Photo: David Wolff

J.D. Franz, superintendent at Cottonwood Creek Golf Course in Waco, Texas, used soil testing to help his course handle more than 53,000 rounds of golf in 2004.

# The science of nutrient management

## NITROGEN HAS THE GREATEST IMPACT ON TURFGRASS GROWTH

by DAVID WOLFF

Ask a dozen superintendents about the nutrient management programs for their greens, and you'll probably get 12 different answers – each one of them correct.

Different climates, root-zone mix composition, golfer expectations and budgets all play a role, making fertility management something of an art. However, recent advances in the understanding of nutrient behavior have put more science into the process.

Researchers at the University of Wisconsin-Madison contend that management of nitrogen stands apart from all other nutrients in its impact on turfgrass growth.

"If you want to increase the content of any other nutrient, you have to put down nitrogen (N) because that is what drives the uptake of everything else," says Wayne Kussow, Ph.D., of the department of soil science. "Our research shows that most soils on greens are perpetually nitrogen deficient. Nitrogen results in a surge of growth, which also requires more phosphorus (P) and potassium (K). That's what we call nutrient demand."

Nutrient demand occurs at the root surface. A precondition is a growth factor such as the supply of a particular nutrient that's limiting shoot growth. When the limitation is overcome, the plant strives to increase its growth rate. The shoots then signal to the roots that additional quantities of other nutrients are required.

"In the way we fertilize turfgrass, nitrogen is the most limiting nutrient and drives plant growth in the absence of heat or moisture stress," Kussow says. "There are times when nitrogen is not the most limiting

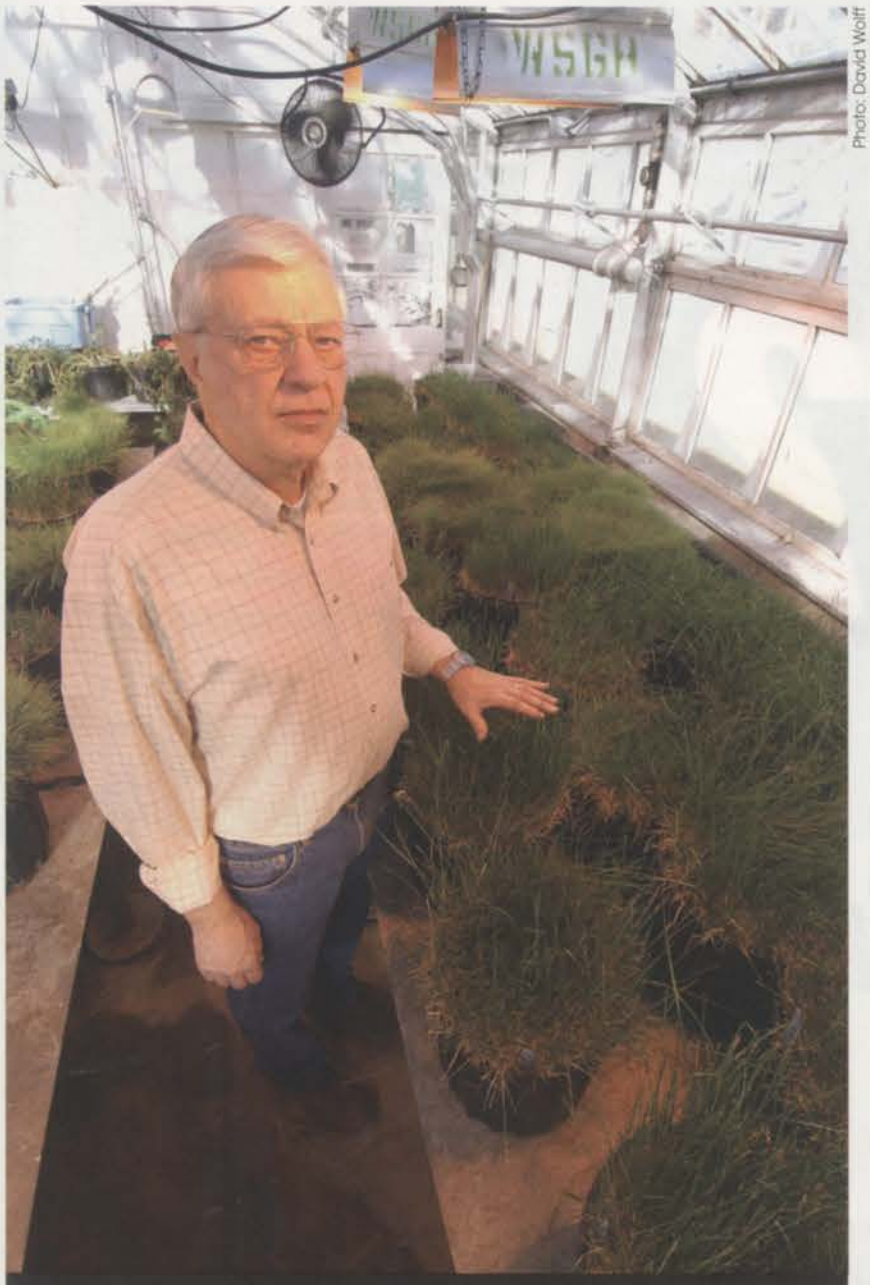
Photo: David Wolff

Wayne Kussow, Ph.D., of the soil science department at the University of Wisconsin, says nitrogen drives plant growth in the absence of heat or moisture.

growth factor, but as a whole, clipping production is limited more by nitrogen supply than anything else. Nitrogen-stimulated growth requires additional phosphorus and potassium, and the uptake of these nutrients becomes a function of the nitrogen supply."

