A PRACTICAL RESEARCH DIGEST FOR TURF MANAGERS

TURFGRASS TRENDS

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TURFGRASS WEED CONTROL

Predict Smooth Crabgrass Emergence Using Degree-Days

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The Crabgrasses (*Digitaria* spp.) were originally cultivated as a grain crop, and were grown for food thousands of years before gaining a reputation as a troublesome weed in turfgrasses and agricultural crops (Mitich, 1988). For example, crabgrass was an important food crop in China in 2,700 B.C. In 1849, the United States Patent Office introduced large crabgrass as a forage crop. Today, both large and smooth crabgrass are considered the most competitive, destructive, and invasive weeds in turfgrass sites maintained on golf courses, lawns, and landscapes (Figure 1).

Crabgrass can be effectively controlled through the intervention of cultural practices, and herbicides. However, the ability to predict crabgrass seedling emergence might allow turfgrass managers to precisely time and target weed control strategies. A successful crabgrass control program with a pre- or postemergence herbicide depends on accurate application timing, which is related to the stage of crabgrass growth and development. For example, a preemergence herbicide that is applied too late in the spring will not provide control for the crabgrass that has already germinated and emerged.

In one of the earliest published investigations on crabgrass population biology in turfgrass culture, Gianfagna and Pridham (1951) reported that large crabgrass germinated from May 25 to September 15 in New York. One of the first published reports on crabgrass

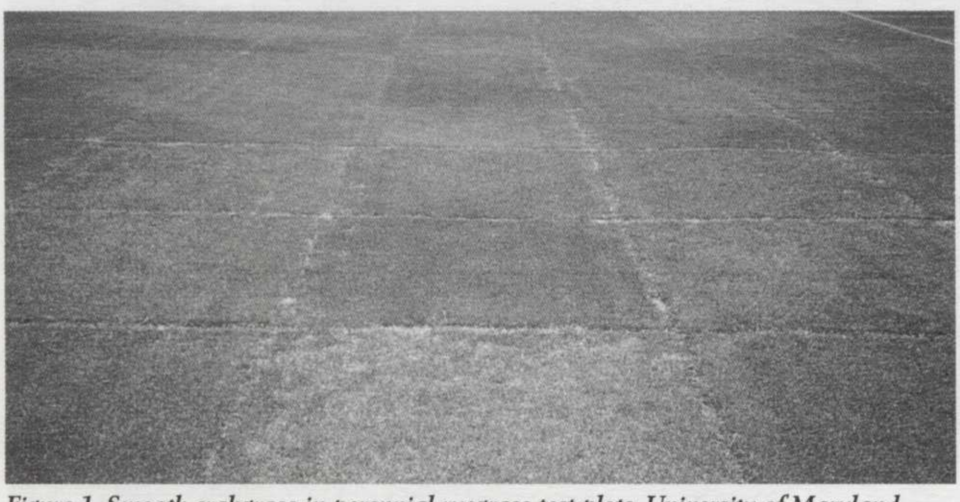

Figure 1. Smooth crabgrass in perennial ryegrass test plots. University of Maryland, Silver Spring, MD.

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emergence timing was by Peters and Dunn (1971) who observed over a three year period that large and smooth crabgrass first emerged in mid-to-late May, which coincided with the flower withering of *Forsythia* spp. and the onset of the flowering dogwood (*Cornus* spp.). However, this method can be unreliable at times. For example, in the Mid-Atlantic region in 1998, the warm weather attributed to "El Nino" caused the dogwoods to bloom in mid-February. At this time, soil temperatures remained too low for crabgrass seed germination.

Using other occurrences in nature to predict stages in a pest's lifecycle is related to the science of phenology. Phenology is the study of the relationship between biological events, such as seedling emergence, plant growth, plant development, or an insect's lifecyle, and the environment (specifically temperature). Typically, temperature is used in the development of plant and pest predictive methods since the growth and development of plants and other organisms is dependent on temperature (Danneberger, 1993). A precise way to relate the effects of temperature on plant growth and development is with degree-days.

Degree-days are calculated from temperature data and are used to establish a relationship between temperature and biological processes or events (Baskerville and Emin, 1969). Some synonymous terms used to describe the process of accumulating temperature information over time to predict plant and pest growth processes include: degree-days, growing degree-days, heat units, heat sums, or thermal units (Ritchie and Nesmith, 1991). This measure of accumulated degrees or heat is known as physiological time or thermal time, and this time is measured in degree-days (Ritchie and Nesmith, 1991; Zalom et al., 1983). Many degree-day based methods and models have been developed for use in turfgrass management (Table 1). For a more detailed description on calculating degree-days, please refer to "A Note On Calculating Degree-Day Accumulation" included with this article.

Developing a crabgrass degree-day model

Materials and Methods

Recently, research was conducted at the University of Maryland (at Silver Spring, MD, near Washington, D.C.) with the purpose of developing a reliable degree-day based method for determining the onset of smooth crabgrass emergence in turfgrass and the extent of smooth crabgrass emergence throughout the season (Fidanza et al., 1996; Fidanza, 1997).

