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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 290 projects at a cost of $25 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***.

Phosphorus Movement and Uptake in Bermudagrass Putting Greens

E.A. Guertal

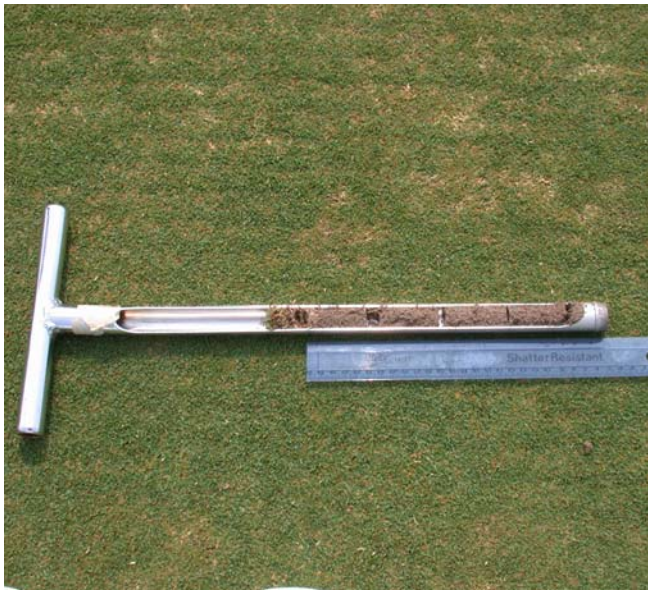
SUMMARY

Research at Auburn University was initiated to determine the effect of P rate and P placement on P uptake, extractable soil P, and turf performance in two hybrid bermudagrass (cv 'TifEagle') putting greens. The study found:

- In both years of the study, Mehlich extractable soil test results indicate that, according to those recommendations (P at 130 lb P_2O_5 $acre^{-1}$), additional P fertilizer was needed 3 to 5 months after the initial P application.
- Application of P in excess of recommendations (195 and 260 lb P_2O_5 $acre^{-1}$) did not appear to be prone to downward movement (0-12 inch sampling) within the one-year period of evaluation.
- Shoot density, dry weight of roots (0- to 3-inch depth), clipping yield, and P uptake by bermudagrass all increased as P rate increased, typically up to a P fertilization rate of 195 lb P_2O_5 $acre^{-1}$.
- The method of P application (band or broadcast) rarely affected extractable soil P, and the only agronomic factor which was affected was P uptake by bermudagrass. In that case, bermudagrass growing in plots which received banded P had greater uptake of P than bermudagrass growing in pots with broadcast P.
- Phosphorus fertilization of sand-based greens should not be neglected, and slightly higher rates (or more frequent application) than that recommended by current AL soil-test recommendations may be warranted. Additional research is needed in this area to make sure that long-term environmental impacts via P accumulation do not develop.

Although it is one of the three fertilizer nutrient needed (along with nitrogen and potassium) most commonly applied as a turfgrass fertilizer (2), research on phosphorus (P) fertilization is somewhat limited. Except for a few P runoff studies that were completed under fairway turf conditions, there is little information about P leaching, P uptake, or P fertilization requirements in USGA-type putting greens. Additionally, alternative application methods such as deep placement via core aerification have never been explored, even though deep placement of P in no-till cropping systems has often shown such placement to be an effective method for maximum P availability, crop uptake, and use. As a final concern, extensive research in pasture systems has shown that excessive surface application of P can lead to reduced quality in surrounding bodies of water as P moves in runoff and waterborne sediment via overland flow (3, 4). In very sandy soils (such as a USGA-type putting green) that have extremely high levels of P, previous research has shown that P will leach (5, 10). Thus, a key to P fertilizer management in turf systems is to supply sufficient P for plant use, while avoiding buildup that could negatively affect the environment.

The objectives of this research were to determine the effect of P rate and P placement on P uptake, extractable soil P, and turf performance



Use of a wider sampler was not possible with the depth (0- to 12-inch deep) samples that were collected on a quarterly basis. At least 20 samples were collected randomly from within each plot, and samples were sectioned into 2-inch increments for future soil analysis.

