Volume 10, Issue 3 • March 2001

DISEASES

Genetic resistance to snow mold fungi in bentgrass

By Michael Casler, Jeff Gregos, Zhichun Wang and John Stier

www.inter diseases of turfgrass, collectively referred to as snow molds, are a major problem on golf courses and other turf areas in Wisconsin and similar regions. Golf course greens, fairways and tees are of primary concern because of their high dollar value. Nearly all golf course superintendents spray putting greens with fungicides to inhibit snow mold fungi. Most superintendents also spray tee boxes, while many also spray their fairways.

This control method is highly expensive, it has limited effectiveness and it may adversely affect the environment. In addition, some fungal pathogens have developed resistance to fungicides after years of repeated applications.

Our objective was to determine if existing cultivars of creeping bentgrass (Agrostis palustris

Nearly all golf course superintendents spray putting greens with fungicides to inhibit snow mold fungi. This is expensive, has limited effectiveness and may adversely affect the environment. L.); colonial bentgrass (Agrostis tenuis Sibth.); creeping red fescue (Festuca rubra L.); and Chewings fescue (Festuca rubra L. commutata Gaud.) differ in snow mold reaction. In addition, our goal was to determine if snow mold resistance is genetically inherited in creeping bentgrass.

Creeping bentgrass is a highly desirable species for golf courses, but most cultivars are generally considered to be highly susceptible to various snow mold pathogens.

Snow mold fungi

Snow mold fungi are facultative parasites, capable of surviving and growing on necrotic tissue, becoming particularly serious when susceptible hosts are compromised either through injury or stress. These pathogens are most active at temperatures ranging from 32 to 55°F and are favored by extended snow cover. Disease symptoms begin as small, round patches (2 to 4 in. in diameter) with a

water-soaked appearance. As the pathogen grows, the turf foliage dies, leaving brown patches that coalesce into extensive areas of severely damaged turf. In Wisconsin, areas of golf courses that routinely receive severe snow mold damage will have a low population of perennial turf grasses and a high population of annual-type Poa annua that regenerates in late spring from the soil seed banks.

There are four common snow mold fungi in Wisconsin. Pink snow mold is caused by Microdochium nivale and occurs throughout the state. Gray snow mold is caused by Typhula

N THIS ISSUE

Genetic resistance to snow mold fungi in bentgrass. .1

Snow mold fungi

Cultivar variation

Creeping bentgrass clonal collections

Spoon-feeding with granular materials?7

Spoon-feeding fertility programs

Materials and methods

- Management Forum: Fertilizer formulations..15

TURFGRASS TRENDS

Executive Editor Sue Gibson 440/891-2729; 440/891-2675 (fax) sgibson@advanstar.com

Managing Editor Curt Harler 440/238-4556; 440/238-4116 curt@curt-harler.com

Senior Science Editor Dr. Karl Danneberger

Group Editor Vern Henry

Senior Graphic Designer Jeff Landis 440/891-2702; 440/891-2675 (fax) jlandis@advanstar.com

Senior Production Manager Karen Lenzen 218/723-9129; 218/723-9576 (fax) klenzen@advanstar.com

Circulation Manager Cheryl Beeman 218/723-9271; 218/723-9433 (fax) cbeeman@advanstar.com

Group Publisher John D. Payne 440/891-2786; 440/891-2675 (fax) jpayne@advanstar.com

Corporate & Editorial Office 7500 Old Oak Blvd. Cleveland, OH 44130-3369

New Subscriptions 888/527-7008

Abstracts: 800/466-8443 Reprint: 440/891-2744 Permission: 440/891-2742 Single copy or back issues: Subscription/Customer Service 888/527-7008; (fax) 218/723-9437 Web site address: www.landscapegroup.com



Chairman and Chief Executive Officer Robert L. Krakoff

Vice Chairman James M. Alic

VP-Finance, CFO & Secretary David W. Montgomery

Executive Vice Presidents William J. Cooke Alexander S. DeBarr Morris R. Levitt Daniel M. Phillips

Vice President & General Counsel Eric I. Lisman

Treasurer and Controller *Adele D. Hartwick*

DISEASES

incarnata and occurs throughout Wisconsin. Speckled snow mold is caused by Typhula ishikariensis and occurs largely in the northern half of Wisconsin. Another fungus of unknown pathogenicity, Typhula phacorrhiza, occurs largely in the far northern part of Wisconsin.

