tern. "As soon as you can figure out what the weather pattern is and what the cycle length is, then you can project forward and make predictions based on the patterns we have been through," says Lezak.

In a way, the past provides information about the future. Of course, each year this pattern is altered. "The biggest challenge is in that September/October period when a new weather pattern sets up. By about January 1st, we know the weather pattern and Weather 2020 knows when a storm is going to occur in a location."

As far as this year's Masters is concerned, the forecast is both good and bad.

"I think it's going to rain for the practice rounds, then dry out. For the Masters tournament itself, there may be one brief period of rain, but most of that tournament is going to be in the 70s and nice. That's our forecast based on the pattern," says Lezak.

Weather 2020 currently offers an app for IOS7 devices that provides forecasts 12 weeks in advance. The long-range weather predictions can be helpful for everything from planning events and vacations to long-term plans on the golf course. Lezak suggests that this app could reduce uncertainty of weather patterns for superintendents.

"When is it going to be wet? When is it going to be dry? When is the most likely time to have rain and storm systems? You'll be able to use the app to see which weeks will be wet, which weeks will be dry. It's really a cool tool as we evolve from here," says Lezak.

When dealing with the future however, certainty can never be guaranteed. In the past year, Lezak has been able to document his success rate through the Weather 2020 app. "Out of the last seven long-range forecasts we've made, we're six out of seven," says Lezak. He continued to say weather predications are not 100 percent accurate, but after getting one incorrect, he strives to be right the next time around.

Despite the lack of guarantee, Lezak is confident that Weather 2020's long-range forecasts could be beneficial for companies and organizations. "One of the things we will be able to provide is to allow companies to prepare for future weather events. We know what's going to happen in the future. We are predicting the future." Ⓖ

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Super Science

//**SURVIVING WINTER**

CREEPING BENTGRASS VS. ANNUAL BLUEGRASS DURING COLD DEACCLIMATION

Xian Guan, Michelle DaCosta, Ph.D., and Scott Ebdon, Ph.D.

Turfgrass deacclimation during winter and early spring can negatively impact freezing tolerance, leading to winter injury. Superintendents managing mixed stands of annual bluegrass (*Poa annua*) and creeping bentgrass (*Agrostis stolonifera*), have often observed differences in winter injury susceptibility of these two species. This may be attributed to differences in their ability to resist deacclimation in response to winter warming. To improve winter survival of annual bluegrass in northern climates, a better understanding of the physiological factors that contribute to freezing tolerance and deacclimation sensitivity is needed.

The objectives of this study were to compare the freezing tolerance of annual bluegrass and creeping bentgrass during cold acclimation and deacclimation and to examine changes in carbon metabolism during deacclimation. Plants were removed from the field and progressively exposed to the following treatments in a growth chamber: non-acclimated control at 68 °F; cold acclimation at 36 °F; cold acclimation at 28 °F; and deacclimation at 46 °F. Changes in freezing tolerance were determined based on lethal temperature resulting in 50 percent kill (LT_{50}). In addition, carbon metabolic activities were monitored based on canopy photosynthesis and respiration rates, along with chlorophyll fluorescence parameters.

Differences in winter survival of annual bluegrass and creeping bentgrass following a mid-winter warming event.

PHOTO BY: M. BURAS

Overall, creeping bentgrass exhibited higher freezing tolerance following cold acclimation and maintained higher freezing tolerance during deacclimation compared to annual bluegrass. Photosynthesis, respiration and photochemical yield of annual bluegrass increased more rapidly during deacclimation. This suggests that metabolic and physiological activities of annual bluegrass were activated earlier in response to warmer temperatures. Although rapid up-regulation of carbon metabolism may provide annual bluegrass with a competitive advantage during spring recovery, these responses may also lead to greater susceptibility to freezing injury in response to mid-winter warming. Research is currently underway to understand additional factors that may be responsible for differences in deacclimation sensitivity between annual bluegrass and creeping bentgrass.

