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GAS EXCHANGE IN THE ROOT-ZONE

A misleading fact is that the leaves of a turfgrass plant are the only portion of the plant that accumulates air and disposes carbon dioxide for transpiration. The roots are an important gas-exchange medium also. In fact, roots are the primary source of a grass plant's mechanism to capture oxygen. The roots gather oxygen from the soil matrix and release the carbon dioxide waste product into the soil. Carbon dioxide will gradually increase in the soil, and the oxygen content will decline, unless air circulation or soil permeability permits the release of carbon dioxide-rich soil gases with the atmosphere and the replenishment of the oxygen supply. Venting the root-zone with solid tines throughout the summer months helps balance the soil-gas ratio and evaporate moisture to cause a cooling effect to control high temperatures.

AERIFICATION, ORGANIC MATTER DILUTION AND GAS EXCHANGE

The golf maintenance industry has not found a superior cultural program to replace regular hollow core aerification. In an effort to increase play days this important cultural program has been neglected or reduced to increase rounds and revenue. Hollow core aerification relieves compaction, aerifies and removes organic material.

Historically, aerification relieves compaction and permits air to permeate into the root zone. With several hollow core aerifications annually it has been found to control and manage organic material build-up.

Organic material is removed with cored plugs. Removing organic material and filling the cavities with straight sand reduces the amount of organic material in the upper root zone. In addition, organic material gets diluted and migrates through sand-filled aerification cavities and dissipates into the lower root zone.

Green root-zones with high organic concentrations (>2.5 percent) will contaminate the sand-air macro pores and seal off these larger cavities. Organic concentrations in the upper three inches of the root-zone less than 2 percent generally do not have this sealing effect. Organic material continues to migrate through the sand with the percolating water, but the lesser amount of migrating organic material does not materially inhibit the cavity's air permeability.

It is a common phenomenon of hollow coring that the turf initially responds positively to the aerification. Unfortunately, the turf eventually returns to its original condition. On some greens the decline is rapid while slower on other greens. It is believed the phenomenon is explained by the organic sealing off the sand-filled cavities. The difference observed between turf systems is primarily attributable to differences in the upper root zones' organic content. While the cavities remain open, the turf thrives. Once the cavities are sealed off, the grass reverts to its former condition. As a common observation, it will take four to six hollow core aerification applications, with at least a $^{5}/_{8}$-inch tine, before the observed positive changes to the turf will appear permanent. Some root zones require less applications, many root zones require more applications.

At minimum it is recommended that USGA-specification greens receive, on average, twice-annual aerification to merely maintain their physical condition. That is, twice-annual aerification is needed to merely remove the organic material deposited by the roots. This general rule, however, has its exceptions.

If twice-annual hollow core aerification applications are required with $^{5}/_{8}$-inch tines or similar equipment to maintain a root system, an accelerated program is required to reduce the organic concentration. On grossly organically-affected root-zones the recommendation is an accelerated aerification program consisting of at least four aerification applications per year.

An accelerated aerification program is not intended to be permanent. In time, the greens will achieve optimal visual and physiologic properties which are capable of being maintained, due to the changes in the root-zone's physical properties, during periods of stress. It is possible to over-aerify a green; however,

(continued on page 80)

Hitting the Re-do button

The following are write-in responses to the question: "If you had a re-do button, what would you have changed for turf to better survive the summer of 2010?

