BY MIKE BOEHM, JOE RIMELSPACH, AMY NIVER, YOUNG-KI JO & TODD HICKS

Tired of managing dollar spot?

The secret might be the timing of fungicide applications

Table 1. Impact of preventive fall and spring fungicide applications on dollar severity: 2001/2002 field study.

			Dollar spot infection centers/plot[a]		
Treatment	Fungicide applied	Date of application	OTF[b]	Wedgewood	Brookside
1	nontreated		46.3	1.6	2.8
2	propiconazole[c]	Nov. 10, 2001	24.3	0.8	1.6
3		April 26, 2002	21.3	0.5	1.9
4		May 22, 2002[i]	3.4	0.0	0.5
5	propiconazole[d]	Nov. 10, 2001	12.8	1.0	1.9
6		April 26, 2002	16.8	1.1	1.3
7		May 22, 2002[i]	6.1	0.6	0.0
8	chlorothalonil[e]	Nov. 10, 2001	53.8	1.0	2.8
9		April 26, 2002	27.5	1.0	2.3
10		May 22, 2002[i]	7.8	0.5	0.5
11	thiophanate-methyl[f]	Nov. 10, 2001	39.3	1.5	3.0
12		April 26, 2002	1.6	1.4	2.5
13		May 22, 2002[i]	0.5	0.6	1.6
14	iprodione[g]	Nov. 11, 2001	12.8	1.1	2.9
15		April 26, 2002	18.0	0.4	2.5
16		May 22, 2002[i]	0.5	0.1	0.0
17	BASF 505[h]	Nov. 11, 2001	16.3	1.1	1.8
18		April 26, 2002	25.0	0.8	1.6
19		May 22, 2002[i]	0.8	0.1	0.0
		$LSD_{(P=0.05)}$ =	9.1	1.0	3.2

a Dollar spot severity was rated on June 24, 2002 by counting the number of dollar spot infection centers (DSIC's) per plot. (4 replicates per treatment per location).

b Wedgewood = Wedgewood Golf & County Club; Brookside = Brookside Golf & Country Club; OTF = OTF Turfgrass Research and Education Facility.

c propiconazole (1.0 oz/1000 ft^2 Banner Maxx, Syngenta Crop Protection, Greensboro, N.C.).

d propiconazole (2.0 oz/1000 ft^2 Banner Maxx).

e chlorothalonil (3.2 oz/1000 ft^2 of Daconil Ultrex, Syngenta Crop Protection, Greensboro, N.C.).

f thiophante-methyl (2.0 oz/1000 ft^2 of 3336 F, Cleary Chemical Co., Dayton, N.J.).

g iprodione (4.0 oz/1000 ft^2 of 26GT, Bayer Environmental Science, Research Triangle Park, N.C.).

h BASF 505 (0.2 oz/1000 ft^2 (BASF, Research Triangle Park, N.C.).

i Preventive fungicide applications made every 14 or 28 days starting on May 22, 2002.

Spray for dollar spot in the fall before snow flies or in early spring as turfgrass breaks dormancy and significantly reduce the amount of disease to worry about the following June or July. Sound crazy or too good to be true? Perhaps, but researchers might be on to something.

The research in this update was conducted to answer two questions: (1) Is it possible to make fungicide applications on healthy turfgrass during the previous fall and/or early spring and control disease outbreaks the following season, and (2) if it's possible to deploy fungicides in this manner, when is the best time to make such applications."

This research is ongoing. Although the focus of this update revolves around fungicide use and timing, superintendents shouldn't forget about the importance cultural management practices have on turfgrass diseases.

Dollar spot, caused by the fungus *Sclerotinia homoeocarpa*, is one of the most economically important diseases of cool-season grasses. It's routinely cited as the most sprayed for turfgrass disease and typically tops the list of golf course diseases most difficult to manage. Although increased nitrogen fertility and cultural practices related to the removal of dew/guttation water and the maintenance of adequate soil moisture can reduce the severity of dollar spot, fungicides are usually necessary to provide acceptable levels of management on most golf courses.

Concerns about the development of fungicide resistance and the environment, along with recently enacted restrictions on fungicide use, encouraged research into alternative approaches for managing turfgrass diseases.

To find new ways to manage dollar spot effectively while trying to minimize the development of fungicide resistance and extend the shelf life of registered fungicides, attention has turned to exploring the impact of fall and/or early spring preventive fungicide applications made to asymptomatic or healthy turfgrass. This work is an extension of an applied research program focused on the integrated management of turfgrass diseases and on the biology and ecology of *S. homoeocarpa*.

