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PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 350 projects at a cost of $29 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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Phosphorus Leaching from Sand-based Putting Greens

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SUMMARY

Researchers at Auburn University conducted a two-year investigation into the effects of application rate (180 versis 360 lb P_2O_5 per acre) and application method (surface or sub-surface applied) on the ability of phosphorus to leach through a sandy rootzone. The study's findings included:

- Leaching of P may occur in sand-based putting greens.
- There were no agronomic or environmental benefits to sub-surface application of P fertilizer.
- Uptake of P and clipping yield were better when P was broadcast applied than when the P was band applied.
- Applying a 2x rate of P fertilizer never improved grass establishment, clipping yield, shoot yield, or P retention in the rootzone.
- Application of P at a 2x recommended rate makes no agronomic or environmental sense.
- When applying P fertilizer to a sand-based putting green, use smaller amounts applied at a more frequent interval, using soil-test recommendations.

Even though phosphorus (P) is the nutrient needed in the third greatest amount for turfgrass growth and production (1), the amount of research that has been done on P fertilization of turf is rather limited (6). This is especially true when the larger amounts of potassium (K) and nitrogen (N) required for turfgrass growth and development are used as a reference point.

Lack of research about P nutrition for turfgrasses may be for several reasons. First, although P is needed in larger quantities than micronutrients (such as Fe, Mn, Cu and Zn), the amount typically required is much smaller than amounts of N and K, so it is easy to develop a mind set that P is less important. Second, years of field-crop research have shown that P is less mobile than N, so it is thought that P is less likely to be lost from the rootzone via leaching. Leaching of N from sand-based putting green mixes has been widely studied in turfgrass systems, but there is less evaluation of P leaching because it has not thought to be a loss pathway of much environmental consequence. Loss of P via runoff, with subsequent possible pollution of surrounding surface water, has received far more study in turfgrass systems (11,12,13,14).

A third reason for limited P research in turf is that P fertilizer recommendations are made as a result of years of soil-test calibration and are not based on crop-response calibration curves. Soil testing and fertilizer recommendation methods for P have long been evaluated for field and pasture crops (5). Because it tends to be a regional issue and related to factors such as crop, soil type, and soil extractant, there are only a few studies that have evaluated turf growth and response related to extractable soil P, especially in high-sand greens (4).

Turfgrass putting greens are unique because they use constructed rootzones, typically high in sand, and thus have very low cation exchange capacities. There is evidence that P will leach in sandy soils. In one recent turfgrass study,

An example of the first-generation lysimeters, which were built prior to the switch to plastic cattle waterers. This top view shows four individual lysimeters, each of which drains into a collection vessel.

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P leaching losses from a St. Augustinegrass residential landscape in a sandy Florida soil were measurable, and were highest during lawn establishment and immediately after heavy rain (3). Leaching of P is especially likely when P accumulates in excess of that capable of being held by the soil (2, 7, 10). This accumulation of P at the soil surface can occur as a long-term effect of P application in no-till crop production systems.

Because a putting green cannot be inverted or tilled, a putting green can be viewed as a no-till soil. Thus, many of the research findings from agronomic no-till research might be a starting point for P research in putting greens. For example, research in no-till corn has shown that band placement of P (in a narrow strip alongside the seed) can increase early growth of corn, compared to when that P was broadcast (8). This is because banded P is less prone to rapid fixation by soil clays because less of the P comes into contact with the soil. When broadcast applied, P may accumulate at the soil surface, resulting in stratification of P within the soil profile (9).

Phosphorus placement research has not yet been completed in putting greens, and we don't yet know if P will stratify (or move) in a sand-based putting green. We also do not know if banded P would be more available to a growing turfgrass plant than if that same P was broadcast applied. In turf production, "banded" P would actually be a vertical band (referred to as sub-surface P), as P would be applied as a part of core aerification, with P fertilizer swept into holes left by the aerification procedure. Thus, for this research project, one objective of the research was to determine if deep placement of P in aerification holes (banded, or sub-surface applied) increased P uptake by turf. A second objective was to determine if P placement (sub-surface or broadcast) or P rate affected P leaching in a high-sand USGA-type putting green.

A closeup photo of the collection vessel, which is simply a 5-gallon gas can built into a wood-framed box. The plastic tube which drains into each gas can is attached to the drainage hole of each 70-gallon cattle waterer, which is buried to ground level. Each collection vessel is emptied once per week unless sufficient rainfall occurs to require additional collection.