Xian Guan, Michelle DaCosta, Ph.D., and Scott Ebdon, Ph.D., University of Massachusetts. Michelle DaCosta can be contacted at mdacosta@umass.edu for more information.

NEWS UPDATES

GCSAA TO BRING BACK DIRECTOR OF RESEARCH POSITION

In early April GCSAA posted on their website the open position of "Director of Research" — a position they eliminated in 2010.

"GCSAA is seeking a dynamic and innovative director of research to serve as the technical and scientific expert to support various internal programs and perform external outreach activities," the position description states. "Key duties include conducting and directing GCSAA research projects, writing and evaluating research proposals and overseeing applied agronomic research projects on golf courses."

The position will be located at GCSAA headquarters in Lawrence, Kan. A Ph.D. in Agronomoy, Turfgrass Science or related field and extensive experience (7 to 10 years) in research and program development is required. Those interested have until May 2nd to apply.

The last person to hold the position of GCSAA's director of research was Clark Throssell, Ph.D. He is now the research editor for *Golfdom.*

GCSAA
GOLF COURSE SUPERINTENDENTS ASSOCIATION OF AMERICA

"IN MANY CASES, FUNGICIDE CLASSES SUCH AS THE BENZIMIDAZOLES, DICARBOXIMIDES AND DMIS MAY BE USELESS OR HAVE EXTREMELY SHORT RESIDUALS."

Jim Kerns, Ph.D.

(see full story on page 34)

//TARGET ACQUIRED

Factors affecting fungicide performance

Part 2 of 3: Disease pressure and fungicide resistance

By Jim Kerns Ph.D.

***Editor's note:** This is the second of three articles by Dr. Kerns on disease management and control.*

After selecting the appropriate fungicide to control the target disease, the next thing to consider is disease pressure and fungicide resistance. This article will discuss how disease pressure influences rate selection and application intervals. It will also dive into a discussion of fungicide resistance prevention and management.

THE DISEASE TRIANGLE

Disease is a rare event in nature; it takes three factors to come together in time, in order for disease to develop: a susceptible host, a virulent pathogen and a conducive environment.

These three factors comprise the disease triangle. The severity of the disease is governed by the length of each side of the triangle. For example, planting a more disease-resistant turfgrass species or cultivar can shorten one side of the triangle and thereby reduce the amount of disease. Many new cultivars have some disease resistance, but in order to take advantage of this, a significant renovation is typically required. When a renovation is planned, it is important to consider these new cultivars that have resistance to dollar spot or other diseases, as they will likely save on fungicide applications.

Unfortunately, our turf pathogens are ubiquitous organisms which wait for our turf plants to succumb to stress and then they attack. Although it is difficult to eliminate pathogens from turf systems permanently, understanding the biology of the pathogens can aid in designing fungicide programs that maximize efficacy and efficiency. For example, many turf pathologists have revitalized efforts to research biology and epidemiology of dollar spot. Some are working on the population structure and dynamics of the pathogen to develop a more appropriate classification for the fungus and to understand how genetic diversity may lead to fungicide resistance. Others are working on developing a forecasting model for the disease.

Dollar spot and the start of brown patch developing together on a creeping bentgrass putting green.

UNIVERSITY STUDIES

Dr. Damon Smith and I developed a fairly robust forecasting model while I was at the University of Wisconsin-Madison and he was at Oklahoma State. The model worked well in both locations and then we expanded our testing to include the University of Tennessee (Dr. Brandon Horvath), Penn State (Dr. John Kaminski), and Mississippi State (Dr. Maria Tomaso-Peterson). Fortunately, the model has also performed well in these additional locations.

Focusing on epidemiology also showed us that the dollar spot fungus could cause disease at temperatures ranging from 59 to 95 degrees F as long as relative humidity remains above 70 percent for five consecutive days. At each location we were able to save, on average, a single fungicide application per year when using the dollar spot forecasting model. If applied to a large area like a fairway, the savings could be significant. Currently we are working on publishing this work in a peer-reviewed scientific journal and we hope to deploy the model later this year for general use.

