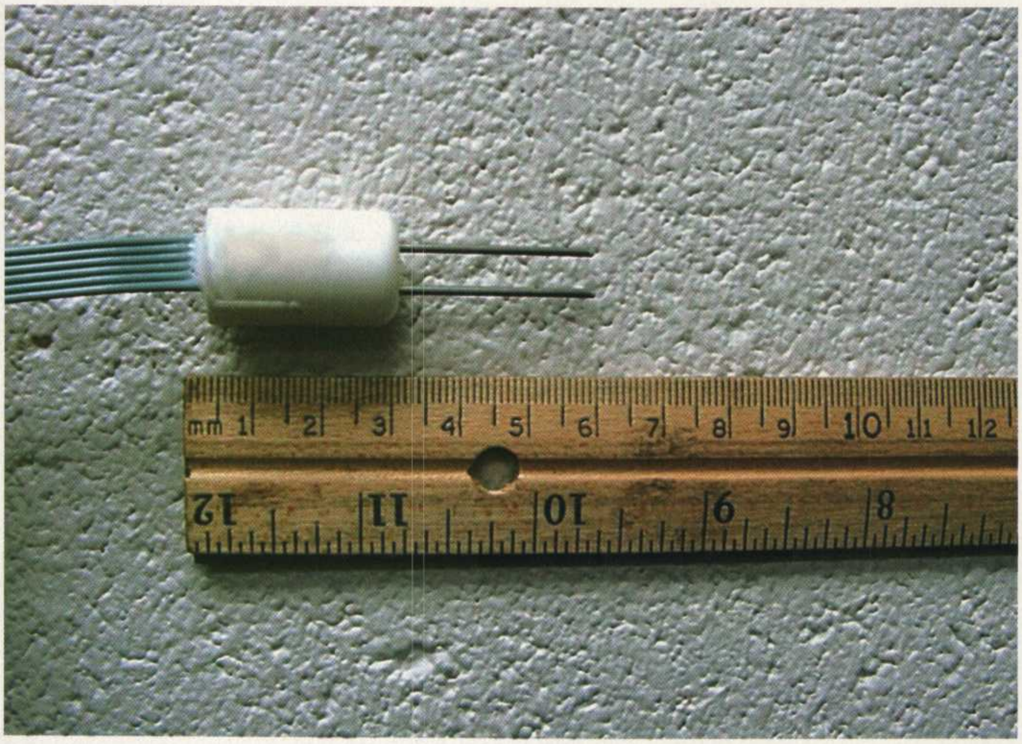

This dual-probe heat capacity sensor built at Kansas State University can help superintendents measure the effectiveness of their irrigation systems more accurately.

The effects of the various irrigation treatments on overall turf quality will also be evaluated. The goal is to determine the minimum thresholds where plants remain healthy and without stress symptoms. Delaying irrigation to this threshold may result in water savings. Furthermore, turf health should improve in the long run since the turf would be irrigated before the onset of stress symptoms.

Another consideration is the optimal depth of soil-moisture sensors. Ideally, soil-moisture sensors should be placed in the active part of the root zone where most of the water is extracted, and that depth may vary by turf species and mowing height.

For example, dual-probe data from perennial ryegrass mowed at fairway height suggest that optimum sensor placement may be at a 2-inch depth. Optimal placement may be deeper in tall fescue. Dual-probe measurements under tall fescue revealed that soil-moisture depletion was greater at 6 inches than at 2 inches or 12 inches, suggesting that 6 inches may be a better depth of placement of sensors in tall fescue (Table 1). Other practical factors may need to be considered when positioning soil-moisture sensors.

Ideally, sensors should be installed with the irrigation system during the construction of a golf course to minimize the disruption to turfgrass and to players. However, this will not always be possible. Installation in established turfgrass could cause temporary destruction of turfgrass and disruption to players, although wireless, remotely accessed soil-moisture sensors may minimize these problems.

KSU research is underway to control irrigation automatically using dual-probe heat capacity sensors — new technology that provides measurements of soil water content near the surface.