The information in this update represents the hard work of many individuals, including Rick Latin, Ph.D. and Bruce Clarke, Ph.D., two turfgrass pathology colleagues at Purdue and Rutgers Universities, respectively. The work wouldn't have been possible without the generous support of the Ohio Turfgrass Foundation, chemical companies and several forward-thinking superintendents in Ohio – Keith Kresina (The Golf Club in New Albany), Carl Wittenauer (Brookside Golf & Country Club in Columbus), Scott Schraer (Scioto Reserve Golf and Athletic Club in Powell), Joe Noppenberger Jr. (Wedgewood Golf & Country Club in Powell) and Todd Voss (Double Eagle Club in Galena).

Table 2. Impact of preventive fall and spring fungicide applications on dollar severity: 2003/2004 field study.

Application schedule	Disease severity[c]			
Fall[a]	**Spring[b]**	**OTF**	**Brookside**	**Purdue**
nontreated	not treated	153	39	14
	propiconazole[d]	2	20	1
	not treated	130	32	16
	chlorothalonil[e]	42	6	4
	not treated	146	33	11
	(propiconazole + chlorothalonil)	0	8	1
3 X (propiconazole + chlorothalonil)[f]	not treated	1	11	5
	propiconazole	0	1	1
	not treated	5	12	8
	chlorothalonil	1	3	2
	not treated	2	10	5
	(propiconazole + chlorothalonil)	0	1	1
1 X (propiconazole + chlorothalonil)	not treated	86	54	17
	propiconazole	1	7	2
	not treated	98	38	7
	chlorothalonil	11	17	2
	not treated	91	26	11
	(propiconazole + chlorothalonil)	0	14	1
$LSD_{(P=0.05)}$		32	17	6

a Single fall applications were made on 9/26/2003.
b Single spring applications of each fungicide treatment were made on 5/6/2004.
c Disease severity determined by counting the number of dollar spot infection centers (DSIC's) per plot area.
d Banner MAXX 1.0 fl oz/1000 ft^2
e Daconil Ultrex 3.2 oz/1000 ft^2
f Three combination applications (tank mixed) of both fungicides were made on 9/26, 10/17 and 11/7/2003.

THE EARLY YEARS

The first clue something significant was taking place with fall fungicide applications and dollar spot came about during several years when a residual or season-to-season carryover effect was occasionally observed from fungicide applications made in fungicide efficacy trials. Plots treated with fungicides labeled for dollar spot occasionally looked clean or had reduced disease the following spring and summer. Initial observations were made on plots treated with the demethylase inhibitor fungicides, propiconazole and triademefon. When this work was repeated on a calendar-day basis, results were sporadic.

FALL 2001 TO SUMMER 2002

In fall 2001, Ph.D. student Young-Ki Jo established replicated field plots on fairways at Wedgewood, Brookside, and the OTF Turfgrass Research and Education Facility, also called the OSU Turfgrass Facility.

Treatments in this study included single fall (either Nov. 8, 9 or 16, 2001 depending on the location of the plots) and single spring (April 26, 2002) applications of propiconazole (two rates used – 1.0 ounce of Banner

Helpful hints

Recommendations for making fall and/or early spring fungicides to help manage dollar spot

- **Know what fungicide(s) work against dollar spot on your golf course.**
- **Apply an effective dollar spot fungicide after the second mowing in the early spring. Leave an adequate number of check plots so you can gage the impact of the application.**
- **Consider applying an effective dollar spot fungicide application in mid- to late-fall, about six weeks prior to when mean daily low temperatures range from 20 to 30 degrees F for one week.**

Maxx from Syngenta per 1,000 square feet and 2.0 ounces of Banner Maxx per 1,000 square feet), chlorothalonil (3.2 ounces of Daconil Ultrex from Syngenta per 1,000 square feet), thiophanatemethyl (2.0 ounces of 3336 F from Cleary per 1,000 square feet), iprodione (4.0 ounces of 26GT from Bayer per 1,000 square feet) and an experiment compound (0.2 of an ounce of BASF 505 from BASF per 1,000 square feet).

In addition to these single applications, preventive applications of each fungicide were made every 14 or 28 days according to label recommendations starting May 22, 2002. All fungicide treatments were applied with a hand-held, CO_2-powered boom sprayer using 6503 TeeJet nozzles at a pressure of 40 psi, (water equivalent to 2.0 gallons of water per 1,000 square feet). A nontreated control was also included.

Dollar spot symptoms first were observed in the nontreated control plots at the OSU Turfgrass Facility May 23, 2002. Dollar spot severity was rated every two weeks by counting the number of dollar spot infection centers per plot between May 23 and July 23, 2002. Differences in disease severity among treatments were assessed via analysis of variance using PROC GLM of SAS (SAS 9.1; SAS Institute in Cary, N.C.). Differences among treatment means were determined using Fisher's protected least significance difference at P equals 0.05. Although differences existed at multiple rating dates, only results from the June 24, 2002 rating date are highlighted in the update (Table 1).

