



## Control strategy for retractable roof and walls for Sweet Cherry production

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While individual sweet cherry varieties are harvested for only 1-2 weeks (though seasonal harvests may extend 5 weeks or more using a range of early-, mid-, and late-ripening varieties), the yield, fruit size and quality are determined by the growing environment over the entire 52 weeks prior to harvest. To maximize the benefits of an automatic retractable roof and walls, it is critical to think carefully about the different stages of tree development, the various climatic factors that can impact tree and fruit development positively or negatively, and how to enhance or mitigate these critical climatic factors as the weather changes seasonally in concert with tree, flower and fruit growth.

In establishing an orchard, after the nursery trees have been planted, the goal is to create the best possible growing environment during the natural growing season to optimize photosynthesis in order to maximize the tree's structural and canopy growth. The amount of growth achieved in Years 1-3 is directly proportional to the future yield potential in Years 3-5. Optimizing establishment growth helps the tree reach its commercial harvest 1-2 years sooner than if the tree was just grown outside.

Once the trees are mature enough to flower, the goals and strategies should change to optimization of the growing environment during the different life cycle and developmental stages throughout the year:

- Chill accumulation
- Flowering and pollination
- Leaf area and fruit development
- Fruit ripening and harvest
- Post-harvest tree recovery and flower bud formation for the next year
- Onset of endodormancy and cold acclimation

### Overview of control strategy:

- First determine whether you want to advance or delay the harvest
  - create the control strategy to either accumulate heat units or prevent heat unit accumulation to shift the time of flowering
- Then create the best possible seasonal conditions to influence tree and crop development by:
  - Increasing or decreasing the temperatures of the buds, leaves, fruit and soil
  - Managing the transpiration rate to ensure that trees are experiencing optimal water status to:
    - maximize fruit development and quality during the fruiting season
    - optimize the levels of photosynthesis post-harvest to ensure optimal tree recovery and flower bud development for the following season

Stage	Problems	Solutions
<b>Orchard establishment (canopy development and maturity)</b>	<ul style="list-style-type: none"> <li>Climatic stresses (cold temperatures, wind, rain-disseminated diseases) slow tree canopy development after planting, resulting in trees reaching fruiting maturity 4-5 years after planting of orchard</li> </ul>	<ul style="list-style-type: none"> <li>Initiate earlier growth in cold springs and protect trees from excessive wind and transpiration during the growing season, resulting in a higher daily average photosynthetic rate causing trees to achieve canopy maturity 1 to 2 years faster</li> </ul>
<b>Chill accumulation (to break endodormancy)</b>	<ul style="list-style-type: none"> <li>Chill hours can be negatively affected by excessively warm or cold temperatures, resulting in weak or abnormal bud break in spring</li> <li>Winter injury to stem, shoot and buds from extreme low temperatures and wind damage Risk of secondary infections such as bacterial canker.</li> </ul>	<p>If temperatures are <b>too cold</b> for chill accumulation:</p> <ul style="list-style-type: none"> <li>close the roof and walls 100% when the black plate drops below the desired minimum temperature to increase temperatures inside to the range suitable for chilling accumulation</li> </ul> <p>If temperatures are <b>too warm</b> for chill accumulation:</p> <ul style="list-style-type: none"> <li>close the roof 50%-80% and leave the walls retracted when the black plate temperature is higher than the air temperature to block infrared radiation (direct sunlight) and reduce the warming of buds above the range that negates chilling accumulation</li> <li>activate misting system over the tree canopy to evaporatively cool buds</li> <li>retract the roof and walls 100% when the black plate is lower than the air temperature (during nighttime) to maximize heat loss from the tree and soil</li> </ul> <p>Protect wood from extremely low temperatures as well as tree damage from wind/rain to prevent canker susceptibility.</p> <ul style="list-style-type: none"> <li>close the roof and walls 100% when the black plate drops below the desired minimum temperature; provide supplemental heat as needed</li> <li>close roof 50-80% and walls 100% to prevent wind-induced tree damage</li> </ul>
<b>Bud break</b>	<ul style="list-style-type: none"> <li>Once adequate chilling has occurred to break endodormancy, bud break can be advanced or delayed compared to trees outside</li> </ul>	<p>If you want to <b>advance</b> bud break, it is important to <b>increase</b> the temperature of the buds, not the air</p> <ul style="list-style-type: none"> <li>close the roof and walls 100% when outside temperatures are too cold (black plate is below 10°C)</li> </ul> <p>If you want to <b>delay</b> bud break, it is important to <b>reduce</b> the temperature of the buds, not the air:</p> <ul style="list-style-type: none"> <li>close the roof 50%-80% and leave the walls retracted when the black plate temperature is above the air temperature to reduce</li> </ul>