This three-year field study was initiated in 1992, however, data from 1993 and 1994 were used to develop a degree-day model for smooth crabgrass emergence (1992 data was incomplete). In 1992, the study was conducted on a mature stand of 'Fylking' Kentucky bluegrass. In 1993, the study was conducted on a mature stand of 'Sydsport' plus 'Merion' Kentucky bluegrass blend. In 1994, the site was a mature blend of unknown perennial ryegrass cultivars. All sites had a history of crabgrass infestation, and were located in close proximity to each other. At each site, the turfgrass plots were maintained at two mowing heights, 1.5 inch versus 2.5 inch, and mowed twice weekly, with clippings removed.

Smooth crabrass emergence was monitored at both mowing heights on a weekly basis from April 1 through August 31. At the University of Maryland test site, records kept since 1982 indicated that smooth crabgrass typically first germinates in bare ground areas during late April to mid-May. Since soil temperatures typically are not favorable for crabgrass germination prior to April 1 in the mid-Atlantic and northern regions of the US, this appeared to be a reasonable starting date for initiating degree-day accumulation. Obviously, the starting date would vary in other regions, especially in the southern areas.

In each experimental plot, smooth crabgrass seedlings were counted and removed from three permanent or fixed grids per plot measuring 10 by 10 inches. Air and soil temperatures were measured with thermocouples, and were monitored and recorded with a datalogger, which is essentially a microcomputer that measured and recorded the environmental information (Figure 2). Two air temperature sensors were used, and three soil temperature sensors were placed in each plot. Air and soil temperatures were recorded at five-minute intervals, averaged each hour, and averaged for each 24-hour period. Air temperatures were measured 12 inches above the turfgrass canopy, and soil temperatures were measured at the 0, 1-, and 2-inch depth.

Although both air and soil temperatures were monitored and recorded, degree-days were calculated from soil temperature data at the 1-inch soil depth because temperatures recorded at this depth were highly correlated statistically with smooth crab-

TABLE 1. MODELS DEVELOPED FOR USE IN TURF MANAGEMENT USING DEGREE DAYS, ENVIRONMENT-BASED DATA, OR PEST BIOLOGY.*

Proposed models for the growth and development of turfgrasses and turfgrass weeds.

Target:	Description:	Reference:
Annual Bluegrass	Predicts seedhead emergence	Danneberger and Vargas, 1984. Agronomy Journal 76:756-758.
Annual Bluegrass	Timing of seedhead control method	Danneberger, Branham, and Vargas, 1987. Agron. J. 79:69-71. Branham and Danneberger, 1989. Agron. J. 81:741-752.
Annual Bluegrass	Predicts temperature stress periods	Danneberger and Street, 1985 Ohio J. Sci. 85:108-111.
Cool-Season Turf	Predicts temperature stress periods	Danneberger and Street, 1985. Inter. Turf. Conf. 5:802-806.
Kentucky Bluegrass	Predicts root growth	Koski, Street, and Danneberger, 1988. Crop Science 28:848-850.
Smooth Crabgrass	Predicts seedling emergence	Fidanza, Dernoeden, and Zhang, 1996. Crop Science 36:990-996.
Tall Fescue	Predicts seedhead emergence	DiPaola, Lewis, and Gilbert, 1987. Agronomy Abstr. 13.

Proposed models for environment-based turfgrass disease warning or risk systems.

Anthracnose	Disease forecast model	Danneberger, Vargas, and Jones, 1984. Phytopathology 74:448-451.
Brown Patch	Disease warning model	Fidanza, Dernoeden, and Grybauskas, 1996. Phytopathology 86:385-390.
Brown Patch	Disease occurrence periods	Schumann, Clarke, Rowley, and Burpee, 1994. Crop. Prot. 13:211-218.
Dollar Spot	Disease occurrence periods	Hall, 1984. Canadian J. Soil Science 64:167-174.
Pythium Blight	Disease forecast system	Nutter, Cole, and Schein, 1983. Plant Disease 67:1126-1128.

Proposed models for predicting the life cycle of turfgrass insect pests.

Chinchbug	Predicts life cycle	Lin and McEwen, 1979. Environ. Ent. 8:512-515.
Sod Webworm	Predicts life cycle	Tolley, 1986. Journal of Econ. Ent. 79:400-404.
Fruit Fly	Predicts life cycle	Tolley and Niemczyk, 1988. J. of Econ. Ent. 81:1346-1351.

*adapted from: Danneberger, T.K. 1993. Turfgrass ecology and mangement.

grass emergence. However, air temperature data also could have been used to calculated degree days. With degree-day based predictive methods, many organisms rely on a base temperature of 50 degrees F, however, it was determined that a base temperature of 54 degrees F was the proper temperature to use for this smooth crabgrass study at this test site in Silver Spring, MD. At the Maryland test site, crabgrass seedlings typically emerged when the minimum soil temperature reached 54 degrees F.

Expressing crabgrass in terms of a population enables us to develop a weed population model to estimate plant population behavior and weed emergence patterns over time.