Dollar spot severity was significantly greater at the OTF Turfgrass Facility compared to either golf course. In general, the greater the disease severity, the more dramatic the results, visually and statistically. As anticipated, dollar spot was significantly less severe in plots receiving preventive applications of the fungicides on a regular interval (i.e., treatments four, seven, 10, 13, 16 and 19). At the OSU Turfgrass Facility, where the dollar spot is sensitive to all fungicides, all treatments, except the single fall applications of chlorothalonil and thiophanatemethyl, effectively reduced dollar spot the following

Impact on the business

Research might cause change in timing, number of fungicide applications BY JOHN WALSH

It's no secret superintendents are a hard bunch to convince. Keith Kresina, golf course superintendent at The Golf Club in New Albany, Ohio, and Carl Wittenauer, CGCS, at Brookside Golf & Country Club in Columbus, Ohio, are no exceptions.

The two superintendent, among others, are working with Mike Boehm, Ph.D., of the Ohio State University's plant pathology department on dollar spot research. Boehm is trying to pinpoint a certain time in the fall when superintendents should apply fungicides to suppress dollar spot the following season. Although Kresina and Wittenauer haven't changed their fungicide application programs much based on Boehm's research so far, they think he's on to something.

Kresina and Wittenauer hadn't heard of spraying for dollar spot in the fall before working with Boehm.

"I was doing the opposite of what Mike was suggesting," Kresina says. "The thought was there was no reason to put something down until signs of dollar spot appeared, which wasn't until the spring. But by October, it was very difficult to control. The fact that it was lasting that long was crazy. It wasn't making sense. When I talked to Mike, I wasn't sure where he was going, but it seemed logical."

Wittenauer had suspicions.

"I'm a PCNB user for snow mold, and I've always questioned whether there was some benefit to that fall spray in the following spring," he says. "There seemed to be some correlation."

Kresina says superintendents in the Cleveland area spray for snow mold, and if they're using a fungicide that's effective for dollar spot control and they hit a certain window, they probably didn't see dollar spot in the spring. However, they didn't know they were suppressing dollar spot with the fungicide application for snow mold.

FIELD ASSESSMENT

At The Golf Club, Boehm's research is being done on the tee end of a fairway. Kresina leaves one-third of the fairway untreated and two-thirds treated, which he marked.

"When you take a study and put it on a golf course, then it becomes real world," he says. "Mike didn't give me any restrictions except putting down fungicides (in a certain area). It's interesting to see results from not applying fungicides, one application, two applications, three applications and four applications."

Kresina says the most difficult part of the research is pinpointing exactly when the fall applications should be applied.

"I can't spray all through the fall and spring because we'll go broke," he says. "We need to pinpoint two times in the fall for effectiveness in the spring."

But temperatures have impacted the results of the study negatively.

"In the fall of '03, Mike nailed it, but the following years, the weather was different, and the results weren't consistent," Kresina says.

Kresina says there are things in the fall – such as wet weather, which causes muddy turf conditions, and aerification – that can make it difficult to apply fungicides. And adding fungicide applications in the season. On average, the reduction of dollar spot severity was about 50 percent – better in some cases. Although significant from a scientific standpoint, this level of disease suppression wouldn't likely be considered commercially acceptable to most golf course superintendents. One month later, on July 22, treatments three through seven, 10, 12, 13, 16, 17 and 19 continued to have significantly less dollar spot than the nontreated controls. (Data not shown.)

The results from the study clearly revealed single fall and early spring preventive applications of fungicides significantly reduced dollar spot severity the following season.

FALL 2003 TO SUMMER 2004

In September 2003, Amy Niver, a master's degree student, and Mike Boehm, Ph.D., designed two follow-up studies as a continuation of the study conducted by Young-Ki Jo. Latin joined at this time. There were 18 treatments in the first 2003/2004 study. A detailed list of the treatments used in the experiment is listed in Table 2.

The first six treatments weren't treated with any fungicide in fall 2003. The second six treatments received three applications of a combination or tank mix of chlorothalonil (3.2 ounces of Daconil Ultrex per 1,000 square feet) and propiconazole (1.0 ounce of Banner Maxx per 1,000 square feet) on Sept. 26, Oct. 17 and Nov. 7, 2003, respectively. The last six treatments received a single application of the chlorothalonil/propiconazole combination Sept. 26, 2003.

The thinking behind this approach was to have the turfgrass going into winter with different levels of pathogen activity, not necessarily disease. Specifically, the hypothesized dollar spot fungus would be the least active in the plots sprayed with the three applications of fungicide, active in the nontreated plots and somewhere in between in plots receiving only one application of fungicide. Latin confirmed suspicions by having a mild dollar spot epidemic late in fall 2003 and was able to document (data not shown) that disease pressure was moderate in the nontreated plots and absent in all plots that received any type of fall fungicide application.

