MODERATOR STOUTEMYER: Thank you, Charley, for a most interesting talk. Our final presentation in this session will be given by Dr. Harry Kohl, Jr., who will speak to us on the control of plant height; Dr. Kohl.

CONTROL OF PLANT HEIGHT

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It should be understood from the outset that this paper is not a review paper in the sense that it attempts to bring together the literature pertaining to plant height control. Instead it is hoped that what is presented here will be a discussion which will stimulate new practical methods of control based on noting and understanding older methods and exploitation of little-recognized possibilities such as photoperiod control.

Genetic Control

Although the majority of this discussion will be concerned with physiological control methods, it should be understood that genetic control of plant height is not only practical but in many instances is the preferred way to solve a problem in height control. Examples are numerous. Zinnias come in a wide variety of height classes from petites to giant, as do other garden flowers such as marigolds, asters, and stocks. The desire here for plants differing in height from the normal, usually towards shorter forms, has been met by judicious breeding and selection. Shorter forms of food crops such as bush beans, non-lodging wheat, and corn more suitable for machine harvesting, likewise have been attained through breeding programs rather than by treatment of existing varieties.

Likewise many dwarf and pyramidal forms of woody ornamentals are obtained by selection of progeny genetically different from the parent. However, in this instance the genetic difference is only that of a single gene and the new form is found as a bud sport or mutation rather than as a seedling from a breeding program.

A particularly interesting mutation is that of a bush rose to a climbing type. The mutation occurs frequently enough so that rose breeders need not concern themselves with breeding climbing roses. They can depend upon bush rose mutations to supply the demand.

The above should not be interpreted to mean that dwarf, woody plants can not be obtained as seedlings. To the contrary, beds of forest tree seedlings frequently contain dwarf forms and the progeny from almost any azalea cross where a forcing-type azalea is a parent will result in a rather high frequency of dwarfs.

Chemical Control

Next let us turn our attention to chemicals used to control height, restricting our discussion to those chemicals which need only be used in small amounts and which might therefore be considered to have hormonal action. These height-promoting and reducing chemicals are relatively new, having been recognized and studied within only the last few years.

The first of these chemicals was gibberellic acid and its many close relatives, collectively called the gibberellins. This group of chemicals among other things, such as influencing flowering, dormancy, and growth rate, tends to elongate plants. Since elongation of the stem alone is usually not horticulturally attractive, the gibberellins have not found a practical application for this purpose.

On the heels of the general announcement of the finding of the gibberellins, the first of the growth retardants, Amo 1618, was discovered at the U.S.D.A. in Beltsville by Mitchel and Marth. This is a dwarfing compound and is one of a rapidly enlarging number of compounds that have been found to have similar effects. Two of these compounds, phosphon and cyclocel, are commercially available, as is Amo 1618.

In general these compounds are remarkable in that they dwarf the plant by shortening the internodes without affecting the leaf or flower size. Plants usually have a darker green color and tend to grow at a slightly slower rate than do untreated plants. These compounds also show remarkable specificity. All growth retardants do not work well on all plants. Amo 1618, for instance, which dwarfs chrysanthemums, is not effective on poinsettias. Phosphon has been found to be effective on both chrysanthemums and poinsettias as well as other species, both woody and herbaceous. Cyclocel also affects a rather broad spectrum of plant species. It is not possible, however, to predict that any of the growth retardants will be effective on an untried species.

Several other points are interesting. One is that the rate of effective application on the same species may change with the season. Such a situation has been reported by Stuart on azaleas. The other point of interest is that carry-over effects have been noted in the seedlings from seed of a treated crop. This might lead to an interesting application by seed producers as, for that matter, might an inclusion of dwarfing compound with the seeds in a packet. So far as I know this has not been tried.

Almost every conceivable way of applying growth retardants has been tried, including dipping rooted and unrooted cuttings, dipping pots, inclusion in the soil mix, spraying on the plant tops and drenching the soil, after the plant is established. Of these methods, the soil drench after the plant is established is perhaps the most useful. At least this is the procedure for the use of phosphon on chrysanthemum which is the only established commercial program of chemical dwarfing with which this author is acquainted.

