Constructing Sand Based Putting Greens to Reduce Nitrogen Leachate

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PROLOGUE

A significant body of research has been published that shows established turf allows relatively little nitrate leaching to occur (Geron et al., 1993; Kussow, 1998; Liu et al., 1997; Miltner et al, 1996). Research has also documented that the barren nature of putting greens during establishment, coupled with the need to frequently apply nitrogen at moderate to high rates in order to produce a usable turf as quickly as possible, will undoubtedly lead to leaching of nitrate (Brauen and Stahnke, 1995). Although we as an industry have known this for over 10 years, there have been no significant steps taken to reduce the problem. It's been assumed the problem is unavoidable and in the long run, relatively insignificant. While nitrate leaching during establishment may contribute a low total amount to our surface and groundwaters, it's our responsibility to make attempts to correct the problem. Sometimes it takes a person with a mindset not limited by what is "known" to come up with a solution.

A few years ago an undergraduate student from civil engineering who'd been working for us at the O.J. Noer Facility asked if I thought a layer of crumb rubber in a putting green could reduce nitrate leaching. I was skeptical because I knew the Michigan DNR had concluded crumb rubber to be chemically inert. The student, though, was persistent and worked with his major professor conducting laboratory tests to measure nitrate leaching in sand:rubber profiles following nitrogen fertilizer application. They were able to show that a 4 inch crumb rubber layer in a sand profile reduced nitrate leaching 22% compared to a conventional USGA putting green profile (USGA, 1993). Laboratory data are great, I thought, but the real test would lie in the real world. We knew we had to conduct field trials to truly measure the effectiveness of crumb rubber to reduce nitrate leaching.

THE TRIAL

We constructed a putting green at the O.J. Noer Turfgrass Research and Education Facility during the summer of 2001, dividing it into 9 mini putting green profiles separated by plastic barriers. We used a randomized block design with 3 replications of 3 profiles to test the effectiveness of a crumb rubber layer to reduce nitrate leaching: USGA profile, USGA profile with coarse rubber substituting for the gravel layer, and a USGA profile with the choker layer replaced by fine-grade crumb rubber (Fig. 1). Lysimeters were installed under the drainage layer for collecting water samples as they leached out of the putting green (Holder et al., 1991).

The area was seeded to 'Penncross' creeping bentgrass at 1 lb/1000 ft^2 on 11 September 2001 and irrigated up to four times daily during establishment. Fertilizer was applied on 11 and 18 September (15-24-8) to supply 0.6 lb N/1000 ft^2, again on 1 and 11 October (46-0-0) to supply 1 lb N/1000 ft^2, again on 16 November (21-3-12) to supply 0.7 lb N/1000 ft^2, and a final time on 21 May 2002 (21-3-12) to supply 1 lb N/1000 ft^2.

Water samples were pumped from the lysimeters within 1 day after rainfall or approximately

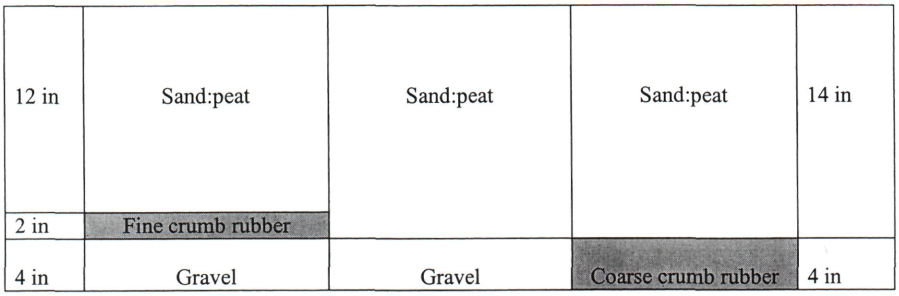

Fig. 1. Putting green profiles used at the O.J. Noer Turfgrass Research and Education Facility in Verona, WI, to compare the effects of replacing either the choker layer or the gravel layer with crumb rubber.

