The growth chamber approach to this problem appears to give highly satisfactory results, since by regulating the controls the cuttings or seedlings can readily be hardened off for potting or transplanting before they are removed from the case. When peat pots are used the automatic watering system can be employed. This has worked especially well with the propagation and hardening off of bedding plants and small seedlings of woody plants.

It is hoped several additional uses will be found for this system in the future.

MODERATOR HOULIHAN: Thank you, Prof. DeWerth. The next paper will be given by Mr. Zophar Warner, Warner Nurseries, Willoughby, Ohio.

INEXPENSIVE PLASTIC STRUCTURES FOR WINTER PROTECTION OF PLANTS

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There is a great deal of information about plastic houses. The Cunningham house was described before this Society two years ago. This presentation can be found on page 142 of the 1961 Plant Propagators' Proceedings. Harvey Templeton has some pipe frame and woven wire structures. The Berryhill Nursery has been using quonset hut type plastic structures for several years. I am sure there are many other good ones in use, some with wood frames.

The most obvious requirement of an inexpensive plastic structure is that it cover the most area or furnish the most cubic feet of space at the least cost per square foot or cubic foot. On this level, it is an engineering problem in which local snow and wind loads must be taken into consideration. If this were the only problem this audience would be better served by having an architect or engineer furnish structural data that I am in no way qualified to present.

I would like to depart to a large extent from the structural aspects of "Inexpensive Plastic Structures For Winter Protection Of Plants." I think this can be done without departing from the spirit of the subject. Anyway, we can rewrite the title using exactly the same words to read "Inexpensive Winter Protection Of Plants in Plastic Structures." The structures in themselves may or may not be expensive since they are only one of several factors contributing to cost.

The first requirement of inexpensive winter storing is success!

When John Roller asked me to give this talk I was reluctant to make a presentation based on failure. After giving the matter some thought, I decided information based on known failure

might be better than information based on accidental success. A few years ago we had substantial success in wintering plants under snow. This is the most economical protection known to man but unreliable or non-existant and is too costly to make with snow machines.

Last year we built these 10 foot wide huts of 6x6x6 reinforcing mesh with pipe ridge pole supports. We filled them through the side with a wide assortment of broadleafed material grown in containers. Four mil polyethylene was then stretched over the whole structure including the ends to make it as air tight as possible. Our figures showed that we had a very economical structure. However, when spring came our losses in all types of material was greater than the cost of construction. What happened? Stated simply the plants were killed by prolonged cold temperatures reaching 25° below zero. Specifically, they were killed by one or more of the following:

1. Soil temperatures too low for the roots to live.
2. Temperatures too low for the tops to live. Tolerance of temperature extremes by the tops of plants is almost always greater than the roots.
3. Desiccation caused by low humidity in turn caused by moisture condensing on the plastic and running down the sides.

If the winter had been normal, I am sure no losses would have occurred.

However, not everything we did turned out badly. Why we were successful under other conditions can best be shown in pictures of our use of polyethylene. It has occurred to me that anyone growing material likely to be winter damaged might do it more economically by keeping the whole operation under plastic structures covered in winter, uncovered in summer.

Since I can see no possibility of affording this economy, at least all at once, it is essential to divide structures for winter storage into two categories.

The first is constructed over the plants in the growing area.

The second is stationary and the plants are moved from the growing area and placed in the structures. Both have their uses but can be used to good advantage only if planning is done in advance.

The first type structure should be used to cover plants that are some time from maturity or sale and can be left through another growing season undisturbed.

The second is the place for permanent structures and should be used for small plants such as flatted material that is economical to move. Larger material should be placed in these permanent structures only if they have reached selling size and the winter storage is part of the selling operation. The cost of moving from the growing area to a plastic house for storage, back to the growing area, then back to storage the following autumn is prohibitive.

In fact, in most cases the permanent structure for wintering should be designed as a integral part of the shipping and

selling facility where it can be used as a display for selling.

During the early 1950's while we were having mild winters, we worked out a system in which we wintered rooted cuttings consisting mainly of broad leaves and ericaceous plants in the greenhouse or cold frames. The next spring they were planted in peat beds for one or two years. From there they were sold, field planted or more recently placed in containers for growing on one or two years. In the beginning we found it unnecessary to use shades winter or summer. Polyethylene was unheard of. Since then, we have experienced a series of increasingly severe winters and we have made increasing use of Polyethylene.

The following pictures will show what we are now doing without making basic changes in our method or production.

The first pictures show poly covered frames. Last winter we suffered some loss of Ilex cuttings due to extreme cold. This year we have placed an inner lining of 2 mil poly over poultry netting. The netting is necessary because the poly alone would not support the condensation that drips down from the outer layer.

The azaleas beds are 80 inches, center to center. Two lines of one inch structural galvanized pipe unthreaded are supported every ten feet on concrete block. The joints are made by inserting the one inch pipe into a one foot section of 1¼ inch pipe. This 1¼ inch piece is kept from moving by a galvanized nail in the center. Forty eight inch snow fence is then rolled over the center of all the beds before the alternate paths are covered. Four mil poly is then placed over the whole area and weighted down with gravel. It is important to seal the ends and sides with the poly not only to keep it from blowing away but to prevent evaporation. Keeping the air space at a minimum maintains higher humidity since the ratio of cubic feet of air to the available moisture is better than it would be in a higher structure.