Another consideration is the potential for sensors to be damaged by routine aeration treatments. For example, if the depth of aeration is greater the depth of the sensors, then

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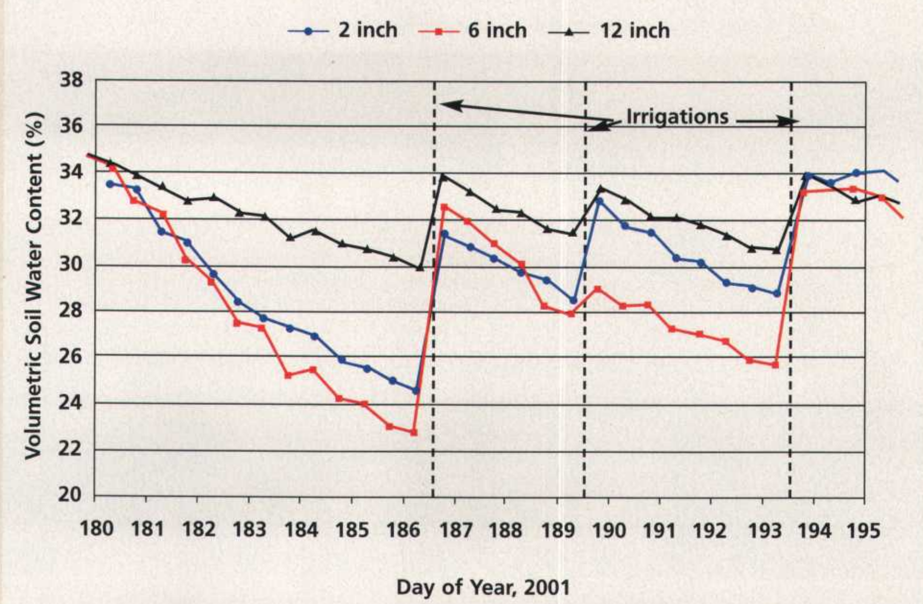
TABLE 1

Soil moisture in tall fescue



Continued from page 51

there is potential for damage. Compaction in heavily trafficked areas also may affect the accuracy of soil-moisture sensors because the readings of a number of sensors are affected by the change in bulk density.

The rapid development in soil-moisture technology may help to overcome these challenges in the not-so-distant future. For example, remote sensing techniques are being developed to estimate soil water content in the surface layer without sensors being installed in the soil (called passive microwave; Schmugge et al. 1992). This would avoid the problem of aeration spikes or deep divots ruining soil-moisture sensors.

Another possibility may be to install soil-moisture sensors along underground irrigation pipes near each riser. Because of advances in technology, the type of soil-moisture sensor used in current studies is probably less important in the long run than the fundamental information obtained. For example, the relationships between soil-moisture levels and plant physiological stress, and the establishment of lower and upper irrigation thresholds for turfgrass are factors that will be the same regardless of the type of soil-moisture sensor used.

Although soil-moisture sensors offer much promise for automated control of irrigation in turfgrass, they won't solve all irrigation problems in turf. For example, under extremely high temperatures plants may be under stress and require light watering (syringing) even if soil-moisture levels are adequate (Beard, 2002; Huang et al., 1998). In other instances, soil-moisture sensors may initiate irrigation even when rainfall is imminent. Incorporation of weather data, in combination with soil-moisture sensors, into the irrigation control system could provide a solution to these problems.

Control systems that use fuzzy logic and

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A computer's fuzzy logic would not take control away from the operator, but would "learn" how the superintendent makes irrigation decisions.

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neural networks (also called artificial intelligence) are already in use by other industries and may be well-suited for controlling irrigation in turfgrass. Such systems can make accurate decisions based on uncertain or approximate inputs (Kasabov, 1996).

Looking ahead, it's quite possible to imagine that irrigation management in turfgrass in the future will be managed by automated, computerized systems that use soil-moisture sensors, weather data and an adaptive fuzzy logic control system.

In the future, irrigation at golf courses will likely be controlled by complex central computers that will use a combination of data to operate.

Such systems would allow turf managers to override the systems for manual control if necessary, and the control system could actually "learn" from inputs provided by the superintendent. Thus, fuzzy logic would not take control away from the operator, but would actually "learn" how the superintendent makes irrigation decisions.

Conclusions

In summary, using soil-moisture sensors in irrigation scheduling will become more important as the costs of water rise and as water restrictions are imposed. Research is under way to determine fundamental relationships between soil-moisture levels and physiological stress in turf and to determine upper and lower limits for irrigation thresholds.

Although there are a number of practical limitations to using soil-moisture sensors in irrigation scheduling, new technology will likely overcome these limitations.

The benefits in water conservation and improvements to water quality will outweigh the difficulties associated with the deployment and maintenance of soil-moisture sensors.

In the future, irrigation at golf courses will likely be controlled by complex central computers that use a combination of data from soil-moisture and weather station sensors to make irrigation decisions and to make the most efficient use of irrigation water.

