Viticulture and Enology

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Grapes 101

How Grapevine Flowers Form

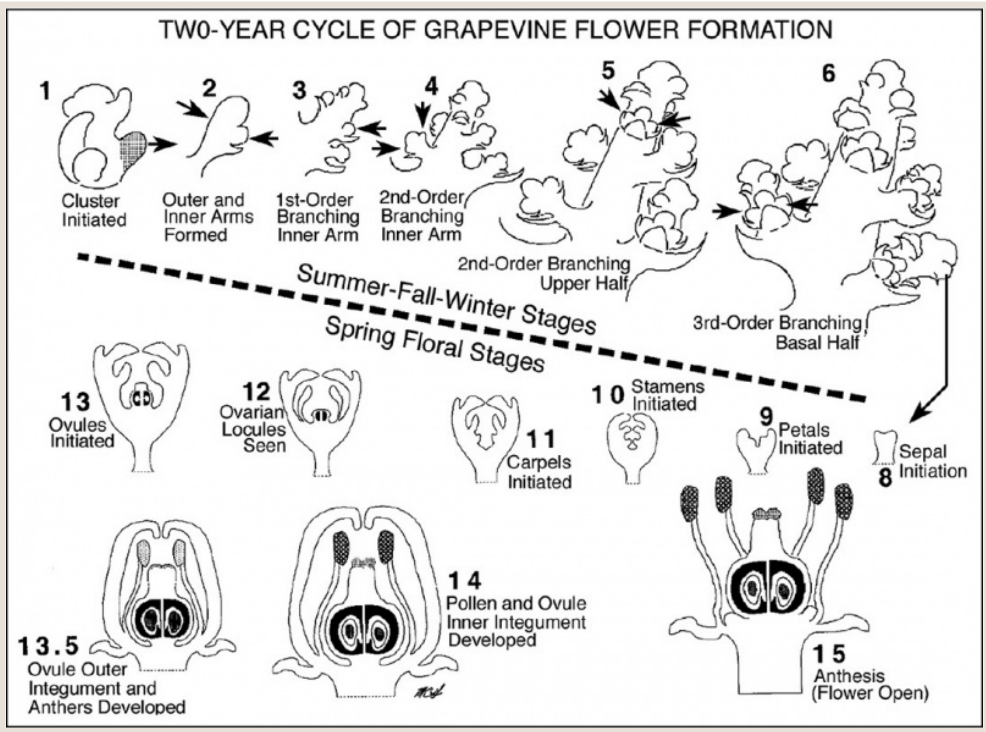

Figure 1. Floral development follows a two-year cycle. Stages 1 to 6 depict initiation of clusters in primary buds of grapevine in June to time of winter dormancy in December. Stages 8 to 15 depict post-winter stages from floral initiation through anthesis

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Grapes 101: How Flowers Form

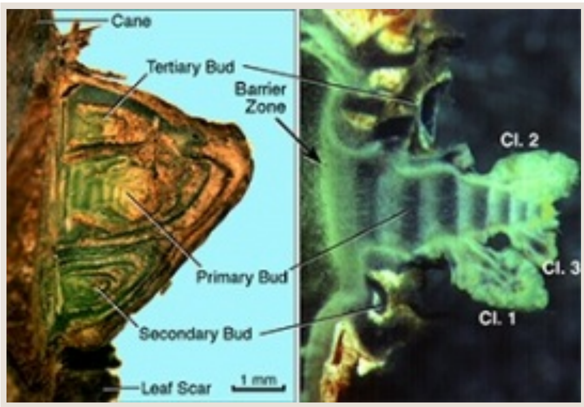
(bloom) the next growing season. Stage 7 would describe the very rare instance of a flower initiated by winter. Figure by Martin Goffinet.

How grapevine flowers form

By Tim Martinson

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

Ed. Note: This summary is based largely on material found in Chapter 2 of Markus Keller's book The Science of Grapevines (first edition). Thanks to Martin Goffinet for the figures and a helpful review of this article.



Dormant buds carry the crop potential for the coming year. They have a set number of clusters, whose development started around bloom during the previous growing season. Photo by Martin Goffinet.

