Effects of Rootzone Mix Sand Bentgrass Establishment in USGA Greens

By Kevin R. Henriksen

The moisture retention capacity of the rootzone mix in USGA putting greens appears to a key property for rapid and uniform bentgrass establishment (Carlson and Kussow, 1994; Kerkman, 1994; Kerkman and Kussow, 1995). Good stand density and uniformity translate into high green quality, which is also strongly related to the moisture retention capacity of the rootzone mix (Kerkman and Kussow, 1995). From these observations, it is reasonable to say that rootzone moisture retention capacity must be relatively high to have high quality USGA putting greens.

In 1994 Kerkman observed the effect of peat particle size on bentgrass establishment and moisture retention in simulated USGA putting greens. While peat particle size was found to influence bentgrass establishment and this was related to differences in moisture retention in the top 2 to 3 inches of the rootzone mix, the actual influence on the amount of moisture retained was quite small. The moisture in the top two inches of the greens differed by less than 1.0% when the peat particle size was reduced from 6.3 to 12.5 mm to less than 0.85 mm.

The purpose of the present study was to determine the effect of sand particle size distribution on rootzone moisture levels in simulated USGA putting greens. The results, when compared with those of Kerkman (1994), should allow for response to the question of the relative importance of peat particle size versus sand particle size as far as moisture retention in the rootzone mix and the rate and uniformity of bentgrass establishment is concerned.

Table 1. Particle size analysis of sands used to prepare rootzone mixes

Size fraction	Waupaca sand	Janesville sand	50:50 blend
		%	
Fine gravel	0	0.21	0.28
Very coarse sand	0.45	9.14	4.57
Coarse sand	11.41	27.80	18.77
Medium sand	68.61	49.79	62.81
Fine sand	19.45	12.41	13.20
Very fine sand	0.05	0.50	0.29
Silt+clay	0.03	0.15	0.08

Experimental Methods

Peat for the study was prepared by grinding Canadian sphagnum peat to pass through a 20-mesh sieve. The final product contained 95.5% organic matter and the particles were all between 0.5 and 0.05 mm in diameter. The peat was blended with two commercially available sands and a 50:50 mix of the two sands at a sand:peat ratio of 80:20 (v/v). Sieve analysis of the sands are shown in Table 1. Note that the Waupaca sand is finer than the Janesville sand and contains 19.4% fine sand, which is very near the 20% maximum allowed by USGA standards. As expected, the particle size distribution of the 50:50 blend of the two sands was intermediate between those of the Waupaca and Janesville sands. All three sands satisfy USGA specifications for rootzone mixes.

The rootzone mixes were packed into 6-inch diameter PVC cylinders to a depth of 12 inches. The rootzone mixes were underlain by 3 inches of pea gravel held in the PVC cylinders by hardware cloth. Starter fertilizer was incorporated into the top 1/2-inch of the rootzone mixes and the cylinders seeded with 2 lb/M of SR 1020 pure live seed. After wetting the simulated putting greens until drainage occurred, they were loosely covered with plastic sheeting until the bentgrass began to emerge. The greens were then watered lightly 3 to 4 times a day until emergence appeared to be complete. The watering frequency was then reduced to once per day. Clipping of the greens at 1/2-inch began as soon as this height was achieved. The greens received 0.2 lb N/M as urea after the first clipping.

Observations made included visual rating of the greens for emergence rate, seedling vigor and color, growth rate and stand density. Clippings were collected over an 18-day period and the total weight recorded. At this time a Time Domain Reflectometer was used to measure rootzone moisture content 24 hours after irrigating to the point where drainage from the cylinders occurred.

Table 2. Bentgrass quality ratings and clipping production during establishment.

