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In a Nutshell
Tulare County

Budbreak, Bloom, and Pollination Events Mark the Start of the Walnut Season

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Spring leaf out and flowering signals the start of the walnut season, but the processes giving rise to the current year's crop were initiated only weeks after flowering the prior year. As a result, growers and orchard managers are concurrently managing the crop of two seasons for approximately 10 months of the year. Understanding the main botanical and developmental processes occurring throughout the season may aid in better managing two consecutive years of crop. This article will highlight the spring developmental events in California walnut orchards from bud break through bloom and pollination.

Walnut buds. Walnuts are monoecious, meaning they have male and female flowers on the same tree. The male flowers are assembled in structures called catkins (Figure 1), which are borne directly on the prior year's growth (Figure 1). Prior to leaf out, the catkins are visible and easy to identify (Figure 1). Walnuts do not have traditional "simple" female flower buds, but rather a compound bud (Figure 1) that contains the preformed shoot with female flowers at its terminus. At leaf out, the preformed shoot expands and compound leaves begin expanding prior to the appearance of the pistillate (female) flowers (Figure 2). The fact that the female flowers are at the end of the preformed shoot explains why walnut cultivars are characterized by both their leaf out date and bloom date, as well as the date of pollen shedding (anthesis); these occur progressively over time. Generally, the buds on mature trees enclose 4-5 preformed leaves. Often walnut flowers are assembled in pairs; however, it is not uncommon for female flowers to appear singly or in groups of three or four.

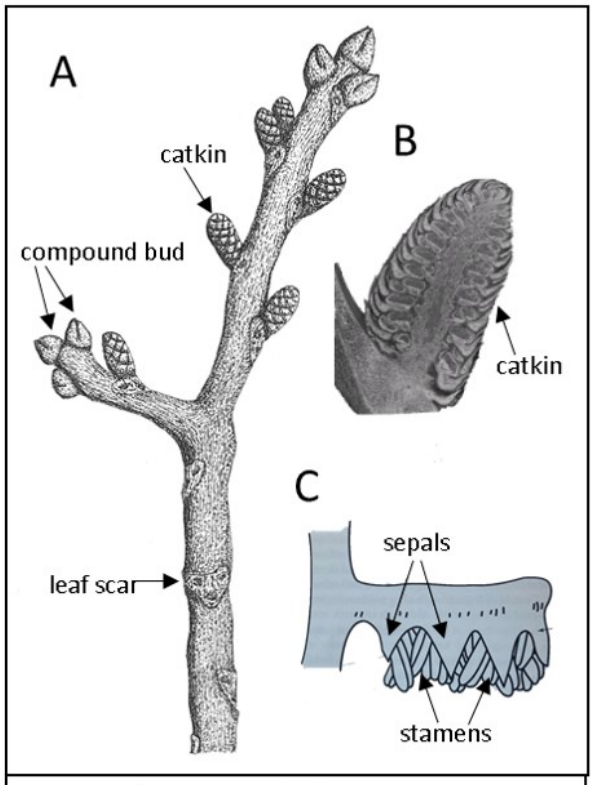

Figure 1. A) A walnut twig bears catkins on the prior year's growth and compound buds contain the current year's shoot and pistillate (female) flower buds. B) A high resolution computed tomography (HRCT) image of a catkin on a dormant twig C) Each catkin contains numerous, non-showy, staminate (male) flowers. Illustration credit (A): H. Hartzog; Photo credit (B): B. Pratt; Illustration credit (C): V. Polito

Successful pollination. At anthesis pollen shed from staminate (male) flowers (Figure 1C) is disseminated by wind, thus eliminating the need for showy flowers adapted to attract insects (as in almonds). Due to its low water content, walnut pollen only remains viable a short time, generally 24-48 hours. Because wind-

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blown pollen must fall on the stigma of a receptive female flower (Figure 2) by chance, wind-pollinated crops produce copious quantities of pollen, thus facilitating the probability of successful pollination.

Female flowers are only receptive to pollination for a short time. Pollen must be deposited on one of the two stigmas (Figure 2) on a female flower for a nut to develop. The stigmas are only receptive after they expand and separate. They remain receptive until they part to approximately a 45° angle Figure 3). During this receptive phase, an exudate is present on the stigmatic surface, allowing viable pollen grains to stick, hydrate and germinate.

