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Fertilizing calcareous sand greens

For calcareous sand putting greens, the answer may not be more fertilizer but more careful applications.

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Many sources of sand for use on golf courses in the Intermountain West are calcareous with alkaline pH. Turfgrasses growing on these sands commonly exhibit phosphorous and iron deficiencies. These shortcomings are magnified when calcareous sands are used in modified root zones where nutrient levels change rapidly because of low cation exchange capacity (CEC) and high leaching potential. In addition, many nutrients become less available at high pH. Maintaining high-quality, functional turf on these sands involves careful management of applied nutrients and water to minimize leaching losses.

The CEC of sand root zones is typically increased by adding organic matter, usually peat moss, and by organic matter deposited in the root zone by the turfgrasses themselves (1). However, organic matter deposition by turfgrasses can occur very slowly in calcareous sands because of poor growth. To determine how to improve the growth of putting green turf on calcareous sands, we evaluated the effects of nitrogen (N), phosphorus (P) and potassium (K) fertilization and their interactions on the growth of creeping bentgrass



Photo courtesy of Paul Johnson

All fertilizers were prepared in bottles and applied to the plots in liquid form.

(*Agrostis stolonifera* Huds.) in the unique soil and climate environment of sand greens in the Intermountain West.

Materials and methods

The site for this study was a research putting green constructed in 1995 to USGA recommendations (11) in North Logan, Utah. The only departure from these specifications was a greater percentage of fine sand than recommended by the USGA, with 23.1 percent in the 0.15-0.25-millimeter particle size and 12.1 percent in the 0.05-0.15-mm particle size. The root-zone mix was 95 percent sand and 5 percent peat to a depth of approximately 12 inches. The root-zone sand was tested three years after construction in 1998 and contained 95 percent sand, 4.5 percent silt and clay, and 0.5 percent organic matter. The putting green turf was Providence creeping bentgrass.

Initial soil tests (9) indicated low P and K levels. Zinc and sulfur levels were also low and were amended in fall 1998 and spring 1999 with elemental sulfur (87.5 pounds/acre) and a micronutrient fertilizer. In general, the turfgrass quality of the putting green would not have been acceptable for a typical golf course at the time these studies were initiated because of poor density and lack of growth.

Irrigation and fertilization

Two separate but related experiments were initiated in 1999 and continued through September 2001. In experiment 1, P and K rates were varied and N was held constant. Experiment 2 involved varied rates of N and K with constant levels of added P. In 1999, the fertilizer treatments were divided equally among six monthly applications between late April and November. Some burning of the

KEY points

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- We evaluated the effects of N, P and K** and their interactions on the growth of creeping bentgrass in a calcareous sand putting green.
- Creeping bentgrass responded well** to relatively low levels of soil test P.
- The highest N rates** produced dense dark green turf, but also resulted in excessive thatch and puffiness.
- Potassium cannot be "banked"** in calcareous sand greens and must be available to the plant as it is needed.

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turf was observed, so in 2000 and 2001 the same yearly nutrient amounts were divided equally among 12 applications, applied every two to three weeks, to more closely simulate fertilization intervals on putting greens.

The plots were irrigated with 0.1 inch of water immediately after the treatments were applied in all three years. Irrigations were scheduled to replace approximately 80 percent of ET_0 every two days. The turf was mowed at 0.16 inches four times each week, clippings were removed at each mowing. The summer growing seasons of 1999, 2000 and 2001 were nearly rain-free, so the water applied to the experiment was highly controlled.

Visual quality

Visual ratings of turfgrass quality were made at least once each month using a 1 to 9 scale, where 1 is brown, dormant turf and 9 represents the best quality. Shoot density and color were also rated in a similar manner at least once each year. Soil samples from each plot were collected five times each year

and analyzed for P and K levels. Tissue samples were collected and analyzed yearly in early August. Green speed, or golf ball roll distance, was measured using a modified Stimpmeter with the ball release notch at 7.48 inches from the beveled end (7).

