

- (2) Talk to fellow nurserymen about what they are using and their experiences with their facilities. You can learn from their experiences, but you should keep in mind your climate and the particular functions desired for your own facility. Not everyone's operation will be the same.
- (3) Shop at least three suppliers of the equipment you will need. Listen to their proposals and try to determine which one seems the most knowledgeable about your particular application. The lowest bid is not always the cheapest in the long-run. You should also consider the supplier's ability to service the equipment after it is installed.

Some of the things that I have mentioned here might seem elementary or self-evident. However, I have found that when I take the elementary things for granted that is usually when I get into trouble. Careful attention to seemingly minor details is important when making such a large investment.

LITERATURE CITED

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STORAGE OF DORMANT PLANTS

HUGH STEAVENSON

*Forrest Keeling Nursery
Elsberry, Missouri 63343*

Forrest Keeling Nursery is located in northeast Missouri on the hills above the Mississippi River, almost equi-distant between the Gulf and the Canadian border. Here normal minimum temperatures range between 0° and -10°F, but recent cold winters have seen temperatures plunge as low as -25°F.

We are in-ground or field growers. Therefore, we do not have the over-wintering problems facing northern container growers. However, we do grow several million deciduous seedlings, liners, and other trees and shrubs harvested bare-root. These are mostly dug in the late fall or early winter when they are dormant and just before the ground freezes. This material requires most careful and attentive storage to retain its viability until it is ultimately planted by the customer the following spring.

In addition to this bare-root stock, we grow trees, shrubs, and evergreens, which are harvested balled and burlapped (B&B) or, mostly, balled and potted in fiber pots (B&P). A considerable portion of this balled material is harvested in the fall for early spring shipment and thus requires protective storage.

SIMPLE STORAGE METHODS

Storage can be simple or sophisticated. Some of the simplest procedures, if done with adequate care, can be quite as effective as the more involved methods. For example, good heel-in storage or bare-root stock may be unsurpassed. However, the heel-in method is seldom suited to modern-scale production.

I once heard a true story of a chap in his early years as nursery grower. He had shown a buyer his field of shrubs and they stopped under a huge spreading oak to consummate their deal.

"Where is your packing shed?" the buyer asked. "You are standing in the middle of it," the young nurseryman replied.

Now, you can picture stacks of desiccated shrubs handled in such fashion. On the contrary, the nurseryman in question dug to order, did a good job of protecting his stock with tarps and other cover from lifting to packing and delivered entirely acceptable, viable plant material. Obviously, this rather primitive procedure would not be practicable for any but small operations.

BARE-ROOT HARVEST

We do have a number of mail-order and other customers that must have limited quantities of bare-root stock for fall shipment in October. This is really too early to harvest and we dig only such quantities at this time as are essential to fill these limited orders. Otherwise we do no digging until stock is well-defoliated and obviously dormant.

Our first killing frost occurs about October 20, but we do not reach a low of 15°F until about November 10. Then several species and cultivars become defoliated and we can start harvesting. Although a number of defoliants have been placed on the market and various leaf-stripping devices have been introduced, we have no interest in them as we want our plants to become dormant naturally before harvest can proceed.

The period between thorough dormancy and ground freeze-up is indeed limited. We have to go flat out to complete our fall harvest in this brief period. We pretty much put all hands, including our female grading crew, on this chore. Tender hands do not relish pulling frosty shrubs. But we emphasize that unless the plants are in storage there will be no grading work through the winter.

Incidentally, recent introductions in harvesting equipment have substantially speeded this operation. The Grayco modified potato digger pulled with a hydrostat tractor is a real boon where soil conditions are right. We seem to tear up two or three of the Edgedall bed lifters each season, but they are handy devices. The new, one-row, off-set lifter gives good performance with modest power investment.

During drying weather we keep a tank truck in the field to water down this bare-root material as it is dug and placed in pallet crates. A fungicide, such as Benlate (benomyl, duPont) is aded to the water to reduce likelihood of mold once stock is in storage. The crates are loaded on wagons, tarped down for protection against sun and wind, and hauled the short distance of a mile, or less, to the storage buildings

BARE-ROOT STORAGE

Our new storage houses, each with 200,000 plus cu. ft. capacity, are sufficiently insulated with 4 inches of styrofoam so that subfreezing temperatures can be prevented without supplemental heating. We believe it is very important to insulate adequately due to the escalating costs of energy. Before any plants are brought in for storage the houses are thoroughly cleaned and drenched throughout with copper sulfate solution to eliminate residual mold spores. Of course copper sulfate cannot be used on plants. With our control of temperature, humidity and, especially, ventilation (described below) *Botrytis* or other mold build-up is usually not a severe problem. But we do use a spray of Benlate, Botran (DCNA, Tuco) or other fungicidal spray as added protection.

