The Impact of Turfgrass Pest Management System Techniques on Surface and Ground Water Quality

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Abstract

The impact of various turfgrass pest management strategies (PMS) on water quality has recently become a concern for many golf course superintendents, sports facilities managers and homeowners. With water quality standards becoming increasingly stringent, management practices have had to follow suit. Uses of alternative control strategies have become increasingly important. This includes the use of biological, cultural and preventative control practices to reduce pest pressure, as well as environmental impacts. Turfgrass is, no doubt, a beneficial addition to most ecosystems, yet when mis-managed can cause harm as well. Mis-management of the turfgrass ecosystem can greatly influence the nitrogen, phosphate and pesticide levels in surface and ground water, causing problems for communities that depend on clean water for consumption as well as recreation. Aquatic ecosystems as well can be severely harmed by increased levels of nitrogen and phosphate, which can cause algal bloom, decreased dissolved oxygen levels, and eutrophication, which in turn has an impact on nearly all ecosystems. Pesticides that find their way into surface or ground water pose a problem to exposed species ranging from fish to humans. When managed correctly, turfgrass provides many positive attributes, including increased UV absorption, CO_2 remediation, soil stabilization, ground and surface water filtration, and aesthetic benefits. It is our goal to test the impact of three of the most commonly implemented turfgrass pest management systems, (preventative, IPM, and organic systems) on surface and ground water quality and turfgrass performance. The results will hopefully provide answers on how to produce acceptable turfgrass quality while benefiting the environment.

Introduction

Three distinctly different turfgrass management techniques are currently being tested at the Cornell University Turfgrass Field Research Laboratory located in Ithaca, NY. The three pest management techniques are Preventative, Integrated Pest Management (IPM) and Organic methods. Research plots of each method have been established to quantify the impact of pest control techniques including fertilization on runoff and leachate of nitrogen, phosphate and pesticides.

Preventative PMS plots were seeded with high quality expectation turf. All pests, i.e. weeds, insects and disease, will be treated prior to or at first observance of any infestations, and thus will be expected to maintain a high quality turfgrass. Density, color and overall quality will dictate application of materials. Nutrient applications will consist of high rates of water-soluble sources to maintain consistently high visual quality.

Integrated Pest Management plots will utilize all current "state of the art" practices to maintain both high quality turfgrass with a focus on water quality protection. Pest resistant grasses were established to reduce potential pest pressure. Where practical biological controls will be used to manage diseases and insects. Scouting for pest is done on a regular basis, and controls are selected for their efficacy, and relative risk to ground and surface water contamination. Fertilizer applications will be applied based upon soil and tissue test, to maximize efficacy. Slow release and/ or organic sources of nutrients will be used with care to the timing. Pesticides will be applied only when absolutely needed, during periods of low risk to heavy rainfall and using only low risk (to surface and ground water contamination) pesticides.

Organic plots will utilize only natural organic compounds for application. Fertilizers will be composts or derived from organic sources. No synthetic pesticides will be applied. All pest control applications will be limited to natural organic- biocontrol materials.

Both runoff and leachate will be collected and analyzed for nitrate, phosphate and pesticides. Runoff and leachate collected from rain events will be frozen until analysis can be performed.

Objectives

The goal of this project is to evaluate the impact of the three pest management systems on ground and surface water quality. More specifically:

1. To evaluate and categorize the extent to which nutrients (NO3, NH4, and PO3) and pesticides are found in runoff water from the plots during the establishment phase.
2. To evaluate and categorize the extent to which nutrients (NO3, NH4, and PO3) and pesticides are found in leachate from the plots (leachate plots are separate than runoff plots).

Materials and Methods

Runoff and leachate plots were established June and July2000 at the Cornell University Turfgrass Research Center Ithaca, NY. Site selection for runoff plots was characterized as to the direction and slope. All plots are located on a slope of 8to10 per cent and oriented with contour lines so as to face directly down slope. Soil type of the area was found to be Arkport fine sandy loam, which has a medium risk of surface and ground water determination, based on USDA-NRCS rating (WIN PST). Nine 20 x 20 foot plots (3 reps of each Pest Management System) were measured and prepared for planting in early July. Trenches were dug on the down slope side of the plots, and aluminum gutters positioned to catch any runoff and transport it to catch basins were water will be collected until samples can be obtained. All trenches are enclosed allowing only runoff to enter the catch basin.