Results

Actual smooth crabgrass seedling emergence trends were similar in 1993 and 1994 (Figures 3 and 4). During both years, seedlings first emerged sporadically prior to a short, rapid emergence period, immediately followed by a decline in emergence. A second rapid emergence period occurred (more pronounced in 1994), which was followed by a steady decrease through to the end of the season. For the purposes of this field study, these rapid emergence periods were referred to as major emergence periods. Despite the differences in the onset of seed germination and the major emergence period in 1993 and 1994, seedling count data from both mowing heights were similar (data not shown). Since turf cover was uniform within the fixed grids, the lack of crabgrass competition was probably the primary factor responsible for the similar seedling counts between mowing heights in 1993 and 1994. Therefore, seedling counts averaged across both mowing heights are shown in figures 3 and 4.

Soil temperatures and degree-day accumulation associated with smooth crabgrass emergence periods are listed in Table 2. In 1992, smooth crabgrass seedlings were first observed on April 26 on bare ground areas near the test site. Seedling emergence in the study area was first observed on May 4. Between April 27 and May 3, seven days prior to first emergence, the minimum and average soil temperatures were 55 and 61 degrees F, respectively. Degree-day accumulation since April 1 across the site averaged 52.

In 1993, seedlings were first observed in the plot area on April 26, which corresponded to minimum and average soil temperatures of 51 and 57 degrees F, respectively. Average degree-day accumulation since April 1 was 42. During the major emergence period of May 17 to July 6, minimum and average soil temperatures were 67 and 73 degrees F, respectively, and began when the degree-days total reached 140.

In 1994, crabgrass seedlings first

TABLE 2. SOIL TEMPERATURES AT 1 INCH DEPTH AND CUMULATIVE DEGREE-DAYS RELATING TO EMERGENCE OF SMOOTH CRABGRASS.

Year	Soil temperature (°F) at the 1" depth averaged over a 7-day period prior to the first emergence period			Soil temperature (°F) at 1 inch depth during the major emergence period		
	Minimum	Average	Degree Days[1]	Minimum	Average	Degree Days[1]
1992	55	61	52	—[2]	—[2]	—[2]
1993	51	57	42	67	73	140
1994	55	64	78	69	77	230
3-Year Average	54	61	57	68	75	185

[1]Degree-days calculated beginning April 1 using a base temperature of 54°F. [2]Data not available.
University of Maryland Turfgrass Research Facility, Silver Spring, MD.

emerged on April 29, coinciding with minimum and average soil temperatures of 55 and 64 degrees F, respectively, and began when the degree-days total reached 78. The major emergence period occurred between June 1 and June 29, with minimum and average soil temperatures equal to 69 and 77 degrees F, respectively, and began when the degree-days accumulated to 230.

Over the three-year period, in this study the smooth crabgrass first emerged when minimum soil temperatures averaged 54 degrees F, and the degree-day accumulation averaged 57. Utilizing only 1993 and 1994 data, the major emergence period began with minimum soil temperatures reached an average of 68 degrees F and when an average of 185 degree-days were accumulated.

Since smooth crabgrass seedling counts per square foot and degree-day information differed from year to year, the 1993 and 1994 data was converted to represent cumulative percent emergence over time, essentially expressing the crabgrass population as a percentage that has emerged over time. Expressing the crabgrass in terms of a population, instead of individual seedlings emerged per square foot, enables us to develop a weed population model that can be used to estimate plant population behavior and weed emergence patterns over time.

Over time, the cumulative seed germination curve is typically sigmoidal or "s" shaped and begins with a lag phase (little or no emergence), followed by an exponential phase (period of rapid emergence), then levels off as emergence subsides (Bahler et al., 1989).

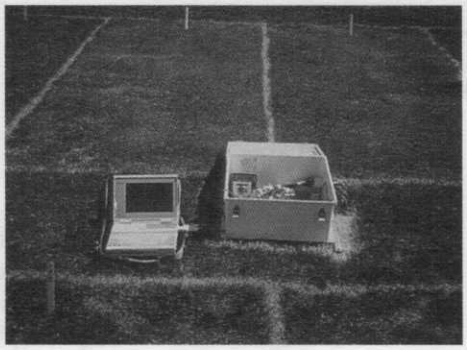

Figure 2. Datalogger and laptop computer used to download air and soil temperature data from the University of Maryland test site.

In this study, when the actual seedling emergence counts were expressed as cumulative percent emergence, no statistical differences were detected between mowing heights or between years. Cumulative smooth crabgrass emergence expressed as a percentage, was accurately described by a "model" (Figure 5). The "observed" values in figure 5 are the results from actual 1993 and 1994 data, and the "predicted" values were calculated from the mathematical equation or model.

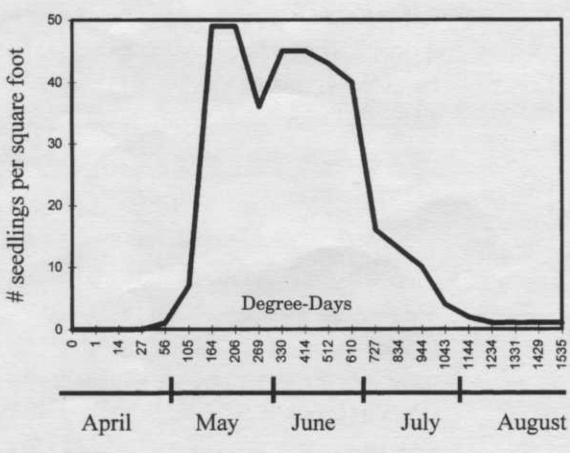

Figure 3. Smooth crabgrass seedlings averaged across turfgrass mowing height treatments of 1.5 and 2.5 inches. 1993

