# Degree-Days:

## The Calculation and Use of Heat Units in Pest Management

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600

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### Temperature thresholds

The notion that the growth and development of many organisms is dependent on temperature dates as far back as the middle of the 18th century, and it is still a useful concept in modern agriculture. In general, it holds that the cooler the temperatures are, the slower is the rate of growth and development of plants and invertebrate animals. Table 1 illustrates this point, showing the differences in development of cotton during a warm year (1978) and a cool year (1982), and under 30-year temperature averages. Similar differences would be observed for a range of crops as well as pest and beneficial insects, but a warmer or longer season with a greater degree-day accumulation does not necessarily imply that crop yields will be higher or that pests will be more abundant. In some instances, high temperatures can aggravate cultural problems and increase crop stress.

Figure 1A shows that an organism takes quite a long time to grow through successive stages at low temperatures. As the temperature increases, development time progressively decreases until the temperature becomes high enough to affect growth and development negatively. Figure 1B illustrates the same relationship in a slightly different manner, plotting development rate (1/days to develop) as a function of temperature. The rate of development is simply the percent development per day for a specific temperature.

The lower developmental threshold for a species is the temperature at and below which development stops. In practice, an estimate of this threshold is obtained by projecting the straight segment of the curve (Fig. 1B, broken line) until it intercepts the temperature axis. This "linear approximation" method normally overestimates the lower developmental threshold, but this is of little practical concern since little development occurs at temperatures close to the threshold. The upper developmental threshold is less well-defined but is often taken as the temperature at and above which the rate of growth or development begins to decrease. For many cropping systems upper thresholds are not used, because data for such estimates are lacking.

In practice, information such as that in Figure 1 is obtained from laboratory experimentation in which groups of organisms are grown at several different constant temperatures and their development times recorded. Figure 2 graphs the development of laboratory-reared cotton bollworms from newly hatched larvae to newly emerged adults. As temperature increased, the time taken to develop decreased, but the heat accumulation required to complete development remained approximately the same.

This measure of accumulated heat is known as physiological time. Physiological time provides a common reference for the development of organisms. The amount of heat required to complete a given organism's development does not vary. It makes no difference whether the temperature is constant or fluctuating, the combination of temperature (above the lower threshold) and time will always be the same.

Physiological time is measured in degree-days (°D). One degree-day is equal to one degree above the lower developmental threshold over 24 hours.

### Methods of calculation

Field temperatures normally follow a cyclical pattern, as shown by the 3-day period of Figure 3. The degree-days accumulated during this period depend on the lower and upper thresholds. The lower the lower threshold is, the more degree-days accumulate (Fig. 3A versus Fig. 3B); the lower the upper threshold is, the fewer degree-days accumulate (Fig. 3A versus Fig. 3C). Two species such as a crop and its pest may differ in their thresholds and in the number of degree-days they require to complete development. Although it is fairly simple to estimate the degree-days accumulated at a constant temperature in the laboratory, as illustrated in Figure 2, the daily cyclical temperature fluctuations that occur in nature (Fig. 3) often necessitate more detailed methods.

Several techniques are available for calculating degree-days through the use of daily maximum and minimum temperatures. From the simplest to the most complex, these are: 1) averaging, 2) single triangulation, 3) double triangulation, 4) single sine, and 5) double sine. All of these are considered "linear" methods, because the rate of development is presumed to be a straight line directly related to temperature, as in Figure 1B. There are nonlinear methods as well, but they are more complicated calculations most appropriately used in research.

**Table 1. Acala SJ-2 cotton development. Growth stages during a warm year (1978) and a cool year (1982) as compared with the 30-year temperature average.**

| Growth stage | 1978 | 1982 | 30-year average |
|---|---|---|---|
| Emergence | April 27 | April 22 | April 22 |
| Square initiation | June 6 | June 8 | June 7 |
| First blooms | June 20 | June 23 | June 23 |
| First green bolls | June 26 | June 28 | June 28 |
| First open bolls | August 10 | August 20 | August 12 |
| 95% open bolls | October 21 | —* | November 2 |

*Did not reach 95 percent open.

Note: Dates based on April planting, using Corcoran, California, temperatures.