To determine the relationships between turfgrass visual quality and soil test P and tissue P, we used models to estimate critical levels of soil and tissue test P above which turfgrass quality was not improved.

Results and discussion

Phosphorus

The quality of the creeping bentgrass turf improved in color, growth, and density in response to P applications at all but the lowest application rate. Improvements in quality began to appear within two months of the first applications. The plot area was clearly deficient in P before the experiments, with characteristic purple deficiency symptoms and a thin stand of turf. Plots receiving 0.25 pound P_2O_5 /1,000 square feet/year were defi-

cient in P and of poor quality throughout experiment 1. The remainder of the treatments resulted in improved turfgrass quality and were not significantly different from each other. Phosphorus fertilization increased soil test and tissue P, which translated into improved turfgrass quality. Soil test levels beyond 4-5 milligrams P per kilogram of soil and tissue levels above 0.4 percent did not increase turfgrass quality.

The lowest P application rate resulted in significantly longer ball roll (22 inches) compared to the higher-rate P treatments because of the thin stand of turf. The 1.25-pound P treatment resulted in less ball roll (20.5 inches) than the 0.25-pound P treatment, but ball roll was still significantly higher than that produced by the 2.5 and 5.0-pound treatments, which had ball rolls of 19.5 and 19 inches respectively.

Although these ball roll distances are significantly different, the actual difference on a putting green as experienced by a golfer may not be as large. Researchers have reported that the minimum ball roll distance detected by players is approximately 6 inches, using an unmodified Stimpmeter (8). We estimate that 1.2 inches on the modified instrument as used in this work equals 5.9 inches on the unmodified instrument. Using 1.2 inches as the "practical significant difference," ball roll on the 1.25-pound P plots was longer than that on plots fertilized with the highest P treatment.

These results indicate that creeping bentgrass requires relatively low levels of soil test P. Phosphorus levels can be kept very low, possibly discouraging *Poa annua* L. and reducing P pollution concerns. Turf fertilized at the lower P levels also has the potential for longer ball roll while maintaining adequate quality.

Nitrogen

Nitrogen is the nutrient that guides most putting green fertilization programs. The trends we found with creeping bentgrass turf response to N applications were similar to past research (4,5,12). The rate of 2-pound N/1,000 square feet/year did not provide adequate turf quality. The stands were thin, and of poor color and growth. The rate of 3-pound N/1,000 square feet/year provided marginal turf quality, and the 5-pound N/1,000 square feet/year and 7-pound N/1,000 square feet/year rates provided the best turf quality in nearly all evaluations with

INITIAL SAND CHARACTERISTICS

| Soil test parameter | Value | Nutrient status |
|---------------------------------|--------------------------|-----------------|
| pH | 7.7 | alkaline |
| Salinity | 0.2 millimhos/centimeter | low |
| Organic matter | 0.5% | |
| Sand | 95% | |
| Silt | 3% | |
| Clay | 2% | |
| CaCO ₃ equivalent | 3.2% | |
| P [†] | 2.5 milligrams/kilogram | very low |
| K [†] | 16 milligrams/kilogram | very low |
| NO ₃ -N [§] | 2.1 milligrams/kilogram | low |
| Zn ^{//} | 0.15 milligrams/kilogram | low |
| Fe ^{//} | 3.52 milligrams/kilogram | moderate |
| Cu ^{//} | 0.3 milligrams/kilogram | high |
| Mn ^{//} | 1.45 milligrams/kilogram | moderate |
| SO ₄ ^{-5#} | 2.02 milligrams/kilogram | low |
| CEC | 1.3 cmoles/kilogram | low |

[†]Olsen and Sommers 1982 (10).

[‡]Haby et al.1990 (8).

[§]2 N KCl extract.

^{//}DTPA-extractable.

[#]CaCl₂ extract.

These are the initial chemical and physical characteristics of the root-zone sand used in the putting green (Sept. 1998).

