lication, carried a good article on the origin and development of this red delphinium within the last year.

MR. JOLLY BATCHELLER: When Dr. Doorembos got his Ph.D. at U.C.L.A., he took the seed back from a native plant. I don't know whether he was actually in on the development of it or not.

MR. DARA EMERY: The man who did the work on the hybrid delphinium was Legro.

DR. DENNISON MOREY: In connection with the *cardinelli* hybrids, if you're anticipating development work, get in touch with Dr. Gustav Melquist at Storrs, Connecticut. He initiated work at U.C.L.A. with *cardinelli* twenty years ago and has been carrying it on with some of the Pacific hybrids. I think he is now concerned with rhododendrons. I know him well enough to know that he would have material that the *cardinelli*'s left and it might be of interest to you.

THE ROLE OF RESEARCH IN PLANT PROPAGATION[1]

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THE EFFECT OF SEVERAL ANTI-TRANSPIRANT MATERIALS ON APPARENT TRANSPIRATION OF SELECTED ORNAMENTAL PLANTS[1]

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Although anti-transpirants have been known and used for more than fifteen years, there is little information based on experimentation concerning the effects of these materials on transpiration. Before considering some of our recent work with these anti-transpirants, let us briefly review what is meant by transpiration and how it occurs.

Transpiration is the evaporation of water from plant tissue. Basically it follows the physical laws which govern the evaporation of water; however, there are modifications based on plant structure. Woody twigs may lose water through the lenticels; however, the major path of water loss from the plant is through the leaves.

An examination of the structure of a leaf will help to understand transpiration more completely (Figure 1). Both the upper and lower surfaces of a leaf are covered with a layer of

[1]These studies were partially supported by funds supplied by the New Jersey Association of Nurserymen and the North Jersey Metropolitan Nurserymen's Association.