## Averaging

The simplest method used to estimate the number of degree-days for one day is averaging:

$$\frac{\text{high temperature} + \text{low temperature}}{2} - \text{lower threshold}$$

This averaging method ignores the upper threshold. Figure 4A illustrates the estimated accumulation of degree-days for a 3-day period. The area of degree-days

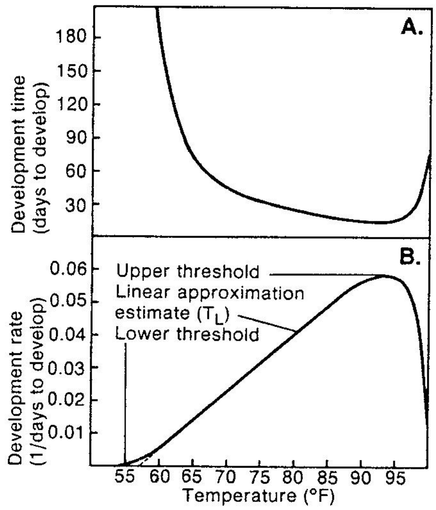



**Fig. 1. An organism develops more quickly as temperatures increase up to a point, after which development slows. From Wilson and Barnett (1983).**

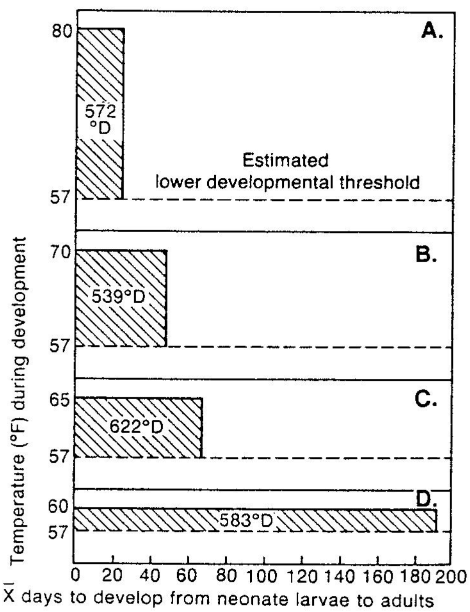



**Fig. 2. Heat accumulation, or degree-days (°D), for cotton bollworm remains about the same, even though development time differs at different temperatures. From Wilson and Barnett (1983).**

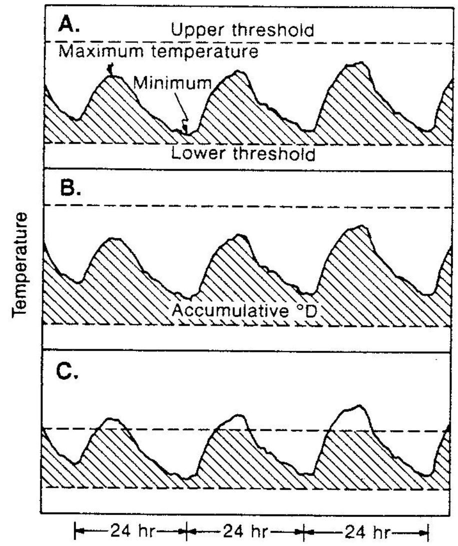



**Fig. 3. In daily cyclical temperatures (A), the lower the lower threshold, the more the accumulated °D (A versus B); the lower upper threshold, the fewer the °D (A versus C). From Wilson and Barnett (1983).**

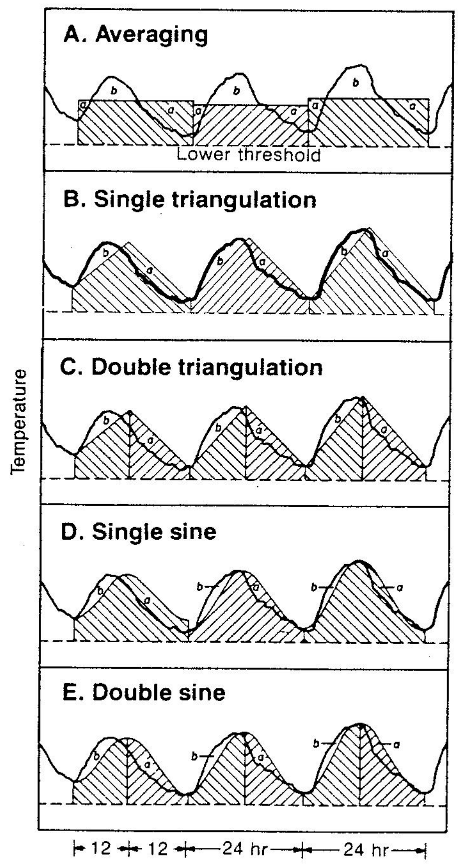



**Fig. 4. Five linear methods for calculating °D accumulation, from the simplest (A) to the most complicated (E). From Wilson and Barnett (1983).**

represented by $b$, which is underestimated by this method, is balanced by the overestimate of $a$. Minimum temperatures below the lower threshold or unusually high maximum temperatures will result in error.