Treatments were randomly assigned to plots. Plots were then treated with Finale @ 2 oz./gal. to kill vegetation prior to having the sod stripped. All plots were the tilled to a depth of aproximately. 3 in. and Endicot compost (composted bio-solid and year waste use for fertility and disease suppression) was incorporated into the soil at the rate of 1 lb. N/1000sq.ft. on the IPM and organic plots. Preventative plots received 1 lb. N/1000 sq.ft. in the form of Lesco 18-24-12 starter fertilizer.

Analysis of the Endicot compost was performed at the Woods End Research Laboratory in Maine. The total nitrogen was found to be 1.67%, phosphorus at 0.95, and potassium at 0.14%, all on a dry weight basis. Organic matter on a dry weight basis is 74.9% and the C/N ratio 24.2/1. All applications of compost were therefore made on a dry weight basis (sub-samples taken, oven dried and moisture content determined and used to adjust the application rate).

Preventative plots were seeded with 80% Indigo bluegrass and 20% Brightstar ryegrass at the rate of 3 lbs./1000sq.ft. IPM and Organic plots received 80% Indigo bluegrass and 20% mix of equal parts Prelude II, Plamer II and Repell II endophytic ryegrass at 3 lbs./1000sq.ft. Plots were seeded on July 20, 2000.

Preventative plots were treated with siduron (Tupersan @ 2.5 oz./1000sq.ft). to control crabgrass preemergent. Lime was applied based on soil test results on July 20, 2000: preventative plots all received 20 lbs. of pelitized lime per plot, Organic plot #1 received 26.7 lbs. pelitized lime, with all other plots yielding adequate pH levels and requiring no added lime. Plots were irrigated as needed during the summer months, never receiving more than 1.5 in. of water per week (maximum of 0.4 in. day) and amount recorded.

Leachate collection plots were established in the Soil Amendment facility designed to collect water leaching the root zone, approximately, 18 in. deep soil zone. Plots were 38 sq.ft. (7.5' dia. plastic container with drainage line for collection) that contain the same Arkport fine sandy loam as the runoff plots, and received the same treatments. Water collected is considered pre-ground water at an 18-inch depth. Samples were collected following any rain event, or scheduled irrigation. Total volume of leachate is recorded and a sub-sample collected and frozen until analysis for nutrients and pesticides. Since irrigation was applied daily during the summer and into the fall at the rate of 1.5 in./wk., volumes in the leachate collection containers were not of adequate to quantity to constitute a sample for analysis. Therefore, sub-samples collected every day were combined on a weekly basis to yield one composite sample per plot per week.

Broadleaf weed treatments were applied in late September (9/27/2000) to the preventative and IPM plots. Preventative plots received Trimec (2,4-D, MCCP, Dicamba) at the rate of 1.5 oz/gal. IPM plots received Weedone (2,4-D acid isoctyl, 2ethel hexyl ester) at 1 pint/acre. Applications were made during time of low risk of rainfall, and applied at the labeled rate. Organic plots received no weed control products.

Early fall fertilizers were applied on September 26, 2000 to all plots. Preventative plots received Lesco 24-5-11 Poly plus coated fertilizer (50% slow release) at 1 lb. N/1000sq.ft. IPM and Organic plots received a further 1 lb. N/1000sq.ft. of Endicot compost. Note both runoff and leachate plots received fertilizer at the same rate on the same date.

Late fall applications of fertilizer were made to the Preventative and IPM plots in an attempt to remedy low density on many of the plots. Lesco 24-5-11 Poly plus coated fertilizer was applied at 1lb. N/1000sq.ft. to both the Preventative and IPM plots. Organic plots received no fertilizer, as temperatures were low, as it was thought that the addition of a product which depends on microbial processes to release the nitrogen would not have much impact when applied late in the year. The compost would ultimately end up not being utilized by the turf and could easily moveable by runoff should a significant rainfall event occur. To date there have been nine rainfall events which have caused runoff and leachate from at least 1 plot in each event.

Results

There were nine runoff and leachate events sampled to date, but we have analytical results from only four events (7/31/00, 8/16/00, 8/24/00, and 9/9/00). Both nitrate and phosphate concentration in runoff (Table 1) and leachate (Table 2) water varied widely, not only between treatments, but also between individual plots with in an event and rain events. No pesticide results are available to date.