- Mowing practices ranged from using smooth front rollers sooner, skipping mowing, raising heights of cut and rolling less and rolling in place of mowing.
- Add drainage
- Added more fans for air movement
- Better-timed fungicide
- Changed tournament scheduling
- Cooled my irrigation water
- Drainage in greens
- Drainage was the key, surface, sub-surface and air
- Flush greens more
- Go to smooth rollers sooner
- Had covers available
- Hand water
- Have roots checked for pythium infection
- I did all the rest of the items on the list
- If I had them, run sub-airs and fans
- Improve air circulation
- Improve winter drainage
- Increased watering
- Just not mowed at all
- Less mowing when wet
- Less verticutting
- Listen less to the members, do what is necessary playability be damned
- Managed wetting agents more carefully
- More fans
- More fans installed
- More hand watering and wetting agent use
- More roll, less cut
- Mowed less often
- Possible snow removal to reduce freeze thaw cycles from day to night.
- Push it harder with fertilizers in the spring and use more wetting agents in the spring when it was wet
- Put up more fans
- Raise height of cut earlier than I did.
- Raise it sooner
- Reduce applications of growth regulators
- Reduced rolling
- Reduced traffic on greens
- Remove tree canopies
- Shoveled all the snow
- Skip mowing greens on days of extreme heat
- Solid tine aerify
- Solid tine and then vent the same
- Stop growth regulator applications on greens sooner
- Switched to smooth rollers quicker, most importantly on cleanup mower
- Tree removal
- Used fans on pocketed greens
- Use different wetting agent
- Used more wetting agents
- Use impermeable covers
- Water a bit more. I was too conservative during the most extreme periods
- Watered more
- Tree removal
- Switch to solid rollers
- We aerified greens pretty aggressively on June 8-9 thinking we had plenty of time to recover. This year the heat hit early and never let up causing thin stressed turf by late June, with the whole rest of the summer to go. In hind sight, we would have been better served if we had not been so aggressive (heaving surface and tearing roots).

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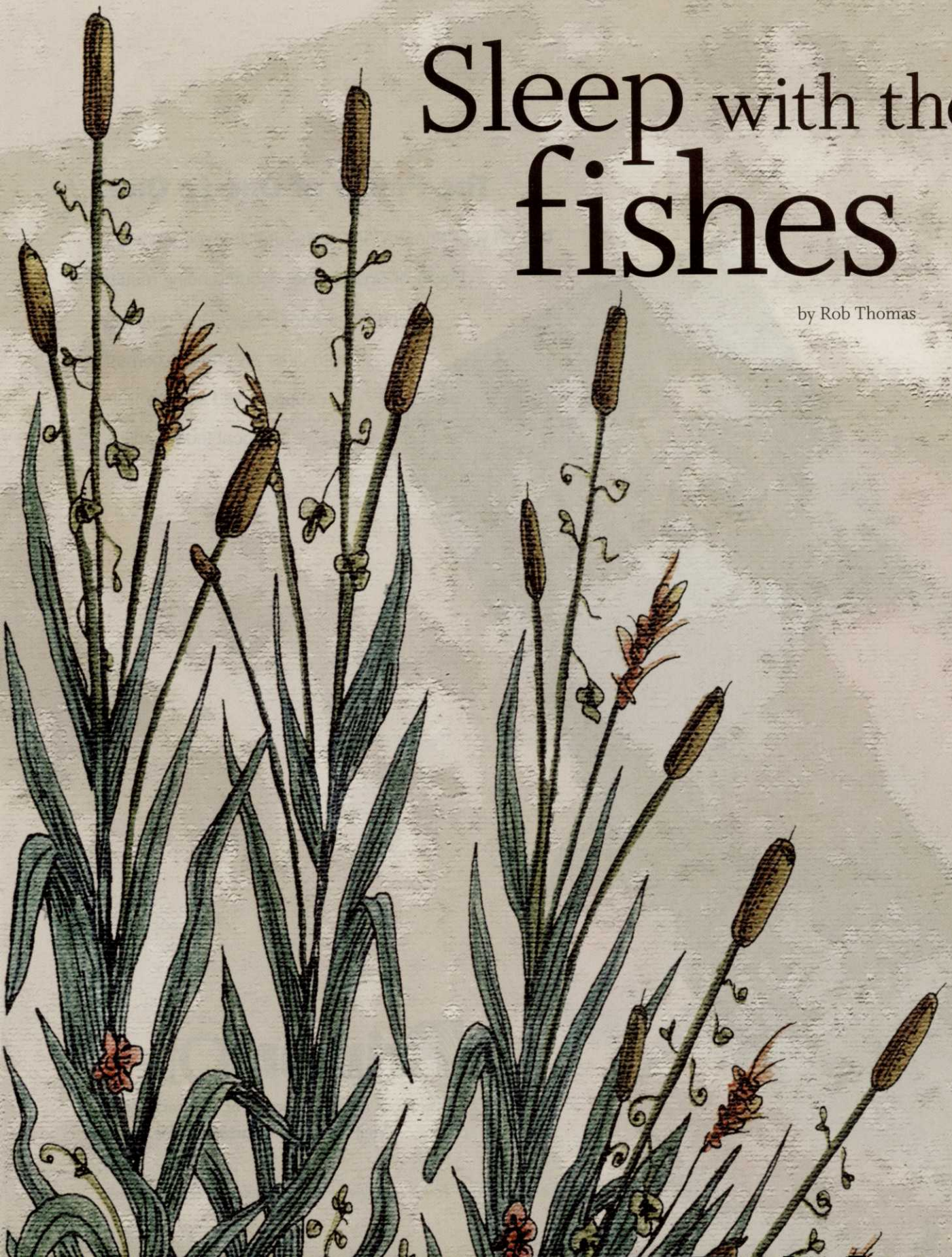
Sleep with the fishes

