Australian Cherry Production Guide 2017

Chill and heat requirements:

From dormancy to flowering

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Introduction

Cherry trees originated in the cold climates of Europe and western Asia. As an adaptation to very cold winters, cherry trees enter a period of dormancy designed to protect cold-sensitive tissues such as shoots and flowers from freezing injury (Darbyshire, 2016). Successful release from dormancy requires a specific minimum cold temperature requirement be met for growth to resume when temperatures warm in spring. This cold temperature requirement is cultivar specific and referred to as the "chilling requirement". Dormant trees in an Australian cherry orchard are shown in Figure 1 below:

Figure 1: *Dormant cherry trees (Photo: I. Cover)*

The effects of insufficient chill are significant and result in delayed and prolonged bud burst. Lack of chill can also cause abnormal growth in trees such as apical dominance, that is vegetative bud break at the shoot tips, but buds below the tip do not grow simultaneously or uniformly. This can cause uneven shoot development, flowering and fruit maturity. In extreme cases, the number of flowers are substantially reduced or have abnormalities and are shed (James 2011).

The photographs below (Figure 2) show budbreak when (a) chilling requirements have been met, and (b) when they have not.

Figure 2 (a): *Uniform blossom break with very little vegetative growth when chill requirements have been satisfied (from left to right: Tieton on Gisela 5 with except for the first 8 trees in row 3, which are Bing on G5). (Photo: C. Brunt).*

*Fig**ure 2(b):** The tree in the foreground (Sweetheart on Colt) shows signs of insufficient chill. Note how the vegetative buds broke before the fruit buds (also see Figure 4 on page 11). The trees in the background (Sweetheart on Gisela) do not show signs of insufficient chill (photo: M. Chapman).*

Given these adverse impacts, cultivar specific information in the scientific literature is scant and confusingly, requirements are reported using many different chill models, methodologies and units.

In addition, flowering does not rely solely on meeting the minimum chill requirement; a minimum "heat requirement" is also needed in spring. The heat requirement is explained later in this chapter.

Chill Models

Of the available models, the "Dynamic Model" is generally preferred as it biologically structured, consistently out-performs other chill models and is comparable between sites (Darbyshire 2011, 2016).

For consistently productive orchards, **the annual accumulated chill at a particular orchard location should exceed the minimum chill requirement of the cherry cultivars planted**. To facilitate cultivar selection, classification of cherry varieties according to their chill requirements was made by compiling information from the published literature and supplementing it with grower observations.

Table 1 shows how values from different chill models were categorized to form the chill groupings shown in Table 2.

Chill Rating	Chill Portions (Dynamic model)	Chill Units (Utah model)	Chill Hours
Low	20-40	600-800	300-500
low-Moderate	40-50	800-1000	500-750
Moderate-high	50-60	1000-1200	750-1000
High	60-80	1200-1400	1000-1500
Very high	>80	>1400	>1500

Table 1 *Chill groupings from three commonly used models used in Table 2.*

Table 2 shows the chill requirements as estimated by the Dynamic model measured in Chill Portions (if known) for commonly grown Australian varieties. Chill Portions are in some cases presented as a range of values which shows the uncertainty of the precise value due to difficulties in determining the chill requirement across different:

- (i) Locations
- (ii) Rootstocks
- (iii) Management systems
- (iv) Research methodologies.

A project to collect uniform chill data under Australian conditions would be advantageous for industry.

Productivity Index

The Productivity Index developed by Grahams Factree is designed to help growers choose and manage varieties based on potential crop load of scions on non-precocious rootstocks.

Mazzard F12/1 is considered to be a non-precocious rootstock, the Gisela series and Krymps precocious rootstocks while Colt is intermediate.