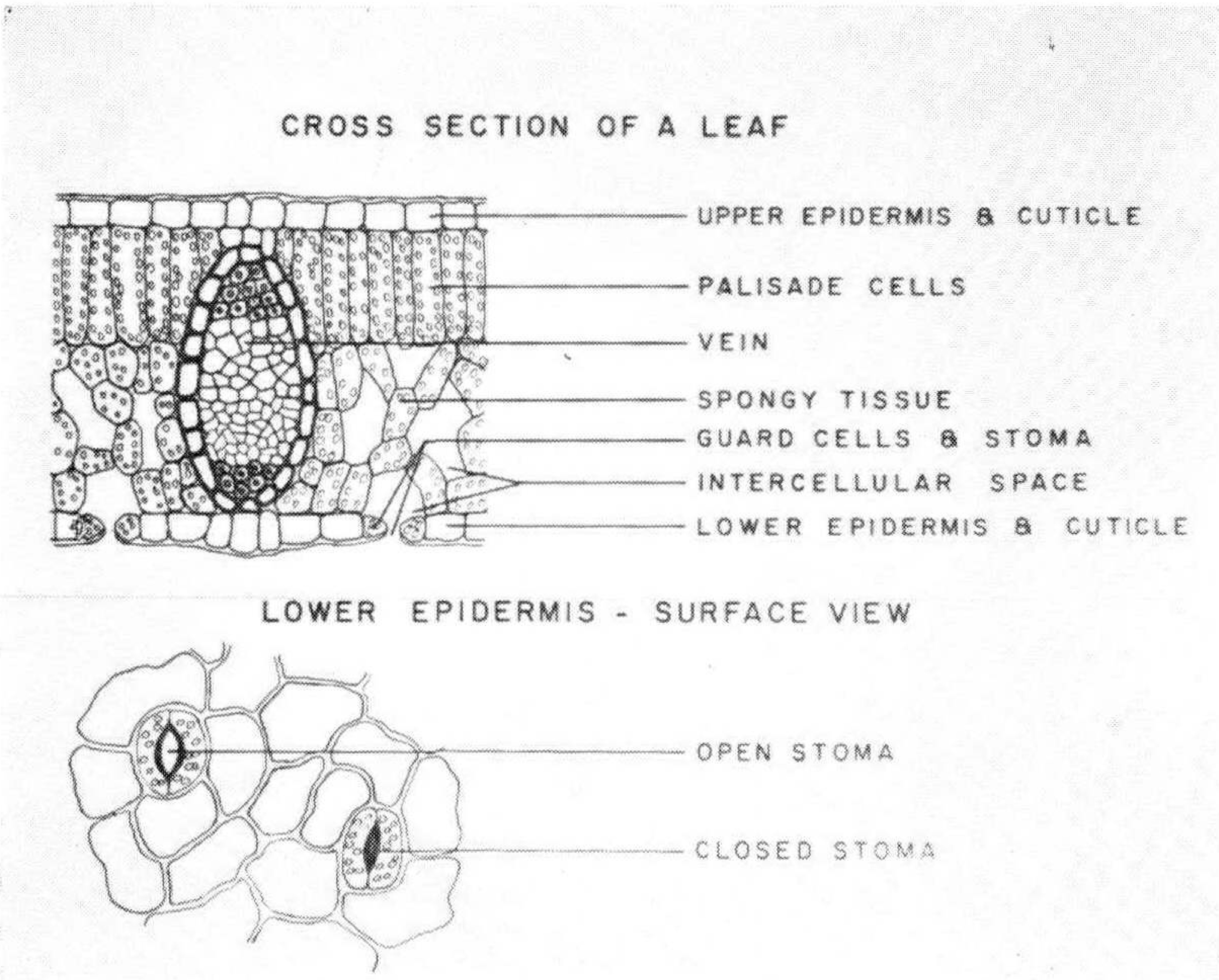

Figure 1. Diagrammatic representation of the cross-section and lower epidermis of a leaf.

cells called the epidermis. A layer of waxy material, called the cuticle, is found on the outer surface of the epidermis. The cuticle is continuous except where small openings, called stomata, occur. The cuticle varies considerably in thickness for different kinds of plants and very little water or gas passes through it.

The epidermis may be broken by small openings, called stomata (singular, stoma). Scattered among the ordinary epidermal cells are pairs of crescent-shaped cells called guard cells. When full of water these guard cells become distended, causing the stomata to open. When low in water, the guard cells collapse and the stomata close.

Immediately below the upper epidermis will be found a layer (occasionally two or more layers) of cigar-shaped cells. These cells contain the majority of the chlorophyll and are known as the palisade layer. Below the palisade layer and extending to the lower epidermis are loosely connected cells. This area resemble the structure of a sponge and is known as the spongy tissue. The large passage-way between these cells are known as intercellular spaces and are connected with the stomatal openings. Veins, which contain the water and chemical conducting units, are found near the juncture of the palisade and spongy tissues.

Stomata may occur only on the lower surface, only on the upper surface, or on both surfaces. Of thirty species of woody ornamental plants examined this summer, we found stomata only on the lower surface of 27 species and on both surfaces of 3 species. Stomata are very small. In holly they average 12.5 by 6.5 microns (one micron = 1/25,000 of an inch). They are exceedingly numerous, 72,000 per square inch of leaf surface having been reported for black poplar and 625,000 for the scarlet oak. An area equal to the cross-section of the lead of an ordinary pencil would contain between 600 and 2,700 stomata, depending upon the species of plant. When open, the stomatal area is frequently only about 1% of the total leaf surface. In spite of the small area occupied by the stomata, approximately 95% of the water lost by the leaf occurs through the stomata and only about 5% through the epidermis.

Characteristically the stomata are open during the daylight hours and closed during darkness. The major function of the stomata is to permit the entrance of carbon dioxide into the plant so that carbohydrates can be manufactured (photosynthesis). With the stomata open, there is created a natural exit for water vapor from the leaf. Transpiration does perform a beneficial function in that the heat required to evaporate the water prevents the build-up of high leaf temperatures.