by Rob Thomas



Three superintendents share how they rub out troublesome aquatic pests like algae, cattails and milfoil on their courses.

There is more in those ponds than just fish swimming and errant golf balls resting in their watery graves. From algae to cattails, aquatic weeds are the superintendent's often evident and sometimes sneaky foes.

CYPRESS LAKES GOLF & COUNTRY CLUB

For Heath Puckett, CGCS, at Cypress Lakes Golf & Country Club in Muscle Shoals, Ala., beauty is in the eye of the beholder. His course a par-71 layout designed by Gary Roger Baird has 20 water features touching 17 of the 18 holes... some with cattails.

"I like the way they look," says Puckett. "And I feel they improve water quality by serving as a buffer... although some would disagree, especially regarding the aesthetics or lack of ability to find an errant golf ball."

Cattails and their accompanying leaves generally stand between 5 and 10 feet high and feature distinctive cylindrical, brown spikes that resemble cigars. They primarily grow in marshes, ditches and shallow water of lakes, ponds and rivers. A fibrous root system and rhizomes often lead to the formation of dense colonies.

While it is illegal to kill cattails in some states, such is not the case in the Heart of Dixie. Puckett says they have seen success with multiple, repeated biweekly applications of glyphosate and oil of limonene.

"We first cut and removed all above-ground plant material, and began treatment immediately after," he says. "It was a very slow process though, and took most of the season to finally get complete control of the cattails. I have also resorted to digging them up with a backhoe in the past."

In addition to cattails, Puckett deals with algae in his ponds. Fountains and aerators help, but aren't practical in every case.

"Since we do not have a lot of resources devoted to lake management, we've only used minimal inputs in our ponds that do not have a fountain or aerator," he says. "Keeping oxygen levels elevated is the best method to curtail algae problems, in my opinion."

According to Puckett, grass carp can also be very effective in preventing aquatic weed problems until their metabolism slows down and they don't eat as much.

Puckett's team applies light rates of copper sulfate preventatively in some of the smaller ponds that are not aerated or stocked with grass carp. For curative applications, late in the summer they use a mixture of Reward, Cutrine and oil of limonene sprayed over the top on sunny days. Last year, he also used Regal Chemical Co.'s Earth-Tec to reduce the algae and eliminate the bad odor with good results.

From fountains and grass carp to barley straw bales and chemical and biological controls, Puckett has mixed feelings on the results.

"Most of the biological control products I've used for algae have not provided enough control to justify the extra cost," he says, adding that they would prefer natural solutions over chemicals. "I have experimented with them in the past, but budget pressure and unsatisfactory results have required us to return to using more cost-effective chemical controls."

A superintendent for seven years, all at Cypress Lakes, Puckett says there are some benefits of having algae and cattails.

"Certain types of algae are beneficial to the pond ecosystem," he says. "However, due to imbalances in the water and high nutrient load from runoff, algae can become a smelly eyesore. Filamentous algae is the source of our problem because it develops into a floating mat."

Though cattails can be aesthetically pleasing to some and provide a buffer for the pond to help filter surface runoff, he says they are very aggressive plants and cannot be left unmanaged.

