MR. PETER VERMEULEN: Have you made any comparative studies on the cost as compared with the semi-permanent type of plastic, like Mylar? We have repetitious costs in applying polyethylene every year.

DR. LEISER: No, I haven't at all. One reason I guess is that I have known half a dozen different people who have been very unhappy with Mylar. They have known it to split in two or three years. Apparently this has been a bad application. These problems have seemed to rule it out, and I haven't particularly considered it for this reason.

PRESIDENT VAN HOF: Two more.

DR. FRED J. NISBET (Asheville, N. C.): I have invested in Mylar. I had looked over Mylar houses from Mentor to Mobile and I have found too many that failed. The main cause of failure was using poor lumber, so that we stress when putting on Mylar to get it drum tight.

MR. ARIE JAN RADDER: (Conn.): We built a plastic house this fall and we inquired about a heater. We got a propane gas heater. It throws out 138,000 BTU for $175. This is a check type heater. It is ignited by a spark plug, electrically ignited. It has a fan behind it and by pulling a switch you can use the fan for cooling. I felt I should mention it since yours throws 75,000 BTU.

DR. LEISER: This is a unit heater?

MR. RADDER: It is portable. We place it in the center of the house.

DR. LEISER: Like used for corn drying.

MR. RADDER: I don't know what they use it for. We also put air conditioning pipes on it and heat wherever we want. The only thing, there might be some dead spots and I might have to put fans in it.

DR. LEISER: I inquired somewhat of this and the man selling them was afraid it wouldn't be too suitable for propagation houses because of the high heat, spot heat effect. He felt it would be too hot in some areas. If you have good luck with it, this is good news.

PRESIDENT VAN HOF: Thank you, Dr. Leiser.

Next in order is "Dwarfing of Ornamental Plants by Grafting." We tried to get it last year but something else came up. We have a capable man doing this, John P. Mahlstede. Dr. Mahlstede is from Iowa State University.

DWARFING OF ORNAMENTAL PLANTS BY GRAFTING

John P. Mahlstede
Iowa State University

Several months ago, without giving it much thought I accepted Dr. Synders' invitation to discuss the topic of the Dwarfing of Ornamental Plants By Grafting. When the time came to survey the literature associated with this subject, I found that he had restricted me to ornamentals. This means that we can come as close as the ornamental crabs, but not fruits, an area in which most of the dwarfing work has been reported. The title also restricted dwarfing to that resulting from grafting, which in turn eliminates a discussion of Bonsi, and the techniques associated with this ancient culture. To further complicate the preparation of this paper, I find that Dr. Karl Saxs' scholarly talk to this Society in 1957 summarizes the literature connected with this subject most admirably.

I would propose that we discuss the topic of Dwarfing In Ornamental Plants under the general headings of:

1. History of Dwarfs
2. The advantages and disadvantages of dwarf ornamentals
3. Sources for dwarfing components
4. Methods of producing dwarfs by grafting
5. Theoretical causes for dwarfing, and
6. The future outlook for dwarf ornamentals.

HISTORY OF DWARFS

Early history associated with dwarf plant materials is essentially The History of Dwarf Fruit Culture. The existence of plant parts used as the rootstock or scion was known to the greeks over 2000 years ago. When the emphasis shifted from that of food production on the continent, the ornamental phases of Horticulture began to take form. The use of special or selected rootstocks to dwarf a few of the more choice ornamentals, popular in the renaissance period has been reported. Such plant materials were adapted to methods of training for both utilitarian and aesthetic purposes. Of course, in the gardens of Early Europe records tell us of plants selected specifically because of their dwarf or low growing habit. Jardinieres and urns represent a type of culture which actually represent the forerunner of modern container culture. It was in this connection that many of these dwarf plant materials were utilized.

There has been this continual shifting of emphasis between food and ornamental crops, as influenced by the economy of the nations of the world. This shift of emphasis has been directly related to the wars, periods of recession, and the so called periods of good times.

