Protecting against cold damage

Plan now for next year, because you can’t always blame the weather

By Carolyn Scagel

In Oregon’s nursery production areas, the winter temperatures are generally mild when compared to our Midwest and East Coast counterparts. A mild climate has many benefits to the Oregon nursery industry, but it can also lead to unforeseen crop losses related to cold injury or damage, particularly with container-grown plants.

The worst of the winter damage usually occurs sometime between Thanksgiving and Valentine’s Day. By the time this article is in print, many Oregon nurseries will have already spent considerable time and expense preventing cold damage.

There are several strategies Oregon nurseries routinely use to protect their plants against these losses. One of the keys, and one that’s often overlooked, is plant nutrient management.

Is weather the only culprit?

Damage from cold temperatures occurs because of unusual or unpredictable weather events. These are the easy culprits to identify, especially when winter protection strategies were not in place when needed during later autumn or early spring.

Many growers routinely have winter protection for their plants during the time when there is the greatest potential for cold weather, but may not be prepared for unusual temperature events that occur outside this window. This happened in spring 2011 in the Willamette Valley (see Figure 1).

More commonly, the underlying cause of most winter cold damage is not as obvious as one specific cold event. Detection of cold injury is also complicated by when the damage occurs and what parts of the plants are damaged.

In some cases, the nature and degree of cold damage is readily apparent soon after it occurs (e.g.,

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Figure 1. Daily minimum and maximum temperatures around Corvallis, Ore., January 2008 to September 2013. (Data from Agrimet, U.S. Department of Interior, Bureau of Reclamation, www.usbr.gov/pn/agrimet/).
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bark splitting, shoot or bud necrosis). However, most of the time, the damage remains concealed and growers don’t see the full extent of the carnage until spring, in the form of tip dieback, bud abortion or death.

Often, winter injury isn’t revealed until early summer, when the thought of winter cold is far from our minds. Most cold injury to aboveground structures on plants is detected long before the aftermath of cold injury to roots is observed.

Tolerance to cold temperatures is part of the genetic makeup of a plant. However, the ability of a plant to remain unscathed in cold temperature is a direct result of its physiological condition during cold events.

Cold hardiness progresses in the aboveground structures on woody perennial plants in three stages: first, cold temperature acclimation; then, maximum winter hardiness; and finally, winter de-acclimation (Regan, 2012). When and how a plant becomes cold hardy is a result of the plant’s growing environment including nutrient and water availability, temperature and light, and applications of pesticides and herbicides.

For the last decade, researchers at the USDA-ARS Horticultural Crops Research Lab, in collaboration with faculty from the Department of Horticulture at Oregon State University, have investigated methods to improve how efficiently and effectively fertilizers are used in crop production systems. Anecdotal information on winter injury from nurseries and several nutrition studies have indicated that nutrition may play a role in winter injury that cannot be rationalized by weather alone.

What is too little?

Common sense indicates that healthy plants are better able to withstand stress. Adequate nutrients are needed for plants to fully acclimate. Nutrient deficiency may predispose plants to winter injury.

Nutrient deficiency can promote early cold acclimation in Rhododendron (Scagel et al., 2008). Early cold acclimation may be good operationally for a nursery, but it may make the plants more prone to winter injury. Additionally, nutrient deficiency can promote early de-acclimation, making plants more susceptible to bud and stem damage from cold temperatures in late winter and early spring.

The challenge is being able to determine what the nutritional targets should be for proper development of cold hardiness and de-acclimation.

Nutrients are commonly considered deficient in plants when we observe visual symptoms of deficiency or we can see that growth is limited. A broader definition of nutrient deficiency also includes how lack of nutrient(s) alters normal plant function. Visual deficiency symptoms and poor growth are the end result of plant metabolism that is already nutritionally compromised and is not functioning normally.

In other words, a plant can be nutrient deficient without appearing to be. This type of “hidden hunger” can result in unpredictable injury from cold.

What is too much?

Excess fertilizer application can negatively affect hardiness development. Late-season nutrient applications may also delay acclimation, especially if it results in new growth.

There are numerous reports, however, of autumn applications of nutrients that have no influence on hardiness development. For example, spraying leaves with urea in the autumn increases plant nitrogen (N) content, has no detectable impact of acclimation, and may improve plant growth the following spring (Tagliavini et al., 1998). In contrast, N applied to the growing substrate at the same time may result in increased cold injury.

The form of nutrient in the fertilizer can complicate the effects of fertilizer applications on cold hardiness. Green ash (Fraxinus pennsylvanica) trees grown with N from ammonium nitrate exhibit greater cold damage in the spring the following year than trees grown with urea formaldehyde (Scagel et al., 2010). Woody perennial plants appear to metabolize and store nutrients in different forms (e.g., amino acids, proteins) and plant structures depending on when and how the fertilizers are applied and what form of nutrient is used. This means that the timing of fertilizer application, the type of fertilizer, and the methods used to apply fertilizer can alter a plant’s ability to withstand cold damage.
Aren’t hardy plants protected from cold?

