in many conifers (3) some germination can occur even without stratification but the results are erratic and germination is very slow. Increasing the length of stratification thus can increase not only the percentage of germination but also the rate of germination. It can reduce the effects of the high temperature inhibition shown in Figure 3.

The variability of time requirement in individual lots creates an important practical problem. Thus, if the time to remove seeds from stratification is established by the time that the first sprouting occurs, then many of the seeds will still be dormant. On the other hand, if one waits until all seeds of the lot have sprouted to indicate that the stratification period in all seeds is complete, then many will be over

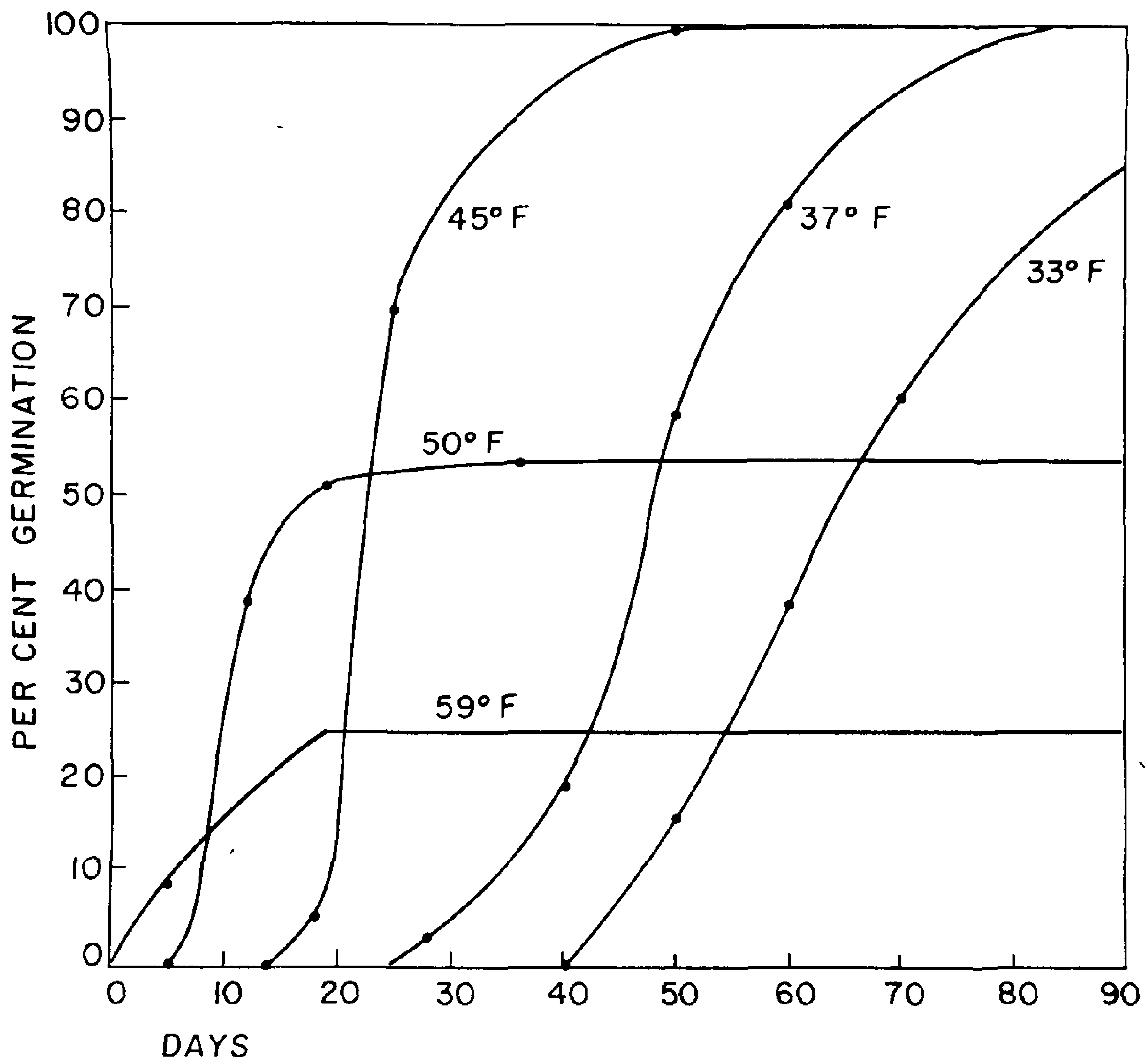

Figure 3.—The effect of temperature on germination of apple seeds that had been previously stratified for 65 days at 37° F. The abscissa is the days following stratification From De Haas and Schander (8).

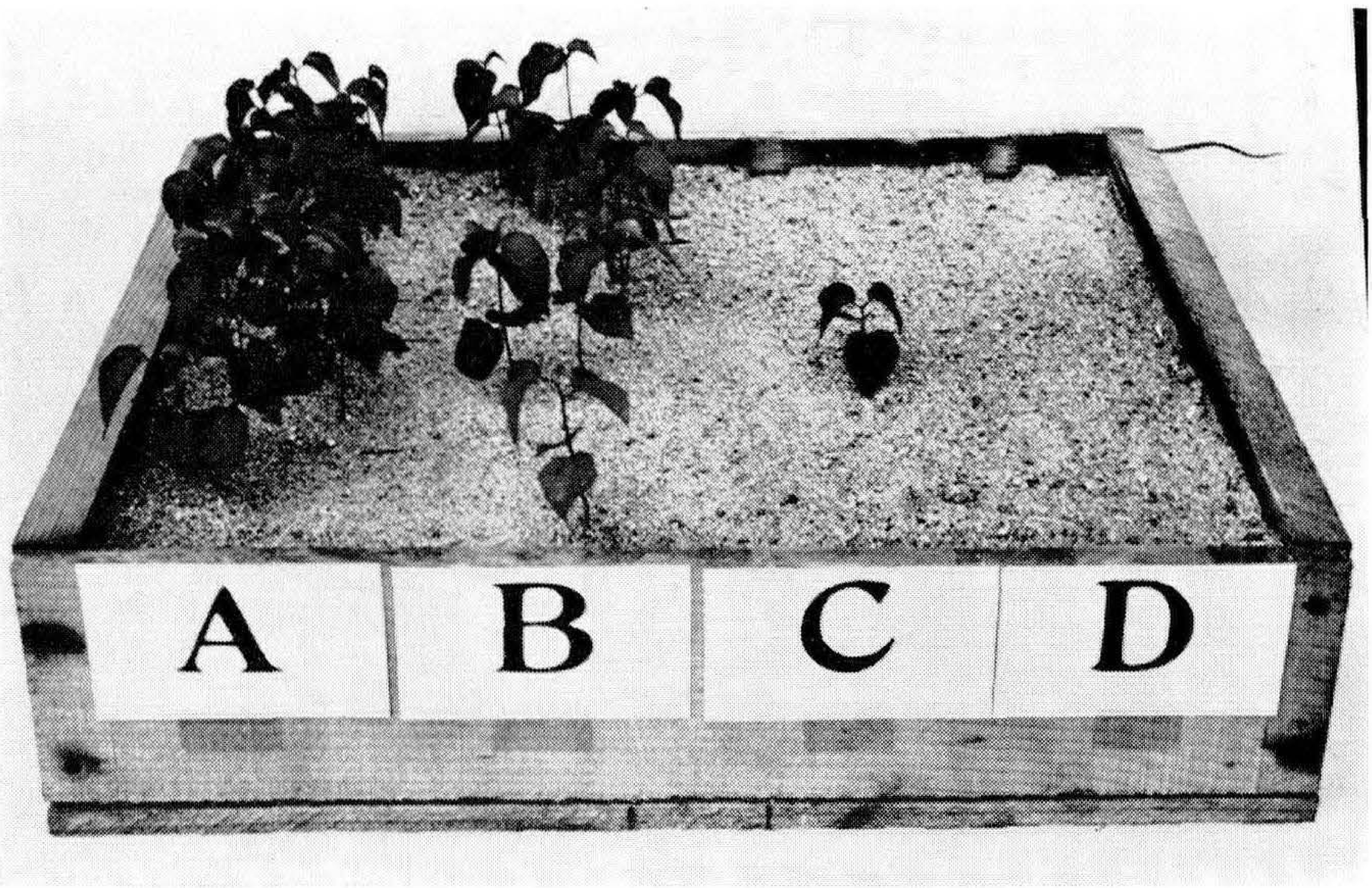

Figure 4.—The effect of stratification time on germination in Mahaleb cherry seeds. A. stratified 127 days. B. stratified 89 days, C. stratified 39 days, D. unstratified. Temperature of stratification was 32° F. Reprinted from Hartmann and Kester (11).

sprouted and injury during planting is likely to occur.

Differences in time requirement also exists between diffrent species as indicated by the time requiremnt for the following common fruit tree species.

American plum	5-6 months	Pear	1½-3 months
Almond	3-4 weeks	Peach	1-3 months
Apricot	3-4 weeks	Myrobalan plum	3-4 months
Apple	2-2½ months	Mahaleb cherry	3-4 months

Differences can also exist among varieties of a species and among different seed sources.

Methods of Stratification

Fall planting of seeds requiring stratification is a widely used and an adequate method of handling seeds. It relies on the subjection of the seeds to natural winter chilling. Certain problems are involved, for example, the control of weeds, rodents, moisture, etc. In view of the previous discussion it is likely that the environmental conditions of temperature and moisture, both during the winter and during the spring, could have a great bearing on its success.

Outdoor stratification pits have been widely used in nursery practice. This procedure involves the stratification of the moist seeds in outdoor pits between layers of sand or other media. The same environmental problems as in fall planting would likely occur. Inadequate sanitation of the seeds could also be a problem.

Controlled temperature storage is probably preferable to the other procedures if available. At the Department of Pomology, Davis, California, pre-soaked seeds are mixed with a half sand-half peat mixture (dampened only to the extent that water can just barely be squeezed out) and placed in five gallon egg cans covered with heavy paper that has been perforated. These containers are placed at 36° F until they begin to sprout. If planting is delayed, the containers are shifted to 32° F until planting.

Polyethylene plastic bags have proven particularly satisfactory as stratification containers The plastic holds moisture but allows aeration It is transparent so that the beginning of sprouting can be noted

Aseptic stratification of seeds in sterile water and glass flasks is the method used almost exclusively at Davis, California, for seeds to grow seedlings in breeding work on stone fruits. The method, worked out by Gilmore (10) is particularly useful for small lots of valuable seed The method could possibly be extended to other species. The procedure consists of sterilizing the dry seed in a 50 per cent alcohol solution of

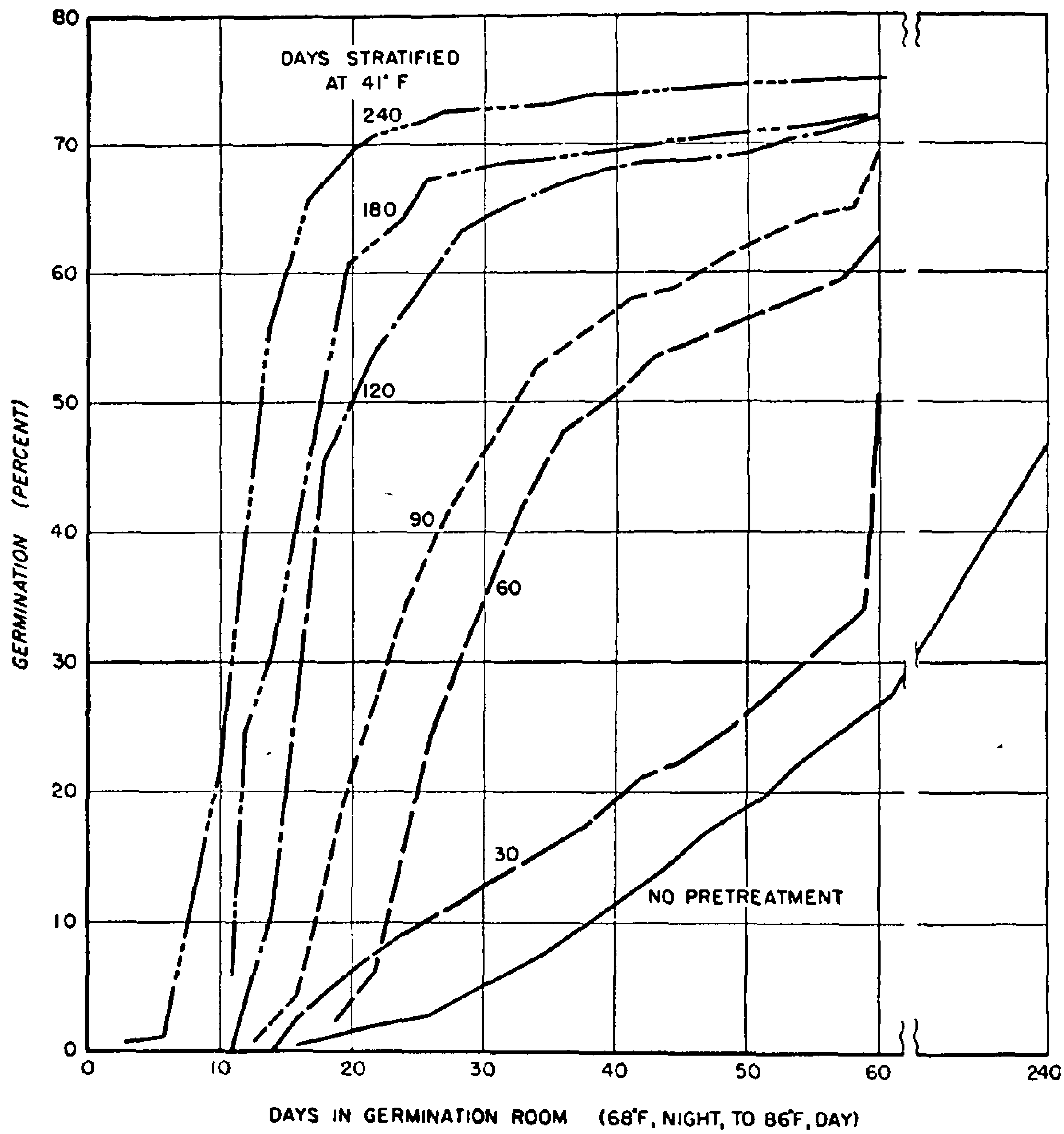

Figure 5.—Effect of length of stratification on germination of Abies seed. From Woody Plant Seed Manual (17).

merthiolate 1:2000 for five minutes followed by a five minute washing with sterile water. The seeds are stratified in sterilized glass flasks covered with inverted cotton lined beakers.

Workers in Germany have described a method of handling apple seeds which deserves recognition (7). Its success depends upon proper manipulation of the factors of moisture, temperature and time previously discussed There are two stages involved in the procedure. The first stage is the normal stratification treatment at 36° F, the second stage involves the period between the end of stratification and the time of planting. During the second stage the seeds are separated from the stratification medium and air dried at 28 to 31° F. Once the seeds are dry they can be stored for a considerable period of time without their sprouting and without altering the internal state of dormancy of the seed. The dry seeds can then be machine planted. Prompt uniform germination is reported to result.

