Completion Report

Minimum Maintenance Turf Management for Aquifer Protection

by

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for

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Geological Survey

and
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The activities on which this report is based were financed in part by the Department of the Interior, U.S. Geological Survey, through the Rhode Island Water Resources Center. The content of this publication does not necessarily reflect the views and policies of the Department of the Interior, nor does mention of trade names or commercial products constitute their endorsement by the United States Government.

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ABSTRACT

In an effort to protect ground water resources in shallow aquifers, research was initiated to investigate the potential for minimum fertilizer use in turf maintenance. Since the soils in much of southern New England overlaying shallow aquifers are highly suited for turfgrass culture, either as recreational facilities or commercial sod production, it is critical that the use of fertilizers and pesticides that might leach beneath the root zone be used at minimum rates. Based on research conducted over the past ten years, it seems reasonable that fertilizer-N rates used on turf could be reduced to 1 lb/1000 sq-ft (<50 lbs/acre). This is possible if fertilizers are used so as to supplement nitrogen released in the soil through natural mineralization of organic matter.

Three nitrogen sources were applied to newly installed Kentucky bluegrass sod at two or three times in early spring and early and late summer such that the total amount used was 1 lb N/1000 sq-ft. A 3 lb N/1000 sq-ft and an unfertilized control were included among the seven fertility treatments. Suction lysimeters were installed below the root zone in each plot and used to monitor the nitrate content of soil water throughout the year. These data together with net water percolation rates were used to estimate nitrate leaching from turf. During the 1994 growing season, grass clippings were sampled on four dates and analyzed for total nitrogen. These analyses provided an indication of turf nutritional status and an estimate of nitrogen recovery from the soil. Results during this year of establishment were more reflective of the sod's initial nutrition than of fertility treatments imposed on it. The sod became well established, good base-line data were collected and by the end of the season the effects of fertility treatments were beginning to become evident. By mid-fall, turf quality on all plots was good to excellent. The 1995 season will provide the first true test of the theory that turf can be maintained at 1/4 normal nitrogen rates if the nitrogen is applied when the turf's nutritional demands are greatest. This research is being continued through 1995-96.

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INTRODUCTION

Land development in southern New England is of such intensity that most areas are or soon will be subjected to some level of use. Shallow aquifers, especially those representing sole-source water supplies, need special protection but the land overlying them is often highly valued for residential or commercial development. It is important to identify those land uses which constitute the least threat to these sensitive areas. Turf culture (residential, commercial, institutional and recreational) has come under much media criticism as an environmentally risky land use wherever ground water protection is important (Jenkins 1994). This has influenced land use planning policy in spite of an ever growing body of research which shows turf to be a relatively effective ground cover for minimizing both nitrate and pesticide leaching to ground water (Cohen et al. 1990; Petrovic 1990; Kenna 1995).

While turf may constitute an environmentally sound ground cover over high value aquifer systems, it is important that managers of turf and those responsible for protecting ground water resources understand the best cultural practices for minimizing nutrient release from turf areas. Such knowledge will maximize the protective functions of turf and permit policy makers to assure the public that effective safeguards for the preservation of water quality are being implemented. Most research has concentrated on quantifying the discharge of pollutants into ground water. This study helps define fertilizer management strategies for turf culture which are most protective of ground water quality.

This research was developed from the substantial base of data on nitrate recovery and discharge in turf which we have generated over the past decade. While our studies have emphasized worse case situations in order to determine the potential for nitrate leaching, we have learned much about the seasonal patterns of soil water nitrate flucuations and the annual cycle of nitrogen demand by turfgrasses. Based on such information, we are convinced that a turf fertilization program can be devised which will utilize about 25% of the nitrogen commonly applied to turf with no decline in turf quality. This research is an evaluation of several approaches to achieving this marked reduction in nitrogen use and hopfully one or more strategies will emerge as successful and can be recommended to turf managers.

RESEARCH OBJECTIVES

The research reported here is the first year of a study which has the following three objectives.

1. To minimize nitrogen fertilizer use on turf by applying it only when soil nitrogen supplies are not adequate to maintain turf quality. Emphasis has been placed on spring and early summer applications with less use in the fall.

2. To compare fertilizer sources for their ability to deliver nitrogen in the amount and at a rate required by turfgrasses. Readily available and slow release organic nitrogen sources are being compared.

