Assessing Phenology of Almonds

Dane Thomas, SARDI, Adelaide, Australia

Joseph Connell, University of California Cooperative Extension Emeritus Advisor, Butte County, California

27 June 2018

Why focus on phenology

Phenology is the study of when particular events occur, with emphasis on the effect of seasonal or climatic changes. It provides useful information to aid in orchard operations. The value of this information is enhanced when measurements are collected in a uniform and consistent manner. This factsheet describes how to measure phenology of a particular developmental stage with specific examples of measuring flowering and hull split. A photoscale for stages of flowering and for hull-split are included.

How to assess phenology of almonds

This methodology is based on that used in Californian research trials and uses a compromise between accurately determining phenology using a large number of samples collected throughout tree canopies with the need to sample a larger area (many varieties, orchard blocks, or multiple orchards) in a timely and cost effective manner. The method accounts for the fact that the top and bottom of the tree canopy often bloom at different times. Physically sampling the upper canopy is difficult as it can't be easily reached while the lower canopy, which can be reached from the ground, is often either ahead of the upper canopy or behind depending on the variety. In essence the method visually assesses upper and lower shoots / branches, and undertaking a few quick visual counts to confirm these observations to determine the percentage of open flowers that best represent the overall canopy at that point in time. A similar method could be used to assess any chosen phenological stage.

The phenological stage must be defined

Estimating a particular phenological stage requires the particular stage be accurately defined, and that preceding and subsequent development stages are also defined. This will ensure the stage of interest is not confused with other stages. A written description and accompanying photographic or illustrated images of the relevant stages are useful for this purpose. Commencing scoring before the stage of interest allows for greater certainty that the beginning of the stage of interest can be observed. Similarly recording the subsequent stage will provide greater certainty that the end of the stage of interest was accurately observed.

How many trees should be assessed?

The number of estimates will depend on the variation of observations. There is no easy way to define the required sample size without an initial assessment of this variability, but as a general rule a larger sample size (for example 30 or more) is usually better. Estimates can consist of systematic sample points or of random points within a number of areas. Either method is acceptable so long as systematic biases are avoided such as sampling trees near the ends of rows. A different set of branches, trees or rows may be observed at each time, or the same points may be repeatedly observed at each time in which case tagging trees or branches is an easy way of ensuring you are sampling the same place. Either method is acceptable.

How often should phenology be assessed?

Observations over a period of time will need to be made to subsequently determine the date when the percentage of flowers, fruit or development stage was considered to be at the specific stage of interest. For example, sampling on many days may be required to subsequently estimate/calculate the date that 10% of flowers could be classed as open. The time interval between the sampling dates can be critical to findings. Generally more accurate information is obtained if the number of days between sampling is shorter. A different sampling interval may be required to assess different phenological stages. Flowering of almonds requires observations every 2 to 3 days, while once a week is acceptable to assess hull split for most growers.

Assessing flowering

In almond conditions during the entire bloom are important because the goal is to set the maximum number of nuts. The flowering stages typically used by almond growers and researchers include 1% (beginning bloom), 10%, 50%, 80% (full flowering or full bloom), 90% and 100% (end of bloom).

Observing when approximately 5-10% bloom occurs is of commercial interest in order to time protective brown rot fungicide applications. Evaluating the entire bloom period for bee flight and potentially successful cross-pollination opportunities helps provide a subsequent understanding of why certain varieties or crops may be heavier or lighter in production in different orchards or regions.

The phenological stages to note are swollen bud (B), calyx visible (C) or 'green tip', corolla visible (D) or 'pink tip' or when more advanced 'popcorn' (also known as D2), stamens visible (E) and open flower (F). Subsequent stages are petal fall (G), 'jacket stage', 'jacket split', and fruit set (H). The letter notation refers to the scale used by Felipe (1988) and shown on the attached photoscale.

How many measurement trees?	The first step in assessing flowering is to decide on the appropriate sample unit. These may be individual trees, group of trees, or whole rows. It is usually preferable to assess several smaller units (e.g. trees) and then average these individual values to obtain a number for a larger unit (whole row or block) rather than measure the whole unit (row or block) once for a single value. This is because each assessment is a scaled up value based on an assessment of a small part of the complete unit, and measuring many small units is likely to reduce errors (over and under-estimating) of the actual value for the unit of interest (which is usually a row, block or orchard).
Practice	These estimates are done by first counting roughly 100 floral buds/ flowers on a few branches to get an idea what 100 floral buds/ flowers looks like.
Assessment frequency?	It is desirable to commence observations before any flowers have opened and repeat assessments **every 2 to 3 days for several weeks**. This frequency allows the previous rating to be a check on where your current rating placed the % bloom.
	An initial assessment may be of one or two flowers in the top of the trees and might only be on a few trees. This may be followed by observations of 10-20 open flowers in the tree tops on most trees. Considering an almond tree may have over several thousand flowers, this small number cannot realistically be converted into a percentage, and serves more as an indication that the process of flowering is commencing. Subsequent observations will consist of estimating the percentage bloom.
Make your estimates	Next, estimate how many out of the roughly 100 floral buds/ flowers are open on **several groups of branches scattered throughout the tree**. **This is important as the top and bottom of the tree canopy often bloom at different times.** The measurement process is essentially: does this look like 1 out of 100? (1%), 5 out of 100? (5%) which is the same as 1 out of 20? (5%), 10 out of 100? (10%) which is the same as 1 out of 10? (10%), 50 out of 100? (50%) which is the same as 5 out of 10 (50%)……
	Make a few counts of 10 or 20 floral buds/ flowers to check your initial estimate.
	Settle on an estimate of the percentage flowers that are open. Suggested percentages are 1%, 5%, 10%, 20% followed by 10% increments, 90%, 95%, 100%. The key points in defining bloom stages are 1%, 10%, 80% as full bloom, 90%, and then 100%.
	Estimating the higher percentages can be difficult. These can be best achieved as the difference between 100% and the percentage of floral buds/ flowers that have not reached 'open flower' and those that have proceeded to petal fall or jacket stage.