As the utilization and availability of the principle crop land became a problem in Europe, China and Japan, as well as in other countries, the need for more varieties and species that could be grown in a limited area, the need for dwarf ornamental and fruit plants has increased.

The use of interstems for the purpose of dwarfing is a technique of relatively recent origin, dating back only some 300 years or so. It is virtually an untried and untested entity in the production of dwarf ornamental trees, shrubs and vines. One reason for this is the lack of information, which can be attributed to the fact that only recently has there been a need for this type of plant material. Coupled with the increased cost of production, and comparatively high price that a nurseryman must receive for this product, as well as the customer, who is not yet willing to pay this premium, dwarf ornamentals have not received the attention they deserve. Still another factor that has complicated the selection and introduction of dwarf plant materials is that of interest. It has been only recently with the popularity of the 80' X 100' lot that a real need has existed. It did not much matter if a three story house on a one or two acre plot was planted to the 8-10' Bridalwreath, or 10' Privet, or the 120' Silver Maple. With our single story ranch, these plants soon look out of place if a regular maintenance program is not practiced; and practiced it is not by most people.

Because there has not been this need, only the stirringly different, the odd, the unusual dwarf has been picked up by the nursery industry. The large seedling growers have looked for the most vigorous, the best adapted stock, and used these to vegatatively propagate clones. The dwarfs, or so-called runts have either been rouged out or discarded. I would guess that many select, dwarf forms have been discarded long before introduction, because of their slowness to makeup, and the reluctance of nurserymen to risk an investment in an item which had a questionable market.

ADVANTAGES and DISADVANTAGES of DWARFS

There are a number of advantages and disadvantages associated with the use of dwarf plant materials. The lower maintenance costs of dwarf, usually slower growing plants, heads the list of dwarf attributes. Reduction in the frequency of pruning and the ease of spraying, and ultimate removal of the plant are included on the positive side of the ledger. Utility companies spend some $125 million dollars a year on line clearance. City and State governments also spend sizable sums each year on building, sidewalk, street and sewer repair brought about by the activity of wind and ice storm effects on trees, and the action of tree roots.

The advantage of dwarfs to contemporary architecture, inclusive of public building sites, industrial locations, recreational areas and homes has already been mentioned. The production of small pop plants, for mass market sales, the production of more compact plants, with shorter internodes, earlier maturity, the delay in pot binding, the control or elimination of tall, straggly plants, are also attributes of dwarf plant materials.

Disadvantages include the higher cost of production, brought about by the longer period of time required to obtain a salable plant, the greater number of plants required for planting, especially if immediate effect is desired, are also disadvantages for the nurseryman and customer alike. Since dwarfing may involve grafting, the factor of incompatibility and resultant problems of poor anchorage, brittle graft unions, and overgrowth are problems which suggest the need for more research. Hardiness, disease and insect problems may be aggravated by dwarf plant materials, resulting from the more compact, dense growth produced. Suckering, delay of flowering may also be aggravated by incompatibility problems. The limited number of plant materials of desirable color, foliage type, texture, and stature are also problems associated with our dwarf inventory.

SOURCES OF DWARFING COMPONENTS

At the present time there are some fifty or more of the most important genera of trees and shrubs that have known dwarf forms. Of these genera, 16 are broadleaved evergreens, 6 are narrow leaved evergreens, and the remainder gerera of deciduous trees and shrubs. The possible sources for future dwarf components, that is scion varieties, interstems, and rootstocks, include: (1) Specialized breeding programs in some of our most important genera, (2) Natural selection and the propagation of these selections by nurserymen, (3) Sports or mutations of now vigorous species, (4) Induction of chimeras incorporating a now vigorous variety and one of its closely related dwarf forms, and (5) Introduction or selection of virus carrying components which impart stunting, or slow growth, but which do not impair the aesthetic qualities of the plant when used as an ornamental.

The success of the entire venture of selection and introduction of new dwarf forms lies with our botanical gardens, arboreta, the ornamental breeding programs at our land grant institutions, and with the nursery industry. Those plants produced as dwarfs through grafting will require still another step in the development program, ie., research and testing on compatibility of various dwarfing combinations. This can only be solved through time.