In the spring of 1998, we initiated a series of experiments to compare several cultivars of creeping bentgrass (Cato, Penncross, Penneagle, Seaside II, and SR 1119); colonial bentgrass (Astoria, Highland, SR7100, Tendez, and Tiger): creeping red fescue (Dawson. Jasper, and Pennlawn); and Chewings fescue (SR5100, Tiffany, and Victory). Plots were seeded at three locations in Wisconsin: O.J. Noer Turfgrass Research and Education Facility near Verona (southern WI), Sentryworld Golf Course near Stevens Point (central WI). and Gateway Golf Course near Land O' Lakes (northern WI). All plots were managed as golf course fairways with a mowing height of 1/2 in. at Verona and Stevens Point and 3/4 in. at Land O' Lakes.

Each experiment was planted in spring 1998 and late summer 1999. The experimental design was a split-split-split-plot with host genus as whole plots, host cultivar as subplots, pathogen as sub-sub-plots, and inoculated (cultured inoculum) vs. non-inoculated (natural inoculum) as sub-sub-sub-plots.

Isolates of each pathogen were collected from each experimental site and used to inoculate plots only at their respective site. Isolates were cultured and multiplied in the laboratory on millet seed. Because T. phacorrhiza was not found at the two southern sites and T. ishikariensis was not found at O.J. Noer, these treatments were not included at these two sites. Plots were inoculated in October of the establishment year and visually rated for snow mold damage the following spring.

Cultivar variation

The fine fescue cultivars were consistently more resistant to all snow mold fungi than the bentgrass cultivars (Table 1). The differences were greatest at the central and northern locations where there was greater average snow mold damage. T. ishikariensis was the most pathogenic to bentgrass at the central and northern locations and to fescue at the northern location. T. incarnata was most pathogenic to fescue at the central location and to both species at the southern location.

There was a considerable amount of natural inoculum at each site, as indicated by the damage to non-inoculated plots. Inoculation with T. ishikariensis or T. incarnata significantly increased damage to bentgrass at all locations. Inoculation with T. ishikariensis at the northern site or T. incarnata at the central site significantly increased damage to fescue. M. nivale and T. phacorrhiza did not cause increased damage to either bentgrass or fine fescues.

Compared to creeping bentgrass, colonial bentgrass was damaged less by all snow mold fungi at all locations (Table 2). This difference was significant (P<0.05) in nearly all cases, the only three exceptions being the most pathogenic isolate (T. ishikariensis at the northern site) and the two treatments with the least damage (non-inoculated and M. nivale at the southern site).

In some cases, creeping bentgrass cultivars had more than double the damage to colonial bentgrass cultivars. Increases in damage to creeping and colonial bentgrass cultivars, due

RELEVANT LITERATURE

- Hsiang, T., N. Matsumoto, and S.M. Millet. 1999. Biology and management of Typhula snow molds of turfgrass. Plant Dis. 83:788-798.
- Jönsson, H.A. and C. Nilsson. 1992. Grass variety reaction to selection for resistance to Typhula ishikariensis. Norwegian J. Agric. Sci. Suppl. 7:25-34.
- Posselt, U.K. and F. Altpeter. 1994. Improvement of snow mould resistance by conventional and in vitro techniques. Euphytica 77:251-255.
- Tronsmo, A.M. 1992. Resistance to snow mould fungi in breeding material of grasses. Norwegian J. Agric. Sci. Suppl. 7:35-38.

to inoculation, were generally similar, with the exception of T. incarnata at the central and southern sites.

For creeping bentgrass, cultivar x environment interactions were frequent. Creeping bentgrass and fine fescue cultivar rankings were highly inconsistent across locations, years, and fungal species. Colonial bentgrass cultivar rankings were somewhat consistent across these environmental factors. Across all locations, years, and fungal species, SR7100 and Tiger ranked lowest in damage (30 and 34%, respectively) compared to Astoria and Highland (42 and 44%, respectively).