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CHAIRMAN HERB FOWLER In the stratification of cherry seeds, Mahaleb and Mazzard, is it desirable to store the seeds moist after harvest?

DR. KESTER: Apparently, cherry seeds have some problems in germination, more so than some of the other fruit species. It goes back to the long stratification time that is required. There is little question that if you dry seeds out, you do not reduce viability, with cherry or any other of the fruit tree seeds that are normally stratified. Now there is also experience of some people that if you keep them moist, you can increase percent germination. I think this goes back to the question of stratification time. However, holding seeds moist creates the problem of storage. If you could dry them and stratify them at the proper time, it would be much simpler handling for the nurseryman. Cherry seeds require three or four months, at least, for stratification, possibly more and I think it is a matter of giving a required length of time.

CHAIRMAN FOWLER: Is it possible to lower the temperature to slow down germination?

DR. KESTER: Yes, once they start to sprout, you can shift the seeds to lower temperature and slow down germination. We have done this in our own experience.

Chairman Stoutemyer introduced Mr Dennison Morey, Director of Research, Jackson and Perkins Company of California, Pleasanton, California, who discussed seed stratification procedures with special regard to roses.

SEED STRATIFICATION TECHNIQUES, WITH EMPHASIS ON ROSES

DENNISON MOREY
Jackson and Perkins Company of California
Pleasanton, California

Several of my more sophisticated friends in the trade have asked me what I felt this new society was going to accomplish. I think this is a fair question I doubt that there is anyone who does not have trouble finding the time to get things done Few of us have time for frivolous affairs. I cannot blame anyone for wanting to be sure we are going to amount to something before investing much time in this embryonic society. Unfortunately, I must confess to them that I don't know what we are going to accomplish. I do know what I think we can do and should accomplish. Frankly, I believe this group can contribute a great deal to the stability and profitability of the nursery business

There are two primary reasons for my view. The first is that the more dependable and economical propagation becomes, the more predictable and profitable production becomes. The second reason is my belief that only through cooperative development of knowledge and techniques can we hope to advance our methods fast enough to keep pace with the social and political structure in which we operate and in which we often find ourselves at a serious disadvantage.

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I propose to illustrate the importance of cooperation, liaison, out-group contacts, or whatever you wish to call joint efforts at idea and fact recruitment.

I feel the most important thing we can do in an organization such as this is to combine our energies in order to assemble ideas and techniques, ideas and techniques from which new general principles and new specific methods can be generated. As an illustration I will add my own small grain of sand to the dunes of knowledge, something all of you can do as well as I and something you must do if we are to succeed.

Plant propagation texts ordinarily provide a general discussion of seed stratification based upon an impressive amount of research and various fragments of an even more extensive experience. They also ordinarily give lists or tables of techniques which have been used and found helpful Some discuss principles from which new techniques may be devised. However, it is seldom that the empirical way in which these techniques have been developed is noted and never is it pointed out that a few simple experiments will often produce an improved technique.

We must all appreciate the fact that one or two men and one or two books can only do so much. But by contrast, an association of the sort we are working on here can fill a great many gaps in a hurry if we get organized.

The following is an example of what I believe anyone can do.

A formal definition of stratification came to my attention recently which provides a very good beginning It says, "stratification is the pretreatment of seeds by storing them in a moist medium and at carefully controlled temperatures, to condition them for rapid germination the following spring" (Wells, 1958)

I do not feel that this definition is quite as general on the one hand nor as specific as it needs to be for our purposes. I feel an "anything goes" approach is what we need. Personally, I should like to see it put something like this: "Stratification is the preplanting treatment of seeds in a medium or under conditions which will enhance uniform and immediate germination and growth upon planting."

I do not want to put any conditions on the time at which treatment is made, nor the factors involved in the treatment nor any restrictions on what tolerances are acceptable, nor in any way to prejudice the design or interpretation of the techniques. Emphasis on temperatures and controlled temperatures I believe are unfortunate. The common connotation associated with controlled temperature is controlled *constant* temperatures which for purposes of seed stratification are, in my experience, to be looked at with a very fishy eye See Lasn and McCrory (4). Moreover, in my own experience the amount of control required to go from efficiency of 80% in germination improvement by means of stratification to 95% is economically unfeasible I feel that in general, rather generous limits are tolerable in temperature control in stratification of seeds and it behooves anyone with a germination problem to run a few crude experiments before investing in any costly control equipment. In short, much more would be forthcoming by encouraging everyone to try some sort of stratification on reluctant seeds and to report his experiences In this way new information would increase rapidly. To give the impression that involved basic research is the only source of progress, if basic research is defined to mean carefully controlled experiments, will see us fail in our designs.

I intend to show you what I think each of us can do with the means readily available to everyone and I will ask the question now that I hope we can answer optimistically and confidently later How much progress would we see in technique in just ten years if everyone ran a few tests and told everyone else his experiences?

I am going to describe to you a few experiments of the type to which I refer which we have conducted from time to time at Livermore. I must warn you first, however, that the most important thing to keep in mind is that these techniques probably won't work for other problems until adapted through practical experience. They are offered primarily as a philosophy of approach and only secondarily as a source of data upon which one might predicate general principles which might eventually help with other problems.

I shall not take the time to trouble you with an extensive review of applicable literature. Critical references are mentioned in the several excellent texts on plant propagation especially Hartman and Kester, pp 152-155 For those wishing to consult the literature, I can recommend that you refer to this excellent source book However, I would like to begin my story with a brief comment on the report of Von Abrams and Hand (1)

It has long been known that the seed produced in hybrid rose breeding varies tremendously in the degree to which it will germinate without stratification. Not only does each particular cross vary but the same cross made in different years will also vary. Von Abrams and Hand have gone a long ways toward explaining this anomaly They showed that the temperatures prevailing during seed maturation are largely responsible for regulating the ability of hybrid rose seeds to undergo immediate germination. They showed that 9 degrees Centigrade (50° F) daily mean temperature for the 30 days prior to seed harvest resulted in seeds which would germinate from 0-11% upon planting, while at temperatures of 15 degrees Centigrade (60° F) daily mean for the thirty days prior to harvest, germination ranged from 11% to nearly 70%. They also showed that seed from crosses with normally high germination responded most to the higher temperature and seed from crosses that normally had a low germination responded the least An earlier report by Calvino (2) claimed no germination problems were encountered with hybrid rose seed produced at San Remo, Italy and those of us acquainted with the rose breeding program at Hemet, California have tended to view the germination claims of Bob Lindquist with almost as much doubt as envy though a look at his seed flats is all that is needed to substantiate his claims His results as well as those of Calvino fit the Von Abrams - Hand findings

Von Abrams and Hand also showed that by removing the testa and pericarp reluctant germinators would germinate in high percentages, also see Heit (6), Flemion (7, 8) regardless of the maturation temperatures These findings certainly do little to tell us what the causes are but they do suggest a few things to try for a cure

In my own work I have been stratifying rose seeds for ten years. Some curious events have been observed in that time which have been helpful in developing a fruitful point of view One of these observations is that rose seeds will germinate in cold storage after a certain amount of stratification as long as the temperature is above freezing if only for even a few hours each day This germination takes place only after a suitable period of time has elapsed. This suitable period varies with the seed lot but in general, most seeds of cultivated roses will germinate in high percentage by the fourth month at 33° F It is often the case that the seed coat is not significantly softened The radicle will push its way out the end of the achene leaving the cotyledons and plumule imprisoned in the very hard, firm, unyielding pericarp.

It is common knowledge that very effective germination can be induced in *Rosa multiflora* seeds by cold treatment, but even better germination may be induced by warm stratification over a wide range of temperatures. Despite this, neither the ordinary cold, hot, mixed nor occasionally effective chemical treatments have any apparent effect on *Rosa laevigata.*

In handling hybrid rose seeds a combination treatment of the type described by Barton and Crocker (3) for a *Taxus* seems to work best. The effectiveness varies tremendously between seed lots, and the most effective temperatures for each lot are different. However, in general initial temperatures of over 90 degrees F. are most effective and these temperatures are difficult to obtain without special heating in the greenhouse because of evaporative cooling of the flats. In roses we have gotten around this problem by permitting the flats to dry out well beyond optimal seedling growth levels until germination has taken place.

The most important feature of all of this it seems to me is that it was done entirely incidentally to normal operations. Even so, we have learned a few new tricks. Having done this much we wanted to refine our knowledge and at the same time devise *profitable* techniques.

We decided to work with *R canina* seeds. This rose species is extensively used in Europe as an understock in spite of its germination problems (two years are often necessary for 50% germination). It is rarely used in this country for several reasons among them the germination difficulties The possibility that this might prove to be a useful understock in America, provided good uniform germination could be assured seemed possible We, therefore, undertook a series of experiments using *R. canina* to evaluate the relative importance of the warm initial stratification and the subsequent cold one. We also tried to determine optimum intervals At the same time we hoped to find out how to handle *R canina* at the commercial level. It appears that in both the warm and cold treatments there are optimal intervals and optimal temperatures Moreover, this basic warm-cold pattern seems to work on other materials collected in California including *Malus, Juglans, Prunus, Cornus, Magnolia,* and *Fraxinus* In the case of *Rosa canina,* the optimal intervals and temperatures are: 80 degrees F for two months followed by three months at 40 degrees F.

These observations should be sufficient for me to make the point which I wish to make here

There are very few problems which cannot be helped by recourse to fundamental research and fundamental biological knowledge but there are very few applications to which such research and knowledge may be put without intelligent practical experience. Very often observations made during the course of trial and error experimentation have led to major discoveries in biology, e.g. day length response, growth hormones, etc.

If 140 people would pool their accumulations of fragmentary data and cursory observation, the total would undoubtedly be valuable to all and in all probability result in progress that would seem little short of miraculous.

Simply because a piece of experience is incomplete and not worth writing up or publishing, doesn't mean it may not be the keystone of a most vital arch, which when combined with the other pieces of the whole can make a mighty impressive structure.

It is my belief that if there is any one general principle involved in plant propagation it is this: significant progress will only be made when all possible knowledge is brought to bear in the most effective way. No one is apt to quibble with me on that. The problem is implementation. In connection with plant propagation I am convinced that this objective can best be achieved by bringing all observations regardless of how minor, into a common pool of knowledge.

I can best illustrate this point by regressing to the handling of multiflora and canina seed.

When a germination problem is encountered stratification is ordinarily ones first thought. However, the most effective temperatures and intervals for a new material are often unknown. *R multiflora* was once in this state Stratification of multiflora seed was variable in efficacy in early trials and poor germination a serious handicap. After the work of Crocker and Barton (9), *R. multiflora* germination ceased to be a problem except for the time and cold storage space needed to achieve it. However, the practical man soon found that multiflora seed gave perfect germination with only warm stratification and that the warm stratification could be done immediately before the desired planting time In contrast to this, *R. canina* gives optimum germination only after both a warm and a cold stratification. At the moment it seems that *R. laevigata* does not appear to respond to either heat or cold but only to time, three years being required to effect germination

There are, of course, a multitude of similar examples. To my mind the essential consideration is this. All information about the response of plants to their environment especially new information, is of importance to the plant propagator. This is true whether the information deals with response to natural or ordinary events or to new and strange chemicals or conditions. The hazzard lies in anyone of us thinking that his observations are unscientific and of no importance In my opinion, the worst thing that can happen to a new piece of information is to have it hidden away or perhaps having a prescription for its practical application attached to it, but this is another matter. The greatest benefits will in my opinion be realized if all information whatsoever is presented to a receptive common sense audience with no preconceived strings attached. The results will be progress and profits.

It is my observation and experience that regardless of how well one studies another man's techniques, his own success with the same materials is rarely as great in the beginning as he hoped but without the basic idea, there would have been no beginning. Moreover, it has been my experience that when a new project is begun, regardless of how well it is prepared and executed, its success invariably increases as time goes on The point is that the application of new methods and ideas becomes more effective and most rapidly effective in actual application than in any other way.

This puts a considerable burden on the practicioner. He must locate enough bits to begin and then hope for the best He must encourage and be receptive to all new knowledge concerning plants and he must make every effort to obtain and develop this knowledge. I hope that I have demonstrated that it behooves us all to give such facts as we may possess, to state what these facts mean to us all in as general terms as possible, being at the same time specific enough to show exactly what has been accomplishd with the new information. When a report on a practical technique has been given, everyone should be encouraged to comment, especially our scientific friends so that we may determine as nearly as possible why the new method works better than the old and what additional basic facts are known which might make it work even better

I have described the results of Von Abrams and Hand (1). Their findings indicate the critical factor in Hybrid rose seeds is associated with the inner integument. Whether or not permeability or an auxin effect is responsible for the dormancy is not known. There may be something entirely new involved. Whatever is responsible, it can be inactivated by high temperatures thirty days prior to harvest, by post-harvest warm treatments (at least in some cases), or by cold stratification of 60 to 90 days at 35 to 40 degrees F. except in the case of *R. laevigata,* which does not germinate well until held for two or three years despite combined warm, cold, dry, wet, alternating, undulating, etc., etc. treatments.

In connection with this problem my own thoughts for the future are considerably influenced by Went's (5) ideas on dormancy in desert annuals and by the general occurrence of environmentally controlled balanced hormone systems in plants. This, I trust, indicates how far afield an idea can be and still provide a signpost.

It seems to me that we have been looking at the role of the seed-coat in dormancy in reverse. Instead of keeping water out, which it does indeed do, the real function is to keep certain substances which induce dormancy within the seed. By reorienting ones thinking in view of this theory new possibilities arise and new progress ensues. The important point is that if this should be true it can only serve once again to prove the blind hog can find acorns.

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CHAIRMAN HERB FOWLER. When rose seedlings are taken from cold storage, under what temperature and humidity conditions are they placed?

MR MOREY: The seeds are planted in seed flats with a mixture of half Georgia peat and half sand. The flats are put in cold storage until the seeds begin to germinate. They are removed to the greenhouse and whatever the temperature and humidity happen to be are the ones that the seedlings grow in I only maintain enough heat to keep the frost out of the greenhouses. Temperature and humidity are not too critical. The bad thing is the hot weather in the summer. Germination should be all finished and the seedlings pricked off by the end of May or you will be in trouble

Chairman Stoutemyer introduced Mr. William Stuke, Stuke's Nursery, Gridley, California.

SEED and SEED HANDLING TECHNIQUES IN PRODUCTION OF WALNUT SEEDLINGS

WILLIAM STUKE

Stuke's Nursery, Gridley, California

For the past 30 years, I have been specializing in the growing of walnut trees. It is, indeed, an honor to speak to this distinguished group. During this time, many changes have taken place in the techniques of growing trees; also some in the demands of different stocks used for walnuts.