3. To determine if good quality Kentucky bluegrass turf can be maintained with annual nitrogen applications of not more than 1 lb N/1000 sq-ft (less than 50 lbs. N per acre).

METHODOLOGY

Experimental Design: The plot area utilized for this research is located on the Turfgrass Research Farm of the Rhode Island Agricultural Experiment Station at Kingston, RI. The soil type is an Enfield silt loam (Coarse loamy over sandy skeletal, mixed, mesic, Typic Dystrochrept). The site had been in turf for the past 25 years but not utilized for experimentation since 1989. In early April, 1994, the existing sod was killed by a topical application of glyphosate [*N*-(phosphonomethyl)glycine] and the dead turf removed with a sod cutter. The site was limed and prepared for sodding. Commercially grown Kentucky bluegrass (*Poa pratensis* L.) sod was installed on April 26, 1994. The sod was grown within 500 yards of the plot site using a commercial blend (Lofts Seed Inc.) consisting of 25% by weight 'Suffolk', 25% 'Sydsport', 25% 'Baron', 15% 'P-104' Kentucky bluegrasses and 10% 'Jamestown II' Chewings fescue. Past experimentation has shown Kentucky bluegrass to be least efficient in recovering nitrate from solution (Liu et al. 1993) and the most demanding of fertilizer nitrogen. If Kentucky bluegrass turf can be maintained at 1 lb N/1000 sq-ft/year, the same can be done with any cool-season turfgrass.

Seven nitrogen fertility treatments were initiated on June 20 as summarized below:

N source	Rate	Time & fraction of application
	lbs N/1000 ft^2/yr	
Urea	3	June - 1/3; Nov. - 2/3
Urea	1	April - 1/2; June - 1/4; Sept. - 1/4
CORON	1	April - 1/2; Sept. - 1/2
CORON	1	April - 1/2; June - 1/4; Sept. - 1/4
Compost	1	April - 1/2; June - 1/2
Compost	1	April - 1/2; June - 1/4; Sept. - 1/4
Control	0	

The 3 lb urea-N treatment simulated conventional fertility management for a home lawn. Urea is a water soluble, readily available, and inexpensive nitrogen source commonly included in commercial turf fertilizers. CORON is a liquid methylene diurea product, 28% N by weight of which about 30% is urea and 70% is controlled release polymerized material. In our research, it has supported good quality turf, provided little leachable nitrate, and is the sort of nitrogen formulation popular with lawn maintenance companies. The compost used was Earthgro Lawn Food with an analysis of 8-2-4. It consists mostly of composted leaves and poultry manure fortified with $NaNO_3$. Its 8% nitrogen is about 50% water soluble and 50% insoluble. It is typical of commercially available 'organic' lawn fertilizers and in our research, has supported good quality turf but tends to leach some nitrate. These nitrogen sources represent the spectrum of materials currently used in lawn fertilizers and were intended to provide a realistic assessment of minimum fertility turf management. In this study, most fertilizer was applied in the spring when soil nitrate concentrations are lowest and absorption by grass roots is greatest (Hull et al. 1993). Low applications in September are intended to enable grass to recover more quickly from summer injury to the root system caused by drought, high temperatures, insect predation and human activity. An unfertilized control plot was included in each of the four replications to monitor natural seasonal changes in soil mineralization of organic nitrogen and normal fluctuations in soil water nitrate levels.

All mid-June nitrogen applications were made on 20 June 1994 which included all treatments except Coron early spring/late summer and the unfertilized controls. Plots were hand irrigated with about 0.1 inch of water within one to two hours of the time fertilizer was applied. The late summer nitrogen applications were made on 1 September followed by 0.5 inches of irrigation the following morning. This involved all plots except the 15 g urea-N/m^2 (3 lbs/1000 sq-ft) and the unfertilized control. The late fall application to the 15 g urea-N plots was made on 17 November. In 1995, all early spring applications were made on 13 April, and late spring applications on 15 June.