Sand in the rootzone mix	Quality ratings Emergence	Color	Vigor	Growth	Density	Clipping weight
	Scale 1 to 5,		5 = best			mg
Waupaca	5.0	4.5	4.8	5.0	5.0	893
Janesville	2.5	3.9	2.2	2.8	2.2	414
50:50 Blend	3.5	4.0	4.0	4.0	3.8	693

Observations

For a given rootzone mix, there was strong correspondence among the visual ratings of the green and with clipping weight (Table 2). In other words, if a particular mix had the highest emergence rating, it also ranked highest in all other quality ratings and in clipping production.

Use of the Waupaca sand in the rootzone mix led to the fastest bentgrass emergence and highest stand density and uniformity (Table 2). Lowest in this regard was the Janesville sand green. The blend of the two sands provided intermediate ratings and bentgrass clipping weights.

Moisture contents of the putting greens differed primarily in the top 1 to 2 inches of the rootzone mixes (Figure 1). At this depth the Waupaca sand mix retained 12.6% water while the Janesville mix contained only 7.72% water. The blend of the two sands retained 11.2% moisture at this depth. While these differences in moisture retention capacitites may appear to be small, they did largely account for differences among the rootzone mixes in average bentgrass quality ratings (Figure 2) and clipping weights (Figure 3).

Fig. 1. Moisture retention by rootzone mixes differing in the sand used.

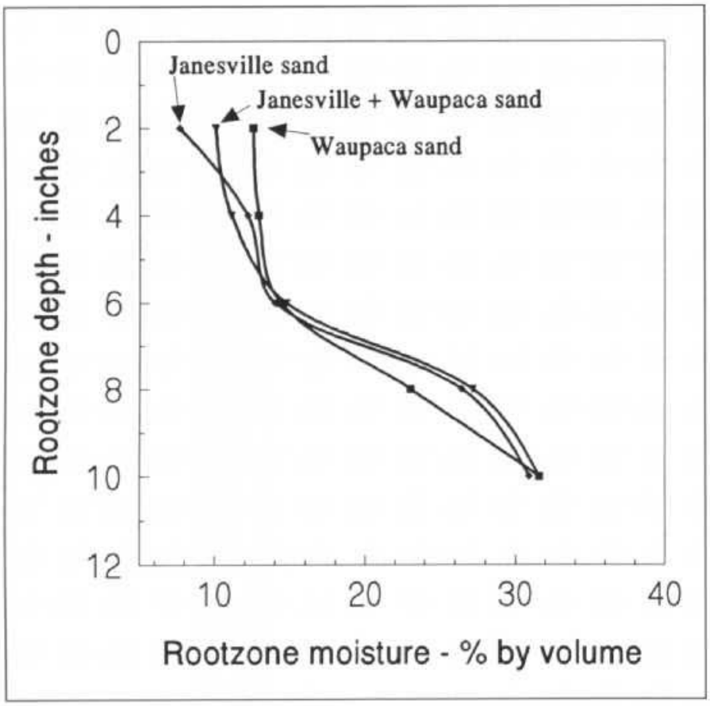


Fig. 3. Relationship between rootzone moisture at a 2-inch depth and total clipping production by bentgrass 18 days following the beginning of emergence.