The idea from this work is that the biology of these pathogens drives disease severity. Therefore, having a basic working knowledge of when diseases develop will help you to develop more effective fungicide programs. Although scheduling fungicide applications using a calendar can be effective, we have seen many failures using this approach. Fungicide purchases are made in the off-season, but those were likely made on data collected from many seasons at your location.

I advocate looking at historical weather data to schedule fungicide applications for the upcoming season because fungi respond to environmental stimuli. For example, Figure 1 shows average daily air temperature and relative humidity for Raleigh, N.C. for the past 48 months. Notice that temperatures are typically conducive for dollar spot development in early April, but our relative humidity does not consistently eclipse 70 percent until May. Based on our work, dollar spot will not develop unless we have four to five consecutive days of 70 percent relative humidity or higher.

I am not saying dollar spot will never develop in April because each year is different. However, I would advocate that your first fungicide application in April for preventative fairy ring or take-all patch would keep dollar spot suppressed.

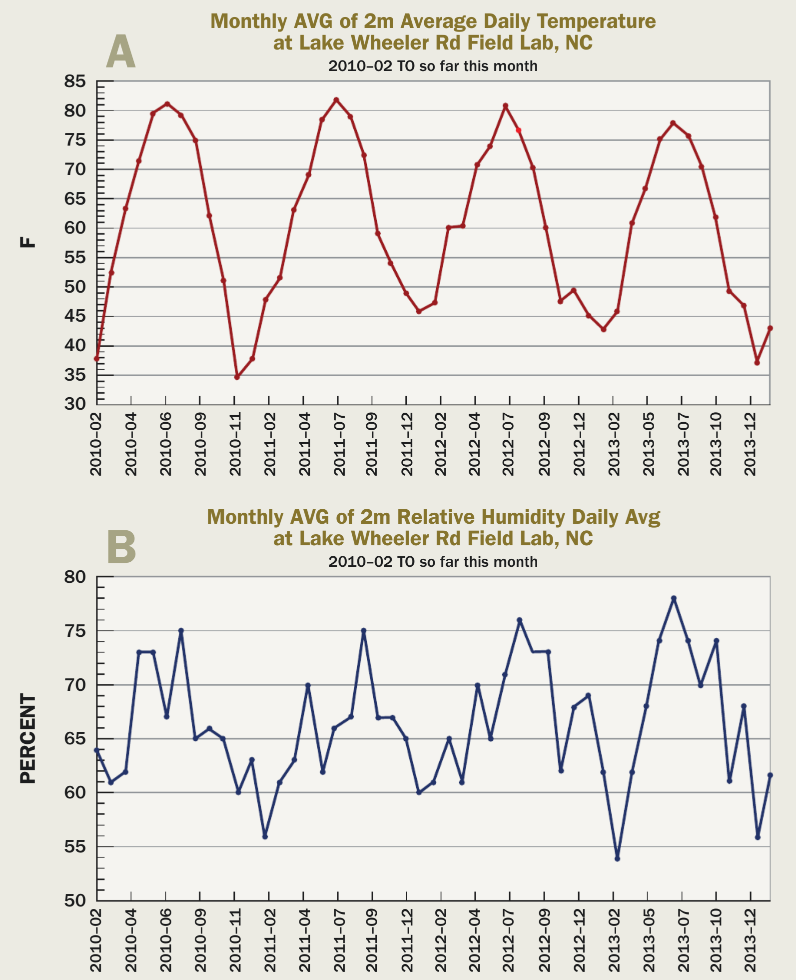
PLANNING AHEAD

Many turf pathologists have observed long residual dollar spot control with fungicide applications applied well before disease development. When applying fungicides preventatively, turfgrass managers have more choice with their application strategy.

Once a disease has developed, usually the only effective chemical management strategy is high rates on short intervals. Not only are you fighting very active pathogens, but you are also fighting fungicide depletion. This will be covered more in the next article.

FIGURE 1

Average daily air temperature and relative humidity for Raleigh, N.C. for the past 48 months.



