What You Do Now Will Affect the Next Bloom

This season I have talked to growers that have reported patchy bloom/no bloom; bare shoots; witches' broom growth (bud failure); or limited extension growth, etc. Each of these reflect, in part, effects on bud initiation and development. Bare shoots, for example, may result from failed bud formation, bud death before emergence, abnormal development, or extended dormancy. The causes of disrupted or abnormal bud initiation and development are not all understood, but it is known that buds are influenced individually or in combination, by their genetics; environmental conditions; nutritional, chemical and water status; and by biological organisms.

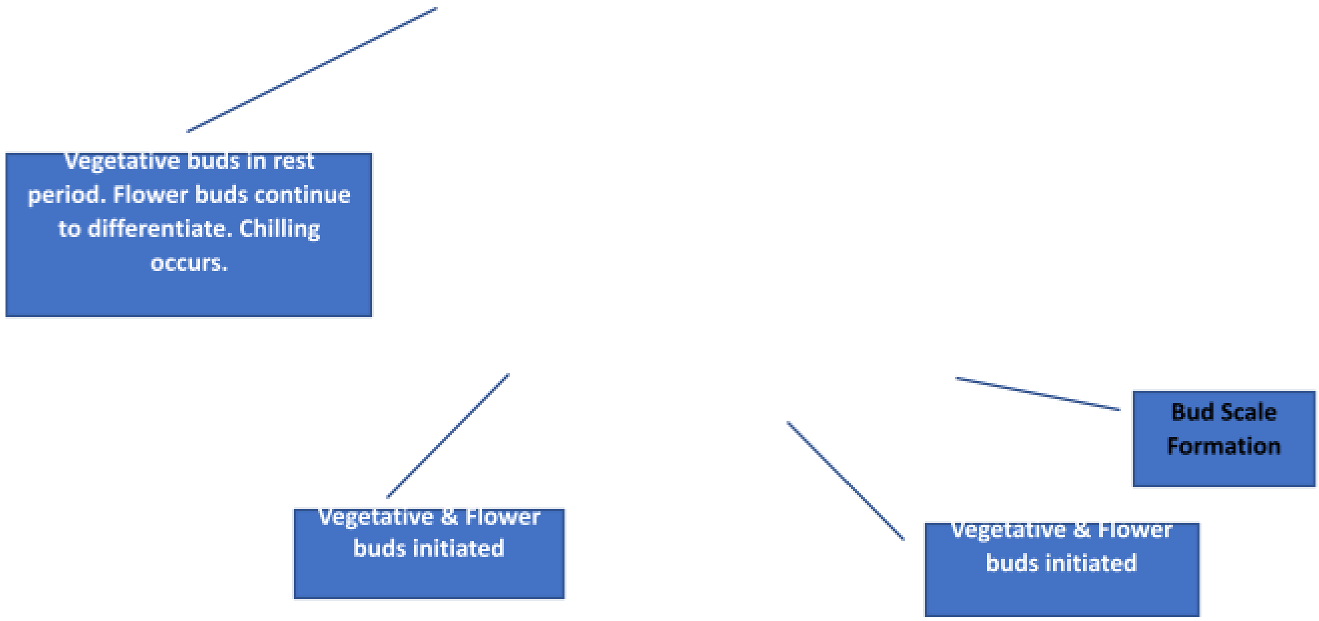
Factors influencing almond bloom intensity started 9 months prior to bloom. In almond, bud development generally occurs in late spring. During the early phase of bud development, vegetative and flower buds are all similar. In late summer a portion of the buds will differentiate to form flower buds. Consequently, the physiological and pathological stresses exerted on almond trees influence bloom and subsequent yield in the next year.

Bud initiation and development determine the potential productive capacity of an almond tree. Bud initiation and formation are directly affected by seasonal conditions (especially temperature extremes and water stress), genetics, nutrition, and tree structure. Some of these influences are within the control of growers, it is critical that growers understand the stages of bud formation, and the relative sensitivities of each stage, to the influential factors.

Flower bud initiation is the foundation of tree fruitfulness and yield potential. Therefore, all factors that influence initiation and development of flower buds influences next year's Bloom and yield. The processes that result in nut formation start before the previous crop has been harvested. The processes are complex and often in conflict with other management practices.