"They spread rapidly and are difficult to control," Puckett says. "Our best success with them has been on the edges of some of our deeper ponds... where it's difficult for them to establish beyond a few feet. In shallower ponds, they can spread and take over the entire pond basin."

ARIZONA NATIONAL GOLF CLUB

Water may be a precious commodity in the desert, but aquatic weeds certainly do not treat it with reverence. Located in Tucson and home to the University of Arizona's men's and women's golf teams, Arizona National Golf Club is not immune to these nuisances.

Superintendent Rick Darby is charged with maintaining the Robert Trent Jones, Jr.-designed layout situated in the foothills of the Santa Catalina Mountains. Both algae and cattails have tried calling his course "home."

"The only benefit to cattails is [they] provide environment to wildlife," Darby says, adding that he sees no benefit to algae. "Otherwise they are a nuisance and extremely invasive. They can become a major problem if not kept under control."

Cattails are common in a protected water crossing at Arizona National, but the state does not rule against their killing as long as aquatic-label herbicides are used when spraying them. Darby says his team chooses Aquamaster (glyphosate) and sometimes adds Reward (diquat) to spray the cattails, at labeled rates, though mechanical methods seem to work best.

"We did our [mechanical] removal during the winter," he says. "In the previous fall, we sprayed every three to four weeks until the growth stopped. February or March we started mechanical removal."

Darby's team designed a rake made out of $\frac{5}{8}$-inch rebar, which was about 4 feet wide and 2 feet tall and had "about six or eight tines." The rebar handle was roughly six feet long and they used a tractor to pull the rake through the cattails and the mat it had developed over the years. The rake was placed about 20 to

Cattails and milfoil can ruin the aesthetics and health of a pond, but creative superintendents find ways to deal with them like this fabricated cattail rake.

30 feet into the cattail area and a few of the team stood on it to hold it down and dig in. Then the tractor would pull cattails to the edge, where they were then allowed to dry for a day or two.

"This is a messy process but I think the guys thought it was somewhat fun at times, seeing who was the messiest or cleanest at day's end," Darby says. "You definitely need a few good pairs of hip-waders.

"It is a time-consuming process, but the areas I did last year had less than a 10 percent grow-back," he adds.

According to Darby, the removal labor cost used has already been recouped by not cutting the cattails down at water level every month in the summer. When they cut them down monthly, that was six cut downs, with two working for two days.

As if cattails weren't enough, an irrigation lake on the property that holds approximately 4 acre-feet of reclaimed water complete with a waterfall that circulates its contents.

Excess nutrients, often from fertilization run-off near greens and fairways, grass clippings and fish food or feces, are generally the cause of algae. The ability of sunlight to penetrate through to the bottom soil makes shallow, clear ponds highly susceptible to this foe, which not only can leave the water unsightly, but also malodorous. Of the three most common algae superintendents battle – planktonic, filamentous and attached-erect – only planktonic serves any useful purpose.

Darby, who has been a superintendent for 13 years and approaching eight seasons at Arizona National, combats algae by injecting microbes into the lake, which has worked well.

"Other methods on algae have failed," he says. "Using any form of copper is very short lived... only good for a few days."

OLD OAKLAND GOLF CLUB

Paul Anderson, a superintendent for a dozen years, is in the minority. He has not had to worry about battling aquatic weeds since joining Pinewood Golf Course in Elk River, Minn., in 2006. That's because the city-owned executive course has only one pond, which is blessed with a manmade liner.

"This was done three years ago and we haven't had any problems with weeds there," says Anderson.

Chase Walden, superintendent at Old Oakland Golf Club in Indianapolis, is not so fortunate. The 27-hole facility has six ponds in all, totaling approximately four acres. He has hit the trifecta of aquatic weeds: cattails, algae and milfoil.

Milfoil or the scientific term *Myriophyllum*, which comes from Latin *myrio* meaning "too many to count" and *phyllum* meaning "leaf" is a submersed aquatic plant with whorled leaves that are finely, pinnately divided. The leaves above the water are stiffer and smaller than the submerged leaves on the same plant. The flowers are small with four petals and are borne in the leaf axils or in a terminal, emergent spike.