The productivity index has been included in Table 2 and is based on the the scale below:

- 1-2 Poor crop, requires a precocious rootstock
- 3 Light crops, perhaps best on a precocious rootstock
- 4 Medium crops, will benefit from a precocious rootstock and good management
- 5 Consistently good crop, needs strong soil and good management if you use a precocious rootstock
- 6 Heavy crops, be very careful if using a precocious rootstock
- 7 Tends to over crop (Grahams Factree www.factree.com.au).

Dwarfing rootstocks are recommended help increase yield consistency for cultivars with a Productivity Index of 4 or less (Graham's Factree www.factree.com.au).

Cultivar	Chill Portions (CP)	Chill Rating	Productivity Index*
Bing		High	4
Black Star	60	Moderate-high	3
Brooks	37	Low-moderate	3
Celeste		Low-moderate	1
Chelan		High/very high	2
Christobalina	30	Low-moderate	
Early Burlat	48, 58	Low-moderate/Moderate-High	5
Garnet		Very high	
Grace Star		Moderate-high	3
Index		High	3
Kordia (Attika)	67	High	2
Lapins	45-52, 66, 62	Low-moderate to Moderate-high	7
Marvin	58	Moderate-high	
Merchant		Moderate- high/High	4
Minnie Royal		Low	
Newstar	54, 78	Low-moderate / Moderate-high	
Nordwunder		High	3
Rainier	45	Low-moderate	5
Regina		High	3-4
Rons		Moderate-high	5
Royal Hazel		Low	6
Royal Helen		Low	6
Royal Dawn		Low	6
Royal Lee		Low	
Ruby	48	Low-moderate	
Sam	70	Moderate-high	
Samba (Sumste)		Moderate-high	2
Simone		Moderate-high	6
Skeena		Moderate-high	4
Somerset	48, 74	Low-moderate	6
Sonata		Moderate-high	
Stella		Moderate-high	5-6
Summit		High	3
Sunburst		Moderate-high	4
Sweet Georgia		Moderate-high	5
Sweetheart	54, 74	Moderate-high	6-7
Sylvia		Very high	3
Tulare		Low	
Ulster		High	5
Van		Moderate-high	7

Table 2: *Chill requirement in chill portions (CP) with the chill grouping and Productivity Index. The Productivity Index describes the cropping potential for cultivars on non-precocious rootstocks where 1 is "poor crop" and 7 is "tends to over crop" (* modified from Graham's Factree).*

Calculation of chill requirements

A standardised approach to assessing chill is needed for direct comparison between seasons, cultivars and sites. This can be done simply by entering daily minimum and maximum temperatures into a spreadsheet to calculate Chill Portions. Some agronomists provide this service and some devices are able to perform these calculations automatically.

Recorded temperatures can also be used to calculate degree days to model insect development and time sprays and other interventions (e.g. codling moth, light brown apple moth etc).

To calculate Chill Portions for your area or region:

1. Download the Chill Portion calculator (Dynamic model) from http://www.hin.com.au/resources/chill-portion-calculator-for-australian-fruit-trees. Instructions on how to use the Chill Portion calculator are included in the spreadsheet.
2. Obtain temperature records from on-farm weather stations, the Bureau of Meteorology (http://www.bom.gov.au/climate/data/), or other reliable sources.
3. Begin calculations on the **1st of March** – the Dynamic model is self regulating (e.g. it will only start to accrue chill when the weather is cold enough). The early start date will ensure that chill portions are not missed early in the season allowing seasons and regions to be compared.
4. Finish chill calculations on the **31st of August**.
5. **Record:**

   Cultivar: ………………………………………………… Rootstock: …………………………………………………..

   Date budswell: ……………………………………… *Date 10% flowering ………………………………………

   Date full bloom: ……………………………………………… *Date petal fall ………………………………………….

   Length of flowering: [ ] 1 week [ ] 2 weeks [ ] 3 weeks

   Use of dormancy breaker: Product(s): ………………………………………………………………………….

   Application date(s): ……………………………………………………………………………………………………….

   Treatments used to reduce vigour: …………………………………………………………………………………….

   Number of Chill Portions accumulated from 1 March to 31 August: ……………………………………..

