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The Myth of Mineral Magic

"Adding potassium or magnesium to your landscape plants will increase their cold hardiness"

The Myth

A recent article in a popular gardening resource contained several suggestions for gardeners who like to push the "hardiness envelope" and grow landscape plants outside their natural climate. With winter weather on the way, this information is generally useful for protecting marginally cold-hardy species, though one suggestion was new to me. An addition of wood ashes (for potassium) and Epsom salts (for magnesium) was recommended to promote cold hardiness of plants grown outside their range. Further investigation on the web revealed this to be common knowledge among both popular and some educational sources. In particular, potassium is mentioned hundreds of times as "promoting cold hardiness, disease resistance, and general durability." We are informed by one horticultural consultant that "what the potassium does is strengthen the cell walls of the plant and will displace the amount of water in the cells making it harder for them to burst during freezing temperatures. Water freezing, expanding and bursting." The recommendation to add magnesium for increased cold hardiness is less common on the web, and the rationale behind its use is not clear. Where did these recommendations originate?

The Reality

(Before we address the science behind potassium and magnesium use in improving cold hardiness, I first need to dispel the notion that freezing temperatures cause plant cells to burst. This is a common misconception, but in fact rarely happens in nature. What generally happens is that water freezes in the spaces between the cell walls, and this ice formation draws liquid water from the living cells. The living cells are actually stressed and sometimes killed by the dehydration imposed by water moving into these spaces. The frozen water in these spaces does not injure the plant, since it is outside the cell membranes. Only rapid freezing rates will cause water inside cells to freeze and rupture cell membranes – not cell walls.)

Potassium:

There are a number of scientific publications that address the involvement of potassium and/or magnesium in cold hardiness development. Briefly, potassium is vitally important in regulating cell membrane activity and water relations within the plant. A deficiency in potassium results in foliar symptoms including chlorosis, necrosis, warping, and cupping. If a plant is deficient in potassium, adding this macronutrient will obviously help. Potassium levels can be deficient in acid sandy soils and in intensively managed farmland, but is rarely limiting in non-agricultural soils.

While potassium's importance in water relations is clear, its role in cold hardiness is anything but. In eight separate studies on coniferous species, additional potassium had no effect on cold hardening, while four other studies found a negative relationship between increased potassium and improved cold hardiness. Two studies found an improvement in cold hardiness: one with actively growing turf grass and one with hydroponic seedlings. Three studies found that additional potassium is related to spring hardiness (i.e. late frosts) of vegetative and floral buds that have already broken dormancy. There is absolutely no scientific evidence, however, that additional potassium will increase the winter hardiness of marginally-hardy landscape species.

Magnesium:
Magnesium, like many metals, assists in enzyme activity and like potassium is generally not limiting in non-agricultural soils unless they are quite alkaline. Two conflicting papers looked specifically at interactions between cold hardiness and magnesium in coniferous species: in one, cold damage is associated with high soil magnesium and the other reports the opposite relationship. It is not clear why magnesium has been associated with cold hardiness; it certainly is not based on available science.

Other research:
There are about a dozen other papers that considered potassium and magnesium either together or in conjunction with other minerals. Some of the studies' conclusions conflicted with others; cold hardiness is reported to increase, decrease, or not change as a result of the nutritional regime in question. Potassium and magnesium were occasionally reported to interfere with each other when added in excess. The combined results of these studies can be easily summed up in the words of one of the authors: "there was no clear relation between the pattern of frost hardiness and nutrient concentrations."

Many of these and other papers recognize that cold hardiness is not affected by the presence or absence of one mineral nutrient, but instead is influenced by other environmental conditions. Abiotic factors including drought, flooding, compaction, salinity, mineral deficiencies and toxicities, and air pollutants such as ozone and acid deposition can all increase or decrease cold hardiness, as do biotic factors including pests, disease, and human activities. Often, mild environmental stresses will increase the plant's resistance to that particular stress as well as others – but at other times stresses will make the plant more susceptible to further stress. There is no simple model for predicting environmental stress interactions, and certainly no magic bullet to preventing or treating the plants exposed to them.

It is disappointing that so many university extension websites promote the myth of mineral magic. While a few species may tend towards potassium deficiency (certain turf grasses and palms, for example), this information cannot be generalized to include all woody trees and shrubs. Even where deficiencies exist there is no rational linkage between deficiency and cold hardiness. A few extension web pages do report the lack of science behind this myth, but they are unfortunately the exceptions.

In brief, the best way to prevent cold damage to marginally hardy plant material is to install plants where the microclimate is warmest year round (e.g. leeward of winter winds) and to insulate both the plant and the soil surface from cold temperatures (e.g. by using mulch). During the growing season, be sure other environmental factors are optimal; a healthy plant has a better chance of surviving winter stress. In the winter, the critical point is to prevent the plant from experiencing lethal low temperatures, and no amount of any mineral element will accomplish this.

The Bottom Line

- Before adding any mineral supplement to your landscape, have a soil test done first to determine if deficiencies exist
- Addition of chemicals (organic or inorganic) to a landscape where no mineral deficiency exists is a waste of money, time, and resources, and is environmentally irresponsible
- There is no conclusive evidence that addition of either potassium or magnesium will increase the hardiness of native landscape species
- There is no evidence whatsoever that addition of either potassium or magnesium will increase the hardiness of non-native, marginally hardy landscape species
- To grow marginally hardy species, take advantage of microclimates to maximize their chances for survival
- The best strategy for overwintering marginally hardy species is to insulate them and the surrounding soil

For more information, please visit Dr. Chalker-Scott's web page at http://www.theinformedgardener.com.