Many hand calculators can easily be programmed so that the averaging calculation can be made simply by entering the low and high temperatures for the day and the lower developmental threshold for the organism.

### Triangulation

Figures 4B and 4C illustrate the two triangulation methods. The single triangulation method (Fig. 4B) uses a day's low and high temperatures to produce an equilateral triangle over a 24-hour period: degree days are then estimated by calculating the area between the two thresholds that is enclosed by the triangle. Using a 12-hour or half-day calculation (Sevacherian, Stern, and Mueller, 1977), the double triangulation method (Fig. 4C) draws straight lines between minimum and maximum temperatures and calculates the area between thresholds that falls within the resulting triangle. Over a 24-hour period, the overestimated area $a$ will be balanced by the underestimated area $b$. These methods give good estimates of heat units, and their equations are easy to use as well as adaptable to programmable calculators and microprocessors.

### Sine

Figure 4D illustrates the single sine curve method (Baskerville and Emin, 1969). This technique uses a day's low and high temperatures to produce a sine curve over a 24-hour period, and then estimates degree-days for that day by calculating the area above the threshold and below the curve. Again, the $a$ areas balance the $b$ areas, resulting in good degree-day estimates. The UC Integrated Pest Management (UC/IPM) computer network uses this method to calculate degree-days. It is a more complicated method, but can be adapted to hand calculators or microprocessors.

Figure 4E illustrates the double sine method (Allen, 1976). The only difference between this and the single sine method is that this fits a sine curve through the minimum temperature of the day and the maximum temperature of the day. It then fits separate sine curves through the maximum-temperature period of the day and the mimimum-temperature of the next day. The double sine method more realistically follows the daily temperature cycle. Its calculation, however, is more complex, and would probably require the use of a microprocessor.

### Precalculated tables

Precalculated tables using any degree-day method can be constructed where the low for the day is charted across the top and the high down the side. Tables presented in UC Integrated Pest Management Manuals[1] or generated from the UC/IPM computer use the single sine method. To find the degree-days accumulated for a day, the user locates the appropriate high and low temperatures and follows the column and row until the two intersect (Table 2). Different tables must be used for species having different thresholds.

**Table 2. A portion of a degree-day table indicating the number of degree-days (19) that had accumulated on a day when the maximum temperature was 94 and the minimum temperature was 44.**

| Maximum temperature | Minimum temperature (°F) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (°F) | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 |
| 118 | 20 | 21 | 21 | 21 | 22 | 22 | 23 | 23 | 24 |
| 116 | 20 | 20 | 21 | 21 | 22 | 22 | 23 | 23 | 24 |
| 114 | 20 | 20 | 21 | 21 | 21 | 22 | 22 | 23 | 23 |
| 112 | 20 | 20 | 20 | 21 | 21 | 22 | 22 | 22 | 23 |
| 110 | 19 | 20 | 20 | 20 | 21 | 21 | 22 | 22 | 23 |
| 108 | 19 | 19 | 20 | 20 | 20 | 21 | 21 | 22 | 22 |
| 106 | 19 | 19 | 19 | 20 | 20 | 21 | 21 | 22 | 22 |
| 104 | 18 | 19 | 19 | 19 | 20 | 20 | 21 | 21 | 22 |
| 102 | 18 | 18 | 19 | 19 | 19 | 20 | 20 | 21 | 21 |
| 100 | 18 | 18 | 18 | 19 | 19 | 19 | 20 | 20 | 21 |
| 98 | 17 | 17 | 18 | 18 | 19 | 19 | 19 | 20 | 21 |
| 96 | 17 | 17 | 17 | 18 | 18 | 19 | 19 | 20 | 20 |
| 94 | 16 | 16 | 17 | 17 | 18 | 18 | 18 | 19 | 20 |
| 92 | 16 | 16 | 16 | 17 | 17 | 17 | 18 | 18 | 19 |
| 90 | 15 | 15 | 16 | 16 | 16 | 17 | 17 | 18 | 18 |
| 88 | 14 | 14 | 15 | 15 | 16 | 16 | 16 | 17 | 18 |

### Formulas

Six possible relationships can exist between the daily temperature cycle and the upper and lower developmental thresholds. The temperature cycle can be: 1) completely above both thresholds, 2) completely below both thresholds, 3) entirely between both thresholds, 4) intercepted by the lower threshold, 5) intercepted by the upper threshold, or 6) intercepted by both thresholds. When degree-day approximations are calculated, different equations are required to compute degree-days for each case. The relationships among maximum and mimimum temperatures and the developmental thresholds are used to select the proper equation. Tables 3, 4, 5, and 6 provide equations for each of the six possible cases, using single triangulation, double triangulation, single sine, and double sine methods, respectively. Test data for computer validation of each of these equations are presented in Table 7.