   Date of harvest: …………………………………..

   Chill requirements met: [ ] Yes [ ] No. Comment: ………………………………………………………………….

   A photographic record is advantageous to compare flowering from year to year.

   *Optional dates

Chill in a changing climate

Global temperatures have already increased by an average of 1°C since industrialisation. Climate change scientists predict that by 2050, air temperatures will increase further by between 2-4°C depending on mitigation activities (Measham and Quentin, 2014). These temperature increases will alter the amount of chill received in cherry growing regions and potentially alter their suitability for sweet cherry production in the future (Measham and Quentin, 2014).

Historical chill, as measured in Chill Portions for selected cherry growing regions are shown in Table 3 along with future projections under low (best case) and high (worst case) warming scenarios (Darbyshire et al, 2016).

The information is designed to allow growers to assess their individual situations and plan for the future.

Site	Historical	2030		2050		2090	
		Worse-case	Best-case	Worse-case	Best-case	Worse-case	Best-case
Applethorpe	66.5–82.3	55.8–65.1	60.9–71	45–54.6	55.7–67	19.4–32.3	52.3–63.2
Batlow	98.2–110.2	90.9–105.1	93.4–105.5	85.9–97.1	93–104.4	70.6–81.6	86.3–99.8
Young	79.6–89.3	70.8–81.8	71.6–84.3	63–73.5	69.4–82.7	41.3–51.8	64.8–77.2
Donnybrook	52.9–66.6	38.4–56.1	44.5–60.6	30.6–47.4	41.7–59.5	11.9–23.9	37.1–56.3
Lenswood	86.9–102.9	77.5–91.3	79.9–96.8	63.9–78.7	79.2–96.1	41.6–55.1	74.6–89.2
Manjimup	63.7–79.6	54.2–69.5	57.5–73.6	42.8–62	55.8–73.8	19.9–35.9	52.2–68.1
Huonville	102.5–115.7	92–105.9	96.1–112.8	86.3–100.7	94–109.7	51.3–67.7	90.4–105.8
Spreyton	91.1–105.3	80.3–93.5	83.1–97.7	71.6–85.2	82.5–97.9	41.7–56.9	74.3–90.7
Tatura	76.8–90.1	70.2–80.2	70.2–82.4	61.5–72.1	68.3–81.9	38.1–50.9	63.2–74.9
Yarra Valley	89.7–103.8	81–94.2	81.7–96.8	76–85.9	80–96.5	50.1–62.9	77.9–89.9
Mildura	56.6–70.0	42.9–56.6	46.4–60.9	34.6–46.6	42.4–57.7	12.8–24.8	39.5–52.7
Griffith	62.1–75.3	53.6–67.3	54.7–67.7	45.8–58.2	51.5–65.5	21.2–34	47.7–60.3
Swan Hill	63.7–76.6	53.4–65.9	58.1–69.9	44.6–58.3	53.8–67.2	20.4–34.5	47.3–62.3
Renmark	51.9–68.3	40–53.6	44.3–58.6	29.8–42.5	41.8–55.6	12.3–22	36.6–50.3
Orange	87.3–99.3	81.7–92.5	82.9–93.8	73.5–85.3	82.2–93.8	52.6–65.7	76.8–88
Swansea	87.0–101.7	73.4–87	77.9–90.6	66.5–81.3	75.6–88.3	26.7–42.6	69.5–84.9

Table 3*: Historical chill accrual (1981-2010), as measured in Chill Portions (Dynamic model) for selected cherry growing regions along with future projections under low (best case) and high (worst case) warming scenarios (from Darbyshire et al, 2016).*

Another way of representing the risk of inconsistently meeting minimum chill requirements in the future is shown graphically in Figure 3 for Lapins which have an estimated upper chill requirement of 66 Chill Portions. The graphic includes best case and worst case climate change scenarios through the use of colour (Darbyshire et al, 2016).