Water from the soil enters the plant through the roots, and moves up the stem and into the leaves through the vascular tissue — cells specialized to conduct materials. Water evaporates from the cells of the leaf into the intercellular spaces and passes through the stomata into the atmosphere.

Figure 2. Method of growing the plants and adding water during the test periods.

Since the greatest amount of transpiration occurs through the stomata, the effectiveness of chemicals to reduce water loss must be by controlling stomatal transpiration. There are two major types of anti-transpirants: one, chemicals which are absorbed through the roots and cause the stomata to remain closed for a period of time regardless of the presence or absence of light, and two, chemicals which are applied as a film to cover the leaf surface — both epidermis and stomata. The discussion today is limited to recent investigations of the effectiveness of several polyvynal chemicals applied as a film to the leaves.

In these studies of transpiration, measurement of water loss was determined by differences in weight. Plants were placed in containers sealed with polyethylene as shown in Figure 2. The weight was taken at the start of the test and again at specific intervals. The difference in weight, thus, is a measure of apparent water loss. A slight error results from any increase in weight of the plant during the test period; however, this error was found to be negligible for the 3½-day periods between weighings. The amount of water lost by transpiration was replaced by the use of a hypodermic syringe and needle as shown in Figure 2.

Well rooted cuttings or seedlings which had become established in 3-inch pots were used in all tests. The plants were not dormant but had completed active growth for the season.

The test materials used included Foli Gard, Plant Shield, Rhoplex, Vapor Gard and Wilt Pruf. The stem and leaf parts of the plants were dipped in the test materials at a strength of one part of the material to four parts of water and allowed to dry. Preliminary tests had shown that spraying and dipping were equally effective.

The results of these experiments are expressed as water lost by treated plants as percent of water lost by the untreated control plants. For example, if the untreated plants lost 100.0 grams of water during a period and if the plant treated with an anti-transpirant lost 57.8 grams, the water loss for the anti-transpirant-treated plant would be expressed as 58% water loss.

Before determining the percent water loss, the quantities of water lost were adjusted for equal leaf tissue to compensate for differences in leaf size of the test plants.

Briefly, the results of this series of tests show that the effectivenes of polyvynal materials in reducing water loss varies

1) with the anti-transpirant used,
2) with the kind of plant, and
3) with the time following the treatment.

Let us now examine some of the specific responses.

The test results revealed that anti-transpirants would not reduce water loss for all species of plants and that the several anti-transpirants were not equally effective. The water losses, expressed as percent of the water lost by the untreated plants, for fourteen plants are shown in Table 1. The data represents

WATER LOSS AS PERCENT OF UNTREATED PLANTS

PLANT TESTED	FOLI-GARD	PLANT SHIELD	RHO-PLEX	VAPOR GARD	WILT PRUF
TAXUS HUNNEWELLIANA		98	99	94	96
JUNIPERUS HORIZONTALIS	80			80	63
J. CHINENSIS 'PFITZER'		83	74	17	40
THUJA OCCIDENTALIS NIGRA	83			68	65
TSUGA CANADENSIS	56			63	24
ILEX OPACA 'HEDGE HOLLY'	77			81	78
ILEX CRENATA CONVEXA	87			74	48
ILEX CRENATA ROTUNDIFOLIA		75	71	55	62
BUXUS SEMP. 'NEWPORT BLUE'	88			98	91
MAHONIA BEALEI	66			84	56
WEIGELA FLORIDA			116	122	110
FORSYTHIA SPECTABILIS			91	75	61
LIGUSTRUM OVALIFOLIUM			76	56	40
L. OBTUSIFOLIUM REGELIANUM			108	93	88

Table 1. Effect of polyvynal materials applied to the foliage on water loss expressed as percent of water lost by the untreated plants.

the water lost during a five-week period following treatment with the various anti-transpirant materials.

