# FRIDAY AFTERNOON SESSION

## December 1, 1967

The Friday afternoon session convened at 1:15 p.m. in Ballroom A of the Admiral Semmes Hotel. Hans Hess was moderator of the first part of the afternoon session and Dr. Kenneth Reisch was moderator of the second part.

MODERATOR HESS: We are very fortunate this afternoon to have on our program Dr. Harrison Flint of the Arnold Arboretum. Dr. Flint will speak on the "Winter Storage of Young Nursery Stock".

## WINTER STORAGE OF YOUNG NURSERY STOCK

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Winter storage of young nursery plants has been a popular topic of discussion for a long time, but increasing production of nursery stock in containers in the North has stimulated even greater interest on the subject. My first inclination in preparing to talk to you on this subject was to share with you some of my own experiences and experiences of other people in the New England area. But in the process of visiting nurseries and other establishments, watching their practices, and assembling all this information, I began to realize that if I were to follow my original plan I would probably do nothing more than add confusion to an already confused subject. The one thing that impressed me more than anything else in these visits is that there are so many successful methods in use. I think we've all been impressed by this fact as we have listened to speakers on this subject over the past several years. So for today, let's look for a few universal facts or common denominators that we can use in comparing some of the methods that are now in use. In the process we may discover what the essentials are, and be in a better position to evaluate new methods of protection.

The first thing to remember is that young plants in containers are prone to all the winter hazards that threaten older plants established in the ground, and more besides. But, on the other hand, the fact that they are portable makes it possible to use protective measures that would not be economical in field situations.

There are four basic causes of winter injury:

1) *Mechanical damage*:

When we think of this we usually think of heavy ice and snow breaking branches of plants, but other kinds of possible mechanical damage include chewing by mice or rabbits, windwhipping of branches protruding through a snow crust, or even the collapse of an under-designed protective structure.

2) *Seasonal cold*:

Low temperatures are the obvious cause of winter injury — the thing that we all think of first. But too often we think of the lowest temperature that comes in January or February and fail to appreciate the fact that killing or damage by cold can happen at almost any time of year in the North. An established plant of a "hardy" species has the ability to harden in the fall before the onset of low temperatures. This doesn't mean that overnight it suddenly attains its full hardiness for that winter. It simply means that its progressive hardening during autumn manages to stay ahead of the progressively lower temperatures. These plants also remain dormant in late winter and early spring long enough to allow the seasonal warming trend to keep ahead of dehardening at that time of year. But young plants of the very same species can present a different situation. Young plants tend to be more vigorous than older plants, especially when rapid growth has been encouraged by good cultural methods. This vigor encourages late growth in plants of some species. Since cessation of growth is a prerequisite for hardening, such plants are likely not to have developed as much hardiness in fall and early winter as older, slower growing plants of the same species. This is why young plants of some species are destroyed or damaged by "stem splitting" at the first hard freeze in the fall but are not so susceptible to this injury later in life. This injury can be prevented by delaying the onset of freezing temperatures in autumn until plants have had time to harden sufficiently. This is usually done by trapping heat in cold frames or greenhouses, with or without auxilliary heat, or by placing plants in controlled cold storage in autumn.

Up until now we have been talking about hardiness in general. When we do this, most of us think in terms of the hardiness of the above-ground parts of plants — the stems and buds, forgetting the plant parts that are out-of-sight in the soil. Root hardiness has been measured in only a few species, but in these cases roots usually have been found to be more tender than hardened stems of the same species. This, coupled with the fact that roots of potted plants left outdoors are exposed to more extreme cold than those of plants in the ground, makes root systems of container-grown plants especially prone to winter injury. Often they are damaged beyond recovery even when no direct cold injury has been sustained by stems of the same plants. My first experience with this type of injury came at the University of Rhode Island in 1958 when plants of *Cotoneaster adpressa praecox* left outdoors over winter in containers failed to make new growth in the spring, even though the winter air temperature had not fallen below zero.