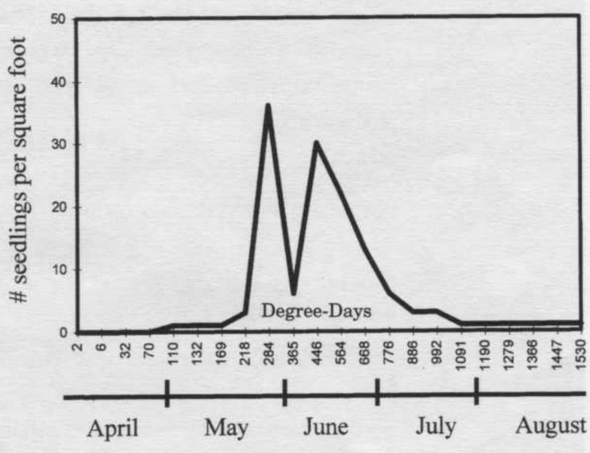

Figure 4. Smooth crabgrass seedlings averaged across turfgrass mowing height treatments of 1.5 and 2.5 inches. 1994

Practical applications for degree-days to predict crabgrass emergence.

The use of degree-days observations on crabgrass germination and emergence, and emergence patterns expressed as cumulative emergence data over time, could be used as a guide for targeting pre- and post-emergence herbicide applications. Herbicide strategies for crabgrass management fit into four programs: (1) preemergence, (2) pre- followed by post-emergence, (3) pre- plus post-emergence tank-mix, and (4) total post-emergence.

For example, referring to figure 5, a pre-emergence herbicide applied at 300 degree-days would have missed 25 percent of the crabgrass that has already germinated and emerged. In this case, a pre- and post-emergence herbicide tank-mix would probably work best, with the post-emergence herbicide targeting the 25 percent of the crabgrass population that has already emerged, and the pre-emergence herbicide targeting the 75 percent of the crabgrass population that has yet to germinate and emerged.

Also, degree-days can provide information about the crabgrass population, and assist the turfgrass manager with deciding on the proper and most effective herbicide strategy. Refer to table 3 for a list of commonly used pre- and post-emergence herbicides for crabgrass control in turfgrasses.

Turfgrass managers can utilize their own local weather and temperature data, and their own observations about the crabgrass emergence occurrences at their particular site, to develop their own degree-day based predicton method. The University of Maryland study was conducted over a three-year period, however, the more sea-

TABLE 3. LIST OF PRE- AND POSTEMERGENCE HERBICIDES COMMONLY USED FOR CRABRASS CONTROL IN TURFGRASSES*

Preemergence crabgrass control herbicides:

Common Name	Trade Name (Manufacturer)
benefin	-Balan (Dow AgroSciences)
benefin + trifluralin	-Team (Dow AgroSciences and others)
bensulide	-Betasan (many)
DCPA	-Dacthal (ISK Biosciences and others)
dithiopyr	-Dimension (Rohm and Haas)
oryzalin	-Surflan (Dow AgroSciences)
oxadiazon	-Ronstar (Rhone Poulenc)
pendimethalin	-Pre-M (many)
prodiamine	-Barricade (Novartis)
siduron	-Tupersan (many)

Postemergence crabgrass control herbicides:

dithiopyr	-Dimension (Rohm and Haas)
fenoxaprop-p-ethyl	-Acclaim Extra (AgrEvo)
fluazifop-p-butyl	-Fusilade II (Zeneca)
MSMA	-Daconate (ISK Biosciences)
	-MSMA (LESCO)
	-many others

*No endorsement of named products is intended, nor is criticism implied for products that are not mentioned.

sons included in the observations, then the more accurate your degree-day predictions should be. It is important to realize that biological occurrences won't begin on a specific degree-day total, but rather will respond to a range of degree-days (for example, with the University of Maryland study, crabgrass first germinated within a degree-day range of 42 to 78).

Further research is needed to confirm the relationship between degree-day accumulation and smooth crabgrass emergence on a regional basis. Also, both air and soil temperatures should be evaluated for calculationg degree-day accumulation. In addition, information on soil moisture can further improve the degree-day based prediction methods. In conclusion, degree-day methods and models should become more useful to turfgrass managers who will be able to utilize this information to make more knowledgeable decisions regarding herbicide use in their integrated turfgrass management programs.

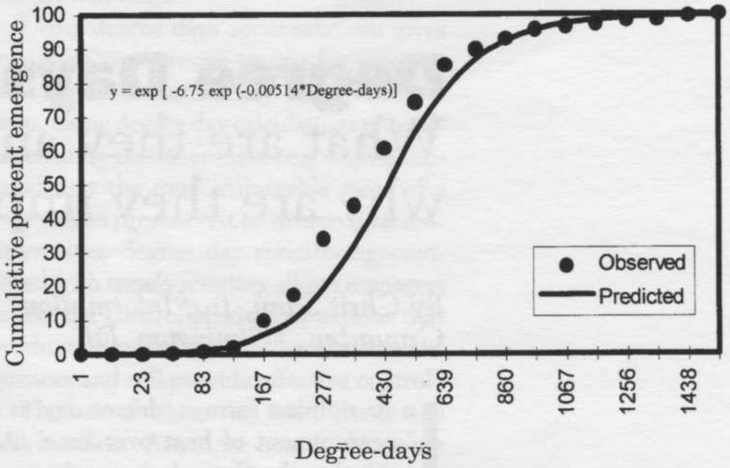

Figure 5. Cumulative percentage smooth crabgrass emergence versus degree-day accumulation combined for 1993 and 1994. Observed = actual crabgrass emergence; predicted = predicted crabgrass emergence generated from degree-day model.