METHODS OF PRODUCING DWARFS BY GRAFTING

The techniques of grafting, or joining two components of a graft combination together are well known to members of this Society. The type of graft, that is the veneer, side, whip and tongue, speed or splice grafts, to mention a few, will have little influence on the success of a scion if it has been properly handled, is mechanically sound, and the components are compatible.

The methods of producing or arranging components of a graft combination in such a way as to result in the production of a dwarf plant fall into seven groups. These include:

1. Use of dwarfing rootstocks grafted to an otherwise vigorous scion variety.
2. Dwarfing scions grafted on otherwise vigorous rootstocks.
3. Dwarfing interstems inserted between two vigorous components.
4. Dwarfing resulting from an interaction between otherwise vigorous components. This would occur after union.
5. Girling or interruption of food transfer to the rootstock.
6. Bark, ring, spiral, inverted bark, and phloem blocks.
7. Two other techniques, which deserve further attention as possible methods of producing dwarf ornamentals have been described

by Garner and Nicolin. Nicolins' method of double shield budding as adapted by Dr. D. B. White who described it at this meeting two years ago, bears further investigation by researchers interested in compatibility bridges and dwarfing interstems. The length of interstem, overgrowth, and other possible effects from this thin shield should be studied.

THEORETICAL CAUSES FOR DWARFING

From observation we know that there are degrees of dwarfing, brought about by the use of specific rootstocks, interstems and/or scions as well as the union of certain of these elements in a prescribed manner. With some dwarfing rootstocks or combinations of rootstocks and specific scion varieties, there result plants which are too dwarf to be of any use commercially. The question in point now, is why do certain plant materials, when used alone, or in combination with other, closely related plants, cause dwarfing? The theoretical causes may be separated on the basis of plant physiology, plant morphology, and plant pathology.

Thomas Andrew Knight, the first president of the Royal Horticulture Society of London, postulated in the year 1822 that dwarfing and early flowering (and fruiting) were the result of the checking of flow of nutrient supply to the roots in combinations utilizing a dwarfing interstem piece.

This check in the flow of nutrients results in the accumulation of food in the tops, which subsequently stimulates flowering, fruiting and hastens maturity and differentiation. The interstem, if defined literally, is a living, well controlled phloem block or girdle.

In reviewing the literature on stock-scion influences, Tukey and Brase have concluded that when considering vigorous wood, no one part dominates the growth of the entire plant, since all have, at one time or another, a marked influence on the growth pattern of the combination. Where dwarfing wood is used, the dwarfing character predominates, regardless of its position in the combination.

The cyclic suberization of the roots of dwarf trees, as well as a differential water relationship of the particular dwarfing rootstock or interstem has been suggested as a possible cause or effect of dwarfing (Colby, Pao & Berry). Beakbane and his co-workers discovered that dwarfing stocks generally have smaller cross-sectional areas of vessels, smaller volume of Xylem fibers, and greater volume of Xylem Parenchyma and Meduallary Rays. They suggest that the smaller vessel area of dwarfing stocks may reduce water uptake, and that the increase in the volume of living cells, such as Parenchyma and Ray tissue may serve as a carbohydrate reservoir. Both of these factors may lend to the throwing of the balance to differentiation, early flowering, and fruiting.

Always associated with grafting and a discussion of dwarfing are the attendant problems and complexities of incompatibility. We know, for example, that incompatible unions are characterized by:

1. Limited and contorted elements of the union
2. Structural weaknesses
3. Inward curving of the layers of cells or crevices in the bark and xylem.
4. Others rosetting bud death.

Toxic secretions have been held responsible for certain stock, scion, and stock, interstem scion combinations reactions.