The storage houses are equipped with Bahnson humidifiers, which can create a dense fog in the buildings. We also have intake and exhaust fans that can be thermostatically controlled with outdoor-indoor thermometers; however, we find manual control of the buildings more satisfactory. As I live on the premises, one of my chores is to check the 10:00 pm T.V. weather report. At night, of course, the temperature normally drops while the humidity often rises to or near the saturation point. Wind direction and velocity are also taken into account. Usually this combination of present and forecast conditions will call for maximum or substantial ventilation of the buildings, particularly during the fall and early spring.

Plants, even thoroughly dormant deciduous plants, give off an amazing amount of heat through respiration. When the storage buildings are stacked to the ceiling with pallets of such plants, it takes either a tremendous amount of outside cold air or refrigeration to cool the stored plants to near the freezing point. We do

have a substantial portion of the buildings refrigerated; however, using outside cold air for cooling is a lot less expensive than cooling by refrigeration. Furthermore, most refrigeration systems, excepting double-jacketed cold storage or counterparts, are dehydrators.

On a night when the outside temperature may drop as low as 15°F with high humidity and not much wind, we find we can open the storage doors wide and still not get the inside temperature to the freezing point. Of course the doors are sealed at sunup, normally the coldest hour of the day.

Thus, with careful manipulation of humidistats and air circulation, near ideal conditions can be maintained in good common storage until the warmer days of spring approach. Now it is increasingly difficult to catch subfreezing nights to cool the buildings when plants have "awakened" from their winter rest and are ready to grow. Hopefully, by this time, most stock has been shipped. What hasn't must go into the refrigerated section where temperature can be held near the freezing point.

Some nurserymen store stock under refrigeration in a frozen state slightly below the freezing point, or about 28°F. This seems to work fine with no injury to tops or roots of hardy plants. Under our conditions with grading and shifting of stock proceeding at a hurry-up pace all winter, such storage would present a bit of a problem, not to mention the extra energy cost involved.

Something else — there are indications that the "shock" to certain species taken from subfreezing storage to sudden warm weather planting conditions is harmful to the growth cycle. It would be helpful to have more study on this point.

Storage of this dormant bare-root stock really continues through the packing and shipping process and even after it reaches the customer. We use a heavy telescoping poly-lined corrugated fiber shipping case which generally travels in good condition regardless of shipping method. The insulated walls of the case protect against all but severe or sustained freezing and the polyliners seal against dehydration of the stock. We do add a bit of sphagnum moss or cedar tow for window dressing, but find it necessary to add a card to point out the function of the poly film. It is amazing, after all these years, that some customers still do not understand the function of a polyethelene shield in protecting plants against drying.

STORAGE OF BALLED OR POTTED STOCK

The use of poly-covered quonsets for over-wintering container or balled stock is so commonplace and universal as to need little elaboration. With our in-ground production we are not faced with the over-wintering problem attending the northern

container growers. But we do need to store and protect some stock for two reasons: (a) to have a quantity of stock ready to go for early spring shipment and (2) to protect tops of certain cultivars from winter burn and have the plants in a good, salable condition with the onset of spring weather. The evergreen euonymus is an example of plants in the latter category. Indeed, most evergreens — conifers, as well as broad-leaved plants have a brighter, more appealing color in early spring coming from proper storage than from the field.

We find the “double tent” system economical and quite satisfactory for this type of storage. We used a standard 30 ft wide quonset with a gravel (aggregate) floor and a grade that assures excellent water drainage as well as air drainage when ends or doors are open. The gravel floor also is a good conductor of soil heat to the potted plants. Plants are balled and placed in fiber pots in mid-to-late fall. Before double-stacking in the house, one edge of a sheet of 4 mil clear poly, 16 ft wide, is fastened to each inner side of the house baseboards. The houses are filled with stock by Thanksgiving or the first of December. Now the top cover of 4 mil white poly, 40 ft wide, is stretched in place over the house and firmly fastened to the baseboards. Ends will remain open a bit longer — until about December 10 to provide ventilation. Now the house ends are closed, the potted plants thoroughly soaked and the poly blankets pulled over the plants and fastened to the edges of the center aisle.

With this “double tent,” or blanket within a tent, adequate protection is provided in our most severe weather. We have found temperatures only slightly below freezing when subzero temperatures and high winds prevailed outside. With this system we can see no need for using supplemental heat, the more expensive microfoam blanket, nor for laying plants flat or taking other cumbersome steps. Stored plants need little, if any, attention through the winter. The final soaking before covering with the blanket usually suffices until spring. Of course, if gale winds rip off inadequately secured house covers, or if snow or ice loads collapse the house, all bets are off. We do provide extra bracing against snow loads and try to secure our covers against any expected winds. The combination of a white copolymer tent with clear poly blanket over the plants also prevents advanced spring growth so that the stock can be delivered for display on sales yards at proper time in a fresh but still dormant condition.