		<p>warming of the tree by blocking infra-red radiation (direct sunlight)</p> <ul style="list-style-type: none"> <li>• activate misting system over the tree canopy to evaporatively cool buds</li> <li>• retract the roof and walls at night to maximize heat loss (black plate will be lower than air temperature during nighttime)</li> </ul>
<b>Flowering and pollination</b>	<p>Flowers can be damaged by:</p> <ul style="list-style-type: none"> <li>• frost</li> <li>• excessive wind</li> <li>• high heat and radiation</li> <li>• rain</li> </ul> <p>Optimum temperatures for pollen release are 20°C and higher, with humidity below 70%</p> <p>Pollinators (bees) are not active when temperatures are too cold or windspeeds are excessive</p> <ul style="list-style-type: none"> <li>• Bee activity falls dramatically when air temperatures drop below 13°C</li> <li>• Bees find it difficult to forage in wind speeds above 10 kph (6 mph). Bee activity stops completely with wind speeds above 25 kph (15 mph)</li> </ul>	<p>Close the roof and walls only when:</p> <ul style="list-style-type: none"> <li>• black plate temperature is too cold (to protect flowers from freezing)</li> <li>• black plate temperature is significantly higher than air temperatures to maximize flower longevity and the effective pollination period</li> <li>• wind sensor indicates windspeeds in excess of 10 kph (6 mph)</li> <li>• close roof during rain to prevent blossom infections from fungi and bacteria</li> </ul> <p>Decide whether to use bumble bees or honey bees for pollination:</p> <ul style="list-style-type: none"> <li>• Bumble bees visit twice as many flowers per minute vs honeybees, forage further from hive and carry more pollen grains due to their size</li> <li>• Bumble bees are more active at lower temperatures (10°C) and in low light intensity</li> <li>• Bumble bees do not communicate like honey bees do, which reduces the risk and loss of pollinators to neighbouring crops. If a bumble bee finds an attractive food source elsewhere, it cannot inform its companions like honeybees</li> <li>• Bumble bees fly between trees more often than honey bees. This increases the rate of cross pollination</li> </ul>
<b>Fruit and leaf development</b>	<p>Fruit can be damaged by:</p> <ul style="list-style-type: none"> <li>• a late frost</li> <li>• heavy rains</li> <li>• hail</li> <li>• excessive wind and periods of high heat</li> </ul>	<p>Close the roof and walls only when:</p> <ul style="list-style-type: none"> <li>• black plate temperature is 0C or colder</li> </ul> <p>Close the roof and walls variably when:</p> <ul style="list-style-type: none"> <li>• wind sensor detects windspeeds in excess of 15 kph (9 mph), close windward wall(s) and when excess of 30 kph (18 mph), partially (40-60%) close roof</li> </ul> <p>Close the roof only when:</p> <ul style="list-style-type: none"> <li>• black plate temperature exceeds ~32C for 20 minutes</li> <li>• rain sensor detects rain</li> <li>• barometric pressure drops rapidly, indicating an oncoming storm</li> </ul>

<p><b>Ripening and harvest</b> (~25% of a cherry's final size and weight is gained in the last week before harvest)</p>	<p>Fruit size and quality can be reduced due to:</p> <ul style="list-style-type: none"> <li>• Excessive fruit temperatures</li> <li>• Excessive transpiration due to high radiation, low humidity and strong winds</li> <li>• Strong winds</li> <li>• Rain-induced cracking</li> </ul> <p>Rapid ripening can result in small fruit or fruit not being harvested at peak maturity Excessive heat or transpiration can cause harvest to stop early in the day to preserve fruit quality Excessive humidity, wind, and heat can promote brown rot infections</p>	<p>Close the roof only when:</p> <ul style="list-style-type: none"> <li>• black plate temperature exceeds ~32C for 20 minutes</li> <li>• rain sensor detects rain</li> <li>• barometric pressure drops rapidly, indicating an oncoming storm</li> </ul> <p>Close the roof and walls variably when:</p> <ul style="list-style-type: none"> <li>• wind sensor detects windspeeds in excess of 15 kph (9 mph), close windward wall(s) and when excess of 30 kph (18 mph), partially (40-60%) close roof</li> </ul>
<p><b>Post-harvest (tree recovery and flower bud formation)</b></p>	<p>Photosynthesis stops during periods of excessive transpiration and water stress which typically occurs on sunny days when the black plate temperature exceeds 35C, especially when outside RH is &lt;50% and when wind exceeds 10 kph</p>	<p>When the black plate temperature exceeds 35C for 30 minutes:</p> <ul style="list-style-type: none"> <li>• close the roof +/- 85% to reduce the transpiration rate</li> <li>• activate misting system to pulse for 5-10 seconds every 2-5 minutes to increase RH to at least 50%</li> </ul> <p>If the wind exceeds 20-30 kph (12-18 mph), close the roof 50-70% and walls 100% to reduce transpiration and prevent damage to leaves</p> <ul style="list-style-type: none"> <li>• Close the roof 100% when raining for at least a week to prevent open wounds from getting wet.</li> </ul> <p>Close the roof 100% whenever it rains to prevent canopy infections of cherry leaf spot and bacterial canker during healing of pruning wounds Do not mist around pruning. Allow wounds to heal before operating mist again</p>
<p><b>Onset of endodormancy and cold acclimation</b></p>	<p>Delayed cold acclimation if temperatures remain suitable for growth Risk of disease infection such as bacterial canker if temperatures are cold and rain occurs after pruning</p>	<p>Roof should always be open in fall as temperatures begin declining, except when rain sensor detects rain</p>