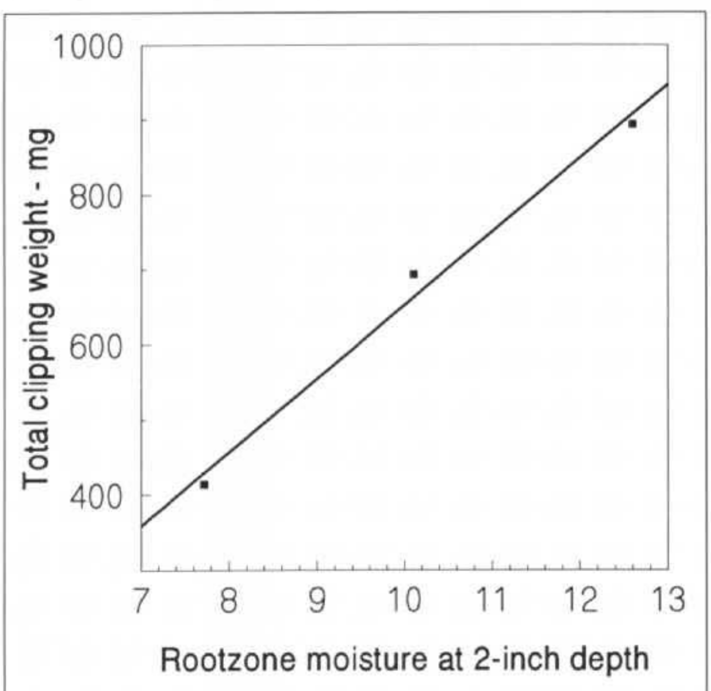
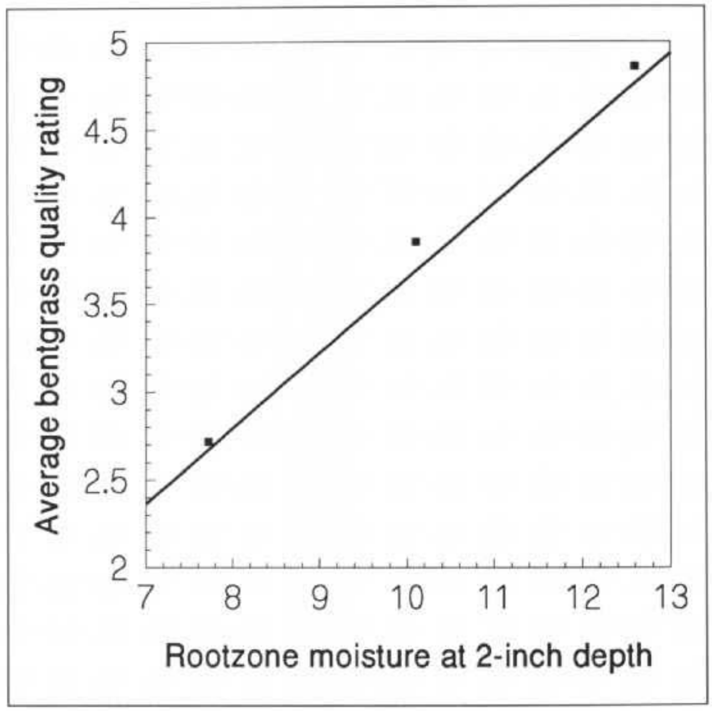


Fig. 2. Relationship between rootzone moisture at a 2-inch depth and the average of ratings for 5 different putting green quality parameters during bentgrass establishment.



Conclusions

The results of this study and those cited earlier collectively illustrate the importance of the rootzone mix moisture retention capacity during bentgrass establishment on USGA putting greens. Comparison of the results of this study with those of Kerkman (1994) lead to the conclusion that moisture retention is much more dependent on the particle size distribution of the sand used in the rootzone mix than on peat particle size.

Editor's note: Kevin Henriksen is a December 1994 graduate of the University of Wisconsin-Madison Turf and Grounds Management Program. This study was conducted as a Special Problem under the guidance of Dr. Wayne R. Kussow.

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PINE HILLS PLAYS HOST FOR OCTOBER MEETING

By Kris Pinkerton

The October meeting of the WGCSA was held at Pine Hills Country Club and hosted by superintendent, Rod Johnson. "Ninety-eight" members and guests showed up on what was to be a gorgeous autumn day. Beautiful fall colors were very evident, but outstanding course conditions took precedence! Rod and his staff should be commended for their fine work, especially this late in the year.

The luncheon speaker featured Dr. Frank Rossi, Assistant Professor at the University of Wisconsin-Madison. The main topic of discussion focused on, "How to decide what bentgrass you should use?" Dr. Rossi offered the following insight:

- Superintendents should come out to the O.J. Noer Research Center and take a look at the bentgrass cultivars. Dr. Rossi offered the opportunity for anyone to cut a hole out, to look at root structure, thatch development or whatever they want.
- Obtain your own cultivars of seed from dealers and grow them in a nursery condition. Also consider placement of those bentgrasses in various parts of your golf course to see how they hold up.
- Read information from the National Turfgrass Evaluation Program (NTEP) trials. However, be careful to select information relevant only to your area!