Degree-days may also be calculated using hourly temperatures by determining the number of degrees that fall between the maximum and minimum developmental thresholds each hour, summing the values for a day, and dividing the total by 24. The hourly method more realistically approximates the actual amount of heat accumulated during a day than is possible using daily maximum and minimum

[1]UC Integrated Pest Management Manuals, published by Agricultural Sciences Publications, are available for biological and chemical control of pests in field crops, fruits and nuts, vegetables, and livestock. See ordering information at the end of this publication.

**Table 3. Formulas for calculating degree-days by the single triangulation method. Accumulated degree-days are shaded areas of diagrams.**

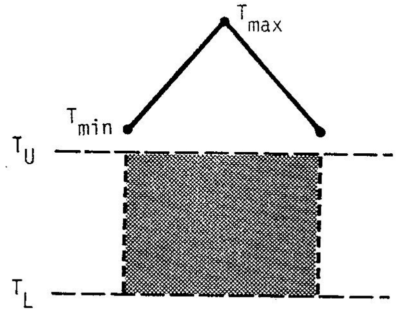
$T_U$ = Upper threshold

$T_L$ = Lower threshold

$T_{max}$ = Maximum temperature

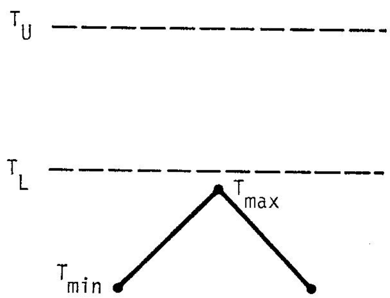
$T_{min}$ = Minimum temperature

**1.**



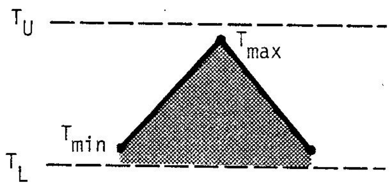

$$°D = T_U - T_L$$

**2.**



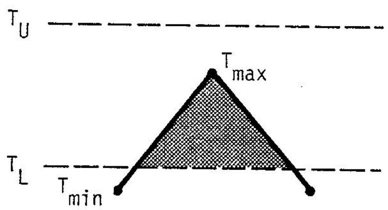

$$°D = 0$$

**3.**



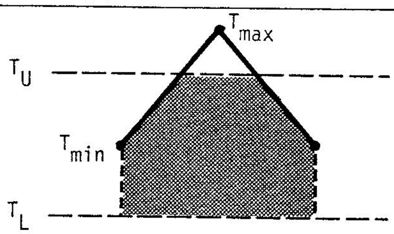

$$°D = \frac{6(T_{max} + T_{min} - 2T_L)}{12}$$

**4.**



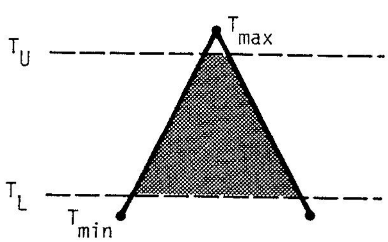

$$°D = \frac{6(T_{max} - T_L)^2}{T_{max} - T_{min}} \div 12$$

**5.**




$$°D = \frac{6(T_{max} + T_{min} - 2T_L)}{12} - \left[\frac{6(T_{max} - T_U)^2}{T_{max} - T_{min}} \div 12\right]$$

**6.**




$$°D = \left[\frac{6(T_{max} - T_L)^2}{T_{max} - T_{min}} - \frac{6(T_{max} - T_U)^2}{T_{max} - T_{min}}\right] \div 12$$

**Table 4. Half-day formulas for calculating degree-days by the double triangulation method. Accumulated degree-days are shaded areas of diagrams.**

