A PRACTICAL RESEARCH DIGEST FOR TURF MANAGERS

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AGRONOMY

Runoff of phosphorus from simulated golf fairways

By *Larry M. Shuman*

Phosphorus is not an element that most turfgrass managers would associate with water quality problems. Certainly, pesticides and nitrates easily come to mind when considering possible contamination of surface water. However, recognizing water quality problems and the awareness that there are extremely high maintenance levels for golf courses, sports fields and areas led to concern about phosphorus contamination of surface waters.

Today the media bombard the public with environmental hazard information, and phosphorus has recently been highlighted as a problem, especially related to manure and wastewater applications to grassed fields. This includes concerns about fertilizer phosphorus placed on high maintenance golf courses and other areas. The number of golf courses is escalating, and they often are next to rivers or have streams running through the course. Many have ponds, which can become contaminated by nutrients.

Adding phosphorus at low amounts more often throughout the year is better than putting on a one or two year supply at one time.

In Atlanta, the U.S. Geological Survey has monitored phosphorus in watersheds that impinge on the metropolitan area. Findings show that phosphorus concentrations decreased after phosphate detergents were banned. However, now the phosphorus that is found is thought to come mostly from agricultural and urban fertilizers.

Finding phosphorus sources

The need for determining the sources of this contamination is growing, so that it can be addressed. Especially important is alleviating public concern about commercial operations including golf courses, professional lawn maintenance companies and commercial areas causing surface water pollution through fertilizer applications.

Surface water can be considered phosphorus contaminated with concentrations as little as 50 to 100 µg P /kg (parts per billion). Although algae require both nitrate and phosphorus to live and proliferate, nitrogen is not usually the limiting element.

Phosphorus runoff research has been concentrated in the area of row crop agriculture. There, much of the phosphorus that is carried from the field by rainwater is in the form of "particulate" phosphorus. That is, the phosphorus is physically or chemically bound to soil particles, which are carried off in the form of sediment. Only a portion of this phosphorus is available to algae, and it may require some time before it does become available through desorption or solubility processes. Of course, some of the phosphorus (even from cropland) is carried by the runoff water in the soluble form, which is immediately available to algae.

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Testing and analysis

Recognizing forms of phosphorus has led to the development of testing procedures to estimate the amounts of what is called "biologically available phosphorus." This is a specialized analysis attempting to measure both soluble phosphorus and the portion of the particulate phosphorus that may become available to algae. Other forms measurable in the laboratory are total and soluble phosphorus. The difference between those two forms is designated as particulate phosphorus.

Since there are many parameters that affect phosphorus runoff, it is difficult, if not impossible, to study every soil type, slope, turfgrass type, rainfall amounts, fertilizer sources and other variables that may be encountered. One way to generalize research data is to build models using existing research data on runoff and the many parameters that affect runoff and then use these to predict what will happen in other situations. Current models have been developed for cropland, but are not calibrated or even set up for turfgrass.

Thus, much more data is needed at present just to develop the models, let alone calibrate them once they are developed.

Although phosphorus is certainly needed for good plant growth, it often is added either when not needed or at rates that exceed the needs. One reason is that for fairways, agricultural fertilizer grades are often used because of economics, and are balanced (same percentages of nitrogen, phosphorus and potassium). Phosphorus fertilizer is usually added when the fairway is first seeded or sodded in order to promote good root growth. Thereafter, it is added in the spring and in the Southeast, when the warm-season turf is overseeded with ryegrass in the fall.

Nontarget areas

One situation impacting the quality of runoff water is having fertilizer remain on nontarget areas such as roads, cart paths and other hard surfaces. This fertilizer is washed directly to storm drains that usually exit into streams.

Golf courses are designed with fairly steep grades and with streams and ponds. All these features exacerbate the problem by increasing possible runoff or making runoff water move directly into surface water areas. Although there is some problem with nontarget areas receiving fertilizer in golf courses, this is more likely to be a problem with residential properties. These practices and course design factors have not been scrutinized very carefully to date to determine the risk.

This research is part of a broader project that includes both runoff and leaching of phosphorus.

Although the project emphasizes phosphorus, nitrate leaching and runoff data are also being collected. The goal of the research is to evaluate potential movement of phosphorus and nitrogen following application to golf courses and to develop best management practices to reduce potential transport to potable water systems where eutrophication may lead to reduced water quality. The objectives were to determine the amounts of phosphorus that are transported in runoff from a Southeastern Piedmont soil using various fertilizers at different rates.