In a 1964 report entitled "Watch Root Temperatures of

Some Plants", Dr. John Havis of the University of Massachusetts pointed out the importance of protecting roots of some species from winter cold. He found the killing temperature for roots of hardened plants of *Ilex opaca* and *Ilex crenata* to be about 20°F. The killing temperatures for roots of similar plants of *Cotoneaster horizontalis* and *Pyracantha coccinea* were about 15° to 18° F., but plants of several ericaceous species withstood temperatures lower than 15°F. without root injury.

In a preliminary experiment conducted at the University of Vermont shortly before I left that institution, we compared the hardiness of lower stems and roots of well-established and hardened rooted cuttings of a number of species. Both the stem-killing temperatures and the root-killing temperatures varied widely among these species, as shown in Table 1. In all cases but one, stems were considerably hardier than roots. The extreme case found was *Philadelphus virginalis* where stem and root killing temperatures were -44°F. and + 24°F. respectively. In all the species studied, the average difference in hardiness between roots and stems was about 30°F. In one case, that of *Indigofera kirilowii,* root and stem killing temperatures were nearly equal, 3° and 5°F. respectively, not surprising when we remember that this plant is frequently top-killed in several hardiness zones where the root system persists without difficulty.

In essence, prevention of root killing involves knowing what temperature roots can tolerate without injury and then keeping the temperature above this critical point. Since root-killing temperature of most species are not known, a more practical alternative may be to keep root temperatures of a questionable species above or at least close to the freezing point. Needless to say, root hardiness is an area in which additional research is badly needed.

3) *Sudden cold*:

It has been known for many years that the rate of cooling can sometimes be just as important in determining winter injury as the minimum temperatures attained. One of the most familiar examples of this is sun scalding of tree trunks, in which the living tissues of the bark are first heated by radiant energy from the sun and then freeze rapidly as the sun sets or passes behind some object. White and Weiser at the University of Minnesota have shown that the same kind of injury can be sustained by leaves of certain evergreens. The situation they found can be illustrated in this way: picture a cold, bright winter day in the northern United States, when the maximum temperature reaches only 10°F. At the same time, the temperature of evergreen leaves may be as high as 40°F., because of radiant heating by the sun. On such a day, if the sun disappears behind a cloud or other object in mid-afternoon, the temperature of the leaves will very quickly approach the temperature of the surrounding air. Since their temperatures differ by some 30° to begin with and are nearly equalized within a minute or so, it is obvious that the leaves cooled very rapidly.

Table 1 Stem and Root Killing Temperatures of Hardened Rooted Cuttings

| *Species or cultivar* | Killing temperature (° F) Stems | Roots |
|---|---|---|
| *Hydrangea paniculata* '*Grandiflora*" | -44 | 0 |
| *Philadelphus virginalis* | -44 | 24 |
| *Viburnum trilobum* | -44 | 16 |
| *Abeliophyllum distichum* | -22 | 7 |
| *Symphoricarpos chenaultii* | -15 | 25 |
| *Weigela* 'Bristol Snowflake' | -15 | 19 |
| *Weigela* 'Vanicek' | -15 | 23 |
| *Elsholtzia stauntonii* | -14 | 12 |
| *Forsythia* 'Karl Sax' | -13 | 18 |
| *Forsythia* 'Lynwood' | -13 | 14 |
| *Weigela* 'Bristol Ruby' | -11 | 18 |
| *Indigofera kirilowii* | 5 | 3 |

Under such conditions severe damage resulted to *Thuja occidentalis* in the Minnesota study, and it seems safe to assume that other species are affected in the same way. In milder climates than Minnesota, *Thuja occidentalis* is less prone to this kind of injury, but some of the tenderer species grown probably react in the same way. This kind of injury is not peculiar to young container-grown plants — it occurs in the field as well. But with the portability of container-grown plants, more can be done to prevent it. Probably the simplest way of protecting against this kind of injury is to shade the plants from full sun. This is often done with lath shades, but coarse burlap, saran cloth, and other materials have been used equally well.