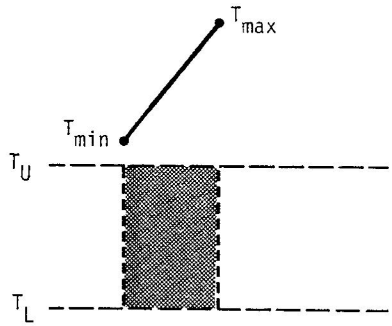
$T_U$ = Upper threshold

$T_L$ = Lower threshold

$T_{max}$ = Maximum temperature

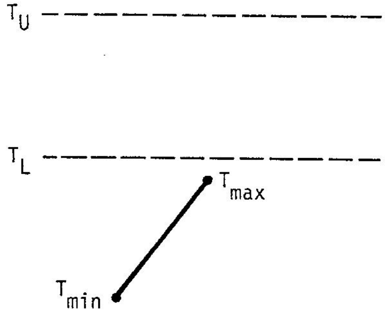
$T_{min}$ = Minimum temperature

**1.**



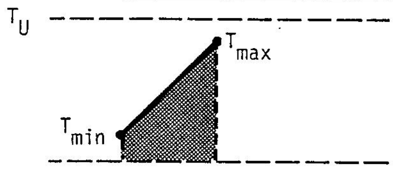

$$°D = \frac{T_U - T_L}{2}$$

**2.**



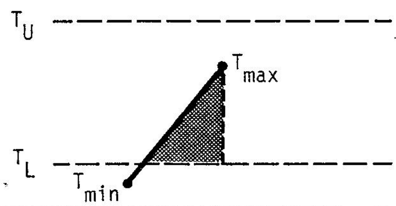

$$°D = 0$$

**3.**



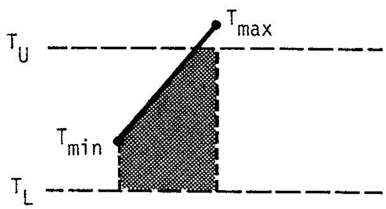

$$°D = \frac{6(T_{max} + T_{min} - 2T_L)}{24}$$

**4.**



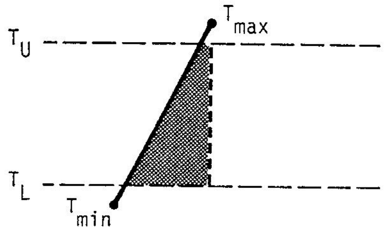

$$°D = \frac{6(T_{max} + T_L)^2}{T_{max} - T_{min}} \div 24$$

**5.**




$$°D = \frac{6(T_{max} + T_{min} - 2T_L)}{24} - \left[\frac{6(T_{max} - T_U)^2}{T_{max} - T_{min}}\right] \div 24$$

**6.**




$$°D = \left[\frac{6(T_{max} - T_L)^2}{T_{max} - T_{min}} - \frac{6(T_{max} - T_U)^2}{T_{max} - T_{min}}\right] \div 24$$

**Table 5. Formulas for calculating degree-days by the single sine method. Accumulated degree-days are shaded areas of diagrams.**

$T_U$ = Upper threshold

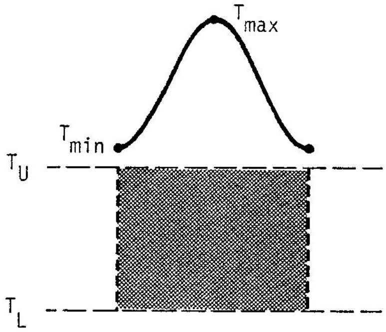
$T_L$ = Lower threshold

$T_{max}$ = Maximum temperature

$T_{min}$ = Minimum temperature

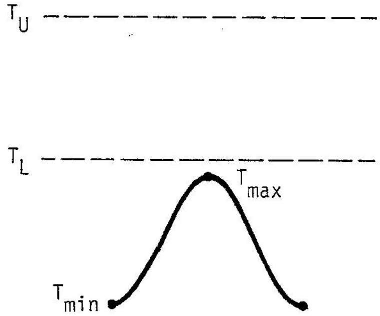
$$\alpha = \frac{T_{max} - T_{min}}{2}$$

**1.**



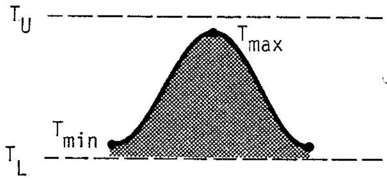

$$°D = T_U - T_L$$

**2.**



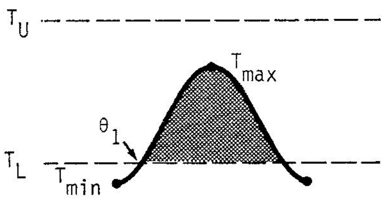

$$°D = 0$$

**3.**




$$°D = \frac{T_{max} + T_{min}}{2} - T_L$$

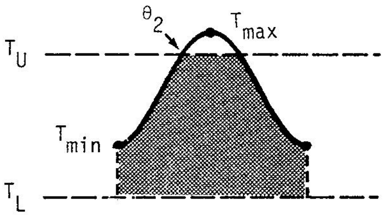
**4.**




$$°D = \frac{1}{\pi}\left[\left(\frac{T_{max} + T_{min}}{2} - T_L\right)\left(\frac{\pi}{2} - \theta_1\right) + \alpha\cos(\theta_1)\right]$$

$$\theta_1 = \sin^{-1}\left[\left(T_L - \frac{T_{max} + T_{min}}{2}\right) \div \alpha\right]$$

