RESEARCH REPORTS & NOTES

A Model for Estimating the Completion of Rest for 'Redhaven' and 'Elberta' Peach Trees[1]

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Abstract. **A mathematical model relating environmental temperatures to rest completion of 2 peach cultivars has been developed. The model equates temperatures to effective chill-units, such that, one can predict when rest will or has been completed with a high degree of accuracy.**

Deciduous fruit trees will not noticeably grow during a period in the winter, even if temperature and soil water conditions are favorable. This physiological condition is termed "rest." Such rest is broken by exposure to cold temperatures.

The standard method of determining the time of rest completion is to bring shoots into a greenhouse and expose them to growing temperatures (18-24°C). If shoots develop within a 2 to 3 week period, rest is considered completed. This approach is time consuming and for many purposes such a delay in obtaining results is too long. Hence, a more rapid and simple method of estimating the time of rest completion is needed.

One such approach has been to relate the no. of hours below a given base temp, generally 7.2°C (45°F) 1, 2, 3, 6, 7) to the time when rest is completed. This method has not been very satisfactory because the no. of hours required for rest completion is not the same for years with different temp regimes.

Erez and Lavee (4), using controlled conditions, observed that a temp of 6°C (43°F) contributed more to rest completion than any other of their test temperatures. They reported that 10°C (50°F) was about half as efficient in breaking rest as 6°C and that 21°C (70°F) when alternated with a low temp, nullified the effect of the low temp. They suggested a weighted chilling hour wherein 3°C (37.4°F) and 8°C (46.4°F) were 90% as effective as 6°C, while 10°C was only 50% as effective.

The chill-unit model. Using data from the literature and results of our own research, a model relating environmental temperatures to the time of rest completion was developed. The model is based on the accumulation of chill-units where 1 chill-unit equals 1 hour exposure at 6°C (43°F). The chilling contribution becomes less than 1 as temperatures drop below or rise above the optimum value. A negative contribution to the chill-unit accumulation occurs at temperatures above 15°C (60°F) and 0 unit contribution occurs below 0°C (32°F). Specific temp values and their equivalent chill-unit contributions as used in the model have been tabulated in Table 1.

Table 1. Conversion of selected temperatures to Chill Units.

Temperature °C	Temperature °F	Chill units contributed
<1.4	<34	0
1.5 – 2.4	35 – 26	0.5
2.5 – 9.1	37 – 48	1
9.2 – 12.4	49 – 54	0.5
12.5 – 15.9	55 – 60	0
16 – 18	61 – 65	–0.5
>18	>65	–1

Converting temperatures to chill-units. To determine the chill-unit accumulation for a 24-hr period, a computer was programmed to convert each hourly temp to the equivalent chill-unit values given in Table 1. These values were then accumulated for the entire 24 hr period.

Hourly temperatures needed to calculate chill-units are usually not available in orchards, so a method of synthesizing hourly values was developed. This method assumes that a daily temp curve can be approximated by plotting max and min temp at 12 hr intervals and connecting these points with straight lines. The line was then divided into 11 equal segments with the endpoint of each segment representing an hourly temp.

Although there was considerable difference between actual hourly temperatures and these synthesized values, these differences tended to average out over a period of several weeks. Tests for 2 different years covering the winter season at Salt Lake City Airport gave chill-unit accumulations within 2% of the accumulation obtained using measured hourly temperatures.

Chilling unit initiation. To determine when accumulated chill-units become effective in meeting rest requirements, chill-unit accumulations beginning in late summer were plotted as a function of time. During the late summer the temp is usually above 15.6°C (60°F), hence chill-units are negative. Positive chill-units begin to accumulate just after the day in the fall when the largest negative accumulation is experienced.

Determining chill-unit requirements. To determine the no. of chill-units needed to meet the rest requirements of 'Redhaven' peaches, the accumulation of chill-units at Saint George and Ogden, Utah during the 1968-69 and 1969-70 seasons were calculated. Thermograph recorded temperatures were correlated with rest completion, as determined by the GA_3 method (5) for 'Redhaven' peach leaf buds at these 2 locations. During 3 of the 4 studies 870 chill-units were required to break rest. Similar calculations for the 1966-67 season were made for Ogden, Utah using 'Gleason Early Elberta' peaches. 'Gleason Early Elbertas' required 790 chill-units (Table 2).

Testing the model. The chill-unit model was tested at Farmington, Utah, during the 1973-74 season by collecting samples of 'Redhaven' peaches 3 times a week and placing them in a greenhouse. The observed date of rest completion occurred with the samples taken on Feb. 3 and 5, 1974. The calculated date using the model was Feb. 1, 1974.