4) *Drying*:

Because of limited space and favorable moisture and nutritional levels, root systems of well grown plants in containers are usually smaller in relation to their tops than those of comparable field-grown plants. This, together with the possibility of rapid drying and frequent freezing of the limited soil volume, makes container-grown plants unusually susceptible to dehydration when fully exposed to the winter environment. This is especially true of evergreens, as they transpire substantial amounts of water in the wintertime.

Drying of evergreen foliage is a common occurrence in some areas, and is referred to as "winter-burning", "sun-burning", and "wind-burning". It is caused by excessive water loss from foliage, whether by the effects of sun or wind, under conditions when water cannot be picked up from the soil to replace that lost. This kind of injury is sometimes difficult to distinguish from the foliage "burning" caused by sudden temperature drops, as the symptoms of both kinds of injury are dehydrated or "burned" leaves.

Prevention of injury from drying requires frequent inspection of plants and watering as necessary. Many container-grown plants have been lost during the winter simply because their root systems were allowed to dry out. Protection may also include reducing evapo-transpiration, by shading to reduce heating of evergreen foliage, by building glass or plastic enclosures to capture evaporated moisture, or both.

In summary, protection of plants against these four principle causes of winter injury involves (1) eliminating mechanical damage by suitable protection against ice and snow, and against rodents and other animals, (2) either reducing a young plant's tenderness in early winter or delaying the onset of severe cold, (3) providing some shade from full sun for evergreen plants, and (4) preventing drying of plants during the winter.

*Methods of Protection*

Protection of young container-grown plants can vary all the way from no protection at all to complete temperature control. The degree of protection that must be used varies with the climate in a particular location, with the species of plants being handled, and with the degree of risk that a particular organization feels is acceptable. In general, greater degrees of protection are more expensive than lesser degrees, so the economics of each situation must be weighed carefully, and each organization may do this somewhat differently. For example, at the Arnold Arboretum some plants are protected by mulching, others by placing them in an unheated polyethylene greenhouse, but the majority of our young plants are placed in a storage building in which the temperature can be maintained at or slightly above freezing during the entire winter. This building is equipped with refrigeration that can be turned on in late winter and early spring to insure that the temperature is kept below 40°. The cost of this building would prohibit its use in just about any commercial establishment, but since we are dealing with many plants that are irreplaceable or at least very difficult to replace, we cannot tolerate much risk. On the other hand, looking at the extent of plant losses resulting from inadequate protection in the Northeastern United States over the past several years, it seems that many organizations have been willing to accept too high a level of risk, and have suffered economically as a result.

1. *Mulching.* For many of the hardiest species grown in containers in southern New England, the only protection that is needed is to pull the containers closely together and mulch them to give some protection to the roots. This is true of many deciduous materials and a few evergreens such as junipers and certain yews. In some cases, containers have been tipped over on their sides, with variable results. When these methods are used, winter precipitation may supply enough moisture to pre-

vent serious drying, but it would be a mistake to assume this will be the case and neglect to check for drying regularly.

2. *Shading.* This can be done in several ways. The traditional method is to use a lath house. The one illustrated is at Imperial Nurseries in Connecticut where several very large lath houses of the type shown are in use. Roger Coggeshall at Cherry Hill Nurseries, and his predecessors there, have used to good advantage a pine grove located on the property. These large pine trees furnish almost complete shade from direct sun for plants underneath. During the winter Ghent and other azaleas are stored in ball and burlap, along with flats of rooted cuttings of junipers and yews. In this protected area, the earliest snow cover is likely to persist and the later snows of winter remain as protection rather late in the spring, giving excellent protection. This nursery has also used screens of snow-fencing about four feet from the ground over transplant beds but are now getting away from them because of problems with snow breakage and inconvenience in working under them.

