

Chilling Accumulation: its Importance and Estimation

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Stone fruit trees such as peaches develop their vegetative and fruiting buds in the summer and, as winter approaches, the already developed buds go dormant in response to both shorter day lengths and cooler temperatures. This dormancy or sleeping stage protects these buds from oncoming cold weather. Once buds have entered dormancy, they will be tolerant to temperatures much below freezing and will not grow in response to mid-winter warm spells. These buds remain dormant until they have accumulated sufficient chilling units (CU) of cold weather. When enough chilling accumulates, the buds are ready to grow in response to warm temperatures. As long as there have been enough CU's the flower and leaf buds develop normally. If the buds do not receive sufficient chilling temperatures during winter to completely release dormancy, trees will develop one or more of the physiological symptoms associated with insufficient chilling: 1) delayed foliation, 2) reduced fruit set and increased buttoning and, 3) reduced fruit quality.

Insufficient Chilling Symptoms

Delayed Foliation. A classic symptom of insufficient chilling is delayed foliation. A tree may have a small tuft of leaves near the tips of the stems and be devoid of leaves for 12 to 20 inches below the tips. Lower buds will break eventually but full foliation is significantly delayed, fruit set is reduced, and the tree is weakened. Furthermore, heavy suckering from lower parts of the tree causes management problems, and normal development of next year's fruit buds can be impaired.

Reduced Fruit Set and Buttoning. Flowering, in response to insufficient chilling, often follows the pattern seen with leaf development. Bloom is delayed, extended, and due to abnormalities in pistil and pollen development, fruit set is reduced. In many peach cultivars, flowers drop before or around shuck split, but in others such as 'Jersey Queen' and 'Harvester', buttons form. Buttons result from flowers which apparently have set but never develop into full-size fruit. The fruit remains small and misshapen as they ripen. If you cut these fruit open, the seed is dead. Because buttoning is not apparent early in the season, growers can not thin off the abnormal fruit and the developing buttons serve as a food source and overwintering site for insects and diseases.

Reduced Fruit Quality. The effects of insufficient chilling on fruit quality are probably the least discussed but appear to be very common especially in central and south Texas. The effects on leaf growth and fruit set are dramatic but the effects of insufficient chill on fruit quality are subtle, and can occur when other symptoms do not. Insufficient chilling will cause many cultivars to have an enlarged tip and reduced firmness. Furthermore, fruit ground coloration may be greener than usual, possibly due to the fruit losing firmness before the ground color can fully change from green to yellow. The extent of these quality problems depends on the cultivar and the degree of chilling deficiency.

Chill Accumulation Models

The question of what is dormancy and what constitutes 'chilling temperatures' has yet to be clearly defined. Most people agree that temperatures below freezing or above 60 degrees F are not effective for chilling unit accumulation. There are various models used to calculate chilling, each one defining what a chilling unit is. The three most common models (Table 1.) are: the number of hours below 45 degrees F model, the number of hours between 32 and 45 degrees F model, and the Utah model. The first two models are simple and define a chilling unit as one hour below or between certain temperatures. The Utah method is more complex because it introduces the concept of relative chilling effectiveness and negative chilling accumulation (or chilling negation).

Table 1. Common chill accumulation models

45° F and Under Model

1 hour \leq 45° F = 1.0 chill unit

32° F - 45° F Model

1 hour between 32° F and 45° F = 1.0 chill unit

Utah Model

1 hour below 34 degrees F = 0.0 chill unit

1 hour 35-36 degrees F = 0.5 chill units

1 hour 37-48 degrees F = 1.0 chill units

1 hour 49-54 degrees F = 0.5 chill units

1 hour 55-60 degrees F = 0.0 chill units

1 hour 61-65 degrees F = -0.5 chill units

1 hour $>$ 65 degrees F = -1.0 chill units

All of these models require hourly temperatures to be recorded for calculation, and the point in time to begin recording chilling temperatures is not well defined. In addition, since these models were developed in states where high chill-requirement peach cultivars are grown, their usefulness under medium and low chill-accumulation conditions has been limited.

Mean Temperature Model (Table 2.). Another approach, the mean temperature model, uses mean winter (December and/or January) monthly temperatures to estimate accumulated chilling units. Researchers in Georgia and Florida independently developed a relationship between the mean monthly temperature of their coldest month(s) and total chill unit accumulation. Combining data from both studies the Stone Fruit Breeding Program at Texas A&M University developed a method to estimate chill accumulation which has demonstrated to be accurate for estimating chill accumulation in Texas from the Lower Rio Grande Valley up to the Red River, and should work well throughout the southeastern U.S.

Chilling accumulation, determined with this model, has been tested and compared to peach tree behavior at Stephenville, Fredericksburg, College Station, Yoakum, and Weslaco, TX. The coldest month or months are used for the calculation. In low chill regions (regions where average January temperature is 59-63 degrees F) where January represents the dormancy season, January mean temperature is most accurate for estimation. In high chill regions (regions where average January temperature is below 48 degrees F) a mean December-January temperature is recommended. In medium chill regions (regions where average January temperature is 48-58 degrees F) January mean temperature has been best for calculating chill accumulation except in years when mean temperatures between December and January differed by more than 6 degrees F. In this case, the December-January mean was more accurate.

Table 2. Mean temperature chill accumulation model calculations.

For January mean: Total chill accumulation = $3547 - (54 \times \text{January mean temperature})$

For December-January mean: Total chill accumulation = $4280 - (68.8 \times (\text{December} + \text{January mean temperature} / 2))$

Also, this method will make it possible for the grower to know, before fruit thinning time, if chill accumulation was sufficient for a given cultivar. If insufficient chilling is suspected for a cultivar, the grower can implement management and marketing strategies to reduce the impact on costs and labor. Furthermore, chemical sprays such as Dormex that help break dormancy are being researched. These chemicals can be used in late January or early February if insufficient chilling is suspected. On the other hand, the expense of a dormancy-breaking

chemical can be avoided if the grower knows that trees have received sufficient chill accumulation. Hopefully the mean temperature chill model will prove to be a tool that can help us select cultivars better and manage our present cultivars to minimize detrimental effects of mild winter.

Williamson County Example

Mean December, 2005 temperature is 42.6°F and mean January, 2006 temperature is 51.5°F

Chilling Units = 4280 minus 68.8 X [(Dec. mean + Jan. mean)/2]

Chilling Units = 4280 - 68.8 X [(42.6° + 51.5°)/2]

Chilling Units = 4280 - 68.8 X 47.05

Chilling Units = 4280 - 3237

Chilling Units = 1043