On May 6, 2004, a single application of Banner Maxx, Daconil Ultrex or a combination of the two as described above was applied to half the plots. The goal was to overlay the treatments imposed in fall 2003 with an early spring preventive application. Another such application was intended to be made on the other half of the plots later in May, however, central Ohio and much of the Midwest and East was hit with a serve dollar spot epidemic about May 8. Because the intent of the study was to evaluate the impact of preventive fungicide applications on dollar spot, it was decided not to make these late May applications.

Each treatment was replicated four times per location. The experiment was performed simultaneously at three locations – the OSU Turfgrass Facility, Brookside and the Purdue University Turfgrass Research and Education Center in West Lafayette, Ind. (Data not shown.)

The results of this study supported early findings in that fall and spring applications of fungicides significantly reduced disease

spring is difficult because one has to fight the wind and rain, which can prevent fungicides from being applied to the target effectively.

"The way you deliver the fungicide to turf is important," he says. "I'm now using more water – 2 gallons per thousand square feet – and a tapered, flat fan nozzle. Using more water seems to be effective. Guys were cutting back on the amount of water used to stay ahead of play."

Kresina says applying fungicides in the fall might be easier than in the spring because springtime is when many superintendents are finishing winter projects and applying herbicides and insecticides.

Among the plots at Brookside, some were clear of dollar spot through June with the fall applications. For Wittenauer, the fall fungicide application for dollar spot would add another application or two to his program. He says his average fairway application is between $3,500 to $5,000.

"Mike had good results with two and three applications," he says. "He has real impressive plots – clean into July compared to the check plots that were covered with dollar spot. However, the idea is to eliminate some sprays in the spring, but that depends on the facility, budget and management."

Wittenauer, who runs a strict preventive program, hasn't changed it yet because of Boehm's research.

"I'm always a proponent of getting after it early before you see it," he says. "Get ahead of it early in the spring if you can't make the application in the fall."

Wittenauer says the spray season is longer than it used to be. Ten to 15 years ago, he wouldn't spray before May 15. Now he's starting to spray at the end of April, and the dollar spot season has extended to mid- or late October, spraying every two weeks. He says he's spraying earlier in the spring, but not in the fall because of his budget.

"Mike still has a lot of timing questions that need to be answered," he says. "I'm looking for more definitive research. But in the meantime, I'll still go through mid-October with fungicide applications for dollar spot, but I'm not fighting it as much in summer from a curative standpoint."

Kresina suggests superintendent conduct research on their own.

"If you really want to see this work, you need to have some areas where you don't spray fungicides," he says. "Leave an area unsprayed and tell membership you're making sure fungicides work, that's why we have dead grass."

FUTURE OPPORTUNITIES

But the magical question remains: Is it worth it to spray and spend the extra money?

"I don't know if I'm looking to save money, but I'm looking for a better use of the product and a better fairway," Kresina says. "I don't know if the results of the study will reduce the need for applications in the spring, but hopefully Mike nails this down, and we treat dollar spot like crabgrass," he adds.

"I don't see a huge difference in spraying in the fall as opposed to spraying early in the spring," Wittenauer says. "Right now, there are too many variables to convince me of the extra spray in the fall. As superintendents, we're looking to save money and be environmentally conscious, and still meet members expectations. This is a new area of dollar spot control, and time will tell. If we can apply fungicides in the fall and not see dollar spot until June or July, everyone will do it." GCI the following season (Table 2). Three fall applications of chlorothalonil and propiconazole were extremely effective at reducing dollar spot to commercially acceptable levels the following spring. At the OSU Turfgrass Facility, where disease pressure was high, even a single fall application of this fungicide combination significantly reduced disease by about 40 percent. The impact of single fall fungicide applications at Brookside and Purdue were less striking given the overall lower disease pressure at these locations (Table 2). Not surprisingly, the single May 6, 2004 fungicide applications, applied immediately prior to the outbreak of dollar spot, were effective at reducing this disease.

In addition to the study just described, a second replicated field study was conducted in Columbus at two locations – OSU Turfgrass Facility and Brookside. In this study, single applications of propiconazole (1.0 ounce per 1,000 square feet), chlorothalonil (3.2 ounces per 1,000 square feet) and a tank mix of the two fungicides (same rates) were made to asymptomatic turfgrass every two weeks throughout fall 2003 and spring 2004. Disease was rated the following season as described above. This study was located adjacent to the other 2003/2004 study. The same preparations of fungicides, spray equipment and applicator was used, allowing the results of the two studies to be compared to one another.

