LEACHING OF PHOSPHATE AND NITRATE FROM SIMULATED GOLF GREENS

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Abstract. Fertilizer nutrients can leach from porous golf greens potentially causing degradation of surface water quality through eutrophication. A greenhouse experiment was carried out with 52 cm columns (15 cm diam.) made to US Golf Association green specifications and sodded to bermudagrass to determine the effects of fertilizer sources at various rates on P and N leaching. Fertilizer sources were a soluble salt solution and a granular controlled-release product. Four fertilizer rates were applied each week for 6 weeks. Irrigation rates were 0.63 cm per day initially and increased to 1.25 cm per day at week 7. Weekly leachate collections were analyzed for P and NO_3-N concentrations and volume of the leachate was measured. Concentrations of N and P were lower in the leachate for the granular source than for the soluble source. Leaching of P continued for the entire 23 weeks of the experiment, whereas N was essentially exhausted by week 15 indicating that P leaches at a slower rate than N. For the low P rate (5 kg/ha) for the granular controlled-release source there was no increase in P concentration in the leachate compared to control. Thus, low P rates will not result in degradation of water quality due to increased P. Results show that P leaching is a potential problem only at high rates of soluble sources and high irrigation, whereas N is more readily leached.

INTRODUCTION

Water quality is becoming more of a public concern, and one of the pollutants is plant nutrients, which can cause eutrophication. Intensively managed golf courses, where many applications of fertilizer and high irrigation rates are used, are certainly part of that concern. Sandy golf greens are especially designed to drain quickly, which presents a dry playing surface and helps keep the turf healthy, but may exacerbate leaching of nutrients such a nitrate and phosphate. Data from sand-based greens show that the nitrate concentrations in the leachate can exceed the 10 mg/L drinking water standard for most of the growing season (Brown et al., 1982) and in another study on an animal pasture nitrate exceeded 35 mg/L for months even where no fertilizer was added (Magesan et al, 1996). The nitrate leached is related to both fertilization rates and irrigation rates. Certain controlled-release fertilizer sources can increase plant use efficiency and possibly help reduce leaching.

Although there are considerable data available on nitrate leaching from golf greens, there are very little available on phosphorus. Phosphorus can be more of a problem for increased eutrophication because it is often the limiting element. Most phosphorus research on contamination of surface waters comes from agricultural cropping systems where high rates of inorganic fertilizers are used or where manures, which are high in phosphorus, are used. Although little leaching is expected in fertile agricultural soils, leaching can be a problem in sandy soils. Column leaching experiments have indicated that phosphorus will move in soil profiles at high flow rates. One study yielded 1 to 13 mg/L phosphorus in the leachate, enough to degrade water quality (Gerritse, 1996). The current study was initiated with the objective of determining the effect of fertilizer sources at various rates on leaching of phosphorus and nitrate-nitrogen from simulated golf greens.

MATERIALS AND METHODS

Greenhouse lysimeters (32) were constructed to include turfgrass growth boxes (40 X 40 X 15 cm deep) on top of columns (Smith et al.,1993). At the inside-center of the growth boxes a 13-cm length of polyvinyl chloride (PVC) tube (15 cm diam.) was fastened to the bottom with acrylic caulk. The base of the lysimeter consisted of a 52 cm length of PVC tubing (15 cm diam.) capped at the bottom with a drain tube for the collection of leachate. The rooting mixture (sand:sphagnum peat moss) used had proportions of 80:20 sand:peat by volume (96.8:3.2 by mass). This mixture has been prescribed by the USGA for bermudagrass greens. The lysimeter bases are filled with sized gravel (10 cm), coarse sand (7.5 cm), and rooting mix (35 cm) in ascending sequence simulating USGA specifications for greens construction. 'Tifdwarf' bermudagrass sod was placed on the rooting medium in the growth boxes on 14 and 15 May, 1998.

A track irrigation system controlled the rates and times of irrigation. The boxes were irrigated daily at 0.625 cm. for the first seven weeks of the experiment. The irrigation rate was too low and resulted in very low leachate rates, so the irrigation rate was doubled for the next seven weeks. The irrigation rate was returned to 0.625 cm/day for the next four weeks and was again increased to 1.25 cm/day for the last five weeks of the experiment because of low leachate volumes. The turf was mowed twice a week at a height of 1.0 cm. using a hand clipper to simulate a reel-type mower.

