Impact of Turfgrass Fertilization on Nutrient Losses Through Runoff and Leaching

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Figure 2. Slit ABS pipe placed at the lowest part of the plots to collect runoff water.

Figure 1. Excavated plot with the two plastic sheets and the drain used to collect leachate.

Figure 3. Tipping bucket used to measure water volume from leaching and runoff and plastic container used to collect water sample.

Introduction

Over the last few years, there have been increasing concerns from the population about the effects of turfgrass fertilization on nutrient losses to nearby water bodies. Several cities have even adopted by-laws to restrict, or even ban the use of fertilizers on turfgrass. However, those by-laws are generally not based on science, and their effect to reduce nutrient load to water bodies has not been demonstrated. Furthermore, it has been shown that unfertilized turfgrass can result in higher nutrient losses compared to properly fertilized turf. Indeed, healthy fertilized turfgrass is denser and more efficient to reduce runoff and erosion than unfertilized turfgrass[1–3]. In 2011, we started a research project to quantify nutrient losses through runoff and leaching from two conventional fertilization programs based on industry practices and one program based on a typical by-law. We also included unfertilized treatments as controls.

Methodology

This project was established at our research facility located on Université Laval campus in Québec city. With the help of an excavation company, we built 15 hydrologically isolated plots during the summer of 2011. These plots are 5 m wide by 10 m long, and have a v-shaped bottom with a depth of 50 cm in the middle and 30 cm on the sides. Two sheets of plastic were placed at the bottom of each plot in order to isolate them from the water table, and a perforated drain was placed in on top of these plastic covers (Figure 1). Plots were then filled with the excavated soil and graded with a laser in order to obtain a 5% slope at the surface. Kentucky bluegrass was then sodded on the plots that will be used for the three fertilized treatments. In order to accelerate the effects of not fertilizing turfgrass for the control plots, we harvested turf that was not fertilized for five years from a nearby area, and used that to cover the control plots. In addition to grasses (30% Kentucky bluegrass, 15% sheep fescue, 15% colonial bentgrass) this cover contained about 20% clover and 20% of other broadleaf weeds (dandelion, plantain, orange hawkweed, etc.).

In each plot, we installed three capacitance soil moisture probes (at depths of 10, 20 and 30 cm) and one temperature sensor (at a depth of 10 cm) that automatically took readings every hour. In order to collect runoff water, we placed a 4” ABS pipe with a slit at surface of the soil in the lowest part of the plot (Figure 2). The result is that each plot has two water collection pipes: one for leachate (through the perforated drain) and one for runoff (from the PVC pipe). In order to measure water volumes from these two sources, we placed a tipping bucket hooked to a data logger under each pipe (Figure 3). Once the bucket is filled with 500 mL of water, it tips and the data logger registers this tipping event. By multiplying the number of tips recorded by the data logger by 500 mL, we can determine the total volume of water exiting the plot through runoff and leaching. Since we also collect a water sample from each tip and analyze it for nutrient content

(N and P), we can determine the total nutrient load in the water coming off the plots.

We started applying the treatments in the spring of 2012. Five treatments were evaluated as a completely randomized design with three replicates. The three fertilized treatments were based on industry practices (treatment 1 and 2) and on a typical city by-law currently in place in Québec (treatment 3). We also have two unfertilized treatments, one with some maintenance practices applied (aerification, topdress, overseed) and the other one unmaintained. Specifically, the evaluated treatments are:

1. Synthetic fertilizer: 20-0-12 with 50% slow-release N (1.5 kg N/100 m^2/yr) split in four applications (May, June, August, September).
2. Natural fertilizer: 9-2-5 (1.5 kg N/100 m^2/yr) split in four applications (May, June, August, September).
3. Compost: 1.8-1-0.9 (1.5 kg N/100 m^2/yr) applied all at once in May
4. Unfertilized maintained
5. Unfertilized control

The plots were irrigated in order to prevent turf dormancy. We calibrated the irrigation system to make sure each plot received the same amount of water during the irrigation events. We also evaluated turfgrass visual quality monthly on a 1 to 9 scale (1 = low quality, 9 = high quality, 6 = acceptable quality).