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Degree Days
What are they and why are they important?

By Chris Sann, Turf Information Group Inc., Wilmington, DE

In its simplest form, a "degree day" is a "measurement of heat over time". As applied to the Green Industry, the concept of degree days lies at the heart of better, more efficient pest management strategies that can dramatically help turfgrass managers in the everyday process of managing their sites

What is a degree day?

Strictly speaking, a degree day is - one day (24 hours) where the average temperature is one degree (Fahrenheit or Celsius) above a threshold number. The daily degree day numbers are determined by subtracting a predetermined threshold number from the average daily temperature. The resulting daily degree day number is accumulated as a running total and the total is then compared to a timeline or degree day model that predicts an specific occurrence at a specific number of degree days.

If the degree day calculation relates to an occurrence based on heat and the result is a negative number, then the result is ignored. If the calculation relates to an occurrence based on cool temperatures and the result is a positive number, then that result it is ignored.

Calculating a daily degree day number - To calculate a daily degree day number, add the maximum temperature for a day to the minimum temperature, divide that number by two, and subtract the threshold number. The result is the daily degree day number.

The Daily Degree Day Formula is: ((max. temp. + min. temp.)/2) - threshold number.

Example: If the daily maximum temperature = 70 F. ; daily minimum temperature = 50 F.; and the threshold number is 50 F.

70 F. (max.) + 50 F. (min.) = 120 F.
120 F. / 2 = 60 F.
60 F. - 50 F. (threshold) = 10 F

The daily degree day number is 10.

Why use degree days measurements? Degree day calculations do a good job of representing the progress of processes that are primarily heat driven. In the case of animals, plants, and fungi that are exothermic (meaning cold-blooded), their life processes are driven by external heat. Reptiles, insects, green plants, mushrooms, and many other living things all rely on external heat sources to drive their internal processes. In many cases, these plants and animals are essentially dormant at temperatures below 50 F, hence the 50 F threshold used above. Not only are turfgrass plants themselves exothermic, but so are all of the pests that infest turf sites.

Insects and degree days - Although complex growth processes involving other variables than heat can in part be modeled using degree days, insects are the best example of how external temperatures are the prime influence on life cycles progress.

In the case of insects, the intervals between their growth stages, or phenologies, can best be represented as a function of accumulated heat rather than a sequence of days. The protein synthesis process (the growth process) in insects is controlled by heat rather than time. The more heat, the faster the process works; the less heat, the slower.

Whether the process is fast or slow, each interval has a predestined pathway that must be completed before the next stage can begin. Changes from one growth stage to another (i.e., from egg to larva, larva to pupa, pupa to adult, etc.) can take weeks in cool weather or can be completed in only days in warm to hot temperatures.

How to use degree days

Timing of events based on daily degree day number accumulations is actually very common. Degree days accumulations are used to determine when to deliver heating oil, how to size heating and air conditioning equipment in buildings, how to insulate housing, and many other applications.

The ability to predict heat driven conditions by temperature accumulation gives far more YTD accuracy than traditional calendar based or average date based methods.

For instance, if an insect larval stage is normally present on a host plant in June and that stage can be easily controlled at that time, then, in a warmer than normal year control applications made by a "normal" calendar might not be effective, because the insect could have entered a pupal stage which is not controlled with insecticides. The same may apply to a colder than normal year since the insect may still be in its egg stage, another hard to control growth stage.

Using degree days accumulations gives managers very precise timing for scouting and maximum efficiency for control of pests. Using degree day calculations or models ensures that there is a very high likelihood that the most vulnerable stage of a pest will be present. At environmental sensitive sites, degree day monitoring combined with timely scouting allows managers to use the control product or actions that produce the fewest unintended consequences and still provide effective control.

The use of degree day based prediction will increase. Any time heat is the prime determining factor in a process, degree days, or some derivative thereof, will be used to more accurately measure what effect the actual YTD weather has had on pests and hosts. As more research identifies the basic life processes of plants, animals, and fungi the use of degree day models will substantially increase plant manager's understanding of and efficiency at controlling pests while reducing the impact of operations on the environment and in the long run reducing cost.

FIELD TIPS

Insects Take Priority Over Weeds

When it comes to priorities, golf course superintendents rank insects above weeds for degree-day calculations. Advances in preemergent weed control have reduced concern over timing for some weeds. Yet, obtaining local readings of degree days from on-site weather stations is highly desirable.

Dan Dinelli, superintendent of North Shore Country Club in Northbrook, IL thinks soil temperature would help him more than air temperature. "Crabgrass germination in an open area is a lot different than a shaded one," he remarks. "A cloudy day should not result in the same degree days as a sunny day. But, I still think a weather station capable of degree-day calculations is valuable."