## Consequences

There are several consequences of nutrient demand. First, what constitutes an adequate supply of phosphorus and potassium in sand greens varies with the application rate of nitrogen. The greater the amount of nitrogen, the greater the demand for the other two nutrients.

"We've documented this by noting the rate of 'drawdown' of soil phosphorus and potassium when increased annual rates of nitrogen were applied to creeping bentgrass," Kussow says.

A second consequence of nutrient demand occurs when soil levels of phosphorus and potassium are already at levels that satisfy this demand. Applying additional amounts serves no purpose because it has no influence on their concentrations in or the amount of clippings produced.

"In short, once turfgrass demand for phosphorus and potassium is met, there is no further uptake, even when supplies are increased through fertilization," Kussow says. "Nutrient demand gives rise to a strong link between the concentrations of nitrogen, phosphorus and potassium in turfgrass shoots. It will vary somewhat with the time of year and weather, but on an annual basis, it stays close to a 9:1:7 ratio for a high-quality creeping bentgrass green. In fertilizer terms, this equates to an N-$P_2O_5$-$K_2O$ ratio of 4:1:3. In other words, the bentgrass utilizes the equivalent of ¼ pound $P_2O_5$ and ¾ pound $K_2O$ for every pound of nitrogen applied. But to compensate for potassium leaching in sand putting greens, one pound of $K_2O$ needs to be applied for every pound of nitrogen."

## Soil testing

University researchers have analyzed more than 300 greens throughout Wisconsin, and the results vary. For example, the greens on one course had a phosphorus concentration of 175 parts-per-million when they only needed 4 ppm. On another course, the pH level on the greens was less than five. The superintendent didn't know because he had never done a soil test.

"People have said for years that there seems to be a fairly constant ratio of N-P-K, but didn't know why," Kussow says. "Now we know it's because nitrogen is driving the uptake of phosphorus and potassium. I call it the '4:1:3' because that's about the ratio a bentgrass green is going to utilize. And that becomes a very useful management tool. Let's say a superintendent wants to increase his soil test phosphorus. All he has to do is apply more than ¼ pound $P_2O_5$ for every pound of nitrogen. If the phosphorus level is high, don't put any down and over time the level will drop."

Using these ratios from soil tests, superintendents can pick out a grade of fertilizer that will increase, maintain or reduce the levels of these nutrients. Fertilization rates should be based on soil tests. While the frequency of testing varies, the key is studying trends.

"A superintendent should look at his soil tests and note increases or declines in nutrient levels over time," Kussow says. "If he doesn't need to increase the level, then back off. From our research, the constancy in plant tissue N-P-K ratios implies that if your current soil test levels of phosphorus and potassium are where you want them to be, you can hold them near those levels simply by adhering to the 4:1:3 ratio in your fertilizer applications."

Many superintendents strive to keep bentgrass shoot potassium levels high with the belief that this improves drought tolerance and reduces winter injury.

"If your soil test potassium levels are high, all you have to do to increase tissue potassium concentrations is apply nitrogen," Kussow says. "If you do choose to apply potassium, create some demand for it by applying nitrogen as well."

Superintendents often ask Kussow what lab to use. He tells them they're all good, just stay with one.

"Different labs give different results, so just be consistent," Kussow says. "Over time they can track the results and determine how well they're managing the soil. Soil testing is a very useful tool to tell superintendents if they have a problem at the moment. Repetitive testing over time is the best guide. It tells them what they need to be doing."

## Test critical areas

At Blackhawk Country Club, an 18-hole private course in Madison, Wis., superintendent Monroe Miller, who has been at the facility more than 32 years, only conducts soil tests every three to five years because of his familiarity with the property.

"On greens, we take about 20 subsamples to get one composite sample," Miller says. "We take fewer subsamples on tees. Fairways are where experience and local knowledge really come into play. There can be quite a variation in soils within 500 yards. We take samples in critical areas for more meaningful results."

Fertilizer application rates on greens depend on yearly conditions, but Miller's primary concern is the nitrogen-potassium ratio.

"We don't concern ourselves much about

"If you want to increase the content of any other nutrient, you have to put down nitrogen because that is what drives the uptake of everything else." – WAYNE KUSSOW

## A championship plan

The following is the month-by-month fertility plan for greens developed by Straits Course superintendent David Swift for the 2004 PGA Championship at Whistling Straits in Kohler, Wis.

"Our fertilization program hasn't changed too much in the last few years," Swift says. "The course is six years old now, and our soil tests show we are starting to mature, which has helped make our program easier to monitor."