Creeping bentgrass clonal collections

In 1997, we began a creeping bentgrass breeding program with the objective of developing genetic resistance to snow mold. Seeded cultivars of creeping bentgrass consist of heterogeneous seed mixtures. Each seed potentially contains a different combination of genes so that its appearance, or phenotype, will differ from that of its neighbors. On golf courses, this leads to natural selection between neighboring plants for adaptation to various stresses and management factors. One can easily see this phenomenon on golf courses by observing patchiness of a single species on putting greens or fairways.

In our search for genetic resistance to snow mold, we focused on fairways of Wisconsin golf courses with three criteria: north of U.S. Hwy 10; infrequent or no treatment with fungicides to control snow mold fungi; and frequent snow mold damage following a typical winter. We sampled plants that had a large diameter, green color and absence of snow mold patches within two weeks of the final snow melt. We also collected plants from golf course greens in both northern and southern Wisconsin, with selection based on large diameter, bright green color, fine leaf texture and absence of Poa annua within the bentgrass patch.

We screened 326 of these clones for reaction to an isolate of T. ishikariensis during the summer of 1999. The clones were split into six pieces, grown in 1.25 x 1.25 x 2-inch containers, and managed to simulate a fairway with a half-inch mowing height. The clones



SR 7100 creeping bentgrass at Sentryworld Golf Course inoculated with T. ishikariensis (top) not inoculated (bottom).

were arranged in a randomized complete block design with six replicates. Flats were placed in a growth chamber to simulate a fall hardening period, with a gradual temperature reduction to 41°F and a gradual reduction in day length.

Four of the six replicates were inoculated with T. ishikariensis and all plants were kept in the dark for 8 weeks. Plant chlorosis/necrosis was scored weekly using a 0-to-10 scale, where 0 = completely green plant and 10 =completely dead plant. Plants were then placed in a greenhouse where they were scored two more times, using the same rating scale.

We screened a subset of 72 clones twice in a second experiment. The second experiment was similar to the first, but included an isolate of T. incarnata and a second isolate of T. ishikariensis. There were three replicates each of the control and the three fungal isolates and two separate runs of the second experiment. Five creeping bentgrass clones will be intercrossed to make an experimental synthetic population in summer 2001.

DISEASES

Clonal variation in creeping bentgrass

Plant chlorosis/necrosis scores were highly repeatable and significant differences (P<0.01) were found among clones for the control (non-inoculated) treatment, the inoculated treatment, and the difference. Clonal variation within the control was due to variable tolerance to extended cold/dark conditions. Clonal variation within the inoculated treatment was due to a combination of cold/dark tolerance and disease resistance. Therefore, the difference was used as a measure of disease reaction.

Chlorosis and necrosis symptoms developed gradually during the dark period. Scores for inoculated and non-inoculated treatments were highly correlated during the first three ratings, because disease symptoms were not highly expressed. As disease symptoms became highly expressed during the last three weeks of cold/dark conditions, the correlation between inoculated and non-inoculated approached zero. All data in this paper are taken from means over the last three weeks of cold/dark conditions and the two weeks of recovery in the greenhouse.

Clones selected from fairways had a mean difference between inoculated and non-inoculated of 1.9 compared to clones selected from greens with a mean of 3.0 (P<0.01; Fig. 1). If we define snow mold resistant clones as those with mean differences <1, fairway collections had 22% resistant plants and green collections had 3% resistant plants. As expected, based on snow mold management, there appears to be more natural selection for snow mold resistance in low-maintenance golf course fairways than on putting greens.

There were also large differences among golf courses in the frequency of resistant plants, with a range of 0 to 42% resistant

TABLE 1

BENTGRASS VS. FINE FESCUE: PERCENTAGE OF PLOT SHOWING SNOW MOLD DAMAGE IN SPRING OF THE 2ND YEAR.