Even though he has a weather station, Merrill Frank at Columbia Country Club in Cockeysville, MD still calls Data Transfer Network for degree days to reconcile his course readings. "I check primarily for white grubs and *Poa annua*," he adds.

Sean Remington at Chevy Chase Country Club also has a weather station, but he taps into UMD's Ag Online for degree days. "Black aetenius is my main concern because it's life cycle is different from other major pests," reveals Remington.

Web Sites That Turf Managers Can Use

By Chris Sann, Turf Information Group Inc., Wilmington, DE

Weather and the Net

The recent arrival of spring and the winter-long media dialogue about the effects of El Nino sent me looking for good sites on the Internet to find both images and information about weather. Two sites that I recently came across approach the subject from different points of view, but both can be credible resources for turfgrass managers with a good browser and a reliable internet service provider (ISP).

Agricultural Weather.com - This site calls itself "Agricultural Weather dot Com" and touts itself as the "the Internet's most complete Agricultural weather". Its Internet address (URL) is www.agriculturalweather.com.

This site, owned by Weather Site Inc. of Coral Gables FL, is a well laid out, no frills site that combines weather and agricultural market data (farm reports and commodity prices).

The weather coverage at the site appears to be bare bones, but looks are deceiving. It is quite thorough.

The site has a series of "click to expand" maps - such as a "current national radar map", a current national surface temperature map, and several medium range forecast maps for temperature and precipitation.

Located to the left of these graphics is a "wolf in sheep's clothing" in the form of a innocuous looking columnar listing of forecasts and current condition reports for all 50 states. A quick review of a few of the listed states reveals a massive amount of climate, weather, and other information about the listed state.

The information listed by state ran from an air pollution index, climate summaries, current and forecast weather, hydrologic data, and river and flash flood forecasts for Arkansas to climate summaries for all large cites, marine forecasts, hourly weather summaries, travel advisories, and hazardous weather outlooks for New York and min/max temp and precip tables, temperature and precipitation summaries and biweekly water resources reports for Pennsylvania.

Hidden down below the farm reports on the left side of the site are a series of links to visible and infrared satellite images and links to the Climate Prediction Center's (CPC) 10 to 14 day temperature/precipitation maps, 14 day soil moisture maps, and the 1-3 month national temperature and precipitation forecast maps.

Still further down the left side are two links to computerized precipitation model forecasts for the next 48 hours. These maps leave no question about what precipitation the next 48 hours will bring. These models produce impressive graphics.

Impression: Although I could do with out the farm reports, this site is loaded with information that turf managers and farmers need to plan their short to longer term activities. Don't let the utilitarian look fool you, this is a good weather site.

WeatherNet - This site is produced by The Weather Underground at the University of Michigan at Ann Arbor. They call the site "the Internet's premier source of weather information" and the hits counter at the bottom of the opening page proves it with 77 million plus hits. Its URL is http://cirrus.sprl.umich.edu/wxnet.

As utilitarian and sparse as the Agriculturalweather.com site looks, this site is rich with information and features. This site is a weather weenies idea of heaven. The opening page starts with hot or new features, but the listing of the site's main features really sets the tone for this site as a serious weather watchers location.

The main features are:

WeatherSites - a comprehensive list of over 300 WWW, gopher, telnet, and FTP weather sites on the Internet.

USA Weather - city by city forecasts, current conditions, warnings and graphics for all 50 states.

Radar and Satellite - access to Nexrad and color satellite images.

WeatherCams - live images of weather conditions at over 700 locations in North America.

WeatherMaps - a comprehensive listing of surface and upper air maps, along with temperature, regional weather, and jet stream maps.

Weather Software - a listing of over 24 PC and Mac software applications to chart and follow the weather. Perhaps the best feature of this feature packed site is the clickable Nexrad and regular radar national map. As good as the regular radar that this site can produce is, the Nexrad radar, the recently completed Doppler radar system, is several times better. It is so sensitive that on clear days it can show the temperature differences in the atmosphere as well as a flight of birds. On days with precipitation, it can show the accumulated precip totals as well as highlight areas that may spawn severe weather. Give NOAA a few more years working with this system and we might be pleasantly surprised as to the extra information they learn to produce.

This is an industrial strength Internet weather site. It may not have all the minutia the Agriculturalweather.com has, but it doesn't need it - this is a very impressive site.

RESEARCH SUMMARIES

Dollar Spot Resistance

Plant Disease
Volume 81, Number 11.

Control of Dollar Spot of Creeping Bentgrass Caused by an Isolate of Sclerotinia homeocarpa Resistant to Benzimidazole and Demethyla-tion-Inhibitor Fungicides:

L.L. Burpee, Dept. of Plant Pathology, University of Georgia, Georgia Experiment Station, Griffin

Failure to control dollar spot with with DMI fungicides representing pyrimidine and triazole groups was first reported in 1992 by Vargas, Golembiewski and Detweiler. Confirmation of resistance in isolates of *S. homeocarpa* was disclosed in 1995.

Laboratory and field results indicate that at least one isolate was resistant to both propiconazole and thiophanate-methyl. The reduced sensitivity of the particular isolate to chlorothalonil in vitro was not evident in the field.