With advancement of agricultural sciences and the extensive research work by our men in the University in the different departments, many things have been learned which we did not know 20 or 30 years ago. For instance, we know that certain organisms attack the roots of walnuts. The ones with which we are primarily concerned are nematodes, more specifically, the lesion nematodes, *Pratylenchus vulnus* and *Pratylenchus penetrans* which are the most damaging to walnuts There are, of course ,other disorders with which we are concerned, such as crown gall, rootknot nematodes, crown rot, etc.

We learned also of the desirability of other rootstocks which possess resistance to some of these diseases as well as adaptability to certain soil conditions, not shown by the stocks that we were using

Our principle rootstock was Northern California Black Walnut (*Juglans hindsii*) but due to extensive research by the departments of the University, they have discovered advantages in the Paradox Hybrid, which is a resultant cross between Black and English Walnuts. To define it further, we use seed from Black Walnut trees that have been naturally cross-pollinated by the English, which gives us the first generation seedling.

This stock has many advantages, namely, (1) its very good vigor (2) resistance to the disorders that we are mostly concerned with, i e , the two nematodes previously mentioned, and crown rot, and (3) adaptability to heavy, wet and shallow soils.

While we in the past used from 30 to 50 sacks of seed at an approximate cost of about $50 we now use hundreds of sacks which results in a cost of approximately $7,000 to $10,000 per year.

This presented other problems, such as having to obtain seed from many trees (as many as several hundred) with nearly as many different locations to secure the scarce Paradox producing seed. Variation from year to year in the percentage of hybrids produced from a given source placed us in a position of not knowing what we may be able to depend on as to the number of Paradox produced.

It also presented us with the problem of obtaining good germination so that we would not lose our most expensive seed because it is purchased and paid for on a sliding scale based on percent Paradox produced. Thus the better seed (that is with higher percentage of Paradox), is very expensive, and we had to be sure that we could take full advantage of its potentiality. We have learned how to pick our better lots before the time that the seed must be taken from the beds to be planted in the field; this gives us the advantage in using the better lots.

Knowing more about the specific walnut diseases, in the past few years, we have been following a rigid program of fumigation in all areas of our operation. This insures us, as much as possible, against these pests, mainly the lesion nematodes, crown gall and others. This in turn has placed a very high initial cost on the land that is to be used, because of the extensive preparation, cost of material used, and the necessary precautions that must be taken to prevent contamination.

In order to avoid contamination of the growing grounds from the seed, we have extended our program of fumigation and sterilization to include treating stratification beds and dipping seed to guard against any possible avenue infestation.

Our seed stratification beds are made of redwood material constructed to make them 12 feet long, 5 feet wide, and 15 inches high. These are nailed to 2″ x 4″ material on its edge in order to elevate them to facilitate the drainage, in excessively heavy moisture conditions. Holes 1 inch in diameter are drilled along the sides, just above the bottom boards to provide drainage to the seed. These beds are filled with coarse, sterilized sand to a depth of 4 inches. All of these beds are provided with wire covered top frames to prevent rodents, squirrels, dogs, cats, and whatever else from walking over the seed and contaminating it.

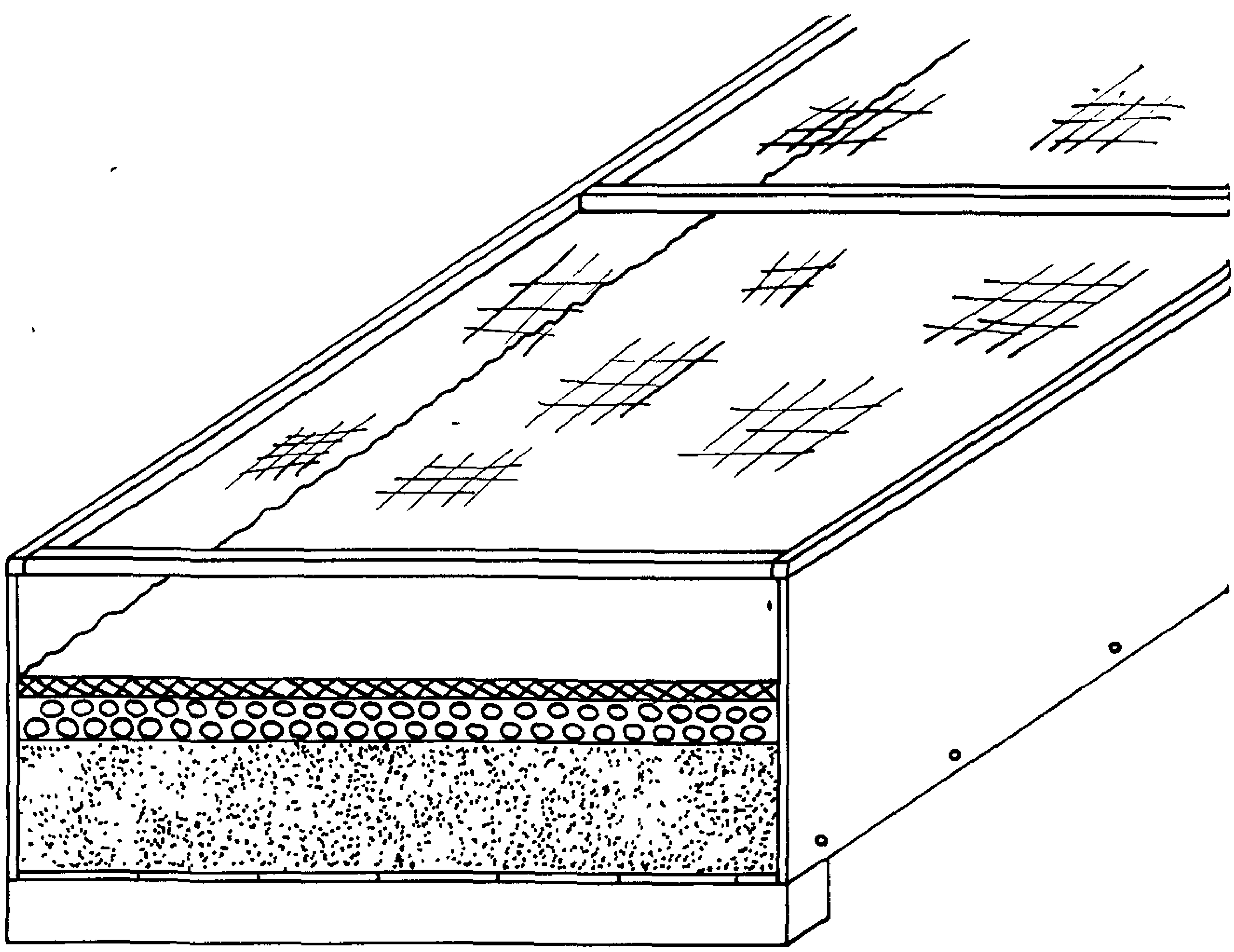

Figure 1.—Cross-section of seed stratification bed showing sand, seed, top covering of vermiculite, and screen.

In the past we have fumigated the beds with Shell D.D. fumigant 60 days prior to stratification time. Last year, we changed our procedure to use Methyl Bromide and applied it in the following manner:

1) The beds were covered with gas-tight plastic tarps and the edges were sealed with sand.
2) Methyl Bromide was applied through a hot water coil, at the rate of 1½ lb. per 100 square feet of area.
3) An electric fan under the tarp was run for about 30 minutes during and after the gas was injected, to thoroughly disperse the gas under the tarp
4) A halide leak detector (using propane) was used to detect any leaks along the edges of the tarp.
5) The tarp was left over the beds for a minimum of 36 hours

SEED HARVEST

Our Black Walnut seed is gathered in October, November, and December from Northern California Black trees, either known to produce Paradox seedlings or to test new potential sources As the seed is gathered, each bag is tagged, so that the identity of the seed is maintained through all the different stages of handling In this way, we know the Paradox productivity of every single tree source. A lot number is given each individual tree, and this number is carried through seed beds, and fields and maintained until the trees are sold. Wet seeds or those with green hulls are air-dried (we do not remove the hulls from our seed) by placing the bags of seed in bins over a pot hole drier, and air forced through until dried. Heated air is not used: this could reduce germination. After being dried and weighed, seeds are stored in a dry place until the time for stratification.

STRATIFICATION PROCEDURE

Seeds are dipped in hot water before stratification. This is done because seed gathered in many different locations under varying weather conditions accumulates mud and dirt which may serve as a source of infestation.

The equipment used is an iron dipping vat 10½ feet long, 18 inches deep and 18 inches wide, placed on brick supports a foot from the ground Under this are three butane burners, each supplying 36,000 BTU per hour to heat the water in which the seed is being dipped.

The water is brought to boiling temperature and maintained to 190° or more.

The seed, identified by its lot number, is brought out on pallets, by means of a fork lift. Seed is put into a wire basket constructed to fit inside the vat in order to submerge the seed in the boiling water. To insure complete submersion of all the seed, a lid is placed over the seed to force it under the water and agitated gently to make sure that all of it is submerged and receives the same amount of treatment. After 1½ to 2 minutes, the basket of seed is lifted out and poured into a box dumper, which is handled by a fork lift. This dumper has a spout attachment at the bottom, through which the seed is run out. The box itself can swivel 360° which makes it adaptable for working between two parallel rows of beds.

After any particular lot is dipped, it is placed in the bed or beds on top of the 4″ layer of coarse sand. The seed is spread out evenly over the sand, not more than two walnuts deep, covered with expanded vermiculite to a depth of 1″ and watered down During the winter months, frequent checks are made to see that adequate moisture is in the stratification beds. If they are too dry, the seed will not sprout uniformly — if too wet, much of the sand is apt to drown out.

Under normal conditions, the seed usually begins to sprout in early March. Unseasonably warm and moist weather encourages sprouting before normal planting time.

The sprouting seed is carefully taken out of the beds by use of a trowl. Each lot is handled separately as to maintain identity by lot number as originally given. All deformed or twisted sprouts are discarded and the good seed placed into field lugs, covered with a moist burlap bag and taken to the field In the field, a shallow furrow approximately 6″ deep is made with a cub cultivating tractor and the seed is hand planted, spaced from 3 to 4 inches apart in the row and covered with dirt.

Later when the seedlings have emerged, they are thinned to a final spacing of 9 to 12 inches apart. The identity of the seed is maintained in the field by placing a stake with its corresponding lot number. A map is made of our growing grounds, showing locations of all lots planted

This general procdure that we now follow has worked out well for the problems confronting us at this time. Other modifications may be needed in the future as conditions change

*   *   *   *   *   *

CHAIRMAN HERB FOWLER: At what stage of germination do you prefer to move walnut seedlings?

MR STUKE· Seeds germinate over a period of time, so vary in their development. Some of the sprouts will be out 4 or 5 inches, whereas others are just beginning to show the tip. We try to remove the seedlings only at two times. We get approximately half of the seed out the first time. We put the rest of the seed back, take them out one more time and get all the sprouts out.

Chairman Stoutemyer introduced Mr. Hugh Steavenson of Forrest Keeling Nursery, Elsberry, Missouri.

FIELD PRODUCTION OF SEEDLINGS IN A CENTRAL STATES NURSERY

HUGH STEAVENSON

Forrest Keeling Nursery
Elsberry, Missouri

Each nursery, or certainly each region, evolves its own methods and techniques of propagation, according to local conditions of soils, climate, marketing opportunities, available skills and historic precedent.

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As a student many years ago, I came under the forest nursery influence Shortly thereafter, in the mid-thirties, I had the opportunity of setting up one of the early soil conservation nurseries in Iowa, and this was followed by a 10-year stretch of developing and managing a similar nursery in Missouri While Uncle Sam steered clear of the ornamental field, the wildlifers called for just about any kind of hardy shrub and vine, as well as many evergreens, while the foresters demanded an assortment of trees for erosion control and other plantings

Thus when I established my own commercial nursery several years ago, it was only logical to pick up seedling production practices where I had left off working for the government.

In other discussions we have referred to our system at Elsberry, Missouri, as the "mulch bed method of seedling production." In our rolling hills rising from the Mississippi River, we are blessed with a mellow loessal soil, recognized wherever found for its horticultural merit. A portion of this loessal mantle has been washed out onto the adjacent river bottom lands during the farming period before conservation. This alluvial outwash, where deep enough, has properties similar to the wind-deposited hill soils.

While these soils are excellent for plant growth, their colloidal properties, humus limitations and the intensive tillage of the past years, make for a crusting problem Soil crusting and germination of tree and shrub seeds do not go together, as you well know. This is where the sand area seedling growers have an advantage. But we think our compensation is in growth performance after germination.

Many of the forest nurseries use a sand covering over seeds to secure good seedling emergence. For many years we have tested a variety of organic substances. Several have proven more satisfactory than sand. The one that has proven most efficacious and economical for our conditions is a stringy sawdust called "header-tow," a by-product of local saw mills making bourbon barrel heads. As long as the white oak trees keep growing and the drinking habit persists, we are assured of a reasonable supply of this material We do use ordinary sawdust as a substitute when tow is not available, but plain sawdust blows, washes and packs where the stringy material resists these hazards.

None of the seeds we sow — and we do grow a wide range of over 100 tree, shrub and vine species — are drilled or otherwise covered with soil All are broadcast on the seed-bed surface, firmed by rolling, and then covered with the tow. The thickness of the tow covering will vary from one-half inch to two inches or more, depending upon the diameter of the seed and time of sowing It will be observed that a tow covering much thicker than a soil covering is permissable and desirable, seedlings will readily emerge through a relatively thick mulch covering

The essential function of this tow mulch is to create a surface to facilitate seed germination and seedling emergence. Germination is abetted by the more uniform moisture and temperature environment of the seed and emergence is facilitated by the loose, porous structure of the material The heavier applications of tow are also helpful in weed control.

After using this material for some two decades, at the rate of a couple of hundred truckloads per year, we have never observed any toxicity to any plant species. (Nor have we observed toxicity with any kind of sawdust.) Nitrogen starvation is another matter. The fertilizing program must be modified to supply the extra nitrogen which is absorbed as the mulch breaks down. There is, of course, no tillage of the bed surface under this method of seedling production. It is a well-known phenomenon that soil structure improves markedly under a mulch culture, and we believe that the very large quantities of organic material that are incorporated into the soil, balanced with high-nitrogen fertilizer, significantly add to the soil humus content over the years.

All seedlings are produced in raised seed-beds formed with a Larchmont bed former. In the early years we have tried seeding "on the flat" and we became convinced that we wanted a seed-bed raised some 6 inches above the path

The primary purpose of a raised bed is to improve soil drainage and aeration. We have almost concluded that there ain't no such animal as too much drainage. Another benefit of the raised bed is that it is possible to finish it off to a near-perfect seeding condition without any hand work whatsoever.

Beds are four feet wide, paths two feet wide. The actual seeding is done on a three-foot strip down the center of the bed, giving us a 6-inch bed shoulder. All of our equipment used in seedling production has a wheel spacing of 6 ft. center-to-center. This applies to all tractors, diggers, manure spreaders used to spread mulch, wagons and any special carts used for moving shade and the like.