Location/	Inoculum ^a			State of the second	
Host genus	None	Mniv	Tinc	Tish	Tpha
NORTHERN WI					
Bentgrass	47.0	44.0	71.3*	80.0*	52.5
Fine fescue	15.3	16.8	14.0	54.8*	17.1
P-value ^b	<0.01	<0.01	<0.01	<0.01	<0.01
CENTRAL WI					
Bentgrass	39.4	38.6	59.5*	69.7*	
Fine fescue	34.6	27.3	49.1*	39.2*	-
P-value ^b	0.01	0.03	<0.01	<0.01	
SOUTHERN WI					
Bentgrass	10.8	12.5	18.5*		
Fine fescue	3.6	1.9	5.3	-	
P-value ^b	<0.01	<0.01	<0.01		

* SIGNIFICANTLY DIFFERENT FROM THE RESPECTIVE NON-INOCULATED VALUE AT P<0.05.

A MNIV = MICRODOCHIUM NIVALE, TINC = TYPHULA INCARNATA, TISH = TYPHULA ISHIKARIENSIS, AND TPHA = TYPHULA PHACORRHIZA.

b = PROBABILITY THAT DECLARING A DIFFERENCE BETWEEN BENTGRASS AND FINE FESCUE MEANS WILL RESULT IN AN INCORRECT STATEMENT.

4

plants on the northern-WI golf courses. Thus, local conditions and/or the source of the original bentgrass germplasm has a lot to do with the likelihood of finding snow mold resistance.

The proof of the above snow mold challenge would come with repetition, which could only be done on a smaller set of clones. The 72 clones chosen for the second experiment were based on the full range of reactions in the first experiment. The repeatability of these ratings was similarly low to that observed for creeping bentgrass cultivars in the field studies reported above. Correlations between experiments, runs of experiment #2, and between fungal isolates of experiment #2 were all positive, but low, ranging from 0.1 to 0.4.

Despite this low apparent repeatability, each experiment was internally highly repeatable, with significant differences observed among clone means for reaction to all isolates and to the control in each run and averaged over runs of experiment #2.

After sifting through all this data on these 72 clones, were able to find five clones which appeared to have higher-than-average resistance to each snow mold isolate (Table 3). These clones had mean disease reactions consistently lower than the other clones for all four inoculations. They did not differ from the other clones in chlorosis/necrosis as control plants, indicating that they appeared to be unique in having repeatable snow mold resistance but were average for cold/dark tolerance.

Because the comparisons made in Table 3 are data-based (i.e., they were suggested by the results), the P-values are not correct, but they nevertheless suggest the type of consistency that is necessary in order to make successful selections.

TABLE 2

CREEPING VS. COLONIAL BENTGRASS: PERCENTAGE OF PLOT SHOWING SNOW MOLD DAMAGE IN SPRING OF THE 2ND YEAR

Location / Inoculum ^a					
Host genus	None	Mniv	Tinc	Tish	Tpha
NORTHERN WI					
Creeping bentgrass	54.5	55.5	78.5*	81.8*	63.7
Colonial bentgrass	38.7	31.4	63.8*	77.6*	40.0
P-value ^b	<0.01	<0.01	0.01	0.43	<0.01
CENTRAL WI					
Creeping bentgrass	52.2	48.2	85.7*	83.5*	
Colonial bentgrass	26.2	29.0	29.9	54.7*	Harry - State
P-value ^b	<0.01	0.05	<0.01	<0.01	
SOUTHERN WI					
Creeping bentgrass	11.8	14.3	24.0*	-	-
Colonial bentgrass	9.8	10.7	13.0		-
P-value ^b	0.22	0.06	<0.01		

* SIGNIFICANTLY DIFFERENT FROM THE RESPECTIVE NON-INOCULATED VALUE AT P<0.05.

A MNIV = MICRODOCHIUM NIVALE, TINC = TYPHULA INCARNATA, TISH = TYPHULA ISHIKARIENSIS, AND TPHA = TYPHULA PHACORRHIZA.

b = PROBABILITY THAT DECLARING A DIFFERENCE BETWEEN CREEPING AND COLONIAL BENTGRASS MEANS WILL RESULT IN AN INCORRECT STATEMENT.