Bud Initiation and Development as Steps in the Almond Growth Cycle

SEASON	MONTH	TREE GROWTH STAGE		BUD DEVELOPMENT STAGE
WINTER	January	Bud burst – Full Bloom		Emergence of floral buds on shoots or spurs; pollination Emergence of vegetative buds – leaves
	February			
SPRING	March	Shuck Fall – Early Set		Leaf development and active growth of new shoots
	April	Nut growth	Nut Fill	Growth interruption; bud maturation
	May			Bud scale formation
SUMMER	June			
	July		Hull split	Vegetative buds develop. Flower buds initiated
	August	Harvest		
FALL	September			Flower buds continue to differentiate
	October	Post-Harvest		
	November	Leaf Fall – Dormant		Vegetative buds in rest period. Flower buds continue to differentiate. Chilling occurs.
WINTER	December			
	January/February	Bud burst		Emergence of flowers, followed by leaves



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FLOWER BUDS

The floral buds encompass a terminal flower, but no leaves. More than one floral bud may form on a single spur, or along the length of shoots more than a year old. Almonds have late flower bud differentiation (i.e. the transition from vegetative to floral buds). In almonds bud initiation and development (for the following season's nuts) usually coincides with the current season's hull split-to-post-harvest period. Management decisions over that time, influence the tree's capacity and potential yield in the next season, in terms of bloom density and therefore, yield. Management decisions that affect crop load, carbohydrate reserves and general nutritional status, also influence fruit set.

Classic research on flower bud development was undertaken in 1925 (Tufts and Morrow, 1925) and more by Lamp et al. (2001). They investigated the effect of bud position and leaf area on the timing of flower differentiation, between and within spurs. Each investigation included the almond variety Nonpareil, while Lamp et al. (2001) also investigated Carmel and Butte. These researchers found that floral initiation in some varieties (Carmel and Butte) preceded hull split, but for Nonpareil they concluded floral initiation occurred after hull split. Almond flowers undergo continuous development (even during dormancy) once their transition commences. Vegetative buds however have a rest and maturation period.

VEGETATIVE BUDS

Vegetative buds form the structure and bearing potential of trees and the capacity to sustain the tree through water uptake, nutrient capture, and energy conversion. Leaves are formed in vegetative buds which are pointed in shape. Flowering buds are plumper, and flat-domed at the apex. The terminal bud of a shoot or spur is always vegetative and hence the capacity of almond trees for on-going shoot growth and canopy expansion. The relative growth of terminal and lateral vegetative shoots determines the potential fruit-bearing capacity and structure of the different varieties. The vegetative terminal and lateral buds form during the previous year, then elongate and expand mid-summer. In conditions of excessive nutrition, or when mild conditions extend through autumn, the wood, leaf and bud maturation may be delayed, and the duration of active growth extended. In contrast, water-stressed trees may lose leaves prematurely and have reduced vegetative growth and compact canopies. Each of these scenarios influence carbohydrate accumulation at the end of a season, and its availability for leaves emerging from second year wood, in the subsequent spring.

Genetics

A bud development disorder attributed to varietal genetics (and environmental), is prevalent in the Carmel variety (but also documented in Nonpareil, Price and several other varieties) and has curbed the planting of Carmel in California. At its worst, non-infectious bud failure (NBF) may first appear in the spring of the second leaf. It presents as leafless lengths of one-year-old wood that may or may not carry nuts. On occasions a tuft of vegetative growth appears at the ends of bare shoots suggesting that leaf buds (which are formed early or late in the season and therefore often in cooler conditions), remained viable despite the other lateral, vegetative buds between dying or failing to develop the previous summer or autumn. It has been concluded that the vegetative buds which fail in NBF trees, formed and were initially viable. However, the affected buds die prior to spring in the following season, and most likely during the previous autumn and winter.

Nuts on NBF shoots are evidence that the floral buds have survived despite often being at the same position as a failed vegetative bud. In NBF trees, the bloom period may be delayed. Once present, NBF cannot be eliminated. The NBF-potential is dynamic, with temperature exposures, drought stresses, fruit load, tree pruning and management.

TEMPERATURE EXPOSURE

Although flower initiation is controlled by naturally occurring plant hormones, the timing and duration of the floral development stages is directly affected by tree genetics and temperature exposures at critical times. The temperature triggers for normal bud development – heat-induced dormancy, chilling hours, and the subsequent warm temperatures to break dormancy and trigger growth. Almonds rarely have insufficient chill, but floral buds may drop before bud swell if the winter has been mild. Although the vegetative buds may not drop under similar conditions, they often develop abnormally with an extended leaf out period and weaker shoots. Frosts may kill buds, flowers or cause early abortions, depending on their developmental stage, and the duration and severity of the frost. Cumulative high-temperature exposure in the previous summer, affects NBF onset and expression. It is proposed that NBF may also be indirectly triggered in stressed trees since premature defoliation may result in increased canopy temperatures.