EXPERIMENTAL N, P AND K

| Nutrient | Experiment 1 | Experiment 2 | Nutrient source (1999) | Nutrient source (2000-2001) |
|----------|---------------------------------|----------------------|------------------------|-----------------------------|
| | P&K Study | N&K Study | | |
| | (pounds/1,000 square feet/year) | | | |
| N | 5 | 2, 3, 5, 7 | urea | urea |
| P | 0.25, 1.25, 2.5, 5.0 | 5 | phosphoric acid | monoammonium phosphate |
| K | 0, 2.5, 5.0, 7.5 | 0, 2.5, 5.0, 7.5, 10 | potassium chloride | potassium chloride |

dark green color, a dense leaf canopy, and vigorous growth. The 7-pound N rate provided consistently higher quality, especially for color, in 2000 and 2001. All three years showed similar response patterns.

Although the highest N fertilization level gave the highest visual quality in these evaluations, this amount of N is excessive for most golf turf in a cool-arid environment like northern Utah. Turf in the plots with the high N rate was very dense and dark green in color but had excessive growth and thatch production. Increases in thatch caused puffiness of the turf and a tendency for turf to be scalped with a mower. These treatments also had more localized dry spot, possibly because of the increased thatch layer (1). These nitrogen results are not new to most superintendents.

Potassium

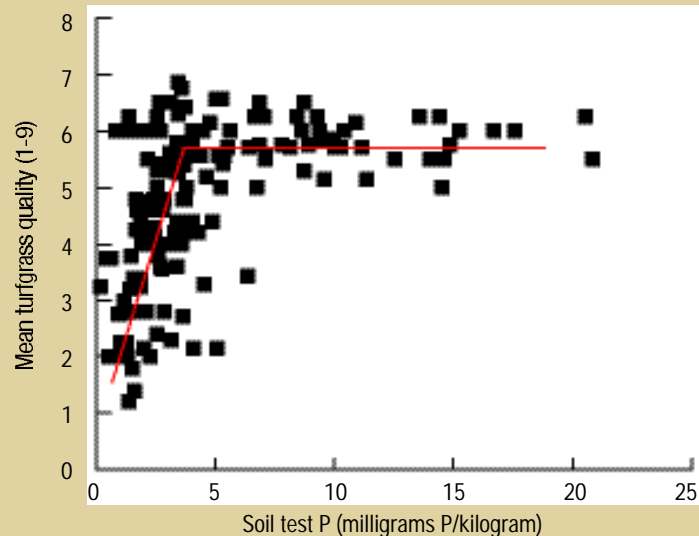
Although potassium is usually the second-most important nutrient for turf, we observed little positive influence of high K fertilization rates on visual quality of the turf. Soil test K was increased slightly by K application rates, but not in proportion to the amount applied. Tissue K showed a weak positive correlation to turfgrass quality. No interaction existed between nitrogen and potassium in these experiments. In other words, increased K fertilization rates did not reduce the need for N.

Lack of turf quality response to K has been observed in other research and has been explained by the lack of stress on the turfgrass

plot area or inherently high amounts of K present in the sands (5,6). Because K is known to increase tolerance to heat, drought and traffic stresses (3,10), future work should include the effects of traffic and water stress with K treatments. Other explanations for lack of K response are the potential for leaching of the highly mobile (soluble) nutrient through the root zone and soil profile and the inability of the sands to absorb K because of low CEC. More frequent applications of K fertilizer, or

alternative types of fertilizers may be possible solutions. The soil test K in the plots ranged from 15 to 65 ppm. The lack of response is not because turfgrass does not use K, but because the K is not being made available to the turfgrass. If the K fertilizer had remained in the root zone, much higher K concentrations would be detected. Using trends in finer-textured soil, soil test K would have increased to approximately 240 mg/kg. Even low K application rates may have exceeded the CEC

P FERTILIZATION



Mean turfgrass quality response to soil test P. Data are combined over three years (1999-2001). Mean turfgrass quality is the mean of six to seven turfgrass quality evaluations on each plot each year.

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of the sand (1.3 milliequivalents/100 grams). If the soil had a higher holding capacity for K, quality differences, and possibly interactions with N, might be observed.

Removal of clippings would also remove some K from the turfgrass/soil system and contribute to the low soil test K response.

