How Grapevines Reconnect in the Spring

GRAPES 101

Grapes 101 is a series of brief articles highlighting the fundamentals of cool climate grape and wine production.

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After bud swell, new shoots rely on carbohydrate reserves from canes and roots to fuel their growth. New shoots initiate vascular connections to canes and trunks, reactivating the vascular cambium that produces new conductive xylem and phloem layers down the trunks to the roots – a process that is completed around bloom. Starch is stained black in the figures above.

When vines are fully dormant during the coldest part of the midwinter, grapevine buds are isolated from the plant’s vascular system, desiccated, and filled with compounds that resist freezing. Vascular elements in the canes and trunks are either plugged with callose tissue (phloem) or emptied of water (xylem). When growth starts in the spring, the grapevine needs to re-establish the vascular connections between buds and roots. This process, which begins at bud burst, only becomes complete around bloom, and is driven by the developing buds and new shoots.
In a previous Grapes 101 article, we described how buds gain and lose cold-hardiness. In this article, we’ll focus on what happens during the early stages of vine growth in the spring when the grapevine re-establishes the vascular system between buds, canes and roots, how winter injury to buds and trunks can affect early season growth, and the key role that live buds and new shoots play in driving this process.

**Dormant buds and canes**

To survive the coldest part of the winter, grapevine buds are isolated from the vine’s vascular system (water-conducting xylem and nutrient-conducting phloem) and dehydrated. It takes both increasing temperature and tissue wetting for bud break and shoot emergence to occur. In dormancy, canes are protected from external wetting by a water-resistant periderm (cork) layer, and the vascular cambium—the thin meristematic tissue between the inner xylem and outer phloem—is inactive.

Once vines enter winter dormancy, their buds will not break in early winter, even if given warm temperatures, as buds must experience a minimum time below about 40°F (5°C) to "prime" bud break. Bud deacclimation is a real threat if warming occurs, especially if it is prolonged, because it becomes more difficult to reacclimate buds toward late winter and early spring. In late winter, after minimum chilling requirements have been met, buds can push if adequate heat and moisture are present for any length of time.

As warm temperatures in the spring increase and buds are rehydrated (whether from actual bud wetting, from highly humid air, or by slow perfusion of water through the bud cushion at the cane), they gradually deacclimate and become less resistant to cold temperature. As temperatures rise above freezing, temperature-dependent enzymes begin to activate, their rate of activity doubling with each 10°C rise in temperature. As soils warm, root absorptive activity increases and capillary
action draws water up through the trunk's xylem vessels, resulting in sap flow and increasing hydration of buds. As buds swell they initiate new vascular connections at their attachments to the canes.

The new shoot

Inside the overwintering compound bud lies a fully formed compressed shoot (the primary bud), complete with cluster primordia and several nodes of leaf primordia. As this shoot starts to expand, its apical meristem becomes active and begins to initiate new leaves. If this central, primary bud is damaged, smaller buds at its base can become activated. These (termed the secondary and tertiary buds) bear fewer leaves and fewer or no clusters and therefore may produce a leafy canopy but a poor crop.

Live buds reactivate the vine's vascular system

The actively dividing shoot tip produces auxins, which are hormones that stimulate reactivation and development of the vine's vascular system. These auxins send signals out from the emergent bud that result in the growth of new vascular traces at the bud base, uniting the bud and its cane and then stimulating the cane to activate cell division in the vascular cambium. This stimulus proceeds downward through the canes into the cambia of cordons and trunks; thus there is a downward wave of initiation of new xylem vessels on the cambium's inner side and new phloem elements on its outer side. Winter injury to buds and trunks can disrupt this process and cause disruption of shoot-to-root connectivity.
Xylem and Phloem

The xylem tissue consists of several cell types: lignified supporting fibers, water-conducting vessels (dead, lignified tubes) for conducting water up from the soil, and ray cells for storage and radial transport. Outside the xylem is the phloem tissue, which conducts nutrients and carbohydrates to and from the new shoots and the roots. Phloem consists of storage cells, bands of fibers, and long strands of conductive sieve tubes. Sieve tubes in stems live about 18 months, so only one functional increment of phloem is produced each year, and that increment must survive the winter. This phloem lies just below the brown bark and periderm layer and is also the stem and trunk tissue most susceptible to winter injury. In spring, conductive phloem cells—only a few layers thick—mobilize by dissolving the callose that plugs the sieve tubes, and then they transport stored starches and nitrogen reserves to developing tissues, until a new phloem layer is produced by the activated vascular cambium.

Root growth

In spring, soils typically warm up more slowly than the air, so production of new xylem and phloem also lags behind aboveground growth. Root growth is also dependent upon the auxin signals from shoot tips, and it is thought that the vascular system—from shoot tip to roots—only becomes fully reactivated within a week or two of bloom.

Reserves Fuel Early Growth

(See photo at top of article) Early vine growth is fueled by nitrogen and starch reserves stored in canes and trunks (1/3) and roots (2/3). Starch and nitrogen stored in these tissues is mobilized between bud burst and bloom, first from the cane tissues closest to the buds. (Figure at left shows starch concentration from bud break to bloom). By bloom, the developing canopy is capable of producing enough carbohydrate to support vine growth. The vine's vascular system is reconnected and able to take up the nutrients, including nitrogen, and water needed for continued growth. (See Sources and Sinks: Allocation of Photosynthates During the Growing Season for more information).
Impact of Winter Injury

This process of vascular development proceeds automatically in temperate climates, but when winter injury damages buds or trunks, these processes can be disrupted.

Bud mortality

Winter injury to buds can have a lasting impact on trunks and canes downstream of them. If most of the buds on a cane or spur are dead, then the vine's vascular cambium directly downstream of the bud's potential auxin flow will not be reactivated. Only vascular traces from live shoots will stimulate the vascular cambium downstream to produce a new layer of conductive xylem and phloem cells.

Trunk Injury

Rapid temperature drops while the vine's xylem is conducting water—often early or late in the dormant season—can lead to trunk splitting as water freezes and expands within the tissue. Split trunks can dehydrate rapidly and localized wound-compounds can seal off vascular flow. The phloem layer, just under the bark and periderm, is susceptible to freeze injury. Even when buds are apparently alive at the start of the growing season, injured trunks may supply enough water and nutrients for the early part of the season, only to suddenly collapse later in the growing season.

Inadequate Vine Reserves

Grapevines are good at storing reserves for the dormant season. However, in extreme situations where vines are defoliated early or harvest is delayed until after
a killing frost, vines may enter the winter with inadequate stored carbon or nitrogen reserves. Weak shoot growth the following spring can be a consequence.

Management

Winter injury, varying in frequency, is a fact of life in cool climate regions. The key role that grapevine buds and vine reserves play in reactivating vascular tissues should be uppermost in a grower's mind in understanding and reacting to winter injury. While vines are able to tolerate and recover from moderate bud injury, growers will need to react to more severe bud and trunk injury. Growers can compensate for bud injury by leaving extra buds to produce a marketable crop following winter injury, but significant cold injury signals the need to carefully monitor vines and prepare to renew trunks.

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