Of the fourteen species of ornamental plants included in these tests, ten lost appreciably less water following treatment with the anti-transpirants than did the untreated plants. These included four narrow-leaf evergreens (*Juniperus horizontalis, J. chinensis 'Pfitzer,' Thuja occidentalis nigra,* and *Tsuga canadensis*), four broad-leaf evergreens (*Ilex opaca 'Hedge Holly,' I. crenata convexa, I. crenata rotundifolia* and *Mahonia Bealei*), and two deciduous species (*Forsythia spectabilis* and *Ligustrum ovalifolium*). The water loss was not appreciably affected by the anti-transpirants for three species (*Taxus hunnewelliana, Buxus sempervirens 'Newport Blue,'* and *Ligustrum obtusifolium regalianum*). With one deciduous species, *Weigela florida*, there was an indication of an increase of water loss following treatment with the anti-transpirants. This possible stimulative effect needs to be verified and, if true, would be of extreme interest.

An examination of these results also shows that the several anti-transpirants varied in the effectiveness of reducing water loss. No single material was superior for all species; however, Foli Gard, Vapor Gard and Wilt Pruf were consistently more effective in reducing water loss than were Plant Shield and Rhoplex.

The responses to four anti-transpirants for one species studied (*Juniperus chinensis 'Pfitzer'*) are shown in Figure 3. Comparable results were obtained with several other species. The data is expressed as percent water loss of the water lost by untreated plants and is shown for weekly periods following a