Materials and Methods

The two-year study was started in 2002 using 16 small individual putting greens at the Auburn University Turfgrass Research Unit, located in Auburn, AL. Built in 2001, the putting greens consisted of 70-gallon plastic cattle watering tanks buried in the ground with the edge of the tank even with the soil surface. Each green drained to a 5-gallon collection chamber, enabling leachate to be collected and measured. The greens were filled with an 80/20 (sand/peat) USGA-type greensmix, and in March 2002, each green was sprigged with 'Tifdwarf' hybrid bermudagrass. One month after sprigging, P fertilizer treatments were initiated when each putting green was at 50% establishment.

Phosphorus fertilizer treatments consisted of two rates of P fertilization (180 lb P_2O_5 acre^{-1} and 360 lb P_2O5 acre^{-1}) and two types of P placement (‘band’, or sub-surface, and broadcast). The P rates were based on the Alabama recommended rate (180 lb P_2O_5 acre^{-1}) of fertilizer P for a bermudagrass putting green with an initial “very low” P soil test (average P soil test was 2 lbs P_2O_5 acre^{-1}). The higher P rate was twice the recommended rate and was selected to represent a worse case scenario: a high rate of P applied to the soil surface. The higher rate would not represent a recommended practice and could pose an environ-

mental hazard via accumulated P at the surface.

Sub-surface treatments were applied by core aerifying the green (3/8-inch diameter cores, 4 inches deep, 4-inch spacing), removing the cores, and sweeping the P fertilizer (triple superphosphate, 0-45-0) into the aerification holes, followed by sand topdressing. Broadcast P fertilizer treatments were applied by aerifying the plots, removing the cores, sweeping topdress sand into the aerification holes, and spreading P fertilizer across the entire plot surface. Phosphorus treatments were applied on April 18, 2002 and reapplied on April 16, 2003.

The research area received irrigation as needed to provide a total of 1 inch of total rainfall/irrigation per week. Plots were mowed with a walking greens mower to maintain a mowing height of 5/32 inch. In 2002, percent establishment was visually evaluated in each plot until 95% establishment was recorded. Each week, the total volume of leachate from each green was measured, and a subsample was taken for solution P analysis. At 3, 6, 9 (2003 only), and 12 weeks after P fertilization, soil samples were collected from each plot. Samples were taken at 2-inch increments to a depth of 10 inches, and P extracted with Mehlich III extractant for phosphorus determination. Each month clipping yield was measured and P content of the clippings determined.

Results

Figures 1 and 2 illustrate the results from two years of leachate collection. Results are shown as mg of collected P, determined by multiplying the volume of collected leachate (mL) and the concentration of P (micrograms/mL) in the collected subsample. Over the two years the study was conducted, there was rarely a significant P rate x P method interaction (6 times out of 79 leachate collections), indicating that differences in leached P were largely due to P rate, or the method