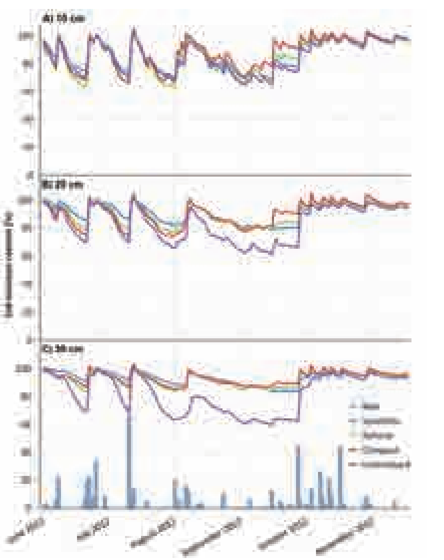

Figure 4. Soil water content at three depths (10, 20 and 30 cm) in the research plots throughout the 2012 growing season.

Results

The results presented here are only from the first year of experiment, and this project is planned to run for at least another year. Thus, they should be considered preliminary. Since we did not apply any maintenance (aerification, topdress, overseed) in 2012, both unfertilized treatments were merged together for the result analysis.

Soil water content. The summer of 2012 was exceptionally dry in Québec city, as shown on the precipitation and soil moisture readings chart (Figure 4). We did observe significant differences in soil moisture content, especially at depths of 20 and 30 cm. The fertilized plots (regardless of the treatment) had a consistently higher soil water content compared to the unfertilized plots. Dry root mass was also significantly smaller in the unfertilized plots (data not shown). Some of these differences are likely due to the type of cover (i.e. Kentucky bluegrass sod, vs mixed species cover), but we do not know yet the exact explanation for these observations.

Leaching. When we look at the total volume of water leached through the plots, as measured with the tipping buckets, we can see that plots fertilized with the synthetic fertilizer have a significantly lower leaching volume than the other plots (Figure 5). Since all plots received the same amounts of water, and that soil water content was similar for all fertilized plots, this difference could be caused by an increased evapotranspiration rate in these plots. Since this treatment is the one that supplied the most readily available N (50% of quick release N), it probably resulted in an increased growth rate, with plants actively using water.

We observed significant differences between the treatments in nitrate (NO_3-) and ammonium (NH_4+) content in the leachate (Figure 6). There was more nitrate losses through leaching from the fertilized plots than from the unfertilized plots. However, there was more ammonium lost in leachate from unfertilized plots compared to fertilized plots. It is interesting to note that there were no significant differences in nitrogen losses between the different fertilizer sources.

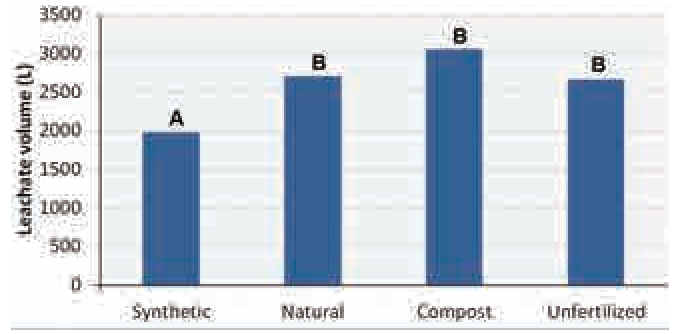

Figure 5. Total leachate volumes as affected by the different treatments during the 2012 season. Columns with the same letter are not statistically different.

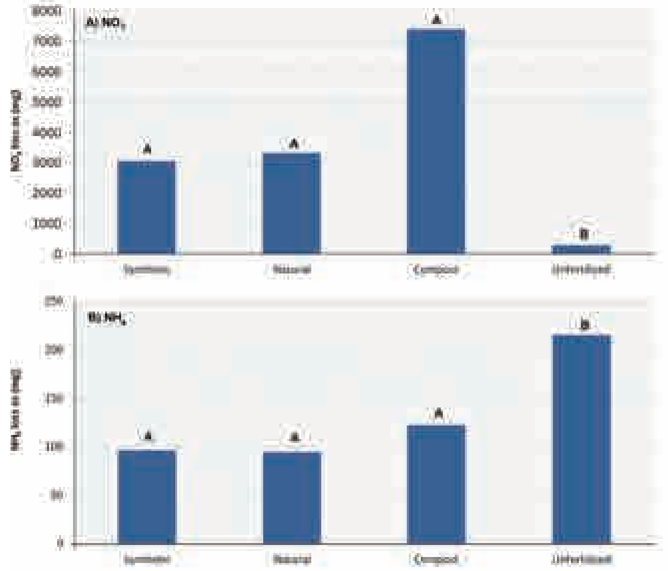

Figure 6. Total nitrogen losses from the experimental plots during the 2012 growing season in A) nitrate and B) ammonium. Columns with the same letter are not statistically different.