Results from the Modified Michelob-(2-man) Event were:

Low Gross First Place	Rick Nuss Tom Baumgartner	(71)
Low Net First Place	Tony Larson Scott Von Spreeken	(63)
Low Net Second Place	Scott Schaller Jeff Craig	(66)
Low Net Third Place	Tom Kornkven Wayne Horman	(67)
Closet to the pin	Tom Baumgartner	(Club Car Golf Bag)

* It was reported that Roy Zehren was later seen leaving the Pine Hills premises with a large buck tied to his Blazer. ???

Host Rod Johnson.

Professor Frank Rossi spoke at noon before the golf event started.

REINDERS TO CONTINUE DACONIL PROGRAM

Ed Devinger has announced that Reinders will continue its Daconil Program for the 1995 golf season. The company wants to thank its customers who participated in the 1994 program—they are listed below.

The 1994 donation made by Devinger to the Wisconsin Turfgrass Association on behalf of Reinders was $6,520. The seven year total is an impressive $38,000!

1994 Program Participants

Black River CC
Blue Mound Golf & DD
Brown County GC
Brynwood CC
Buttes Des Morts CC
Camelot CC
Chenequa CC
Cherokee CC
Clintonville Riverside GC
CC of Wisconsin
Countryside GC
Crystal Springs GC
Dairymen's CC
Deer Run GC
Dell View CC
Dodge Point GC
Deer Creek
Eagle River GC
Edgewater GC
Elks GC
Fox Hills CC
Fox Valley GC
Gateway GC
Gilmore Graves Golf
Golf Clubs, Inc.
Green Bay CC
Greenwood Hills CC
Hiawatha GC
Hillview GC
Indianhead GC
Ishnalla CC
Ives Grove GC
Kenosha County Parks
Kettle Moraine GC
Koshkonong Mounds GC
LaCrosse CC
Lake Breeze GC
Lake Windsor CC
Lake Wisconsin CC
Lawsonia GC
City of Madison
Maple Bluff CC
Maple Grove CC
Maple Valley GC
Maplecrest CC
McCauslin Brook GC
Minocqua CC
Moundview CC
Muskego CC
Nakoma GC
Neilsville CC
Nine Springs GC
North Hills CC
Oneida Golf & Riding Club
Old Hickory GC
Pine Acres GC
Pine Mountain GC
Platteville Golf & CC
Pleasant View GC
Quit-Qui-Oc GC
Racine CC
Ridgeway CC
Scenic View CC
Silver Spring CC
Stoughton CC
St. Germain GC
St. Johns Military Academy
Sundown GC
Tee-Hi GC
The Bruce Company
The Springs CC
Thornberry Creek CC
Timber Ridge CC
Trout Lake GC
Tuckaway CC
Tyranena GC
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Golf in Illinois... Same Game, Different Turf

By Pat Norton

Move out of Wisconsin? "Never," we said. "Not a chance. Not to Minnesota, which is just across the Mississippi from our former home in Onalaska. And most certainly not to Illinois...no way...ever!"

So what in the heck are we doing down here in Grundy County, Illinois? How did our little family, born and bred in the Badger State, end up down here in the flatlands southwest of Chicago?

I mean, hey, I've always had this thing about Illinois, growing up on the Wisconsin/Illinois border in Green Country we used to mock 'those flatlanders'. Our family excursions to Chicago were really interesting, but as we all grew older the gravitational pull was strongly toward Madison and the University of Wisconsin.

The only contact that I'd had with Illinois over the past twenty years or so has been through relatives and sporadic visits. We certainly never expected to leave Wisconsin. But...here we are, and liking it!

Illinois really is an okay state, although proximity to Chicago is both positive and negative. Lakeshore Drive, downtown in the Loop, Wrigley Field, etc. are part of Chicago's charm, and so are the 10 p.m. newscasts reporting the day's mayhem. There are some pretty sad and disgusting happenings in that city on a daily basis.