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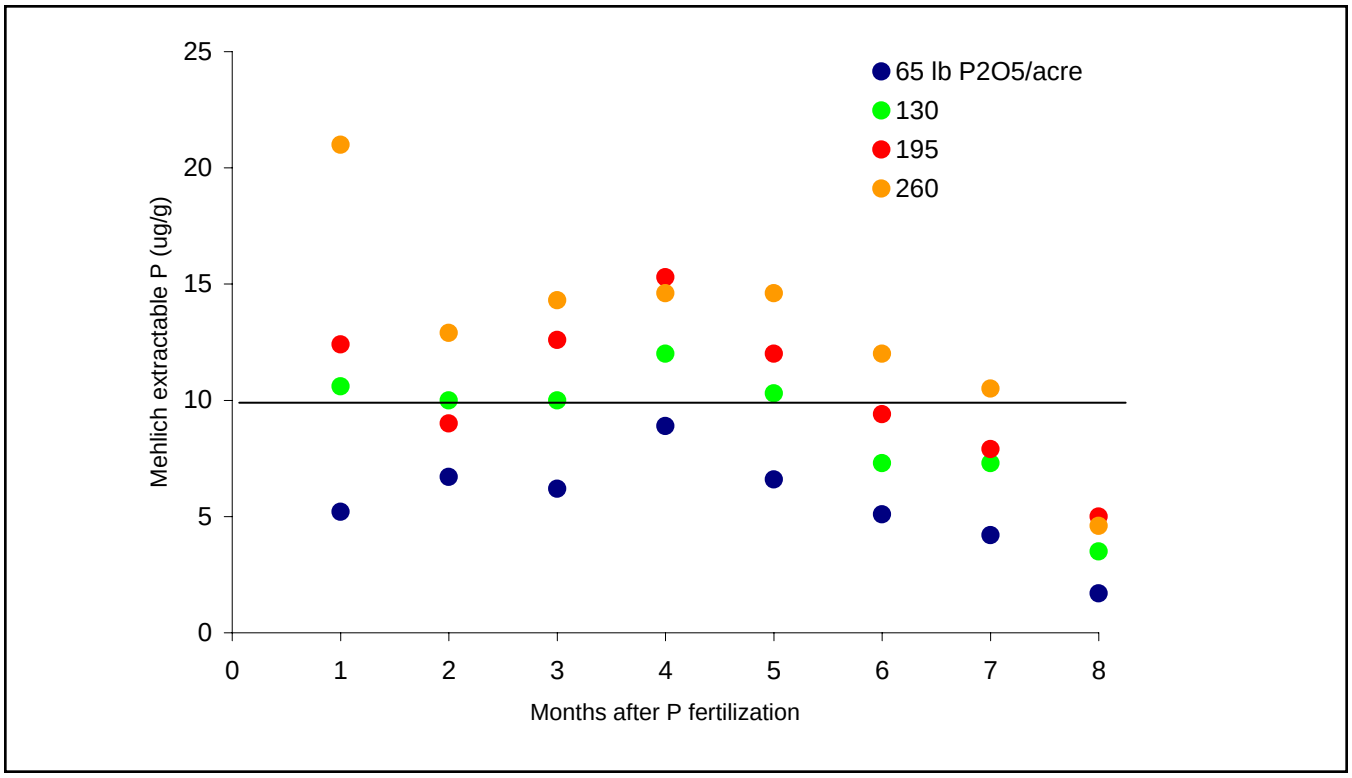

Figure 1. Mehlich extractable soil P as affected by P rate and month of sampling, for eight months after the initial P fertilizer application (2001-2002 study, AU Club).

in two hybrid bermudagrass (cv 'TifEagle') putting greens. The study was performed for two years (2000-2001 and 2001-2002), with new treatments installed in each year in a new section of each putting green. The research was performed at two locations: 1) the Auburn University Club, located in Auburn, AL, and 2) the Auburn University Turfgrass Research Unit located in Auburn, AL. Soil type at the AU Club was a two-year-old USGA-type putting green of 90% sand and 10% reed sedge peat. The location at the AU TGRU was a native soil (Marvyn fine loamy sand) push-up green, sprigged with hybrid bermudagrass in 1999.

