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FACT SHEET

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What are Growing Degree Days?

Growing Degree Days (GDD) are a measure of heat accumulation based on daily air temperature. Growing degree days are used to estimate the growth and development of plants and insects during the growing season. Plants and insects will start their development once the air temperature is above a minimum development threshold or base temperature. As development starts and temperatures rise further into the season, plants and insects will develop into different growth stages, such as plant emergence, floral bud formation and open flowers.

The basic concept is that as plants and insects receive enough heat from the environment and reach the required accumulation of GDD, they develop into different growth stages. Growing degree day models of crops, weed species or insects study those species' growth stages aligning with their GDD.

Once the model is developed, it can be used year after year to understand and predict how plant development progresses in the season based on the current season's daily temperature starting from a pre-determined date at the beginning of the growing season. Growing degree day can be quite accurate during a 'normal' growing season, but if a plant is stressed from other factors such as drought or pest pressures, its development may not be modelled properly by temperature alone. Growing degree day can often be a much more reliable method to predict plant and insect development than calendar days.

How are Growing Degree Days calculated?

There are several methods of calculating GDD. The most simple and common method involves using the daily maximum temperature (T_{MAX}) and daily minimum temperature (T_{MIN}) as well as a "base" temperature (T_{BASE}). The idea is that development of a particular plant or insect will only occur if a temperature is above a minimum temperature threshold or base temperature. These base temperatures are determined through research experiments and will be different for each crop and organism. Many insect models use a base temperature of 10°C.

Some models may also have a maximum threshold value meaning they will not grow or develop above a certain high temperature. Note that models with these parameters will use a slightly different formula. On days where the T_{MAX} exceeds the maximum threshold value, you simply replace T_{MAX} with the max threshold value. For example, if the maximum threshold value is 30°C and your T_{MAX} was 33°C, you would set your T_{MAX} as 30°C.

The first step in calculating GDD using the basic method, also known as the "averaging method", is to calculate the daily mean temperature (T_{MEAN}) by adding together the max and min temperatures and diving by two.

$$T_{MEAN} = \frac{T_{MAX} + T_{MIN}}{2}$$

The next step involves using this daily mean temperature and the base temperature to calculate GDD

$$GDD^* = T_{MEAN} - T_{BASE}$$

*NOTE: GDD = 0 if the T_{BASE} is less than T_{BASE}. In other words, you cannot have a negative GDD value as an organism's development will not reverse.

The date from which you start calculating GDD will also depend on the organism you are interested in modelling and the region you are located. It is important to make sure the start date and the T_{BASE} you are using are verified for your crop and region. Please consult with your trusted agronomic advisor for additional information on verified models you can use in your region.

Accumulated growing degree days mean that you simply continue adding together the GDD from all previous days to give you your current GDD accumulation value. For example, if your model starts on April 1, continue adding together the GDD for each day from that date onward. When developing models, based on the crop type and study regions, the beginning accumulation date can be different as well.

Why are there multiple methods of calculating GDD?

The simple GDD calculation method of using the daily high and low temperature to calculate the average daily temperature works quite well, is relatively simple for producers to calculate, but there can be some limitations. Especially early in the season when there can be large differences between daily high and low temperature, or if the lows are much less than the base temperature, the basic GDD calculation can underestimate heat accumulation. As well, if there is a very short period of high or low temperature during the day, this can skew the daily average and not accurately represent the heat accumulation for the day.

More complex methods have been developed to account for these factors. The Baskerville-Emin method is one method that fits a sine wave curve to the daily temperatures then calculates the area under the curve to estimate GDD. This method estimates heat accumulation more accurately than the averaging method and is widely used with many pest and insect models.

The main limitation, however, is that this method requires more complex calculations and cannot be easily done by hand. Many modern weather stations and apps can record data at minute or hour intervals and GDD calculations can be automatically calculated for each data point and added together to give a daily total. This can give highly accurate heat accumulation values, but it is important to match your calculation method to the model of interest. For example, calculating GDD using the averaging method and comparing the output to values developed using the curve method will give inaccurate estimations.

What is a biofix date?

When Growing Degree Day models are used for modelling insect development, it is common to use a 'biofix' or 'biological fix' date. This refers to the date that will be used to start calculating accumulated growing degree days. Typically, this date will be triggered by a biological event, such as first capture of an insect in a trap. From this date onward, GDD will be added together to estimate an insect's growth and development as determined by daily heat accumulation.

Automated weather stations can be used to record temperature data for growing degree day calculations.

Interested in trying Perennia's Growing Degree Day Tool?
Find out more here

Also see Perennia's fact sheet:
Understanding Growing Degree Days in Wild Blueberry Production