Inorganic Soil Amendments in New Sand-Based Rootzones Can Reduce Nitrogen Loss

By Cale A. Bigelow

Most modern golf course putting green root zones are constructed using high sand contents, sometimes 90 percent or more by volume. Sand is an excellent rootzone material for heavily trafficked areas such as putting greens because it resists compaction and maintains air-filled porosity and drainage. Furthermore, it is a relatively inexpensive material and is readily available most anywhere.

Although sands provide favorable soil physical properties, nutrient retention is generally poor and water-soluble nutrients like nitrogen are prone to leaching.

Young putting greens may receive 6 pounds to 8 pounds of actual nitrogen per 1,000 square feet annually, and applications of 10 pounds to 12 pounds during the first year of establishment are not uncommon.

Often nitrogen is supplied using highly soluble sources like ammonium sulfate or urea. Given all of the following conditions — porous rootzone media, water-soluble nitrogen applications, and regular irrigation — it is easy to see why nitrogen loss is a concern.

It is well-documented that a dense mature turfgrass system, even on sandy soils, is very effective in capturing nitrogen because of its extensive root system. Although the potential for nitrogen leaching from mature turfgrass systems may be rather low, the same is not true for young turfgrass plants on newly built sand rootzones. In these situations, turfgrasses are either planted as seed or sod that is frequently irrigated because there is little or no root system to absorb water from the rootzone.

Light, frequent irrigation is required to ensure survival. Not only is the shallow root system unable to explore the rootzone for water, it is also less efficient at nitrogen absorption, which further increases the leaching potential.

Historically, the most popular method for sand-based golf green construction has suggested amending sand with a stabilized organic matter, such as peat moss (USGA, 1993). This amendment is added to improve water and nutrient retention. In the past, many inorganic soil amendments, such as porous ceramics, diatomaceous earth and clinoptilolite zeolites, have been investigated and marketed as alternatives to peat moss (Davis et al., 1970; Waddington et al., 1974). These inorganic products may be better suited to sand rootzones because they are not susceptible to biological degradation and may sustain the original rootzone physical properties longer than peat moss.

Several researchers have documented the benefits of various porous ceramics and zeolites on turf establishment and growth when incorporated into sandy growing media. These results are not surprising since the base mineral for most porous ceramics is clay and many clays and zeolites have cation exchange capacities ranging from 50 centimoles of charge per kilogram (cmolc/kg) to 220 cmolc/kg compared to sand, which often is less than 1 cmolc/kg.

Most surprising was that by incorporating either of these amendments to even a rather shallow depth of 1 inch, ammonium losses could be decreased by almost 25 percent.

While a wealth of research information exists for several zeolites, comparable data for other commercially available inorganic amendments or experiments directly comparing the amendments to peat moss has been lacking. Thus, the objective of these laboratory studies was to evaluate how a variety of inorganic soil amendments compared to a sphagnum peat moss for reducing nitrogen leaching in simulated quartz sand putting green rootzones. Specifically, the effects of amendment type, incorporation rate and depth were documented.

Experimental procedures

A locally available washed quartz sand conforming to USGA size guidelines was amended with the following amendments: Irish sphagnum peat moss; a clinoptilolite zeolite (Ecolite); an extruded diatomaceous earth containing 5 percent of a clay binder (Isolite); and two porous ceramic products (Greenschoice and Profile).

The cation exchange capacity (CEC) of each of the inorganic amendments was:

- 185 cmolc/kg to 220 cmolc/kg for zeolite;
- 1.0 cmolc/kg for shale-based porous ceramic;
- 0.8 cmolc/kg for diatomaceous earth;
- 33.6 cmolc/kg for clay-based porous ceramic; and
- 75 cmolc/kg to 100 cmolc/kg for sphagnum peat.

Values were taken from the manufacturer's product literature. A complete description of all experimental procedures can be found in Bigelow et al., 2001.

Briefly, however, sand or amended sand mixtures were installed into 3-inch-diameter by 12-inch-tall acrylic columns, placed over a 4-inch-tall gravel sub-layer.

After 24 hours at saturation, each column was placed on a screen and allowed to drain for 24 hours to reach field capacity. A liquid ammonium nitrate solution containing nitrogen equivalent to 1 pound nitrogen per 1,000 square feet was applied to the surface of each rootzone and leached with twice-distilled water.

The leachate was collected in small aliquots and analyzed for the presence of ammonium (NH_4 +-N) and nitrate (NO_3-N).

Amendment effects

When incorporated at 20 percent by volume, all amendments significantly decreased ammonium loss, which ranged from 8 percent to 69 percent (Table 1).