Nitrate Leaching, Nitrogen Recovery in Clippings and Turf Quality: Suction cup lysimeters were installed in each plot at a depth of two feet on June 1. Lysimeters consisted of a ceramic cup 0.88 inch OD by 2.75 inches long mounted on a 21 inch long PVC pipe 0.8 inch OD. The ceramic cups were obtained from Soilmoisture Equipment Corp., Santa Barbara, CA and rated for standard flow rate. During installation, cups were set in a slurry of silica flour to insure good contact with the soil matrix. When the lysimeters were evacuated to -0.8 bars, 10 to 50 mL of soil water were drawn into the cup over a two hour period.

During 1994, soil water samples were collected on nine dates; the first on June 7 and the last on December 28. These were analyzed for nitrate-N by passing a water sample through a cadmium/copper reduction column and analyzing the resulting nitrite spectrophotometrically (Keeney and Nelson 1982). The results were used to estimate nitrate leaching by multiplying the soil water nitrate concentration by leachate volumes calculated for each precipitation event based on soil and meteorological data using the hydrologic component of the CREAMS model (Smith and Williams 1980). Soil water was also sampled and analyzed during 1995.

Clippings were harvested on four dates during the 1994 growing season from a 10.3 sq-ft area of each plot. Clippings were oven dried, ground to pass a 30-mesh screen and analyzed for total Kjeldahl nitrogen according to Easton (1978). Nitrogen recovered in clippings is a nondestructive means of estimating nitrogen absorption by roots and transport to shoots and for monitoring the nutritional status of turf. Clippings are being harvested at biweekly intervals throughout the 1995 season.

All plots were scored for visual quality on four dates during the 1994 growing season. Quality scores constituted a subjective integration of turf color, texture, uniformity and freedom from weeds, disease and other injury. Perfect turf was assigned a score of 9 while dead turf would be scored at 1. A score of 6 or higher indicates acceptable turf quality. Plots are being scored throughout the 1995 growing season.

RESULTS AND DISCUSSION

Turf quality:

Turf quality scores were made on four dates following the June fertilizer application (Table 1.). Because the early summer of 1994 was dry and the irrigation system was not operational until midsummer, the sod became drought stresses on several occasions. Hand watering prevented any turf death but periodic episodes of drought stress did cause the newly established sod to go off-color and lose density with resultant invasion of some weeds. This is reflected in lower quality scores from June through September. By early November, moisture conditions had been favorable for some time, grass root systems had become established and turf quality markedly improved. No differences between nitrogen treatments

Table 1. Quality scores of Kentucky bluegrass turf fertilized with three nitrogen sources at three rates.

Nitrogen source	Yearly rate	Months applied	Quality scores*					
			7-22	8-15	9-6	11-7	1994	4-13-95
	$gN\ m^{-2}$							
Urea	15.0	6 & 11	4.8	5.0	5.2	9.0	6.0	8.6
Urea	2.5	6 & 9	4.8	4.8	5.5	8.5	5.9	5.2
Coron	2.5	9	4.8	4.8	5.5	8.8	5.9	5.6
Coron	2.5	6 & 9	5.0	4.8	5.5	8.8	6.0	5.5
Compost	2.5	6	4.5	5.0	5.5	8.0	5.7	5.0
Compost	2.5	6 & 9	5.2	5.0	5.8	8.5	6.1	5.8
Control	0	-	4.5	4.8	4.5	8.2	5.5	4.9

* Quality scores: 9=perfect turf, 1=dead turf

were significant although a trend toward lower turf quality on the unfertilized plots is suggested. The 17 November application of urea at 2 lbs N/1000 sq-ft to the high nitrogen control plots was reflected in significantly greener turf during mid-April of the following spring.

The capacity of low nitrogen applications made at strategic times to maintain high quality turf will be tested more rigorously during the 1995 season.

Soil water nitrate and nitrate leaching:

Soil water samples were collected on nine dates following the June nitrogen applications and their nitrate-N concentrations are summarized in Table 2. Because of dry conditions throughout the midsummer of 1994, many lysimeters failed to produce a water sample even following irrigation. For that reason, the data are a bit uneven and rarely were differences between nitrogen treatments statistically significant. Because of the limited root development from sod installed in the spring (Geron 1993), the soil water nitrate concentrations increased following low nitrogen applications more than would normally be expected (Gold et al. 1990; Hull et al 1993). Mineralization of soil organic nitrogen probably caused the elevated nitrate-N levels in soil water from unfertilized control plots. Limited root growth by newly laid sod during a dry summer limited the ability of turf to capture much mineralized nitrogen. The 3 lb. urea-N rate was clearly reflected in elevated soil water nitrate which persisted into February when all lower nitrogen rates had dropped to levels well below 1.0 mg/L. The Earthgro compost is enriched with $NaNO_3$ which explains why it resulted in somewhat elevated soil water nitrate levels following the all fertilizer applications. By April,

Table 2 Soil water nitrate-N concentrations from Kentucky bluegrass turf plots fertilized with three N sources at three rates.