Nitrate levels in runoff water, measured in mg/L (ppm), varied from 1.75 to 304 mg/L in the preventative treatments, 2.58 to 186 mg/L in the IPM treatments and 2.96 to 225 mg/L in the Organic treatments. On average, the runoff water, regardless of pest management method, than nitrate concentrations in excess of drinking water standards (10 mg/L, health advisory limit, HAL) starting at the first sampling date (12 days after fertilization, DAF) for at least 52 DAF. The peat nitrate concentration occurred 18 to 26 DAF and rapidly drop when the next runoff event occurred 52 DAF. Pest management method had little if any effect on nitrate levels in runoff.

Nitrate levels from the leachate plots (Table 2) were lower than those of the runoff plots, but still contained some readings above 40 mg/L, four times the health advisory limit for nitrates in drinking water. Generally, the levels of nitrate observed in leachate water were below 20 mg/L. Nitrate concentrations 12 DAF were below 5 mg/L, half the HAL, but as observed in runoff, peak at 18 to 26 DAF and dropped lower by 52 DAF but still above the HAL.

Phosphate levels in runoff (Table 1) were not as variable as the nitrate levels from the four events, ranged from below detection levels (0.2 mg/L) to about 5 mg/L. Pest management method appeared to have little influence phosphate levels in runoff. Phosphate levels in the leachate water were much lower and always below detection level of 0.2 mg/L.

While no significance was found to exist between the treatment means in terms of concentration nitrate or phosphate, it should be noted that preventative pest management systems plots have produced fewer runoff and leachate events than either the IPM or organic plots. The preventative plots averaged 7 runoff events, and just under 9 leachate events, while both the IPM and Organic pest management system plots averaged 8 runoff events and a full 9 leachate collection events. The concentration data was combined with the volume collected during each runoff or leaching events and used to calculate a nutrient flux (mass of nitrate-phosphate/plot/day) and mass of nutrient loss (mass/plot). Since only 4 of the 9 events were analyzed to date, this data was not shown.

Table 1. Concentration of nitrate and phosphate in runoff as influence by pest management method. Plots were fertilized on 7/19/2000.

		Nitrate (mg/L)				Phosphate (mg/L)			
		Sampling date				Sampling date			
Fertilizer Applied	Plot	7/31	8/16	8/24	9/9	7/31	8/16	8/24	9/9
1 lb. N/1000 sq. ft.	2	0*	64.6	1.75	29.11	<.2^	0.98	1.63	1.12
18-24-12	4	3.21	112	167	13.96	1.08	<.2	<.2	.82
Preventative	5	39.45	304.1	234.9	120	1.16	<.2	1.89	1.08
	Ave.	14.2	160.2	134.6	54.4	0.8	0.4	1.2	1.01
1 lb. N/1000 ft. sq.	3	24.75	127.7	130.2	23.5	0.83	<.2	1.2	1.23
Endicot Compost	6	12.27	84.15	99.7	18.4	<.2	<.2	1.09	0.72
IPM	8	2.58	185.1	186.5	14.7	1.07	<.2	<.2	5.34
	Ave.	13.6	132.3	138.8	18.9	0.63	<0.2	0.76	2.43
1 lb. N/1000 ft. sq.	1	9.36	128.8	17.02	32.12	<.2	<.2	1.06	1.02
Endicot Compost	7	88.37	119.7	282	57	<.2	<.2	<.2	<.2
Organic	9	2.96	225.2	183.4	72	3.86	<.2	<.2	0.76
	Ave.	33.6	157.9	160.8	53.7	1.29	<0.2	0.35	0.59

*no runoff available for collection. ^ Below detection limit of 0.2 mg/L.

Table 2. Concentration of nitrate-N in leachate samples as influenced by pest management method. Fertilizer was applied on 7/19/00.

		Nitrate-N (mg/L)				Phosphate (mg/L)			
		Sampling date				Sampling date			
Fertilizer Applied	Plot	7/31	8/16	8/24	9/9	7/31	8/16	8/24	9/9
1 lb.N/1000	14	3.61	9.35	19.35	10.48	<.2*	<.2	<.2	<.2
18-24-12	16	6.8	9.34	15.83	12.77	<.2	<.2	<.2	<.2
Preventative	19	3.48	10.72	33.58	30.61	<.2	<.2	<.2	<.2
	Ave.	4.6	9.8	22.9	18.0	<0.2	<0.2	<0.2	<0.2
1 lb. N/1000	10	11.75	4.61	50.8	6.3	<.2	<.2	<.2	<.2
Endicot Compost	12	2.85	15.92	30.25	30.21	<.2	<.2	<.2	<.2
IPM	13	2.97	5.94	18.77	8.09	<.2	<.2	<.2	<.2
	Ave.	5.9	8.8	33.3	15.1	<0.2	<0.2	<0.2	<0.2
1 lb. N/1000	5	4.73	7.73	8.75	4.5	<.2	<.2	<.2	<.2
Endicot Compost	7	3.14	14.4	19.87	25.39	<.2	<.2	<.2	<.2
Organic	8	3.79	36.48	7.32	5.91	<.2	<.2	<.2	<.2
	Ave.	3.9	19.5	12.0	11.9	<0.2	<0.2	<0.2	<0.2

