Text by Jared Bernard
Photos by David Cavagnaro, Jared Bernard and William Hrycan

SECRETS OF OVERWINTERING PLANTS

Any Canadian gardener worth their salt knows their hardiness zones by heart. A plunge in temperature can be lethal to shrubs and gardens. Even native plants may not survive a rogue cold snap. Yet somehow, as the weather gradually cools during autumn, these same plants prepare themselves to survive the frigid depths of winter. I want to know how the experts prepare their plants for winter.

Frost on red cabbage

In Sangudo, Alberta, Bruce Bashforth approaches what looks like everyday plots of ornamentals or crops. Instead, he's faced with rows of blazing meadowstar, alpine sweetvetch and blue beardtongue. Bashforth, co-owner of Bedrock Seed Bank, has been supplying Albertans with native and non-native garden plants for twenty years.

"The plants we overwinter are divided into two main categories," Bashforth tells me. "Those in containers, cell blocks, pots, etcetera, which are destined for sales or project installations—these are watered very well until complete freeze up so the root balls are basically iced in."

Then he indicates the plants growing in the ground. "These are left completely alone in the field. None of the vegetation is removed in the fall, in order to trap snow around the plants. No particular care is given to any of the species, native or non-native, for fall preparation."

Without any help, the plants arm themselves against the impending winter. How well they accomplish this is referred to as cold hardiness, which indicates the minimum temperature the plants can withstand before they die. But exactly how plants do it is something botanists have been trying to understand since the late 19th century. Now, finally, they are starting to piece together the answer.

Plant antifreeze

Larry Gusta at the University of Saskatchewan investigates how plants like canola combat environmental stress. He explains that when our shrubs and trees prepare for winter, what they are actually doing is preserving their tissues with freezing, using the cold to their advantage.

But it's not that simple. If you fill a plastic bottle to the brim with water and freeze it, what happens? It bursts because the water expands as it freezes. Plant tissues are essentially bottles of water. If they freeze, they will burst open with ice. They may get frost-burned. That's why frozen vegetables become distorted. More likely, they will die because their tissues are too badly damaged. For plants to live through winter, something has to prevent that from happening.

The answer lies in the hills above the ancient city of Lisbon, Portugal, which are sprinkled with pink-flowered trees. These are almond trees, and Pedro Barros is the botanist who is prying open their secrets. Last year, he published an article in the *Journal of Experimental Biology* that illuminates how plants deal with freezing temperatures.

The solution is antifreeze. Just as we put antifreeze in our water heaters or cars to prevent them from cracking from the expanding ice, plants also use a sort of antifreeze. "A plant's response to stress can be divided into two different parts," Barros says.

He explains that first, when the plant detects cold stress, a protein nicknamed ICE1—an appropriate title—is activated inside the plant's cells. ICE1 turns on a special gene called C-repeat binding factor, which I'll call CBF for short. Barros noticed that the amount of CBF in his trees increased as the weather cooled throughout the autumn.

In the second step, the protein that CBF produces sits on the plant's DNA to activate another gene called dehydrin. This is what makes antifreeze proteins.

You can imagine this whole series of genes as a waterfall made up of pools, each needing to be filled before it will spill into the next pool. The pools are genes and the water they deliver to the next pool is proteins. In order to activate the cold response in plants, all the pools must flow so the stream will run into the valley below.

Overwintering Tips

Here are a few tips to keep in mind for your overwintering plants.

- Leave litter around the plants to trap snow for insulation. Remove dead material from herbaceous perennials every couple years.
- Don't fertilize in August or September to encourage growth to harden off for the winter.
- Water sparingly in September to encourage winter preparation. Provide a deep watering at the end of October so plants have enough water in their tissues to survive the dry winter.
- Consider fertilizing with higher phosphorus fertilizers in October for root growth.
- Plant less hardy plants in areas sheltered from cold winter wind, or in places where snow tends to accumulate.
- Watch for spring cold snaps that will kill new growth. If plants are in containers, consider bringing them in the house or garage.

Barros tells me that this last antifreeze-producing gene, dehydrin, is the key that "will be involved in cellular protection and adaptation to the stress conditions." Dehydrin is like the last pool in the waterfall, which empties into the valley stream.

As the weather becomes warmer again in the spring, Barros discovered that his almond trees were deactivating CBF. This is the reverse of what he saw before winter, like damming a pool in the cascade so the lower pools remain dry. The trees are no longer armed for winter; they're susceptible to cold snaps. He explains that "growth resumption leads to a decrease in cold hardiness. Newly growing flowers are no longer able to respond to low temperatures."

Researching cold hardiness

Other research is adding to our understanding of what overwintering plants need from us in order to prepare for winter. Michael Wisniewski says plants need to stop growing to become cold tolerant. Wisniewski does his research in the Appalachian Mountains of West Virginia, where he was named researcher of the year by the American Society of Horticultural Science.