Biweekly fungicide applications were made in fall 2003 starting Sept. 26 and ending Nov. 21, 2003. Unfortunately, applicator error resulted in an overspray of the chlorothalonil and propiconazole combination treatment plots Oct. 10 and 24, resulting in a double application of fungicides on the plots. Biweekly applications resumed during the spring of 2004 on April 9 and concluded May 20. All applications were made to asymptomatic turfgrass as described previously. A nontreated control was included as a means to assess the efficacy of all fungicide timing treatments.

Dollar spot severity was assessed throughout May and June 2004 and the data analyzed as described previously.

The results of this study are shown in Table 3. The statistical coding was removed to simplify the figure. Boxes were placed around those fungicides and application dates that significantly reduced dollar spot severity. In general, the results of this study support the findings of the other studies highlighted in this update – i.e., fall and spring fungicide applications made to asymptomatic turfgrass can significantly reduce dollar spot severity the following season.

What's new and interesting about the results of this study, however, is that for the first time, important insights are gained as to when such applications should be made. In regards to the timing of fall applications, there was a clear window of timings – mid-October 2003 – that correlated to reduced dollar spot severity in May – June 2004. Applications made on Sept. 26 weren't effective. Similarly, applications made in November weren't effective. The data for the spring is equally interesting because it shows even applications as early as April 9, 2004 were effective at bringing about a reduction in dollar spot later in the same season.

Considering prevailing mean daily high and low temperatures for Sept. 1 through Nov. 31, 2003 (data not shown), the two effective fungicide applications were made in

Table 3. Impact of the timing of spring and fall fungicide applications on dollar spot severity – 2003/2004. Treatment boxes significantly reduced dollar spot severity in May and June 2004.

Fall 2003 applications		Spring 2004 applications	
Tmt	Description	Tmt	Description
1.	Nontreated	18.	Daconil Ultrex - 9 April 2004
2.	Banner Maxx - 26 Sept. 2003	19.	Banner Maxx - 9 April 2004
3.	Daconil Ultrex - 26 Sept. 2003	20.	Banner Maxx/Daconil Ultrex - 9 April 2004
4.	Banner Maxx/Daconil Ultrex - 26 Sept. 2003	21	Daconil Ultrex - 22 April 2004
5.	Nontreated	22.	Banner Maxx - 22 April 2004
6.	Daconil Ultrex10 Oct. 2003	23.	Banner Maxx/Daconil Ultrex - 22 April 2004
7.	Banner Maxx - 10 Oct. 2003	24	Banner Maxx - 20 May 2004
8.	Banner Maxx/Daconil Ultrex - 10 & 24 Oct. 2003	25.	Daconil Ultrex - 20 May 2004
9.	Daconil Ultrex - 24 Oct. 2003	26.	Banner Maxx/Daconil Ultrex - 20 May 2004
10.	Banner Maxx - 24 Oct. 2003	27.	Daconil Ultrex - 20 May 2004
11.	Banner Maxx/Daconil Ultrex - 7 Nov. 2003	28.	Banner Maxx - 20 May 2004
12.	Daconil Ultrex - 7 Nov. 2003	29.	Banner Maxx/Daconil - 20 May 2004
13.	Banner Maxx - 7 Nov. 2003	30.	Nontreated
14.	Nontreated	31.	Nontreated
15.	Daconil Ultrex - 21 Nov. 2003	32.	Banner Maxx/Daconil Ultrex - 6 May 2004
16.	Banner Maxx - 21 Nov. 2003	33.	Daconil Ultrex - 6 May 2004
17.	Banner Maxx/Daconil Ultrex - 21 Nov. 2003	34.	Banner Maxx - 6 May 2004

mid-October. The point is to highlight the weather trends surrounding these two effective mid-October fungicide applications. As discussed above and shown in Table 3, applications made before or after this window were ineffective at suppressing dollar spot the following season.

Why this is the case is the focus of several ongoing studies. One explanation is that the dollar spot pathogen might be especially sensitive to fungicides at this time of the year. Lower pathogen populations going into the winter mean lower populations going into the spring and a longer time required for the pathogen to reach damage or disease-causing levels. If this is true, this could explain why the Sept. 26 and November applications weren't effective.

For example, even though it's known when dollar spot symptoms tend to show up and disappear, turfgrass pathologists don't have a good idea as to what, if anything, the dollar spot pathogen is doing in turfgrass or thatch when not causing disease. It's not known when the pathogen goes dormant or when it wakes up. It could be possible the September applications were ineffective because the pathogen, although temporarily inhibited by the fungicides, had the opportunity for its populations to rebound before winter.

Along this same line of thinking, the November applications might not have been effective because the pathogen had already hardened off or went dormant for the winter at the time the fungicides were applied, thus having no impact on the population dynamics of *S. homoeocarpa*. Since the tools needed to monitor populations of *S. homoeocarpa* in turfgrass aren't available, everything shared about why fall applications do or don't work is conjecture. Alternative possibilities exist. The study was repeated at multiple locations last season.