One tool we have found that is most useful in rolling and finishing the bed is the Brillion corrugated seeder-roller. This roller has very narrow two-inch corrugations. Seeding is done with this tool, with a Gandy seeder, or by hand. Miscellaneous small lots of seed are more practicably sown by hand, while hand broadcasting usually is best with stratified seed and various types that do not lend themselves to mechanical seeders.

As a guide in processing, pre-treating, sowing and growing the crop, a "Seed Sowing Data Sheet" is maintained for each species or accession of seed. This sheet serves not only as a production plan but also as a record for future reference You will note that the sheet records such data as accession number, common and botanic name, source, amount of seed, seed per pound, cutting test, estimated emergence, estimated plants per pound, production goal, quantity of seed to sow, seedbed density desired, bed feet to sow, preplanting treatments, seeding details, disease and insect control treatments, germination notes and counts as the season progresses.

Fertilizing treatments and soil development are similar to any other good nursery practice. In starting a new seedbed area, we try to bring the land to a finished grade with a land leveler. Then we go through a perennial sod crop, involving a fibrous-rooted grass like brome-grass or perennial fescue, for at least two years. During this period we strive to bring the soil to an optimum level of fertility. Necessary liming and rock phosphate go on, usually prior to seeding the sod crop, and supplementary fertilizing is done as indicated by soil tests and plant growth to achieve a high, balanced level of fertility. Growth of the sod crop is either grazed or mowed and allowed to fall back on the ground, rather than removed as forage.

We attempt to maintain the pH level somewhat on the acid side (about pH 5 5 to 6 0) which is near optimum for most of the seedlings we grow. Rarely are acidifying amendments necessary as in our area do not grow any of the ericacious plants under open field conditions.

Needless to say, on such an intensive crop as tree and shrub seedlings, it is economical to apply whatever fertilizer is indicated to maintain an optimum level of the major elements. (Trace elements under our system have not been a problem) Indicated amounts of fertilizers are applied prior to bed formation. Supplementary feedings, primarily nitrogen, are made as the seedling crops grow, either with a bed spreader or, preferably, in soluble form through the irrigation system

WEED, DISEASE, INSECT CONTROL

In preparing new ground for seed-beds, particularly following a sod-crop, we treat with Dieldrin or a similar insecticide as a protection against grubs and other root-attacking insects.

We used to worry a lot about damping-off control and possibly should be a little more concerned now. In times past we have run the gamut of various chemicals suggested for controlling damping-off diseases, but we now use no specific for this purpose, except where a known or anticipated critical problem exists If we can get our seedlings germinated and growing during their normal early spring germination period, our damping-off difficulties appear much less pronounced. This usually means either fall seeding or early spring sowing of stratified seed. The non-dormant early-summer fruiters, such as certain maples and elms, respond with little damping-off difficulty when sown during their normal dispersal period. In fact, seeding when nature normally disseminates her seeds is an excellent rule of thumb. Stratification is usually an acceptable substitute for over-wintering (or over-summering) seed in the bed but failure will often attend the practice of sowing after-ripened seeds when seed-bed temperature conditions do not correspond with those under which the seed normally germinates

We very much subscribe to the theory of cleaning up the seed-bed area of weed seeds and pathogens prior to seeding, and wish there was a more efficient, economical means of doing this Among the chemical methods, methyl bromide is certainly outstanding. The objection is the cost and the labor of laying tarps. For $400 or $500 per acre we can do a lot of hand weeding.

We have in years past used calcium cyanamide effectively against weed seeds This does entail a several-month time lag from treatment to seeding and involves cumbersome mulching. Furthermore, it will certainly raise hob with soil pH if you want to stay on the acid side.

We have tested the various proprietary soil sterilants without getting too enthusiastic. For some years we have been using allyl alcohol, which can be applied safely and conveniently through the irrigation system. In fact, that is the only way I would want to touch this stuff.

An application of 25 gal. per acre will run about one-sixth the cost of methyl bromide and will clean up 90% or so of the weed seeds. No control of pathogens or insects is ascribed to this treatment, but we suspect there are some benefits in this direction. There is certainly no substitute for a good sanitation program that prevents weeds from going to seed.

For post-emergence chemical weeding we use the standard Stoddard solvent treatment with conifers. There is no chemical we can use on the broad-bladed seedlings. For transplants, which are something else again, we have tested a number of the herbicides and find that Simazine seems to be the best so far.

We still have hand weeding to do. But the fact is that it is much less of a job than it used to be in the early years. Instead of 50 weeders in a 10-acre field of seed-beds in June, we can get along with a dozen, thanks to chemicals.

SEED PRETREATMENT

I have touched on this subject and time does not permit a run-down on treatment by species. Suffice it is to say that any seedling grower would do well to have a file of the Boyce Thompson Institute bulletins on woody plant seed studies. Another "must" is the U.S. Forest Service 'Woody Plant Seed Manual," Misc. Pub 654. The various seed propagation papers in the *Proceedings of the Plant Propagators Society* are among the very best references available.

For 20 years we have vacillated between fall seeding vs. stratification and spring seeding. There are hazards either way. Here on the West Coast where you have little if any cold period, the dormancy problems of your seed subjects would certainly be different to ours where we have honest-to-gosh winters. With few exceptions, such as those species that mature their fruits in the spring or early summer, the woody plant seeds we propagate have dormancy of some kind, and this is a fascinating subject in itself. Often as not there will be a factor of seed-coat impermeability combined with internal dormancy. A large number of the desirable genera, such as Viburnum, Crataegus, Ilex, Tilia, Taxus, etc., are members of the "two-year" class, which require a warm after-ripening period preceding a cold period. Impermeable seed-coats (which most legumes possess) are usually handled by scarification. We have standardized on a bath in sulphuric acid for all our scarification work.

SEED PROCUREMENT

We obtain seed from a number of domestic sources and foreign sources, as well as from our local harvestings. Every seedling grower bats his head against the problem of importing seed and getting it in time to sow or stratify at the proper period. In many cases there simply isn't any answer except to carry the seed over an extra year. We have gone to some effort to establish hedge rows or other stock plantings to produce our own seed of several species. If one will only look ahead far enough, this is an excellent step.

Seed propagation will always have its limitations because of the necessity to produce clones vegetatively. But where a subject can be propagated by seed, this practice has much to commend it. I believe it is a rare instance where a properly-produced seedling will not outperform in growth a cutting-grown plant of the same species. Sometimes this difference is spectacular. Seedlings are needed in quantity as understocks But again, where a seedling type is comparable in characteristics to the selected clone, the seedling may have important advantages. Incompatability problems or graft weakness often appear years after planting, sometimes with disastrous results. Seed propagation is required to select new and better types, and many types will, of course, come reasonably true from seed. So in the art and science of propagation we will always have a place for the sexually-produced plant. It is a fascinating field and may offer rewards comensurate with vegetative techniques

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Chairman Stoutemyer introduced Mr. Gerd Schneider, Saratoga Horticultural Foundation, Saratoga, California, who presented his paper on the production of tree rootstocks

PRODUCTION OF ROOTSTOCKS FOR ORNAMENTAL TREES IN THE CONTAINER NURSERY

GERD SCHNEIDER
Saratoga Horticultural Foundation
Saratoga, California

For the discussion of rootstock production of ornamental trees in the container nursery, I have selected five trees widely planted in Central California Although clonal reproduction is practiced with all of these trees, most of them are planted as seedlings Seeding techniques for container production differ only in few respects, when the young plant is to be used as a rootstock and when it is to be grown as a seedling specimen for planting The purpose of this paper is to focus on the seedling, which is to be used as a rootstock and to point out the practical steps and considerations necessary to produce that plant. I shall emphasize the selection of the seed parents, with a view toward obtaining material which is vigorous and of uniform size in the seed bed. I also want to emphasize some aspects of propagation unique to each tree.

The following trees will be discussed: *Liquidambar styraciflua, Pistacia chinensis, Ginkgo biloba, Magnolia grandiflora* and *Quercus ilex*

Liquidambar styraciflua is monoecious; every tree has the potential to bear fruit and seed. Although reports from the Eastern United States indicate that the tree has to be almost 25 years old before it starts to bear fruit, we find that the trees in Central California usually start to bear fruit when they are seven to eight years old, often yielding heavy crops at the age of fifteen.

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It is our observation that *Liquidambar styraciflua* has a narrow range of variability in size and vigor, since one tree in a large neighborhood of trees produces the same quality and quantity of seedlings every year, while the tree beside it does not show the same qualities at all. In spite of much variation in size among the neighboring trees the seedlings of one tree seem to be rather uniform We conclude that in selecting the seed parent for *Liquidambar styraciflua,* one should endeavor to find one superior seed specimen, regardless of the quality of the neighboring trees A good time for seed collecting is late October. The fruits should be picked when still green and then exposed to sunlight. Soon they will open, and the viable seeds can then be separated from the abortive seeds, which are discarded at the same time The dried seed should be stored in a cool airtight container. A stratification period of sixty days at 41° will produce 95% germination.

Seeds planted in early March are ready for transplanting by the first of May. No more than 400 seeds should be planted per square foot of seed flat, in order to give enough room for the development of a strong seedling We recommend in our Saratoga climate that the young plant be kept shaded through the liner stage. Twelve to 14 months after the seedlings were first transplanted, they are ready for budding

When considering the habits of the seedparents of *Pistacia chinensis,* we are confronted wth two difficulties: alternate bearing and a wide range of variability in size among the seedlings, which is probably caused by frequent cross-pollination.

We select a number of seed trees one year and keep the harvest of each tree separate through the first and second growing season. Each tree will show different results with regard to percentage and time of germination and also uniformity and vigor in the seed bed. The same trees will not produce a satisfactory seed crop the following year, so that another group of trees should be selected and treated in the same way as in the previous year. After a number of years, it should be possible to recognize the best seed parent in each group. If no consistency can be found, the seeds should always be collected from fruits which have a blue-green color, and relatively large, and ripen about the same time. Early October is a good time for seed collecting. The pulp can be removed from the seed by rubbing the fruit over a screen after a brief soaking in soap water. Thorough drying of the seeds before they are placed in storage is important. A stratification period of 40 days will result in germination of about 90% of all potential germinators. Not more than 250 seeds should be planted per square foot of seed bed.

Seeds sown in early January, followed by transplanting into peat pots in early March and canning in May, will result in 75% of all plants being ready for budding in June of the following year In spite of proper care in selecting good seed parents, we find that there is a wide range of variability among the seedlings, if the seeds are collected in a neighborhood of trees covering a city block

The third tree, *Ginkgo biloba,* has seeding habits which are in some respects unique, compared with most other trees After the seeds are collected in early October and the pulp has been removed, we have a Ginkgo nut that has an undeveloped embryo at that time. The cleaned seeds should be packed in layers of moist sand, while exposed to normal outside temperature During the next ten weeks, the development of the embryo will take place. In late December, we sow the seeds in outdoor seed beds. We prefer row planting and plant about one pound of moist and clean seed per square yard. After one growing season, we dig and grade the seedlings before they are planted into gallon cans. After another growing season in gallon cans, they are ready for budding. Alternate and irregular bearing of *Ginkgo biloba* is quite common. Their range of variability is rather narrow, although the seeds are picked in a large neighborhood of trees The grading of the seedlings is an important procedure to secure uniform rootstock material.

With *Magnolia grandiflora* the proper selection of the seed parents seems to be very important They show a wide range of variability The seeds from one tree yield seedlings of considerable variation in

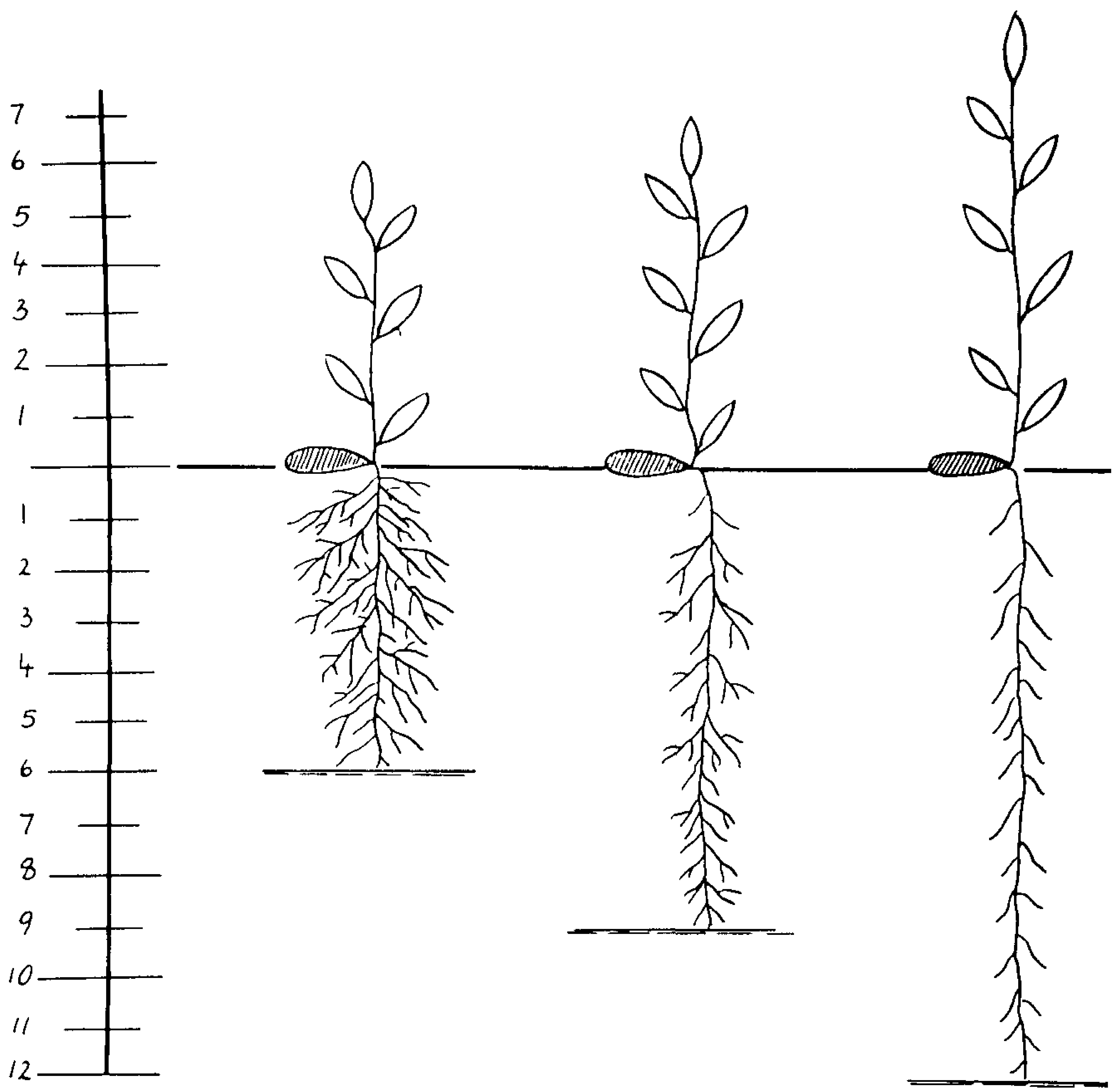

Figure 1 Influence of the depth of copper wire on the root development of Quercus ilex.

vigor. Also the viability of the seeds differs from tree to tree It is our observation that trees of uniform size and age should be preferred as seed parents. Uniform trees in an isolated location provide the most uniform seedlings. For best results in germination, the seeds should be fully ripe. Cones which are harvested in the first part of October when still partly closed produce seeds with a small percentage of germination. Seeds collected from the same tree about twenty days later showed excellent germination results. When the red seeds are visible all over the fruit, the best time for seed collection has come. After extraction of the seed, the red pulp should be removed immediately and the seeds thoroughly dried before being placed in storage

A stratification period of 60 days at 41° usually results in germination of 80% of the potential germinators. No more than 250 seeds should be planted per square foot of seed flat. Transplanting can be performed successfully after three to four true leaves are developed. A growing period of about 17 months in a gallon can produces an excellent rootstock.