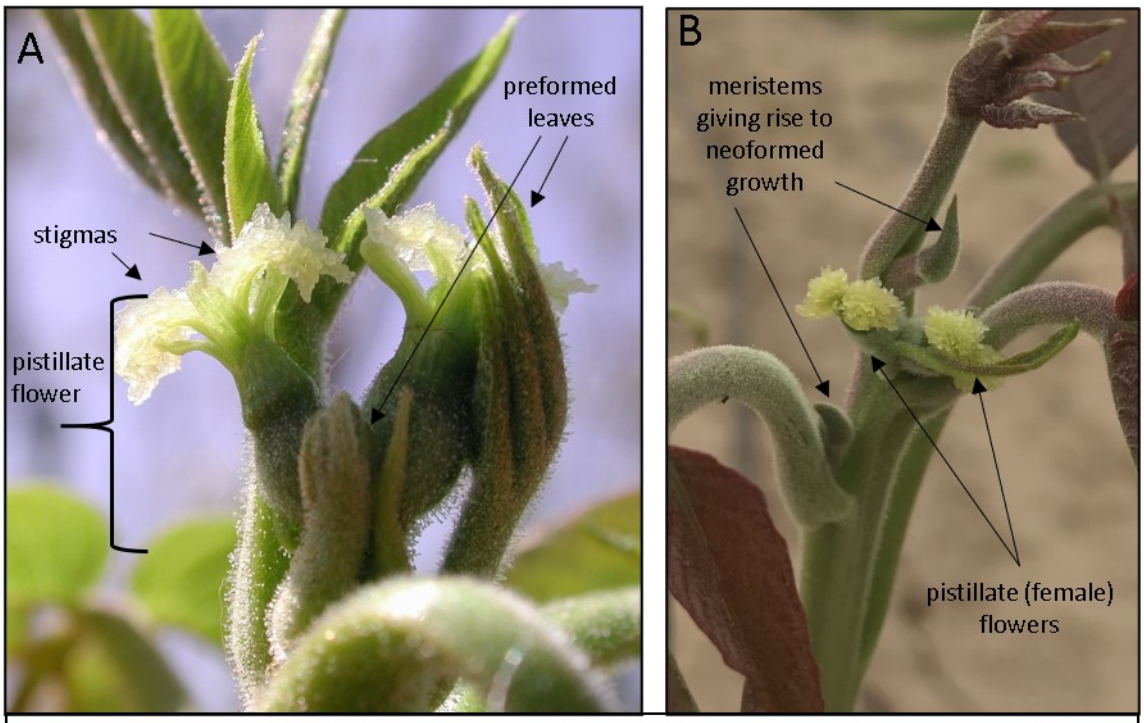


Figure 2. In **A**, two pistillate flowers have emerged at the end of a preformed shoot. New meristems emerge in **B**, giving rise to neoformed (in-season) growth. Photo Credit (A): V. Polito.

Self-compatibility and cross pollination. Walnut is self-compatible, meaning that the pollen shed by catkins on one tree is capable of pollinating pistillate flowers on the same tree - or other trees, regardless of variety. However, walnuts have adapted a mechanism called dichogamy to reduce the degree of inbreeding. In dichogamous plants, pollen shedding and pistillate bloom occur at different times, increasing the likelihood of outcrossing with other individuals. Walnuts are heterodichogamous meaning that the female bloom may either precede or succeed the male bloom. Most commercial walnut varieties (ie. 'Tulare', 'Chandler', 'Howard', 'Serr') are *protandrous*, meaning that the male flowers mature and pollen shedding occurs before female bloom begins. 'Ivanhoe', 'Gillet', and 'Forde' are *protogynous*, meaning that the female flower begin opening prior to the pollen shedding. Using 'Ivanhoe' as an example, the female flowers begin becoming receptive at about the same time that 'Serr' is shedding pollen, thus 'Serr' may be a large contributor to 'Ivanhoe' pollination (Table 1). Dichogamy is the reason that including pollenizers in orchards is recommended for some varieties and situations, for example with main varieties that do not have good male-female overlap or in isolated walnut blocks that might not have sufficient local pollen to set a crop. In most walnut-growing regions, however, there tends to be sufficient pollen movement among orchards to set good crops. For more information on

appropriate pollenizers for commercial walnut varieties, visit: http://fruitandnuteducation.ucdavis.edu/fruitnutproduction/Walnut/Walnut_Cultivar_Table/.