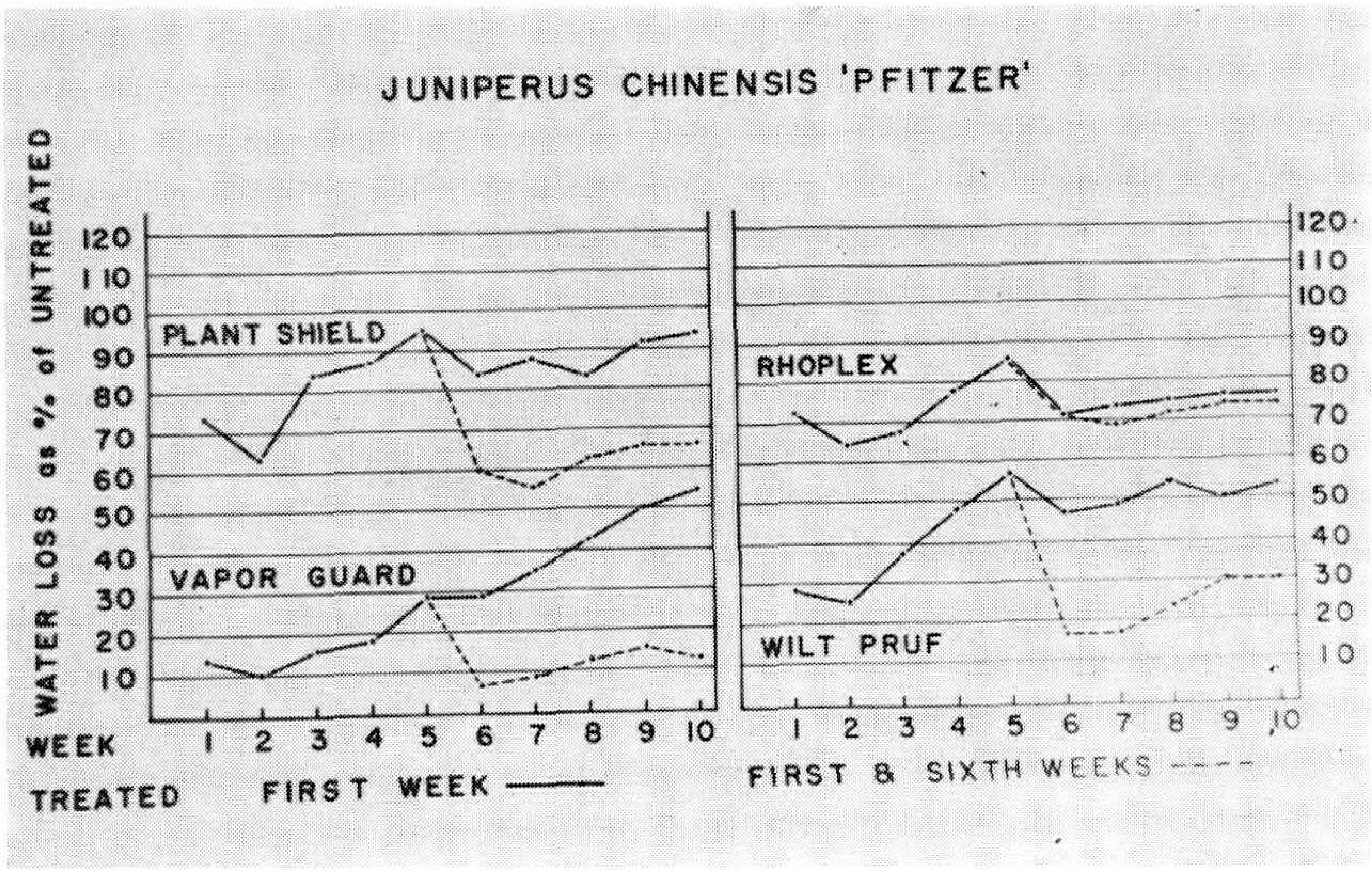

Figure 3. Effect of four polyvynal materials on the water lost by Juniperus chinensis 'Pfitzer'.

single treatment (expressed by the solid line) and for a second application made at the start of the sixth week (expressed by the broken line).

It is obvious from these data that all four anti-transpirants reduced water loss compared with the untreated plants and that Vapor Gard and Wilt Pruf were more effective than Plant Shield and Rhoplex. Following the initial treatment there is a marked decrease of effectiveness of the anti-transpirant treatment until the fifth week, after which only a moderate reduction in water loss was measurable. Re-treatment at the start of the sixth week re-established the effectiveness of the anti-transpirants. During the five weeks following the second treatment, the effectiveness of the treatment to reduce water loss remained about constant.

The weekly water loss for two species, *Ilex crenata rotundifolia* and *Juniperus chinensis 'Pfitzer,'* treated with Vapor Gard is presented in Figure 4. Groups of plants were treated at the start of the experiment (represented by the solid line) and a second group was given a second treatment at the start of the sixth week (represented by the broken line). The results are expressed as percent water loss of the water lost by the untreated plants. It is readily apparent that Vapor Gard was more effective in reducing water loss for the Pfitzer's juniper than for the roundleaf Japanese holly. It is also apparent from the data that there was a gradual decrease in the effectiveness of the treatment during the five weeks immediately following the initial treatment. About the sixth week there was a rapid loss of effectiveness of the anti-transpirant treatment for the holly. The loss of effectiveness of a single treatment was gradual over the ten-week period of testing for the Pfitzer's juniper.

A second treatment, made at the start of the sixth week, brought about a marked increase in the effectiveness of the anti-transpirant to reduce water loss. Following this second treatment, there was a gradual loss in the effectiveness of the treatment with time.

Comparable results were obtained with the other anti-transpirants studied and with the other species of plants.