Twelve identical Tifway 419 bermudagrass plots were developed on a Cecil soil that are 12 by 25 feet and have a slope of 5% back to front (Fig. 1). At the bottom of the

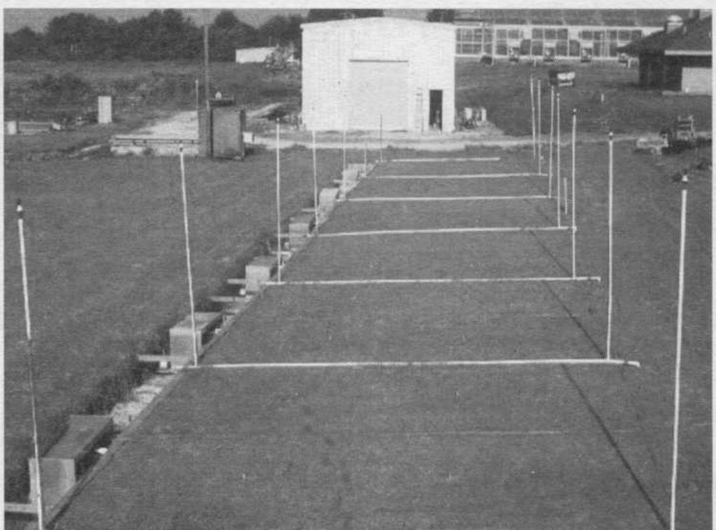

Figure 1. Simulated fairway runoff plots.

slope is a ditch wherein is a trough for each plot to collect runoff water and channel it into measuring and sampling devices. The volume of runoff is measured using tipping buckets that are instrumented with a data logger to count the tips for an individual runoff event.

A sample of the runoff water is also caught in a slit between the two buckets and run into a sample holder for laboratory analysis. The simulated rainfall was provided by overhead sprinklers especially designed for the purpose, which supplied about an inch per hour. For the experiments reported here, 0, 0.22, and 0.44 lb. P/1000 sq. ft. were added in sequential experiments using all the plots as replications. The sources were superphosphate (46% P_2O_5) and a 16-25-12 starter fertilizer.

Rainfall was simulated at the rate of two inches, four hours after treatment (4 HAT) and again two inches at 24 HAT, one inch at 72 HAT and one inch at 168 HAT. The volume was measured and soluble phosphate concentration was determined in the runoff. These are somewhat severe conditions, but not out of the question for the Southeast.

Runoff results

As might be expected, most of the phosphorus that is transported from the simulated fairways by runoff water comes at the first simulated 2-in. rainfall just after the fertilizer is added (4 HAT). Figure 2 shows representative data for P concentrations in the runoff. Here it is for superphosphate, but a similar pattern has always been observed no matter what the phosphorus source or rate.

The volume of runoff is highest at the second simulated rainfall at 24 HAT, but it is not much larger that for the 4 HAT treatment. The 1-in. simulated rainfall events at 72 and 168 HAT yield much less runoff water volume and also much lower phosphorus concentrations as can be seen in Figure 2. These concentrations are very high compared with government guidelines for phosphorus concentrations in streams, which run in the 50 to 100 ppb range (0.050 to 0.100 mg/L in the same units as reported in Figure 2).

However, one has to consider that this phosphorus would have a great dilution before it actually would be measured in stream or pond, so the contribution to the total "load" or weight of phosphorus for the entire body of water would be small. A stepwise increase in the phosphorus concentrations due to the different rates of phosphorus added are evident for both the 4 HAT and the 24 HAT rainfall events. Thereafter, the concentrations are not much different for added phosphorus and the zero added control.

TABLE 1:

PERCENT *P* IN RUNOFF OF THAT ADDED IN FERTILIZER TREATMENTS

Phosphorus Rate	NH4NO3 - Superphosphate	6-25-12	**Mean**
(kg ha-1)	(% in runoff)	(% in runoff)	**(% in runoff)**
11	21	22	**21.5**
21	14	29	**21.5**

Calculating mass

The mass of phosphorus transported from the simulated fairways by the runoff water was calculated by multiplying the phosphorus concentration by the volume of runoff water. These values are not instructive in themselves, but can be used to calculate the percent of the added phosphorus found in runoff.