"The background colour represents the risk category according to the worse-case scenario and hashing relates to the risk category according to the best-case scenario. Green is low risk, yellow is medium risk, orange is high-medium risk and red is high risk" (Darbyshire et al, 2016). In this way, growers are able determine the likelihood of chilling requirements being met over the long, medium and short term; incorporate their personal risk appetite and any adaptation strategies necessary to overcome shortages in chill accrual (Darbyshire et al, 2016).

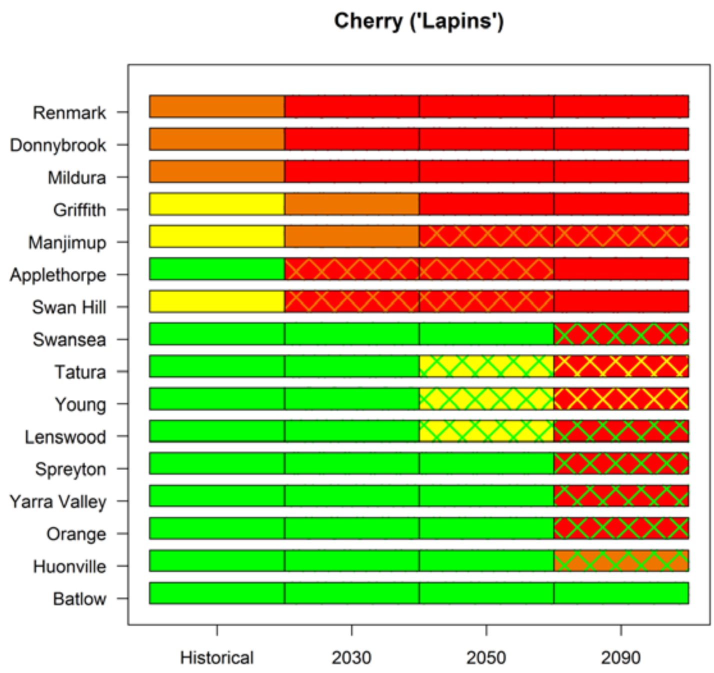

***Figure 3**. Cultivar-specific risk assessment of meeting chilling requirements at selected cherry growing regions. The background colour represents the risk category according to the worse-case scenario and hashing relates to the risk category according to the best-case scenario. Green is low risk, yellow is medium risk, orange is high-medium risk and red is high risk*

Going forward, strategies to enhance chill will be required in some region and/or in low chill years.

Strategies to overcome insufficient chill

Insufficient chill may be managed by implementing adaptation strategies. Short term adaptation strategies are solutions that a grower can apply in marginal areas or in years of low chill. Long term adaptation strategies are those that require significant investment and change in production systems.

Short term adaptation strategies

Short term solutions require some investment and a change in management practices for example, the use of plant bio-regulators and/or the use of evaporative cooling. Plant bio-regulator chemicals are usually sprayed on the tree. Evaporative cooling is a form of tree misting to increase chilling.

1. **Control vigour**

   Grower experience suggests that strong vigorous growth can affect flowering, fruit set and fruit growth. Controlling vigour is essential for obtaining good fruit set and fruit development.

   Factors that reduce vigour include rootstock selection, pruning, regulated deficit irrigation, nitrogen management and the application of growth regulators such as paclobutrazol (Cultar, AuStar, Payback) or prohexadione-calcium (Regalis).

   Even within the same tree, differences in vigour impact budbreak. Flowering can be delayed on strong branches relative to weaker limbs (see Figure 4).

***Figure 4**: Note the effect of vigour within the same tree (Rainier) where bloom is delayed on strong branches compared to the weaker/desired limbs. Trees were treated with RBAs (photo: S. Rouget).*

2 Use dormancy (rest) breaking agents (RBAs)

Rest breaking agents are designed to substitute part of the chill requirements and therefore have a greater effect in low chill years than in high chill years (Grant, n.d.).