What's new and interesting about the results of this study, however, is that for the first time, important insights are gained about when such applications should be made.

PCNB'S INFLUENCE

Additionally, a Penn State pentachloronitrobenzene study reveals insights about the timing of fall fungicide applications. The aforementioned findings were shared with Peter Landschoot, Ph.D., from Penn State University. He thought about a study he and his colleagues published in 2001 that related to the nontarget effects of PCNB on putting greens. The study was initiated in 1996 and ran four consecutive seasons.

The main goal of the study was to determine the influence of two PCNB formulations applied at different rates and intervals on foliar discoloration, nontarget diseases (to include dollar spot) and *Poa annua* encroachment. Specifically, they compared the impact of single and multiple late fall, winter and early spring applications of PCNB, as well as a single late fall application of iprodione/chlorothalonil combination treatment and a nontreated control. All liquid applications were made using a 2-gallons-per-1,000-square-feet spray volume. They didn't have significant dollar spot pressure in 1997 or 1999, so they couldn't collect dollar spot data in these years. However, they were able to collect such data in 1998 and 2000.

They found the single fall application of iprodione and chlorothalonil in their study had a significant impact on dollar spot severity in 2000 but not in 1998. Their data from fall 1999/spring 2000 in this study echoed OSU's findings regarding the efficacy of fall applications. However, like OSU's early work that yielded sporadic results, PSU's observations from fall 1997/spring 1998 didn't. The weather was the reason for the sporadic results.

Mean daily high and low temperatures were recorded from Nov. 1 through Dec. 31 for fall 1997 and 1999 for Landschoot's study. The dates of the fall iprodione and chlorothalonil applications were made Nov. 21 1997 and Nov. 23 1999, respectively. Although there were only two calendar days separating the dates of the applications in 1997 and 1999, significant differences in the mean daily low temperatures were present at the times when these applications were made – cold in 1997 and warmer in 1999. Do weather patterns going into the winter influence the impact of fungicides on dollar spot? Does the dollar spot pathogen harden off for the winter, thereby becoming insensitive to fungicides? The jury is still out on these questions, but the observations and results collected to date might help lead to the answers – and many more questions.

CONCLUDING THOUGHTS

Several of the 2003/2004 studies were repeated in 2004/2005 and yielded similar results. Additional studies also were conducted using additional fungicides – at university research facilities and on golf courses. Most of these studies were repeated in 2005/2006 given the weather patterns. Only time will tell regarding the research's impact on the ability to manage dollar spot and perhaps other diseases. GCI

The authors work in the department of plant pathology at The Ohio State University in Columbus.

References

Dwyer, P.J., Jr., and Vargas, J.M., Jr. 2003. Golf Course Management. October issue. (Available online at www.gcsaa.org/gcm/2003/oct03/10Cutting.asp).

Han, D.Y., Unruh, J.B., and Davis, S.B. 2004. Dollar spot control on ultradwarf bermudagrass putting greens with curative and preventive fungicide applications. Phytopathology 94:S38. (Available online at www.apsnet.org/ meetings/2004/abstracts/a04ma0253.htm; verified September 9, 2004).

Landschoot, P.J., B.S. Park, and W. Uddin. 2001. Nontarget effects of PCNB on putting green turf. International Turfgrass Society Research Journal 9:679-685.

Vincelli, P., Dixon, E., Williams, D., and Burrus, P. 2003. Efficacy of fungicides for control of dollar spot in a mixed creeping bentgrass/*Poa annua* soilbased green, 2002. Biological and Cultural Tests.

Because water availability is becoming one of the most serious problems affecting the population, more golf courses are using reclaimed water to irrigate turf. Photo: Toro

BY ANNA BOTTA AND RAFAEL PIÑOL, PH.D.

Minimizing damaging effects

Amino acid-based products positively influence low-quality golf course irrigation water

Water availability is one of the most serious problems affecting the world population, especially in arid and semiarid regions where long droughts can jeopardize development. Because of this increasing concern, water management for irrigation has evolved to optimize this resource for agriculture. For more and more golf courses, this evolution has led to the use of reclaimed water.

However, if the advantages of using recycled water are clear from a conservation perspective, the suitability of the water for irrigation purposes can be a nightmare for golf course superintendents. The extra chemical components and heavy metals in the water can damage the turfgrass, requiring more management of the water, soil and plant. (Y.L. Qian 2005)

Water quality depends on the type and concentration of substances in it. In most cases, reclaimed water contains a high dissolved salt content that potentially can be toxic to turfgrasses (R. Emmons 2000). These salts are generally chlorides of sodium and magnesium, sulphates and bicarbonates of calcium and magnesium, sodium carbonate, nitrates, ammonium, etc.