The propagation of *Quercus ilex* has one very interesting aspect The acorns should be planted in a deep box which has copper mesh at the bottom As soon as the actively growing root tip contacts the wire, it will die. Side roots are forced to develop. If the acorns are planted soon after they are picked in the fall or early winter, root action will start after about two to three weeks The number and quality of side roots in relation to the amount of top growth depends largely upon the depth of the copper mesh under the acorns. Best results are obtained if the wire is placed 6″ below the acorns. The number and quality of side roots will decrease rapidly if the copper wire is nine or twelve inches below the acorns. Five months after sowing the seeds, the seedling is ready for transplanting directly into a gallon can. After one growing season, the seedling can serve as a rootstock.

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CHAIRMAN HERB FOWLER. Why does a copper screen kill the root tip of Oak seedlings?

MR. SCHNEIDER: As far as I know, copper is toxic. Copper naphthenate painted on the bottom of a flat will give the same result.

MR. IVAN STRIBLING: Will you tell me a compatible and dwarfing rootstock for Magnolia St. Mary?

MR SCHNEIDER· I don't know of a dwarfing rootstock for Magnolia St. Mary. We do know that Magnolia St. Mary is sensitive to the variation among the seedlings. If somebody could secure a seed source which produced small seedlings and could get buds to grow on them, he would probably end up in the long run with Magnolia St Mary plants which are smaller than normal.

MR. STRIBLING: Are Magnolia cuttings under mist as successful as budding?

MR SCHNEIDER: I do not know about budding *Magnolia grandiflora* or cuttings under mist, but I do know that *Magnolia grandiflora* St. Mary can be rooted from cuttings, but during the winter time when there is more mist operation and when the cutting material was quite hard.

SATURDAY AFTERNOON SESSION

October 15, 1960

Mr. Louis LeValley, Head of the Department of Ornamental Horticulture, Fresno State College, Fresno, moderated the Symposium Chairman LeValley introduced Mr. Lloyd Joley, Director, U S D.A. Plant Introduction Station, Chico, California.

EXPERIENCES WITH PROPAGATION OF THE GENUS PISTACIA

LLOYD E. JOLEY
U.S. Department of Agriculture
Chico, California

INTRODUCTION

Your program committee asked me to discuss our experiences concerning the propagation of *Pistacia* at the U.S. Department of Agriculture, Plant Introduction Station, Chico, California, particularly as these experiences relate to *P. chinensis.*

Interest in the genus *Pistacia* is rapidly increasing throughout much of this country Thus far this attention has centered on *Pistacia chinensis* Bunge, a fall coloring shade tree, and on *P vera* L., which produces the edible pistachio nut of commerce Additional species such as *P atlantica* Desf, *P. integerrima* Stewart, *P. Lentiscus,* L., *P. terebinthus* L, and some hybrids of these are also promising as shade trees or for rootstocks

Most of our research with *Pistacia* has been concerned with *P. vera* as a potential new crop for this country. To a lesser extent this research has also included work with *Pistacia* species and hybrids as rootstocks for *P vera,* and with *P. chinensis* as an ornamental shade tree Although there are problems in propagation peculiar to each species the principles that apply to one are applicable to the others. The notes and data presented are by no means a complete review of the subject, but they do cover many of the problems commonly encountered

VEGETATIVE PROPAGATION

References in the literature concerning the vegetative propagation of *Pistacia* are often sketchy and conflicting Propagation by cuttings is seldom mentioned and generally unfavorable. In the past 25 years attempts have been made at Chico to root cuttings of *P. vera, P. chinensis, P. lentiscus* and other species. Seldom has there been more than 5 percent rooting of the hundreds of cuttings set and usually less regardless of the time of year the cuttings were taken. We have not thoroughly tested all species under mist but one trial of *P. lentiscus,* an evergreen shrub, was unsuccessful.

Budding and grafting are the methods most commonly used for vegetative propagation of *Pistacia* species other than *P. lentiscus.* Budding is apparently more widely practiced than grafting In Iran (1, 3,

9) the ring-bud and shield or T-bud are favored, but bark and cleft grafts are also used. Better results were obtained from ring grafting than any other method at the Nikita Botanical Garden in the Crimea (7). In Turkey (2, 3, 4, 9) and other pistachio nut producing areas of southern Europe the T-bud is preferred. Bark grafting was more successful than cleft grafting in some early work at Chico (9) but over the years the T-bud has consistently been the most successful An orchard planting of over 100 seedling rootstocks near Red Bluff and a smaller nursery planting near Walnut Creek, California, were topworked in the spring of 1957 by experienced grafters using the whip graft. In both instances the grafts failed completely. On the other hand, two growers near Bonsall and Elsinore, California, have had better results from grafting. These differences suggest need for further research on this problem.

While propagation by budding is generally successful for all species except *P. lentiscus* (which incidentally is propagated chiefly from seed) enough failures have occurred to suggest that possibly *Pistacia* can be as variable and uncertain at times as walnuts. Some of these failures are probably due to the propagator, but undoubtedly more are due to the environment and to the condition of the budwood and rootstock Holmes (5) has reported that at the Mt. Arbor Nurseries, Shenandoah, Iowa, budding of stone fruits is stopped when temperatures reach 95° F In Uzbekistan, U S S.R., (8) maximum results were obtained when pistachio buds were set between 5 and 8 a m and 6 to 8 p.m

At Chico, from August 14 to 28, 1958, well-grown vigorous buds of *P vera*, taken from a single tree, were set on seedling rootstocks of *P. atlantica* and *P. terebinthus* During this period daily temperatures ranged from 85 to 105° F but were below 96° on only three days. By the time the budding was completed an undetermined but small percentage of buds were showing various stages of injury that seemingly indicated they had been overheated. However, most buds remained plump and firm until mid-September when losses rapidly increased By late October this loss was so heavy that an inventory was taken. It became apparent there was a close correlation between the condition of the rootstock and the loss of buds for the better each rootstock had grown the higher the take of buds. This correlation was such that the loss and take of buds could be estimated with surprising accuracy by noting the growth and condition of the seedling rootstock.

Opinions differ as to the best time of the year to set *Pistacia* buds. Some references consider that April and May are the best months whereas others believe buds take better in late summer or early fall. Data Dr. Whitehouse and I published (10) indicate that at Chico buds set in March and early April take poorly, if at all, but there is a marked increase in bud take as the time of budding is extended through the summer and fall. This failure of buds in early spring can be anticipated if the weather is rainy or cool but in a couple of instances bud take in April was high during extended periods of warm, sunny weather.

Studies reported from Russia (6, 11) indicate it is better to remove the wood from the bud shield before setting the bud. Likewise, a few

California growers and nurserymen have reported better bud takes following removal of the wood. At Chico, (10) no particular benefit was obtained from this practice. However, when the bark is slipping easily the wood tends to slide out during insertion of the bud, in which case the wood is usually removed.

Experience has shown the importance of using well-grown budwood from vigorous current season's growth, produced either as water-sprouts or as strong terminal growth. One way to produce good budwood is to cut back one or more limbs on a tree in early spring forcing out new growth. Cutting back insures a greater supply of vegetative buds since many of the lateral buds on the current season's growth of mature trees are flower buds. Flower buds on most species can usually be recognized in early summer by their plumpness and increased size. Flower bud shields may unite with the stock, but the buds drop out either before or after flowering. In case of doubt one can use the vegetative terminal buds of *Pistacia*.

A rubber budding strip has, until now, been our favorite material for tying *Pistacia* buds At Chico the 3/8 x 8 inch size is preferred because it handles easily and effectively covers the wound made to insert the larger *Pistacia* bud. In 1959, a non-adhesive vinyl nursery tape became available in local garden shops Limited tests of this material as a tie for buds appeared favorable. In September 1959 an experimental pistachio rootstock block was topworked, tying 126 buds with vinyl tape, 120 buds with rubber strips and 95 buds with nursery tape The last tape, a combination adhesive and cloth-backed material, was included because a grower had reported very favorable results from its use.

Bud takes of 92.9 and 92.5 percent for vinyl tape and rubber strips were so nearly identical as to suggest they can be used interchangeably. Lack of stretchability makes handling of the vinyl tape somewhat awkward at first but one soon becomes as adept with it as with rubber strips. The chief fault of vinyl tape is its inability to decay readily in sunlight thus requiring considerably more time to cut loose. Besides contributing to a lower take of buds (71 6 percent) nursery tape is difficult to apply as it tends to stick and tangle unless kept taut and straight It is also difficult to remove and has a tendency to peel off the outer surface of the bark.

SEED PROPAGATION

All *Pistacia* species are dioecious, that is, the male and female flowers are borne on separate trees. No positive way has been found to determine the sex of a *Pistacia* tree prior to its flowering. To produce seed for propagation purposes a staminate, or pollen tree, must be planted near the pistillate or seed tree and then flowering should coincide to insure a good seed harvest. It is feasible to topwork a staminate limb into a pistillate tree to conserve space, but the male limb will overgrow the tree unless it is kept in balance by pruning. Most *P. chinensis* trees presently sold by the nursery trade are seedlings, approximately half of which are females. Since the more vigorous, non-seeding males are preferred for street and lawn planting, interest in the development and use of clonal selections of *P. chinensis* and other species is increasing.

The time for gathering *Pistacia* seed varies with the species and individual clones within the species. At Chico, seed of *P. integerrima* and *P. weinmanifolia* Poiss, matures in July and August, *P. vera* varies from late August to late September: *P atlantica*, *P. mutica Fisch* and *Mey*, and *P. terebinthus* late September to early October, *P. chinensis* late September and throughout October and *P lentiscus* in December. *Pistacia* seed should be gathered as soon after full maturity as is practicable Maturity of fertile seed can be determined by the color of the external hull or epicarp For most species the epicarp turns blue or green at maturity except *P lentiscus*, which turns black, and *P vera*, that turns whitish and softens to the point where it slips off easily when squeezed between the fingers

Pistacia seed are knocked off the tree with poles or a power shaker and collected on canvas sheets spread underneath. The soft outer hull may inhibit or cause reduced germination if left on the seed. Immediate removal of this hull is preferable while it is easily rubbed off for seed dried with the hull intact requires a few hours soaking in water in order to soften and loosen it again. Immediate cleaning of the seed also discourages storage insect infestation. At Chico, we use a mechanical seed cleaner similar to a vegetable peeler but *Pistacia* seed can also be rubbed and washed on a coarse screen. Freshly cleaned seed should be dried rapidly to avoid danger of molding, preferably at temperatures below 100° F. Blowing air over and through damp seed with a fan or spreading them out in a thin layer on screens raised off the ground and held in the shade is an easy way to accomplish this rapid drying.

Seed of *Pistacia* species can be planted from late fall to early spring, but fall planting has consistently given better germination Another excellent aid to germination is the use of a planting mixture of 5 parts sand and 2 or 3 parts of peat by volume. This mixture can be used in flats, greenhouse benches, and ground beds In the nursery, a ½ inch or more layer of the mixture can be spread in the bottom of the seed trench, the seed planted and then covered with another layer of the mixture before filling the trench with soil

It is very important that the germination medium be kept damp and free of crusting throughout the germination period. A mulch is very helpful in reducing evaporation Materials such as sand, sawdust, leaf mold, newspapers, polyethylene or anything that shades the soil can be used With newspapers or other similar shading materials, an opening to the light must be made as soon as the young plants appear

A series of germination tests made at Chico several years ago indicated that most *P. atlantica*, *P. chinensis*, *P integerrima* and *P. lentiscus* seed would germinate without any pregermination treatment other than soaking in water for 2 or 3 hours This soaking becomes more helpful when seed planting is delayed until late March or early April.

For some unexplained reason our particular strains of *P. terebinthus* are somewhat variable in their germination response, especially if planting is delayed until March or April. One treatment that helps is to soak the seed in water 2 or 3 hours, drain and then keep them constantly moist at approximately 70° F. until germination starts, which is usually within 2 weeks.

In addition to fall or winter planting, an effective way to stimulate germination of *P vera* seed is to soak the seed in water held at 40° F. for 2 weeks prior to planting. In one variation of this treatment used in Turkey the seed is put in a burlap bag, soaked for 1 or 2 days in cool preferably running water, drained and the sack of seeds stored and kept damp in a cool, shady spot until germination starts

Early planting of seed, combined with careful watering and regular applications of nutrients, is essential for maximum first-year growth of *Pistacia* seedlings. Early planting also gets the young seedlings off to a good start before growth is slowed down during the heat of July and August The first 2 or 3 months is a critical period in the life of the *Pistacia* seedling. It is a period when care must be exercised to make sure the young seedlings are not over-watered lest damping-off and "wet-feet" problems develop. Slight mounding of the soil beside each seedling helps in keeping free water away from the crown. Should sudden blackening and death of seedlings occur from injury in the crown or roots, withhold water and let the soil dry and aerate. Thrips sometimes become very active around the terminal growth of young seedlings and cause both malformation of the expanding leaves and dwarfing of the plants. These insects are easily controlled by spraying.

Young *Pistacia* seedlings growing under a relatively low nitrogen level may grow only 2 or 3 inches then form a rosette of leaves and cease growing. This semi-dormant condition may persist for several weeks or even months if no treatment is given, but can generally be broken by application of a side-dressing of some nitrogenous fertilizer.

Pistacia species seedlings tend to suffer considerably from shock in transplanting. The roots are also very sensitive to air and will not withstand exposure without danger of damage. High loss after transplanting is a hazard that is ever present for the nurseryman producing them as well as the grower purchasing bare-rooted trees. Some aids for reducing this danger are transplanting as soon as possible after leaf-fall in December or January,transplanting as quickly as possible after lifting the seedlings,and holding the roots in damp soil or sawdust while transporting from the nursery to the planting site Thorough watering of each tree also helps to compact the soil around the roots and prevent air pockets.

