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

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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-methyl-phenyl 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	"

Continued:

Common and Latin Name	Response to Applications of Phosfon	CCC
Hydrangea macrophylla Thunb.	Inactive	Active
Lily, Easter, Lilium longiflorum Thunb.	Active	"
Mimosa, Albizzia julibrissin Durazz.	Active	"
Maple, Red, Acer rubrum L.	Active	"
Oak, Red, Quercus borealis Michx.	Active	"
Pear, Pyrus cummunis L.	Inactive	"
Petunia hybrida Vilm.	Active	Inactive
Poinsettia, Euphorbia pulcherrima Willd.	Stunts	Active
Privet, Ligustrum japonicum Thunb.	Inactive	"
Rhododendron, Rhododendron maximum L.	Active	"
Sycamore, Platanus orientalis L.	Stimulates	"

* Mention of commercial products herein does not constitute their endorsement. Phosfon is registered for use on chrysanthemums by commercial florists. CCC is still in the experimental stage of development, and is not generally available, and is not recommended for commercial use. Results reported herein for phosfon and CCC are given as research results only and do not constitute official clearance or recommended use.

The basic concept of using growth-retarding chemicals is being extensively tried on many kinds of plants. Most foliage plants, such as Dieffenbachia, Peperomia, and Philodendron, grow without apparent responses to applications of phosfon and CCC. High dosages (100 to 500 times the dosages used on chrysanthemums) frequently stunt growth and result in a reduction of leaf size, drying of the margin of the leaves, and the development of few or no lateral shoots. Plants of chrysanthemums, coleus, and Schefflera actinophylla (Endl.) Horms respond to applications of both chemicals by continuing to form leaves at the same rate as untreated plants but the distance between leaves decreases with increasing dosages.

Woody plants as a group are not particularly adapted to the immediate utilization of growth-retarding chemicals because they grow for only a few weeks during the year and the root system tends to be extensive. Preliminary testing is being conducted with plants growing in clay pots on long days. Plants of several holly species, Euonymus, Ligustrum, Rhododendron, and oak respond to applications of phosfon and CCC. Plants which grow in flushes such as oak and holly respond only to much higher dosages than does chrysanthemum. The time from period of growth (flush) to another is delayed slightly and the number of nodes per flush is smaller than on untreated plants. The actual internode distance on these plants may be unaltered, but the number of nodes is smaller than on untreated plants.

Plants from many different families such as chrysanthemum, Rhododendron, Hydrangea, and Mimosa, respond to applications of CCC at dosages of 10 gm/cu. ft. of composted soil. In contrast, the optimum concentration for growth retardation by phosfon varies from 0.16 gm/cu. ft. of potting soil for chrysanthemum, to 4 gm/cu. ft. for Rhododendron.

The application of growth retardants to monocots has generally been disappointing. Although wheat responds markedly to CCC, the other grains have responded only at fairly high dosages or not at all. (4) Tillering was promoted on treated plants and occurred earlier than on untreated plants. The tendency of the plants to node was also reduced.

These points are vital in the use of growth-retarding chemicals: Prepare soil plant regulator mixtures of varying dosages by dissolving the required amount of chemical in water, pouring it on a known volume of composted soil, and mixing thoroughly to distribute the chemical throughout.

Plants already established in soil may be drenched with the chemical at rates similar to those used in the soil-amendment procedure. The latter procedure is preferred for treating at a specific stage of growth. Plants sprayed with aqueous solutions of phosfon develop yellow spots on the leaves. At high dosages, the veins are cleared of chlorophyll and the leaves develop marginal browning which persists throughout the life of the plant. Other plants sprayed with aqueous solutions of CCC develop yellow tips. Eventually the leaves regain their green color. The margin of safety between retardation without injury and with injury from growth retardants is very small and should not be considered for general use as a method of applying them at the present time.

Amo-1618 and phosfon persist in the soil for more than one crop of plants, whereas CCC did not persist for the growth of one crop. Amo-1618 was slightly more active in summer than in winter in retarding growth of plants, phosfon much more active in summer, and CCC much less active in summer.

All varieties of a given plant species are not equally sensitive to growth-retarding substances (2).

All plants treated with growth retardants appear more resistant to heat and drought stresses (1).