Grapevine flowers turn into berries, so the process by which they are formed is a key component of vineyard productivity. How many inflorescences form and how many florets and berries they end up producing is heavily influenced by the process of bud formation, the light environment in which the buds are formed, and the physiological state of the vine – both during the middle and end of the growing season, and early on as buds awaken from dormancy in the spring.

Like many other perennial crops, grapevine bud and flower formation is a two-year process. Buds initiated during shoot growth in the first season produce shoots with flowers for the following growing season. Anatomists divide flower formation into three separate processes:

Inflorescence initiation. Inflorescences form within complex, or compound, buds in grapevines. Fruitful buds are initiated in leaf axils (located where the leaf stalk, or petiole, meets the growing shoot). A bud's apical meristem (cells at the tip of developing tissues that actively divide) produces lateral meristem primordia that are at first "uncommitted" – that is, each lateral meristem can either develop into a tendril or an inflorescence, depending on factors influencing tissue differentiation. This occurs within each of the individual bud branches (primary, secondary, and tertiary) that will make up the final compound bud retained over the coming winter period.

Flower initiation. Around the time that four or five leaf primordia have been formed inside the newly-developing bud, the lateral meristem tissue differentiates into either an inflorescence or a tendril. This process is influenced by the light environment surrounding the bud and leaves (particularly the leaves on the same side of the stem that are one node above or below the developing bud), the amount of photosynthate flowing into the developing bud, temperature conditions, and the vine's nutrient status.

By around véraison (about three months after budburst), the number of inflorescences within "fruitful buds" up and down the canes is pretty much set.

Floral differentiation: Inflorescence branch formation before dormancy. Committed inflorescence primordia further develop by forming branches (initiating several lateral meristems that turn into branches and individual florets). This process begins around bloom, starting with the most basal buds and moving up the shoot, and continues until buds enter

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Véraison to Harvest

dormancy. At dormancy, inflorescence primordia branching is well developed, but individual flowers and their parts are not yet initiated.

Floral differentiation: Bud swell to bloom. As buds are reactivated in the spring, floral development resumes. Each fine-branch meristem produces clusters of 3-4 flower primordia before bud burst, with formation of a calyx (fused sepals at outer edge of flower).

After bud burst, individual flower organs (corolla made up of fused petals and pollen-producing stamens) first appear, followed by the pistil, ovaries and individual ovules (female organs). This process may be largely complete by about 15 days after bud burst.

Anthesis (flowering). About two weeks after ovules are formed, the calyptra (fused petals surrounding flower parts) separates at the base, and is shed. In our climate, most flowers open within 5-7 days; but cool temperatures can delay and extend the bloom period. Bloom is well-synchronized in our climate with its severe winters, but can extend over 3-4 weeks in Mediterranean climates with mild winters (see: Climate, Duration of Bloom, and the Window of Risk for Grapevine Diseases). Anthers (pollen-laden structures at the tip of stamens) release pollen after cap fall.

Pollination. Commercial cultivars with perfect flowers (both male and female parts) are often self-pollinated, but most wild grapevines have either male or female flowers, and require cross-fertilization. Once the pollen lands on the stigma (receptive part of the pistil), the pollen germinates and produces a pollen tube, which fuses with the ovule.

Importantly, the rate of growth is critical, because the ovules are only receptive for a short time after bloom. At high temperatures (25-30° C) fertilization occurs within 12 h; at 20°C, this process takes 24 h, and at low temperatures (15°C), 48 hours. With cooler temperatures, growth of the pollen tube may be so slow that fertilization doesn't occur.

Factors affecting flower formation and fertilization.
Weather conditions, the light environment, and vine stressors such as water or nutrient deficits can have dramatic effects on the processes leading to inflorescence and flower formation, and ultimately fruit set – many of which are beyond a grower's control. Here are a few of them:

- **Light environment**. Shoots that are shaded in a dense canopy tend to have less fruitful buds. In practic