Cold hardiness assessments are based on characteristics of the aboveground structures. They may not be indicative of root responses of container-grown plants, where roots are exposed to greater temperature extremes than plants in the landscape.

Roots of perennial plants are capable of growth at any time, given the right conditions, and do not undergo dormancy like aboveground structures on plants. Cool temperatures slow or stop root growth. Stems and buds (and leaves on evergreen plants) can generally tolerate lower temperatures without injury compared to roots (Matbers, 2003). Plant nutrient status is associated with winter injury to roots. Winter root death in container-grown Rhododendron and Vaccinium increased when plants were grown with high rates of N fertilizer. Additionally, greater root death occurs in December and January when plants were fertilized with N in the substrate, compared to foliar sprays (Scagel et al., 2008b).

Plants with cold-injured roots grow more slowly in the spring and may be more susceptible to other stresses, such as water stress or pathogen attack. The long-term ramifications of root death in the winter are commonly not detected until late spring, or sometimes, early summer. By then, plant losses or lack of vigor are often attributed to sources of secondary stress and not the “root” cause (see Figure 2).

Do we need more of specific nutrients?

There is an abundance of literature available describing the roles specific nutrients play in plant physiological processes, including cold hardiness. Unfortunately, little of this information has been translated into nursery nutrient management practices that consistently help mitigate cold injury.

Late season nutrient loading strategies with potassium (K) and magnesium (Mg) have been suggested for protecting plants from winter injury, but their usefulness has not been consistently shown (Chalker-Scott). Soil and foliar K amendments to container- and field-grown Rhododendron and Vaccinium increased plant K concentrations but hardiness was not consistently altered by K additions (Scagel et al., 2008, 2010).

There is strong evidence that another cation, calcium (Ca), may help protect plants from cold injury. Calcium also plays important roles in several plant stress responses, and has been implicated in resistance to freeze-thaw injury to plant cell membranes (Percival and Barnes, 2008). In fact, one of the theories for why high N fertilizer application can increase cold damage is related to the negative effects of high N on Ca in cell membranes.

Container-grown woody perennial plants commonly accumulate Ca in the autumn if it is available in the growing substrate. Calcium loading is not routinely done by Pacific Northwest nurseries as a potential strategy for minimizing cold injury. The lack of adoption, in part, is due to a lack of knowledge about target tissue concentrations and methods for application.

Recent research has shown that both soil and foliar Ca applications, in the form of Metaosate® Ca in early autumn, increased Ca in plants and improved stem and bud cold hardiness of Vaccinium, Rhododendron, Euonymus, and Salix by 3 C to 7 C.

We are currently evaluating how different timing, concentration, and formulation of Ca additives can be used to decrease shoot and root damage from cold temperatures.

Fertilizer application rates, nutrient type, and method of application differentially influence plant nutrient status and, therefore, alter the ability of plants to tolerate stresses (e.g., disease, drought, cold, salinity). Unpredictable factors, such as winter injury, that decrease quality of nursery plants have a large impact on profitability of nursery systems.

Nitrogen is most commonly thought of as the major nutrient that alters cold...
tolerance of buds and stems. The specific relationships between cold tolerance and plant nutrient status and fertilizer application methods need further investigation, however.

**What to do when drinking eggnog**

Here are steps you can take during December to help protect the health of your future plants.

1. While planning for next year, make a note to check root health early in the season. Noticing and acting on visible winter injury to roots, if caught early enough in the year, may save time and money in June and July.

2. Many nurseries routinely perform nutrient analyses, whereas others only perform analyses when deficiencies or toxicities are suspected. If historical nutritional analyses are available for plants, it is a good practice to look for patterns of how nutrients may play a role in winter injury by comparing nutrient analyses with readily available weather information. Check whether changes in fertilizer formulations, application times, or amounts are seemingly related to increased winter injury observed the following year.

3. Think about 2014 growing season changes that may minimize winter injury next year. Make a list of plants (those you haven't decided to stop growing) that randomly show signs of winter injury not related to dramatic changes in weather. Focus on some of these plants as potential candidates for altering their growing environment in 2014. Consider how current practices, including nutrient and water availability, temperature and light, and applications of pesticides and herbicides, could be altered to decrease losses from winter damage.

Enjoy your eggnog — the fog will lift soon and you will soon be too busy to ponder items 1–3.

**Disclaimer**

Chemical names and trade names are included as a convenience to the reader. Their use in this publication does not imply endorsement or discrimination against similar products or services not mentioned.

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**References**