Production as container-grown plants apparently has become standard procedure for marketing *P. chinensis*. The wisdom of using gallon cans appears doubtful for a tree so definitely taprooted, but growth in a container does assure that it can be transplanted at any time with little danger of loss. We suggest to growers interested in producing rootstocks for the pistachio nut that one very satisfactory method is the use of a soil tube 4 or more inches in diameter and a minimum of 18 inches but preferably 24 inches tall to accomodate the long tap root. By planting the ungerminated seed or transplanting young germinating seedlings into each tube of soil it is possible to grow a large number of seedlings in a compact space. These tubes can be made of black felt building or sheating paper or even heavier material cut to length and formed around a piece of pipe of the required diameter Each tube is held together by tacking or stapling the seam to a wood strip or by sealing with some waterproof adhesive such as hot tar or plastic glue.

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CHAIRMAN FOWLER. Is it necessary to bud a male branch into every female *Pistacia vera* tree to insure fruiting? If not, what percentage of male trees is necessary in an orchard?

MR. JOLEY: Our general recommendation for the Pistachio nut in commercial production is one male to every 10 or 12 females How many males one should use depends on weather conditions during the time of blossoming The poorer the conditions for pollination, the more males one should use All *Pistacia* are wind-pollinated and it is important that you locate the pollinator tree so that the pollen will drift to the female trees. If you have only one or two trees, I would graft a pollen-bearing variety onto a limb of one. If I had 10 trees, I would use one tree as a pollinator. You will use the equivalent of one tree, no matter how you do it. It is more efficient if you use one tree than if you graft limbs, because there is a tendency for the male limb to overgrow the tree.

CHAIRMAN FOWLER: You indicated that poor results were obtained when *Pistacia* were budded in the spring. Did orientation of the bud on different sides of the stock have any effect on the results?

MR JOLEY: I do not know if there is an effect on bud take due to season of budding and compass position of the bud on the rootstock. Data Dr. Whitehouse and I published only covers buds set in September and for one year. The data do not indicate any definite effect, there being a maximum range of 4 percent between the compass positions with highest and lowest bud takes. I have not observed a different trend or effect for buds set at other times of the year but in the absence of data this cannot be interpreted to mean the effect is not there. On the other hand there is an abstract of a Russian report (see No 8 under literature citations) which mentions that *Pistacia* buds set on the south side took better during the hottest summer months than did those set on the north side. One other interesting item in that report is the suggestion that bud injuries and failures during very hot weather may be due to the heat of the sun melting and setting turpentine free from the gum formed around the bud wounds. This turpentine then penetrates underneath the bud-shield injury the tender cambium tissues of both the bud and the rootstock

CHAIRMAN FOWLER: Do female trees always have yellow fall color?

MR. JOLEY: I have checked some 350 mature *P. chinensis* seedlings and the answer is no Color variation is genetic I believe. Among the population of seedlings available for study some trees have yellow leaves, some have red leaves, while others are combinations of these. It does not seem to make much difference whether the tree is male or female. However, there appears to be more uniformity of coloring from year to year in the male than in female trees Color of the female tree may vary depending on the set of fruit, the heavier it sets seed the less it may color but when it does color it is similar to what it was in preceding years

CHAIRMAN FOWLER: What do you mean when you say the roots of *Pistacia* are sensitive to air? Why, more so than other plants?

MR. JOLEY: That is my way of defining the fact that *Pistacia* roots will not stand exposure to air for more than a very short period of time As I said this afternoon we were evaluating the roots of several *Pistacia* species and hybrids for root-knot nematode susceptibility. We had about 200 seedlings ready for this evaluation. It was a cool, rainy day and seemingly ideal for examining roots without danger of their drying. Some roots were exposed to the rain for approximately 3 hours but others were exposed less than an hour All but a very few died after transplanting. This is not an isolated observation: other staff members have observed the same reaction at different times and under different conditions. In fact it was first noted on *Pistacia* seedling roots heeled in sand beds containing sand of plastering grade and size. Patches of gum form on the roots and wherever this gum occurs the bark tends to die and slough off On the other hand I have stored *Pistacia* seedlings in damp sawdust well over a month at 40° F with very good survival after transplanting.

CHAIRMAN FOWLER: Do the roots have a mycorrhize complex that you know of?

MR. JOLEY: I do not know of any nor have I read of any mycorrhize complex on *Pistacia* roots. This is a good question.

CHAIRMAN FOWLER: Are larger size *Pistacia* easy to move with a ball of soil?

MR JOLEY. When they are grown in containers it is easy to move large size *Pistacia* seedlings I have planted moderately large, dormant, bare-rooted seedlings in 5 gallon cans in early March and later moved these to the field the following August and September without apparent injury or shock as long as the ball of soil remained intact. Furthermore, there is a commercial planting of several thousand seedlings under way that were grown in soil tubes and transplanted during the heat of July, August and September with almost no losses from transplanting shock

Chairman LeValley introduced Mr. Dwight Long, Street Tree Foreman, Modesto Parks and Recreation Department.

BUDDING AND GROWING PISTACIA CHINENSIS FOR STREET TREES

DWIGHT LONG
Modesto Parks and Recreation Department
Modesto, California

The *Pistacia chinensis* has great possibilities as a street tree in all but the coldest climates, even in narrow planting spaces. The Pistacia becomes more value when budded from selected males on rootstock that has been selected for type and vigor. The best techniques for budding, growing and training have not, as yet, been fully established The City of Modesto Parks and Recreation Department, in the last five years, has tried a number of ideas with encouraging results.

We use the shield bud and have had the best success with using buds that have not pushed or enlarged, and the wood mature enough to be firm This selection has given about a 96% take, whether budded in spring or fall, or at what height the bud is placed on the seedling stem

In growing the Pistacia, we have tried several methods and are still using or testing three. They are described as follows:

1. Plants are field grown and bare root transplanted.
2. Plants are field grown and bare root transplanted to five gallon cans for the second year growth in the nursery.
3. The seeds are started in small, bottomless containers and when about five inches high, they are placed on top of five gallon, soil filled, bottomless cans to complete growth in the nursery.

Three root prunings are performed. They are listed as follows:

1. The root is cut 9″ below surface when the seedlings are from 3″ to 5″ high and the small tap root is 12″ to 20″ deep. With container grown plants, the root is pruned when plant and container are being moved to larger containers.
2. The second root pruning is done at the end of the first season's growth, just in time to check and harden tender tip growth and to confine winter storage of plant food. Roots of container grown plants are cut just under the large container. Roots of field grown plants are cut about 15″ below ground level with power-drawn tree digger

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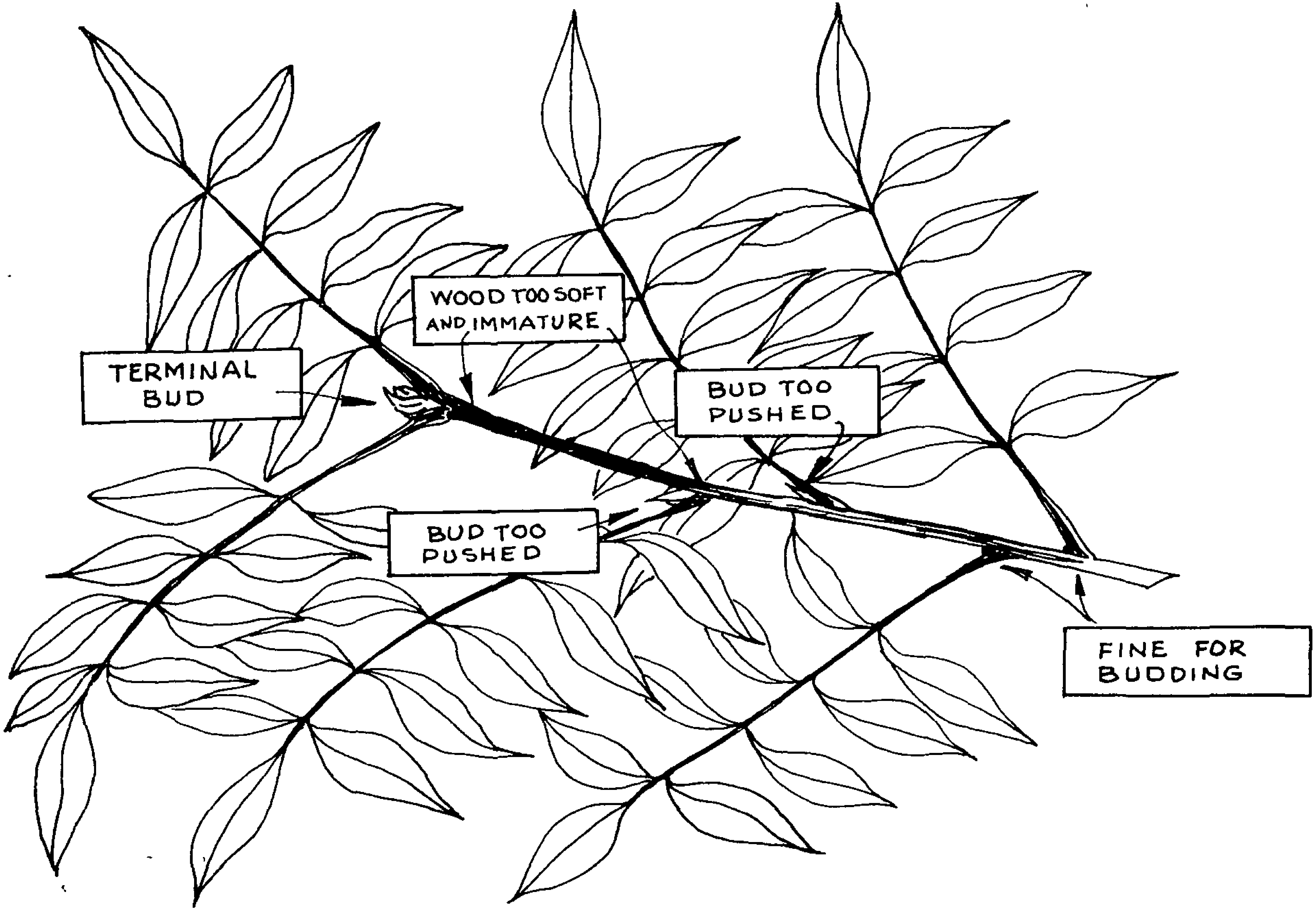

Figure 1.—Pistacia chinensis shoot with buds in different stages of development in relation to budding.

3. The third root pruning is done at the end of the second season. about 3″ deeper than the second root pruning and for the same reasons.

Digging the tree for planting on streets is done about a month later and at the same depth. We examine, make clean cuts and correct or remove objectionable roots at every opportunity when roots are exposed. All three of these methods give us about a 9-inch undivided tap root and 18 inches of additional branched roots, trained and selected for growing deep We are now able to produce trees ready for street planting in two years. We realize that our method is more expensive than commercial methods, but the results are more satisfactory in the long run. We expect very soon to be using one system, greatly simplified.

We are testing other techniques, such as starting the seed in a greenhouse or hot bed in December. This method will have the tree ready for the first root pruning and transpanting by the time danger of frost is over This will give us a larger and more fully developed tree

Each year, we select some of our most outstanding seedlings and plant them where they can be observed in our vicinity, hoping to select a better source of seed or bud stock.

By planting large numbers of cross-pollenized seeds and observing them, we have already developed two trees with a combination of several good qualities We may soon be using these new varieties for our source of root and bud stocks.

We wish to thank the U.S.D.A. staff at Chico; Mr. Van Rensselaer, Director of Saratoga Horticultural Foundation; and Dr. Harris, Landscape Horticulture, University of California at Davis, for their help and encouragement.

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CHAIRMAN FOWLER: When and for how long do you bend the *Pistacia chinensis* at an angle to produce low branch development?

MR. LONG: Well, this year we thought we would be successful without doing it, and so it was quite late (early, September) when I found I wasn't getting as much low branch development as I wanted I bent them over by running a wire two feet high down between the rows, pulled them over, and with plastic tape just gave them a quick tie. In three weeks, 90% had all the side branching they needed and I was afraid to leave them down any longer, because at this time of year, they might get so hard when we went to straighten them back up, some might break. I hate to take so much time on this, because I don't think you wholesale nurserymen can quite go to that trouble — but for us concerned with street tree planting, it is worth a lot to us, because it saves money in not having to stake them so long, and they don't sunburn. I will go ahead and follow up on what I am going to do another year. I really believe now with some I tried this year that the most successful way is in the spring when we cut back. We cut about 5 inches above the bud and then we destroy the buds that are above our scion buds.

When that scion bud starts, we have that stem to tie it to, and we do not place a stake to the side We don't put up the stake until the new shoot is up about three feet high This year, I am going to bend them at that time. When they begin sprouting, we will put in the stake and cut that five inch stub off.

CHAIRMAN FOWLER: How many years do you have to stake this tree before it will support itself?

MR. LONG: If I can put them out on the street with plenty of low branches, I don't need a stake or a support more than two years. If they go out straight. it may take six years, and so we have to go back and restake them. The little extra trouble I can go to in training is worth it.

CHAIRMAN FOWLER: With *Pistacia chinensis,* does a root bound condition in a gallon can indicate a complete loss?

MR. LONG: Well, it's a complete loss as far as the use that we have for it I wouldn't take one of them even as a gift.

Chairman LeValley introduced Mr. Robert Weidner, Buena Park Greenhouses Inc, La Habra, California.

PROPAGATION OF TROPICAL PLANTS FOR THE FOLIAGE PLANT TRADE

ROBERT WEIDNER
Buena Park Greenhouses, Inc.
La Habra, California

There is scarcely a species in this field that is difficult to propagate There is scarcely a field where disease is so great a factor For this reason, we can never separate disease control from propagation.

We have reduced cutting loss to a point so close to zero that it no longer interests us to figure loss Cuttings grown under glass are expensive! We cannot afford to lose them.

In addition, under the sanitary conditions of the U. C. System, we have cut production time almost in half by being able to propagate a large percentage of our material in the pots in which they are sold. For example, Crotons take twenty-eight days to root to satisfy us. If rooted in bed, bare-rooted, then potted, we must allow nearly the same time for establishing. By rooting in the pot, we use merely the twenty-eight days From our point of view ,this is a gift of 60% to 70% more greenhouses.

We have the usual aids — low and high pressure mist, heating cables, fan and pad cooling, etc. We have learned from our use, which aids fit which plants.

We might divide all our propagation into several classes by methods.

- Leaf Cuttings
- Tip Cuttings
- Cane Cuttings
- Leaf & Eye Cuttings

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Leaf Cuttings. — The joys of this world would rapidly increase if all our plants would so respond. We get a heavy production of leaves per plant. The commonest plant so propagated is the African Violet, yet the method does move into our field. Peperomia Emerald Ripple is our most popular number propagated by leaf cuttings An essential part of growing this plant as a stock plant is in its watering. We try to minimize water on the foliage Splashing spreads any disease there might be present, and there is always disease present Leaves are stripped off with almost all the petiole. They are removed to the propagation area. We have devised a small tool to reduce petioles to a required and standard length.