The following treatments were applied: 1) P fertilization at rates of 65, 130, 195, and 260 lbs P_2O_5 $acre^{-1}$, and 2) P placement as a broadcast or band application. Phosphorus rates were determined base on an initial soil test for the green, with P applied according to Alabama soil-test recommendations. Thus, 65, 130, 195 and 260 lbs P_2O_5 $acre^{-1}$ represented 1/2x, x, 1.5x, and 2x the recommended rate of P_2O_5, with 130 lb P_2O_5 $acre^{-1}$ as the recommended rate (x).

Phosphorus fertilizer was applied using triple superphosphate (0-45-0, N-P_2O_5-K_2O) which had been ground to greens-grade particle size. Each P rate was applied either as a broadcast or banded application. To broadcast the P the fertilizer, fertilizer was hand-spread evenly across the surface of each plot. Banded P was applied as a vertical 'band' by first core aerifying each plot (3/8 inch diam. tines, 4 inches deep), broadcasting the P rate treatments, and sweeping the fertilizer into the aerification holes. In order to eliminate core aerification as a confounding treatment effect, broadcast-applied plots had been previously (one day in advance) core aerified, with topdressing sand swept into those holes to prevent broadcast fertilizer from falling into the holes. Banded P plots were topdressed as well, immediately following fertilizer application and incorporation.

The study was arranged as a randomized complete block design, with four replications of each P rate/P application combination treatment.