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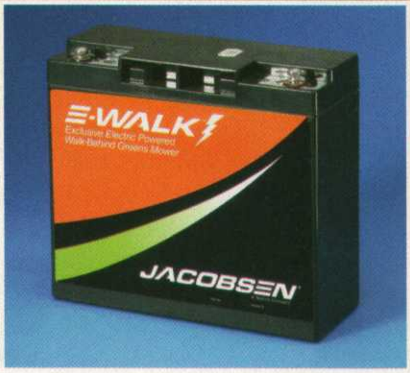

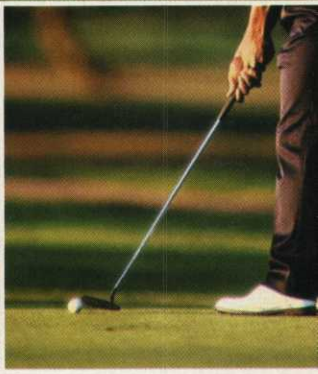

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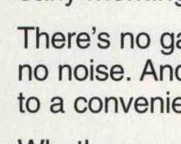

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CIRCLE NO. 123

Aerification Doesn't Need to Disrupt the Game

By David A. Oatis

The single biggest problem facing superintendents today is the pressure to avoid disrupting the golf schedule with maintenance practices.

As a result, superintendents are finding it increasingly difficult to find the time necessary to carry out standard turfgrass maintenance tasks.

Cultural activities such as verticutting, topdressing and fertilization are frequently delayed or missed entirely as a result of a heavy golf schedule.

Aerification often suffers a similar fate. Aerification of putting greens generally means disrupting the putting surfaces for as few as a day or two, to as many as three or four weeks or more.

Not suprisingly, tremendous pressure can be brought to bear on superintendents to aerify less and to choose the least disruptive equipment, such as smaller or soild tines.

Not surprisingly, tremendous pressure can be brought to bear on superintendents to aerify less and to choose the least-disruptive equipment (such as smaller or perhaps solid tines).

If everyone dislikes aerification so much, one has to wonder why in the world putting greens still get aerified. The answer is simple: Despite the many advances in the science of turfgrass management, good old-fashioned hollow-core aerification remains one of the most important tools available to superintendents today.

A properly timed and conducted aerification program can help superintendents address a number of different problems, but the trick is getting it done with minimal disruption to the course — and perhaps even your career.

There are many different aerifiers on the market today, and there are just as many options for equipping them.

We have conventional aerifiers, deep-tine aerifiers, drilling and filling machines, and high-pressure air and water injection machines, for example.

TABLE 1

Tine size and surface area chart

Tine size (in.)	Spacing (in.)	Number of holes per ft. sq.	Surface area of one tine	Percent surface area affected
1/4	1.25 x 1.25	100	0.049	3.41%
1/4	2.5 x 2.5	25	0.049	0.85%
1/2	1.25 x 1.25	100	0.196	13.64%
1/2	2.5 x 2.5	25	0.196	3.41%
5/8	2.5 x 2.5	25	3.07	5.33%

Courses with a particular need to modify soils or reduce thatch require more holes per sqaure foot to have an impact on as much surface area as possible. Unfortunately, it isn't always easy. Larger holes increase both surface disruption and golfer dissatisfaction.

The conventional high-impact vertical piston type can be outfitted with solid or hollow coring tines ranging in diameter from one-fourth of an inch to 1 1/8 of an inch or more. With all of these options, the key to success is to identify your soil problem and design a program to address it.

When it comes to modifying soils, the number and size of the aerification holes are critical. More and larger holes cover more surface area, and larger holes are much easier to fill with topdressing material. So the choice should be an easy one, right?

Courses with a particular need to modify soils or reduce thatch need larger holes (so they can be filled) and more holes per square foot to have an impact on as much surface area as possible. Unfortunately, it isn't always easy. Larger holes increase both surface disruption and golfer dissatisfaction.

If your putting green soils require modification, this turf tip is for you. It comes from Eric Greytok, superintendent at Winged Foot GC in Mamaroneck, N.Y. It is unique in that Greytok has discovered a method of aerifying greens and effectively modifying their soils, and this is accomplished with less surface disruption. That may sound like a tall order, but if you listen to this turf tip, I think you'll agree.

Greytok's tip is very simple. Use a narrower spacing pattern and a larger tine. Greytok uses Ryan Greensaire aerifiers, but this could probably be accomplished with many of the other available models. Eric had the quadra-tine holder attachment, but modified it to accept a larger tine.

In addition to drilling out the tine holders, the slots in the turf hold-down kit had to be widened. Instead of the traditional 2.5-inch spacing, the quadra-tine holder has 1.25-inch spacing.

With a larger hollow tine, it now has the capability of affecting an impressive amount of surface area. Most surprisingly, the surface disruption is actually reduced, and the end result is impressive.

Switching from a quarter-inch tine to a half-inch tine quadruples the amount of surface affected, and changing the spacing from 2.5-inch to 1.25-inch also quadruples the number of holes per square foot. All told, using a half-inch tine on a spacing of 1.25-inchs affects an impressive 13.64 percent of the surface area.