Fluazinam, a nonsystemic, pyridylaniline compound, was the only fungicide tested that suppressed dollar spot caused by the isolate to a threshold of less than five percent disease for more than 21 days.

The dose-response data collected in vitro and in the field in 1996 indicate further that a second isolate responded similarly to increasing concentrations of fluazinam. The long-term control of dollar spot provided by Fluazinam was surprising for a nonsystemic material. However, due to extremely low inhibitory concentrations, residual suppression of fungal growth may be longer than other nonsystemic fungicides on leaves, on shoots, and in turfgrass thatch. Fluazinam will be a useful fungicide for management of dollar spot caused by benzimidazole and or DMI-resistant strains of *S. homeocarpa.*

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Composts
To Improve Turfgrass Performance

by Peter Landschoot, Ph. D,
Pennsylvania State University

Composts are used as soil amendments during turfgrass establishment, as topdressing on established turf, and as low analysis fertilizers. In heavy clay soils, a good quality compost will increase permeability to air and water, enhance aggregation of soil particles, reduce surface crusting and compaction, and provide nutrients. In sandy soils, the organic matter in compost will increase water holding capacity and nutrient retention. The effects of good quality composts on turf include, faster establishment, improved density and color, increased rooting and less need for fertilizer and irrigation.

Not all composts are alike. Composts are made from many different sources, including municipal wastes (garbage), leaves and grass clippings, sewage sludges, animal manures, paper mill by-products, and food wastes, just to name a few. The influence of a particular compost on turf depends on the source and how it is produced, its chemical and physical properties, and how it is applied.

Organic matter

When using composts as organic matter supplements, keep in mind that not all of the product is organic. In fact, some composts contain less than 50 percent by weight of organic matter. Organic matter content can be determined by a lab test, but the most common procedure employed by labs will consider everything that is combustible as organic matter (including wood chips, bark, leaves and possibly even garbage.) Hence, a lab test might not tell you everything about the quality of the organic matter.

Although it is impossible to determine how much organic matter is present simply by looking at the product, a visual examination can tell you if the compost contains mostly well-graded humus-like material or if it is mostly undecomposed material, such as wood.

Moisture content

The moisture content of a compost is important where an even application and uniform mixing with soil is desired. Composts with moisture contents between 30 and 50 percent are usually ideal for handling surface applications, and soil incorporation.

Wet composts (greater than 60 percent moisture content) tend to form clumps that are difficult to break apart. Thus, they do not spread evenly when applied as topdressings. Rototilling wet material into soil results in poor mixing and a less-than-desirable establishment. Wet composts are also heavy and difficult to handle.

A dry compost (less than 20 percent moisture content) is easy to handle and spreads easily, but may produce a lot of dust. On windy days, the dust can leave a film on windows or siding. Dust can be inhaled or get into the eyes of the applicator. Dry composts that are high in organic matter content tend to "float" on the surface while attempting to incorporate them into the soil. In this case, the equipment operator might have to spend more time and effort working the material into the soil.

pH range

The pH of most composts is between 6.0 and 8.0, a range favorable for turf root growth. A few composts, however, fall outside of this range. The pH of a compost may be detrimental when very high (greater than 8.5) or very low (less than 5.5).

Extremes in pH can result in reduced availability of some plant nutrients and/or toxicity problems. In an establishment study at Penn State, we noticed seedling inhibition following incorporation of a two-inch layer of poultry manure compost (pH of 9.1) into a clay loam soil. It is likely that the high pH and presence of ammonium in the compost caused ammonia toxicity and subsequent death of the seedlings. Fortunately, most soils are buffered against rapid and drastic changes in pH and even composts, with extremes in pH, might not alter the overall soil pH a great deal. To be on the safe side, however, try using materials with a pH as near to neutral (7.0) as possible.

Nutrients

When compared with fertilizers, composts generally contain low amounts of plant nutrients. Whereas a small amount of quick-release ammonium nitrogen is present in some composts, most nitrogen is in the organic form and is slowly available to turf. Studies with composted sewage sludges show that only about 10 percent of the total nitrogen is available to plants during the first growing season. This means that large amounts of compost must be applied to supply all or most of the turf's nutritional requirements.

Little is known about the nitrogen release characteristics of other composts. Other nutrients, such as phosphorus, potassium, calcium and magnesium can be present in significant quantities in composts. Some composts, however, may contain very low concentrations of one or more of these nutrients. Thus, fertilizer supplements may be required.

Many questions remain concerning the availability of nutrients from composts.

In most cases, composts are applied to the soil surface at a rate between a one-inch layer (about 2.2 cu. yds./1000 sq. ft.) and a two-inch layer (about 4.4 cu.yds./1000 sq. ft.) then incorporated into the soil to a depth of four to six inches. In order to get maximum performance from your application, make sure the compost is thoroughly mixed with the soil and is not forming a layer at the soil surface. Depending on the material, this may require several passes with rototilling equipment. The lower rate (one inch layer) would be better for fertile soils and the higher rate (two-inch layer) for sandy soils, clay soils or sub soils low in organic matter). We have found that if more than two inches are used, it can be difficult to mix the material four to six inches into the soil. On heavy soils, it is helpful to rototill the soil first, then apply the compost and incorporate.