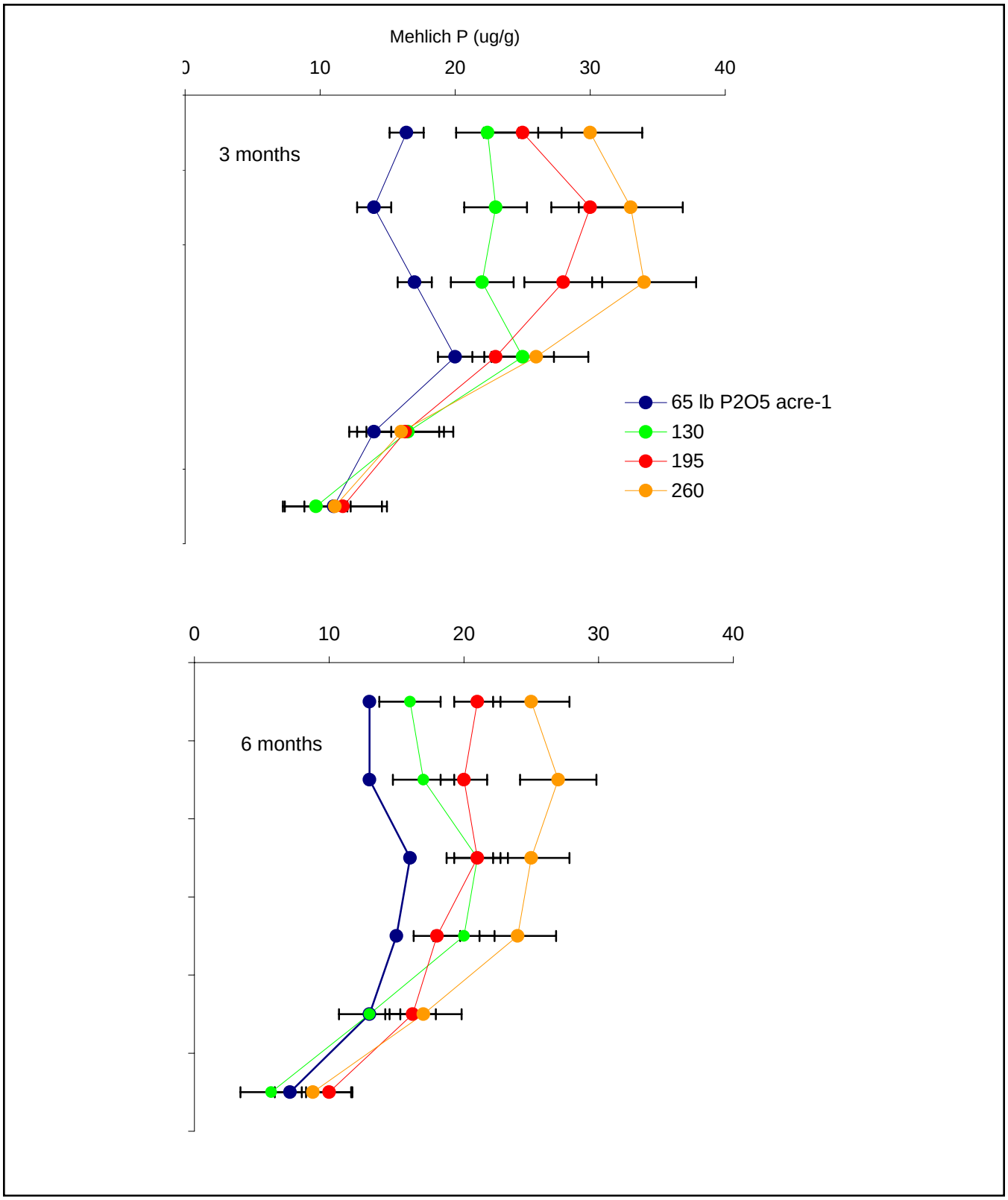

Figure 2. Mehlich extractable P as affected by soil depth (0-12 inches) and P rate at three and six months after P fertilizer application (AU Club, 2001-2002 study).

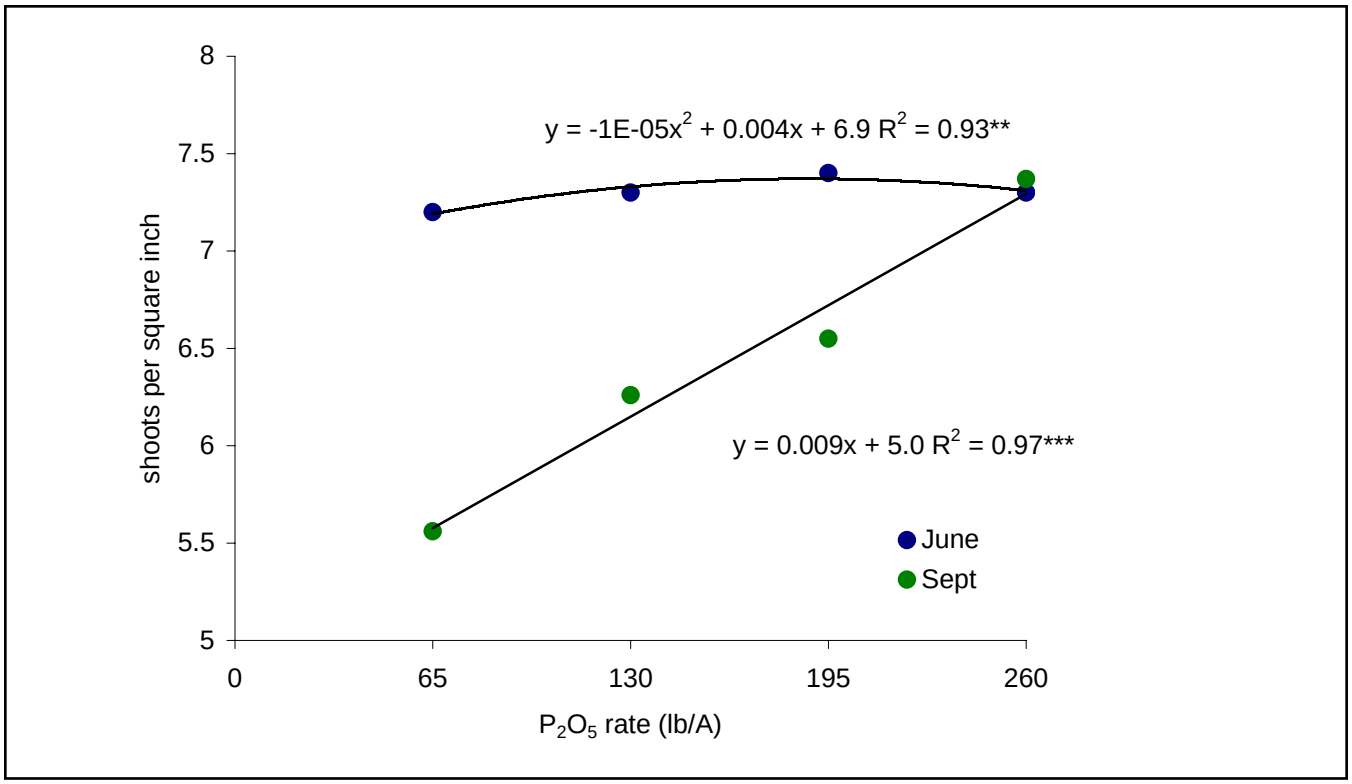

Figure 3. Shoot density of 'TifEagle' hybrid bermudagrass as affected by P fertilization (Auburn University Club, 2001-2002 study). Samples were collected in June, 2002 (10 months after experiment start) and Sept, 2002 (13 months after the experiment started).

