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TURFGRASS TRENDS

NITROGEN AND LEACHING

Do Organic Nitrogen Sources Leach Less Nitrate from Turf?

By Richard J. Hull, José A. Amador, Haibo Liu and Joseph C. Fetter

In an effort to minimize the amount of fertilizer nitrogen (N) that might leach as nitrate-N into ground water, many turf managers have resorted to using natural organic N fertilizers. This is done in the belief that such materials contain less readily soluble N and thus release nitrate-N into soil water more slowly, resulting in greater uptake by plant roots and less potential for nitrate leaching. While this seems reasonable, there are few published studies that actually compare nitrate leaching from organic and synthetic N sources applied to turf. However, a recent report from the University of Rhode Island concludes that there might be little if any difference in nitrate leaching between organic and synthetic N fertilizers.

Squid hydrolysate vs. synthetic N fertilizers

In this study, a by-product of calamari production (squid waste) was hydrolyzed and formulated into a liquid fertilizer stabilized with phosphoric acid (3.3-7.3-2 = % N-P_2O_5-K_2O) or combined with clay and extruded as granules (7.2-1.2-2). These materials were applied to perennial ryegrass (*Lolium perenne*) turf plots at the University of Rhode Island Turf Research Farm at rates of 1, 3 and 6 lbs. N/1,000 sq. ft./year (43, 130 and 260 lbs. N/acre/year). These were compared with commercial synthetic liquid and granular fertilizers (20-9-20 and 19-5-9, respectively) applied at the same N rates and times. The synthetic liquid fertilizer contained 7.6 percent ammonium-N and 12.4 percent nitrate-N. The synthetic granular fertilizer contained 8.3 percent ammonium-N, 5.5 percent water-insoluble N, 2.2 percent urea and 3 percent other water-soluble N. An unfertilized control treatment was also included for a total of five treatments at each rate of N applied. Eight liquid applications were made between May 2008 and October 2009, while four granular applications were made at twice the N rate during each year. Differences in seasonal values of nitrate-N in soil pore-water and in amounts of nitrate-N leaching among fertilizer types and formulations within or among application rates were analyzed using a Kruskal-Wallis one-way analysis of variance. Statistical significance was evaluated at $p \leq 0.05$ (95 percent probability).

Soil water samples were collected every two weeks in suction lysimeters that had been installed in each plot with the porous ceramic sampling cup set at a

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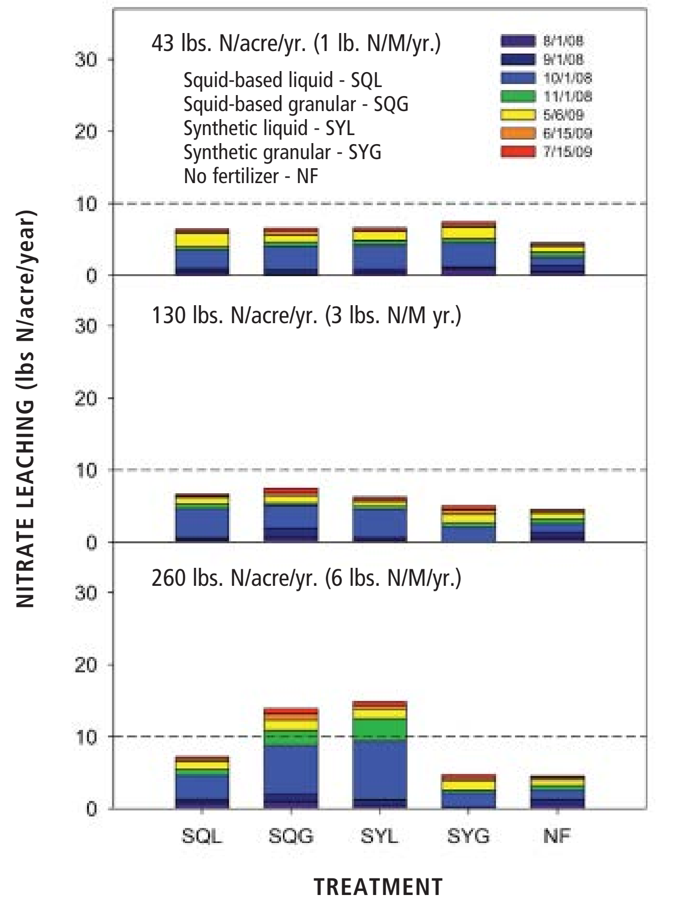
FIGURE 1



Mass of NO_3-N leached from perennial ryegrass plots fertilized with squid and synthetic hydrolysate applied in liquid and granular form at three nitrogen rates between July 15, 2008 and July 15, 2009. Horizontal dashed line indicates N that fell naturally on the turf as particulate deposition and N dissolved in rainfall.

