Growing Degree Days (GDDs)

Introduction

Development of many crops, weeds, and insect pests is temperature dependent. The onset of important stages, such as crop maturity and insect pest emergence, can be predicted by tracking the accumulation of heat over time. Growing degree days (GDDs) are a measure of heat units accumulated during a day or over multiple days in a growing season (Figure 1). Because temperature varies from day to day and year to year, cumulative GDDs are more useful for forecasting crop and pest development than calendar days or dates. Monitoring GDDs is useful for timing specific crop management decisions such as nutrient and pesticide applications, as well as cultivation for weed control. This fact sheet will discuss how to calculate GDDs and use this information for management decisions for common field crops.

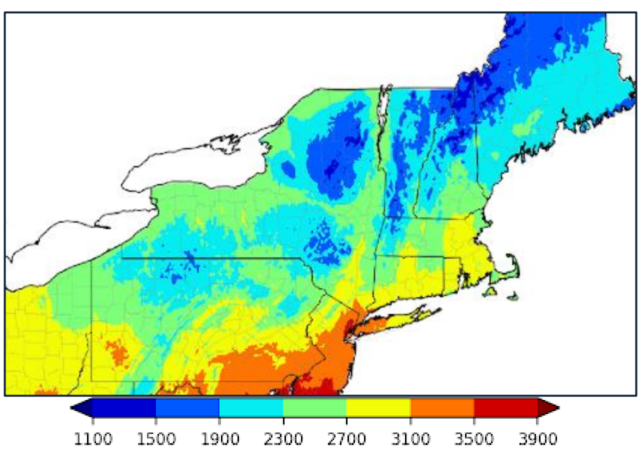

Figure 1: Cumulative GDDs for March 15-October 12, 2020, from Cornell Northeast Regional Climate Center.

Calculating Growing Degree Days

Growing degree-days (heat units) accumulated per day are calculated by subtracting the base temperature threshold of the target species from the daily temperature average (Box 1).

$$\frac{\text{Min temp} + \text{Max temp}}{2} - \text{base temp} = \text{daily GDDs}$$

Box 1: Growing degree day calculation for a day is based on minimum and maximum daily temperature compared to a base temperature that is species-specific.

Base temperature threshold is the temperature below which no significant plant or insect development occurs. This varies among species of plants and insects. For example, the base temperature is 50ºF for corn and 32ºF for wheat. For cabbage and onion maggot, the base temperature is 40ºF versus 39ºF for seed corn maggot.

For many crops and pests, no upper limit is applied. However, development of some species stops or slows significantly above certain temperatures. For example, 86ºF is the maximum temperature threshold for corn because heat beyond 86°F does not contribute to additional corn growth or development.

If the average daily temperature is below the base temperature, no heat units are accumulated (GDD=0). If the maximum daily temperature is above the maximum temperature threshold for the species, the daily maximum temperature is set at the maximum temperature threshold. Two examples for corn are shown in Box 2 and 3.

$$\frac{44\,^{\circ}F + 74\,^{\circ}F}{2} - 50\,^{\circ}F = 59 - 50 = 9 \text{ GDDs}$$

Box 2: If the daily low is 44ºF, the daily high is 74ºF, the daily GDD accumulation for corn is 9.

$$\frac{54\,^{\circ}F + 86\,^{\circ}F}{2} - 50\,^{\circ}F = 70 - 50 = 20 \text{ GDDs}$$

Box 3: If the daily low is 54ºF and the daily high is 94ºF, the daily GDD accumulation for corn is 20.

Cumulative Growing Degree Days

Growing degree day values for multiple, consecutive days can be summed to determine the cumulative GDDs for a growing season or a year. The starting date of the cumulative GDDs is commonly referred to as a 'biofix'. The biofix varies by species. It may be the date that a crop is planted, a specific plant growth stage such as tasseling, or the emergence of a particular pest.

The Cornell Climate Smart Farming (CSF) program has developed a GDD calculator. A user can simply select a field location from a map, select the biofix, and choose a base temperature threshold from a dropdown menu. The calculator automatically displays the cumulative GDDs for the season to date and provides a season outlook as well (Figure 2).

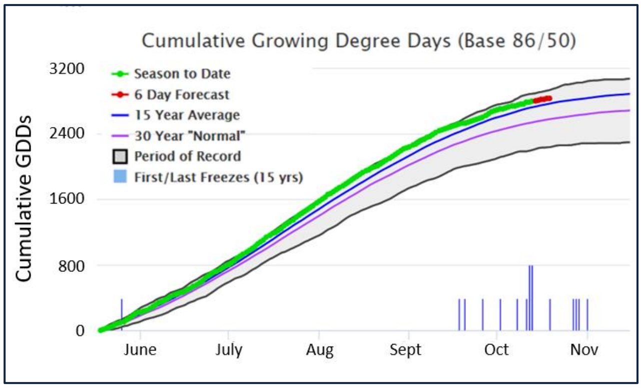

Figure 2: Growing degree day accumulation using a biofix of May 1 (base 50ºF, maximum 86ºF). Adapted from the [CSF Growing Degree Day Calculator.](#)

Use of Growing Degree Days in Agriculture

Predicting Harvest Dates.
Cumulative GDDs can be used to predict harvest dates for crops. For corn silage, whole plant dry matter (DM) content of 32% is reached at about 750-800 GDDs after tasseling/silking. If 35% DM is desired, harvest may be 4-7 days later. Crop development can vary from predictions based on GDDs when a crop has experienced atypical stressors, such as drought or excessively wet conditions. Thus, in-field confirmation of corn moisture content levels will remain necessary as cumulative GDDs is only an approximation.

Insect, Weed, and Disease.
Pest control measures are most effective when implemented at vulnerable developmental stages. Important physiological stages for insect control vary among species, and can include egg hatch, larva, nymph, pupa or adult stages. Stage onset can be predicted based on GDDs. For example, main egg hatch of the alfalfa weevil takes place about 280 GDDs (base 50ºF) after adults are observed (consistently) in spring (biofix). For more information see the Degree Day Calculator from the Network for Weather and Environmental Applications (NEWA).

Knowledge about germination and early growth stages is important for effective weed control. For example, foxtail species have a large increase in seedling emergence around 400 GDDs with 50% seedling emergence between 380-420 GDDs (base 50ºF, biofix January 1). Thus, pre-emergence herbicide application is most effective before 300 GDDs.

Nutrient Management.
Knowledge of cumulative GDDs can improve the accuracy of variable rate or sensor-based nitrogen side-dress applications. However, sensor-based approaches are more complicated and require the use of a nitrogen rich reference strip to guide nitrogen application decisions. Research is ongoing to refine these sensor-based technologies. For more information, see Agronomy Fact Sheet #89.

Summary

Growing degree days are typically more reliable than calendar days for weed, insect, disease and nutrient management decision making because weather can be highly variable among years. Accurate assessments of cumulative GDDs at important crop or pest life stages over time can aid in timely implementation of best management practices.

Additional Resources

- Nutrient Management Spear Program Fact Sheet Series: nmsp.cals.cornell.edu/guidelines/factsheets.html.
- Cornell University Climate Smart Farming. (2020) CSF Growing Degree Day Calculator. http://climatesmartfarming.org/tools/csf-growing-degree-day-calculator/.
- New York State Integrated Pest Management Program. (2020) Degree Day Calculator. Network for Weather and Environmental Applications. http://newa.cornell.edu/
- Northeast Regional Climate Center. (2020). Weekly Growing Degree Summary for New York. http://www.nrcc.cornell.edu/industry/hdd/

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For more information

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http://nmsp.cals.cornell.edu

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