These five creeping bentgrass clones will be intercrossed to make an experimental synthetic population in summer 2001. This population will be tested on golf course fairways to determine if this selection protocol was successful in increasing resistance to snow mold fungi. Our future plans are to continue selecting for increasing levels of snow mold resistance, in new germplasm and in the experimental synthetic, using field-based screening techniques. We have also made crosses to study the inheritance of resistance and to map resistance genes in collaboration with Dr. Geunhwa Jung of the Department of Plant Pathology.

Michael Casler is Professor of Agronomy and Plant Breeding/Plant Genetics; Jeff Gregos is Director of the Turf Disease Laboratory; Zhichun Wang is a graduate student; and John Stier is Assistant Professor of Horticulture, University of Wisconsin-Madison.

TABLE 3

MEAN CHLOROSIS/NECROSIS SCORES FOR 72 CREEPING BENTGRASS CLONES CHALLENGED WITH THREE ISOLATES OF FUNGAL SNOW MOLD PATHOGENS DR GROWN UNDER COLD/DARK CONDITIONS WITHOUT INOCULATION

Experiment/Inoculum ^a						
Measurement/Group	Expt. 1	Expt. 1	Expt. 2	Expt. 2	Expt. 2	Expt. 2
	Control	Tish 3	Control	Tish 3	Tish 1	Tinc 1
COLD/DARK RE	ACTION	b				
Best five clones	2.93	3.55	3.85	5.63	5.53	5.17
Other 67 clones	3.19	6.00	3.75	4.05	6.23	5.64
P-value ^c	0.36	<0.01	0.46	<0.01	0.01	0.02
RECOVERY REA	ACTION b					
Best five clones	1.50	1.30	2.69	6.79	5.21	4.63
Other 67 clones	1.58	3.68	2.75	8.03	6.31	5.60
P-value ^c	0.71	<0.01	0.84	<0.01	0.01	0.01

A TISH = TYPHULA ISHIKARIENSIS AND TINC = TYPHULA INCARNATA.

B COLD/DARK = MEAN OF RATINGS TAKEN AT 6, 7, AND 8 WEEKS AFTER INOCULATION. ALL PLANTS WERE MAINTAINED IN THE DARK AT 41°F. RECOVERY = MEAN OF RATINGS TAKEN AT 1 AND 2 WEEKS AFTER REMOVAL FROM COLD/DARK CONDITIONS TO A GREENHOUSE WITH A 16-HR DAYLENGTH AND 65-72°F. C PROBABILITY THAT DECLARING A DIFFERENCE BETWEEN CREEPING AND COLONIAL BENTGRASS MEANS WILL RESULT IN AN INCORRECT STATEMENT.

6

Should you let a computer do your disease scouting?

By Frank H. Andorka Jr.

The e-mail chilled Douglass Larson to the bone. His Skybit weather service warned him that conditions in July were ripe for a gray leaf spot (GLS) outbreak — the same disease that wiped out fairways and tees in the mid-Atlantic as recently as 1998.

Based on the information, Larson, superintendent at Manufacturers Golf & CC in Fort Washington, PA mobilized his crew members to scour the course for signs of the disease. They found the telltale spots and immediately sprayed a fungicide to prevent spreading. Larson reports that the blitzkrieg succeeded and the course lost little turf.

"We've never seen the disease earlier than September, so the warning took me by surprise," Larson says. "But it's a good thing we received it. If we hadn't, we could have been in serious trouble."

Overcoming skepticism

Despite others' skepticism, Larson and other East Coast superintendents are singing the praises of Skybitis computerized weather service. Boalsburg, PA-based Skybit (www.skybit.com) started 10 years ago as an information technology company that delivered customized weather and disease forecasts to the agricultural and energy industries. In 1994, the company moved into the turfgrass industry.

Skybit gathers weather information from the National Weather Service (NWS) and other remote sites, such as Penn State University's weather station, to provide detailed weather reports for courses, based on their latitude and longitude.

After observing natural disease behavior in the field, researchers develop models based on the factors that they can reproduce in a laboratory, such as evapotranspiration rates, temperature and precipitation. Scientists then create formulas that mirror the way diseases behave.

To make its predictions, Skybit developed its own models and feeds raw data into a computer, which then produces alerts.