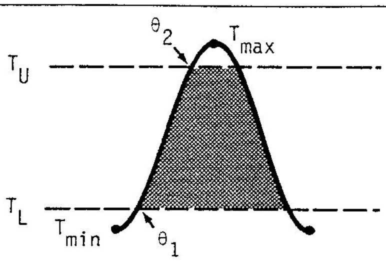
**5.**




$$°D = \frac{1}{\pi}\left\{\left(\frac{T_{max} + T_{min}}{2} - T_L\right)\left(\theta_2 + \frac{\pi}{2}\right) + \left(T_U - T_L\right)\left(\frac{\pi}{2} - \theta_2\right) - \left[\alpha\cos(\theta_2)\right]\right\}$$

$$\theta_2 = \sin^{-1}\left[\left(T_U - \frac{T_{max} + T_{min}}{2}\right) \div \alpha\right]$$

**6.**



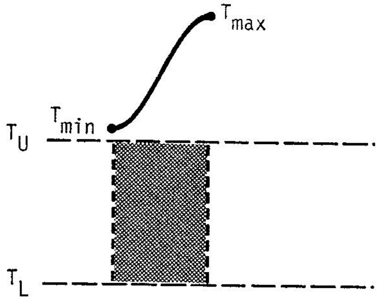
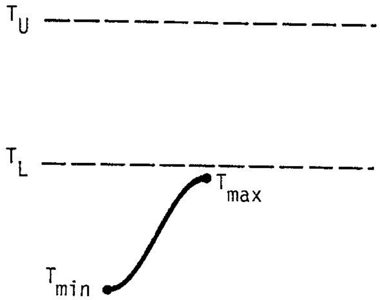
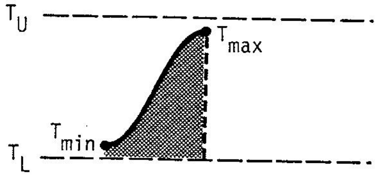
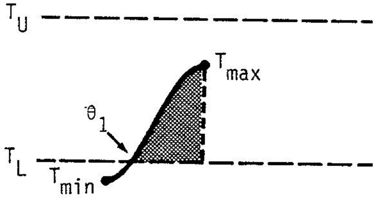
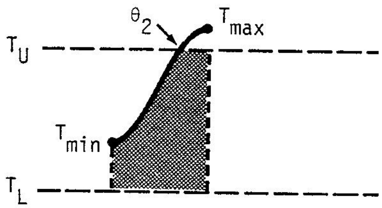
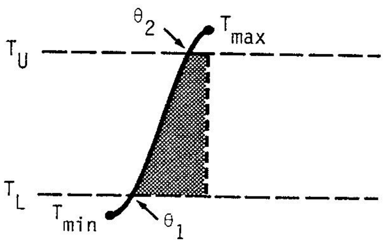

$$°D = \frac{1}{\pi}\left\{\left(\frac{T_{max} + T_{min}}{2} - T_L\right)(\theta_2 - \theta_1) + \alpha[\cos(\theta_1) - \cos(\theta_2)] + (T_U - T_L)\left(\frac{\pi}{2} - \theta_2\right)\right\}$$

$$\theta_1 = \sin^{-1}\left[\left(T_L - \frac{T_{max} + T_{min}}{2}\right) \div \alpha\right]$$

$$\theta_2 = \sin^{-1}\left[\left(T_U - \frac{T_{max} + T_{min}}{2}\right) \div \alpha\right]$$

**Table 6. Half-day formulas for calculating degree-days by the double sine method. Accumulated degree-days are shaded areas of diagrams.**

- $T_U$ = Upper threshold
- $T_L$ = Lower threshold
- $T_{max}$ = Maximum temperature
- $T_{min}$ = Minimum temperature
- $\alpha = \frac{T_{max} - T_{min_1}}{2}$, 1st half day
- $\alpha = \frac{T_{max} - T_{min_2}}{2}$, 2nd half day