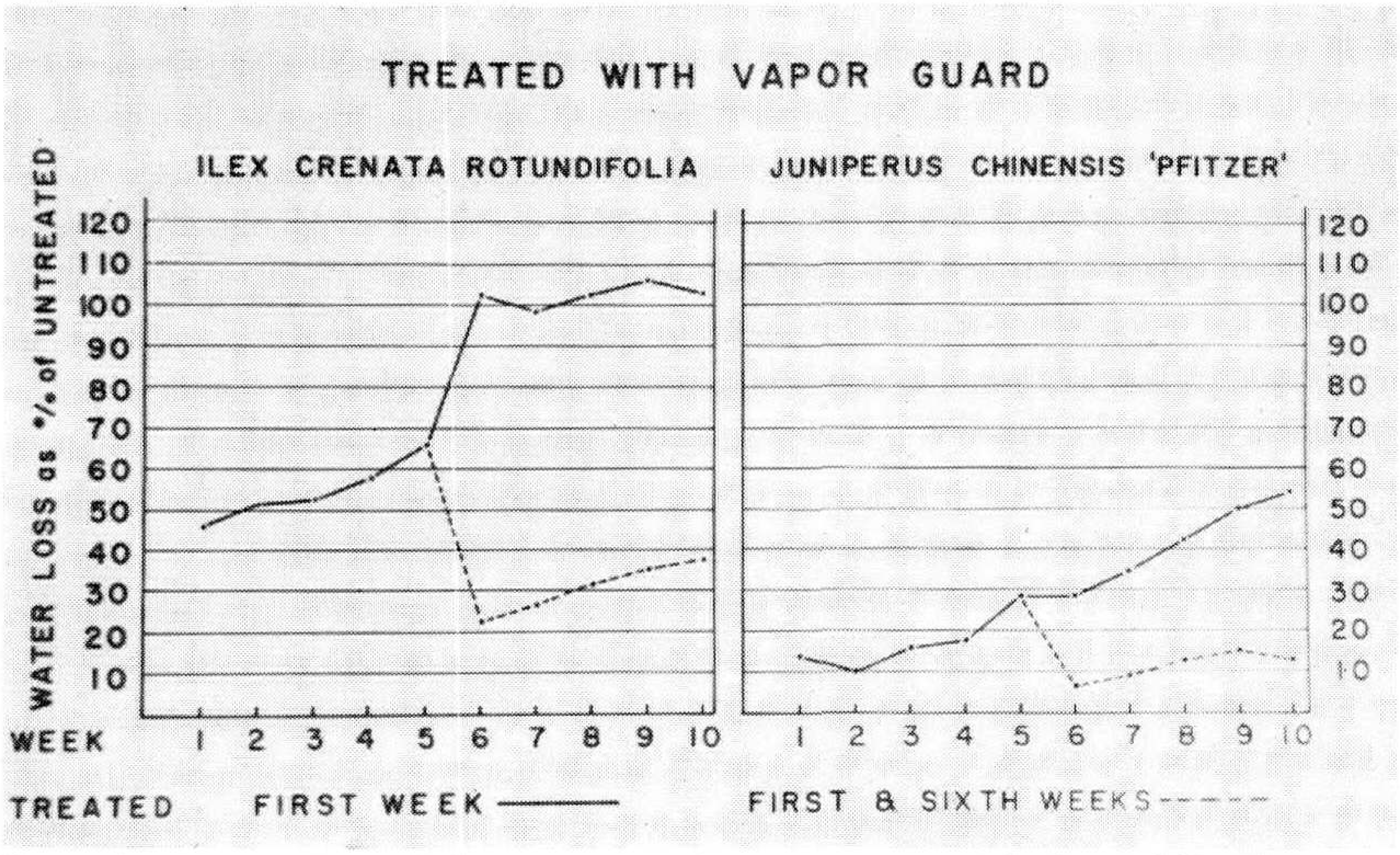

Figure 4. Comparison of the water loss by two ornamental plants following treatment of foliage with an anti-transpirant (Vapor Gard).

From the results of these tests, we may conclude that under greenhouse conditions:

1. Anti-transpirants were effective in reducing water loss.
2. Application of anti-transpirants by spraying or by dipping were equally effective.
3. Some of the anti-transpirant materials were more effective than others.
4. The effects vary with different kinds of plants:
   a. with some the water loss was reduced,
   b. with some the water loss was not affected.
   c. with some the water loss might be increased.
5. The effectiveness decreased with time, and in most instances, the anti-transpirants were relatively ineffective about five weeks after application.

There are, obviously, many questions about anti-transpirants, both basic and applied, that need to be answered.

DR. ANDREW LEISER: I believe you mentioned that you'd used primarily polyvinyl compounds. Have you tried any of the polyethylene emulsions?

DR. WILLIAM SNYDER: It's my understanding that some of the materials which we are currently testing are polyethylene, but I have no results on it.