Table 1 shows that the average percent of phosphorus added that appeared in the runoff for each fertilizer source was 21.5 percent. This rate is quite high and shows the result of the severe runoff conditions imposed in these trials of high rainfall immediately following fertilizer placement. The experiments show extreme conditions that would usually not be found in actual practice.

General conclusions

Our experience in the past three years reveals several conclusions concerning phosphorus transport from golf courses to surface water.

First, leaching of phosphorus from fertilizer applications to greens and fairways does not present a problem. For greens, phosphorus can certainly leach, but in actual practice, very little phosphorus is added to greens after the initial grow-in period.

For fairways, especially in the Piedmont areas of the Southeast, the soil drains slowly and the phosphorus is adsorbed by the soil iron oxides and "fixed" by them forming iron phosphates. However, a potential problem does exist for phosphorus runoff from fairways. Under conditions like those for this experiment, 10 percent to 20 percent of the added phosphorus could be transported to surface waters. Even under less severe conditions, some phosphorus movement is likely.

To exacerbate the problem, the phosphorus that does move into surface water is in the soluble form rather than the particulate form. This form is readily available for use by algae and could contribute to algal "blooms" which deteriorate water quality.

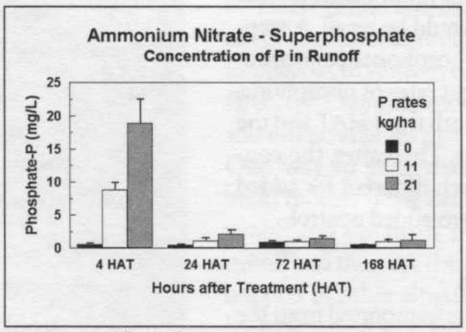

Figure 2. Phosphorus concentration on runoff from simulated fairways for three rates of ammonium nitrate-superphosphate and four rainfall events.

The data generated show that phosphorus can be transported in runoff water under the right conditions of soil moisture, rainfall intensity and time of fertilizer application in relation to rainfall. Under the conditions like those used in these experiments, large amounts of phosphorus can be transported from the turf areas. In actual practice, the rainfall may not be as intense or it may come more than four hours after application, but in many cases the slopes will exceed the five percent used here. Thus, expect some runoff of phosphorus added as fertilizer to fairways.

Turf management options

There are several management practices that can reduce the probability that phosphorus will be transported from fairways to surface water. Most of these are just common sense. First, add less phosphorus. Use soil tests to determine the need for extra phosphorus.

In many cases, the soil will already be at medium or high levels so that added phosphorus is not necessary. Keeping the soil pH at reasonable levels at about 5.6 or above will help to make the phosphorus in the soil more available to the turf. Acid soil pH levels tend to make iron and aluminum more soluble, thus reacting with phosphorus and making it unavailable to the plants.

Following soil test recommendations may lead to less use of balanced fertilizers. If phosphorus is not needed, then an unbalanced fertilizer with no phosphorus would be preferred. Another practice that should be followed is to add fertilizer when the soil is not saturated with water or near saturation. If the soil is relatively dry, rainfall will not be as likely to runoff as it is if the soil is very moist.

Of course, it makes sense not to fertilize if rainfall is imminent. Letting the fertilizer have a few days to react with the soil should cut down on runoff loses. If fact, this is the next aspect of management that we will be addressing in our runoff trials — that of letting giving some time between fertilizer application and the rainfall events. We also will try adding about 0.25 inch of water to wash the fertilizer into the soil. This is a practice that turf managers would be wise to follow so that the fertilizer is in contact with the soil and not sitting on the verdure or the thatch layer. If it is not in contact with the soil, it may be carried off in runoff water as fertilizer granules, dissolving in the water.

Using controlled-release fertilizers may help to reduce runoff losses, but our data show little difference between regular agricultural and slow-release sources. There is a difference between these types for leaching, but not for runoff. Lower rates of phosphorus will help, so adding it at low amounts more often through the year is better than putting on a one- or two-year supply at one time.

Avoid nontarget areas such as cart paths, roadways and other hard surfaces. Fertilizers placed there usually wash directly into storm sewers and surface water. This may mean using drop spreaders instead of cyclone or large truck spreaders. Finally, if you have ponds or streams on your course, test the water for phosphorus (and nitrate) on a regular basis to monitor changes that may be caused by fertilizer applications. If increases are found after applications, better management practices may be necessary.

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