RBAs may be ineffective in low chill years if too little chilling has accumulated prior to the time of application (Grant, n.d.). This is because the buds are too physiologically immature to respond to the treatment. In very low chill years, the applications of RBA's should be moved to later in the treatment window for each substance but never so late that green tissue is showing as this is when the plant is metabolically active and more susceptible to phytotoxic effects (Grant n.d., Glozer, 2010).

The use of rest breaking agents comes with a financial cost and not without risk:

- The advancement of flowering may potentially increase the risk of damaging frost events; and
- Potential phytotoxic effects if not applications are not timed appropriately.

If adequate chill has been received, the application of RBAs may not provide a benefit, yet still incur a financial cost (Glozer, 2010).

Rest breaking agents may be used to:

- Compact the flowering period. Some cultivars are particularly prone to extended flowering periods and this is further accentuated when their chill requirement is not fully satisfied.

- To shift the flowering period of a cultivar (earlier) so that it aligns with another cultivar to assist with pollination and fruit set. Pollen compatibility and relationship of the *S* alleles is critical to ensuring good fruit set and potential yield. If compatible cultivars are unlikely to reach peak flowering at the same time, dormancy breakers can be used to align their flowering periods.
- To advance flowering and therefore harvest. This strategy can sometimes increase the risk of frost damage in some areas. The primary reason this is undertaken is to obtain a marketing advantage and possible premium price point for early fruit. Detailed knowledge of frost or risk of subzero temperatures (which could damage trees) at each location is required to assess the risk-benefit profile of this approach.
- To promote flowering and vegetative bud break. Insufficient chilling results in reduced fruit set and fruit quality, delayed foliation and extended bloom periods.

RBAs include mineral oils (D-C-Tron, , winter and summer based oils), plant bio-regulators such as (Gibberellic Acid (GA 3, GA 4 & 7), Ethephon®, and fatty acids and their esters (Waiken®, Armobreak®, Armogan®) and fertilisers such as potassium nitrate (KNO_3), Erger (mono-, di- and poly-saccharides, proteins and nitrogen) and calcium ammonium nitrate) (e.g. CAN17).

Precise management in the time of pruning, irrigation and fertiliser applications are required if plant bio-regulators are used.

Application timing and calculating "normal" budbreak

For the best effect, treatment timing is very important. Applying RBAs too early will lead to little effect. Apply treatments too late and some compounds exert phytotoxic effects. Many products either stipulate application timing based on days before "normal" budbreak or Chill Portions. Chill portions are likely to be more accurate than "normal" budbreak and easier to calculate.

To get an estimate of the "normal" time of budbreak timing, use the methodology outlined in "Calculation of Chill Requirements" on page 5: Collect data over several years and then use the "average" date as a proxy for the "normal" date for each cultivar.

It is strongly advised to use chemicals registered by Australian Pesticides and Veterinary Medicines Authority (APVMA) for use on cherries. The only dormancy breaking chemical registered for use on cherries is Waiken®. Other plant bio-regulators registered are Gibberellic Acid (GA 3, GA 4 & GA 7) and Ethephon®. The fatty acid and their esters, Armobreak® (alkolated ammine) and Armogan® do not require registration nor does the fertiliser potassium nitrate (KNO_3) or Erger® (natural compounds). Dormex® does not have registration.

Paclobutrazol (AusStar, Cultar, Payback) and Potassium Nitrate

Research on stone fruit has shown the use of plant bio-regulator, Paclobutrazol® (e.g. Cultar AuStar, Payback), soil applied as a collar drench and the fertiliser potassium nitrate (KNO_3), applied as a foliar spray can assist to pre-condition trees and buds to concentrate and enhance bud break and flowering. The plant bio-regulator Paclobutrazol® is usually split into two application times just prior to bud break and just after harvest.