In 2000, the studies were initiated in April (AU Club) and July (AU TGRU), and in 2001 the studies were initiated in August at both locations. A 'TifEagle' bermudagrass putting green was used at both locations over the two-year period, with the P fertilizer treatments applied to new areas of the greens in each year.

Monthly soil sampling (0- to 3-inch depth) was performed to determine Mehlich P concentration. Each time that soil samples were collected, clippings were also collected (if possible), and clipping yield and P content were also determined. Every six (2000 study) or three (2001 study) months the plots were sampled by depth, with soil samples collected at 2-inch intervals over a 0- to 12-inch sampling depth. These samples were also extracted with the Mehlich extractant. All soil samples were collected using a 4-inch wide sampling unit (6, 9). Bermudagrass shoot density and root mass were also determined in the second year of the study.

Results

Figure 1 illustrates Mehlich extractable P as affected by P rate and month of sampling for the first 8 months of sampling in the 2001-2002 study (AU Club location). There was never a significant P rate x P method of application interaction, although the main effects of P rate and P method often affected levels of extractable P separately.

When P was applied at the recommended rate of 130 lb P_2O_5 $acre^{-1}$ levels of extractable P remained at or above the sufficiency level (point at which a fertilizer recommendation is made, illustrated by the black line at 10 ug/g in Figure 1) for five months after fertilizer application. Phosphorus fertilizer applied at half the recommended rate did not increase P soil reserves sufficiently, and at that rate additional P fertilizer would always be recommended during our sampling period. Application of P at the two higher rates increased levels of extractable soil P, but by

