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Lompoc Row Crop Pest Management *Project*

No. 1
Degree-Days:
The calculation and use of heat units in pest management programs

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Information Series #1

February, 1997

Degree-Days: The Calculation and Use of Heat Units in Pest Management

Biology and Chemical Reactions

All biology, or biological development, is dependent on chemical reactions. The rate at which chemical reactions occur is dependent on the amount of heat received at the reaction site. The more heat received, the faster the rate of the reactions; and, in the case of biological organisms, the faster their development within limits.

Temperature Thresholds

The growth and development of insects are dependent on temperature. As the temperature varies during the growing season (and especially from season to season), pest pressure and the need for pest control measures will vary. The cooler the temperatures, the slower the rate of growth and development of insects. As the temperature increases, development time decreases until the temperature becomes high enough to have a negative affect. These limits are defined as the temperature thresholds. The lower developmental threshold (T_L) for a species is the minimum temperature at which development can begin. The upper developmental threshold (T_U) is the temperature at which the rate of development ceases to increase and begins to decrease. Each insect species has its own particular development rate. A general curve illustrating how T_L and T_U are derived is shown in Figure 1.

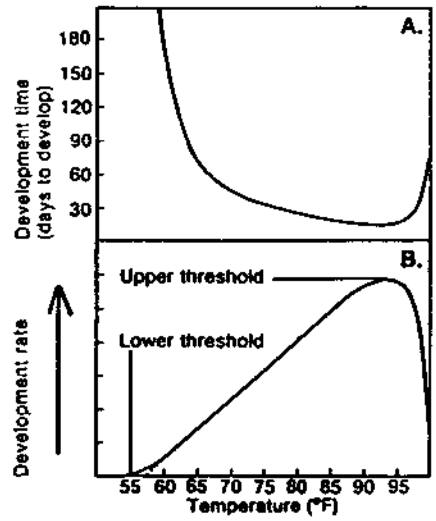

Fig. 1. An organism develops more quickly as temperatures increase up to a point, after which development slows. From Wilson and Barnett (1983).

Degree-Days (Heat Accumulation)

Degree-days (°D) is a measurement unit that combines temperature and time. Figures 2A - 2D illustrate °D for a specific pest (cotton bollworm) at different temperatures. At the lowest temperature, the time to maturity required the most days. At the highest temperature, the time to maturity required the least days. In other words, temperature and time work together such that the time for development of the organism's life cycle, or any stage or portion of the life cycle, decreases as the temperature increases. The key point in Figure 2 is that the heat units required to complete development (maturity) were approximately the same (539 °D - 622 °D). This is termed as the physiological time for development of the organism. Although temperatures and days to maturity may vary, the organism's physiological time (combination of time and temperature) remains relatively constant.

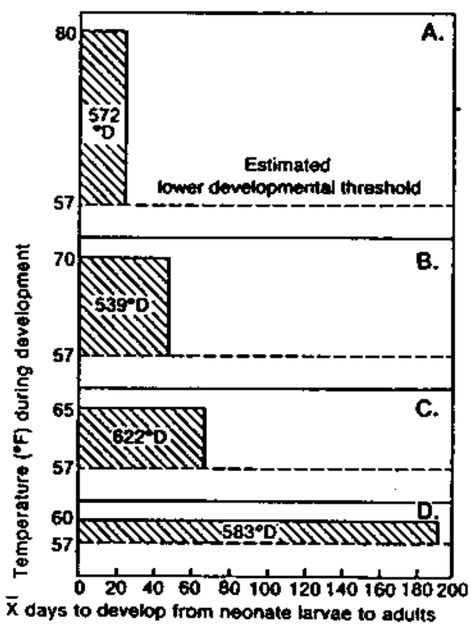

Fig. 2. Heat accumulation, or degree-days (°D), for cotton bollworm remains about the same, even though development time differs at different temperatures. From Wilson and Barnett (1983).

Calculating degree days

One degree-day is accumulated when the temperature is one degree above the T_L for a 24 hour period. There are several methods used to calculate °D in the field. The simplest calculations are the "linear" methods. These types of calculations are based on the assumption that the rate of development is linear with temperature (Figure 1B). Field temperatures follow a cyclical pattern, each 24 hour period having a minimum temperature (T_{min}) and a maximum temperature (T_{max}). The "averaging" method used to estimate °D first takes the average of the day's high and low temperatures, then subtracts from that figure the lower developmental threshold temperature for the specific pest or organism. The equation is $°D = [(T_{max} - T_{min}) / 2] - T_L$.

There are pre-calculated °D tables available that use more complex calculation methods (triangulation, sine curve and modeling). Different tables must be used for species having different thresholds. For example, in Table 1 there are three pre-calculated °D tables. For an organism with a T_L of 50°F, one would use the middle table. If the day's T_{min} was 60° and the T_{max} was 85°, the °D value for that day would be 22.5. The new UC/IPM home page on the World Wide Web (http://www.ipm.ucdavis.edu) provides °D information for weather station sites located all over California. The weather network system set up specifically for the Lompoc Valley also calculates degree days. This information is available to Lompoc Valley growers.

Table 1.
Daily cumulative degree-days for the corresponding maximum and minimum temperatures, and developmental thresholds

	Maximum temperature												
	Threshold = 40°F												
Minimum temperature	50	55	60	65	70	75	80	85	90	95	100	105	110
75						35	37.5	40	42.5	45	47.5	50	52.5
70					30	32.5	35	37.5	40	42.5	45	47.5	50
65				25	27.5	30	32.5	35	37.5	40	42.5	45	47.5
60			20	22.5	25	27.5	30	32.5	35	37.5	40	42.5	45
55		15	17.5	20	22.5	25	27.5	30	32.5	35	37.5	40	42.5
50	10	12.5	15	17.5	20	22.5	25	27.5	30	32.5	35	37.5	40
45	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30	32.5	35	37.5
40	5	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30	32.5	35
	Threshold = 50°F												
	50	55	60	65	70	75	80	85	90	95	100	105	110
75						25	27.5	30	32.5	35	37.5	40	42.5
70					20	22.5	25	27.5	30	32.5	35	37.5	40
65				15	17.5	20	22.5	25	27.5	30	32.5	35	37.5
60			10	12.5	15	17.5	20	22.5	25	27.5	30	32.5	35
55		5	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30	32.5
50	0	2.5	5	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30
	Threshold = 60°F												
	50	55	60	65	70	75	80	85	90	95	100	105	110
75						15	17.5	20	22.5	25	27.5	30	32.5
70					10	12.5	15	17.5	20	22.5	25	27.5	30
65				5	7.5	10	12.5	15	17.5	20	22.5	25	27.5
60			0	2.5	5	7.5	10	12.5	15	17.5	20	22.5	25

Using Degree-Days

From research, many pests and some beneficial species have a known degree-day requirement for a generation to develop to maturity based on their individual T_L. In order to track this development, a starting date is crucial. This starting date is termed as the biofix. Biofix points are usually based on planting dates, first trap catch or first occurrence of the pest. Once the biofix point is established, then tracking and accumulating degree-days can begin. Following degree-day accumulation is helpful to growers in several ways. The grower can determine where he/she stands in relation to the development of the generation of the pest. Using degree-days allows for predicting pest occurrence. Using degree-days can be an aid for scheduling sprays and beneficial insect releases at the optimum time to insure the best results. Using degree-days is also helpful in monitoring pest activity and in determining the best sampling times.

Degree-day tracking is a valuable tool for pest management. If you have any questions or if you need help in getting started using degree-days, call the **University of California Cooperative Extension Office at 934-6240 or at 645-1457** and we will be glad to assist you.