The fertiliser potassium nitrate (KNO_3) is applied as sequential weekly 5% foliar sprays for one month prior to normal leaf drop (4 sequential sprays in total). After the final spray of KNO_3 one spray of 5% zinc sulphate $ZnSo_4$ is applied to increase the effectiveness of the KNO_3 and drop leaves.

Mineral Oil

Mineral oil can be used to compensate for a limited amount of chill. Apply when 47-55 chill portions have accrued.

Waiken®

Waiken® does not have the phytotoxic effects of other dormancy breakers and has been designed to stimulate bud break in cherries. It is very useful under conditions of insufficient chill. It will also concentrate or compress the flowering period, eliminating the effects of an extended flowering period.

Waiken® induces a period dormancy after its application but flowers will emerge with greater uniformly. The timing of Waiken® is therefore critical – it has to be applied 35-50 days before bud break would normally occur. It is critical that you read the label and adhere to the directions of use on the label.

Table 4 outlines information on the application timing of RBAs. Within the suggested ranges of treatment timing for each product, early applications tend to advance bloom more than later ones and later treatments tend to compress bloom more than earlier ones (Grant, n.d.)

Erger® + Activ Eger®

Erger is a biostimulant based on natural compounds (mono, di, and polysaccharides, nitrogen, calcium and proteins) which support plant physiology and stimulate bud break. Product information indicates that it helps to advance flowering, increase uniformity of budbreak and increase fruit size in cherries. It has been shown to be effective on apples (Parkes et al., 2016).

Erger is relatively safe for users and the environment but may exert some phytotoxic effects on cherry trees if they are weak. Erger is phytotoxic to all plant parts after dormancy has been released (Valgro Erger Monograph, n.d.). Apply 45 (+/- 5 days) before normal budbreak.

Rest Breaking Agent	Application timing*	Comments
Calcium ammonium nitrate (CAN 17)	54-58 CP	Risk of toxicity if applied less than 3 weeks before budbreak. May advance bloom by 5-7 days and harvest by 3-5 days (Grant, n.d.)
Erger® + Activ Erger®	Apply 45 (± 5) days before bud break (5% of green leaf tips visible). Early applications (prior to 45 (± 5) days before bud break) are less effective. Late applications (later than 45 (± 5) days before budbreak) are also less effective and increase the risk of phytotoxicity.	Rate: Erger 6% + Activ Erger 8% (www.plantdormancy.net) Thoroughly wet the branches (it is advised 1000-1500L of solution per hectare depending upon the equipment used and plant size). Do not use other RBAs in the same year. Do not use on trees less than 4 years old (Valgro, , n.d.)
Mineral Oil	47-55 CP	Used mainly for compacting bloom. Less effective than other treatment options in advancing bloom (Grant, n.d.)
Paclobutrazol (Cultar AuStar, Payback)	2 applications: just prior to bud break and just after harvest.	Pre-conditioning treatment for cherry trees to enhance bud break and fruit quality. Use recommended Paclobutrazol® rates for cherries and adjust for soil type and vegetative growth rates. Rates have to be adjusted as Paclobutrazol® is highly effective when applied as a collar drench and watered in.
Potassium nitrate and zinc	Weekly applications of potassium nitrate for one	Pre-conditioning treatment for cherry trees to enhance bud size, bud break and fruit quality. Marginal leaf burn will occur

Rest Breaking Agent	Application timing*	Comments
sulphate	month prior to normal leaf drop followed by a final spray of zinc sulphate	with potassium nitrates sprays. However, bud size is increased in stone fruit. Zinc sulphate spray will burn of the remaining leaves. Buds appear to be stronger and enter their dormancy phase in a healthier condition.
Waiken ®	35-50 days before budbreak	Plants appear to enter a deeper dormancy after application, but the Waiken ® application results in an enhanced bud break and flowering patterns.

Table 4: *Application timing of selected RBAs. * Within the suggested ranges of CP treatment timing for each product, early applications tend to advance bloom more than later ones and later treatments tend to compress bloom more than earlier ones (Grant, n.d.). It should be noted that timings, in some cases are based on overseas data and are indicative only*

The plant hormone gibberellic acid (GA) can be used in combination with dormancy breakers to increase their effectiveness. Also various combinations of dormancy breakers can be used to increase their efficacy to achieve good bud release.