Table 1. Nitrogen and phosphorus in leachate from USGA putting greens with and without crumb rubber sub-layers, Verona, WI, 13 September to 28 September 2002.

Treatment	Leachate volume (L)	Average NO_3^-- N (mg/L)	Total NO_3^-- N (mg)	Average PO_4^--P (mg/L)	Total PO_4^--P (mg)	Average pH
USGA†	54.9	6.1 a†	3.2	1.5	32.4	7.06
Rubber choker	40.0	4.7 a	2.7	1.0	23.1	7.04
Rubber gravel	36.0	2.5 b	1.5	0.6	13.6	6.88
LSD (0.05)	ns	2.1	ns	ns	ns	ns

† Values followed by the same letter are not significantly different at $P < 0.05$. The ns indicates no values among the treatments are significantly different at $P < 0.05$.

every 2 weeks to measure volume of leachate and the amount of nitrate-N, ammonia-N, reactive phosphorus, and pH. Nitrogen and phosphorus analysis were conducted using Hach Test'N Tube methods described in Lisi et al. (2004). In brief, water samples were filtered and reacted with the appropriate reagents to produce a colored solution. The amount of nitrogen or phosphorus in the sample was determined by measuring the intensity of color in each sample with a spectrophotometer and comparing it to data from standard solutions of known nitrogen or phosphorus concentrations.

Turf quality and color were rated on a 1 to 9 scale, with 9 being ideal turf, and density was rated on a 0 to 100% scale. Turf infiltration rates were measured on mature turf in the summer of 2002 using a double-ring infiltrometer.

THE FINDINGS

Field data supported the laboratory tests showing crumb rubber could reduce the amount of nitrate-N in leachate from sand based putting greens. Replacement of the 4" gravel layer with similarly-sized crumb rubber reduced the concentration of nitrate-N approximately 60% (Table 1). Replacement of the 2" choker layer with finely ground crumb rubber did not significantly reduce nitrate-N in the leachate. Ammonia-N data were similar for all treatments (data not shown). Phosphorus concentrations and amounts as well as pH were statistically similar for all treatments ($P < 0.05$). Leachate volumes were similar for all treatments (Table 1), as were infiltration data (data not shown). The lack of effect on leachate volumes and infiltration indicate drainage was not affected by replacing either the gravel or the choker layer with appropriately-sized crumb rubber.

As expected, the majority of nitrogen in the leachate occurred during establishment. Nitrate-N concentrations from the USGA profiles exceeded the U.S. EPA drinking water standard of 10 mg/L five times during autumn 2001. Although all treatments resulted in at least two instances of nitrate-N being greater than the EPA standard, water draining from the greens with the 4" drainage layer of crumb rubber consistently had less N than water from the other treatments. By spring 2002 all treatments had N contamination less than the EPA standard, except for 17 March 2002 when water samples from the standard USGA putting green had 10.7 mg N/L.

The project indicates sand-based putting greens can be constructed so as to reduce nitrogen leachate during establishment without adversely affecting putting green hydraulic or turf qualities. The benefits of replacing the gravel layer with crumb rubber are that crumb rubber of the appropriate size may be easier to locate and cheaper to ship than appropriately-sized gravel. In addition, use of the crumb rubber removes it from the waste stream; in essence, recycling a waste rather than using an essentially non-renewable material such as gravel. We are now investigating the potential of crumb rubber in the greens to reduce pesticide leaching.

CONCLUSION

Replacement of the 4" gravel layer of a USGA putting green with similarly-sized crumb rubber significantly reduced nitrate leaching during establishment without affecting drainage or visible turf quality, color, or density.