Cuttings are then dipped in our "triple dip," which consists of:

1 cup Parzate
1 ounce Terraclor
2 tablespoons (heaping) Agrimycin 100
Use in three gallons of water.
Keep agitated while using.

Insertion is then made in a peat and Perlite mix.

Tip Cuttings — Tip cuttings are similar to any propagation from tips except for a few points. Above and beyond all else, we cut to leave the most vigorous leaves on the stock plant. We have amply proven to our own satisfaction that complete or even radical stripping of a stock plant is very costly in terms of subsequent production. Depending on how they are to be sold — long distance or close by — we either insert these cuttings into flats or pots. We use flats heavily, contrary to normal greenhouse practice of beds, to gain greater mobility. Cuttings are often developed beyond the need of propagating conditions, but may need more maturing, or delayed to fit a customer's desires. Those we can shunt to another house.

In potting, we are often faced with extremely large cuttings, for example *Philodendron pertusum*. *Philodendron pertusum* is a plant that we propagate from cuttings which might be up to two feet tall. It would be an absurdity to try to root them in beds or flats. Though they would root well, we would sacrifice greatly by having such a large leaf area on a bare-root cutting. Therefore, we pot them. This is also true of Dieffenbachia. To pot them in a pot of soil commensurate with the size of the plant would throw a weight factor prohibiting long distance shipping, especially by air. Therefore, we substitute sphagnum moss. Sphagnum is light weight, water retentive and an ideal rooting medium for these tropical plants. Again harking back to the huge leaf surface of these plants, we must pay minute attention to humidity. Most tropical plants have a minimum of defense mechanisms from drought. Therefore, we use mist systems constantly over these cuttings. We also violate another rule, and do have a medium on the benches in propagation to hold the plants up They are so light weight on the bases that without this, they would fall like ten pins if somebody blew on them.

In tip cuttings of the huge variety of small plants, we again vary our techniques, depending where the plant is to go, and somewhat, but not greatly by the variety of plant. On certain Peperomias and Philodendron, we use nothing but pure peat. Rooting is accomplished as well or better with some Perlite added, but when they are wrapped for shipment, the slightest abrasive substance would cause a scratch on a leaf that would render the plant unsalable. On most of our tip cuttings we use a preventative dip in what we call "the triple dip." There are some plants that we found are inhibited in growth by Terraclor, others blanched by Agrimycin, so we avoid where experiences teaches us. In addition, some extremely large plants cannot be dipped without bruising. In all other cases, we use the dips. It has been our experience that this is 50% superstition, 25% "being chicken," and 25% value. If there is a heavy infestation of Rhizoctonia or Phytophthora, no dip we have yet found will save our necks

Cane Cuttings. — Cane cuttings are another very large source of supply. We often take cane cuttings of plants where we also use tip cuttings, to achieve a small type plant for a different use on the customer level. Emphasis cannot be great enough at the way of keeping the plant clean. On the majority of cane cuttings, we like to strip the leaves, cut them into the eyes and dip them in the "triple dip." They are then inserted horizontally and given a light covering of peat and Perlite The problem in the use of cane cutting is in the maturity of the wood. The cuttings nearest the base are very mature, nearest the tip, very immature. Germination of the eyes varies with this maturity. We are, therefore, faced with a long period of time for the complete potting from a bench devoted to cane cuttings. In the case of *Philodendron pertusum,* we have at least one full year before the last plants are removed from the bed. We, therefore, put these cane cuttings in closer than we would normally like to do, and thin as they reach a certain determined size

The final general classification of vegetated propagation of foliage plants would be one which would probably cover the greatest number of plants propagated, the leaf and eye cutting. The most popular of all foliage plants, the *Philodendron cordatum* and the second most popular, Pothos, are propagated in this way. We let them grow into vines and when they have reached an economical length from 18″ to 24″ they are cut. You will note that we grow stock plants in pots. This is contrary to other peoples' methods, but we have satisfied ourselves again that this is best for us. First, we gain more plants per square foot. Second, we get more light exposure on every leaf. Third, we are able to rogue quickly if a plant reverts, or if any sign of disease problem creeps up. The leaves are then cut ½″ above the eye, 1″ below. The stem below the eye affords a good anchorage when potted later. In most cases, these are inserted at a very close spacing. because we will pot them when the new growth begins.

There are other cases where we grow two to three leaves on the new plants necessitating a 2-½″ by 3″ spacing. From a propagator's point of view, I cannot over emphasize my belief in disease control. The great results we have achieved in our field have proven it to me We have taken plants that are traditionally slow and made them rapid plants. We have been impressed with the loss of vigor in propagation and in future growth that minor disease can cause. We like to use the example of a cold in a human being. Few people die from colds, but few are very efficient when they have them. We have been working under the U.C. System since its inception, and probably are the world's greatest salesmen of it. There are a few different things that we have bumped into, since using the system. Some of you are familiar with them, but I think they are worthy of repetition. One item is the penalty for sterile conditions. If someone goofs and allows disease to enter, it will sweep through much more rapidly than it would in an unsterile condition. This is leading some investigations at U.C L A. into the use of a steam air mix where a better job is done at lower temperature, leaving competing organisms in the soil.

Another puzzle that is bumping into us as we strive to achieve the best possible plant is what makes a good propagating stock plant We are leaving the belief now that the plant grown to our best ability for sale, a good stout, sturdy plant, is necessarily the plant that responds to propagation best. This is contrary to former beliefs When we have left the problem of disease behind us, we have entered into many problems of this kind that we would formerly have blamed on disease

Once upon a time, a highly skilled propagator was a kingpin Partly due to depression conditions, partly due to misguided information from research stations, the propagator's star waned. One would have thought, from bulletins of some years back, that all propagation could be done on a mechanical basis. The more we work with mechanical contrivances, the more we appreciate the fact that propagation, at its best, is the work of a most skilled man in the nursery.

The following questions were asked during the Question Box

CHAIRMAN HERB FOWLER: Are cuttings totally immersed in the "triple dip"?

MR. WEIDNER: Most of the plants are completely immersed On plants that give us a great deal of trouble, we give as long as a 10-minute soak. Ordinarily, it is just a dip.

CHAIRMAN FOWLER: If the "triple dip' doesn't stop major outbreaks of disease, what does?

MR. WEIDNER: I don't know the answer, but it has been our experience that no chemicals stop major outbreaks. We have found that all we can do is to follow the mechanical method that I described of growing the plant up well-above any water lines or splash and taking the cutting above that level.

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SUNDAY MORNING SESSION

October 16, 1960

Mr. Robert Tichnor, Oregon State College, North Willhamette Branch Experiment Station, Aurora, Oregon, moderated the Symposium. Chairman Tichnor introduced Mr. Martin Usrey, Monrovia Nursery Company, Azusa, California, who presented his paper on techniques of propagating under mist at the Monrovia Nursery Company.

MIST SYSTEMS AND HARDENING-OFF PROCEDURES AT MONROVIA NURSERY COMPANY

MARTIN USREY
Monrovia Nursery Company
Azusa, California

Description of the Intermittent Mist System

The intermittent mist system is composed of a series of mist nozzles controlled by a system of solenoid switches, clocks, and intermittent timers. The nozzles used are the Spraying Systems ¼TTN4W nozzle or the Flora-life wire baffle nozzle. The interval of misting varies between 12 and 18 seconds "on," every 6 minutes during hot weather and every 12 minutes during cooler weather. The TORK timer is used, because of its versatility in setting intervals. The timer makes a complete cycle each 6 minutes, however, by connecting all the interval timers to one master timer any multiple of 6 minutes is possible. In this way, the timers can be set to give the minimum amount of water for the corresponding weather conditions. Electric clocks are set to turn the system on in the morning and shut it off in the evening. The moisture present is usually sufficient to carry over the cuttings through the night.

Description of the Fog Mist System

The fog mist is an electronically controlled high-humidity system. The relative humidity, at 85% or higher, is electronically controlled with an American Instruments Company humistat. Moisture is supplied to the atmosphere through Spraying Systems pneumatic atomizing nozzles through a pressure system. The pressure system is different from the siphon system in that water fed to the nozzles is under pressure. Piping in both mist systems, intermittent and fog, is now being placed overhead for ease of maintenance, and as a protective measure to keep water away from the solenoid switches.

Hardening-off Softwood Cuttings from the Intermittent Mist

Softwood cuttings are normally kept for 4 weeks in the intermittent mist. After rooting, the cuttings are moved into another glasshouse with plenty of air circulation. Misting is continued, but at a much reduced rate. During the first few days, cuttings are mist-watered every hour Gradually, the mist is reduced to two times per day.

The length of time for hardening-off depends on the type of cutting, softwood or hardwood, and also on the species. To give you an idea of the length of time for hardening-off, I will explain the experience we have had with a particular item, *Xylosma senticosa* Orginally, *Xylosma senticosa* was hardened-off for a 10-day period in a well-circulated glasshouse It was then taken out under single lath for 2 weeks before potting After potting, it was placed under double lath. The results were very poor.

For *Xylosmas,* we now lengthen the hardening-off period in the glasshouse to 2 weeks, followed by hardening-off for 2 months under double lath outside

During the hardening-off period, cuttings are fertilized once a week with a weak liquid fertilizer. This fertilizer has all of the major elements plus magnesium, sulfur, and iron. Under this system of hardening-off, the cuttings developed a better root system, and results were 75% better.

Hardening-off Harder Wood Cuttings from the Intermittent Mist

The harder wood cuttings are generally placed directly under double lath outside, and mist is sprayed at a frequency similar to that with the softer cuttings. The cuttings are fertilized once a week with a liquid fertilizer. For example, *Mahonia 'compacta'*, which comes under this heading, was originally kept in a glasshouse 8 to 10 days for hardening-off and then placed outside for 2 weeks under single lath. Survival under this system was very poor We get much better results now by placing Mahonias in a glasshouse with open ventilation — day and night for 2 weeks (essentially outdoor conditions) — and then under single lath for 2 to 3 months. Potting at the beginning of the growing season was the best time for this operation. Cuttings are sprayed and fertilized, as are the softer cuttings.

The two cuttings described above as examples are particularly difficult items for hardening-off. Generally, the period for hardening-off outside is shorter for less difficult subjects

Hardening-off Conifer Cuttings from the Fog Mist

Conifer cuttings taken from the fog mist are placed directly outdoors under double lath and handled as are the harder cuttings above.

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Chairman Tichnor introduced Mr William J. Curtis, Wil-Chris Acres, Sherwood, Oregon.

MIST PROPAGATION WITH EMPHASIS ON HARDENING-OFF

William J. Curtis
Wil-Chris Acres, Sherwood Oregon

Mr. Chairman and Fellow Propagators:

I have been asked to talk to you gentlemen on "Mist Propagation, with Emphasis on Hardening-Off" We in the Northwest who propa-

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Mr. Chairman and Fellow Propagators:

I have been asked to talk to you gentlemen on "Mist Propagation, with Emphasis on Hardening-Off" We in the Northwest who propagate with mist, work under climatic conditions of greater variation than you here in California. However, we must meet certain conditions and factors that are common to both of us. First, a good, clean rooting medium must be used that will afford excellent drainage, second, a supply of good, clean water, third, bottom heat; and fourth, an assist from a rooting hormone.

We have, in the Portland area, good, clean, sharp sand. Several propagators are using PERLITE, a manufactured coarse material that affords excellent drainage yet has the ability to hold a great deal of water in its expanded structure. Clean, pure water is no problem; in fact, we sometimes have too much.

The bottom heat we use depends on the crop we are growing. We had several weeks of high, 90-degree weather this past summer. A 3-foot bench, filled with *Clematis armandi* cuttings, without mist, maintained a bottom temperature of 65 degrees, which seemed to be the right temperature for the best results. When the weather cooled off, the heating cable was turned on.

We also have a climate that offers a great variation in light intensity. Normally, a few warm days are followed by cloudy, dark days. If you use a time clock for your misting intervals and do not change it, you might apply too much water during such dark days.

An intermittent type of mist system, like "Mist-O-Matic," does a satisfactory job for me. Many time clock controlled mist systems are used in the Pacific Northwest, and all seem to be giving good results. At this early stage in mist propagation, perhaps no one can justly say which system is best for applying mist to a bench of cuttings. In July, we start with our deciduous ornamentals. The first are *Magnolia stellata* and *M. soulangana*. We use a standard flat of coarse, sharp sand, firmly tamped. In four to six weeks, they are ready to pot. We then take them from the mist, and hand-water them for a week to ten days, depending on how busy we are at the time. If the weather is hot, we cover them with newspapers for a few days from 10:00 a.m. to 5:00 p.m. A semi-hard wood cutting is used, we snap or cut out the soft tip. The cuttings of *M. stellata* run 100 to a flat, while we only get around 70 of *M. soulangana* to the flat. A 78 to 85 degree bottom temperature seems to be the best. The re-strikes are set back in flats, though not under mist. These are not potted until spring, for deciduous cuttings must have time to grow a little and develop a good root system before going dormant. When the re-strikes show signs of growth the following spring, we pot them. They will catch up to those potted the summer before, and may even outgrow them. We do not delay all potting until spring, because most of the magnolias are sold as fall liners out of 2½" rose pots.

Philadelphus virginalis, *Philadelphus* 'Mulkeyi,' and *Viburnum plicatum* are handled similarly to the magnolias.

Camellia cuttings are taken early in August. A ¾ inch cutting is used for most varieties; the Kumasaki roots well and grows excellently with a single-leaf two-node cuttings. If short of cutting wood, a single-leaf cutting will bring good results. By the time they are rooted, the weather has cooled off and we have been hand-watering for several weeks We do let the sand dry out a little, for one loses fewer if the rooting medium is a little on the dry side.

Rhododendron cuttings are placed in 2½″ spruce veneer bands in a mixture of 45% coarse, sharp sand and 55% coarse peat. This mixture is dampened enough to enable one to fill the bands on the potting bench before setting them in the greenhouse under mist. If a Rhododendron has small leaves, a 2″ band can be used. A heavy wound 1″ long is made on one side of 3-inch-long cuttings. The cuttings are dipped in Hormodin #3. The excess is tapped off against the side of the can A very good percentage is the rule. Mid-August can be hot and dry in Oregon, so Rhododendron cuttings must be under mist. However, one can put many varieties in the bench in October or November and get good results without mist Once again, we have cuttings rooted in the early winter when the mist has been shut off for several weeks If you have some varieties that root easily and are ready when the days are still sunny and warm, you can take them from under the mist and harden them off by hand-watering and covering with newspapers during the part of the day when the sun is most intense.

We have found *Viburnum burkwoodii* roots better in the open bench with hand-watering rather than under mist.