Nitrogen source	Rate	Months applied	June	July	Aug.	Sept.	Nov.	Dec.	Feb.
	$gN\ m^{-2}$					mg NO_3-N L^{-1}			
Urea	15.0	6 & 11	1.6	8.5	9.6	9.7	13.4	12.2	3.8
Urea	2.5	6 & 9	1.3	3.9	2.6	5.6	5.6	0.7	0.2
Coron	2.5	9	2.2	3.4	-	7.2	8.6	1.7	0.1
Coron	2.5	6 & 9	1.5	5.8	5.0	4.7	7.5	1.3	0.3
Compost	2.5	6	1.1	4.8	7.3	8.9	12.3	2.0	0.7
Compost	2.5	6 & 9	2.5	5.5	-	7.1	9.5	4.0	0.3
Control	0	-	-	2.0	7.3	12.6	8.4	0.6	0.6

1995, soil water from all treatments contained less than 0.3 mg NO_3-N/L indicating that an efficient root system had developed from the sod under all nitrogen treatments (data not shown).

Nitrate leaching was estimated based on soil water nitrate concentrations and percolation estimated from the CREAMS model (Table 3). Because several heavy precipitation events occurred during August and September when soil water nitrate levels were relatively high, substantial nitrate leaching occurred. In the case of the compost treatments, the data suggest that all fertilizer nitrogen leached as nitrate. However, it should be noted that the unfertilized control plots also leached almost two grams of nitrogen during this season of turf establishment. Soil mineralization was apparently generating substantial amounts of inorganic nitrogen. Sod does not produce as large a root system as seeded grass especially when established in the spring (Geron et al. 1993). We also have shown that water applied in excess of evapotranspiration will promote nitrate leaching (Morton et al. 1988). These two factors contributed to the relatively high leaching noted in this study.

Table 3 Estimated nitrate-N leached from Kentucky bluegrass turf plots fertilized with three N sources on two dates.

Nitrogen source	Rate	Nitrate-N leached June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
	$gN\ m^{-2}$	$mg\ NO_3\text{-}N\ m^{-2}$							
Urea	15.0	35	226	609	349	0	1448	658	3325
Urea	2.5	29	97	184	190	0	608	39	1147
Coron	2.5	47	86	205	261	0	926	92	1617
Coron	2.5	33	148	349	174	0	812	68	1584
Compost	2.5	23	118	511	320	0	1328	105	2405
Compost	2.5	54	137	593	276	0	1020	216	2296
Control	0	37	50	508	452	0	903	32	1982
Percolation inches		0.85	0.98	2.75	1.42	0	4.24	2.12	12.36
Precipitation in.		3.00	3.35	6.03	4.40	0.63	5.75	2.55	25.71

Clipping yields and nitrogen content:

Clipping samples were collected on four dates during the 1994 growing season following the initiation of fertility treatments (Table 4). Because of the dry spring and early summer, clipping yields were low. This was aggrivated by periods of drought stress which severely retarded the growth of newly laid sod. From August on, rainfall was normal or higher and the turf responded with good leaf growth. Because commercial sod is normally heavily fertilized prior to cutting, the modest nitrogen treatments imposed on this turf were masked by the high nitrogen status of the grass. This is reflected in the nitrogen concentration of clippings harvested in 1994 (Table 5).

Table 4. Dry mass of turf clippings harvested during 1994. Values are leaf growth above a height of 1.4 inches during a 7 to 9 day period.