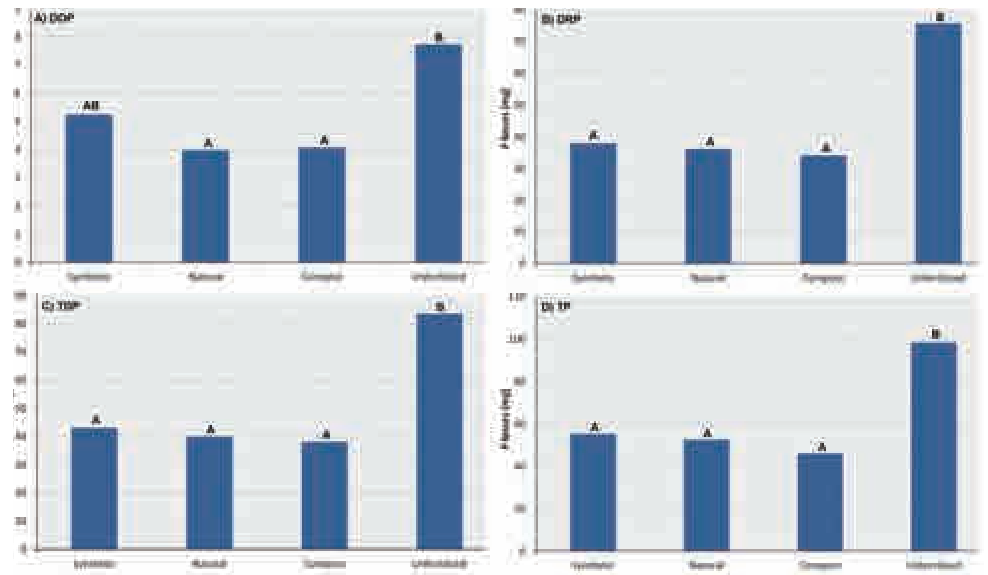

Figure 7. Total phosphorus load in runoff water during the 2012 season. Column with the same letters are not significantly different. (DOP = dissolved organic P, DRP = dissolved reactive P, TDP = total dissolved P and TP= total P).

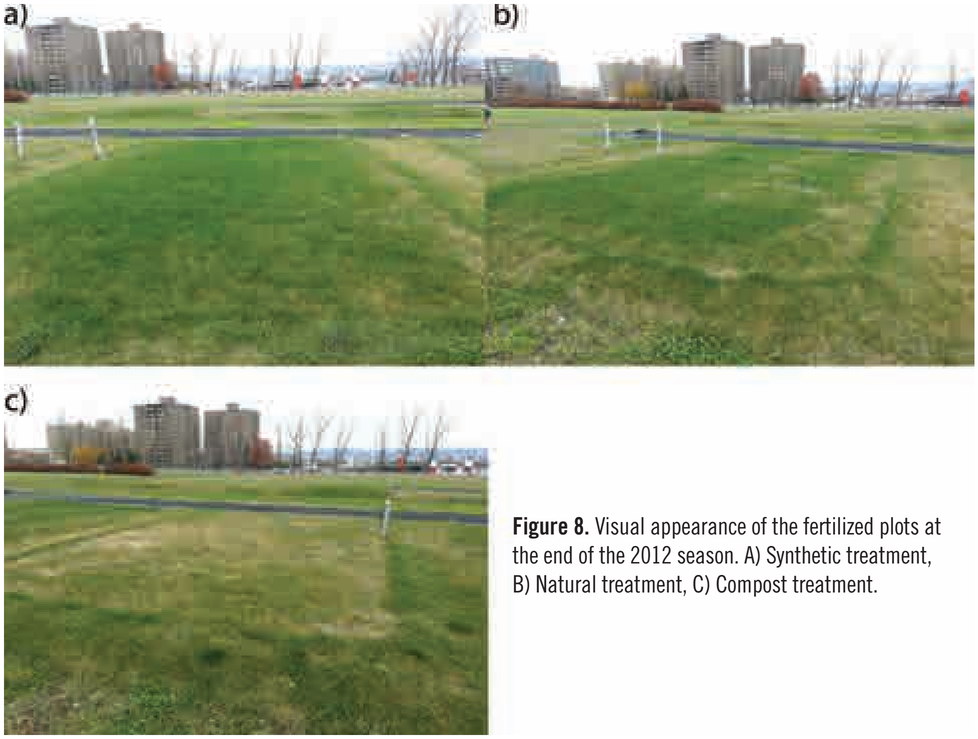

Figure 8. Visual appearance of the fertilized plots at the end of the 2012 season. A) Synthetic treatment, B) Natural treatment, C) Compost treatment.

