Flowering and fruiting of grapevine

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Why flowering and fruiting of grapevine

Crop Value – Expenses = Profit (Income)

Yield
- Number of clusters per vine
- Number of berries per cluster
- Bud break percentage

Bud Fruitfulness
(Number of fertile shoots related to unfertile shoots)

Quality
- Cluster quality
- Berry morphological quality
- Berry organoleptic properties
Grapevine winter bud

Bud initiation and differentiation occurs during the growing season (From bloom up to harvest)

The winter buds, which were formed the previous season while shoots were growing, contain leaf and flower cluster primordia.

Bud formation and development is influenced by several physiological and environmental factors and cultural practices.
Bud differentiation and cluster primordia development

Growing the two crops successfully

http://enoviti-hanumangirl.blogspot.com/2016/06/grapevine-inflorescence-formation-parts.html
Cluster differentiation during the growing season

Larry Williams, *Bud Development and Fruitfulness of Grapevines.*
Bud position and Cluster differentiation in Thompson

Larry Williams, *Bud Development and Fruitfulness of Grapevines*. 
Bud formation in grapes is influenced by several factors.
Conditions that reduce cluster number

Carbohydrates:
• Rapid growth and over-cropping accelerate using carbohydrates and reduce the number of clusters per shoot.

Nitrogen:
• Nitrogen is an essential element required for vine growth and development including keeping a good carbohydrates level.
  • An excess of nitrogen stimulates canopy overgrowth and
  • causes bud shading and reduce fruit bud formation and
  • Produces flat canes with higher percentage of bud necrosis

Water supply:
• Water limitation reduces but differentiation and Excessive water produces large canopy with shaded buds and cases high risk of diseases. Especially if the water contains nitrogen.
Conditions that reduce cluster number

**Environmental condition:**
- Sunlight is required for bud differentiation and it is corelated with the bud fruitfulness.
- In the very hot region fruitfulness is reduced, probably due to lower carbohydrates level.
- Very cold winter and early spring frost cause bud mortality before bud break.

**Cultural Practices:**
- Pruning should be done according to the variety bud fruitfulness, we could leave more buds during pruning if high bud necrosis is expected.
- Selection of good spurs positions reduce bud shading and improve fruitfulness.
- Canopy management such as shoot and leaf removal should be done professionally and on time.
- Trellis system and vine training should be done to expose the maximum of the canopy to sunlight and obtain high fruitfulness.
- Use high concentration of Gibberellic Acid (GA) in table grapes increases bud necrosis.
Losing the main bud results in a low and an uneven bud break, and small clusters.
Losing the main bud results in a low and an uneven bud break
Dormex (Hydrogen Cyanamid) improves bud break and ripening of Flame seedless grapes

Budbreak in DORMEX® treated grapevines (left), showing advanced and uniform budbreak compared to untreated grapevines (on the right).

Earliness in bud Break (Days)            14                14                21                   21
Earliness in harvest (Days)                   5                  5                10                   10

Weeks from expected bud break

Total bud break (%)

- Dormex 4%
- Control

5  6  7  8
94.8  90.8  91.7  83.1
44.6  37.4  41.5  39.7
Grapevine clusters
The calyptra or cap is actually the grape flower petals that cover the stamen (male---mnemonic for me is "men") and stigma (female---mnemonic for me is "ma") until anthesis or bloom when the calyptra detaches from the pedicel exposing the stamen and stigma. Bloom usually occurs from 6 to 8 weeks after budbreak. The bloom period is when things can get tricky and conditions must be just right for fruit set to occur:

Nick K. Dokoozlian, Grape Berry Growth and Development.
Grape perfect flowers

An individual grape flower is shown with floral parts labeled. *Photo by Patty Skinkis, Oregon State University.*
Flower development in grapevine

At 0 weeks the development of the seed is observed and the cap has detached from the flower and fallen apart.

Factors involved in reducing number of flowers per cluster after bud break

Carbohydrates use and accumulation

- Low carbohydrates reserve at bloom causes flower abscission and reduce the number of berries per cluster.
- To keep a good carbohydrates level, an optimum nutrition level should be used.

From: Sugars and flowering in the grapevine (Vitis vinifera L.)
**Factors involved in reducing number of flowers per cluster after bud break**

- Temperature is an important factor in germination and growth of the pollen tube. Fruit set is greatly reduced when temperatures fall below 65°F or exceed 100°F.

- Cold temperatures, rainfall or high humidity are often associated with incomplete detachment of the calyptras leading to reduced fruit set.

- Rain can dilute the stigmatic fluid and interfere with germination of the pollen grains and reduces fruit set.

- High nitrogen level can cause flower abscission at bloom.

- Using exogenous GA spray at bloom increases shattering.

- Drought during bloom increases berry abscission.

- Shaded clusters tend to have lower fruit set.
Grape berry growth cycles

- **First is formation cycle**
  - Berry formation start with cell division and flower starts transform into fruit.
  - Water transfers into berry to enlarge berry.
  - Berry is green and hard, the volume increase rapidly.