The fertilizer source-rate experiment consisted of two sources at four rates. The sources were a Peters water-soluble 20-20-20 (dissolved in 200 mL water per treatment) and a Lesco sulfur and poly-coated micro-granule 13-13-13. The Lesco fertilizer is designed to release nutrients over an 8 to 12 week period. The rates were 0, 0.25, 0.5 and 1.0 lb. N/1000 sq. ft. (0, 12, 24, and 49 kg N/ha) and 0, 0.11, 0.22, and 0.44 lb. P/1000 sq. ft. (0, 5, 11, and 21 kg P/ha) per application. Each treatment was replicated four times in a completely randomized block design. The above rates were placed on the turf on 9 June, 1998 (week 1), and the same rates repeated every two weeks for a total of six treatments. The last treatment was on 18 August, 1998 (week 11). The first leachate samples were taken on 9 June, 1998, and continued weekly until 10 November, 1998, (week 23) . Nitrate-N and phosphate-P were determined colorimetrically using a LACHAT flow analyzer on samples that were filtered through 0.45 μm filters, which results in the "soluble" form of phosphorus

RESULTS AND DISCUSSION

Leachate volume was low initially, so phosphate concentration was low (Fig. 1). However, when irrigation was increased above the standard irrigation rate, a "spike" appeared at week 9 where the phosphate held in the column was evidently flushed through. Brown (1977) also found the same effect where leaching was low until irrigation exceeded the evapotranspiration rate. The concentrations then decreased until week 11 where they peaked for the soluble fertilizer source. They peaked a week later for the controlled-release source. The curves show that phosphorus leached rather slowly leaving long "tails" after the peaks. The lowest phosphorus rate (5 kg/ha) resulted in essentially no leaching for the controlled-release 13-13-13 source, whereas significant leaching resulted for the soluble source at that rate.

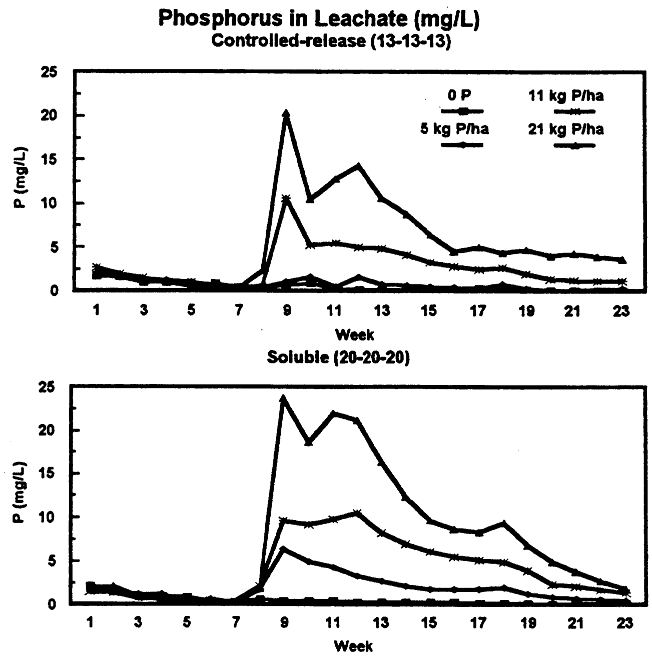

Fig. 1. Phosphorus concentration in leachate for two fertilizer sources at four rates.

Nitrate-nitrogen concentrations in the leachate for the highest rate were higher for the soluble source than for the controlled-release source (Fig. 2). The initial leachate concentrations were near 10 mg/L for all rates including the control. This nitrate must have come from mineralization of the peat in the rooting mix. The peaks for the nitrate concentrations were later for both sources for the higher than for the lower application rates, and were 2 weeks later for the controlled-release then the soluble source (week 9 vs. week 11). Note that nitrate peaks appeared before the irrigation rate was increased at week 8. For both sources all the nitrate was essentially leached by week 15, only four weeks after the last of the six treatments on week 11. This result is quite different than for the phosphorus which continued to leach for the entire 23 weeks of the experiment.

The concentrations of phosphorus in the leachate the 11-week peak are shown in Fig. 3. The soluble fertilizer source resulted in higher phosphorus concentrations for all rates (except control), but more so for the lowest rate (5