Furthermore, when condensation takes place the moisture drops back on the plants thus working in the same way as a sweat box.

A few years ago in Cleveland, I gave a talk before this society on the use of plastic in propagating houses. Before my turn on the agenda came, Mr. Gray had told about wrapping a bench full of cuttings in polyethylene and leaving them sealed until rooted. Mr. Wilson topped this by rooting juniper cuttings in a poly bag in the back of his car on the way home from Florida. I hestitate to make claims this optimistically but, these low, flat, air tight structures require less attention than large houses that can and should be inspected more often.

Unless watering is done and temperatures are above freezing it is imperative that any wintering structure be air tight. Holes or loose sides will cause more dehydration than no cover at all. These plants may be covered two years in this way The shades will be rolled up during the summer since they are generally detrimental in our area.

Where maintaining shade and humidity are not so necessary it is more economical to use 6x6x6 reinforcing mesh. We copied this from Berryhill Nursery. It has also been used by the Perkins DeWilde company and probably many others.

Shown here are container plants that have not reached saleable size and will remain in this area next summer. Next, this year's rootings of various kinds of euonymus have been bedded out. They were planted in September when time is more available and will be substantially better than they would have been if planted in the spring after growth had started. In both cases they have been covered with the mesh and poly.

Where additional temperature and humidity protection are required we are rolling 2 mil poly right over the plants before placing the mesh. We have never tried this before but it should work. If ventilating is necessary we can open the top layer without drying out the plants. When the beds are made or the containers placed on the ground, it is imperative that the edges be straight. The mesh is in 5 foot sections but the 100 lengths of poly cannot be kept tight if there is a bend.

Advance orders and the plants of a saleable size are brought to the shipping area and placed between two rows of baled straw, 20 feet apart. Pipe is placed across the bales to support shades. Here sections of shades are used so a little can be moved at a time as shipping progresses. This whole space is covered tightly with 24 foot 4 mil polyethylene.

Poly has been hung over the pipe every 60 feet or so to further retard movement of air This would be more important if you were working on a slope.

Results under this method of storage have been very good. The Bosley Nursery, Mentor, Ohio has been storing container material in a similar way with good results.

In addition to the humidity advantage, previously mentioned, soil temperatures do not drop as low due to the minimum radiation surface. Even if the soil freezes, it thaws out from the bottom. This is very important, particularly with container grown plants. This is the place for the permanent walk-in structure. We have not built any here because we expect to relocate the shipping area.

We have also had excellent results by laying down 5 gallon square cans, tops to tops, can to can. These were stacked 5 wide and three high and covered with 10 foot wide clear poly. These can be run in long rows and should run north and south so they will shade themselves.

Most of these pictures were taken November 16th of this year while we were still placing the framework. By now, December 7th, the polyethylene is nearly all in place.

I would like to make specific statements of fact that would furnish valid information for everyone present. This is not possible due to the wide range of interests of the members, differing climatic conditions and the wide variety of plants that need to be winter stored. The questions are the same in any case.

The answers reflect local requirements. A winter storage structure should accomplish the following:

1. Raise the soil and air temperature.
2. Maintain high humidity.
3. Prevent sudden fluctuations in temperature, probably by use of shade.
4. Enough light should be provided to prevent defoliation.
5. Should not encourage early growth.

If these items and a few others are dealt with properly, healthy live plants will result.

As mentioned in the beginning this is the first requirement for making storing inexpensive.

Efficient handling of the material, and speed in completing the storage operation in the limited time between dormancy and freeze-up are also important.

Only after the foregoing items are taken care of, can the actual cost of material used in the structure be considered. This in itself is complicated by whether depreciation or obsolescence occurs first.

A good way to reduce costs is to get more than one use from the material. We are using the old poly for weed control and packing. The snow fence can be used for conventional shade.

If we change our minds, we may bend the pipe into arches to make some of Harvey Templeton's 13 foot wide houses and the concrete blocks can be used for permanent frames. However, we have not yet decided to go into the paving business with the old reinforcing mesh! In closing, I would like to suggest that the need for additional information is endless. All the tolerances of all the varieties of plants should be known. A comprehensive review of the availability and use of new material needs to be made every few years.

Presently we are preparing for severe winters.
Will these preparations be detrimental in a mild winter?

MODERATOR HOULIHAN: Thank you very much, Zo, for a very informative paper. Our final speaker of the morning is Mr. Ray Halward, Royal Botanical Gardens, Hamilton, Ontario, Canada.

LEAF-BUD CUTTING TRIALS 1963

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It was pointed out in a brief summary in the March issue of the Plant Propagator under the heading "Field Trials for 1963," that some plants had been propagated successfully using the leaf-bud cutting technique. It was hoped that the field trials this year would add to the knowledge already available.

In answer to the request for participants I received two replies, one from Paul E. Case of Pleasant Grove Nursery, Peach