Getting a Handle on Nature's Clock

Growing degree days — the secret behind nature's calendar.

BY JIM SKORULSKI

Astute farmers have long used plants as natural indicators for seasonal biological events. The connection between the occurrence of plant growth stages with events that impacted crops and livestock was observed long, long ago. *Phenology* is the study of the link between historical climate and biological events, and there are many examples of such links that have been recorded over time. Temperature is one of the primary regulators of plant growth so, in essence, plant growth provides an indirect measure of accumulated heat.

Turf and landscape managers also use specific plants as indicators. One classic plant indicator relied heavily upon by turf managers in the U.S. is forsythia (*Forsythia* sp), and its bloom is used to schedule the application of preemergence herbicides for crabgrass prevention each spring. In the Northeast, forsythia is especially helpful because the late blooming stage of this flowering species correlates well with the presence of sexually mature annual bluegrass weevil adults. As such, many turf managers rely on forsythia bloom along with field sampling data to initiate control programs against this major insect pest of annual bluegrass. It goes without saying that plant indicators are most helpful when the particular plant grows on or close to your site.

While plant indicators are valuable to turf managers, heat accumulation can also be measured directly and is expressed as growing degree days (GDD). Growing degree days are a way to track heat units that accumulate throughout the year and are necessary for the growth and development of plants and insects.

How are GDD calculated? The formula for calculating GDD is quite simple. Begin by calculating the average daily temperature (an easy way to do this is to average the high and

The late bloom, or half green/half gold stage, of common forsythia shrubs is used as a field indicator for peak populations of sexually mature annual bluegrass weevil. Turf managers use forsythia, as well as other plant indicators and growing degree day (GDD) heat accumulation measurements, to better manage pests and predict plant activity on golf courses.

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On-site weather stations make it possible to collect and calculate growing degree day (GDD) data directly from the golf course. This information is useful for monitoring insect and plant activity and serves as a natural guide in administering many pest management programs.

low temperatures for that day). Next, subtract a base temperature; the base temperature is normally 22°F, 32°F, or 50°F, but it varies based on the model. The end result is the number of GDD units for that day.

GDD = AVERAGE DAILY TEMPERATURE – BASE TEMPERATURE

Base temperatures used in calculating GDD can vary depending on the organism of interest or what is being monitored. Scientists developing GDD models for the life cycle events of insects, plants, and other organisms determine base temperatures that are most appropriate for the heat accumulation data. The base temperature most often used in GDD calculations is 50°F, or the temperature when active growth begins for most organisms.

As an example, when calculating GDD, if the high for the day was 76°F and the low was 54°F, then the average was 65°F. If using a base temperature of 50°F (expressed as GDD50), the calculation would be as follows: 65°F - 50°F = 15 GDD50. If on a cool day the average daily temperature falls below the base temperature, then it is treated as zero, or no heat accumulation for that day. A running total of the daily heat accumulation is maintained, and that information is used for predictive field models that are provided to the public.

GDD_{TOTAL} = SUM OF DAILY HEAT ACCUMULATION (OR RUNNING TOTAL OF DAILY GDD CALCULATIONS)

Growing degree days can be calculated using temperature data collected from nearby weather stations, but the most useful information comes from an on-site weather station. Companies producing weather stations and data loggers also provide accompanying software to easily calculate GDD. Regional GDD accumulations are also available on a number of websites or with web applications for smart phones. Keep in mind that GDD data may not be uniform across a golf course due to variations in sun exposure, air movement, and microclimate. As such, turf managers must take site variations into

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Michigan State University GDD Model for Turfgrass		
Annual Bluegrass Flowering	GDD_{22}	1500-2450
Embark Timer	GDD_{22}	680-1050
Primo/Proxy Timer	GDD_{32}	220-501
Crabgrass Germination (peak)	GDD_{50}	200-600
Japanese Beetle Emergence	GDD_{50}	950-2150
Black Turfgrass Ataenius (egg laying)	GDD_{50}	150-1200

This GDD model provided by Michigan State University is based on field work conducted in the Great Lakes Region. Numbers may vary outside that region and should be tested.

account when utilizing heat accumulation data. Again, regional GDD data is helpful as a general indicator for when specific biological events are likely to occur, but the most useful data will be that taken directly from your site.

GDD models have been developed for the life cycle events of many insects and plants and are available from university extension websites/bulletins and in textbooks. The models provide GDD ranges that have been validated through field research. The ranges try to cover some of the variability that can be expected in natural systems. Crabgrass germination, for example, has been shown to begin as early as 42 to 78 GDD50, while peak germination occurs at 150 to 225 GDD50. Turf managers can use this information to develop a strategy that works best for their site. In this way, GDD and soil temperature data are useful in helping time herbicide applications that will produce the most benefit while using the least amount of product.

Growing degree days and plant indicators have proven to be accurate means in forecasting plant and insect activity. The use of GDD data will continue to grow as new models are created and turf managers gain confidence in their use. Integrating GDD data and models with traditional golf course monitoring practices improves our ability to manage golf course turf, landscape plantings, and gardens. In other words, merging modern science with age-old plant indicators helps us better understand and work in concert with nature's calendar.

USEFUL RESOURCES

Michigan State University GDD Tracker — http://www.gddtracker.net/

Northeast Regional Climate Center GDD — http://www.nrcc.cornell.edu/grass/degreedays/degreedays.html

University of New Hampshire Cooperative Extension GDD for Insect Management — http://extension.unh.edu/Agric/GDDays/Docs/growch.pdf

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Because growing degree day (GDD) data help predict the emergence of Poa annua *seedheads, turf managers can better time applications of plant growth regulators to suppress seedhead development. In this way, GDD models serve to improve playability, especially on putting greens, and enjoyment of the game.*

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