Pythium blight and summer patch are good examples of fighting an uphill battle with curative chemical management. Pythium blight develops when nighttime temperatures eclipse 72 degrees F and relative humidity is high. Scheduling preventative fungicide applications even a few days prior to this weather allows for lower rates and longer re-application intervals when compared to managing the disease after it has developed.

Summer patch is another difficult disease, as it is frequently lumped in with take-all patch because it only infects within a specific temperature range. However, in creeping bentgrass in the transition zone, it seems like the fungus in summer patch continues to infect and colonize the host throughout the summer months. Those who have struggled with summer patch should schedule the first application when soil temperatures at a two-inch depth reach 65 degrees F. It is wise to re-apply products at least monthly throughout the summer to ensure protection.

Continued on page 36

Stand symptoms of Pythium root dysfunction on a 'G-2' creeping bentgrass putting green.

Continued from page 35

DEALING WITH RESISTANCE

With some diseases, once the damage is done, fungicides are typically not effective. This is the case with Pythium root dysfunction and take-all patch.

These organisms infect and colonize roots at specific soil temperatures, 55 to 65 degrees F for take-all patch and 55 to 75 degrees F for Pythium root dysfunction, and beyond these soil temperatures the organisms are not active. Once a fungus or a Pythium species stops growing or enters survival mode, fungicides are essentially not effective. This is why so many turf extension specialists harp on preventative fungicide applications to ensure efficient uptake of the fungicides by the target organism.

Curative control is possible with many diseases. Yet due to optimal conditions for the pathogen or inactivity, high rates are needed and failures should be expected. Constantly exposing the pathogen population to high rates of a fungicide may add undue selection pressure on the population, which in turn may lead to resistance.

Fungicide resistance is inherent in many turfgrass pathogen populations due to the ubiquitous nature and size of the population. Initially a population has a certain number of individuals possessing resistance or tolerance to a specific class of fungicides. Repeated applications of the same class of fungicides over time leads to selection of the resistant or tolerant individuals and once that population takes over, we see loss of control in the field.

Thinking about dollar spot and anthracnose, these diseases are omnipresent throughout the U.S. Turf managers frequently spray fungicides for dollar spot and those applications are altering the population dynamics of the anthracnose fungus population and vice versa. We typically only think in a single dimension when applying fungicides. In other words, I have boscalid, iprodione, propiconazole, chlorothalonil, propiconazole and iprodione scheduled for dollar spot control and these chemicals are only affecting the dollar spot population. Yet, all the other potential pathogens are likely present in that system. The fungicide program as a whole should be examined when thinking about fungicide resistance.

THE TANK-MIXING OR ROTATING QUESTION

Since we have many more single-site fungicides (medium to high risk for resistance) when compared to multi-site fungicides (low risk for resistance), the question arises: is it better to tank-mix or rotate?

Our current understanding is that both strategies can extend the life of our products and delay control failures. Concerning diseases with medium to high risk for resistance, I would advocate tank mixing and rotating. Right now it is very expensive to bring new chemicals to the market and with the saturation of the fungicide market, companies need a slam dunk before they will register anything new in turf. Although we are seeing many new products coming in the next few years, it is important to maximize the life of these great products for as long as possible.

When working with diseases such as dollar spot and anthracnose, rotate and tank-mix fungicides. This is relatively easy to do. Look at the top of the fungicide label for the FRAC number and ensure you are throwing as many different numbers at these diseases as possible.

Many turf managers are already dealing with resistance at their golf course. In many cases, fungicide classes such as the benzimidazoles, dicarboximides and DMIs may be useless or have extremely short residuals. Preventative applications of multi-site fungicides such as chlorothalonil and fluazinam are required to ensure good disease management. However, an area that we still do not clearly understand is the fitness cost to the pathogen when the population becomes resistant.

What did the fungus give up in order to circumvent the consistent fungicide application? We know from grape pathology that there is a documented fitness penalty when a resistance develops to the dicarboximide family, which means the population will likely revert to the original non-resistant state. Many labs are working to understand the biological consequences when fungi develop resistance, but we are not quite there yet. The bottom line is that managing fungicide resistance should follow the same strategy as preventing fungicide resistance. I advise superintendents to rotate and tank-mix products when managing fungicide resistance.