Nitrogen source	Rate	Months applied	Clipping yields 6-27	7-22	8-18	10-25	Mean
	gN m^{-2}		g m^{-2}				
Urea	15.0	6 & 11	3.8	2.0	6.9	5.8	4.6
Urea	2.5	6 & 9	3.8	2.1	6.7	6.6	4.8
Coron	2.5	9	3.2	1.6	6.3	6.0	4.3
Coron	2.5	6 & 9	2.6	2.1	6.6	6.5	4.4
Compost	2.5	6	4.2	2.2	6.7	7.0	5.0
Compost	2.5	6 & 9	3.6	2.1	7.4	5.8	4.7
Control	0	-	5.0	1.8	7.3	5.6	4.9

Table 5. Nitrogen content of turf clippings harvested during 1994.

Nitrogen source	Rate	Months applied	N content 6-27	7-22	8-18	10-25	Mean
	gN m^{-2}		mg N g^{-2}				
Urea	15.0	6 & 11	50	48	43	47	47
Urea	2.5	6 & 9	44	47	42	47	45
Coron	2.5	9	42	47	41	46	44
Coron	2.5	6 & 9	44	47	40	47	44
Compost	2.5	6	43	48	41	48	45
Compost	2.5	6 & 9	41	49	40	46	44
Control	0	-	42	47	42	44	44

Kentucky bluegrass leaf tissue containing 4 to 5% nitrogen is not suffering from inadequate nutrition. While treatment differences were not significant during this year of sod establishment and treatment initiation, a trend toward lower nitrogen content in unfertilized grass and a higher level in turf receiving 3 lbs N/1000 sq-ft is evident. This is somewhat more evident when clipping growth and nitrogen content are combined as nitrogen yield per square meter of turf (Table 6).

Table 6. Nitrogen recovered in clippings per square meter of turf during 1994. Values are nitrogen present in clippings produced during a 7 to 9 day period.

Nitrogen source	Rate	Months applied	Nitrogen yields 6-27	7-22	8-18	10-25	Mean
	gN m^{-2}				mg N m^{-2}		
Urea	15.0	6 & 11	193	98	297	270	214
Urea	2.5	6 & 9	169	97	283	311	215
Coron	2.5	9	133	74	259	280	186
Coron	2.5	6 & 9	113	101	267	302	196
Compost	2.5	6	185	107	276	332	225
Compost	2.5	6 & 9	149	102	297	265	203
Control	0	-	208	82	309	245	211

Mean nitrogen recovery in clippings only varied by 21% which again indicates limited treatment effect on nitrogen nutrition during this initial year. Those fertilizers containing readily available nitrogen, urea and Earthgro compost enriched with $NaNO_3$, resulted in slightly more nitrogen recovered in clippings. The methylene urea material (Coron) provided least nitrogen during this initial period and did not differ from the unfertilized controls.

CONCLUSIONS

During this year of project establishment, no true conclusions can be drawn concerning the feisability of maintaining quality turf using 1/4 the nitrogen normally employed. However, the following statements of accomplishments can be made.

1. An experimental plot area was established at the RIAES Turf Research Station utilizing commercially grown Kentucky bluegrass turf. Despite a dry spring and early summer and a failure of the irrigation system throughout May and June, a high quality set of plots was in place by mid-fall.

2. During this season of establishment, soil water nitrate levels, clipping yields and the nitrogen content of clippings reflected the initial nutritional status of the sod rather than nitrogen treatments imposed on it.

3. Soil water nitrate concentrations were higher than normal because of rapid mineralization of soil organic nitrogen as a result of

site disturbance and the limited capacity of newly laid sod to produce an efficient or extensive root system.

4. By season's end, nitrogen treatments began to express themselves in clipping nitrogen contents and soil water nitrate levels.

ACKNOWLEDGMENTS

In addition to the support provided by the Rhode Island Water Resources Research Center, which is gratefully acknowledged, funding was also provided by Earthgro Inc., Coron Corp, and the Rhode Island Agricultural Experiment Station. Fertilizer materials were contributed by Coron Corp. and Earthgro Inc. The technical assistance of three undergraduate students, Keith Cote, Mark Simster and Michael Stimpson during 1994, is also acknowledged with appreciation. The assistance of Paul Santer, Antoinette Snyman and Philip Thibaudeau for completing analysis of 1994 samples during the summer of 1995 is also gratefully appreciated. I thank Carl Sawyer for providing soil percolation data based on the CREAMS model. Greg Fales and his staff at the Turf Research Station is acknowledged for their efforts in installing and maintaining the turf plot area.

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