"In order to increase cold hardiness, a cell must lose a lot of water," Wisniewski says. "If you lose this water, then it is not available [for growth]." So plants must divert a lot of their carbohydrates away from growth to become cold hardy.

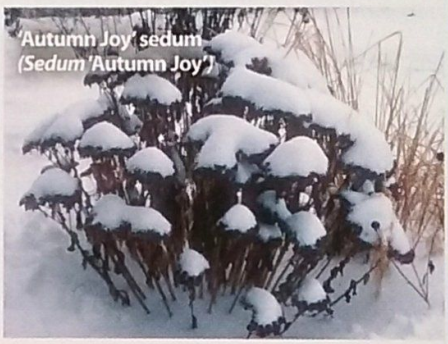
Leonard Perry of the University of Vermont says we should not encourage growth during the late summer. If you fertilize in August and September, the plants will be too busy making new growth to arm themselves before the first frost. Appropriate fertilizing in October, however, could promote root growth. Test your soil for nitrogen, potassium and phosphorus, and only apply the missing elements.

Research will also help us develop plant varieties with better cold hardiness. Do you have an apple or cherry tree in your backyard, or any other overwintering variety, that you feel isn't growing too well? The reason may be related to its cold hardiness.

"There is usually a trade-off between growth and stress resistance, so achieving a balance is not easy," Wisniewski says.

Feather reed grass and 'Autumn Joy' sedum (*Calamagrostis* x *acutiflora* and *Sedum* 'Autumn Joy')

'Vates' collard greens



'Autumn Joy' sedum (*Sedum* 'Autumn Joy')

Pine (*Pinus* spp.)

Crocus (*Crocus* spp.)

Veronica and blue oat grass (*Veronica* spp. and *Helictotrichon sempervirens*)

Hoar frost on pine

Red-twig dogwood (*Cornus sericea*)

Meadow blazingstar (*Liatris punctata*)

Your overwintering plant is likely a hybrid variety. Barros tells me that a breeder crosses a cultivar with cold hardiness and one with vigorous growth or tasty fruits to create a cold tolerant variety. Because it's a trade-off, some amount of growth or tastiness may be sacrificed to help it fare better over the winter. Your crabapple tree may not taste good, but it's great at dealing with the winter! If we can test plant DNA for cold hardiness, Barros hopes we can eliminate a lot of the guesswork and have cultivars with increased cold tolerance.

Cold hardiness research offers insight into what to expect with fluctuations in winter temperatures. If we have a very severe winter, Barros says plants may come out of dormancy. One aspect of cold hardiness is that plants require a certain duration of freezing conditions. It is as if the plants are "counting" the hours of winter. If the requirements are fulfilled early because the winter was colder, the plants break their dormancy, "which may cause flower death since flowers are extremely sensitive to freezing," Barros says.

Gusta describes the flipside. "The problem is further complicated with global climate change. Unseasonal warm spells in midwinter result in bud break, which results in a loss in freezing tolerance. If this is followed by a cold spell the flower buds will be killed."

A sense of urgency

The erratic winters we see these days, warm waves punctuated by harsh cold snaps, are devastating to our overwintering plants. A warm phase tells a plant to stop producing its CBF because it "thinks" spring has come. Our waterfall of cold tolerance is therefore disrupted and the plant is vulnerable to the return of the cold.

"This happened about four years ago in the Midwestern US, and there was over a billion dollars in crop loss to many fruit trees," Gusta says earnestly. "In January this year, there were several killing frosts in Arizona which killed many crops. With the late spring planting this year there is the potential for fall frost damage."

These kinds of crop losses are the reason so many plant researchers are trying to put cold hardiness genes into ornamentals and crops using GMO technology. Researchers are even trying to create cold hardy GMO varieties of things like petunias and flax so they can survive killing frosts, Gusta says. Some of the GMOs have increased their tolerance from -3 to -5° C. So far, no one has been successful beyond this, either with breeding or GMOs.

In the springtime, Bashforth is mowing over his plots of herbaceous perennials in Sangudo. Don't be alarmed. He's removing last year's dead material before it starts growing again. "We recommend that dead growth be removed only every second to third year as the litter is very beneficial to rebuilding soils and conserving moisture," he says.

For over a hundred years, growers have wondered how plants can survive the deep freeze but not cold snaps. Although we now know what's happening behind the scenes, northern gardeners have already learned many of the rules. Bashforth's farm is a prime example of how to work with your plants, native or non-native, in the autumn and spring to help them survive winter.

Jared Bernard is an Edmonton-based freelance writer who has a bachelor of science degree and a keen interest in learning new things about the world. His writing appears in American Forests and Natural History.

American mountain-ash ***(Sorbus americana)***

Spinach

Hoar frost on rose

Pansies ***(Viola* x *wittrockiana)***