In this experiment the two most effective amendments were Ecolite and Profile, which decreased ammonium losses to only 8 percent and 21 percent, respectively, compared to unamended sand. Since no amendment had a significant effect on nitrate leaching — meaning that more than 90 percent of applied nitrate was recovered (data not presented) — this aspect will not be discussed.

TABLE 1

Peak concentration and percentage loss of ammonium in the effluent of sand amended at 20 percent by volume with four inorganic soil amendments and sphagnum peat:

	AMMONIUM (NH4-N) NITROGEN	
Soil amendment	Peak concn. (ppm)	Total loss (percent)
Nonamended sand	59.3 a[z]	96.2 a
Ecolite	3.3 c	7.8 e
Isolite	23.9 b	63.9 b
Profile	8.4 c	21.3 d
Greenschoice	26.9 b	69.4 b
Sphagnum peat	11.0 c	37.7 c

[z] Mean separation within columns by Fisher's protected LSD (P=.05).

As the incorporation rate for the two most effective amendments, Profile and Ecolite, increased from 1 percent to 20 percent by volume, ammonium nitrogen losses decreased in a stepwise manner, with the 20 percent rate resulting in the least losses for both amendments (Table 2).

No difference in nitrogen retention between the two products was observed, except at the 20-percent rate, where significantly less ammonium leached from the Ecolite-amended sand, probably because of the slightly higher CEC soil — 9.6 cmolc/kg vs. 4.6 cmolc/kg — for the 20 percent Ecolite- and Profile-amended sand mixtures, respectively.

Incorporating either of these amendments at 20 percent by volume throughout the entire rootzone depth could be extremely expensive. Thus, it was determined that a 10-percent-by-volume rate would be most cost effective for most situations with only modest decreases in ammonium losses compared to the 20 percent incorporation rate (Table 2).

Based on the results obtained in the amendment rate experiment, the effect of incorporation depth was studied with Ecolite and Profile mixed at 10 percent by volume to 1 inch, 6 inches and 12 inches. Again, as expected, a step-wise decrease in leaching

Continued on page 76

Continued from page 75

losses was observed as incorporation depth increased from 1 inch to 12 inches (Table 3).

What was most surprising was that by incorporating either of these amendments to even a rather shallow depth of 1 inch, ammonium losses could be decreased by almost 25 percent, compared to the unamended sand.

TABLE 2

Peak concentration and percentage loss of ammonium in the effluent of sand amended with Ecolite and Profile at 1 percent, 5 percent, 10 percent and 20 percent by volume:

Soil amendment	Depth (inches)	AMMONIUM (NH4-N) NITROGEN Peak concn. (ppm)	Total loss (percent)
Nonamended sand	0	58.4	95.7
Ecolite	1	49.6 a[y]	75.0 a *[x]
	5	39.1 a ***	52.3 b *
	10	10.3 b ***	17.0 c *
	20	4.3 b ***	7.7 d *
Profile	1	52.3 a	78.7 a *
	5	25.4 b ***	51.6 b *
	10	11.4 c ***	32.6 c *
	20	6.7 c ***	22.4 d *

[x] Means within the same column followed by * or *** are significantly different from nonamended sand at P<.05 or .001, respectively.

[y] Means within columns for the same soil amendment followed by the same letter are not significantly different at P=.05 by Fisher's protected LSD.

TABLE 3

Peak concentration and percentage loss of ammonium in the effluent for sand amended with Ecolite and Profile at 10 percent (v/v) incorporated to 1-, 6- and 12-inch depths:

Soil amendment	Depth (inches)	AMMONIUM (NH4-N) NITROGEN Peak concn.[z] (ppm)	Total loss (percent)
Nonamended sand	0	61.9	97.6
Ecolite	1	30.7 a[y] ***[x]	68.2 a *
	6	20.1 ab ***	38.2 b *
	12	10.4 b ***	17.6 c *
Profile	1	38.1 a ***	76.6 a *
	6	19.9 b ***	49.4 b *
	12	11.4 c ***	32.2 c *

[x] Means within the same column followed by * or *** are significantly different from nonamended sand at P<.05 or .001, respectively.

[y] Means within columns for the same soil amendment followed by the same letter are not significantly different at P=.05 by Fisher's protected LSD.

Conclusions

These experiments support previously published reports regarding ammonium and nitrate movement in newly constructed sand-based rootzones.

As was previously reported by numerous other researchers, nitrogen leaching in unamended quartz sands can be initially very high, exceeding 95 percent of the applied nitrogen especially when turfgrass is not present or mature.

Ammonium losses, however, can be reduced substantially to more than 8 percent by incorporating certain inorganic amendments like Ecolite or perhaps Profile and to a lesser extent sphagnum peat, provided these amendments are providing sufficient CEC to capture the positively charged ammonium nitrogen molecule.