Fortunately, Grundy County is far enough out of the way that we are very much a farm town. I'd much rather put up with grain trucks on Route 47 than drive by shootings on the expressways. We're close enough for lots of golfers to reach us, but far enough away that gangs are not yet a problem.

Believe it or not, there is also a touch of the South here in Illinois. Lots of people work for ConEd (power plants along the Illinois River) who hail from Kentucky and Tennessee. A southern friend, who golfs regularly at Nettle Creek, drawls it out nicely when he calls Grundy County "the _ _ _ hole of the Midwest". Needless to say, he's anxious to end his consulting work here and return home.

All things considered, though, I'd much rather live here than downstate. Those communities and counties are really having problems—rural decay, poverty and a lack of good jobs. In short, if you're going to be in the state, the outlying Chicagoland area is the place to be.

And, there are just about a bazillion golf courses down here, and people are really golf crazy. I am truly amazed at the amount of $$$ that males spend on a public golf course, for their green fees, their booze and their tipping. Money flows like water for some of these guys...

With so many courses there's lots of competition for the golfing dollar, and lots of competition for the golf course dollars, too. I've never had so many overlapping suppliers — three suppliers for Milorganite, Lebanon, Par Ex, or just about any other fertilizer product. It is great to have so many choices.

Also, there are lots of opportunities to meet new people and see their courses. We are embarking on an aggressive program to naturalize this golf course, complete with deep roughs, wildflowers, wildlife habitat ...the works. Others have done a nice job with their courses, so it will be interesting to see how it's done.

There have been many negatives about leaving Wisconsin behind. Friends, neighbors, colleagues, schools, a great part-time job that Sue gave up—all are now in our past. Involvement in the WGCSA, the GRASS ROOTS, and living in "God's Country"—part of the past.

Many times there is a regrettable feeling of starting over from scratch, which is much more difficult for wife Susan and children than it is for myself.

My focus was, and still is, is that we were offered a new opportunity which included a 'piece of the pie', which is rare and valuable.

The process of disengaging from Onalaska and plugging in down here in Morris was, for me, very nostalgic. I left Wisconsin on April 22, 1994 in the following manner:

8:00 a.m. - I say goodbye to wife Susan and children in the driveway...they are staying behind to finish the school year and sell our house. I am eager to go, yet reluctant to leave my family. I am leaving my present life behind and heading to the future....

10:30 a.m. - Arrive at Blackhawk Country Club in Madison, dropping off GRASS ROOTS info into the lap of our longtime editor...haven't really seen that course since my college days...also feeling a strong sense of unfulfilled commitment to that journal.

12:00 noon - Arrive at Monroe Country Club to visit Tom Schwab and dump back onto him the information and

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duties of WGCSA treasurer...another feeling of guilt... much stronger feelings of the past...grew up just across the RR tracks from this place and played golf there endlessly as a youngster. By the way Tom, under the trees behind your 13th green was a great romantic hideaway during the summer of '75!!!

12:30 p.m. - Leave Monroe CC behind, winding my way through the backroads/beerroads of Green County...go past Windy Acres Golf Course...the Krieger family continues to do well there...lots of golf there as a kid also . ...heading to Rockford, then south to the future...a golf course that definitely needs help and an ownership group that realizes just how much work is ahead for all of us...lots of challenges ahead.

Colleagues who have relocated know all about these feelings and how tough it is for everybody to move on after establishing roots in an area. But, look at it this way. Our common ancestors, in settling the Midwest, had the guts to move on and find the pot of gold. Their hardships were much more difficult as compared to anything that any of us have experienced.

Sometimes their calculated gambles failed. I'm hopeful and confident that our gamble will pay off in future years.

The real hardships of 1994 have been to stomach these idiots who call themselves "Bears fans", call any Wisconsin person "Cheez Whiz", and feel that any three twisted deformed trees on a hillside a vista...which down here does indeed qualify as a vista!

