The root function in winter is slower than it is in summer. But many factors work together to affect root efficiency or root damage. Landscaping near a downspout may cause a wet soil in fall. This results in shallow roots forming, which can be injured in winter by winter drought. Shallow roots will not re-grow due to lower soil temperature. They may be injured by winter cold, which will penetrate to the 4 cm deep roots more readily than to normal 8 cm deep roots.

Root physiology is a complex subject. The total present environment affects it (too wet-too dry-too cold). The total past environment also influences winter root function (root rot-high salts-nutrient hunger).

NUTRITION PRACTICES AND MEDIA CONTROLS FOR WINTER PROTECTION

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Media Controls for Winter Protection. Information on the influence of the soil medium on winter protection is not very plentiful. Work done by Self (6) in 1963 showed that, after artificial freezing and thawing of containers filled with several media, those containers with sandy clay as an ingredient were the first to freeze. Containers with charcoal or peatmoss had slower freeze rates. Some work done in Georgia showed that media with pine bark were 2 to 8°F warmer than identical mixes with peatmoss as the organic ingredient (4). Both studies indicate that winter protection of containers can be influenced by the medium used.

The most important factors of a medium that influence cold protecion are its: (a) percent air filled pore space or porosity, (b) moisture, and (c) organic matter content (1).

Air space within a container minimizes heat loss through conductance by serving as an insulator. Potting mixes with a large percentage of ingredients that are fine in particle size, such as the sandy clay and other mineral soils, contain little air space. Ideally, a soil mix should contain 20 to 35% air space for adequate drainage and root development (8). This will also provide adequate insulation for winter protection. Most soil mixes have adequate air capacity at the time of potting but, by winter, there has been a drastic reduction in air capacity due to compaction, shrinkage, and decomposition of organic matter. In order to prevent this, one should use shale, haydite, perlite, coarse sand, or other aggregate materials that will maintain sufficient air space throughout the production cycle.

Moisture or water content of the soil mix is a factor nurserymen should constantly be aware of during the winter season. One question nurserymen commonly ask is "Do you water container plots before a hard freeze?" Yes, if the plants are in a stress situation or will be without a regular watering. One should be careful though, not to waterlog the containers because when there is excess water it replaces available air space and serves as a conductor for heat loss from the container.

Most container potting mixes contain some organic matter such as bark and peat. In terms of cold protection it is an advantage to have a high organic content in potting mixes. Organic matter does not transfer heat as readily as mineral soils, which means there would be more heat retention in the container during freeze conditions. Even though organic materials decompose with time and reduce available air, the insulating property is still retained.

At our Experiment Station, the recommended soil mix for general ornamentals is 3 parts pine bark, 1 part sandy clay, and 1 part shale. This mix, in combination with other cold protection measures such as jamming containers and a north wind barrier on outer rows, has given excellent root protection at the Station. This mix contains adequate air space, organic matter, and retains moisture and nutrients.

Even though I've emphasized the medium's influence on protection, without one or, preferably, both of the above protection measures, effectiveness of the soil mix in reducing root injury will be negated.

Nutritional Practices for Winter Protection. Nutrition's relationship to cold hardiness has been a source of controversy for many years. Numerous reports can be found in the literature concerning nitrogen's and potassium's effect on cold hardiness. Early workers reported high nitrogen levels reduced cold hardiness. Potassium was reported to increase cold hardiness and it became an established cultural practice to increase potassium during winter fertilization.

Some nurserymen for years believed that any fertilizer at all during the winter months would render their plants susceptible to cold injury. It is true that excessive fertilization, especially with readily available nitrogen sources, will result in more cold damage. During the growing season both roots and shoots are actively growing, and a high level of fertility needs to be maintained, whereas in winter only roots are actively growing. This means there is a requirement for fertilizers, but at lower rates.

Early work by researchers in the south showed that early winter and subsequent fertilizations decreased leaf drop, improved leaf color, and decreased root and shoot damage on several ornamental plants (2,5,10). An improvement in spring growth has also been shown to result from winter fertilizations. It appears that roots actively absorb fertilizer elements during winter and some elements are transported to leaves and shoots.

It is very important for nurserymen to realize that the key to using fertilizers during winter is to use a balanced fertilizer, one that contains adequate nutrients to supply plants with optimum levels of the elements that are essential to plant growth. In 1940, Lawless (3) observed that after a hard freeze in Florida citrus groves, those trees receiving a complete nutritional program consisting of proper ratios of N, P, K, Mg, Fe, Mn, Cu, and Zn along with proper pH control, showed adequate cold resistance. A deficiency of one of these elements seemed to predispose the tree to greater cold injury. He concluded that there is no magical virtue in any single element that will change the physical complex of the tree, for it is dependent upon the proper use of all nutrients known to be essential to proper tree growth. This does not agree with the practice of some nurserymen who apply single fertilizer elements, such as nitrogen or potassium alone for increased cold hardiness.

Nutritional practices that render protection must begin early in the growing cycle, preferably 4 to 8 months before winter arrives and continue during the winter season. There are three basic means by which nurserymen can achieve optimum fertility levels in container-grown plants. Regardless of the method chosen, one should include a preplant fertilizer in the potting medium. This preplant fertilizer should contain sufficient lime, superphosphate, minor elements and, preferably, some slowly available source of nitrogen and potassium. Lime is added to adjust the pH between 5.0 and 6.5 and if dolomitic lime is used, it also serves as a source of magnesium. Superphosphate is added because phosphorus is very immobile in soil and needs to be uniformly available to plant roots. Trace elements are addd to provide adequate amounts of iron, manganese, copper, zinc, and molybdenum. Care should be taken in choosing the right source; all trace element mixes are not the same. In order to supplement the basic nitrogen and potassium program, it is an advantage to have some N and K in your preplant fertilizer.

The three basic methods of fertilizing containers today are (a) topdressing with granular fertilizer, (b) liquid fertilization with water-soluble fertilizer, and (c) incorporation of Osmocote-type fertilizers. Most nurserymen use one or some combination of these methods to produce their container plants.

These methods mainly supply the major plant elements nitrogen, phosphorus, and potassium.

Research at the Auburn University Agricultural Experiment Station in recent years has revolved around perfecting the third method (7,9). Salable container plants have been produced in 4 to 8 months without additional fertilizers by incorporating 10 to 15 *pounds of 18-5-11 Osmocote per cubic yard at the time of* planting. The research has also shown that this method of fertilizing can be used during seed and cutting propagation. Generally, 18-5-11 will have enough nutrients left at the end of the growing season for winter nutrition. If not, a balanced topdress or liquid material should be used to supplement.

In conclusion, one should know that no single factor or a small group of factors are involved in cold protection. Nutrition practices and media control should be part of a total protection scheme, because freezing itself involves multiple events. From field observations and experimentation it is our believe that a well-fed, disease-free plant with an extensive root system will sustain less cold injury than one suffering from a deficiency.

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