Daphne odora cuttings taken in August and placed under mist root well and are ready to pot prior to Thanksgiving. We use a 3″ cutting placed in sharp sand with no rooting hormone. Hardening-off is no problem, for we have had the mist shut off for several weeks. Pyracantha cuttings are taken when the side branches of the gallon-can plants have grown six or eight inches long. This gives a 4-6 inch cutting, with some longer We use sharp, coarse sand in flats. In 4-6 weeks, they are ready to pot. We take the flats from under the mist and hand-water, allowing the flat to dry out some, to make digging easier. If we have hot days, which we sometimes do in early October, we cover these with newspapers until they stop flagging.

I have found that Hormodin #3 gives the best results on all cuttings placed under mist. The only exception is *Daphne odora,* which roots excellently without a rooting assistant.

We use St. Julian plum for understock for semi-dwarf peaches, plums, and prunes. Our source of supply of understock notified us in July that they had had a 95% crop failure I immediately put 1,000 under mist and another 1,000 in the open bench, treating all with Hormodin #3. Results· complete failure. Thinking that perhaps the sand was not coarse enough, I used a great deal coarser sand, using Hormodin #3 — Hormodin #2 and several flats without a Hormodin powder. They, too, were a total loss What did we do wrong? Why a total loss? I will try another batch of cuttings when they go dormant.

In summarizing, there are several factors we must consider:

First A clean, sharp rooting medium that affords excellent drainage is a MUST.

Second A supply of pure water.

Third Stiff bottom heat is most important.

Fourth The use of Hormodin powder provides more roots faster than if you do not use it.

Fifth I have not said much about hardening-off, for it is not a great problem with us. By the time the majority of our cuttings are ready to pot, the weather has cooled off and we have shut off the mist and have been hand-watering.

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Chairman Tichnor introduced Mr James S. Wells, James S Wells Nursery, Inc, Red Bank, New Jersey

MIST PROPAGATION — HARDENING-OFF TECHNIQUES

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

Mist propagation has become such an integral part of almost any propagating nursery that it is interesting to recall that the first recorded instance of its use in plant propagation was in 1936, at Trinidad, British West Indies. By 1940, it was being tested in this country, and an excellent article in the *American Nurseryman,* May 1, 1941, by a nurseryman, Edward Gardner in Wisconsin, gave a long list of plants successfully propagated under mist. Then the war intervened, and most people lost sight of the method, although it was still in use at many of the state experiment stations. It was not until 1946-7 that practical work began once more. Mist, then, is a horticultural development of the first magnitude that has come into general use within the last 10 years.

As an essential preliminary to our discussion, we should first consider briefly some of the wider aspects of the misting techniques. I like to think of misting as being a better method of controlling water loss from cuttings, grafts, or transplanted seedlings. Most of the techniques the skilled plant propagator has used since his work began, have been directly toward the control of water loss from the plant materials with which he is working. A piece of a plant is arbitrarily removed from its natural water supply when it is taken as a cutting, and it is, therefore, in a precarious position It has no well-defined source of water, yet it has an undiminished ability to lose water through its leaves. Such a piece of plant material has to have quite careful attention day by day, even hour by hour, if it is not to die. It requires a special place — a greenhouse — plus the attention of the skilled propagator, and all these efforts are directed to the control of water loss. The syringing of greenhouse walls, the use of double glass or a polyethylene tent, the waxing of a graft union, or the use of mist are all part and parcel of the same thing, control of water loss. In this respect, misting has three distinct aspects. First is maintenance of an extremely high level of relative humidity inside the greenhouse. That is where fogging comes in. The standard humidifier is in this category, and for many cuttings this use of water is entirely adequate. Maintenance of humidity at 95 to 98% is sufficient to prevent undue water loss, particularly on cuttings that do

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Let us now consider each of these three aspects of the use of mist, and discuss in a practical way how best to bring the propagated material back to normal conditions.

Where cuttings have been rooted under a relatively high humidity, but with little or no excess water, the problems are not so great, because the cuttings have been subjected to a fairly wide variation in air temperature and general conditions while rooting, which enables them to go without undue loss through a transition period from semi-controlled to uncontrolled conditions. The easiest way to achieve this successfully is, first, to increase slowly the air circulation in the propagating area by opening vents late in the evening and allowing them to remain open all night, closing them at a slightly later hour each morning. Otherwise, retain your normal system of humidification and modest venting, if temperatures are too high, during the hottest part of the day. A slow extension of this ventilating over a two-week period should suffice.

We now come to cuttings rooted in the greenhouse under intermittent mist. First, we must consider a group of plants that fall naturally somewhere between the first and second groups. These plants will respond to intermittent misting and maintenance of a film of water on the leaves up to, but not beyond the point at which the cuttings commence to root. At that point, excess water becomes harmful and the plants will deteriorate rapidly, if water application is not drastically reduced. Azaleas, when rooted in a greenhouse, are in this category, and so are Pyracanthas and some of the Prunus. Some conifers also are in this group, but in general, conifers prefer a somewhat drier condition than that provided by intermittent mist. The ideal method of hardening-off such cuttings is to maintain misting until rooting commences, and then switch to a condition of controlled humidity, which in turn is slowly changed by shading and increased roof ventilation as the root system of the cuttings develop until the plants reach near normality

A cutting that is rooted in the open, under high light intensity and protected from desiccation by mist is one of the more difficult groups to harden up, because these are subjected to extremes of light and heat, which in turn require somewhat extreme measures of control It naturally follows that any slight deviation from the set pattern can produce a rapid change, and it is rapid change in any form that can be so disastrous to plant materials. Yet this method is an excellent one to use for certain plants, because it enables the cuttings to take full advantage of the high light intensity, and therefore to continue photosynthesis. In this way, cuttings that are poorly provided with chlorophyll, such as *Biota aurea nana,* can be rooted If such cuttings are put in a greenhouse under mist, or humidification, they will not root, or will root very indifferently But, put the same cuttings right out of doors in the full sun and protect them with a good intermittent mist system, and they root very well, indeed. This, I believe, is entirely due to the much greater light intensity, which enables the cuttings to manufacture excess food reserves for use in producing a root system.

This question of light intensity in the rooting of cuttings of all kinds and under all situations, is of great importance, and I would like to digress a little from the theme of hardening-up cuttings under mist to tell you something that happened to me last winter, in the rooting of Rhododendrons that I attribute directly to lack of light. Last year, our sash-type propagating house was used for summer cuttings and was shaded with 50% Saran shade cloth. When the summer crops were finished, the house was cleaned, sterilized, and prepared for Rhododendrons. I am sorry to admit that we just forgot the shade cloth tacked to the outside of the greenhouse Early in September, we began to insert the Rhododendron cuttings. They looked very well at the beginning, and, in fact, after about 8 weeks some began to root This was about the first of November Then, however, the cuttings began to deteriorate rapidly. First, the base of the cuttings began to rot, and then some of the leaves dropped off Sometimes a cutting would root again above the rotted base, and this in turn would rot. Finally, of course, the cutting died. We had these tested for fungus diseases, but all that were found could definitely be stated to be secondary: no primary fungus diseases were present.

The situation became quite serious, and, for want of a better answer, I attributed the problem to some unknown condition of the wood. About that time, I attended the Plant Propagators meeting in Philadelphia, where I heard a discussion given by Dr. Stuart H. Nelson from Ottawa, Canada, in which he described some experiments that were conducted on rooting a wide range of plants in a propagation house under mist. These tests covered deciduous shrubs, conifers and broad-leaved evergreens In the first year's tests, cuttings of all kinds rooted with an average of just over 90% under mist, with each treated with the appropriate hormone. The tests were repeated a second year, but with a drastic drop in over-all rooting (to just over 20%). This violent drop could not be explained by any obvious change in method, for plants, greenhouse, bench, medium, hormone treatment — even the man doing the job — were the same. The only difference was that a permanent lath shade had been constructed over the top of the house a few months before the second set It seemed that this had to be the cause of the trouble. It was torn down, and the experiment was repeated for a third time The results immediately returned to the original high (90%) level.

I returned from the meeting determined to see just how much light I had in my greenhouse, but I was fortunate to have Dr. Nelson and Dr. William Snyder from Rutgers come for a visit I showed them my dying cuttings, and they confirmed my opinion that the light was insufficient Dr. Snyder said that a minimum of 450 foot-candles of light is required to maintain a leafy cutting in good condition, if the bench temperature is 70° F. I called the local light company, who came with a good light meter to test the light, and I was astonished and mortified to find that at mid-day on a reasonably bright winter day, the light intensity was only a little more than 200 foot-candles We immediately stripped off the shade cloth, washed the glass with lye, and cleaned everything up as much as possible, and it seemed to me that the cuttings looked brighter, almost overnight. More light was getting in, so they should, but they looked brighter in themselves. Be that as it may, the situation did change, for the leaves stopped dropping off, and the cuttings began to root. Later batches, put into the house at this time, rooted very well, indeed. Since then, I have had confirmation of the problem and the remedy from two or three sources. I believe we should use, at all times, the maximum amount of light that can be applied without damaging the cuttings.

To return now to our mist system, the quantity of light that can be used is much greater when we are applying mist than when we are not Light usually means heat, and therefore, increased water loss, but where we have the cooling of a mist system, light (and therefore energy) can be applied in much greater quantities without incurring the liability of rapid water loss and ultimate desiccation. Under such conditions, many cuttings can be rooted quickly and successfully. We find that we can take extremely soft cuttings of many plants and maintain them in excellent condition under a mist which, would be quite impossible in any other way Such "butter soft" cuttings can be kept turgid only by the use of mist, and such cuttings usually root with amazing speed

But when we use such soft cuttings, keep them in the open, and maintain their condition by misting. It is obvious that the greatest possible care is needed when we change these conditions in any way to slowly bring the newly rooted plants back to normality. From what I have said, it should be clear that there is an important interplay between misting and light intensity, and, conversely, the lack of light — shade. One can be substituted for the other to a fairly wide degree, especially once the cuttings have begun to root, and I believe that shade is of vital importance in hardening cuttings rooted in this way.

The first procedure should be to reduce the cycle of misting and replace the mist with a fairly heavy shade. What do I mean by a fairly heavy shade? I would say, under extreme conditions, at least 75%

shade, produced perhaps by placing two 50% lath shades, one above the other, with some gap between, or by using a 75% Saran shade cloth. Misting could, then, be reduced by about half, either by increasing the interval between misting or reducing the duration of the misting period. But even then, the cuttings should be watched carefully, particularly after making the first change, to see that it is having the desired effect. It might well be that the interval should not be reduced so drastically for the first two or three days, but, once the cuttings have begun to harden up, the interval between mistings can be slowly increased and shade equally, slowly reduced until the cuttings have come to a nearly normal state. This transition period requires that the skill and detailed attention of the propagator be exercised to the full. Let me emphasize that modern techniques and equipment do not in any way eliminate *the need for careful day-by-day attention by the plant propagator.* We may have fine, mist lines, percentage timers, electronic leaves, hormone powders and whatnot, but they still require the skill of the practiced plantsman to operate them successfully.

Some very successful propagators are rooting cuttings in flats in a mist area and then removing the flats, once the cuttings are rooted, to a semi-controlled area, such as a lath house, in which there may be a few jets, where a relatively high humidity can be maintained and the cuttings moved in bulk from one place to the other to be hardened-off This excellent arrangement works well where the equipment is set up in a proper manner Which brings us to the question of controls. I have used a number of forms of the electronic leaf. There is no question that in theory this is the best means of controlling a mist system, but in practice, I have found it to be somewhat temperamental and unpredictable. For this reason, I still hesitate to place a valuable batch of cuttings under its control I have an electrician friend, who is developing a new version, transistor-powered, with a variable sensitivity control. It has promise, but is still not entirely satisfactory. I, therefore, rely on the Watco timer, which has a 24-hour clock for turning the mist on and off, and a six-minute clock for the misting cycle By adjustment, this will give any number of 10-second squirts that I may think necessary.

To summarize, I believe that the best method of hardening-off all types of cuttings that have been rooted under some method of controlled water supply is to substitute heavy shade for some part of the mist period, and then to adjust both shade and mist until mist is eliminated and shade is the only protection given the batch of cuttings Then, in turn, the shade can be reduced until the cuttings are well-hardened up and have returned to completely normal conditions.

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CHAIRMAN HERB FOWLER: How do you get deciduous Azaleas to break dormancy after being rooted?

MR. WELLS: The rooting of deciduous Azaleas is now fairly well established. Cuttings have to be taken when very soft, early in the spring, in late April and early May There is a rapid decrease in the ability to root from mid-May to mid-June. I am quoting dates from my locality The cuttings will take quite a strong treatment with a hormone powder, up to 2% IBA. They will take from 2 to 2½ months to root, during which time they have to be kept under intermittent mist. The problem is to get them to grow. There are two ways to do this. One is to give supplementary light Once the cuttings have been rooted, give them longer daylengths with supplementary light The other way is to store them at about 35 degrees, but not allowing them to freeze. There is enough cold accumulating through the winter so that the natural dormancy of the plant is broken by spring.

CHAIRMAN TICHNOR. What is the diameter of the copper tubing in your mist system?

MR WELLS: The tubing is half inch, o.d., and a half-inch solenoid. I am only using 8 jets at 60 to 80 pounds pressure. I would dearly love to have all mist systems operate at 600 to 800 pounds. I think that would be by far the best.

CHAIRMAN TICHNOR: What are Florida jets?

MR WELLS: It has a threaded base and various collars and units that fit together Water comes out of an orifice, hits a stainless steel baffle and gives a flat spray in all directions The spray is horizontal, and that, to me is it's greatest value.

Mr Westgate sells Monajets and I have used them. If you have low water pressure, 25 pounds, the Monajet is the best in my opinion, because it is designed to operate well at that pressure. But when the pressure gets much above 25 pounds, then the angle of the mist rises and coverage is not as good. The Monajet is an excellent jet. But if your water pressure is above 25 or 30 pounds, than I think the Florida jets will do a better job.

CHAIRMAN TICHNOR. Can water at 250 pounds pressure be used for a mist?

MR. WELLS. Oh, yes, I think that is perfectly splendid. You should use a stainless steel orifice at that pressure, otherwise you will get worn-out nozzles if you use a brass orifice. At much above a hundred pounds pressure, the nozzles do not last long, so I am told.

MR PHIL BARKER: Would you compare the T-jet nozzle with the Monarch nozzle?

MR. WELLS: Well, I have seen and just tested very briefly the T-jets, so I can't really compare them accurately Some people are using them. I am partial to Monarch, because I began with Monarch. I think they are very good.

MR. CURTIS: Well, I use a Monarch jet and I have a galvinized line right down the middle of the bench. I have just about come to the conclusion that if you have a 4-foot bench, you should use a jet giving a 5-foot diameter mist. You get a little bit better coverage on the edges of your bench My water pressure varies. In the winter time, I maintain about a 35 or 40 pound pressure. In the summer, I have 60 pounds pressure, but the Monarch works all right with either pressure.

MR. WELLS: Now, I would like to say this. We have been ranging over misting and if any of you have the chance, you should go to see Harvey Templeton's setup in Winchester, Tennessee. He has brought together and is applying, in the most practical manner, all these various facets of propagation under mist, that we are talking about.

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