Factors influencing winter injury

Many types of injury resulting from severe winter conditions are collectively termed “winter injury.” In addition to direct freezing damage, winter injury may include frost-splitting of trees, sunscald, desiccation of broadleaf evergreens, frost heaving of newly planted material, and spring frost-damage to flower buds. The incidence of direct freeze damage is a function of the cold hardness of the species and is the primary determinant of their distribution and use. Cold hardness is dependent on the genetic capacity of the species to withstand freezing temperatures and the conditioning of the genetic capacity by certain environmental cues, principally temperature and photoperiod.

Woody ornamentals may be susceptible to freezing injury due to a limited extent of hardiness, a failure to synchronize the acclimation and deacclimation processes with the prevailing environment, and differences in hardiness of various plant organs.

Root hardiness is of prime importance in the storage of woody nursery stock. In general, it has been found that long-day photoperiods in the fall inhibit root hardiness. Short days are necessary for normal root hardiness. Since roots are in soil, any influence of photoperiod on root hardiness must come as a signal sent from the plant tops to the roots.

Successful storage of deciduous plants is dependent on their physiological maturity. Plants harvested “prematurely” are susceptible to freezing injury, metabolic breakdown and possibly microbial infestation, which are commonly manifested as tip dieback, water-soaked necrotic lesions and death. In addition, plant growth after transplanting may be affected by delayed bud break.

On the basis of several detailed studies, maturity is defined as the physiological stage of development in deciduous plants when leaves are no longer necessary for the complete survival of stored plants. Thus to a nurseryman, mature deciduous plants are those that can be successfully defoliated, harvested, and safely stored for long periods at relatively cool temperatures.

Cool temperatures and the shortening day length in autumn combine to trigger a hardening response in the foliage of plants that results in increased cold hardness. Moisture levels should be reduced in late summer or early fall to slow growth processes but not stress plants. In addition, container-grown plant materials should be kept at field capacity prior to freezing in order to insure greater survival. Fertilizer levels should be maintained for satisfactory plant growth; however, attempts should be made to avoid

Woody Ornamental Winter Storage

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The Ohio Cooperative Extension Service and The Ohio State University sponsored a symposium December 9-10, 1977 for members of the nursery production and scientific communities to update their knowledge and exchange ideas as it related to the winter storage of woody ornamentals. The symposium participants discussed the physiology of winter storage, pre-storage practices, determining maturity and prediction of harvest dates, acclimating plants to storage, principles of common and refrigerated storage, construction and orientation of storage structures, poly-coverings, disease control, anti-transpirants, minimum-heat, thermostable blankets, heat saving techniques, and future needs. A summary of the discussions as well as research ideas are presented in this report. Copies of the proceedings of the Woody Ornamentals Winter Storage Symposium can be obtained for $5.00. Persons interested should enclose a check payable to Storage Symposium to Dr. Elton M. Smith, Department of Horticulture, 2001 Fyffe Court, Columbus, Oh, 43210.

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extremely high or low levels during the autumn prior to storage.

In addition, it is suggested that the medium surrounding the plant roots be maintained at or close to field capacity at the time of covering and throughout the overwintering period. Also, root zone temperatures should be kept above $-6.7\degree C$ (20\degree F) to avoid root injury to sensitive species.

**Principles of common and refrigerated storage**

The principles governing the successful storage of nursery stock have basically remained unchanged over the years. The primary purposes for storing nursery stock are to protect the plants from unseasonably severe weather conditions during the dormant period, to facilitate the preparation of relatively large volumes of stock for later distribution and to maintain the stock in a prime condition for transplanting and/or sale.

In common storages that rely on ambient outdoor temperatures to provide cold air, the capacity to maintain an optimum storage environment is limited. Properly maintained refrigerated storages should keep the temperatures in the range of $0\degree C$ in order to keep plants in the dormant condition without any risk of injury to feeder roots and to prevent the development of storage molds. Regardless of the type of storage and the method of cooling, it is important to recognize that extreme care be exercised to prevent injury of material stored in dead air pockets or immediately adjacent to evaporator coils or air intakes. Adequate air circulation is, therefore, important to the successful storage operation.