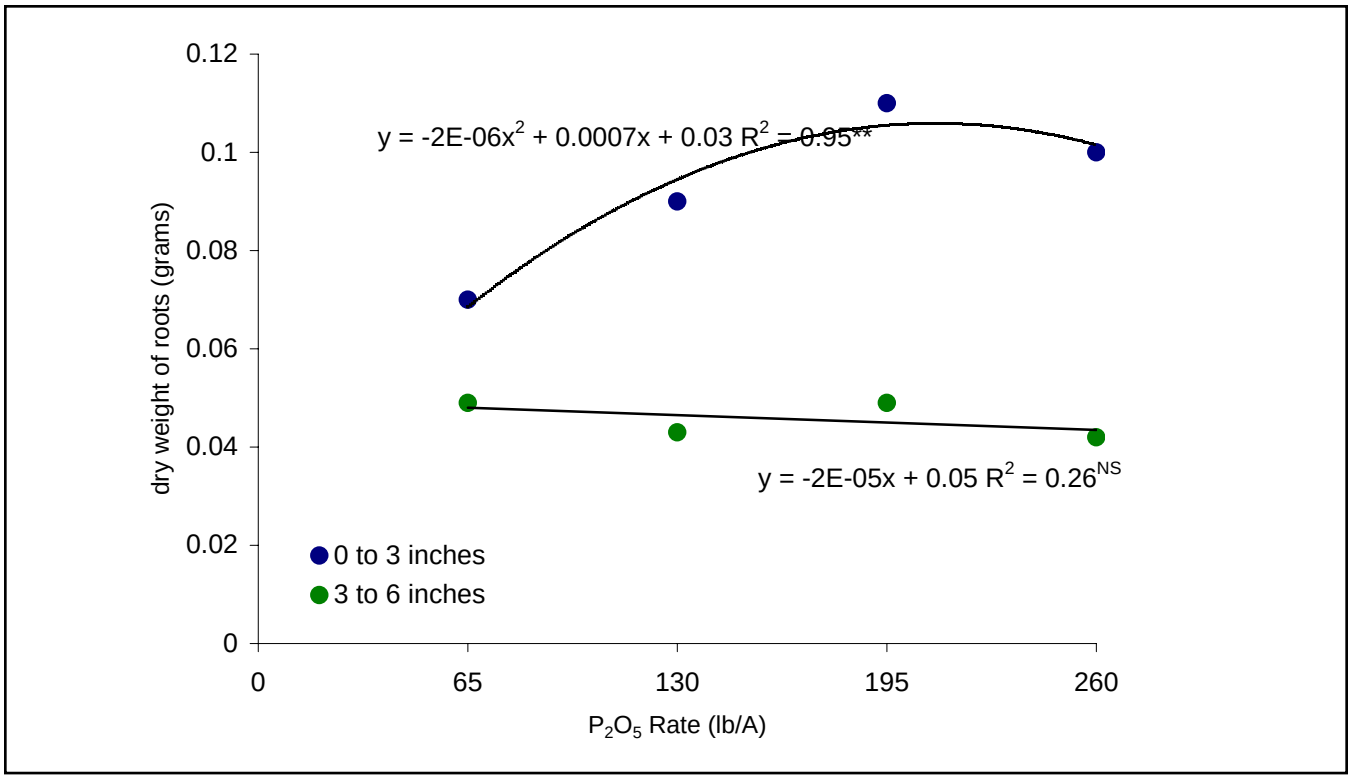

Figure 4. Dry root weight of 'TifEagle' hybrid bermudagrass as affected by P rate and depth of sampling. (Sept, 2002, Auburn University Club)

eight months after sampling additional P fertilizer would have been recommended for all treatments, regardless of initial P fertilization.

Figure 2 demonstrates P movement as affected by P rate at three and six months after P fertilization. The greensmix at the AU Club was a USGA-mix, containing 90% sand, which might be prone to P leaching. At the highest rates of P fertilization there were higher levels of P in the upper six inches of the soil profile. However, at the six-month sampling there was no evidence of downward movement of P, as levels of P declined with sampling depth, regardless of P fertilization rate. Nine- and 12-month depth samplings reflected this same trend (data not shown). Thus, in the two years of study, we did not see excessive downward movement of P, even in greensmix with a high sand content. This short-term finding does not mean P leaching would never occur, as it would be more likely to occur after years of over-application of P, as has been shown in long-term pasture research (1, 7, 8).

In June, 2001, shoot density of the bermudagrass increased as P rate increased to a level of around 200 lb P_2O_5 acre^{-1}. By the end of the test (September), shoot density increased linearly with increasing P rate, a reflection of the continued need for soil P, as no additional P had been applied during the test year.

Phosphorus fertilization affected the dry weight of the bermudagrass roots with root dry weight increasing as P rate increased up to a P rate of 195 lb P_2O_5 acre^{-1}. This impact was only observed in the 0- to 3-inch depth, as root dry weight was unaffected by P rate in the 3- to 6-inch sampling depth. Since the fertilizer P was either surface applied or band-applied into a 4-inch deep hole, applied P would be most likely to create differential treatment effects at the 0- to 3-inch depth, rather than the 3- to 6-inch depth.

The method by which P was applied (band or broadcast) rarely affected Mehlich extractable P, shoot density, or root dry weight. The method of P application sometimes affected P uptake, with more P in harvested clippings from plots which had band-applied P. In the 2000-2001 study at the AU Club, there was a total of seven clipping har-