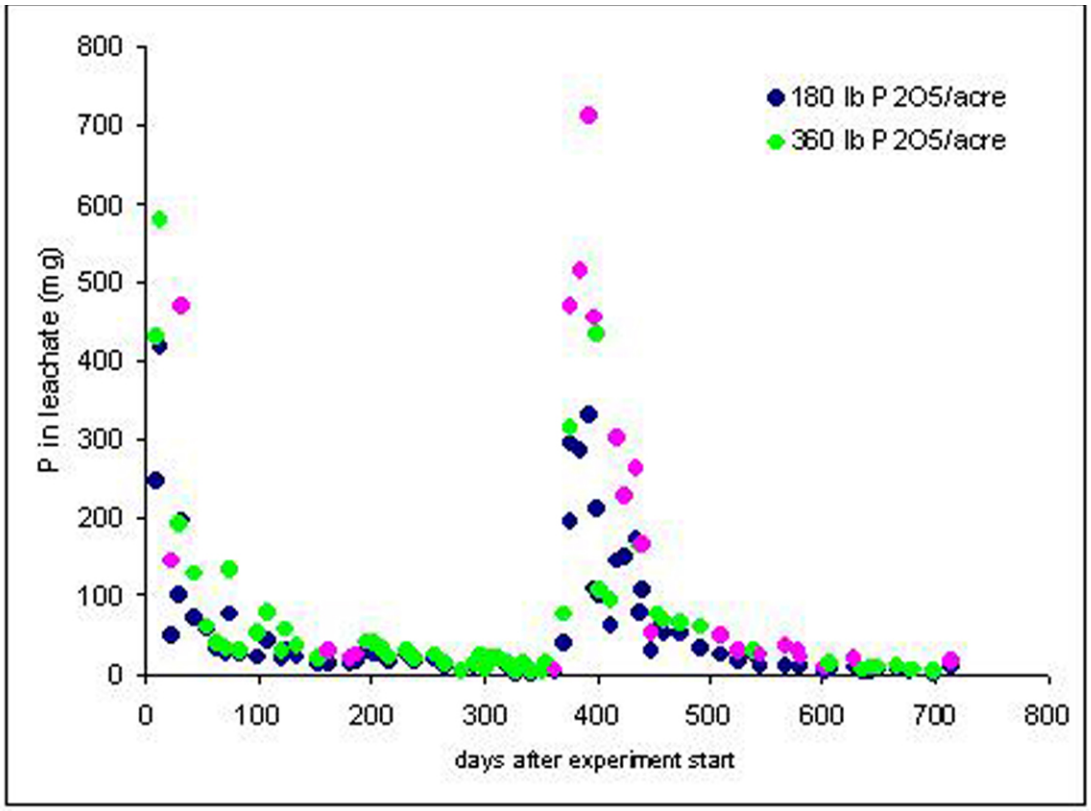

Figure 1. P in leachate (mg) as affected by sampling time and P rate in a 'Tifdwarf' hybrid bermudagrass putting green. Significant differences in leachate P are indicated when the data point for the 360 lb P_2O_5/acre rate is colored pink, indicating a significant difference at that sampling date compared to the 180 lb P_2O_5/acre fertilization rate.