Since no additional rest completion data were available, the model thus developed was tested in 2 ways. First, the amount of energy in the form of accumulated growing degree hours (GDH), the no. of hours above 4.4°C (40°F), from rest to full bloom was determined. To determine these requirements, peaches which were known to have completed their winter rest but stored at a low temp so they would not start growing, were moved into a greenhouse and the accumulation of GDH to full bloom determined. The required no. of GDH (°C) to full bloom for 'Redhaven' was 4922. (Users who

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Table 2. Accumulated chill units for rest completion of 'Redhaven' and 'Gleason Early Elberta' peaches.

Location	Year	Date of chilling initiation	Date of rest completion (GA_3 method)	Chill units
'Redhaven'				
St. George, Utah	1968-69	Nov. 5	Jan. 26	870
	1969-70	Nov. 3	Jan. 26	870
Ogden, Utah	1968-69	Sept. 2	Jan. 20	870
	1969-70	Oct. 2	Jan. 11	890
'Gleason Early Elberta'				
Ogden	1966-67	Oct. 6	Jan. 20	790

Table 3. Full bloom dates[z] used as an index of reliability of chill-unit estimate of end of rest.

Location	Years	Range of differences in days	Avg differences in days	SD
Fort Valley, Georgia	10	−2 to +8	3.0	3.83
Prosser, Washington	8	−8 to +5	0	3.34
Utah	1[y]	−6 to +5	3.7	2.88

[z]Bloom dates determined from weekly observations.
[y]7 orchards.

wish to convert GDH to F should refer to Table 1.) Three replications yielded GDH sums of 4926, 4918, 4926, for 'Redhaven' peaches. The GDH requirement for full bloom of 'Elberta' peaches was 5110. Using a chill requirement of 790 chill-units for 'Elberta' peaches and a GDH accumulation of 5110, dates of full bloom were calculated for 8 years of phenological observations at Prosser, Washington, and 10 years of observation at Ft. Valley, Georgia. Phenological dates had been determined by weekly observations. The difference between calculated and observed dates of full bloom was determined for each year at the 2 locations (Table 3).

A second test of the model was made in Utah during the 1972-73 season. Bloom dates for 'Redhaven' peaches in 7 orchards along the Wasatch Front were determined by weekly visits to the orchards. Using an accumulation of 870 chill-units to determine end of rest and 4920 GDH as the energy requirement, dates of full bloom were calculated (Table 3).

Use of the chill-unit accumulation as an indicator of the time for beginning the accumulation of growing degree hr for bud development is a key to the total climatography model. The accuracy of the computed date of full bloom for such diverse climates as Washington, Georgia and Utah was good verification of the validity of the chill-unit model.

Application of chill-unit concept. Once the no. of chill-units required to complete rest is established for a cultivar and daily max and min temperatures for an area are available, the time of rest completion can be estimated. From this observation a grower might:

1. Determine if there will be enough chill-units accumulated to permit raising of specific peach cultivars in an area.
2. Determine when the energy accumulation in the form of growing degree hours becomes effective in producing bud development.
3. Determine the time when certain cultural practices such as sprinkling to delay bloom should begin.
4. Determine the time when trees will begin to grow with warm temperatures and begin losing their cold hardiness.

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Control of Peach Disease with Benomyl in Full and Modified Schedules[1]

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Abstract. **In fungicide tests using recommended rates of fungicide on peach [*Prunus persica* (L.) Batsch], benomyl in a full season schedule was significantly better than captan against scab and brown rot in 3 out of 4 tests. A 6 application schedule, omitting several cover sprays, was never significantly better than the full captan schedule in the same tests. Bloom sprays did not result in improved brown rot control in 5 tests.**

Benomyl[3] has been cleared for use of peaches and nectarines and is now being used commercially for control of brown rot caused by *Monilinia fruticola* (Wint.) Honey and scab caused by *Cladosporium carpophilum* Thuem. The systemic nature of this new material and its higher cost seems to justify efforts to minimize the amount of fungicide used. Benomyl is effective for peach and nectarine disease control (1, 2, 3). This report summarizes research to determine the effectiveness of several benomyl spray schedules on peach.

The following spray materials were included in these tests: methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate (benomyl); N-[(Trichloromethyl) thio]-4-cyclohexene-1, 2-dicarboximide (captan)[4]; and sulfur 90W.

We first included benomyl in a peach fungicide test in 1967 (1). For 4 years preharvest schedules of benomyl or captan following 6-8 applications of wettable sulfur, were compared with each other and with the recommended captan and sulfur full season schedules. Starting in 1971, benomyl was included in a full season schedule and compared with a "reduced" 6 application schedule which omitted sprays between second

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[3]Benlate 50W.

[4]Orthocide 50W.