Also, even if nitrate losses were higher from fertilized plots, the average NO_3^- concentration (3 mg L^{-1}) was far below the Québec threshold for potable water (10 mg / L^{-1}) (data not shown).

Runoff. We did not observe any significant differences in runoff volumes between the different treatments (data not shown). However, we did observe differences in phosphorus losses through runoff (Figure 7). We measured four different forms of phosphorus in the water: total P (TP), total dissolved P (TDP), dissolved organic P (DOP) and dissolved reactive P (DRP). The concentration of all these forms of phosphorus was significantly lower in runoff from fertilized plots compared to the unfertilized plots (data not shown). Over the growing season, fertilized turf resulted in a 50% decrease in P load in runoff water compared to unfertilized turf. This effect is probably due to vegetation density and composition on the unfertilized plots.

Turfgrass quality. It is difficult to compare turf visual quality between unfertilized turf composed of mixed species and fertilized turf made from Kentucky bluegrass, since some of the broadleaf "weeds" could be desirable to a homeowner who does not fertilize their lawn. However, we did compare the effects of the three fertilizer sources on turfgrass quality during the growing season. The highest visual quality was observed on plots fertilized with the synthetic treatment, followed with plots fertilized with the natural program (data not shown). The compost treatment, based on a city by-law, resulted in the lowest visual quality. A comparison of the visual appearance of the fertilized plots at the end of the season (November 5, 2012) is shown in Figure 8.

Conclusion

While the results of this experiment are certainly promising from the perspective of turfgrass managers, it is important to reiterate that they are based on only one year of research. Thus, they should be considered preliminary for the moment and taken with a certain reserve. We currently are reviewing data from 2013, and we have requested funding for an additional five years in order to be able to observe the long-term evolution of our research plots. We hope that results from this experiment will be useful for both turfgrass managers and government bodies that want to implement fertilizer regulations. Any question related to this project can be directed to Guillaume Grégoire, research associate at Université Laval (guillaume.gregoire@fsaa.ulaval.ca).

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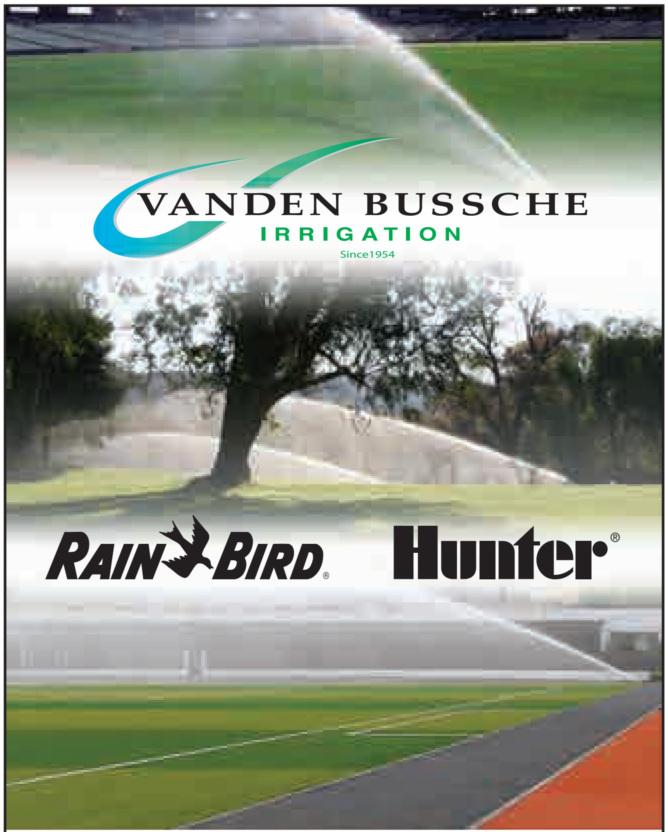

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