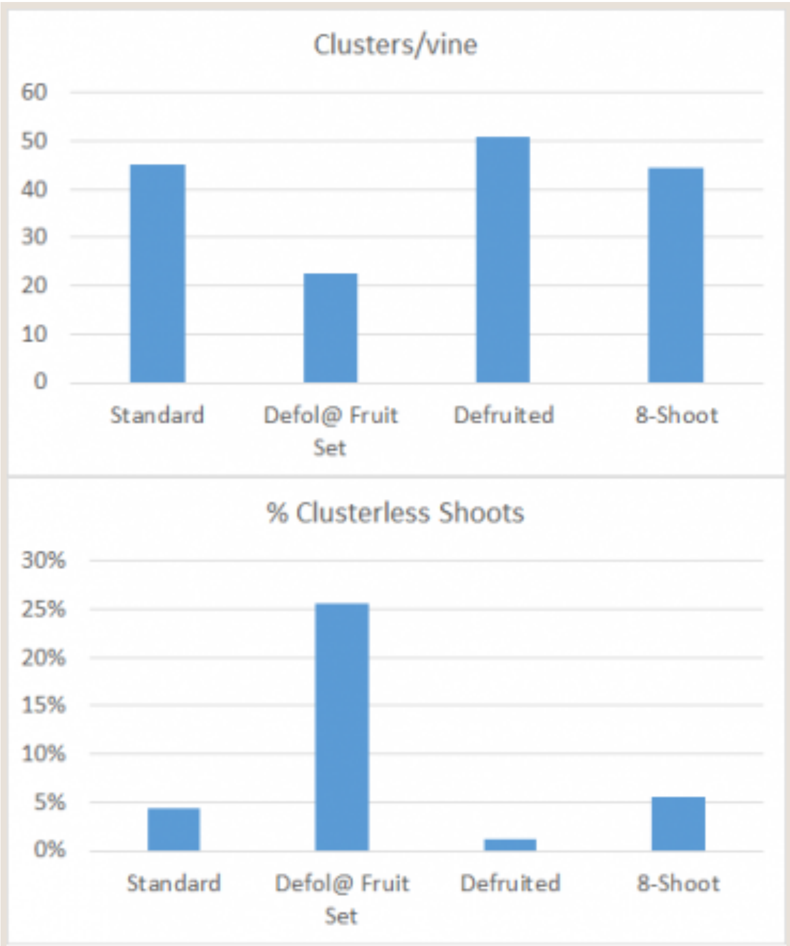

Figure 2. Carryover effects on cluster number and

e, the period of inflorescence induction for the first 6-10 nodes retained at pruning tends to occur during 3 or 4 weeks centered around bloom.

Figure 2: Carryover effects on cluster number and the percent of clusterless shoots in 2018 resulting from complete defoliation at fruit set in 2017.

- **Supply of photosynthates to buds.** Assimilates (sucrose, N), whether produced by leaves or from stored reserves, are key factors influencing inflorescence induction in developing buds. Stored reserves that fuel early-season growth are largely exhausted by bloom (see **Sources and Sinks: Allocation of Photosynthates during the Growing Season**), so reductions in leaf area from cluster-zone leaf removal or poor early-season canopy development can reduce bud fruitfulness and return bloom the following year.

One example comes from a 2017 study where we completely defoliated Riesling vines at fruit set (we left the shoot tips on, and they produced a new canopy by veraison). In 2018, these vines had a 50% reduction in cluster number, and 25% of shoots were clusterless, compared to 4% in the 'Standard' treatment.

- **Stored Reserves.** If vines enter the dormant season with low amounts of stored carbohydrates, floral development in the spring can be compromised. This can be the result of over-cropping, disease that reduces leaf area (think downy mildew), or early leaf fall in cool seasons. Goffinet (2004) measured carbohydrate reserves in minimally-pruned Concord vines, some of which were defoliated at veraison – and therefore over-cropped. The defoliated vines depleted starch reserves the following spring a week earlier than balance-pruned vines, and produced fewer mature leaves to export newly produced photosynthate to the flowers. High crop-to-leaf areas during the ripening season strongly influenced over wintered reserves and primary bud potential.

- **Low temperatures, cloudy weather and extended bloom.** Temperatures at or below 15° C can delay pollen tube growth, resulting in poor set. Cloudy weather that results in less carbon assimilation than on sunny days can limit the supply, also resulting in poor fruit set.

Understanding the timing and sequence of floral development – and the factors that affect it – can help growers diagnose some of the reasons for poor fruit development. Some practices (crop level adjustment, timing and extent of cluster-zone leaf removal) are manageable, while others (weather) are not.

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