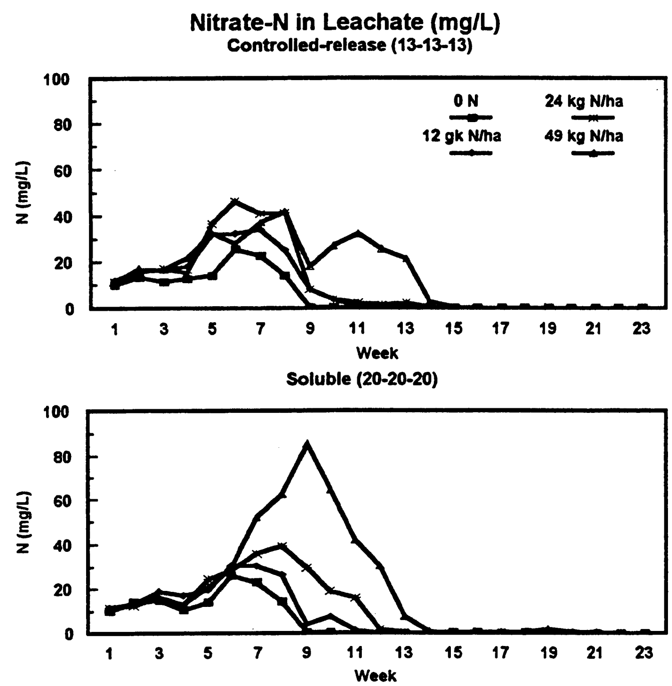

Fig. 2. Nitrate-nitrogen concentration in leachate for two fertilizer sources at four rates.

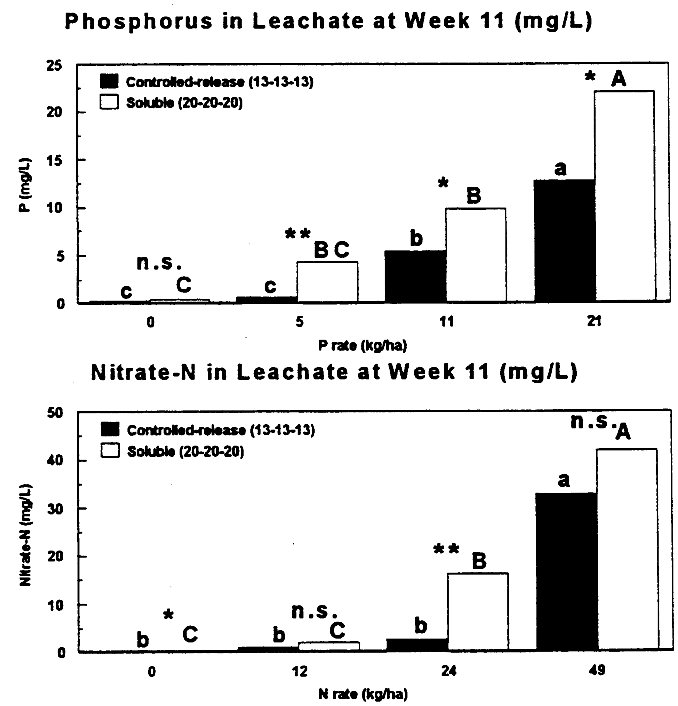

Fig. 3. Phosphate and nitrate-N concentrations in the leachate at the peak at week 11.

kg/ha). The only sinks for the phosphorus in this case is root uptake, adsorption by the soil complex and leaching. The controlled-release source may have been used by the turf more efficiently at the low rate where slow release allowed more uptake before leaching from the root zone. Another explanation would be that the phosphorus was adsorbed more by the rooting medium for the slow-release source. The nitrate concentrations at week 11 show that the sources were different only for the 24 kg/ha rate with the soluble source resulting in much higher nitrate in the leachate than the controlled-release source.

By multiplying the volume of leachate by the concentrations of nitrate and phosphorus, one can determine the total mass of elements leached and also determine the percentage leached of that added. The percentages for phosphorus for the soluble source were all high in the 50-60 % range. However the controlled-release source had less than 10 % leached for the low phosphorus rate. For the low rate of nitrate, the percentages were similar for the two sources at about 20%. For the higher nitrate rates, the soluble source had considerably higher percentages than the controlled-release source. These data show the efficacy of "spoon feeding" golf greens to increase plant use of the nitrate and phosphate and thus decrease leaching.

CONCLUSIONS

The source and rate of fertilizer nitrate and phosphate along with irrigation rate all influence the leaching of these elements from US Golf Association specification golf greens. Results of these experiments show that controlled-release fertilizers will reduce the rate of leaching of both nitrate and phosphate, but more so for nitrate than phosphate. The application rate for phosphorus was the critical factor in leaching, since only at the lowest rate (5 kg/ha) was there a low percentage loss of applied phosphorus in the leachate. The need to use controlled-release fertilizers at the lowest rates feasible, especially at high irrigation rates, is borne out by the results of this experiment. These management practices, along with use of irrigation rates that do not greatly exceed the evapotranspiration rate, will help reduce leaching from golf greens and reduce surface water nutrient loadings that could cause eutrophication.

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