DR. LEISER: Is the loss of control that you observe at five weeks in transpiration largely associated with additional growth of plant and pulling surface or to the weathering of the anti-transpirant materials?

DR. SNYDER: It is not due to additional growth because material which we were testing had completed growth, although they were not complete dormant; they were quiescent. I believe it's due to a breaking of the film.

DR. ROBERT NORTON: What is the effect on gaseous exchange and photosynthesis of these plants?

DR. SNYDER: We haven't done too much in that area. In the material which we carried for the ten week period — Pfitzer Juniper, Holly — we did make comparisons of the dry weight of Pfitzer Juniper and holly at the beginning and the end of the experiments. With that material in which there was no active top growth, although there was probably root action, there was no difference between the treated and the un-treated. In a paper from Israel with the bean plant there was reported an indication of reduction in photosynthesis. We are following up on some of that with clonal material. I would expect there would be some reduction.

MR. RUSSELL BYERLEY: Has there been any work done on storage of dormant roses?

DR. SNYDER: Not to my knowledge has there been any thing done on dormant roses or any other material in storage of this particular item.

DR. MOREY: Practically anybody who has worked with roses has tried some of these materials but hardly in a way that leads to a lot of progress. The materials that have been tried to my knowledge are the polyethylene emulsions, polybutylene emulsions, polypropylene emulsions, polymethylene emulsions, some of the acrylic materials, various emulsions of paraffin, and the old standby of hot paraffin dips. The effectiveness is about in that order, and in general the polyethylene emulsions result in some damage.

DR. MOREY: Dr. Snyder tells me just recently that there is experimental work that shows that transpiration in strawberries can be significantly reduced for fourteen days by giving them 8-hydroxy quiniline sulphate which seems to keep the stomata closed.

DR. SNYDER: We have had some damage to the plant with that material.

DR. MOREY: Some foliar damage. What concentrations?

DR. SNYDER: Thousand parts per million.

DR. WALTER LAMBERTS: I have a patent on a weed killer whose primary function is to prolong dormancy of roses in packages. This product greatly reduces the amount of transpiration in the stems of the roses so that at the end of a month they are not dried out. If any want more details on this, contact me.

COMPLIMENTARY, SUPPLIMENTARY AND SYNERGISTIC EFFECTS IN ROOT INDUCING COMPOUNDS

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The following presentation will be less of a revelation than an appeal. My own experience is limited to a few empirical trials and word of mouth suggestions. It is my feeling that virtually every propagator who works with recalcitrant materials has done and discovered as much. This is particularly true of our academic colleagues who have the opportunity to test ideas which they conceive themselves and ideas stimulated by their more or less constant contact with researchers in the area of auxins and hormones and also contact with the literature.

Unfortunately for everyone this information is diffuse, and difficult to come by. Most of it is considered to be insufficient in content and scope for publication and when published it appears sparsely scattered and so lost from sight and mind.

My intention is to try to accomplish two things today:

1. To illustrate that this scattered information on the subject of my title is of tremendous potential value, and
2. To convince this society that it would be worth while to finance a search of the literature, circulate a fact finding questionnaire, and publish the aggregated information in a concise, useful, practical form.

As stated above, there are few of us who have not experienced beneficial results from using mixtures of things as rooting aids. Ordinarily these contain an auxin plus divers and sundry other classes and genera of chemicals.

In discussing and thinking about these mixtures three kinds of effects may be observed: 1. complimentary, 2. supplementary, and 3. synergistic. The latter, of course, may be a feature of either 1 or 2. There is a fourth event as well called negative results, but I shall exclude failures from this discussion. However, in preparing a good survey, things that don't work need summarization as well as those that do.

In my discussion I shall construe these terms as follows: complimentary—producing an additional benefit in a different way; supplementary—producing an additional benefit through the same kind of event or in the same or similar way; synergistic — the combined effect of two or more substances is greater than the sum of their individual effects.

For example, a mixture of an auxin and an oxidizing agent which gives better results than either alone would be a complimentary event A mixture of two auxins giving a greater or