In 1994, the company was looking for courses willing to test its system, and Dennis Watkins, superintendent at Lords Valley CC in Newfoundland, PA agreed to try it. Prior to subscribing to Skybit, Watkins gathered his weather information from the evening news, which was notoriously inaccurate.

A salesman convinced him to try the service, touting its disease modeling as another weapon in the battle to keep Watkins' course in tip-top shape. Watkins was skeptical, but still signed up.

"I was at a loss to explain the accuracy of its reports," Watkins says. "I spent a year trying to pick the process apart —then I gave up."

The system costs \$75

per month without disease modeling and \$150 per month with it. Watkins says most subscribers use the disease modeling service during the height of the golf season, but remove it during the offseason. For each individual course, Skybit currently tracks five diseases: anthracnose, brown patch, pythium blight, summer patch and GLS. It delivers superintendents the information by fax or e-mail.

Watkins worked with Skybit to develop the GLS model, which has been winning the service accolades this year. Watkins "[Skybit] can compare conditions from the last outbreak of a disease at your course with what conditions are today," Watkins says. "It's the historical database that makes the difference."

says Skybit can break the country down into one-kilometer squares, which are analyzed for weather patterns. Skybit also created a 30-year weather database that allows it to compare weather conditions today with those in the past. That's what makes its disease predictions relevant.

"It can compare conditions from the last outbreak of a disease at your course with what conditions are today," Watkins says. "It's the historical database that makes the difference."

Pythium problem-solver

H. Jim Loke, superintendent at Bent Creek GC in Lititz, PA says the service also helped him deal with an outbreak of pythium blight a few years ago. A heavy rain had flooded his course, and the level of silt that covered his golf course, along with the water, created the perfect conditions for pythium.

"[Skybit] was right on with that prediction," Loke says. "I wouldn't rely on it as the only source of information, but I've found that its temperatures are accurate within a couple of degrees — and that's almost impossible to do where my course is."

While the system may have nailed a GLS outbreak this year, some plant pathologists remain skeptical, and caution superintendents against putting all their faith in Skybit forecasts to fight disease.

One more tool in the kit

"Skybit is a good complementary product to other pest management strategies, but it doesn't replace looking for the disease yourself," says Paul Vincelli, professor of plant pathology at the University of Kentucky in Lexington. "We donit have any data to prove that it will work over an extended period of time."

"It's great that superintendents are getting a heads-up, but there's a lot we don't know about some of these diseases," says Gail Schumann, plant pathologist at the University of Massachusetts in Amherst. "We're going to take a wait-and-see attitude toward the service, but the fact that someone is trying to do it is encouraging."

Schumann says she was getting calls from superintendents throughout New England saying they were warned about GLS by Skybit, but examination of turf samples from the courses showed no evidence of the disease.

"I've heard that for other parts of the country that Skybit's prediction was deadly accurate," Schumann says. "But it never got as far north as [Skybit predicted] it was going to get."

What gives some academic observers pause is the proprietary nature of Skybitis predictive models. Schumann and Vincelli want to see the models undergo scientific scrutiny. Schumann says that no matter how accurate Skybit's models, they will never replace good scouting by maintenance crews.

"Don't think of this as a black box that will give you all the information you need," Schumann says. "You're still going to have to test its predictions yourself and make sure they're accurate.

"You can count weeds, you can count grubs, but there's no way to do that with diseases," she adds. "Predictive models are the closest you can get, and it's exciting that there are people working to take some of the guesswork out of disease prevention."

Watkins understands the skepticism he was once a skeptic himself. But Watkins says the company will let anyone test its formulas, and Vincelli says he is working with Skybit to develop a study at the University of Kentucky, although details are still being worked out.

"I'm treating [Skybitis] models the same way I would if one of my colleagues had put forth a theory," Vincelli says. "I just want to test them under controlled, laboratory conditions."

The service currently has 100 subscribers mainly in the East, but Watkins says it plans to expand the service around the country. Skybit is working on models for bermudagrass and other Southern grasses and expects to sign deals with cooperating university sites within the next few years.

"Right now, we're perfectly situated for the East, but we're not satisfied with that," Watkins says. "We'd really like to make it a nationwide service."

Frank Andorka Jr. is managing editor of Golfdom magazine in Cleveland, OH.

14