I'll be dipped, though, if I'll ever wear a U of Illinois T-shirt or cap...I don't think I could handle that. And the Illinois River is not a river in the Wisconsin sense of the word ...more like a glorified grain shipping canal.

However, I would definitely zip into Chicago to check out "da Bears" or "da Bulls" anytime...just so long as somebody else is buying the tickets!!!

Managing Potassium in Putting Greens

By Dr. Wayne R. Kussow
Department of Soil Science
University of Wisconsin-Madison

Among the 17 essential plant nutrients, none has a wider spectrum of influences on turfgrass physiology and growth than does potassium. Potassium, through its role in cell hydration, regulates the rate of elongation of newly formed cells in the growing points of leaves, stems and roots and the opening and closing of leaf stomata. Insufficient levels of potassium lead to reduced rates of photosynthesis and carbohydrate production and of carbohydrate transfer to roots and shoots. Amino acid and protein synthesis are also dependent on potassium supply.

Given these far reaching effects of potassium on turfgrass physiology and growth, one can readily understand how the nutrient can have multiple effects on turfgrass. Observed responses to potassium fertilization include increased rooting, greater drought and heat tolerance, improved winter hardiness, reduced disease susceptibility and increased wear tolerance. Does this mean that if you increase the amount of potassium you're applying to your putting greens, all of these benefits will become evident?

Applying more potassium will be beneficial only if current supplies do not meet the needs of the turfgrass. Herein lies a dilemma in turfgrass research. A large majority of the reports on positive responses of turfgrass to increased potassium usage fail to indicate what were the soil and plant concentrations of the nutrient prior to and after treatment. This leaves us with little basis on which to judge whether or not application of additional potassium will be beneficial or a waste of time and money.

We've all heard about "luxury uptake" of potassium by plants. This situation arises when potassium concentrations within plants exceed the amounts thought to be necessary for basic physiological processes. Potassium is a unique nutrient in that it is not tightly bound to any plant constituent. It exists largely as a free ion. Thus, it is very difficult to determine what is an adequate amount and what is excessive. The mere fact that plants exert considerable control over potassium uptake suggests that there really is no such thing as "luxury" uptake. In fact, we know that alfalfa that goes into the winter with so-called luxury amounts of potassium has a higher winter survival rate than does alfalfa with lower levels of the nutrient. Thus, what may be a luxury supply of potassium in some climates may be considered adequate for our climate.

So where does this leave us in regard to management of potassium in putting greens? We have to start with the fact that clippings from healthy creeping bentgrass contain at least 2% potassium. In an average 24-week growing season, the total dry weight of the clipping will range between 80 and 100 lb/M. With a potassium concentration of 2%, the amount of potassium in the clippings ranges from 1.6 to 2.0 lb/M. Thus, to replace the potassium removed in the clippings we would need to apply 1.6 to 2.0 lb K/M, which translates into 1.9 to 2.4 lb K2O/M/season and a N:K2O ratio of 1.7 to 2.1. So where does the idea come from that the N:K2O ratio for sand putting greens should be at least 1:1?

It comes from two assumptions. The first is that turfgrass, like agronomic crops, will recover only about 75% of the potassium applied. The second assumption is that potassium leaches readily in sand putting greens and we have to compensate for this.

If we buy into the idea that turfgrass recovers 75% of the potassium applied, then we divide the 1.9 to 2.4 lb K2O removal rate by 0.75 and conclude that we really need to apply 2.5 to 3.2lb K2O/M/season to compensate for less than 100% turfgrass recovery. Then there's the leaching loss of potassium. You may as well pick a number from the air because I've yet to see research that gives a good idea of what this loss might be in a single season. Let's assume a 25% loss rate. Adding 25% to the 2.5 and 3.2lb K2O results in 3.1 to 4 lb K2O and a N:K2O ratio of 1.3:1 to 1:1.

