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GDD (Growing Degree Days): Phenology Forecasting for Crops

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Introduction

Plants require a specific amount of heat to develop from one point in their lifecycle to another, such as from seeding to the four-leaf stage. People often use a calendar to predict plant development for management decisions. However, calendar days can be misleading, especially for early crop growth stages. Research has shown that measuring the heat accumulated over time provides a more accurate physiological estimate than counting calendar days. The ability to predict a specific crop stage, relative to insect and weed cycles, permits better management. This is especially important when three or more crops are being grown on the same farm, each with a different management schedule for pesticide application, fertility management and harvest.

What is growing degree days?

A degree-day is a unit combining time and temperature, used to measure the development of an organism from one point to another in its life cycle.

A degree day or heat unit is the departure from the mean daily temperature above the minimum threshold or base temperature. This minimum threshold temperature is defined as the temperature below which plants do not grow. Sometimes called heat units, degree- days are the accumulated product of time and temperature between the developmental thresholds for each day. Figure 1.1 illustrates the relationship between time and temperature, and the accumulation of degree-days. One degree-day is one day (24 hours) with the temperature above the lower developmental threshold by one degree. For instance, if the lower developmental threshold for an organism is 51°F and the temperature remains 52°F (or 1° above the lower developmental threshold) for 24 hours, one degree-day is accumulated.

$$GDD = \sum_{n=1}^{n=n} \left[\frac{Tmax + Tmin}{2}\right] - [Tb]$$

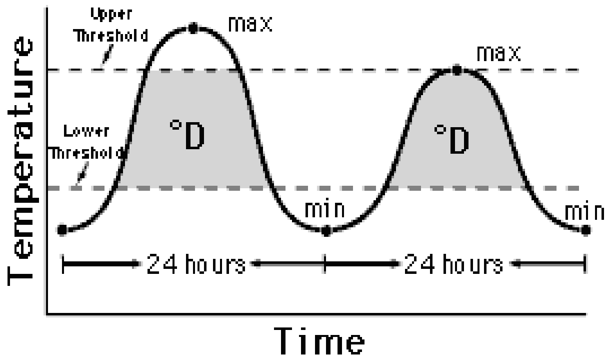

Figure 1. Thresholds and accumulated degree-days

What is phenology and why is it important?

Phenology is the study of cyclic and seasonal natural phenomena, especially in relation to climate and plant and animal life. a branch of science dealing with the relations between climate and periodic biological phenomena (as bird migration or plant flowering).

Importance of phenology forecasting:

1. Accurately forecasting phenology is thus a current objective in many fields, but these fields have widely divergent perspectives. Community ecologists have focused on localized, short-term (generally 1–3 years) studies that emphasize pairwise species interactions, trophic mismatches or competition for resources.
2. The three main non-biological factors that affect phenology are: Sunlight, Temperature ϖ Precipitation (rainfall, snowfall, etc.). These three factors work together to determine the timing of natural events.
3. For example, birds in the Northern Hemisphere begin their migrations to their breeding grounds each spring. One of the main cues they use is the amount of available sunlight. In the spring, the amount of sunlight increases a little each day signalling that summer is right around the corner. Along with sunlight, birds also use the warming temperatures to determine the time of migration.

4. Phenology is an important subject to study because it helps us understand the health of species and ecosystems. Animals and plants do not live in bubbles--every species has an impact on those in its food chain and community. The timing of one species' phenological events can be very important to the survival of another species. Phenology is important because it affects whether plants and animals thrive or survive in their environments. It is important because our food supply depends on the timing of phenological events.

Degree day calculations

Though temperatures often average out from year to year over an entire growing season, there are usually cooler- or warmer-than-normal times during significant parts of the growing season. As the saying goes, "normal" weather is an average of extremes. Warmer-than-normal days advance the plant and insect growth rapidly, while cooler-than-normal days slow them. "Growing degree days" (abbreviated GDD or DD) is a way of assigning a heat value to each day. The values are added together to give an estimate of the amount of seasonal growth your plants have achieved. Degree days are easy to calculate:

- Add each day's maximum and minimum temperatures throughout the growing season,
- Divide that sum by two to get an average, and
- Subtract the "temperature base" assigned to the plant you are monitoring. (Temperature base is the temperature below which plant development stops).

The resulting "thermal time" more consistently predicts when a certain plant stage will occur. When summed together, these thermal times are sometimes referred to as a "thermal calendar."

How to predict a crop stage using degree days

STEP 1: Monitor for suitable soil temperature and seed into sufficient moisture to allow germination.

STEP 2: Record the seeding date and coinciding degree day value (beginning accumulation) by running the degree day accumulation report using the correct base temperature for the crop in question.

STEP 3: When the difference between the beginning accumulation value (which may be zero) and the current accumulated value approaches the Table values, watch for that corresponding crop stage to occur in the field. The descriptive terms included in the Table should help. Note: Under drought stress, GDD requirements will be toward the low end of the reported range for each stage, and wet environments delay crop advancement toward the high range values reported for each stage.

STEP 4: Validate the Table values for your area by recording when the crop stage actually occurs in the field (see Validate Crop Stage below). The difference between the accumulation report value for the day you determine a stage and the Table value is the local correction value. Over time, making this adjustment to the table values will increase the accuracy of degree day forecasting

Advantage of growing degree days

- Assessing the suitability of a region for the production of a particular crop
- Estimating the growth stages of crops, weeds or even life stages of insects
- Predicting maturity and cutting dates of forage crops
- Predicting the best time to apply fertilizers or pesticides
- Estimating the heat stress on crops
- Planning the spacing of planting dates to produce separate harvest dates
- GDD can be a great tool in assessing crop phenology in times of climate change where global warming has an effect on crop growth and development.

Limitation of growing degree days

- The theory uses a linear basis of temperature for relating growth. Plant activity or growth does not take place at an equal rate at different temperatures.
- Use of same threshold temperature for every advancing temperature and the use of the shade temperatures in Stevenson screen deviates from the actual on-site or in crop temperatures.