If the lack of response is due to leaching of K, careful K fertilizer application on pri-

marily sand-root-zone putting greens is important. In finer-textured soils, K can be "banked" or applied in excess of the plant's needs in one year so that repeated K fertilization is not needed. Instead, on these sand greens, K must be applied or made available as the plant needs it, to maintain healthy levels in the plant tissue.

Conclusions

Turf quality and growth responses to the nutrients in the calcareous sands appeared to be similar to turf responses to nutrients in noncalcareous sands (3,10). Fertilization with slow-release K materials and/or foliar applied nutrients, as well as the addition of organic matter to increase CEC may be important. Calcareous sands, and sands in general, may not require higher levels of nutrients applied, rather, how they are applied appears most important.

Acknowledgments

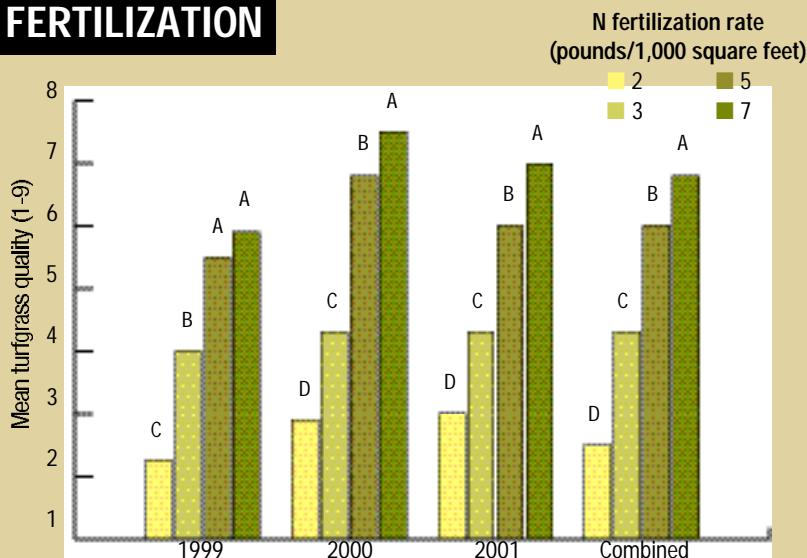
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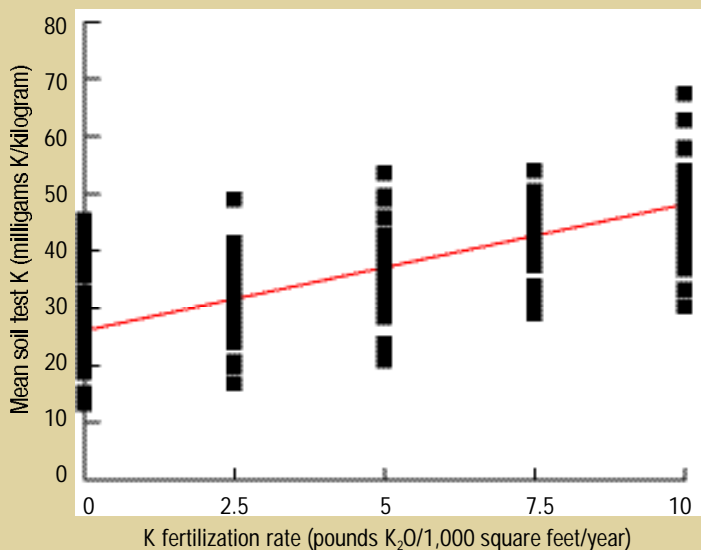
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N FERTILIZATION



Mean turfgrass quality response from yearly N fertilizer rate, experiment 2. Mean turfgrass quality is the mean of six to seven turfgrass quality evaluations on each plot each year. Quality is rated on a scale of 1 to 9, where 9 is the best. Means within each group marked by the same letter are not significantly different at $P = 0.05$ according to Tukey's test.

K FERTILIZATION



Soil-test K response to K fertilization rates, experiment 2. Data are combined over three years (1999-2001).