UTILIZING RESOURCES

The current suite of fungicides is quite awesome with respect to efficacy, but selecting the appropriate product, rate and timing still requires knowledge of the target pathogen. It is important for turfgrass managers to remain current on research surrounding turf diseases. Attend meetings, the GIS and regional shows to catch up on the current knowledge on diseases. Having good resource material in the office is helpful.

Another essential resource, in addition to the ones I mentioned in the previous article, is the "Compendium of Turfgrass Diseases" published by APS Press. It has a beautiful collection of images and succinct descriptions of turf diseases, including conditions that favor disease development. Of course, your local turfgrass extension specialist would be willing to help with building a successful fungicide program as well. However even with all the knowledge they possess, they can only be helpful if the turf managers are completely open and honest with them regarding their situation and issues.

Disease pressure and fungicide resistance enter the thought process when purchasing chemicals and developing a solid disease management program, but what happens to the fungicide after they are applied? The next article will cover that topic!

Jim Kerns, Ph.D. is an assistant professor and extension specialist in turfgrass pathology in the Department of Plant Pathology at North Carolina State University. For more information, Dr. Kerns can be reached at jpkerns@ncsu.edu

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Ad Index

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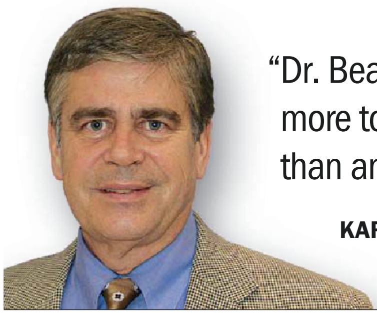

"Dr. Beard is an iconic figure who did more to put the 'science' in turfgrass than anyone I know."

KARL DANNEBERGER, PH.D., *Science Editor*

A catalyst of turf research

A book titled, "Turfgrass History and Literature" by James B Beard, Harriet J. Beard and James C Beard will be released this spring. I have not yet purchased a copy of the book, but given the history of Dr. Beard, I have no doubt that "Turfgrass History and Literature" will be a thorough and comprehensive review of the history of lawn, golf and sports turf.

No one is better suited, or more qualified to write on the history of turfgrass than Dr. James B Beard (Jim). He is an iconic figure who did more to put the "science" in turfgrass than anyone I know. His past personal and professional friendship with Dr. James Watson of The Toro Company during the 1960s and 1970s spurred a combination of academic and commercial knowledge and innovation that propelled the golf industry forward.

Dr. Beard's credentials include publishing over 265 scientific articles, seven books, educating graduate students who became leaders in academia and the industry, being a driving force in the foundation of the International Turfgrass Society and becoming a fellow of the American Society of Agronomy and Crop Science Society (in less than 10 years) to name a few.

Given all of his accomplishments, it is one book published over 40 years ago, "Turfgrass: Science and Culture," that was the seminal piece of work that became the bible of science and turfgrass for college students and industry professionals.

Jim wrote the book "Turfgrass: Science and Culture" during a 10- to 13-year period of time while at Michigan State University when he was not only involved with the activities listed above, but the additional commitments of teaching, doing a National Science Foundation Post-Doctoral study, traveling and speaking. Jim later moved to Texas A&M and continued at a level of high productivity.

Jim grew up in a small farming community outside of Dayton, in Bardford, Ohio. He received his bachelor's degree in Agronomy from The Ohio State University. A little known story from Jim's undergraduate days is that he was recruited to play football by Woody Hayes. Jim declined in order to concentrate on his studies. If you have met Jim or seen him, you can tell by his stature that he could have been a heck of a defensive end or left tackle.

Jim received his graduate degrees from Purdue University. In 2004 Purdue University honored Jim with their highest award, Honorary Doctorate.

