The effect of dormancy and rest-breaking on production and fruit quality
Dormancy

- Dormancy concept - different types of dormancy
- Chilling requirements - factors affecting chilling requirements, monitoring systems, starting, final date
- Methods to determine chilling requirements for new variety
- Timing rest-breaking sprays
Effect of rest breaking on

Budbreak

Future

Vegetative

Production

Generative

Fruit set

Fruit size

Fruit colour

Fruit firmness

Physiological disorders

Stem-end russeting

Ca related disorders (e.g. bitter pit)

Storage potential

Production

Quality

Production export quality fruit

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Definition Dormancy

- **Physiological condition of deciduous fruit trees during which no noticeable growth takes place:**
  - No cell division takes place in terminal or lateral buds.
  - Rest cannot be broken even when temperatures and soil moisture favor growth.
  - No bud break with gibberellic acid or rest breaking sprays (DNOC, Dormex, etc.) and pruning.
  - Dormancy or rest can only be broken by exposure to winter chilling.
Dormancy three stages:

- **paradormancy** (summer dormancy or correlative inhibition)
- **endodormancy** (winter dormancy or rest)
- **ecodormancy** (imposed dormancy or quiescence)

- Paradormancy regulated by conditions within plant but outside bud, e.g. apical dominance
- Endodormancy controlled by conditions within bud, e.g., failure of buds to grow in autumn
- Ecodormancy controlled by conditions outside plant, failure of buds to grow in late winter
End of rest

- 50% of the buds capable to grow within a given period time
- when held at an appropriate temperature with their bases in water
Factors affecting dormancy

Dormancy induction, maintenance and release continuum

Dormancy affected by:
- site of the bud,
- photoperiod,
- environmental induction
  - Low temperature in colder regions
  - Low temperatures + short days in warmer areas
- phytohormones,
- effective chilling temperatures,
- bud differences,
- environment and/or cultural practices,
- dormancy breaking chemicals,
- stress management.

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Factors affecting dormancy

- 1885 H. Muller-Thurgau shortened shoot growth period
- Early inception of bud dormancy and shortens its duration
- 1934 Chandler and Tufts extended growth period of shoots
- Delays bud break the following spring if there is insufficient chilling

Vegetative maturity critical point in dormancy cycle
Vegetative maturity critical point in dormancy cycle

Factors affecting winter rest

- Climate preceding summer
  - C.R. >0-50%
  - High stress
  - Warm autumns
  - Time of leaf drop
    - chilling efficiency < 60%
  - Sink hormones
  - Leaves
- C.R. <20-50%
  - Low stress
  - Lower Chill Req.

Bud Quality
- Weak
  - High Chill reg.

Winter Temp
- Winter rain
  - Bud Temp
  - Anaerobic
  - >rest - breaking

Reserves

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Chill-unit accumulation

- Temperatures > or < 0° C to 7° C are not believed to contribute toward chill-unit accumulation.
- Temperatures below 0° C are considered to have no effect in breaking dormancy.

Models
- "Richardson" or "Utah"
- Temperatures between 0° and 16° C promote the breaking of rest.
- Maximum promotion at 7° C (1h at 7° C = 1 chill unit - CU).
“Dynamic model”

- Temperatures between 0 and 13° have positive effects
- Above 18° C negative
- 13° to 16° C enhance response, cycled with lower temperatures
- Dynamic model differs from Utah Model in that chilling units, once accumulated, cannot be negated by high temperature.

Fixed - temperature 28 hours at 6° C

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South African model
(ICE - Infruitec Chill Units)

- Mixture Richardson/Dynamic
- high temperatures no effect on chill unit accumulation.

<table>
<thead>
<tr>
<th>Degree C</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1.4</td>
<td>0</td>
</tr>
<tr>
<td>1.5 - 2.4</td>
<td>0.5</td>
</tr>
<tr>
<td>2.5 - 9.1</td>
<td>1</td>
</tr>
<tr>
<td>9.2 - 12.4</td>
<td>0.5</td>
</tr>
<tr>
<td>&gt; 12.5</td>
<td>0</td>
</tr>
</tbody>
</table>
Chilling requirements different varieties and rootstocks

- reserve status
- climatic and moisture stress
- pest and diseases
- time of harvest
- time of terminal bud formation

Within seasons

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Completion of rest

buds break when exposed to 20° C in a laboratory

1 August
### Varieties

<table>
<thead>
<tr>
<th>Chilling requirements</th>
<th>Varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category I (extreme high)</td>
<td>Rome Beauty, <strong>Macoun (family of Honeycrisp)</strong>, Northern Spy</td>
</tr>
<tr>
<td>Category II</td>
<td>McIntosh</td>
</tr>
<tr>
<td>Category III</td>
<td>Winesap</td>
</tr>
<tr>
<td>Category IV</td>
<td><strong>Red Delicious types, Golden Delicious types, Cox Orange. Gala types, Fuji types</strong> (Own research)</td>
</tr>
<tr>
<td>Category V</td>
<td>Yellow Newtown</td>
</tr>
<tr>
<td>Category VI</td>
<td>Early McIntosh, Winter Banana, White Winter Pearmain, <strong>Granny Smith</strong></td>
</tr>
<tr>
<td>Category VII</td>
<td><strong>Pink Lady®</strong></td>
</tr>
</tbody>
</table>
# Rootstocks