WATER STATUS

Almond trees are generally considered to be drought-tolerant, however it has been demonstrated that almond trees pass through annual development stages in which water-stress sensitivity varies. The most water-stress sensitive stages in almonds are flowering, fruit set and early stages of fruit growth.

The almond harvest coincides with the floral bud initiation period. The post-harvest period coincides with the floral bud development. The usual practice of ‘holding off’ the water in preparation for, and during harvest and drying, must be managed carefully because pre-harvest water stress affects current season nuts, and post-harvest water stress directly affects bud initiation and development, and therefore the subsequent season's yield. The benefits – minimized trunk damage from shakers, hull rot, and ground moisture and humidity for drying of pre-harvest deprivation must be balanced alongside the less desirable effects – reduced kernel weight, increase in 'partial splits and/or 'hull-tight' nuts, reduction in late season leaf function, and stress presenting as wilt and/or premature leaf drop and biomass reduction.

The pre-harvest to post-harvest water deficit period varies in length each season and across orchards for several reasons: the staggered maturity of pollinators and Nonpareil; orchard size and equipment capacity and availability; and prevailing environmental conditions that may either hasten or delay harvest or drying. The severity and duration of the water deprivation, affect the varietal responses and capacity to compensate and/or recover.

Pre-harvest water stress.

Water stress pre-harvest has less effect on bud development (and therefore subsequent flowering and leaf out) than does post-harvest water deprivation. However, it has been demonstrated in California that the negative effect on annual vegetative growth, may be cumulative over successive seasons of pre-harvest drought conditions. Fruiting spur growth (and therefore potential productivity) may be significantly reduced (Esparza et al., 2001a).

Post-harvest water stress.

It has been clearly shown that post-harvest deficit irrigation or water stress reduces fruitfulness the following season (Goldhamer et al., 2006). Goldhamer and colleagues have undertaken the most comprehensive research on regulated deficit irrigation (RDI), its timing and magnitude. They demonstrated the primary effect of post-harvest water deprivation is yield reduction, because of its direct effect on floral bud differentiation and reduction in flower number. A negative effect on fruit set, kernel yield and fruit load were also reported (Goldhamer and Viveros, 2000). Post-harvest water stress may also promote premature defoliation, and therefore lower carbohydrate reserves. Low leaf retention through autumn results in weaker vegetative growth and reduced fruiting capacity the following season.

Goldhamer, concluded that the application of a limited water volume over a shorter duration in the early part of the season was less effective than irrigating at lower volumes over a longer period (especially when it extended through the post-harvest period), in sustaining production in the subsequent season. In periods of restricted water access, it is particularly important for growers to understand the water-sensitive stages in almond development throughout the season, and to ensure post-harvest water availability.

Nutritional

Tree nutrition influences tree vigor, growth rates, bud size, and the retention of leaves in autumn. Fall is the period when carbohydrate accumulation occurs in the perennial parts of almond trees (roots, branches, and trunk). This carbohydrate is used at the start of the next growing season to support early shoot growth, until the new leaves are functioning and contributing to the tree. It is therefore important to retain leaves on trees as far into fall as possible. Post-harvest irrigation also assists with leaf retention and the period of carbohydrate accumulation prior to dormancy. Since nutrition affects functions throughout the tree and season, not only is the leaf functional period important, but also the relative growth of new shoots, leaves, canopy size, and fruit load, provided evidence suggesting spurs with low leaf area carried fewer floral buds and that these floral buds had a slower developmental rate.

Fall applications are more efficient since trees are still actively taking up nutrients, cold and wet conditions in the spring can delay dormancy break, and spring-applied fertilizers are subject to leaching and runoff. After harvest, trees are recovering from stress, so post-harvest fertilization programs accomplish several things. They replace nutrients removed by the harvest and provide an opportunity to address nutrient deficiency issues before the next growing season. Fall applied fertilizers do not impact tree vigor so what is applied is taken up and goes into tree reserves.

Post-harvest fertilization supports the development of next year's blossoms, growth of the earliest spring leaves and development of immature fruits. Nitrogen (N) can be applied any time after hull split to a few weeks after harvest. The amount needed depends on leaf tissue N from a July sampling. Less N or no N may be needed post-harvest for higher leaf N levels. Potassium (K) can be applied as well although needs may be minimal since the almond hull is the primary sink for potassium. Phosphorus (P) should be considered if deficiency symptoms are observed or low levels in July leaf analysis. Fall is a great time for Boron (B) if hull levels are deficient. Adequate B is needed for nut set and yield in the following year. Zinc (Zn) is needed for flowering and fruit set. Aids the synthesizing of auxins for cell division for uniform budburst, fruit set, retention, and sizing. Zn and B must be present in adequate levels for a successful bloom in the spring.