Plants of Enonymus (Figure 1), Fatshedera and Platanus are stimulated to grow more rapidly following application of certain dosages of phosfon. Higher levels of application result in browning of the leaf margins and stunted growth of Fatshedera while plants of Enonymus were retarded in growth in relation to dosage. Application of CCC retards the growth of these plants.

The photoperiod in which holly, petunia, and chrysanthemum plants grow determines their flowering and growth habits (1). Treating the soil with growth retardants does not alter the response to photoperiod, light quality, or night temperature. Therefore, the action of the retarding substances is different from that imposed by short days. Short days continue to be essential for flowering chrysanthemums and long days for stem elongation of holly and petunia. Primarily, internode extension of responsive species is retarded by a wide range of concentrations of phosfon. The action of growth retardants to shorten

internodes is independent of the other environmental factors, and is specific in activity on internodes since the other parts of the plant are not noticeably affected. Few formative effects on leaves, stems, and flowers are observed.

In most instances, the growth retardants exert relatively little influence on flower initiation of herbaceous plants. Treatment beyond that necessary for moderate reduction of stem length usually delays flowering. Treatment of vegetative azalea, camellia, and Rhododendron with phosfon and CCC, however, results in less stem elongation and earlier flower-bud initiation (2,3).

The search for effective and economical chemicals that can retard the growth of plants will continue. At present their use is limited to container-grown plants. In the future, it is hoped that more chemicals which can be used as foliar sprays will be found. Applying growth retardants directly to the growing point of plants appears to be the only way to use them in field plantings. The dosages or the extended persistence in the soil of the chemicals now available limits them to a few special purposes. The concept of dwarfing plants out-of-doors through the use of chemicals ultimately will depend upon finding ones that are active, safe, and persistent on a wide range of plant materials.

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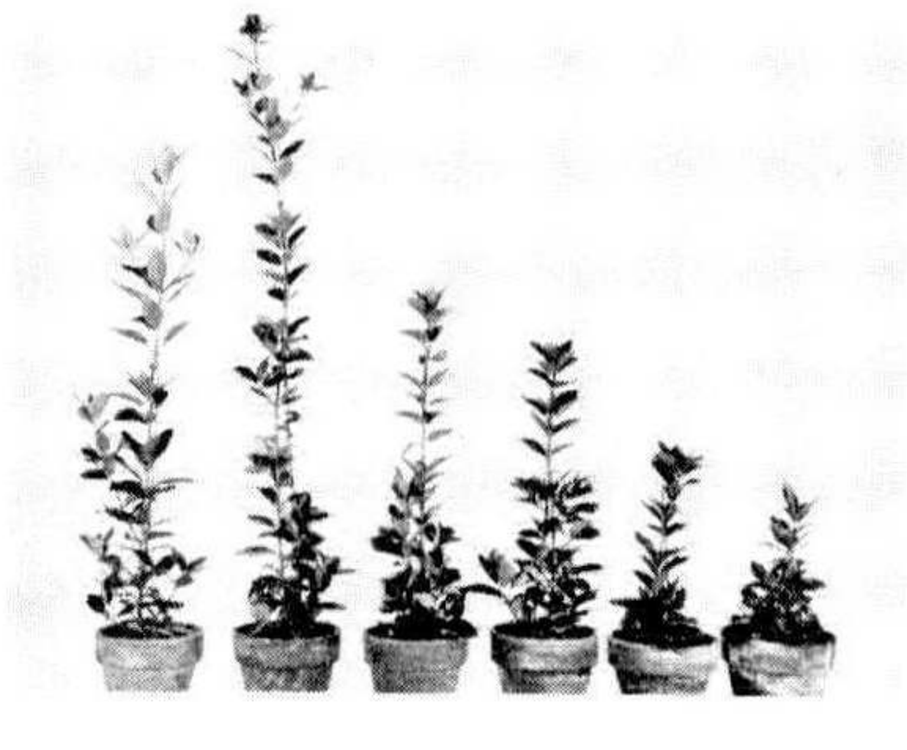

Figure I

Activity of phosfon on Enonymus japonicus L. differs with dosage. Left to right: untreated, 50, 100, 250, 500 and 1000 pounds per acre of phosfon amended in the soil at planting.

PRESIDENT VAN HOF: Gentlemen, there is a little time left for questions. Address your questions to Dr. Mahlstede or Dr. Cathey.

MR. JOHN B. WIGHT (Cairo, Ga.): Out at Beltsville the other day we saw azaleas that were not only retarded in growth but the blooming time was retarded. How much have you retarded azaleas time-wise by CCC?