Basically, the buildup of salinity in the root zone can affect the turf performance in four critical manners (R.R. Duncan 2000):

- High salt concentrations generate low soil water potentials, leading to a drought stress that reduces the ability of plants to absorb water and nutrients. In this condition, turfgrass exhibits typical symptoms of drought stress (growth inhibition, photosynthesis reduction, desiccation) while the soil still appears moist.
- There are ions that cause specific ion toxicity. They include Na^+, Cl^-, CO_3^{2-}, HCO_3^-, pH (H^+ and OH^- ions) and heavy metals.
- The presence of a high amount of some substances in proportion to others can induce nutrient imbalances inside the plant.
- High sodium concentrations might alter the structure of soils because of the so-called sodium permeability hazard.

Symptoms of turfgrass affected by high salt concentrations include:

- growth reduction by inhibiting physiological processes such as nutrient uptake and assimilation;
- loss of color due to degradation of pigments like chlorophylls (e.g., yellowing, browning or purpling);
- wilting caused by the loss of water availability;
- leaf curling, and;
- leaf firing or desiccation (M. Huck 2000).

One of the classic methods that superintendents use to minimize salinity stress is to excessively irrigate to leach the salts. Also, it's important to strictly control the nutrients that the course receives through fertilization and not compound the problem. For this reason, constant soil and water analyses must be conducted in order to have updated information about turf conditions.

MITIGATING SALT DAMAGE

Yet, turfgrass salt damage can be mitigated by amino acids, which are the precursors of proteins and, either solely or conjointly, play a role in numerous biological processes. Some of their functions include the stimulation of

By using reclaimed water, which has high salt content, the buildup of salinity in the root zone can effect turf performance. Photo: Rain Bird

root development, stomata opening and cell membrane permeability.

Amino acids also are precursors of hormones, nucleic acids and other important organic compounds such as chlorophylls. They play a role in osmoregulation, and some of them have complexing capacity with metal nutrients. Additionally, they have a function in the protection of cellular macromolecules and as scavengers of free radicals because of the antioxidant activity of some (M.M.F. Mansour 2000).

Because of their diverse functions, the additional application of amino acids is a complement for plants to save energy for their production and acts as a biostimulant of physiological processes.

The application of amino acids might be particularly helpful under stressful situations, when maximizing energy conservation, reduc-

The advantages of using reclaimed water are clear from a conservation standpoint but can be a nightmare for golf course superintendents. Photo: Toro

ing water loss and using reserves to maintain vital functions as part of the defense mechanism of plants. This becomes true especially in the case of salt stress (V.K. Ray 2002).

For preventing drought stress caused by the high salt content, plant resistance to salinity strongly depends on its osmotic regulation capacity at a cellular level. This regulation is mediated by the accumulation of amino acids and other compatible solutes, which helps to retain water inside the cell and prevents the dehydration of the entire plant (C. Di Martino 2003).

On the other hand, the complex capacity of amino acids can help the soil to retain nutrients (particularly mobile ions such as potassium, magnesium, nitrate, iron and manganese), otherwise lost by frequent leaching (H.D. Aschmead 1986). This complex capacity also is useful with the undesirable presence of any heavy metal in a high amount. Amino acids can buffer their flux by chelating them, which can prevent the heavy metal toxic effect (S.S. Sharma 2006).

However, one of the most harmful effects caused by salinity is probably due to the high concentration of sodium. Excess sodium is likely to cause damage in the soil structure and inside the plant. In the case of soil damage, sodium can displace potassium and calcium from soil exchange sites. Calcium ions are the building blocks that enhance the structural integrity of the clay fraction in the soil profile, hence its loss causes clay dispersion and, consequently, poor soil aeration (R.R. Duncan, 2000). That's why it's necessary to have an application of a calcium source in soils affected by salinity.

Additionally, once inside the plant, a high proportion of sodium can displace calcium in the cell walls and membranes of root tissues and cause root deterioration. In these situations, cells' contents often start to leak; above all, a potassium leakage occurs (M. Huck 2000). Considering potassium's high mobility and its propensity of loss, a regular potassium application might also be needed to maintain a nutritional balance in the turf plant (R.R. Duncan, 2000).

Because of the special requirements of salinity-affected turf, the application of potassium or calcium along with amino acids also can be beneficial thanks to the aforementioned properties of amino acids. In fact, numerous field trials have shown that the application of amino acids enhances the uptake and mobility of macronutrients, probably because of the stimulation of membrane permeability and root development under salinity conditions.