Now let's go back and examine the assumption that plants recover an average of only 75% of the potassium applied. This figure is, in fact, an average derived from multiple studies conducted with agronomic crops on various types of soils. As a general rule, the higher the clay content of the soil, then lower the potassium recovery. This has led to the idea that recovery of potassium is less than 100% because of initial fixation by the clay and subsequent slow release of potassium to successive crops. If we're talking about native soil greens, these observations and concepts may be valid. But what about sand greens where the maximum allowable clay content is only 3%? I seriously doubt that potassium fixation is of any consequence in these greens.

Until this past season, I ascribed to the notion that N and K2O applications on sand putting greens should be at a 1:1 ratio. For two successive seasons we've applied N and K2O at a ratio of about 1.4:1 to greens whose rootzone mixes were constructed using different sands and amendments. In 1994 clippings were removed on three different dates and analyzed because I was concerned that our K fertilization rates may be too low. Was I surprised. The clippings contained 2.4 to 4.3% K! If ever there was luxury K uptake, it is occurring in some, if not all, of our putting greens. This tells me that we do not have a problem with K fixation and leaching losses are far less than assumed.

Our research indicates that applying N and K2O at a 1:1 ratio to sand putting greens will result in bentgrass uptake of excessive amounts of potassium. One precautionary note is in order. We're applying the potassium in small amounts throughout the season in the form of 15-0-30 and 18-4-10 fertilizers. Sand putting greens have the capacity to retain only about 250 lb K/A or 100 ppm K in the exchangeable form. If you exceed this amount by applying relatively high rates of potassium infrequently, you can expect leaching losses to be high. How high? This a question that we're trying to answer now in our research program. If you have sand putting greens and their soil test K exceeds 250 lb/A or 100 ppm, my recommendation is to reduce your annual K2O rates to a N:K2O ratio of about 1.2:1 to 1.4:1. The K rate should be tied to your N rate because one of the primary determinants of K uptake is the bentgrass's demand for K and this is determined by your N rate. If you're not ready to make this type of adjustment, then I suggest that you adopt a fertilization program that embodies light but frequent K applications throughout the season.

For those of you with native soil putting greens, how you might best manage potassium depends on the texture of the soil in the greens and soil tests. Sandy loam or loamy sand greens are likely to behave much like USGA greens. Soil tests above about 300 lb K/A or 150 ppm should be considered very high and the time has come when you can back off a bit on your K fertilization rates by increasing the ratio of N:K2O being applied. Soils of silt loam texture or finer are going to fix significant amounts of potassium, but due to their relatively high cation exchange capacities, allow you to store plant available K in them. You can meet bentgrass demands for K very easily with only one or two fertilizer K applications per season. If soil tests are above 250 lb K/A or about 125 ppm K, this is adequate and all you need to do is keep them near this level by applying about 2.0 to 2.5 lb K2O/M/season. Then re-test you greens every 2 to 3 years to make sure the soil K levels are remaining near these optimum values.

FERTIGATION

By Tom Parent
River Oaks Golf Course

Fertigation is the application of liquid fertilizer through the irrigation system. It allows for the application of micro quantities of low cost nutrients on an as needed basis. Maybe because fertigation sounds too good to be true, few golf courses are fertigating in the northern states. In the summer of 1992 we installed a small metering pump for wetting agents and ferrous sulfate. As the effect of iron and sulfur have such a dramatic color response, we felt this would be a good test of our irrigation system's distribution.

Over the winter of 1993/1994, we decided to install a full scale fertigation system at River Oaks Municipal Golf Course. To the best of our knowledge there were no golf courses using fertigation in the state of Minnesota other than for wetting agents and minor nutrients. On paper it looked like this system could save our golf course between $10,000 and $15,000 annually. The city council agreed to transfer $5,000 from our existing fertilizer budget to pay for the installation. After a great deal of research, we installed our system in mid-May.

A fertigation system can deliver the amount of nutrients that the grass plants will use over a short period of time. This minimizes volatilization and leaching and allows the turf manager greater control over turf growth and color. Being able to deliver frequent small quantities of fertilizer eliminates the fluctuations of growth associated with granular fertilizers.