From Proceedings of the 51st Northwest Turfgrass Conference, Oct. 1997

RESEARCH SUMMARIES

Bluegrass Nematode Damage

Plant Disease
Disease Notes

Pratylenchus fallax on Turfgrass in Ontario

Q. Yu, J. W. Potter, and G.A. Gilby, Pest Management Research Centre, Vineland Station, Ontario, Canada

Surveys in 1995 and 1997 of golf courses throughout southern Ontario for plant parasitic nematodes revealed evidence of *Pratylenchus* spp. in 13 out of 14 samples taken from fairways. The species in the surveys was identified as *Pratylechus fallax* Seinhorst.

Bluegrass (*Poa pratensis*) was the main type of grass on the fairways surveyed. *P. fallax* might cause signficant damage to turfgrass by directly destroying the roots and the wounded roots might become vulnerable to secondary infection by soilborne pathogens.

Plant Disease is published by the American Phytopathological Society, St. Paul, MN.

Biocontrol Agent
Studied for *R. Solani* of Creeping Bentgrass

C. T. Lo, E.B. Nelson, C.K. Hayes, and G.E. Harman, Cornell University, Geneva/Ithaca, NY
Phytopathology, Vol. 88, No. 2

Trichoderma harzianum Rifai has been used as a biocontrol agent to protect plants against root, seed, and foliar diseases and storage rots. Results from field trials indicate that isolates of the biocontrol agent work well under different environmental conditions, possibly biocontrol of *Rhizoctonia solani* on creeping bentgrass plants. However, a number of *T. harzianum* strains must be selected for their activity against pathogens on different crops because the survival traits of these strains can be strongly influenced by crop-specific environmental factors. Studies are now taking place with creeping bentgrass.

Biocontrol agents differ fundamentally from chemical fungicides in that they must grow and proliferate to be effective. Therefore, effective antagonists must become established in crop ecosystems and remain active against target pathogens during periods favorable for plant infection. The survival ability of biocontrol agents needs to be surveyed and associated with biocontrol effects.

Introduced strains of *Trichoderma* spp. are difficult to distinguish from indigenous strains. Moreover, the distribution of the biocontrol agent is difficult to ascertain on crop plants. Production of strains containing reporter or marker genes has provided a new tool for detection.

Transformed strains must be genetically stable and able to maintain their biocontrol activity after introduction to soil or foliage. Results from our mycelial growth rate and biological control of brown patch disease tests indicated there might be a positive correlation between the growth rate and biocontrol ability of transformants. Consequently, it is important to compare the physiological traits and biocontrol ability of the transformants with original strains before carrying out time-consuming ecological studies.

Trichoderma spp. were detected three hours after application and conidia were seen one day after treatment on all parts of creeping bentgrass plants. This widespread distribution probably occurred because of the high spray volume to surface area used. Creeping bentgrass plants are small with a relatively dense but shallow root system. Conidia are easily carried by mass flow of water over the root surface in soil. Similarly, spray applications in field trials produced high levels of root colonization by *T. harzianum* strain.

In our experiments, both transformed and wild-type *Trichloderma* strains colonized and proliferated on all parts of creeping bentgrass plants for the duration of the experiments.

It has been demonstrated that *T. harzianum* produces enzymes that are toxic to a wide range of fungi. The data in this paper indicate that *T. harzianum* damages *R. Solani* at a distance. However, there could be several mechanisms by which this occurs, and several kinds of metabolites toxic to *R. Solani* might be produced by *T. harzianum*. The findings in this paper provide insight for future research.

Phytopathology is the journal of the American Phytopathological Society, Margaret Daub, Editor, (919) 515-6986.

What does an early spring mean for summer course conditions?

Along with the warm weather and greening of the grass comes the excitement experienced by golf course superintendents that the year is ready to begin. Several have mowed greens in April. Late fall/early winter growth probably resulted in the need to remove clippings. Annual bluegrass will normally start growth earlier than bentgrass.

We have had questions about fertilization to encourage early growth. Personally, I would not recommend it if the grass is in good condition. An exception could be where the grass is thin or if snow mold has been active. We could still have a lot of snow mold activity this year, particularly pink snow mold. In my opinion, it is best to let the turf recover naturally and not push it too hard at this time. Heavy nitrogen applications on reasonably healthy turf in spring causes greater growth. Instead of accumulating carbohydrates, the plant grows rapidly. When mowed, the carbohydrates in the leaf tissue are mowed off.

We would prefer to have the plant accumulate those carbohydrates that may be helpful for stress tolerance later, particularly if we should have an early, hot, stressful summer.

Several courses had as many as 200 golfers in two days in late February. Will this be harmful to turf? if the greens are firm and no footprinting occurred, there may have been little damage. Early heavy traffic, when the grass is not growing, could be detrimental. While early play can be great for golfers, there is the question about the long-term injury, depending on the site. Decisions on early play must be based on a site-by-site basis.

Dr. Paul Rieke, Michigan State University, writing in A Patch of Green.

In Future Issues

- N and turf, reconsidered
- Disease control today, out-look for tomorrow
- Reducing crabgrass germination
- More research summaries

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