

#### FLORAL INITIATION

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#### **KEYWORDS**

meristem, fertilization, yield, fruit set, pollination biology, hormones

#### ABSTRACT

Floral initiation is the first step in the processes of flowering and fruit development that take place over two years, culminating with harvest. For fruit crops, floral initiation is arguably the single most important event – the density and distribution of floral clusters largely determines management practices for the year considering the inextricable connection between fruit quantity and quality and their importance in orchard profitability.

Floral initiation includes all biological developments required for the commitment by the developing meristem to produce an inflorescence. This occurs about 50 days after full bloom in apple and pear. In these crops, the cycle of flower development from initiation to harvest often lasts from 9 to 10 months, placing great import on the short lapse of time during which meristem fate is determined (i.e., the appearance and formation of the floral primordia in summer) as well as the the final formation of flower parts in spring. Flowers are initiated during the growing season before winter dormancy, and anthesis occurs in the spring when the chilling requirement of winter dormancy has been satisfied and temperatures are suitable for growth. The apple inflorescence is a



determinate raceme which generally has five flowers (Figure1). Floral initiation in apple and pear is dependent on factors including vegetative development in the growing season before anthesis, the effect of the environment, as well as hormones,

Figure 1. Apple floral bud before (A, illustrated) and after bud break (B). Source: Foster et al., 2003. Ann. Bot. 92 (2): 199-206.



plant growth regulators, and carbohydrates. Research investigating floral initiation in apple implicates seasonal developmental processes and hormonal relationships as the major factors driving floral initiation as opposed to specific environmental stimuli. Clearly, an improved understanding of endogenous and exogenous factors controlling floral initiation will offer insights into practicable mechanisms for manipulating flowering and fruit load. This presentation will review the processes of floral initiation and flower development, and describe how growers may manipulate them via pruning/training and with growth regulators.

### FLORAL INITIATION Matthew Whiting Washington State University

### Floral initiation

- First step in processes of flowering and fruit development
- Evolutionary mechanism through which plant distributes seed
- Manipulated by growers for profit

   Sequence of events
   When, where, why

### Floral initiation to fruit harvest



### Floral initiation

- Flower initials formed within buds
  - Summer and Fall
  - A 15-month process
- Buds either vegetative or mixed



### Floral buds

- A shortened shoot axis with 'leaf formations' at each node
  - -9 bud scales
  - 3 transition leaves
  - 6 true leaves
  - 3 bracts





**Figure 6.2** Bud structure showing, in ascending order, nine bud scales, three transition leaves, six true leaves and three bracts. The axis is terminated by a flower primordium (the king flower) and lateral primordia are formed in the axils of the three bracts and three distal leaves. After Abbott (1970). Reproduced with permission.

### Floral initiation

- Floral buds typically borne on spurs
   2-year-old and older wood
- Lateral buds on current season shoot
   Cultivar-dependent
- Terminal buds on shoots



## Initiation of flowering

- Transformation of vegetative apex to reproductive apex
- Can occur on same tree at widely varying times
  - Not triggered by specific temp or daylength
- Bud will always form flowers unless prevented

## Initiation of flowering

- Key factors interfering:
  - Hormonal balance
  - Availability of nutrients ( $CH_2O$  in particular)
  - Interaction of these
  - Others.....



# Initiation of flowering

- Most flowers borne on spurs
- Vegetative spur breaks in spring to form
  - Shoot
  - Whorl of leaves (spur) with new bud in center



### Floral initiation

- Bud consists first of
  - 1 bud scale + 5-6 leaf primordia
- Season advances primordia added at apex
   & older become scales or leaves
- Bud then can
  - Enter dormancy vegetative
  - Apex produces bract primordia and floral initials

### Bud fate

- Vegetative vs. reproductive
  - Depends on rate of new primordia production (i.e., plastochron)
    - Vegetative buds must be fully developed first
  - Critical node number theory
  - Failure to attain critical number = no flowers
    - 20 for Cox's Orange Pippin & Comice
    - 16 for Golden Delicious

### Bud fate

- First sign of transition to reproductive is doming of SAM
  - Can occur in spurs ca. 50 DAFB
  - Later in shoots ca. 100 DAFB
- Generally if FBI occurs late in season buds are 'young' at dormancy
  - Blossom clusters with long pedicels
  - Set poorly