Extended periods of rain do have a minimal effect on color and growth. This however can be corrected in one or two days of fertigation. The key is to have sufficient fertilizer pump capacity to apply 0.5 to 1.0 oz. of N/M in a normal irrigation cycle. In addition to environmental advantages and greatly improved turf quality are the economic advantages.

A fertigation system allows the use of water soluble agricultural grade fertilizers. We use a mixture of prilled urea, stabilized urea and ammonium sulfate as a nitrogen and sulfur source. Potassium nitrate and ammonium polyphosphate are used for K and P sources. Most of these products constitute a large percentage of slow release mixtures and are twice the analysis at a quarter the cost per pound of active ingredient.

Local fertilizer companies which supply the lawn care industry should carry pre-mixed liquid fertilizer. Typical analysis of pre-mixed liquid fertilizers are 16-2-6, 15-0-5 and 21-0-0. These products can be purchased with varying amounts of slow release nitrogen and custom blended at added cost. We mix our own solutions to have better control of the ratio of nutrients. Because of the minute quantities applied, and the fact they are watered in automatically, there is no burn potential.

We have found the amount of fertilizer required for vigorous turf can be reduced by 50 to 60 percent. At year's end we applied a total of four tons of urea, one and a half tons of ammonium sulfate and one and a half tons of potassium nitrate on around 80 acres of turf. This equates to slightly more than two pounds of N/M on our greens, tees and fairways. At this rate, we have more growth than many would find acceptable.

With a fertigation system you have the ability to apply minor nutrients such as ferrous sulfate, magnesium sulfate, sodium tetra borate ("borax") for boron, etc. As sufficient quantities of these products are absorbed through the leaves, chelated sources are not necessary. Our course has acidic soils, pH 5.6 to 6.3, and nutrient uptake generally has not been a problem. A fertigation system could be ideal for high pH soils where foliar feeding may bypass poor soil chemistry. We anticipate our fertilizer budget for irrigated turf to be around $4,000, not including a granular dormant application.

Some suppliers of fertigation systems have made claims that fertigation can prevent light frosts from forming. Due to the late onset of frost and a wet fall, we could not verify this. Of course, it didn't rain for a month after we turned our irrigation system off! You will drastically reduce your fertilizer application costs. Except for tees, unirrigated rough and a K application to the greens, we did not take the spreader out on the course. The use of fertigation system eliminates the need to schedule fertilizer applications, the use of heavy equipment, the disruption of play and the exposure of equipment to high concentrations of salt.

Our system consists of a large duplex (two pumps driven by one motor) proportional metering pump capable of delivering up to 28 gallons of product per hour per pump, and a 3.2 gallon per hour pump. We use the high volume pumps to deliver nitrogen and ferrous sulfate, wetting agents and high carbon fertilizers.

Because I was unwilling to gamble the cost of a prefabricated system on an untested procedure, we assembled our system from local suppliers. You can save considerable amounts of money by doing this, but it is more difficult. In Minnesota, a fertigation system does require a state approved check valve, a $50 permit, and a system inspection which included a facility inspection, as well.

We spent a total of $6,000 on our system which included metering pumps, proportional control systems, bulk tanks, containment, check valve, electrician costs and permits. If you do not have a flow meter which generates an electrical signal, your system will cost around $500 more, plus installation. A single pump system could be installed for $3,000 to $4,000.

With the system in place for a full season, it has far exceeded our expectations. With the money saved on fertilizer products we have been able to pay for the system and experiment with some of the new biohumated and high carbon fertilizer products on the market, with good results. In 1993 we spent $26,000 on fertilizer. This past year we spent around $8,000 for N, P, K, S, Fe and minors.

There are some drawbacks to this system. All areas of the course are fertilized equally if watered equally. We manage our fertigation to the greens and supplement other areas as needed. Except for the tees and a few fairways that were behind on nutrients, this approach has worked very well.