3. *Unheated structures.* These fall into three categories: (1) cold frames and greenhouses (usually plastic covered), (2) more or less opaque structures that we can refer to as common storages, and (3) refrigerators in which storage temperatures can be closely controlled. These structures come in many types and degrees of elegance. Often they consist of adaptations of existing structures. For example, Imperial Nurseries is using a modified potato storage house. A large amount of roof has been broken out and replaced by fiberglass to allow light to come through in the top floor of this building and evergreen azaleas are stored in it. Shade trees and clematis in containers are stored in the lower level, in darkness. This nursery is also using a variety of buildings formerly used for storing tobacco. Arie Radder of Imperial Nurseries has been carrying on a substantial research program to find the best ways of adapting tobacco sheds to winter storage of nursery stock. Weston Nurseries, in Hopkinton, Massachusetts, is making use of a variety of common storage structures. In one case, an existing cellar hole was roofed over with a gable roof and floored beneath it at ground level, thus providing two levels for storage. Broad-leaved evergreens such as rhododendrons, mountain laurel and andromeda are being stored in this structure. Ed Mezitt of Weston Nurseries has carried on considerable experimentation in cooperation with the University of Massachusetts staff in adapting a variety of structures on the nursery grounds to storage of plants overwinter. Probably the most elegant common storage building that I have seen is located at Corliss Brothers' Nursery in Ipswich, Massachusetts. I expect most of you have read the recent article in the November 1, 1967 *American Nurseryman* describing this building, which has been in operation for two years. The outstanding features of this building are the provisions for ventiliation and the degree of mechani-

zation that has been reached. Balled and burlapped plants and container-grown plants are placed on pallets and carried into the storage building with a forklift. Ventilation during the winter is accomplished with the fan and polyethylene tube method commonly used in greenhouses in which exhaust fans are mounted in an outer wall of the building and perforated polyethylene tubes are suspended from the ceiling serving to introduce and distribute outside air. Further circulation of the air in the storage building is accomplished by 4 Dutch Mill turbulator's spaced in this 50 x 100 foot building. Although this building is neither heated nor refrigerated it is heavily insulated. This keeps temperatures from falling much below freezing in the coldest part of the winter, but makes it possible to keep the temperature below 40°F. through March.

Refrigerated storages have been used widely for holding certain classes of nursery stock in readiness for spring shipment. Some nurseries are using refrigerated storage for holding summer-rooted cuttings for spring planting. Case Hoogendoorn of Newport, Rhode Island, has been one of the pioneers in this use of refrigerated storage in New England, through his own experimentation and his support of research at the University of Rhode Island. Obviously stock stored in refrigerated facilities must have a relatively high value per unit volume occupied.

4. *Heated structure.* These differ from the buildings and structures just mentioned only in that supplementary heat is available for use during the coldest part of the winter. They can range all the way from heated cold frames using steam lines or electric cables to heated greenhouses and storage buildings. Heated structures are not used as commonly in southern New England as they are in northern New England for obvious reasons. Where plastic greenhouses are used for winter protection, the need for heat depends upon the species grown as well as the geographical location. As a rule of thumb, for most young nursery stock currently grown, accessory heat is probably not necessary in areas with an average annual minimum temperature of -10°F. or higher, but in areas having an average annual minimum temperature lower than -10° F. it is probably very risky not to provide some accessory heat, unless the most hardy species only are being grown.

*Summary*

A large number of successful methods has been devised for storing young nursery stock. Without a common denominator this variety of ways to "skin a cat" seems bewildering. But a close look at the principles involved shows us what all successful methods have in common — and makes it possible to devise new methods as the need or the opportunity arises.

MODERATOR HESS: The next speaker on the program has the topic of overwintering evergreens under poly houses. Mr. John Zelenka will give the paper.