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FACTORS AFFECTING PHYSIOLOGY OF ROOTS IN WINTER

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Roots respond to their environment. The greatest response is to temperature with rapid expansion and translocation from 25 to 35°C. As the normal temperature decreases in fall and winter, root activity slows down. Water content of root cells decreases. Sugar and mineral content increases. Roots are easily damaged by freezing, but in November normal roots become more freeze resistant due to normal hormone changes and decreased root activity.

In the container nursery, roots are not in a normal environment — they are hotter in the winter day and colder at night. Most roots are against the side of the container where the temperature changes are most severe. Without examining roots in pots by upending them, you do not realize that two plants with the same size top may be supported in one case by half a root system and in the other by a quarter root system. In the field, roots are spread over a wide shallow area with a moderated air temperature. Freezing is delayed by earth heat. A long fall season aids in the change of root function. Less water and less nitrogen also aid in making roots more freezeproof (depress injury point temperature).

In some plants cool nights and normal short days have been shown to increase hardiness of roots and stems, but each genetic strain has a different response to temperature.

Before winter, other factors affect how many roots there are and how active they are. *Drainage* of field soil or landscape site or container mix is a major factor of root vigor. Adequate soil air and water holding capacity are vital. Slope and soil amendments change drainage and thus affect root physiology. With high organic soils, wettability is a problem if they ever get dry. Capillary flow is slower than in mineral soils from wet to dry soil. This can lead to winter dessication.

Mulches can be misused on poorly drained soil by forcing a very shallow root system to develop, subject to winter drying or winter freezing. Use a soil probe in field soils to see how wet the root zone soil is. The *irrigation* regime is also vital. Many watering systems are left on too long. It is possible to overwater a soil during a summer or winter drought. Planting root balls too deep will result in the old roots death due to anoxia. If the temperature is moderate, a new root system may develop near the surface where there is a better soil water-air mixture. It is especially difficult not to overwater seedling trays.

Improper *weed control* can result in root injury. *After* the roots are injured and their function changed, you can see evidence of the injury in the leaves.

Fertilization affects root action. Acid soils impair root growth and root function. Over-fertilization results in high soluble salt injury. Damage can be shown from one day or one hour of salt concentration. Broadleaf evergreens lose considerable water on every sunny day. Dead or damaged roots cannot supply that water even in small quantitites. Thus, leaf injury follows root injury.

Root disease is a major factor in winter root disfunction. If a pathogen, a root host, and an environment favorable to the pathogen are present, root injury will result. I like to examine the roots of plant samples once a month. Upend the pot or dig in the bed. The grower cannot tolerate root-diseased plants. He must change the environment (usually less water, less pathogen).

In intensive irrigation culture, plants can exist with very few roots, but after placing in the landscape, they die from drought (few roots).

Winter protection — We must remove some of the stress from plants. Reduce their exposure to sun and wind. Insulate from severe temperature drops.

A snow machine may be ideal. Many alpine plants covered with snow do not suffer drought or cold. In a no-snow year they are killed. Sometimes a band of brown paper or saran cloth around the bed of cans will be enough insulation to prevent heat of the soil from blowing away. It is well known that a dry soil will freeze first. Roots on the exposed side of the can will freeze first.

Root growth and root function are related. If a plant is dropped into a can in December, very little root growth will result and tops may dry out. It is important to shade the tops. If dropped in March, roots grow due to higher soil temperature, and can pump water rapidly.

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,