To understand the impact of RBAs on your orchard, small scale trials should be conducted to establish timing and cultivar response. It is very important to include control (untreated) trees so that differences can be observed. Growers are also advised to work closely with their agronomist when learning to use these materials.

3 Evaporative cooling and climatic factors that contribute to a lack of chilling

High day-time temperatures during the dormant period can reduce or even reverse chill accrual. High day-time temperatures have a substantially greater negative effect on chill acclimation than a lack of low night-time temperatures. High temperatures during bud release from dormancy and flowering may also result in abnormal vegetative and fruit growth.

The intermittent use of overhead sprinklers during the day is designed to keep temperatures below 16^{o}C, thereby still allowing chill to accrue and reducing the reversal of chill accumulation. This has shown to be effective on other crops but has not been validated for cherry trees.

Ideally, sprinkler cycles should wet the buds effectively and the interval short enough to keep bud temperatures from rising above 16°C during the day.

The use of evaporative cooling does not come without risks or costs: It can increase the possibility of disease infections due to free moisture remaining on the bark and buds and furthermore, if unexpected frost events strike, bud and bark damage may occur due to freezing injury.

Long-term adaptation strategies

The best long term adaptation strategy is the selection of cultivars that have good yields of high quality fruit and are suited to the particular climatic conditions.

1. Variety selection

Replacement of current cultivars with lower chill cultivars (see Table 1) will allow production into the future at many sites. When selecting new cultivars, consider:

- The chilling requirement of each cultivar;
- The average chill received and the variability in the chill at the growing site; then

- Select cultivars that match the minimum chill level received at the growing site.
    a. Low-chill cultivars for low-chill sites
    b. Moderate cultivars for medium-chill sites
    c. High -chill cultivars for high-chill sites

2. **Rootstock selection**

The choice of rootstock may improve bud break of cultivars growing in warmer climates (Putland 2011; Campbell 2007; Webster 1995) and may therefore be an effective climate change adaptation strategy. This is an area of active research at present.

Responses to a grower survey in 2011 indicated that cultivars on Gisela rootstocks had lower chill requirements than Colt or F12/1 growing in the same location. Cultivars on Gisela rootstocks lose leaves 2 weeks earlier and flower 5-6 days earlier than the same cultivar on other rootstocks, indicating that dwarfing precocious rootstocks accumulate chill more easily or are more sensitive, however, the mechanism by which this occurs is still not known. This effect is illustrated in Figure 4.

Photo 4(a) shows that while Sweetheart on Gisela 6 is in full flower, Sweetheart on Colt exhibits only vegetative growth and possible signs of insufficient chill. Photo 4(b) shows the same trees a week later.

(a)  (b) 

***Figure 4** (a) Sweetheart on Colt in the foreground, Sweetheart on Gisela 6 in the background (**b**) a week later. Also see Figure 2(b). (Photos: M. Chapman)*

The use of dwarfing rootstocks also allows closer planting and therefore increased yield on a per hectare basis (Figure 5).

(a)  (b) 

***Figure 5:** (a) Traditional orchard (b) Intensive orchard on dwarfing rootstock (Photo: I. Cover and C. Brunt).*

Heat units and the chill overlap model

Breaking dormancy is a combination of two processes: winter chill followed by spring heat. Once the chill requirement has been met, internal metabolic inhibitors are no longer present and buds are ready to grow once temperatures increase. If cold temperatures continue, the buds will be maintained in a resting state (Glozer, 2010).

The amount of heat required to break dormancy is not fixed but depends on how much chill was received over winter. For example, in high chill years when cultivars receive chill well above their minimum requirements (termed over chill), the spring heat requirements are less than in lower chill years (Darbyshire, 2016).