- **The second is ripening cycle**
  - Sugar accumulation, phenolics and flavour compounds
  - Color changes from green.
  - Formation of each compound is temperature and light depended

- **These cycles are controlled by the plant hormones**
Hormones vs Growth Regulators

Plant hormones:

- Endogenous organic compounds active at very low concentration
- Essential for regulating plant growth and development
- Produced in one tissue and translocated to another tissue
- Have a specific function at specific stage and concentration
- They act together in a complex pathway

Plant Growth Regulators (PGR):

- Natural or synthetic form of the plant hormones that can be used to control or modify plant growth and also called plant growth substances or growth factors
# Plant hormones synthesis and their function

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Where produced or found</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Auxin</strong></td>
<td>- Embryos&lt;br&gt;- Meristems of apical buds and young leaves</td>
<td>- Stimulates stem elongation at low concentration&lt;br&gt;- Delays color and ripening&lt;br&gt;- Retards abscission</td>
</tr>
<tr>
<td><strong>Cytokinin</strong></td>
<td>- Roots</td>
<td>- Affects root growth&lt;br&gt;- Stimulates cell division&lt;br&gt;- Delays ripening and senescence&lt;br&gt;- Increases fruit set</td>
</tr>
<tr>
<td><strong>Gibberellins</strong></td>
<td>- Embryos&lt;br&gt;- Meristems of apical buds and young leaves</td>
<td>- Promote bud growth and seed germination&lt;br&gt;- Promote cell elongation</td>
</tr>
<tr>
<td><strong>Abscisic acid</strong></td>
<td>- Leaves, stem, root and green fruits</td>
<td>- Inhibits growth&lt;br&gt;- Closes stomata&lt;br&gt;- Promotes dormancy&lt;br&gt;- Enhances coloration</td>
</tr>
<tr>
<td><strong>Ethylene</strong></td>
<td>- Ripening fruits&lt;br&gt;- Aging leaves and flowers</td>
<td>- Promotes fruit ripening&lt;br&gt;- Promotes senescence&lt;br&gt;- Improve coloration</td>
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Grape berry development is controlled by the plant hormones

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*Fortes et al. 2015, Molecules, 20, 9326-9343*
Plant Hormones are classified under two major groups

<table>
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<tr>
<th>Growth Promoters</th>
<th>Growth Retardants / Inhibitors</th>
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<tr>
<td>• Cytokinins</td>
<td>• Abscisic acid <em>(Stress hormone)</em></td>
</tr>
<tr>
<td>• Gibberellins</td>
<td>• Ethylene <em>(Ripening / Senescence hormone)</em></td>
</tr>
<tr>
<td>• Auxin</td>
<td></td>
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Promote cell division and growth  Inhibit cell division and growth
Mode of action of GA in increasing berry size

GA application

Cell elongation

Increases cell size

Increases fruit size

- GA

+ GA
Mode of action of Cytokinin in increasing berry size

Cytokinin application

- More cell division
- Increases number of cells
- Increases fruit size

-CK  +CK
ABA synthesis during grape ripening

Ripening of grape (Non-Climacteric fruit) Vs. tomato (Climacteric fruit)

Ethylene synthesis during grape ripening and its role in berry coloration
Role of the plant hormone ethylene in fruit ripening

- Ripening-related genes
- Other signals
- Vacuole
- Nucleus
- Membrane degradation
- Respiration
- Softening
- Pigments
- Color
- Aroma volatiles
- Odor
- Percepción
- Ethylene synthesis
- Signal transduction
- Transcription factors
- DNA
- Genetically programmed

Key processes:
- Ethylene synthesis
- Cell wall degradation
- Aroma volatiles
- Odor
- Perception
- Color
- Pigments
- Membrane degradation
- Vacuum
- Sugars and acids
- Softening
- Aroma

Ethylene role:
- Autocatalysis
- Other signals
- Perception
- Transcription factors
- DNA
- Genetic programme
Production of table grapes with high quality

A good bud break

GA bloom spray to reduce number of berries per cluster

Manual cluster thinning in some cases

Sizing spray at pea size with GA or CPPU

Color spray in the red varieties

Ethephon
Plant Hormones and PGRs

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<tr>
<th>Endogenous Hormone</th>
<th>Growth Regulators</th>
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<tr>
<td>Auxin</td>
<td>IAA, IBA, NAA, 2,4-D</td>
</tr>
<tr>
<td>Cytokinin</td>
<td>kinetin, BA, 2iP, TDZ</td>
</tr>
<tr>
<td>Gibberellin</td>
<td>GA$<em>3$, GA$</em>{4+7}$</td>
</tr>
<tr>
<td>Abscisic acid</td>
<td>ABA</td>
</tr>
<tr>
<td>Ethylene</td>
<td>Ethephon, Ethrel</td>
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General use of PGRs in table grapes

<table>
<thead>
<tr>
<th>PGR</th>
<th>Purpose of use</th>
<th>Stage</th>
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<tr>
<td>Gibberellins (GA)</td>
<td>Cluster elongation</td>
<td>Before bloom</td>
</tr>
<tr>
<td></td>
<td>Berry thinning</td>
<td>Bloom</td>
</tr>
<tr>
<td>Cytokinins (CK)</td>
<td>Berry sizing</td>
<td>After fruit set</td>
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<tr>
<td>Abscisic acid (ABA)</td>
<td>Berry coloration</td>
<td>Verasion</td>
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<tr>
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The effective concentration of each PGR varies among varieties.
Thanks

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