| | | |
|---|---|---|
| **1.** |  | $°D = \frac{T_U - T_L)}{2}$ |
| **2.** |  | $°D = 0$ |
| **3.** |  | $°D = \frac{1}{2}\left(\frac{T_{max} + T_{min}}{2} - T_L\right)$ |
| **4.** |  | $°D = \frac{1}{2\pi}\left[\left(\frac{T_{max} + T_{min}}{2} - T_L\right)\left(\frac{\pi}{2} - \theta_1\right) + \alpha\cos(\theta_1)\right]$<br>$\theta_1 = \sin^{-1}\left[\left(T_L - \frac{T_{max} + T_{min}}{2}\right) \div \alpha\right]$ |
| **5.** |  | $°D = \frac{1}{2\pi}\left\{\left(\frac{T_{max} + T_{min}}{2} - T_L\right)\left(\theta_2 + \frac{\pi}{2}\right) + \left(T_U - T_L\right)\left(\frac{\pi}{2} - \theta_2\right) - \left[\alpha\cos(\theta_2)\right]\right\}$<br>$\theta_2 = \sin^{-1}\left[\left(T_U - \frac{T_{max} + T_{min}}{2}\right) \div \alpha\right]$ |
| **6.** |  | $°D = \frac{1}{2\pi}\left\{\left(\frac{T_{max} + T_{min}}{2} - T_L\right)(\theta_2 - \theta_1) + \alpha[\cos(\theta_1) - \cos(\theta_2)] + (T_U - T_L)(\frac{\pi}{2} - \theta_2)\right\}$<br>$\theta_1 = \sin^{-1}\left[\left(T_L - \frac{T_{max} + T_{min}}{2}\right) \div \alpha\right]$<br>$\theta_2 = \sin^{-1}\left[\left(T_U - \frac{T_{max} + T_{min}}{2}\right) \div \alpha\right]$ |

temperatures alone. Utilization of hourly temperatures requires more sophisticated temperature recording devices and more time to transcribe the data from these instruments. Biophenometers available commercially will automatically integrate temperatures throughout the day for different developmental thresholds and then provide an approximation of degree-days. The utility of these instruments is generally limited, though, since they do not provide a record of temperatures or daily degree-day values. Such records could prove invaluable historically and could be used to check the accuracy of weather events recorded by the instrument. Individuals utilizing degree-days based on hourly values should be aware that most developmental information available for different organisms has been generated using one of the daily maximum/minimum approximations, and so incorporates the bias of that particular method. In some cases hourly values may be too accurate for our present knowledge of an organism's development.

## Comparing degree-day calculations

The five linear methods and the hourly method were compared using a standard data set for each of the six possible combinations of minimum and maximum temperatures (Table 8). The thresholds were 55° F and 90° F, and degree-days were calculated for a 14-day period.

Five of the methods accumulated degree-days nearly identically. The exception was the averaging method in cases in which temperatures significantly exceeded the upper threshold or descended below the lower threshold.

In general, the five methods were within 2 percent of one another. This error level is acceptable, falling as it does within the limits of error of most recording thermographs. In situations where daily temperatures fall entirely between developmental thresholds, any of the methods of degree-day calculation would be adequate. An excellent comparison of methods with specific attention to the cotton crop system was made by Fry (1983).

## Using degree-days

Because each species requires a defined number of degree-days to complete its development, we are interested in knowing the accumulated degree-days from a starting date. The date to begin accumulating degree-days, known as the biofix, varies with the species. Biofix points are usually based on specific biological events such as planting dates, first trap catch, and first occurrence of a pest.

Population and development models that incorporate developmental thresholds and development rates based on degree-days can help growers and pest control advisors to pinpoint biological events. This results in better pest control

**Table 7. Temperature data and degree-day values. These values for each case and method can be used in validation of calculations. Developmental thresholds used in this example are 55°F (minimum) and 90°F (maximum).**

| Case | Min. temp. | Max. temp. | Min. temp. | Triangulation | | Sine | |
|---|---|---|---|---|---|---|---|
| | | | | Single | Double | Single | Double |
| 1 | 96 | 110 | 91 | 35 | 35 | 35 | 35 |
| 1 | 91 | 105 | 96 | 35 | 35 | 35 | 35 |
| 2 | 45 | 54 | 38 | 0 | 0 | 0 | 0 |
| 2 | 38 | 50 | 45 | 0 | 0 | 0 | 0 |
| 3 | 60 | 80 | 75 | 15.00 | 18.75 | 15.00 | 18.75 |
| 3 | 75 | 88 | 60 | 26.50 | 22.75 | 26.50 | 22.75 |
| 4 | 50 | 82 | 45 | 11.39 | 10.62 | 11.85 | 11.31 |
| 4 | 45 | 70 | 50 | 4.50 | 5.06 | 5.31 | 5.70 |
| 5 | 60 | 100 | 75 | 23.75 | 24.88 | 22.82 | 26.26 |
| 5 | 75 | 95 | 60 | 29.38 | 25.76 | 28.91 | 25.30 |
| 6 | 50 | 101 | 48 | 19.56 | 19.19 | 18.95 | 18.69 |
| 6 | 48 | 95 | 50 | 16.76 | 17.13 | 16.90 | 17.23 |