As a professor, Jim immediately demonstrated the ability to impact the science of turfgrass. Jim's ability to "ruffle feathers" of graduate students who presented papers (including mine) at the Agronomy Society of America is legendary. His famous questioning was never mean spirited, just targeted so that he could know more about the research. I believe some took his criticisms as unfair, but I know from his former graduate students that he expected a lot from them; the same as he expected from himself and as an extension, all turf graduate students. He was a catalyst that took turfgrass research, at that time, to a new level.

Although intimidating on the outside, I have always found Jim to be a softy. He has always cared deeply about his students and the people who make their livelihood in this industry. Jim cares so much for all of us that I think in a strange way, it is a burden on him.

As a final thought before I order my copy of "Turfgrass History and Literature," Jim and his wife Harriet have been battling illness these last few years. Jim is currently recovering at home from a recent illness. If you find the time, whether you know him or not, drop him a note. I know he will appreciate it.

Karl Danneberger, Ph.D., ***Golfdom*'s science editor and a professor at The Ohio State University, can be reached at danneberger.1@osu.edu.**

The end of the overseeded grass

Dave Kopec, Ph.D. is a professor of turfgrass science at the University of Arizona. He has many years of research and practical experience transitioning cool season overseeded grass back to bermudagrass. Kopec can be reached at dkopec@ag.arizona.edu for more information.

Q When is the ideal time to start the transition from overseeded grass back to bermudagrass?

The transition process should begin with the idea that the overseeded grass is gradually removed to coincide with the start of active growth of bermudagrass.

Active growth of bermudagrass consistently occurs when the nighttime low air temperature is greater than 60° F for seven consecutive days.

Bermudagrass may often green-up and grow a little before this, but it does not really "kick it in gear" until then.

The transition back to bermudagrass is a sensitive subject at many golf courses because golfers do not want any disturbances. Superintendents are often forced to conduct spring transition around the golf calendar and golfer preferences.

Q Describe the transition process on a putting green.

Nearly all bermudagrass greens in our area are overseeded with *Poa trivialis.* Superintendents almost exclusively use cultural practices to transition from *Poa trivialis* back to bermudagrass on greens.

They start in late March with light vertical mowing once a week, to nick leaves and the elevated crowns of *Poa trivialis.* Fertilization with small amounts of water-soluble nitrogen, favors the bermudagrass. This is often coupled with slightly reduced irrigation levels.

Since *Poa trivialis* has poor heat tolerance, it gradually fades away as day length and air temperatures increase and the cultural practices thin it out.

Be careful with the intensity of verticutting on ultradwarf bermudagrass greens. They can be severely injured by aggressive verticutting.

Q Describe the transition process on fairways.

Most of the fairways in our area are overseeded with perennial ryegrass and it can persist until early August unless it is actively removed.

Transition starts in late April by gradually lowering the mowing height from 0.5 to 0.4 to 0.3 inches over a period of several weeks. This is accompanied by fertilizing with soluble nitrogen at 0.3 to 0.5 pounds nitrogen per 1,000 square feet every two weeks.

Some superintendents aggressively verticut in late May, after the last tournament, to thin out the perennial ryegrass.

Others might use transition-aiding herbicides to selectively remove the perennial ryegrass. Each herbicide has its strengths and weaknesses, but the amount of perennial ryegrass removed is dependent on the rate of application and the daytime air temperature following application.

The higher the application rate, the higher the air temperature, the more perennial ryegrass will be removed and the faster it will turn brown.

Q Describe the transition process in roughs.

Roughs are overseeded with perennial ryegrass and are the hardest areas to transition back to bermudagrass. It's because the higher mowing height in the rough allows the perennial ryegrass to become well established and produce excessive shading of the bermudagrass.

Superintendents either use aggressive scalping or herbicides to force the transition back to bermudagrass. Some will apply a transition herbicide and then scalp.

Q Anything else you would like to add?

There is interest in new and existing herbicides to remove perennial ryegrass with minimal production of necrotic, straw colored, perennial ryegrass.

Also, once every five years, the golf course should skip overseeding to allow the bermudagrass to recover. One of the shortcomings of transition herbicides is that they turn the overseeded grass a straw color, which golfers find objectionable.