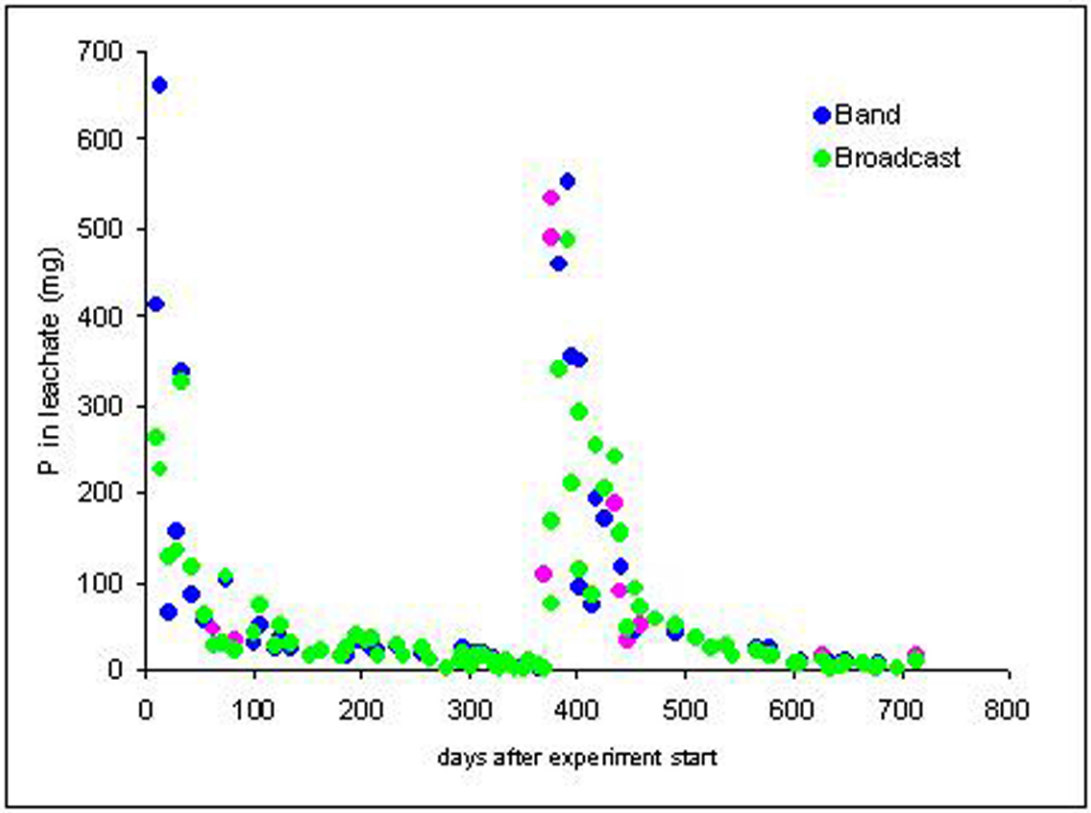

Figure 2. P in leachate (mg) as affected by sampling time and method of P placement in a 'Tifdwarf' hybrid bermudagrass putting green. Significant differences in leachate P are indicated when the data point for the sub-surface applied treatment is colored pink, indicating a significant differences at that sampling date compared to the broadcast P fertilization method.

of applying the P, but not the combination of the two.

Over the 715 days that the study was conducted, leachate was collected and analyzed 79 times. Out of those collections, the rate of P fertilization significantly affected leachate P 26 times (33%), with the P in leachate always higher from plots that received the higher rate of P (Figure 1). The method of P application (sub-surface or broadcast) significantly affected leachate P 11 times (14%) (Figure 2). Most of these significant results occurred in the second year of the study, and is partly reflected as a delay in P leaching from broadcast treatments compared to sub-surface. For example, in 2003, at 7, 13, and 14 days after the P fertilization (DAF) was applied, leachate P from plots in which the P fertilizer was swept into the aerification holes was greater than from plots in which the fertilizer had been broadcast. By 71, 75, 84, and 89 DAF, leachate P was greater from plots in which P was broadcast applied.

In this study, two years of leachate data indicates that, when applied at an agronomically recommended rate, P leaching was greatest in the first month after fertilizer application. The single application of P fertilizer (at a high rate of P) to a sandy putting green soil created a risk of P leaching. Others have shown similar results with P leaching losses greatest in immature landscapes and when rainfall amounts were greatest (3).

When P fertilizer was applied at a recommended and 2x rate, the rate of bermudagrass establishment (Year 1) never increased by the addition of the extra phosphorus (2x rate). However, establishment was faster when the P was broadcast applied, rather than banded. For example, on June 20, plots receiving broadcast P were 88% established, while those receiving sub-surface applied P were 79% established, a significant difference. All plots had reached 95% establishment by July 12, after which clipping yield and P uptake data were collected.

There was never an agronomic benefit to

applying P above the recommended rate of 180 lb P_2O_5 acre^{-1}. Soil-test calibration is a continually evolving issue, as new extractants, methods of calibration, and soil-test devices are developed. Although outside of the objectives of this research, other work at Auburn is beginning to show that current Auburn soil-test recommendations for bermudagrass putting greens may need adjustment, as bermudagrass response may be maximized at a soil-test critical level below that current 180 lb P_2O_5 acre^{-1} recommendation. Re-evaluations of soil-test procedures are a constant research need and are always underway with different crops and nutrients (4, 5, 15).

In 2002, July, August, and September clipping yields were never affected by P rate. When P was broadcast applied, the July and August clipping yields were greater than when P was sub-surface applied. In 2003, clippings were collected in May (twice), June, and July. As in 2002, P rate did not affect clipping yield. The sub-surface application of P only increased clipping yield in the first May clipping harvest, with no significant difference in clipping yield due to method of P fertilization thereafter.

Over the two years of clipping harvests, P rate did not affect P uptake by the bermudagrass, but method of P fertilization did. In 7 of the 8 clipping harvests, P uptake was greater in bermudagrass from plots receiving broadcast P than in sub-surface applied plots. Tissue P content ranged from 1.1 to 6.6%. End of experiment (2004) shoot density was not affected by either P rate or method of P placement.

In summary, leaching of P may occur in sand-based putting greens. There were no agronomic or environmental benefits to band application of P fertilizer. Uptake of P and clipping yield were better when P was broadcast applied than when the P was band applied. Applying a 2x rate of P fertilizer never improved grass establishment, clipping yield, shoot yield, or P retention in the rootzone. Application of P at a 2x recommended rate makes no agronomic or environmental sense. When applying P fertilizer to a sand-based putting green, use smaller amounts applied at a more frequent interval, using soil-test recommendations.

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