* Below detection limit of 0.2 mg/L

Discussion and Conclusion

While results have shown little difference in water quality (based on concentration) from the three pest management systems, the number of runoff and leachate events and the volumes of those events may be considered significant. The mid-summer seeding date and high initial weed competition on the Organic and IPM plots caused very low turf density, <5 shoots per sq. in. As a result, runoff and leachate collection volumes were higher in this case than for the preventative plots which received preemergent herbicide treatments to control mainly crabgrass. Preventative plots had turf densities ranging from 9-11 shoots per sq. in. As a result of lower density on organic plots, water movement over the turf was not slowed and allowed to infiltrate, or be taken up by the turfgrass roots. The water soluble starter fertilizer applied on the preventative plots was available much more quickly to the turf than was the organic compost applied to the IMP and organic plots, allowing the preventative plots to establish a dense turf much more quickly. Generally, runoff volumes from the preventative plots were on the order of 2 to 3 times less than those of the organic plots. The lower turf density and hence ease of water movement in the form of runoff also allowed higher quantities of fertilizer to move with the runoff. Turf density appears to be a controlling factor in water quality not necessarily from a nutrient concentration standpoint, but from a total nutrient load, or flux standpoint, in that plots with higher turfgrass densities had fewer water movement events (leaching or runoff), and lower volumes of runoff or leachate water collected on average.

Rainfall intensity and antecedent moisture conditions also appear to play a role in the volume of water from events, and the concentration of nutrients in the water. In the 2 days prior to the first runoff event on 7/31/00 there was a total of 0.29 inches of rainfall, falling at a steady rate. On the July31st an abrupt, short, intense rain occurred, producing <0.1 inches of rain, which was enough to cause a runoff event on the newly seeded plots. Again on 8/16/00 and 8/24/00 antecedent moisture conditions were high, allowing short intense rainfalls to cause substantial runoff events. However on 9/9/00, there was no rainfall for the week preceding the event, 0.6 inches of rain fell in a thunderstorm, which was just enough to cause minimal runoff from the plots. In short, high levels of antecedent moisture can lead to high volumes of runoff from short intense rainfalls.
It appears that density and moisture conditions are very important in controlling runoff and leachate from the plots. Low density and high soil moisture levels lead to high runoff and leachate volumes, and high nutrient concentrations in the water. If soil moisture levels are low prior to an event, much more rainfall is needed, and volumes of runoff and leachate are lower. We can not control antecedent moisture conditions or rainfall intensity, but we can control density, and this appears to a variable that can drive the whole system. Not only does higher density slow water down and allow it to infiltrate, but higher density is also associated with greater plant water utilization, making less water available to runoff.

Portions ready for implementation and commercial testing

Since this study is in its first year, much of the data is preliminary and samples still need to be analyzed. This was an establishment year and future years will evaluate mature turf conditions. Thus, no part of the study is ready for implementation or commercial testing at this point.

Potential reductions in pesticide use

The potential reduction in pesticide use could be great. Organic management practices which utilize only natural-organic controls have the potential to greatly reduce not only the pesticide load in the environment, but can also be implemented at a lower cost than preventative management practices. The problem is being able to produce a turf that meets the requirements that managers have. IPM practices are perhaps an adequate middle ground. While pesticides and chemicals may be used, other cultural and biological options will be used.

Possible future research to ensure implementation

The long term results of this project is to determine if pest management practices, from totally preventative to natural-organic, have an impact on surface or ground water quality. If differences occur between practices, this information can be implemented and directly used by commercial pest management companies, golf course superintendents, athletic field managers and private residential practitioners to protect water quality with out compromising pest control and turf quality. Thus, this projects needs to be continued to determine water quality impacts from pest management practices on turf that is establishment.