DR. CATHEY: If I may, would Dr. Stuart answer that? He is doing the work on azaleas?

DR. STUART: The delay in flowering depends upon the strength of the CCC applied. Now if the amount is not excessive, as you saw in one of the slides, there was very little delay. But if in your enthusiasm you overtreat, then there is a delay in flowering just as there is a delay or reduction in the amount. I would have to say that it depends upon the variety to some extent, the time of the year, but mainly depends upon the amount of CCC or phosfon you use.

MR. GRAY: Is there a temperature correlation in this application?

DR. STUART: You mean can the material be applied in the spring or fall?

MR. GRAY: Let's say in a greenhouse with a low temperature, would it be actuated as well as at somewhat higher temperature? Say a temperature of 45 versus 65° F.

DR. STUART: We have no application at 45°. We have observed that applications made say at 60° were very effective or at any time in the spring or summer. In other words, you do not have to have a high temperature.

DR. KENNETH REISCH (Ohio State): Just one comment on this dwarfing. Some years ago we reported on dwarfing permanently, crabapples and catoneaster. It was in 1954, and they are only four feet high and rather scrawny, too. They are dwarfed but not particularly good quality.

MR. PAUL KERN (Cincinnati): I want to ask Dr. Cathey, has there ever been made further use of the growth retarding Maleic hydrazide.

DR. CATHEY: Maleic hydrazide is used, for instance, on the Merritt Parkway to cut down the mowings, but unfortunately, the side effect from Maleic hydrazide on some plants is undesirable. The leaves can be malformed, the growing point can be killed. We have two chemicals that I talked about here which when applied properly will in no way cause a malformation of the plant. It will look just like it is a dwarfed plant. For instance, to see an untreated dogwood growing with nodes three or four or five inches long and you can see the inner nodes come right down so the plant is not disturbed. It looks like an ornament. Unfortunately, maleic hydrazide on most plants make it look like a plow has been through.

MR. HOOGENDOORN: How would you go about producing Bonsi plants?

DR. MAHLSTEDE: Jack Hill has a very nice brochure, that you can obtain and put your name on and put out to your customers. Pot binding is one method, root pruning and meticulous care of the top is another. Whenever it grows, cut it off.

MR. WILLIAM FLEMER: I would like to ask Dr. Mahlstede what he thinks of Malus sargenti as understock for fruiting and apples.

DR. MAHLSTEDE: I can't answer that, Bill, we haven't worked with it.

MR. JOHN E. TANKARD (Exmore, Va.): I would like to ask Dr. Cathey if he has had any experience with CO_{11} and if so, would he comment on it?

DR. CATHEY: CO_{11} is extremely new growth retardant chemical and it is primarily active as a foliar spray. That is my talk next year. It is way too new. The strange thing about it, all we have said about phosfon being active to the roots with a perfectly normal, the CO_{11} in our experience is just the opposite. You put it on the roots in the soil and you get a very depressed looking plant for Washington, very depressed, whereas a foliar application in some of the rates it looks quite good. You are shrinking them down, you are getting a rosette. The trees I showed you did not have true rosettes, which is one leaf right on top of the other. This, we feel, is true dwarfing, the scaling of height is past stunting but still perfectly safe insofar as the appearance is concerned. But CO_{11} is extremely new and we don't know a great deal about it, but the little we do know it looks like it is one way of approaching foliar application.

DR. KENNETH REISCH: Do these retardants work on monocots?

DR. CATHEY: Monocots do not respond as easily as the dicots. CCC does work on a pure stand of one kind of grass of some variety but the problem is that seldom do you have a pure stand of crab grass that you can get the right dosage for. On the one that got the CCC it apparently is working but the rates on a mass population of different kinds of plants makes it extremely difficult to get, because some of them will be dwarfed and the others will not be responding at all. I think that is the major problem. You still have to keep your lawnmower, so far.

PRESIDENT VAN HOF: We have to close our meeting on the educational phase. It has, of course, been very enlightening. Everybody contributed. Even if it wasn't by speech it was by their presence. We say thank you to Dr. Mahlstede and Dr. Cathey and with this we will stretch our legs for a while and at 3:30 you will start on a business session. As Harvey Templeton said last year, our guests are invited to stay with us, but please keep mum - no voting. Thank you. At 3:30 we will start the business session.

(The technical session was adjourned.)