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Phenology standard for Almonds

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Why is Phenology important?

Phenology describes when particular growth stages occur, with an emphasis on seasonal or climatic changes. It provides useful information that can assist in orchard operations and to researchers. It is important that the description of the phenological stages is clear and accepted by the users of the standard. There are several phenology scales in use in Australia. These include scales that are mainly associated with bud burst, flowering and fruit growth such as Felipe (1977, 1988) and The University of California (2002); detailed scales of fruit growth such as those defined in Kester et al (1996); and scales that define all stages of annual growth such as those described by the Australian Almond Board (ABA) (2014), and the Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie (BBCH) system. This factsheet compares these different standards and includes a photo-scale of almond development.

The Photo-scale

The photo-scale compares several phenological scales of almonds. The photo-scale is divided into the phenostages showing the progression of floral and fruit growth and maturity, and leaf growth maturity and senescence. Each column is a separate growth stage that may be described by several, but not necessarily all, phenological scales. **There is often, but not always, a perfect match between the different scales;** and because of these non-perfect matches there is some approximation when categorising a separate growth stage into a single particular column.

The first and second rows above the photograph denote the principal growth stages and secondary stages used by BBCH.

The row beneath the photograph describes the scale by Felipe (1977, 1988), and the scales commonly used by growers and includes stages described for example by University of California (2002).

The final row describes the stages of annual growth detailed by ABA (2014).

When is a stage reached?

A usual convention is to assume that a particular phenological stage has been reached when half the organs that you are measuring have reached that stage. These organs may be buds if you are assessing budburst, flowers if you are assessing flowering, fruit with split hulls if you are assessing hull split. In some cases it may be more useful to describe the proportion of these organs that have reached a particular stage. This approach is used in the BBCH system described below. It is also used extensively by orchard managers and researchers when describing flowering and hull split of almonds. Typical categories to describe open flowers include 1% bloom, 10% bloom, 80% bloom, which is also categorized as full bloom, 90% bloom and 100% bloom. The terminology of “Beginning” to denote 1% and “End” to denote 100% are also used.

Similarly the proportion of fruit on a tree (or orchard) that have split hulls can be defined with typical categories of 1% hull split, (or “Beginning”), 10%, 90%, 100% hull split or “End”.

This combination of defining development of individual organs and of describing the development of the entire population of organs on a branch, tree or orchard provides a robust measure of phenological development.

The BBCH system

A universal phenology system that is adaptable to all plants is the BBCH system (Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie). It uses a decimal code system which is divided into 10 principal growth stages which may each contain 10 secondary stages, but not all stages including all principal stages are applicable to each plant. The BBCH system has been described for some stonefruit (Meier et al., 1994; Perez-Pastor et al., 2004) and would be similar in Almond. Eight of the possible 10 principal BBCH stages are used in stonefruit. These are: 0 - bud development, 1 - leaf development, 3 – primary shoot development, 5 – inflorescence development, 6 – flowering, 7 – fruit development, 8 – fruit ripening, 9 - senescence.

In the BBCH system the secondary stages within each principal stage are not always used. These secondary stages usually describe discrete development stages of the organ such as bud swelling and brown bud scales visible; green bud scales visible, petals visible, sepals dying (essentially jacket split); flowers open; or fruit growth with 75 referring to fruit near 50% of final size, 79 being fruit at 90% of final size. The secondary stages may also describe the proportion of organs at a particular stage such as 60 referring to flowers open, 61 to 10% of flowers open, 65 as 50% of flowers open, but 67 refers to majority of petals have fallen.

Grower based scales

Felipe. The scale is based on Baggiolini's scale for peach. It defines primary stages alphabetically, and these may be additionally subdivided numerically within each primary stage. The primary stages are A. Winter Buds; B. Swollen buds; C. Calyx visible; D. Corolla visible; D2. "popcorn", E. Stamens visible; F. Open flower; G. Petal fall; H. Fruit set; I. Young fruit; I2. Fruit near 50% size, J. Fruit near final size; K. Separation of exocarp; L. Detachment of exocarp and mesocarp.

The University of California. This scale defines typical stages of an individual bud – flower – fruit. Stages include: Dormant bud, Swollen bud, Green tip, First pink, Popcorn, Stamens visible, Open flower, Petal fall, Fruit set, Jacket stage, Jacket split, Pit hardening, and Hull split.

Hull split can be further segregated into several stages. The stages include 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); and Split stages of 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 Almond Board of Australia. Seven broad phenological stages of annual growth are detailed from bud swell to dormancy. The stages are 1. Bud burst to full bloom; 2. Shuck fall to early set; 3. Early fruit growth to pit hardening; 4. Pit hardening to early hull split; 5. Hull split to harvest; 6. End of harvest to leaf fall; and 7. Dormancy (leaf drop to bud swell).