The amount of over-chill acts to progressively decrease the amount of heat required for flowering, but even in high chill years, a minimum amount is still required (Darbyshire, 2016). This is seen in cherries grown at relatively warm sites where chill is accumulated slowly. At these sites there is an increased heat requirement post chill before flowering commences (Measham, 2014). As a result, the heat requirements for a particular variety may vary between seasons and locations.

The "Chill Overlap Model" is able to account for the dynamic relationship between chill and heat requirements (Darbyshire, 2016) and is currently undergoing validation for cherries.

Spring heat requirements can be estimated by Growing Degree Day (GDD) models, which are very similar to degree day models for insect development, but with a different base threshold typically 10°C but 4°-4.5C are often used for cherries e.g.

Growing degree day = [(min temp +max temp)/2] –(4.5°C).

Alternatively, single sine or single triangle models can be used in calculations. Growing degree day calculations should be based on observations and begin at green side (shown in Figure 6).

Figure 6*: Cherry bud at greenside development (Photo http://msue.anr.msu.edu/news/southwest_michigan_fruit_regional_report_april_30_2013)*

Growing degree days can also be used to estimate harvest and may therefore useful for planning and marketing.

Growth stages estimated from swollen bud to harvest along with the corresponding number of cumulative degree days are shown in Table 5:

Sweet cherry growth stage	Number of growing degree days (GDD) at 4.5C
First bloom (visible stamen)	108 Bing, 99 Van, 83, Lapins, 108 Sweetheart
Full bloom	125 Bing, 117 Van, 111 Lapins, 123 Sweetheart
Petal fall	181 Bing, 174 Van, 176 Lapins, 177 Sweetheart
Fruit set	210 Bing, 208 Van, 204 Lapins, 225 Sweetheart
Harvest	805 Bing, 765 Van, 852 Lapins, 916 Sweetheart

Table 5: *Sweet cherry growth stages and growing degree-days with different developmental thresholds. It should be noted that these predictions are based on data from Southern Patagonia and have not been validated under Australian conditions (Hochmaier, 2014).*

The Department of Agriculture and Forestry in Queensland have put together a chill and growing degree day (GDD) tracker with a base temperature of 10°C linked to Bureau of Meteorology weather station sites around Australia and is a very useful resource. See https://hort-science.shinyapps.io/ChillCalculator/.

To obtain a GDD or Growing Degree Hour (GDH) spreadsheet in which you can enter values from your own weather or local weather station, please contact Cherry Growers Australia (data@cherrygrowers.org.au).

For more information on current chill related research, or to contribute flowering and harvest data for research purposes contact Dr. Rebecca Darbyshire at NSW Department of Primary Industries Rebecca.darbyshire@dpi.nsw.gov.au.

For more information on the use of plant growth regulators, contact Robert Nissen at the Tasmanian Institute of Agriculture (Robert.nissen@utas.edu.au.

Due to the complexity and interaction of many factors, growers and other experts are encouraged to contribute information to the development of this chapter. To do so, please contact Cherry Growers Australia (data@cherrygrowers.com.au).

Recommendations

- Investigate the synergistic effects of combining dormancy breaking treatments.
- Address gaps in chill and heat cultivar knowledge under Australian conditions and generate data relevant to Australian growers. This could be done through a collaborative research project based on grower collected data using standardised protocols
- Investigate the potential to incorporate weather forecast information to provide predicative information to growers
- Investigate the interactions between cultivars, rootstocks and climatic conditions.

Disclaimer

The information contained in this document is intended for cherry producers only. It is based on the best information available at the time of production and should be used as a general guide only. It is the ultimate responsibility of individual growers to confirm the accuracy and currency of information provided by checking relevant websites/information sources. Cherry Growers Australia Inc cannot control individual usage of the information contained in this manual or the way information is implemented. Accordingly, Cherry Growers Australia Inc will not accept liability for loss or damage of any kind caused by reliance on this information.

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