Compared to the old traditional approach of using five-eighths inch hollow tines on 2-inch spacing, which affects only 5.33 percent, this new approach affects 2.5 times more surface area and leaves the surface much smoother.

Thus, more but smaller holes can result in significantly more surface area being affected with less overall disruption. Hence, sometimes more is less.

The downside? With all those holes, plan on using more topdressing material, and you may need to hand-broom it in for optimum effectiveness.

For more information about aerification hole spacing, tine size and the percentage of surface area affected, read Pat O'Brien and Chris Hartwiger's article, "Aerification by the Numbers," which appeared in the July/August 2001 issue of the Green Section Record.

Oatis joined the USGA Green Section in 1988 and has been director of the Northeast Region since March 1990.

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Options are good.

Salt Tolerance Should Be Considered When Choosing Kentucky Bluegrass Varieties

By Yaling Qian

Salt problems in turfgrass sites are becoming more common for many reasons: accelerated urban development in Western states; fresh water conservation; the use of wastewater or other irrigation waters containing salts; seawater intrusion into turf facilities located on coastal sites; and road de-icing.

The extreme drought in 2002 in New Mexico, Colorado, Wyoming, Utah and Arizona resulted in mandatory turf watering restrictions in many of the major cities in those states. Many golf courses were forced to use low-quality water for irrigation. Reductions in irrigation can also increase soil salinity levels thanks to reduced leaching.

Kentucky bluegrass, one of the most widely used cool-season turfgrasses in the temperate United States, is considered salt-sensitive, reported to tolerate less than 4 micromhos/centimeter (mmhos/cm) soil salinity (Harivandi et al., 1992). While the mmho/cm is used as a unit indicating the level of salinity, it is in fact a unit for electrical conductivity (the higher electrical conductivity indicates the higher level of salinity). It reads as milli-mho per centimeter.

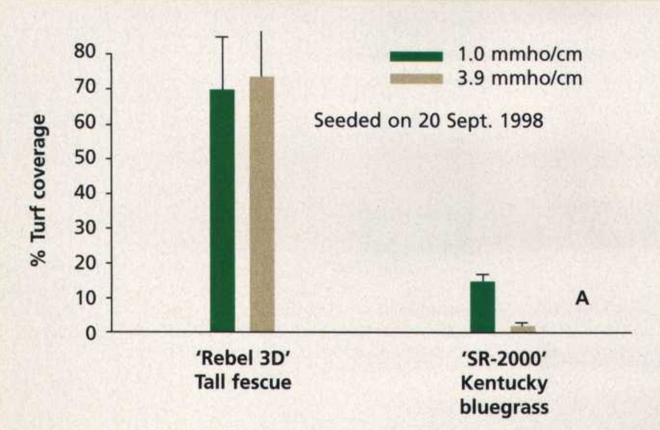
Three major points need to be considered when dealing with bluegrass salinity stress:

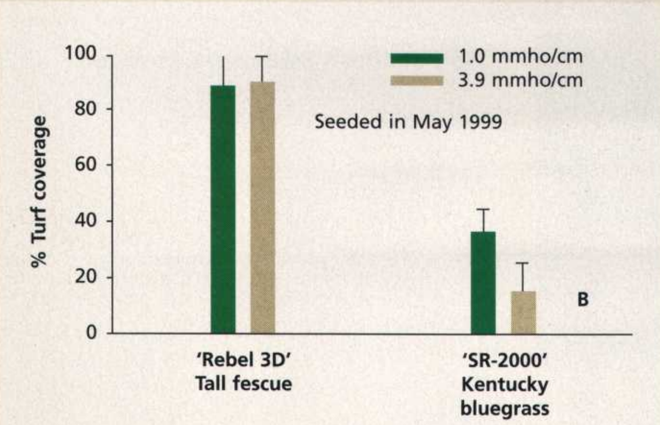
- as salinity levels increase, the temperature window for Kentucky bluegrass seed germination is narrowed;
- high summer temperatures intensify Kentucky bluegrass salinity stress; and
- not all bluegrasses are the same. Under salinity stress, certain cultivars perform better than others.

We will take a look at each of these three issues separately.

FIGURE 1

Effects of salinity on the establishments (% turf coverage) of tall fescue and Kentucky bluegrass. Turf establishment was rated about 2 months after seeding.





Seed germination window

In the South Platter River basin, it is common for underground water to have a moderate level of salinity. We have observed that when irrigation water contains 3 to 4 mmho/cm salts, to establish Kentucky bluegrass by seeding in mid-September in northern Colorado is often unsuccessful.

Environmental conditions, such as tempera-