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soil depth of 24 inches. The nitrate-N concentration in soil water samples was determined by a standard colorimetric method. The volume of water percolating through the soil was calculated for each sampling period using a model that totaled rainfall and irrigation and subtracted water loss by evapotranspiration. When water additions exceeded estimated losses for a sampling period, that excess water was assumed to have leached through the soil. Nitrate leaching was estimated by multiplying the volume of water that percolated through the soil for each leaching event by the nitrate-N concentration in soil water collected after the most recent leaching event. The average nitrate-N leached from each fertilizer-rate treatment during the experimental period is summarized in Fig. 1.

It is evident that no significant differences in nitrate-N leaching were detected among the squid formulations, synthetic N sources or unfertilized plots when N was applied at 1.0 or 3 lbs. N/1,000 sq. ft./year (43 or 130 lbs. N/acre/year). Only when N was applied at 6.0 lbs. N/1,000 sq. ft. / year (260 lbs. N/acre/year) did the granular squid hydrolysate and the liquid synthetic N source appear to leach more nitrate-N than the other fertilizer treatments and the unfertilized plots. Even these differences were significant only during a few fall sampling periods and not when nitrate-N losses for the full year were analyzed.

To put these nitrate leaching losses in perspective, only the squid granular and synthetic liquid formulations when applied at 6.0 lbs. N/1,000 sq. ft./year leached more N than that which fell naturally on the turf as particulate deposition and N dissolved in rainfall — an amount approximating 10 lbs. N/acre/year (horizontal dashed lines in Fig. 1). Even these excesses were attributable to only two or three leaching events occurring during the fall from plots receiving N at the excessively high rate of 260 lbs. N/acre/year.

Comparison of six organic nitrogen sources

The results of this comparison in nitrate leaching between organic and synthetic fertilizers reminded us of an earlier study in which nitrate leaching from six organic N sources applied to four cool-season turfgrasses was compared (Hull et al., 1992). This research was presented at the 1992 meeting of the Turfgrass Science Division (C-5) of the Crop Science Society of America but never formally published as a journal paper. The six N fertilizers compared were:

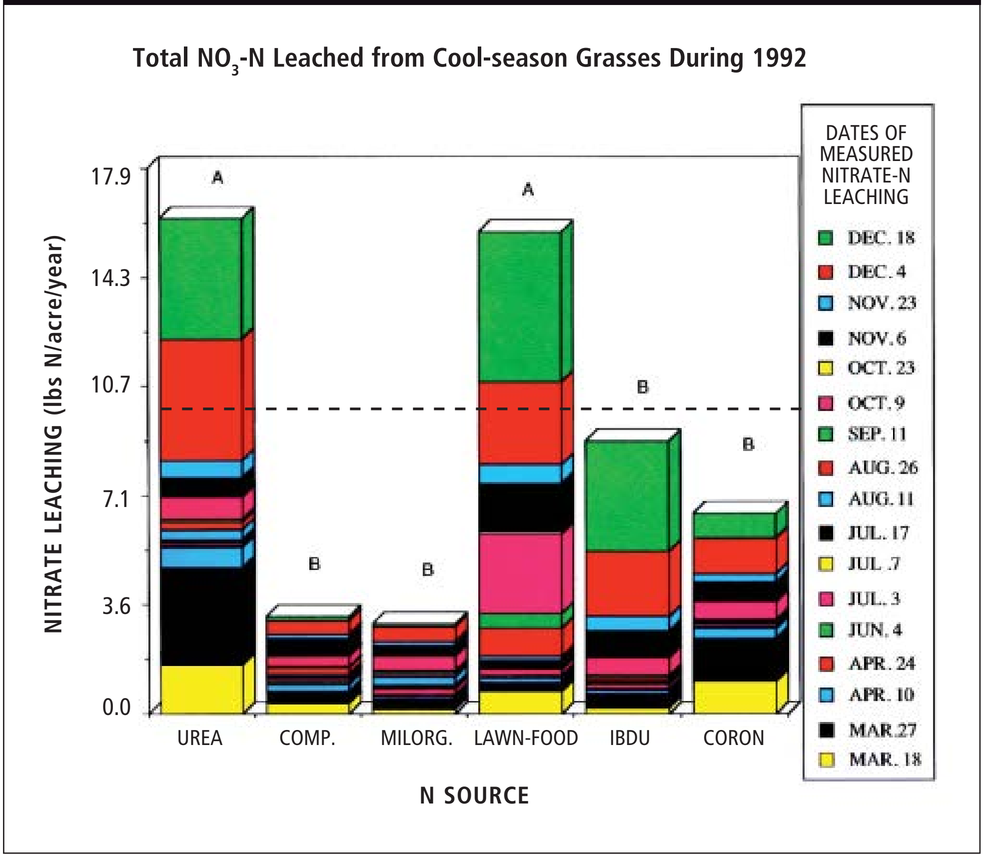
Coron (28-0-0) – Methylene urea liquid formulation

Earthgro cow manure (1.5-2-4) – Cow manure composted soil amendment

Earthgro lawn food (8-2-4) – Leaf and mushroom spoil compost + $NaNO_3$

IBDU (31-0-0) – Urea-based compound – N release via chemical hydrolysis

FIGURE 2



Mass of NO_3-N leached from four turfgrass species fertilized with six natural or synthetic N sources during 1992. Values are the average of four grasses and two fall application dates. Bars topped by a different letter are significantly different. The horizontal dashed line indicates N that fell naturally on the turf as particulate deposition and N dissolved in rainfall.