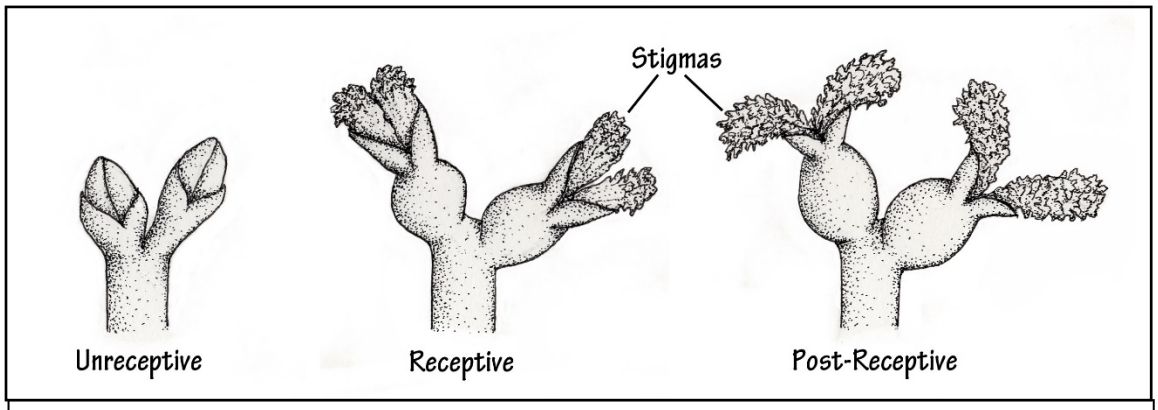
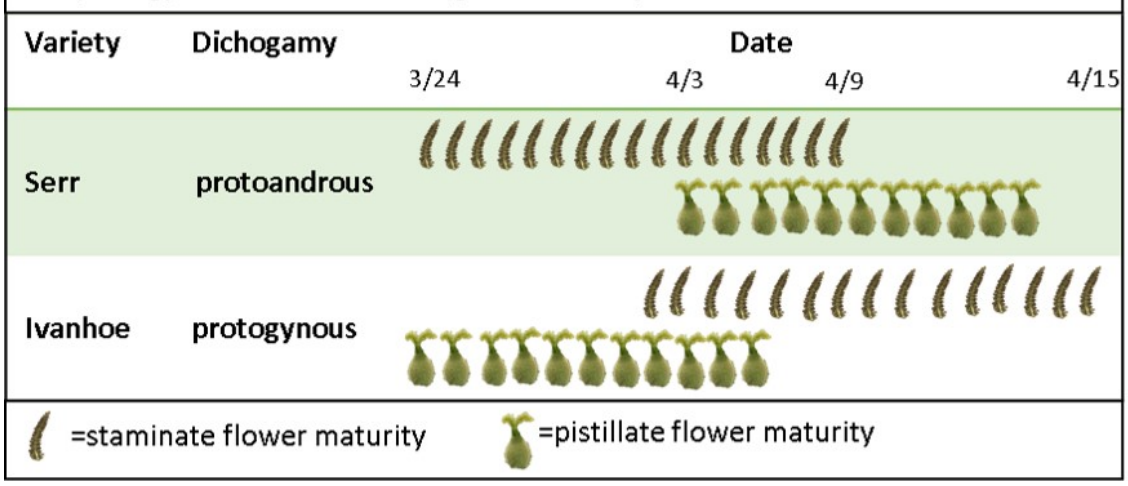


Figure 3. Female flowers are receptive when the stigmas have emerged to an approximate 45° angle. Illustration Credit: H. Hartzog.

Dissimilarity between nuts. The developing nut crop on a tree may have multiple male parents, with the male parentage of each nut determined by the pollen source available at the time it was receptive. The timing of individual pistillate flower receptivity can also affect nut size. Studies have shown that the later blooming flowers give rise to smaller nuts than earlier blooming ones. Climate conditions during bud break and bloom and lack of adequate winter chilling may also impact male and pistillate bloom timing, pollination and, as a result, nut set and size.

Pistillate Flower Abortion. In some varieties, too much pollen may result in pistillate flower abortion (PFA). In California, this phenomenon was first characterized in 'Serr' blocks (termed 'Serr' drop) where nut set was notably higher as distance from 'Tehama' or other pollenizers increased. PFA does occur in other cultivars, mainly 'Tulare', but to a lesser extent. Excessive pollen on pistillate flowers has been determined to be the cause of PFA. Management of PFA may be achieved by reducing pollen load in 'Serr' blocks by removing pollenizer trees or mechanically shaking the catkins from pollenizer trees. If the male and female bloom in a 'Serr' block are expected to overlap significantly, some growers may opt to also shake catkins from the 'Serr' trees. Rain events during bloom remove pollen from the air and may significantly mitigate PFA. PFA risk is greatest in the years when Serr blocks produce abundant catkins, there is large overlap of male

Table 1. The male bloom on the protoandrous 'Serr' overlaps the female bloom on the protogynous 'Ivanhoe' making it a suitable pollenizer for 'Ivanhoe.'



and female bloom and when rain does not occur during bloom. The ethylene biosynthesis inhibitor, Retain® (Valent BioSciences), applied at 5-30% female bloom, has long been shown effective in reducing PFA in susceptible varieties, but the economic cost-return balance (cost of treatment vs expected increase in yield) must be weighed carefully in every situation.

Conclusion. The timing of spring leaf out and female flower emergence and maturation varies widely between cultivars and is heavily influenced by the weather. In years where temperatures drop substantially after the early varieties have leafed out (mid-March), late varieties such as 'Chandler' may be a full month later than their early counterparts. Only 8-10 weeks past bloom, the compound buds housing the pistillate flowers for the following year's crop begin forming, and the process continues.

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