While scientists are looking into ways to turn this invasive plant into biofuel and various animals include parts of it in their diets (like the aquatic weevil, which eats nothing but), superintendents find very little use for milfoil.

According to Walden, Old Oakland had a "bad" Eurasian milfoil problem in 2010. Because it is more common to recreational lakes, he wasn't quite sure what was growing in his ponds.

"I had it identified by two different aquatic professionals," he says. "As for an attack plan... I did a lot of research online."

A representative from SePRO recommended a herbicide treatment to treat the milfoil.

"He performed the application himself and we had very good results," Walden says of the treatment. "Renovate cleared it up with one application."

Control also can be achieved through mechanical management, such as lake mowers, a long-reach lake rake or aquatic weed razor blade tool, but caution must be used since milfoil is a fragmenting plant, and the fragments may grow back. These tools are most effective before seeds set.

Considering the ponds at Old Oakland aren't connected to any recreational lakes through rivers and tributaries, Walden is left to speculate on how it found its way to his property.

"I believe it was brought in on the boats of our pond service company," he says. "I suppose it is possible for geese to transfer it as well."

For Walden, Renovate worked on milfoil, and weekly, contracted copper treatments were a "good success" in managing algae, but he isn't quite sure fountain aeration did much of anything.

Like Puckett in Alabama and Darby in Arizona, Walden is able to combat cattails with little government interference. His team removes them by cutting the weed just below the water line.

Methods for controlling aquatic weeds are seemingly as numerous as the uninvited guests, themselves.

Sometimes, superintendents who have battled the nemesis, or chemical company representatives with expertise on various product offerings, offer the greatest insight into controlling these invasive watery foes. **GCI**

Rob Thomas is a freelance writer based in Cleveland.

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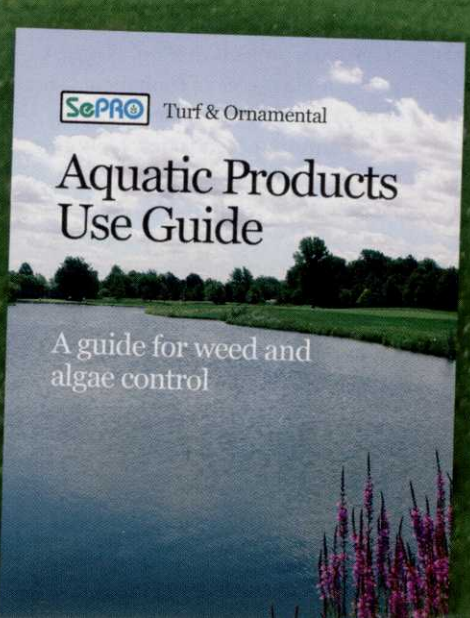

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Brian Vinchesi, the 2009 EPA WaterSense Irrigation Partner of the Year, is president of Irrigation Consulting Inc., a golf course irrigation design and consulting firm headquartered in Pepperell, Mass., that designs irrigation systems throughout the world. He can be reached at bvinchesi@irrigationconsulting.com or 978/433-8972.

IRRIGATING CONTROL SYSTEMS... MORE DECISIONS

There is no doubt that a decoder/two wire system needs to be grounded well. Not that a field controller system doesn't, but the decoder/two-wire systems are more sensitive due to the fact that electronic equipment is installed underground, where high voltages can be induced on the circuit by lightning. If the grounding is not adequate, then the system will be very susceptible to damage. A field controller system is also susceptible to damage, but the overall amount of damage would usually be less in a field controller system versus a decoder/two-wire system. Additionally, the odds of losing several holes or more at once are low in a conventional field controller system since the circuits are isolated in groups of sprinklers per controller.

In a decoder/two wire system, everything is basically connected as one circuit, so a lightning strike can be devastating if the system is not properly grounded and protected. Therefore, a great deal of attention should be paid to grounding. A high percentage of the wire savings from a conventional system should be used to increase the lightning protection. Lightning protection should consist of multiple pieces of equipment – not just grounding rods. These include:

Grounding Electrodes. Lightning occurs at a variety of frequencies, from zero to 100 megahertz. Ground rods are only effective in dissipating the lightning energy into the ground for low frequency strikes. Ground plates are effective at the full range of lightning frequencies because of their large amount of skin in contact with the soil and their low inductance characteristics. The combination of ground rods and plates provide broad band ground grids that dissipate the lightning energy at all lightning frequencies.