Notably missing here is a discussion of maleic hydrazide which was discovered and used as a growth retardant even previous to the discovery of the gibberellins. The reason is that maleic hydrazide is a general metabolic inhibitor rather than being specifically hormonal. Also over-treatment with maleic hydrazide is too easy for its use to be practical.

Cultural Dwarfing

The glamorous way to dwarf plants, at present, is chemically, but in any discussion of height control, the older cultural methods should be touched upon. The most easily understood of these methods is top pruning. In some instances, as with hedges and lemon trees, top shearing is used to keep the plants low but with other orchard species such as apples and peaches, a much less severe and more skillful pruning job is necessary if the tree is to be strong, bear fruit in quantity and not prone to wild suckering.

Root pruning can also be used to successfully reduce the height of and even severely dwarf some species. It is a procedure which is used in the art of bonsai. However, it should be noted that root pruning should be done gradually with all species so that the plant can adjust its top growth slowly. Also root pruning must be a continued process. Some plants, roses being notable, respond poorly to tampering with the roots. Roses typically respond by dropping their leaves and by showing iron chlorosis on the new growth.

Still another cultural gambit which can be used to dwarf plants is limiting the water and mineral nutrient supply. In this respect the mineral nutrient which can best be restricted is phosphorus. Using any other element to retard plant growth usually leads to leaf drop or unsightly deficiency symptoms. However, if growth is restricted by low phosphorus it will be found advantageous to reduce the other mineral nutrients to avoid salinity injury to the leaves.

There is a fundamental difference between the restriction of water and mineral nutrients as a dwarfing method and either top or root pruning. That difference is one of balance. Pruning either roots or tops results in a readjustment of the other to a balanced top-root ratio. Restriction of growth by restricting water and nutrients results in an imbalance in that the roots tend to outgrow the tops.

Finally, there are many ways in which the conducting system in a tree trunk may be manipulated to result in dwarfing. In most instances the manipulation might be classified as a root pruning method in that restriction of the root system results from the manipulation. However, more subtle hormonal balance could be involved. Some of these methods include grafting onto a dwarfing rootstock, using a dwarfing interstock, girdling, reversing a section of the bark, upside-down scions, or buds and tying a knot in the trunk of a young sapling. It is notable that almost all of these methods result in a swelling on the upper side of the manipulation indicating a low rate of carbohydrate and/or hormone transport to the roots which might be expected to result in a reduced root system. Likewise it should be noted that most of these methods do not result in permanent dwarfing since later growth tends to rectify the inhibiting situation.

Temperature and Photoperiod Control

The quantitative effects of photoperiod on plant growth are not often emphasized in plant physiology courses and yet photoperiod can have a rather large effect on height and habit of plants. In general, plants tend to be shorter and branched under short photoperiods, and more elongate with less branching under long photoperiods. This height difference at long and short photoperiods is easily seen with forced Easter lilies. The height of plants finished under a long photoperiod may be half again as great as that of those forced under short photoperiods. Since Easter lilies do not branch, this factor does not complicate the effect of photoperiod on plant height. Quite aside from the purposes of this discussion, but to complete the story, those lilies under long photoperiods bloom somewhat sooner.

It should be noted that short photoperiods may not only restrict growth but may actually cause plants to become dormant which, of course, indicates a no-growth situation.

That temperature can be used to keep plants short is not so well known except in the sense that plants grow less per unit of time at temperatures below optimum. Yet the author has devised a system of variable temperature forcing which has proven effective on poinsettias and Easter lilies. The idea of variable temperature is based on subjecting the plant to lower than optimum forcing temperatures during the period immediately following flower bud formation. The date of flower bud formation is relatively easy to ascertain for poinsettias which are a short day plant for which the critical photoperiod is about October 3. Lowering day and night forcing temperatures by 10°F during the month following bud initiation has been found to reduce height by some 40% without reducing the number of leaves or bract size or causing late bloom.

How many plants will respond to variable temperature growing conditions and photoperiod is unknown and presents a wide field for research. It is hoped that some of the audience here might find this research field of interest.