However, perhaps the most appreciable aspect of the effects of an amino acid-based product application refers to the visible part of the turf plant. One of the greatest concerns of golf managers is probably green color loss of the turfgrass. Environmental stresses such as salinity, drought, cold, heat and so on can cause a physiological imbalance inside the plant, which leads to an oxidative stress.

In these cases, organic cellular structures start being destroyed as a result of potent "reactive oxygen species" that induce the degradation of chlorophylls (yellowing), for example, and the reduction of photosynthesis. In these cases, the plant resorts to amino acid reserves in order to synthesize new proteins and metabolites that will alleviate the oxidative damage and recover the photosynthetic machinery (A. Kumar 2005).

ADD TO FERTILIZATION

In conclusion, on top of the already well-known practices that golf course superintendents implement to minimize the impact of salinity and nutrient imbalances caused by irrigating with recycled water, amino acid-based products can be excellent tools to help turf withstand the stress caused by this practice. Amino acid reserves will allow the plant to overcome stress and provide energy for growth or survival under modified conditions.

However, because of the difficulty in recovering from salinity damage once turf begins to deteriorate, it will always be best to approach the problem before damage is visible. That's why the application of an amino acid-based product is recommended in a fertilization program as a supplement for turf maintenance and as well as a precautionary measure in case of any incoming stress circumstance. GCI

The authors are members of the research and development team at Bioiberica, a Barcelona, Spain-based research company specializing in biochemical molecules and active ingredients for various industries.

Superintendents can use rotors specifically designed for use with nonpotable water. Photo: Rain Bird

References

-Y.L. Qian & B. Mecham, Long-term effects of recycled wastewater irrigation on soil chemical properties on golf courses fairways, Agronomy Journal 97 (2005): 717-721

-R. Emmons, Turfgrass Science and Management, Ed.Thomson Learning, Delmar, (2000).

-R.R. Duncan, Understanding water quality and guide lines to management, USGA Green Section Record 38 (5) (2000): 14-24

-M. Huck et al., Effluent water: Nightmare or dream come true?, USGA Green Section Record 38 (2) (2000): 15-29

-M.M.F. Mansour, Nitrogen containing compounds and adaptation of plants to salinity stress, Biologia Plantarum 43 (4) (2000): 491-500

-V.K. Ray, Role of amino acids in plant responses to stresses, Biologia Plantarum 45 (4) (2002): 481-487

-C. Di Martino et al., Free amino acids and glycine betaine in leaf osmoregulation of spinach responding to increasing salt stress, New Phytologist 158 (2003) 455-463

-H.D. Aschmead, Foliar feeding of plants with amino-acids chelates, Noyes Publications (1986)

-S.S. Sharma & K-J. Dietz, The significance of amino acids and amino acid-derived molecules in plant responses and adaptation to heavy metal stress, Journal of Experimental Botany 57 (4) (2006): 711-726

-A. Kumar & A. Bandhu, Salt tolerance and salinity effects on plants: a review, Ecotoxicology and Environmental Safety 60 (2005): 324-349

Making the most of water shortages

Water availability is a growing threat to all golf courses throughout the country. It seems that every time people pick up a newspaper or turn on the TV news, they read or hear about water bans, shortages or unavailability that challenges the way superintendents maintain golf courses.

Although evapotranspiration-based controllers commonly are cited as one of the best water savings tools, they're not the only solution for water and cost savings.

Despite the availability of reclaimed water, the suitability can be called into question because of the potential for extra chemical inputs such as heavy metals. As such, the turf professional might be required to spend more time managing the irrigation process itself as well as the soil and the turf.

Reclaimed water, or the use of lightly treated recycled water, is an option. This method takes rain water and water used in households or commercial facilities and recycles it for reuse in turfgrass irrigation. It reduces discharge of wastewater into streams and oceans and is less costly and uses less energy than potable water.

These variables can be overcome by using soil inputs that not only help offset salts and other substances stemming from reclaimed water, but might also assist in the growth and vitality of turf.

The use of effluent water and other low-quality water will continue to grow as fewer courses are allowed to use potable sources. This article focuses on how superintendents can use amino acid products to make the best of a difficult situation and still produce quality course conditions.

BUSINESS APPLICATION

There's a need to grow healthier turf with poor-quality water, yet creating better playing conditions with lower-cost and fewer inputs. Amino acid products appear to help buffer the negative impacts of the damaging components of this type of water.

FIELD ASSESSMENT

The application of amino acids might be particularly helpful under stress situations by aiding in energy conservation, reducing water loss and helping the turf to maintain vitality. Contact John Walsh, editor (jwalsh@gie.net) with your experiences.

FUTURE OPPORTUNITY

Effluent water and less-than-desirable water will be the primary irrigation source for many courses in the future.

Amino acid-based producs can be excellent tools to help turf withstand the stress caused by reclaimed water use. This technology is one option for dealing with the issue. GCI