Whistling Straits plays host to 30,000 rounds annually, and gets additional traffic from caddies because it is a walking-only course.

"Along with soil testing, we really monitor thatch accumulation and wear patterns to help keep the fertility as simple as possible," he says. "Fairways and rough are fescues, and greens and tees are bentgrass, which require totally different programs and products. With this in mind, we watch how the different plants are responding from the contrast between them and sometimes adjust fertilization applications accordingly.

"Nearly two-thirds of our fertilizer applied to the greens comes through applications of slow-release granular products," he adds. "The additional applications of nutrients come from a biweekly spray program that can be adjusted according to traffic, Mother Nature and cultural practices."

**April**
14 – spray greens with soluble fertilizer
19 – apply Anderson's Super K, 0-0-45
28 – spray greens with soluble fertilizer

**May**
6 – granular fertilizer application
12 – spray greens with soluble fertilizer
26 – spray greens with soluble fertilizer

**June**
7 – granular fertilizer application
9 – spray with soluble fertilizer
23 – spray with soluble fertilizer

**July**
7 – spray with soluble fertilizer
9 – granular fertilizer application
21 – spray with soluble fertilizer

**August**
18 – spray greens
20 – granular fertilizer application

**September**
1 – spray greens with soluble fertilizer
15 – spray greens with soluble fertilizer
29 – spray greens with soluble fertilizer

**October**
4 – granular fertilizer application

**November**
22 – dormant granular fertilizer application

phosphorus because at this course it doesn't move through the soil," he says. "On greens, we strive for a 1:1 nitrogen-potassium ratio, putting down about three to five pounds of nitrogen a year. This seems to increase the winter hardiness of the turf."

On fairways, the grass tells Blackhawk's staff when it needs to be fertilized.

"When we fertilize, it also depends on the product we're using," Miller says. "Last year we used 1.5 to 1.75 pounds per 1,000 square feet of coated spray fertilizer incorporating a couple of ounces of fine-grade urea fertilizer with a foliar application. We fertilize greens in spring using one pound of nitrogen before we aerify. In the warm season, we use foliar applications. In the fall, we go back to granular when most of the events are over and we're not mowing as frequently."

## Battling high pH levels

Superintendent J.D. Franz has been testing the soil at Cottonwood Creek Golf Course in Waco, Texas, since he arrived in 1997. Soil testing helps him determine the amounts of primary, secondary and micronutrients needed to keep the turf healthy and growing. The 18-hole public course struggles with high alkaline and pH levels, due primarily to the high sodium content in irrigation water.

"We add gypsum when we aerify to help rebuild the soil with calcium," Franz says.

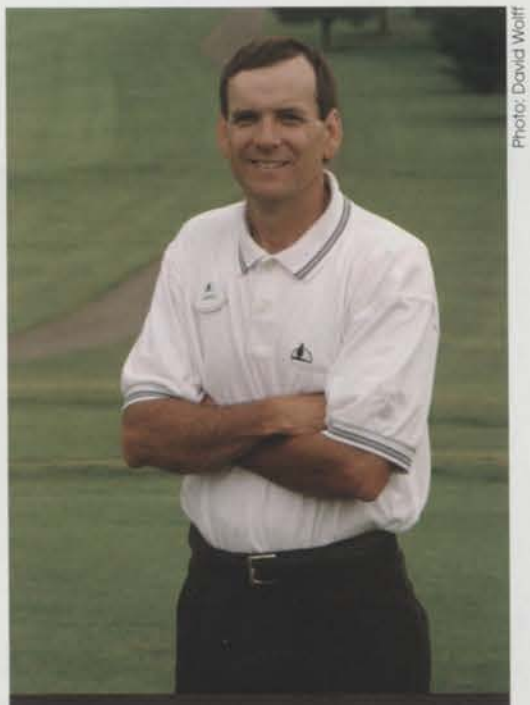

Photo: David Wolff

John Stawovy, superintendent at Cedarbrook Golf Course, has been testing the soil at the course for 15 years.

"This also helps with the cation exchange capacity so we get better nutrient uptake. We keep our nitrogen and potassium ratios relatively close. We add phosphorus only when we overseed to make sure the top one quarter inch of the soil has enough for the new seedlings to develop."

Traffic also is an issue for the fertilization program. Cottonwood Creek recorded more than 53,000 rounds last year.

"All that play wears down the turf and requires more fertilization," Franz says. "We try to keep the course a little lean, but we also want good color. Soil testing, water quality and traffic all play a significant role in determining our cultural practices."

At Cedarbrook Golf Course in Belle Vernon, Pa., superintendent John Stawovy also battles high sodium content in the soil. He uses gypsum to flush the soil.

"If the soil is better biologically, there will be a better environment for growing good, healthy turf," Stawovy says. "We've been testing our soil extensively in spring and fall for 15 years and can't operate without it. Soil testing is vital."

Cedarbrook's fertilization program uses an organic product after spring aerification to build up the microbial population in the soil, which also enhances the relationship with the root system. High calcium lime in a foliar feeding is used during the summer, and organic fertilizer is used in fall to get the turf ready for winter. GCN

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