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**Principal growth stage 0:
Sprouting/Bud development**

00. Dormancy: buds closed and covered by dark brown scales.



A. Winter Bud. Dormant bud

**Principal growth stage 5:
Inflorescence emergence**

51. Inflorescence buds swelling: buds closed, light brown scales visible.



B. Swollen bud.

53. Bud burst: scales separated, light green bud sections visible.



55. Single flower buds visible (still closed) borne on short stalks, green scales slightly open.



C. Calyx visible. Green tip

57. Sepals open: petal tips visible; single flowers with petals (still closed).



D1. Corolla visible. First pink



D2. "Popcorn"

59. Most flowers with petals forming a hollow ball.



E. Stamens visible.

Stage 1 of annual growth commences: Bud swell to flowering.

**Principal growth stage 6:
Flowering**

60. First flowers open.



F. Open flower.

61. Beginning of flowering: 10% of flowers open.



10% of flowers open.

65. Full flowering: at least 50% of flowers open, first petals falling.



50% of flowers open.



80% bloom is commonly recognized as "full bloom".

67. Flowers fading: majority of petals fallen.



G. Petal fall.

69. End of flowering: all petals fallen.



End of flowering.

Stage 2 of annual growth commences: Shuck fall to early set.

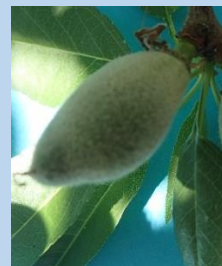
**Principal growth stage 7:
Development of fruit**

71. Ovary growing; fruit fall after flowering.

72. Green ovary surrounded by dying sepal crown, sepals beginning to fall.

75. Fruit near 50% of final size.

79. Fruit at about 90% of final size.



H. Fruit set.

I. Young fruit. Jacket stage

I2. fruit nears 50%

Stage 3 of annual growth commences: Fruit growth to early pit hardening.

Stage 4 of annual growth commences: Early pit hardening to early hull split. Pit hardening occurs when fruit have attained their final size.

**Principal growth stage 8:
Maturity of fruit and seed**

81. Beginning of fruit colouring.

85. Colouring advanced.

87. Fruit ripe for picking.

89. Fruit ripe for consumption: fruit have typical taste and firmness.

90. Mature



J. Fruit near final size

K. Separation of exocarp.

L. Detachment of exocarp and mesocarp.

Hull split stage 1.

Hull split stage 2A.

Hull split stage 2B.

Hull split stage 2C.

Hull split stage 3.

Hull split stage 4.

Hull split stage 5.

Hull split stage 6.

Stage 5 of annual growth commences: early hull split to end of harvest.

Stage 6 of annual growth commences:

**Principal growth stage 0:
Sprouting/Bud development**

00. Dormancy: buds closed and covered by dark brown scales.

01. Beginning of bud swelling (leaf buds); light brown scales visible, scales with light coloured edges.

03. End of leaf bud swelling: scales separated, light green bud sections visible.

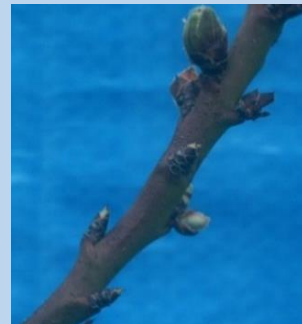
09. Green leaf tips visible: brown scales fallen, buds enclosed by light green scales.

Principal growth stage 1: Leaf development

10. First leaves separating: green scales slightly open, leaves emerging.

11. First leaves unfolded, axis of developing shoot visible.

19. First leaves fully expanded.



Bud swell.

Green Leaf tips visible.

Leaves emerging.

First leaves fully emerged / full size.

No relevant growth stages although coincides with Stage 2 of annual growth commences: Shuck fall to early set, and initial part of Stage 3 of annual growth: Fruit growth to early pit hardening.

**Principal growth stage 3:
Shoot development**

31. Beginning of shoot growth: axes of developing shoots visible.

32. Shoots about 20% of final length.

39. Shoots about 90% of final length.

Shoot growth – 2 leaf, 4 leaf etc.

Shoot 90% of final size.

No relevant growth stages although coincides with Stage 3 of annual growth: Fruit growth to early pit hardening.

**Principal growth stage 9:
Senescence, beginning of dormancy**

91. Shoot growth completed; foliage still fully green.

92. Leaves begin to discolour.

93. Beginning of leaf fall.

95. 50% of leaves discoloured or fallen.

97. All leaves fallen.

Growth after harvest complete.

50% leaf drop.

100% leaf drop.

Stage 6 of annual growth continues: End of harvest to leaf fall

Stage 7 of annual growth commences: Dormancy (leaf fall to bud burst).