The control of humidity is perhaps the single most important factor in a successful nursery storage operation. Although not always commercially possible, the relative humidity should be maintained in the vicinity of 95 – 98%. Since it is difficult to keep moisture in an atomized state at lower temperatures, the need for adequate circulation within the storage to eliminate dead air pockets and the tendency for moisture to freeze on the coils of evaporators in refrigerated storages complicates the problem of maintaining a high relative humidity in nursery storages.

**Storage systems**

In order to minimize the risk of winter injury to B&B and containerized plants, nurserymen in cold climates commonly overwinter plants inside polyethylene covered structures. To minimize winter injury to plants overwintered in poly structures, nurserymen should allow plants to acclimate as much as possible prior to covering for the winter. Covering houses with opaque (white) or painted polyethylene in order to shade and subsequently cool the interior of the poly house will help minimize desiccation damage. In addition, poly houses should be ventilated only if absolutely necessary during the winter months. Excessively high temperatures in poly houses cause desiccation and high temperature injury to plants within the storage structure. Replacing this warm air with cooler exterior air by ventilating will substantially reduce interior air temperatures, however, much of the moisture within the soil-plant-air system will be removed, thus necessitating its replenishment to avoid future conditions favorable for desiccation.

In addition, anti-transpirants have been used on plants in storage structures to reduce the severity of desiccation damage, brought about as a result of excessive transpiration. Benefits of anti-transpirants include a reduction of leaf drop, leaf browning and flower bud desiccation and helping to retain normal green color of broadleaf evergreens. Two applications per season are advised.

The terms poly blanket or inner-liner refers to the practice of directly covering plants in a poly house with new or used polyethylene sheets. These sheets must be secured under the outside row of plants to create an air-tight seal around all the plants in the bed. Both desiccation and freezing injury has been prevented in many nurseries with this practice. Normally the poly is placed over plants in late December and removed in February depending on weather conditions.

Maintaining supplemental heat in poly storage structures will also insure against plant losses from desiccation, low temperatures or bark splitting. Temperatures are normally maintained at or just below freezing by propane or natural gas fired heaters located in the structures. The additional expense of the second layer of plastic, the electrical requirement, the initial cost of the heaters and the constantly rising fuel costs make this practice economical for high value crops only.

**Microfoam**

An alternative to the typical polyethylene covered storage structure, overwintering of containerized woody ornamentals can be accomplished using a structureless microfoam thermal blanket. The microfoam blanket is recommended for storage of container-grown ornamentals with primary root killing temperatures above $-12\degree C$. When using the microfoam thermal blanket, it is recommended that the plants are irrigated thoroughly 24 hours prior to covering. Upright plants be placed on their sides and rodenticides be placed in the middle and along the edges of the bed to control mice.

Once the bed is prepared and the microfoam is in place, cover the bed with 4 mil clear polyethylene and seal to the ground. There is no need to disturb the microfoam thermo blanket during the winter months, however, as spring approaches, it will be necessary to loosen the ends of the thermoblanket to ventilate.

**Economics of winter storage**

One major purpose in storage of nursery stock is the increased value of the larger plant by the end of the following growing season. In general, the cost of storage of a 1 gallon ornamental plant in a polyethylene covered quonset storage facility is about 10¢. In addition to the single layer poly house, nurserymen also have the option of using some additional overwintering technology to reduce the risk of loss. The extra-cost per container for other systems are estimated as follows: double polyethylene (5¢), minimum heat (6-10¢), water-barrels (0.7¢), and microfoam blankets (0.4¢). Over-wintering ornamentals, if efficiently planned, is economical and greatly increases plant value the following season.