Nitrate leaching will continue to be a concern in any sand-based rootzone, particularly during turfgrass establishment. One potential solution to this problem would be to implement best-management practices to minimize leaching. These would be selecting a properly sized sand that does not allow excessive percolation and amending the sand with one or more of the following amendments: peat moss, zeolite or a relatively high CEC porous ceramic like Profile.

During the grow-in period the young turf should be fertilized with either a controlled-release fertilizer or a water-soluble fertilizer that is predominantly ammonium based so that any nitrogen that bypasses the roots can be retained in the amendments.

Some practical questions remain: Is more amendment really better? Should I use amendments in a new construction?

Although Ecolite and Profile were effective in these experiments for decreasing nitrogen leaching, they cost considerably more (five times greater or more) than peat moss when used at equal incorporation amounts (Moore, 1999). This may limit their widespread adoption as peat moss replacements.

Secondly, how do the inorganic amendments affect the rootzone physical properties? In related experiments it was demonstrated that although the amendments do offer some degree of water retention because of their

Continued on page 78

Continued from page 76

internal porosity, they were not as effective as peat moss in extremely drought-prone sands when combined with three varying sand sizes. (Bigelow, 2004).

Lastly, how best can you use the inorganic amendments in an existing putting green rootzone? This may be the best situation for using these amendments. Because they are packaged as dry products (which means they are flowable), they can easily be incorporated into the core cultivation holes. These smaller amendment quantities could make them cost effective and, when repeatedly applied, would improve fertilizer use efficiency once a critical volume of amendment is achieved.

Cale Bigelow is an assistant professor of agronomy/turfgrass science at Purdue University in West Lafayette, Ind. His research program focuses on practical cultural management practices that affect turfgrass nutrition and soil-related problems in commercial/home-lawns and fine turfgrass areas. He can be reached at cbigelow@purdue.edu.

Acknowledgements

Grateful appreciation is expressed to the U.S. Golf Association, Far Hills, N.J., and the Turfgrass Council of North Carolina, Southern Pines, N.C., for their support of these research experiments.

REFERENCES

Bigelow, C.A., D.C. Bowman and D. K. Cassel. 1999. Creeping bentgrass germination and establishment with rootzone amendments. *Golf Course Management.* 67(4):62-65.

Bigelow, C.A., D.C. Bowman, and D.K. Cassel. 2001. Nitrogen leaching in sand-based rootzones amended with inorganic amendments and sphagnum peat. *Jour Am Soc Hort Sci.* 126:151-156.

Bigelow, C.A., D.C. Bowman and D.K. Cassel. 2004. Physical properties of sand amended with inorganic materials or sphagnum peat moss. *USGA Turfgrass and Environmental Research Online.* 3(6):1-14.

Davis, W.B., J.L. Paul, J.H. Madison, and L.Y. George. 1970. A guide to evaluating sands and amendments used for high trafficked turfgrass. *University of California Agricultural Extension.* AXT n 113.

Moore, J.F. 1999. Building and maintaining the truly affordable golf course. *USGA Green Section Record.* 37(5):10-15.

United States Golf Association (USGA)., 1993. USGA recommendations for a method of putting green construction. *USGA Green Section Record.* 31(2):1-33.

Waddington, D. V.; Zimmerman, T. L.; Shoop, G. J.; Kardos, L. T.; Duich, J. M. 1974. Soil Modification for Turfgrass Areas: 1. Physical Properties of Physically Amended Soils. *Pennsylvania Agricultural Experiment Station Progress Report.* 337.

TURFGRASS TRENDS

SECTION STAFF

Managing Editor
Curt Harler
440-238-4556; 440-238-4116 (fax)
curt@curtharler.com

Golfdom Staff Contact
Thomas Skernivitz
440-891-2613; 440-891-2675 (fax)
tskernivitz@advanstar.com

Online Editor
Lynne Brakeman
440-826-2869; 440-891-2675 (fax)
lbrakeman@advanstar.com

Chief Science Editor
Dr. Karl Danneberger
614-292-8491; 614-292-3505 (fax)
danneberger.1@osu.edu

Production Manager
Jill Hood
218-723-9129; 218-723-9223 (fax
jhood@advanstar.com

Art Director
Lisa Lehman
440-891-2785; 440-891-2675 (fax
llehman@advanstar.com

Publisher
Patrick Jones
440-891-2786; 440-891-2675 (fax
pjones@advanstar.com

General Manager
Tony D'Avino
440-891-2640; 440-891-2675 (fax
tdavino@advanstar.com

Corporate & Editorial Offic
7500 Old Oak Blvd.
Cleveland, OH 44130-3369

CONTACT US:

Editorial: 440-238-4556
Web site: *www.turfgrasstrends.com*