Floral initiation

Scanning Electron Microscopy

V: Narrow, flat

R: Domed

V: Broad, flat

Foster et al., 2003 Annals of Bot. 92:199-206









### Epi-Illumination Light Microscopy



A – broadened apex with 2 leaf primordia B – same apex with primordia removed

Dadpur et al., 2008. Intl.J.Bot. 4:49-55

### Epi-Illumination Light Microscopy



C – floral bud initiated – doming apex D – terminal and lateral flowers forming

Dadpur et al., 2008. Intl.J.Bot. 4:49-55

### Epi-Illumination Light Microscopy



- E petals initiated
- F stamens forming, sepals removed

Dadpur et al., 2008. Intl.J.Bot. 4:49-55

FM – floral meristem B – bract tFM – terminal FM S – sepal



Foster et al., 2003 Annals of Bot. 92:199-206



# Flowering

- Variations in quantity and 'quality' of flowers?
- Bud after break
- Flowers, expanded vegetative leaf initiated previous season
- New leaves (L1-L3) initiated by bourse shoot

- Winter dormant bud
- Bud scales, transition leaves, leaf primordia, inflorescence
- Bourse shoot develops from vegetative primordia (circled)

- Fruit load
  - Heavy cropping will inhibit FBI
  - Creates biennial/alternate bearing
  - Excessive crop 'on' year leads to light crop 'off' year
  - Effect is local
    - Half trees can be 'on' or 'off'
    - Effect may be more localized spur only
  - Thought to be GAs produced in seeded fruit + nutritional

- Fruit load
  - Presence of seeded fruit 20-30 DAFB can inhibit 50% flowering
  - In pear, 30-40 DAFB for greatest inhibitory effects



## Flowering pathway

Gibberellins *promote* flowering in Arabidopsis





Year 1

Year 1

Non-thinned trees

Hand-thinned trees

Year 2

Year 2

### Honeycrisp



- Un-thinned trees vegetative
- Flowering shoots when thinned

### Gene expression

- Effect is clear
- Upstream
- Improves understanding of biennial bearing



Figure 7. Quantification of activity of genes related to LEAFY and SOC1 in apple. Gene activity for the apple counterparts of LEAFY and SOC1 (a, b, c) was evaluated 15, 35, 50 and 70 DAFB in thinned (black bars) or non-thinned (gray bars) trees.



J. Amer. Soc. Hort. Sci. 131(1):74-81. 2006.

### Antisense Expression of *MdTFL1*, a *TFL1*-like Gene, Reduces the Juvenile Phase in Apple



- Anti-sense expression of *MdTFL1*
- Induces precocious flowering
- 6 mo vs. 6 yr
- MdTFL1 has key role in juvenility & FBI



### Managing alternate bearing (FBI)

- Reduce risks to balanced cropping
  - Promote tree health and moderate vigor
  - Avoid stress (nutritional, water, heat)
  - Choose site with low frost risk
  - Adjust crop load early!
  - Induce flowering with PGRs
    - Ethephon 100-200 ppm



- Effect of leaves
  - Defoliation treatments show that leaves promote FBI
  - No flowers on spurs defoliated 6-10 weeks after full bloom (Ryugo, 1986)
  - Strong correlation between spur leaf are & FBI
  - Effect attributed to CH<sub>2</sub>O supply and cytokinins

### Floral initiation 'Williams' pear

	Tree with seeded fruits		
Yield (kg)	26.1	26.9	
Number of fruits	215	168	
Seeds per fruit	7.6	0	
% floral initiation	,		
on spurs with the			
following leaf area $(cm^2)$			
Less than 30	0	0	
(4  leaves) 31-50	0	8.6	
(5  leaves) 51-70	0	27.3	
(6 leaves) 71–90	0	44.5	
Greater than 90	0	87.0	

From Huet (1973). Reproduced with permission.

### • Light level

- Inner portions of apple & pear trees have few flower clusters
- Shading response is greater early in season (up to 7 weeks AFB

Number of fruit bud clusters per tree in spring 1972	Percentage full daylight in 1971			
	100%	37 %	25%	11 %
Spur clusters	373	248	190	184
Axillary clusters	22I	19	15	12
Terminal clusters	43	12	16	5

The number of each type of bud cluster at each level of shade was significantly less than the number on unshaded trees.

Data from Jackson and Palmer (1977b). Reproduced with permission.



- Shoot vigor & orientation
  - Inverse relationship between vigor and fruitfullness
  - Training/bending shoots horizontal slows growth and increases FBI
  - Effect within weeks

– 60% (H) vs. 15% (V) floral buds

- Pruning
  - High vigor = lower FBI
  - Summer pruning can improve FBI (ca. 12 lvs)
- Genotype
  - Both cultivar and rootstock have great effect
- Growth regulators
  - GAs inhibit FBI (GA $_3$  and GA $_7$ )
  - Cytokinins promote FBI

### Floral initiation

- Critical first step to productivity
- Controlled by developmental processes, endogenous and exogenous factors
- May be manipulated for profit
   Goal: consistent, balanced floral initiation