Photo-scale for flowering

A.   Dormant bud

B.   Swollen bud

C.   Calyx visible

D1. Corolla visible

D2. "Popcorn"

E.   Stamens visible

F. Open flower

G. Petal fall

H. Fruit set

10% Open flower   50% Open flower   80% Open flower   Petal Fall   Complete Petal fall

Assessing hull split

Almond growers and researchers are usually more interested in the dates that 1% and 100% of fruit have hull splits rather than the date when 50% of fruit have hull split because treatments to protect the crop from pest damage are timed at 1% hull split and harvest can commence when nuts reach 100% hull split.

Hull split can be segregated into several stages (University of California, 2002). The stages are shown in the attached photo-scale. The stages include Stage 1 No separation or clear definition of suture line; Stage 2A Initial separation – less than 50% of suture line clearly visible; Stage 2B Deep V over at least 50% of suture line, but the hull cannot be squeezed open; hull split begins with Stage 2C Deep V over the suture line which is not visibly separated but can be squeezed open by pressing both ends of the hull; Stage 3 Visible opening in suture less than 1 cm in width; Stage 4 Visible opening in suture more than 1 cm in width; Stage 5 Initial drying of the edges of the hull; Stage 6 Completely dry.

The stage of interest when assessing hull split is stage 2C defined by the separation at the suture and indicates the beginning of hull split. When you squeeze a nut at stage 2C from end to end between finger and thumb it will pop open even if hull split is not quite visible. Stages 3 to 4 of hull split show the additional splitting and opening with subsequent desiccation of the hull occurring in stages 5 to 6.

1% hull split is when an estimated 1% of the 'sound' nuts are at stage 2C. Sound nuts are those that contain formed kernels. There are always some nuts that set, abort the embryo for some reason, but remain on the tree. These nuts are referred to as Blanks. In Blanks, the brown pellicle of the kernel is present, as is the shell and hull, but there will be no kernel inside the pellicle. Blank nuts usually range from around 3% of the crop to as much as 10% of the nuts in some years. They always split first, usually a week or more before the beginning of hull split on the sound nuts. They serve as advance warning that hull split is getting close. Check out the first nuts that split open in exposed areas of the canopy, crack them and you'll find the Blanks.

100% hull split is when all nuts in the tree are at stage 2C or drier. Nuts in the lower interior part of the canopy will most likely reach stage 2C last with most nuts in the lower interior canopy at this time being at stage 3 or drier and most nuts in the upper canopy being at at least at stages 4 and 5. This is when Harvest can commence.

Measuring hull split uses a similar approach to measuring flowering. **Making a rating once a week is considered sufficient** to evaluate differences between varieties in commercial orchards. Different observation frequencies may be required to evaluate other effects. Observations and ratings on any given variety over about 6 weeks might look like this:

Week 1   Majority of nuts in the mid and upper canopy in stage 2B

Week 2   Blank nuts in the tree tops are splitting (this happens 7 to 10 days before the beginning of hull split on sound nuts)

Week 3   Sound nuts are mostly in stage 2B but some nuts are in stage 2C (this is probably about 1% hull split with Blank nuts now drying and in stages 4 and 5)

Week 4   Sound nuts mostly in stages 3 and 4 in the majority of the canopy with some nuts in the tree top in stage 5 and blanks in stage 6

Week 5   Sound nuts mostly in stages 4 and 5 with nuts in the lower interior canopy now in stages 2C and 3 (this is when harvest can commence at 100% hull split)

Week 6   Sound nuts drying on the tree and mostly in stages 3 and 4 in the lower interior canopy with nuts in the rest of the canopy in stages 4, 5 and 6 (nuts in the upper canopy are exposed to navel orange worm egg laying longer than necessary)

Photo-scale for hull split

UN-SPLIT Stages

Stage 1.

No separation of suture

Stage 2A.

Initial separation – less than 50% of suture line separated

Stage 2B.

Deep V over at least 50% of suture line, but the hull cannot be squeezed open)

SPLIT Stages

Stage 2C.

Deep V over the suture line which is not visibly separated but can be squeezed open by pressing both ends of the hull

Stage 3.

Visible opening in suture less than 1 cm in width

Stage 4.

Visible opening in suture more than 1 cm in width

Stage 5.

Initial drying of the edges of the hull

Stage 6.

Completely dry

Disclaimer

PIRSA and its employees do not warrant or make any representation regarding the use, or results of the use, of the information contained herein as regards to its correctness, accuracy, reliability and currency or otherwise. PIRSA and its employees expressly disclaim all liability or responsibility to any person using the information or advice.

Horticulture Innovation Australia (Hort Innovation) makes no representations and expressly disclaims all warranties (to the extent permitted by law) about the accuracy, completeness, or currency of information in this document. Users of this document should take independent action to confirm any information in this Document before relying on its accuracy in any way. Reliance on any information provided by Hort Innovation is entirely at your own risk. Hort Innovation is not responsible for, and will not be liable for, any loss, damage, claim, expense, cost (including legal costs) or other liability arising in any way (including from Hort Innovation or any other person's negligence or otherwise) from your use or non-use of the Document or from reliance on information contained in the Document or that Hort Innovation provides to you by any other means.

All enquiries

Dane Thomas, SARDI Climate Applications, GPO Box 397, Adelaide SA 5001.
T 08 8429 0670
M 0475 980 866
E dane.thomas@sa.gov.au