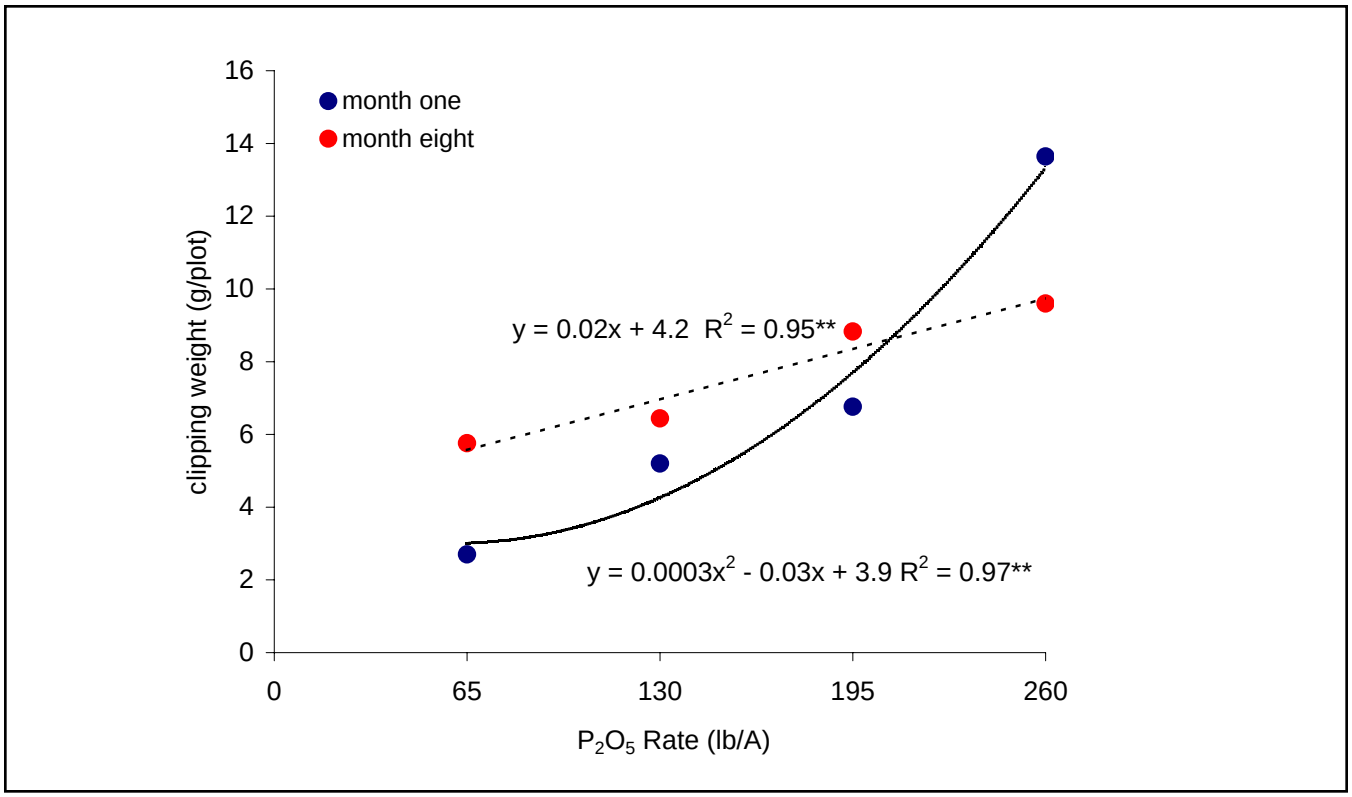

Figure 5. Dry weight of bermudagrass clippings at one and eight months after P fertilization as affected by the inital rate of P fertilization (AU Club, 2001-2002).

vests from which total P was determined. In the 2001-2002 study at the AU Club there was a total of three clipping harvests from which total P was determined. In 2000, there was greater P uptake in band-applied plots at four, five, and seven months after the start of the experiment. In 2001, there was greater P uptake in band-applied plots at one and eight months after the start of the experiment. Such increases in P uptake were only observed at the high-sand greensmix of the AU Club. Uptake of P was not affected by the method of P placement in the native soil green at the AU TGRU.

Clipping yield was almost always affected by P rate, but never by the method of P placement. Additionally, there was never a significant interaction between the two factors. As P rate increased, clipping yield increased, typically maximizing at P rates of between 195 and 260 lb P_2O_5 $acre^{-1}$.

Although banded P has long been used as tool to improve P availability and uptake in no-till corn production, our two-year study saw limited benefits from a vertical "band" of P applied in aerification holes. In fact, the nethod of P application (banded or broadcast) rarely affected the 'TifEagle' hybrid bermudagrass. When P was applied at the recommended rate (130 lb P_2O_5 $acre^{-1}$) we saw little downward movement in a 1-foot-deep sampling depth, even in high-sand putting greens. As P rate increased (to around 195 lbs P_2O_5 $acre^{-1}$), many agronomic measurements of turf quality improved, including shoot density, root dry weight, and clipping yield.

While this two-year study showed limited environmental impact via P leaching, continued work should evaluate P loss over longer periods of time, especially if accumulation of P has been allowed to occur. In our study, applying P according to soil-test recommendations was sufficient (for a three to five month period) to produce quality turf with no measured detrimental impacts.

Acknowledgements

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