DEGREE-DAYS IN RELATION TO AN INTEGRATED PEST MANAGEMENT PROGRAM

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Temperature controls the developmental rate of many organisms. Plants and invertebrate animals, including insects and nematodes, require a certain amount of heat to develop from one point in their life cycles to another. The developmental rate is based on the accumulation of heat units and is therefore measured in terms of physiological time instead of calendar time.

It is well known that little growth occurs below a minimum developmental threshold or above a maximum developmental threshold. These thresholds vary with different species. In general, an organism's development is faster at higher temperatures that are below the maximum threshold (Figure 1). Less development occurs at temperatures nearer the minimum threshold. Minimum and maximum developmental thresholds have been determined for certain plants and pests through carefully controlled laboratory and field experiments. The total amount of heat above the minimum threshold and below the maximum threshold required for the organism to develop from one point to another in its life cycle is calculated in units called degree-days (°D).

Degree-days are the accumulated product of time and temperature among the developmental thresholds for each day (Figure 2). One °D is one day (24 hours) with the temperature above the minimum developmental threshold by 1 degree. For example, if the minimum developmental threshold for an organism is 50 ° F and the temperature remains 51 ° F (or 1 ° F above the minimum developmental threshold) for 24 hours, 1 °D is accumulated.

Several methods have been used to calculate °D. All are approximations of the actual number of °D accumulated for a given set of temperatures and thresholds, and therefore rarely provide the exact °D values. However, most are adequate with respect to the types of weather instrumentation generally used and the accuracy required for pest management decisions. The methods vary somewhat in complexity and in accuracy seasonally or with different climatic regions. Whichever method is utilized, it is important that it is the same method that was used in developing the organism's biological growth relationships.

Calculations of °D can be made by utilizing programmable hand calculators, computers or precalculated tables. Degree-day tables are typically produced using a computer. They may be produced for organisms with known minimum developmental thresholds or known minimum and maximum thresholds. Different tables must be used for organisms with different thresholds.

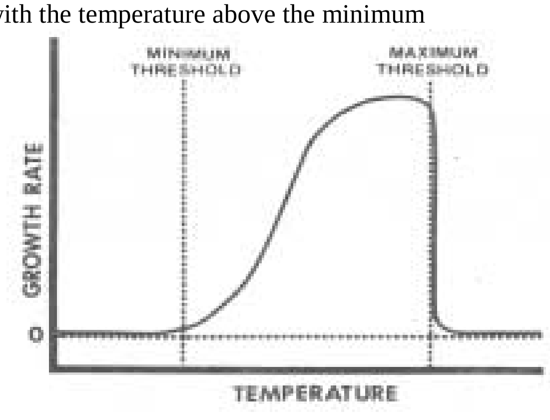

Figure 1. An organism's rate or growth and development is faster at higher temperatures below a given maximum threshold.

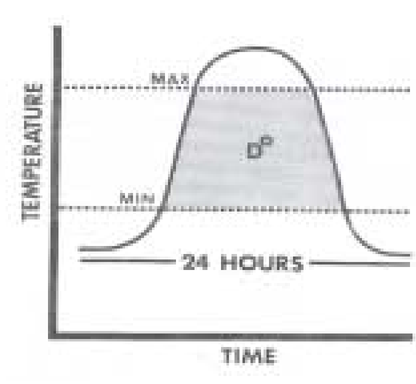

Figure 2. Degree-days are the accumulated product of time and temperature between a given maximum and minimum temperature for 24 hours

	MINIMUM TEMPERATURE								
MAX TEMP	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

Figure 3. 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

On these tables, the low temperature for the day is charted along the top of the page and the high temperature for the day along the side of the page. To find the °D for one day, locate the low and high temperature for that day and follow the column and row to where they intersect (Figure 3). This number represents the total °D for that day.

The total heat unit requirement (or number of °D) necessary for an organism to complete a generation is a constant for each species. It will not change regardless of how heat is applied to an organism or the individual's location. Accumulation of °D is initiated at a specific point in time known as a biofix. This time varies with the organism involved and is based on a specific biological event such as planting date or trap catch. To accumulate °D using a table, simply add together the °D values obtained each day beginning with the date the biofix event occurred for the organism of interest. Again, the °D value for each date is based upon the daily maximum and minimum temperatures. Accumulation of °D should be done in a timely manner, especially when a control action decision is near. This will help to forecast when a control action should be made. In general, °D accumulate more slowly early in the season than later in the season.

Some developmental relationships have been determined that require use of degree-hours. Accurate calculation of degree-hours requires a record of hourly temperatures rather than daily minimum and maximum temperatures which are utilized in calculating °D. This sort of weather instrumentation is often unavailable to the user. In this case, simple approximation of degree-hours can be made by multiplying the number of °D for a given period of time by 24.

Degree-day models can be used as tools in making certain pest management decisions during the season. Where the necessary biological information is known, °D can be used to predict the development of specific pests. This knowledge is useful in adjusting cultural operations to minimize problems associated with pest control operations, in timing pesticide applications to make them more efficient, and in advising the crop consultant or grower of the status of development in the life cycle of a particular pest so that more efficient monitoring schedules are established