<table>
<thead>
<tr>
<th>Chilling requirements</th>
<th>Rootstocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low</td>
<td>Indonesian rootstocks</td>
</tr>
<tr>
<td>Low</td>
<td>M26, M27, B9</td>
</tr>
<tr>
<td>High</td>
<td>MM104, MM106, Northern Spy</td>
</tr>
<tr>
<td>850 ICE/T.A.S.C. units</td>
<td>M9</td>
</tr>
</tbody>
</table>
Start of rest-breaking

Tree reached physiological maturity

maximum depth rest leaf-drop in autumn.

buds deepest rest

$50\%$ leaf drop

gibberellic acid treatments
Effect lack of chilling (or delayed foliation - DF)

Lack of effective chilling has an influence not only on tree development but fruit quality as well:

- **Effect on the tree**
  - Poor and late start of laterals,
  - Relative advantage to terminals,
  - Correlative inhibition of laterals ("bare wood"),
  - Vigorous and long terminal growth,
  - Need for excessive pruning,
  - Few spurs,
  - Delay in fruit bearing,
  - Low yield,
  - Unchecked vegetative growth,
  - High chilling requirement in vigorously growing branches,
  - Delayed and protracted flowering season,
  - Flower buds open prior to leaf buds,
  - Excessive drain on reserves,
  - Lack of leaf coverage during the season, leads to sunburn of wood,
Effect lack of chilling (or delayed foliation - DF)

Lack of effective chilling has an influence not only on tree development but fruit quality as well:

- **Fruit**
  - Poor fruit development,
  - Small fruit,
  - Irregular ripening
  - Size distribution affected,
  - Storage potential affected,
  - Possible increase small fruit and in fruit drop.
Rest - break Agents

Rest-breaking agents

**Efficacy**
- stage / depth endodormancy
- climate

**Timing of rest-breaking spray**
- > 1 August weigh buds
- 2-year-old wood 2x per week

Plant not at same level rest-breaking @ same date

**Bud damage**

Significant increase bud weight = physio. correct stage
Rest - break Agents

**ACTION**

- arsenic, cyanide, mineral oils, thiodiazuron → respiratory metabolism
- thiourea and cyanamide treatments → reduced catalase activity
- hydrogen cyanamide treatments → stress response to the shock treatment
Effect lack of chilling on production and fruit set

- Extended blossom period
- < 30% fruit buds open
- Female flower parts or seed-forming parts deformed
- Male organs or pollen producing parts affected

Fruit set affected

Leaf buds - greater chilling requirement

Emergence > delayed than flower buds

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Consequences lack of chilling

- Poor blossom quality
- Poor pollination
- Increased "drop"
- Leaf development delayed
- Early period - fruit development at expense of reserves
- Poor differentiation fruit buds following season

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Maturity

Fruit maturity less delayed than blossoming

shorter life of the fruit on the tree

Fruit of inferior quality

shorter post-harvest life

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Effect of lack of chilling on fruit quality

Negative effect on

- Fruit size
  - delayed leaf development
  - leaf fruit ratio <
  - seed numbers <
  - Lack of spur leaves

- Gibberellic acid <

- Fruit colour
  - leaf fruit ratio <
  - lower carbohydrate production

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Firmness

Low chilling has a direct effect on cell density of the fruit (see next diagram)

- Calcium levels affected by low chilling
- Ethylene production >
- Respiration rate >
- Ultra structural changes in apple cells

Softening fruit

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Firmness

Previous Season

Stress

Temperature from rest-break until 6 weeks from full bloom

Winter chilling

Blossom thinning
Stem-end russetting

low chilling (<1000 CU) results in stem-end russetting

low levels of gibberrelic acid available to the fruit

spur leaves are lacking

Examples: Gala, Red Delicious, Elstar, Stem-end cracking Fuji?
Calcium related disorders

- Spur leaves responsible large part of the transport calcium
  - First from reserves
  - then from soil via roots

Lack of spur leaves

- Ca - level of the fruitlet at 62 days from full bloom
- bitter pit, lenticel spot, etc.
- low or lack of chilling

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Optimumising flow of calcium towards the fruit

- Fruit on dards with a large actively transpiring leaf area.
- Effective rest-breaking
- Well developed shoot emanating from the bourse capable of an optimum transpiration flow past the end of the dard.
Effect on Fruit quality in practice

Effect chilling on fruit quality – Gala and Elstar

GALA

Brazil
South Africa
New Zealand
Chile
Washington State
USA

Increased Chilling

Fraiburgo to Vacaria

Fruit Quality

Large fruit size
Less BP*
S-E Russetting**

*BP = Bitter Pit
**S-E Russting = Stem -end Russeting

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Effect on Fruit quality in practice

Variety Elstar, Holland more stem-end russeting during years when effective chilling is low

effective chilling is low

- low reserve status
- late termination of growth
- delayed leaf-drop

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