Surge Suppression Devices. These devices, also known as lightning arresters, are required by the manufacturer and are installed at strategic points along the wire path to limit the voltage to a level below the specifications of the irrigation systems electronic equipment. The arresters divert the excess energy to the grounding electrodes and the energy is dissipated in the ground in the form of heat.

Cable Fuse Devices. These handy devices are installed in the communication cabling, usually at tee junctions, to allow one or more legs to be shut off so that troubleshooting can be more easily accomplished. The fuse, when blown, identifies which leg of the cable has a problem. Think of these devices as similar to isolation valves in a hydraulic system.

Exothermic Welding Connectors. Instead of putting a clamp on a rod that requires maintenance – yes, it needs to be cleaned and re-tightened at least annually – an exothermic connection fuses the ground wire to the rod, giving a better and long-lasting connection. Ground rods with pre-welded lead wires are now available.

Shield Wires. A shield wire consists of a solid, bare copper conductor installed 6 to 12 inches above the cabling; or, in a field controller system, above the wire bundle and is there to absorb electrical impulses traveling across and down into the soil. The shield wire is intended to "shield" the wires below it. The shield wire has a lower path of resistance than the insulated wires below it.

Since many of these lightning protection devices are copper-based, they are expensive. The manufacturers have recommendations as to what degree of protection should be employed on their decoder/two-wire control systems, but many times additional lightning protection and surge suppression devices are eliminated or left off the design for cost-cutting, or to look less expensive than the competition or a field controller system. Based on experience, some designers specify and recommend additional or more elaborate protection than is required by the manufacturer, so there will be fewer issues if lightning strikes or other electrical problems occur.

"In a decoder/two wire system, everything is basically connected as one circuit, so a lightning strike can be devastating if the system is not properly grounded and protected."

I would argue that when properly designed and installed, the type of control system, in terms of longevity and reliability, is the same. You decide what control system is the best fit for you and for your golf course. This decision includes not only how you manage the irrigation system but also your budget for the cost of the installation itself and your maintenance personnel in terms of how much time they have to work on any irrigation control system problems. Do your homework, sort through the rhetoric and pick the system that best works for you. **GCI**

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By Kyle Brown

Ready to go

An unpredictable winter means broadleaf weeds are ready to start showing up. Is your program prepared?

Winter might be toying with parts of the country with sudden changes in warm and cool weather, but eventually, spring will show up. With it will come broadleaf weeds, eager for their day in the sun as turf is coming around from a tough season.

Dealing with broadleaf is a top priority this time of year, but the best plan for doing so sounds different from course to course. Is it better to use preemergent or postemergent? What's the best way to determine the right chemical mix?

Regardless of how broadleaf is dealt with, Trey Anderson, superintendent of Hickory Ridge Golf Course in Carbondale, Ill., says it takes a sharp eye early in the season to keep ahead of the weeds.

"We'll go scout out areas in spring to see where broadleaves are going to be a problem," says Anderson. "Then we'll get a good three-way mix and go down and clean those up. Once the summer comes along, it's not really conducive to putting anything on those leaves."

Anderson's transition-zone, zoysiagrass course sees some knotweed and clover, with some broadleaf plantain showing up from year to year. Each year, he and his crew watch for the weeds to start showing up, noting where trouble spots might be and where it might pay off to give a little more attention to a section of turf.

Aside from early recognition, taking notes from year to year will also pay off, according to Patrick McCullough, extension turfgrass weed specialist at the University of Georgia.

Know the enemy:

Be on the lookout this spring for these golf course invaders

1. Buckthorn plantain
2. Common chickweed
3. Corn speedwell
4. Dandelion
5. Hairy bittercress
6. White clover
7. Purple deadnettle
8. Sticky chickweed

PATRICK MCCULLOUGH