Milorganite (6-2-0) – Digested sewage sludge

Urea (46-0-0) – Water-soluble organic nitrogen compound

These materials were applied at 3.5 lbs. N/1,000 sq. ft./acre/year (155 lbs. N/acre/year). An application of 2.5 lbs. N/1,000 sq. ft. (110 lbs. N/acre) was made in mid-September or late November, with an additional 1.0 lb. N/1,000 sq. ft. (45 lbs. N/acre) applied in mid-June. The four turfgrasses used in this study were Chewings Fescue cv. Jamestown (*Festuca rubra* ssp. *commutata*), Hard Fescue cv. Scaldis (*Festuca trachyphlla*), Kentucky Bluegrass cv. Georgetown (*Poa pratensis*) and Perennial Ryegrass cv. Repell. Soil water nitrate concentrations and nitrate leaching estimates were determined using essentially the same methods employed in the squid hydrolysate experiment. The cumulative values of nitrate leaching from the six nitrogen sources during the year are summarized in Fig. 2.

The greatest nitrate-N leaching rate was measured from plots fertilized with urea and Earthgro lawn-food (about 16.5 lbs. nitrate-N/acre). The leaching rate was equivalent to 11 percent of the 155 lbs. N/acre applied. Urea would be expected to leach nitrate since it is rapidly hydrolyzed to ammonia (NH_3) and carbon dioxide (CO_2) with the ammonia readily oxidized to nitrate. Earthgro lawn food – being a composted natural organic material – would not be expected to leach much nitrate, had it not been amended with sodium nitrate ($NaNO_3$) to increase its N content so that it could be marketed as a fertilizer. This nitrate would be immediately available for leaching as soon as rain or irrigation provided water to carry it through the soil. By comparison,

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Earthgro cow manure compost contained only ~1.5% N but also was applied at a rate sufficient to deliver the same 155 lbs. of N/acre during the year. So much of this material was required to apply the 155 lbs. of N/acre that the turf received a virtual topdressing. Its N was so slowly released into the soil solution that most was absorbed by grass roots and nitrate leaching amounted to little more than 3 lbs. N/acre (<2 percent of that applied). Milorganite is a digested sewage sludge, so it contained little free nitrate or ammonia and behaved in the soil much like most composted organic N sources. Its N was slowly oxidized to nitrate and was readily absorbed by plants, leaving little free for leaching.

The results of this comparison in nitrate leaching reminded us of an earlier study.

The IBDU and Coron were probably most similar to the synthetic nitrogen sources with which squid hydrolysate was compared in the 2008-2009 study. In that experiment, the 130 lb. N/acre (3.0 lbs. N/1,000 sq. ft.) rate leached between 6 and 7 lbs. of nitrate-N, which was about 5 to 6 percent of N applied; similar to the amount leached from the 155 lb. N/acre (3.5 lbs. N/1,000 sq. ft.) of nitrogen as IBDU and Coron. The most significant nitrate leaching from these materials occurred following the mid-September application, with the mid-November application leaching much less nitrate. In late summer, root systems of cool-season turfgrasses are reduced due to the stresses of summer heat, insect feeding and drought. However, the soil is warm and favorable for hydrolysis of organic N sources and rapid oxidation of ammonia to nitrate. With a weakened root system having an impaired capacity for nutrient absorption, nitrate was free to leach through the shallow root zone. By late November and early December, turf roots have recovered substantially and the soil is colder, delaying the rate of nitrate release from organic fertilizers. Thus, less leached nitrate from late-November fertilizer applications was recovered in the two-foot deep lysimeters. Accounting for the delay in nitrate leaching to the depth of the lysimeter collection cups, the pattern of nitrate leaching observed in these two studies provides support for this scenario. Fig. 2 presents an average of both mid-September and late-November fertilizer applications, so differences in their leaching are obscured. However, it is evident that late season nitrate leaching was greater than at any other time of the year.

A few important aspects of fertilizer-derived nitrate leaching from cool-season turf are suggested by these studies:

A) If any N source is applied at a reasonable rate to healthy turf when the roots are capable of absorbing nutrients, nitrate leaching will account for less than 10% of the N applied.

B) Readily soluble and easily hydrolyzed N sources may leach significant nitrate below the root zone if conditions stated in (A) are not present and rainfall or irrigation are sufficient to promote free percolation through the soil.

C) Frequent applications of N fertilizers in small amounts will result in less nitrate leaching than one or two large applications.

D) The nitrate leaching potential of organic and synthetic nitrogen fertilizers is essentially the same.

E) Organic N fertilizers may leach more nitrate-N if, in their processing, extensive hydrolytic reactions occur, thereby increasing their content of free ammonia or nitrate. Be sure the sources and forms of N are identified on the label of any fertilizer used on turf.

While each situation is unique, following these general rules should minimize nitrate leaching from turf and protect the quality of your ground and surface water resources.

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