Clark Throssell, Ph.D., loves to talk turf. Contact him at clarkthrossell@bresnan.net.

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NEW PRODUCT HIGHLIGHTS // **SPREADERS**

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LIKE MOST EQUIPMENT IN THIS INDUSTRY, SPREADERS HAVE NEVER BEEN BETTER.

BY THE GOLFDOM STAFF

WE WERE HANGING OUT AT THE COURSE recently when the spreader was pulled out. We got some great photos of aeration, and were looking forward to some shots of the spreader in action. An entertaining discussion about what to set the spreader at — between zero and "WFO" then began.

Thanks to improvements in spreaders, getting the perfect setting is easier than ever. Some of these products prove it.

1. Broadcast Push Spreaders

Featuring heavy-duty polyethylene construction and accurate material feed systems, the broadcast push spreaders are designed to help turf care professionals boost productivity and reduce material waste. **TURFEX** offers four models of the spreaders. The TS65 and TS85 models offer 75- and 120- pound capacities, respectively, and come with powder-coated frames. The TS65SS and TS85SS have matching specifications, but are equipped with stainless steel frames for corrosion protection. With a maximum spread width of 12 feet, the spreaders have precise distribution of granular materials, including fertilizer, pesticide, herbicide and seed. Other features include: a manual on/off lever, a positive-locking gate that reopens to the calibrated setting for each use, a 10-inch molded plastic spinner, large pneumatic tires, a top screen and a clear poly cover. All spreaders are backed by two-year warranty.
turfexproducts.com

2. WideSpin 1550 Topdresser

The **TURFCO** WideSpin 1550 topdresser features an all-new spinner design and new hydraulics for a more versatile, consistent spread. With a new electronic control, operators can switch between a superlight application to ultra-heavy with the touch of a button. Operators can make adjustments for 95 percent of application rates for tees, greens and approaches without leaving the seat. Consistent results are ensured each time by the controller. Also included are a larger capacity hopper and a wider hopper opening. The 1550 is available as an engine or hydraulic tow-behind unit or a hydraulic truck-mounted unit. It's covered by a three-year warranty.
turfco.com

3. ECO 200

Unlike its predecessor, the Eco 100, **ECOLAWN**'s Eco 200 is designed specifically for the sand topdressing market. Where the previous model was designed for compost topdressing and dealing with lighter bulk materials, the newest topdresser handles the heavy bulk materials. At the core of the Eco 200 is its reverse spin, dual-wheel broadcast system. This design is unparalleled in the mini self-propelled, sand-spreading category. The reverse spin, dual-wheel broadcast system delivers a uniform spreading pattern with even the heaviest of materials. Additionally, the Eco 200 has a new four-wheel design for increased weight distribution and stability. While sporting the same 1/3-cubic-yard hopper, the Eco 200 has an improved larger hopper opening. The hopper's support design increases the maximum feed product volume by up to 20 percent.
ecolawnapplicator.com

4. Type L Broadcast Spreaders

Easy to operate and clean, the Type L broadcast spreaders deliver precision accuracy. These single-disc fertilizer spreaders feature a force-feed spreading mechanism that can achieve spreading accuracy up to 52 feet wide. Three models are available. They are PTO driven. Also available is an optional L Carrier that converts the L1500 and L2010 models into a trailer broadcast spreader. All **LELY** spreaders carry a two-year limited warranty and can be outfitted with several accessories.
lelyusa.com

5. Turf Tender 440 and 420

The **DAKOTA** Turf Tender 440 is designed to save time, eliminate labor and operating costs. One operator can topdress, fertilize, repair divots, load small topdressers, fill bunkers and move a wide variety of materials from the seat of the tractor, without having to replace options. With a 4.2-yard capacity, A-frame hitch design and Dakota turf tires, it has what the company says is the lowest PSI in the industry. Options include a hopper vibrator and 4-wheel brakes. The 420 is a medium-sized machine with a 2-yard capacity and most of the same options as the 440.
dakotapeat.com