3.7 CHILLING MEASUREMENT

Fact Sheet Objectives

- Provide an understanding of plant chilling requirements
- Provide information on methods for calculating chilling accumulations

Hourly temp °C	Chilling hours Base temp = 7°C	Base temp = 10°C
9	0	1
8	0	2
7	0	3
6	1	4
5	2	5
4	3	6
3	4	7
2	5	8
1	6	9
0	0	0
-1	0	0
-2	0	0

Table 1. Chilling hour accumulation below a threshold.

This table shows the number of Chilling Hours accumulated for each hourly temperature reading from a temperature recorder for two different base temperatures.

Winter Chilling

The growth and development of horticultural crops such as apples and kiwifruit are strongly influenced by weather, including during the winter. While the winter may look like a time of inactivity many things are actually going on within the trees and vines, particularly with regard to the development of flowers for the coming season. The coldness of the winter has a very strong influence in most horticultural crops on the quantity and quality of flowers, as well as the timing of flowering.

Winter chilling is the term used to refer to how effective the cold of winter has been. For instance a year of high winter chilling will generally mean more kiwifruit flowers, an earlier flowering period once spring temperatures arrive, and often a more compacted flowering period. A number of methods have been developed for measuring the effectiveness of winter chilling. The *chill units* described by each of these methods try to account in various ways for the way a plant is influenced by winter temperatures. Chilling units are most meaningfully described and measured using an hourly time scale.

Chill hours below a threshold

One of the most common methods for calculating chill units is *Chill Hours.* A base temperature is chosen, usually 7ºC. If the temperature is above this base then it is too warm for the plant to accumulate chilling. If the temperature is below 7ºC then the plant is affected by the cold temperatures, with colder temperatures producing bigger effects. As soon as temperature drops below the base temperature for one hour, one *Hour Below Threshold* is accumulated. While this system is simple to estimate, it is not very representative of biological processes.

Chilling Hours

A more widely used system is to recognise increasing amounts of chilling as temperatures drop below a threshold and approach zero. If the temperature is 4 degrees below the base temperature for one hour then 4 Chill Hours accumulates and so on. By summing these hourly amounts of chilling over the winter we have a measure of how cold the winter was from the plant's perspective (see Table 1).

This is a simple linear chilling accumulation in which chilling effects are assumed to remain constant at all temperatures below the threshold. In practice, the chilling effect is maximised at the base temperature (7ºC is assumed for many crops) and falls away as temperatures experienced by the plant rise or fall beyond the threshold

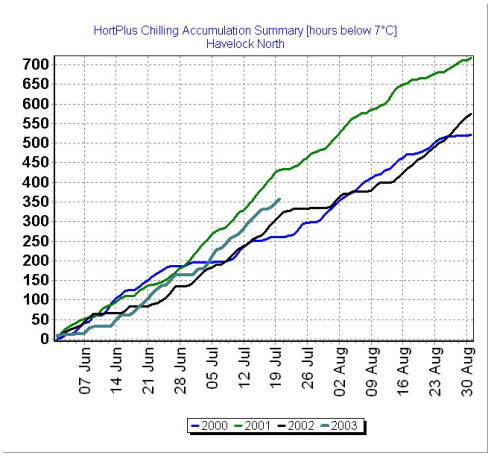
This calculation is based on the same concept as Hours Below Threshold, except that it is assumed that the colder the temperatures then the greater the chilling effect. So with a threshold temperature of 7°C, one hour at 6°C is one chill hour; one hour at 5°C is two chill hours etc. One fairly common variation that you may see on both Hours Below Threshold and Chilling Hours is to assume that temperatures below 0°C give no chilling effect.

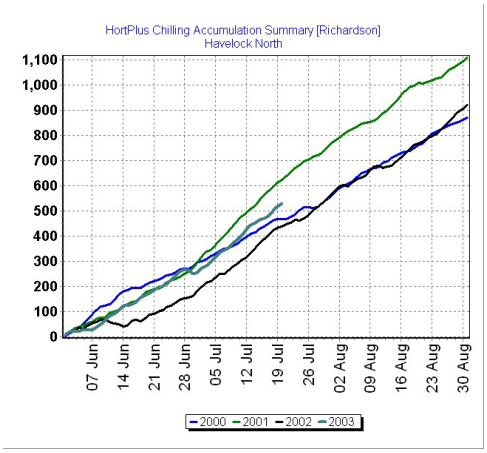
Richardson Chill Units

Originally developed using potted trees in controlled temperature rooms, the Richardson Chill Unit tries to better estimate the chilling effect of various temperatures. The optimum for chilling was found to be 4°C, and so one hour at 4°C counts as one Richardson Chill Unit. Chilling effect falls away to zero as the temperature approaches 0°C, and falls away at higher temperatures with no chill effect at temperatures over 14°C.

Richardson Chill Units with Negation of Chilling

A number of researchers have made improvements to the original Richardson Chill Unit system including refining the temperature response curve, and allowing for the negation of accumulated chill units which can occur when daily maximum temperatures go above 14ºC.





Seasonal comparison of winter chilling recorded at Havelock North in Hawkes Bay: Top graph calculated using hours below 7°C, lower graph calculated using the more sophisticated Richardson Chill Units. Note the larger chilling accumulation for Richardson Chill Units.

Chilling Requirements of Fruit Crops

Fruit Crop	Approximate Hours required under 7°C
Grapes	100 - 200
Kiwifruit	750 - 850
Apples	1200 – 1500
Apricot	700 – 1000
Almond	200 – 350
Cherries	1000 – 1300
European Pears	1000 – 1500
Peaches	1000 – 1200

Chilling Management and Management Responses to Chilling Data

Crop loading and quality can be significantly influenced by winter chilling variability and therefore have profound effects on the commercial performance of the fruit growing operation.

Ideally fruit crops should be grown only in locations where the local climate provides the necessary winter chilling requirements applicable to that crop. The use of available climate data and records will provide a basis for determining geographical suitability of any location for any given crop prior to planting. Local knowledge and experience will also be valuable in determining climate suitability.

In locations where winter chilling may not be adequate, or have not been adequately achieved over any given winter, management tools are available that can artificially simulate the required winter chilling and therefore illicit the sought after flowering response.

The use of 'dormancy breakers' such as hydrogen cyanimide can be used to manipulate flowering and vegetative growth commencement, and flowering duration. The dormancy breakers are applied as a carefully planned pre-season spray.

Summary

- Winter cold has a strong influence in horticultural crops on both the quantity and quality of flowers, as well as timing of flowering.
- Accumulated 'chill hours", or the more sophisticated Richardson Chill Units, are used to measure the effectiveness of winter chilling.
- Geographical location selection is important to ensure adequate winter chilling for any given crop.
- Desired winter chilling effects can be simulated with the use of dormancy breaker pre-season sprays.

Further Information

NZ winter chilling summaries, provided by HortPlus http://www.hortplus.com/Chill/Chilling.htm

UCLA guide to chilling http://www.ipm.ucdavis.edu/WEATHER/ddconcepts.html#Cutoff