Viruses too have been credited with causing degrees of incompatability in plants. The action of growth substances has also been credited for causing dwarfing. It is also known that dwarfing interstems result in a tree that has wider branch angles, in other words results in the production of a spreading tree. These trees may produce as much total growth as standard trees, but the distribution of this growth over the periphery of the plant is different. This characteristic of branching can be shown to be a growth response derived from auxin relationships in plants. In fact, more recently, experiments with certain types of dwarf corn, have demonstrated that dwarfing is caused by auxin destruction during translocation from the point of manufacture in the foliage downstem. Short internodes result from the lack of auxin.

Scholz has explained dwarfing, induced in interstem trees on the basis of reduced water conduction caused by the reduced xylem area in dwarfs and reduced nitrogen translocation through the phloem. This results in reduced shoot growth. Such slowing or cessation of shoot growth, concludes Scholz results in a carbohydrate build up and attendant induction of flowering. It is further suggested that antiauxins may be related to dwarfing as they are linked to carbohydrate accumulation and floral induction.

FUTURE OUTLOOK FOR DWARF ORNAMENTALS

The great majority of the research work on dwarfing, has been done on fruit. This work, principally concerned with the apple, has been brought about by the availability of stocks of known performance. Research on dwarf pears and the quince A, B, and C series is another example of the recent emphasis and interest in this trend to finding out more about the phenomenon of dwarfing and the commercial use of dwarf plant materials. Think now, about the inventory of ornamentals that are available for study. Not only do we have to find dwarfing components for many of our more important plant genera, but we have to find specific rootstock-scion, and rootstock-interstem-scion combinations for specified soil types, climatic ranges, and growth characteristics. These in the ornamental phase of Horticulture have much to look forward to in the future; helping to develop a dwarf inventory of ornamentals.

PRESIDENT VAN HOF: We will go right into the talk by Dr. Henry M. Cathey, Department of Horticulture, Plant Introduction Station, Beltsville, Maryland.

DR. HENRY M. CATHEY: I would like to tell you a different experience in dwarfing. This consists of not using switch blades, which was apparently what we were seeing, but to use your talents in mixing. This is the other side of growth control. This is maintaining your plants and using chemicals to dwarf the plant.

CHEMICAL DWARFING OF NURSERY PLANTS

Henry M. Cathey
Horticulturist
Crops Research Division, Agricultural Research Service
U. S. Dept. of Agriculture
Beltsville, Maryland

Recently developed growth-retarding chemicals provide means for restricting the growth of many plants. They are useful in production and maintenance of plants of smaller size than those typical of the species or the cultivar. They also make it possible to use some species not now suitable for pot use and allow all plants to be fertilized and watered as frequently as necessary.

The leaves of all plants treated with growth-retarding chemicals are much darker green than those of untreated plants. This color is related more to the action of the growth regulator than to mineral nutrition.

Three chemicals have been extensively tested on many kinds of plants (2). These are Amo-1618 (4-hydroxy-5-isopropyl-2-methylphenyl trimethyl ammonium chloride, 1-piperidine carboxylate), phosfon (tributyl,2,4-dichlorobenzyl phosphonium chloride), and CCC (2-chloroethyltrimethyl ammonium chloride). The growth of most plants may be controlled by the proper selection of one of these chemicals. None of the three is active on all plants. Few plants respond to applications of Amo-1618; details are available elsewhere (2). The dosages for phosfon were 0.16 to 4 gm of the technical material and for CCC, 4 to 20 gm/cu ft. of potting soil.

The list* which follows shows the growth-retarding activity of two chemicals on potentially useful plants.

Common and Latin Name	Response to Applications of Phosfon	CCC
Apple, *Malus sylvestris* Mill.	Inactive	Active
Azalea, *Rhododendron* sp.	Active	"
Camellia, *Camellia japonica* L.	Active	"
Chrysanthemum, *Chrysanthemum morifolium* ramat.	Active	"
Dogwood, *Cornus florida* L.	Active	"
Elm, American, *Ulmus americana* L.	Inactive	"
Euonymus japonicus L.	Active	"
Fatshedera lizei (Cocket) Guillaum	Stimulates	"
Holly, *Ilex crenata* Thunb. (Rotundifolia)	Active	"