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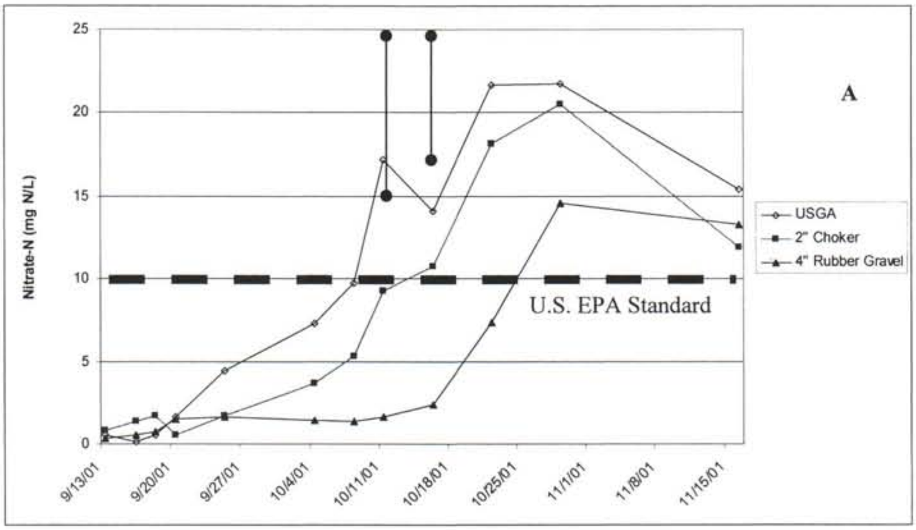
Table 2. Quality, color, and density of 'Penncross' creeping bentgrass (Agrostis stolonifera) on three putting green profiles the year following seeding, Verona, WI, 2002. Quality and color were based on a 1 to 9 scale, with 9 = ideal, 6 = acceptable.

	Quality		Color		Density (0-100%)	
Profile	16 Jul	28 Sep	16 Jul	28 Sep	16 Jul	28 Sep
USGA	4.8	6.0	6.0	6.0	93.3	100.0
Rubber choker layer	5.5	5.7	6.0	5.7	93.3	100.0
Rubber "gravel" layer	5.2	6.0	5.7	6.2	96.7	100.0
LSD (0.05)	ns	ns	ns	ns	ns	ns

ns = not significant at $P < 0.05$.



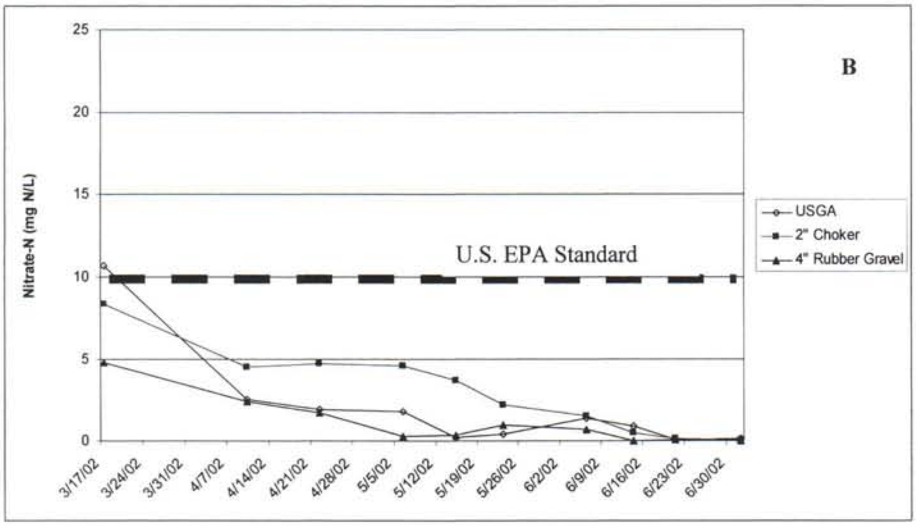


Fig. 2. Nitrate-nitrogen concentrations in leachate from 3 types of USGA-based sand putting greens planted with 'Penncross' creeping bentgrass on 11 July 2001: USGA = conventional, 2" Choker = USGA with 2" choker layer of fine crumb rubber, and 4" Rubber Gravel = USGA with gravel drainage layer replaced by similarly sized crumb rubber. The U.S. EPA drinking water standard of 10 mg/L Nitrogen is indicated by the dashed line. Dates on which data were significantly different between treatments ($P < 0.05$) are indicated by the bar-bell type vertical lines.