**Table 8. Comparison of methods of calculating degree-days. Developmental thresholds used in this example are 55°F (minimum) and 90°F (maximum).**

| Case | Hourly | Averaging | Triangulation | | Sine | |
|---|---|---|---|---|---|---|
| | | | Single | Double | Single | Double |
| 1 | 490 | 637 | 490 | 490 | 490 | 490 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 190 | 201 | 202 | 202 | 202 | 202 |
| 4 | 58 | 20 | 65 | 54 | 64 | 53 |
| 5 | 317 | 313 | 306 | 312 | 306 | 312 |
| 6 | 83 | 84 | 86 | 85 | 86 | 86 |

and crop management decisions. Table 9 lists several organisms for which degree-day–based models have been developed. Some of these models are very simple, providing information on the timing of such events as overwintering emergence and subsequent population build-up. In these models the life cycles of the organisms are measured in physiological time instead of calendar time, as discussed earlier. Therefore, the time between any two points of an organism's development can be discussed in terms of degree-days.

Using degree-days to predict an organism's development makes it possible to minimize conflicts between cultural and pest control operations such as irrigating and applying a pesticide.

Degree-days can tell growers and pest control advisors where they stand in relation to the development of a generation of pests so that they can time pesticide applications more effficiently. This often results in reduced costs and damage from those pests. For example, pheromone traps might indicate an increase in the number of adults of a pest species. The accumulated degree-days would indicate whether this were a real or false peak. For a false peak, treatment could be delayed until the actual beginning of the next pest generation, avoiding unnecessary pesticide applications.

Degree-days can also be used to determine when to do extensive sampling, limiting such activities to times when the pests are present.

## The future

Degree-days provide a valuable tool to pest management. Predicting pest occurrence, scheduling pest management actions, and monitoring pest activity are important examples of their uses. As pest data are more frequently collected in conjunction with degree-day data, our ability to quantify pest biology and its relationship to crop yield will greatly improve.

## Literature cited


ALLEN, J. C.
1976. Modified sine wave method for calculating degree-days. Environmental Entomology 5:388-96.

BASKERVILLE, G. L., and P. EMIN
1969. Rapid estimations of heat accumulation from maximum and minimum temperatures. Ecology 50:514-17.

FRY, K. E.
1983. Heat-unit calculations in cotton crop and insect models. USDA/ARS Advances in Agricultural Technology AAT-W-23.

SEVACHERIAN, V., V. M. STERN, and A. J. MUELLER
1977. Heat accumulation for timing *Lygus* control pressures in a safflower-cotton complex. Journal of Economic Entomology 70:399-402.

WILSON, L. T., and W. W. BARNETT
1983. Degree-days: an aid in crop and pest management. California Agriculture 37(1-2):4-7.


**Table 9. Developmental thresholds (°F) and physiological generation times for selected pests**

| Organism | Developmental thresholds Lower | Developmental thresholds Upper | Degree-days per generation | Data source |
|---|---|---|---|---|
| California red scale | 53° | 95° | 1,030 | |
| Codling moth | 52° | 94° | 1,085 | 1978. Pear Pest Management. UC Div. of Agric. Sci. Publ. 4086. 1982. Integrated Pest Management for Walnuts, UC Div. of Agric. Sci. Publ. 3270. |
| Cotton bollworm | 57° | 94° | 968 | 1983. *California Agriculture.* 37 (1-2): 4-7. |
| Cotton root knot nematode | 50° | —* | 500 | |
| Egyptian alfalfa weevil | 45° | —* | 800 | 1981. Integrated Pest Management for Alfalfa. UC Div. of Agric. Sci. Publ. 4104. |
| Lygus bug | 52° | —* | 1,000 | 1977. *Canadian Entomologist.* 109:1375-86. |
| Oriental fruit moth | 45° | 90° | 963 | 1982. *California Agriculture.* 36 (1):11-12. |
| Peach twig borer | 50° | 88° | 1,060 | 1982. UC Div. of Agric. Sci. Leaf. 21302. |
| San Jose scale | 51° | 90° | 1,050 | 1982. UC Div. of Agric. Sci. Leaf. 21312. |
| Walnut aphid | 41.4° | —* | 572 | |

*No upper developmental thresholds have been defined for these pests.

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Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Jerome B. Siebert, Director of Cooperative Extension, University of California.

2m-12/83-WC/FB

PRINTED DECEMBER 1983