Progress Report

Title: Evaluating the phosphorus runoff potential of current home lawn fertilization practices and recommendations based on soil test results

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Objectives:

1) Determine surface phosphorus runoff from different fertility programs applied to lawns with low (<40 lbs P_2O_5/acre) and high (>60 lbs P_2O_5/acre) soil phosphorus.
2) Evaluate the quality of turfgrass in response to phosphorus treatments applied to soils with different concentrations of available phosphorus.
3) Visually demonstrate to home owners through permanent demonstration plots the differences in turfgrass quality and phosphorus runoff potential of different fertilization scenarios as related to soil test values.

Current status/importance of research area:

In Missouri, approximately 850,700 acres were used for turfgrass cultivation in 2005, which according to current estimates would make turfgrass the fourth largest crop in Missouri by acreage. Turfgrass is fertilized to apply between 100-200 lbs of N/acre annually. Many home owners regularly use products such as 12-12-12 and apply them at recommended rates for nitrogen (100-200 lbs/acre), which over time has greatly elevated the soil phosphorus and potassium levels. Continual fertilization of phosphorus on soils that are in excess of available phosphorus will increase the likelihood of nutrient loss through surface runoff and without providing additional benefits to turfgrass health. Furthermore, surface runoff of sediment and nutrients, especially phosphorus, into surface water is a growing concern that can lead to eutrophication of lakes and streams. On January 31st of 2011, the EPA issued a final mandate to the Missouri Department of Natural Resources to reduce storm-water runoff into Hinkson Creek by 39.6% because of excessive pollutants from runoff. This EPA mandate validates the importance of this research, as the Missouri DNR will be seeking areas which can be regulated to reduce pollutants into Hinkson Creek and other surface waters of Missouri. If residential fertilizer restrictions are proposed, this Fertilizer and Lime Council funded project will provide reliable and local data to assist in reasonable and research based regulations in hopes of preventing an unnecessary burden on the turf fertilizer industry.

Procedures:

Design - Twelve plots were established on a laser leveled 4% slope measuring 5 ft by 20 ft with a two foot buffer between each plot. Initial soil phosphorus levels were determined through soil test and plots were assigned to 'high' (>60 lbs P/acre) and 'low' <40 lbs P/acre) soil phosphorus designations. The differences in soil P were further magnified through triple super phosphate (46% of P_2O_5) fertilization to develop a substantial difference in soil phosphorus levels for the four corresponding treatments with three replications. The treatments are a homeowner scenario with high soil P (treatment 1), a soil test scenario with high soil P (treatment 2), a soil test scenario with low soil P (treatment 3), and a restricted scenario with low soil P (treatment 4)

(Table 1). Once the soil phosphorus level had been adjusted, one single fall phosphorus application in the amount of 50 lbs P/acre was applied to treatment 1 (homeowner scenario with high soil P), and treatment 3 (soil test scenario with low soil P). Treatment 2 (soil test scenario with high soil P) did not receive any phosphorus treatment as based on soil test (no additional P were needed). Similarly, no phosphorus treatments were applied to treatment 4 as it is designated as low soil P, yet is a restricted use scenario. After the fall phosphorus application, simulated rainfalls (4 inches) were applied twice in the fall at 0 day after treatment (DAT) and 5 DAT to induce runoff. The reason 0 day when rainfall was applied was to simulate the extreme condition when homeowners ignored the weather condition and applied the phosphorus fertilizer at the same day when significant rainfall occurs. We also simulated the second rainfall event at 5 DAT to evaluate if residue phosphorus exits. Since we had an unusually dry year, 4 inches of rainfall was necessary to induce runoff from treatment area.

Table 1. Phosphorus fertilizer treatments applied to the runoff plots in 2011.

Treatment	Phosphorus fertilization	Soil available phosphorus
1.Common homeowner scenario	150 lbs P_2O_5/acre	High (>60 lbs P_2O_5/acre)
2. Soil test recommendation	None (as recommended by soil test)	High (>60 lbs P_2O_5/acre)
3. Soil test recommendation	50-150 lbs P_2O_5/acre (as recommended by soil test)	Low (<40 lbs P_2O_5/acre)
4. Restricted use scenario	None	Low (<40 lbs P_2O_5/acre)

Construction – Each 5 ft by 20 ft plot is enclosed by galvanized steel edges that have been imbedded around all the edges. Galvanized steel runoff collection boxes measuring five feet wide, six inches deep, and eight inches wide were constructed and installed down slope from each of the twelve plots (Figure 1). The collection boxes have a built in sample splitter with about one third of the runoff directed to the sample collection bins which consists of 32 gallon collection bins buried 3 ft deep and a removable five gallon bucket for runoff collection. The remaining two thirds of the runoff not collected are directed into a drain tile traversing the plot. Drainage pipe is 4 inch round drainage tile that runs down a roughly 3% slope at a 14 inch depth for about 100 feet, which then takes a 90 degree turn for another 100 feet down a 4% slope at the same depth which eventually discharges into a swale. Each collection box has been individually calibrated to determine the precise percentage of runoff that is directed to the sample collection bins.

Figure 1. Field plots constructed.

Measurements – Runoff water is collected within 12 hours of simulated rainfall event. Total volume is determined and a representative one liter sample is collected and sent to the MU Soil and Plant Testing Laboratory for determination of total phosphorus, dissolved phosphorus, and percent sediments. Plant tissue samples and soil samples are also taken and analyzed by the Soil and Plant Testing Laboratory for total plant and soil nutrients including phosphorus. Weekly measurements (when weather condition permits) include chlorophyll index (Field Scout CM1000), NDVI (GreenSeeker®), and overall turf quality on a 1-9 scale.

Project Accomplishments:

Soil phosphorous concentrations at the initial estimation date (August 25) demonstrated that numerical but not statistically significant differences existed between treatments (Figure 2, blue bars). However, on November 22, treatments 1 and 2 could be classified as high soil P while treatments 3 and 4 could be categorized as low soil P (Figure 2, red bars). This would indicate that we had established treatments within our intended parameters.

Based upon fertilization of treatments 1 and 3 on Day 0, there were significantly higher levels of both total P and dissolved P collected in runoff water compared to treatments 2 and 4 (Table 2). Total P was 6.94-fold higher for treatment 1 compared to treatment 2. This suggests that for soils with high P levels, high rainfall shortly after application of P fertilizer results in a significant loss of that P. Similarly, high rainfall shortly after application of P fertilizer on soils with low P levels also results in a significant loss of P (7.04-fold) compared to treatment 4. However, P application applied on soil with high P level (treatment 1) resulted in significantly higher total runoff P loss than applied to plots with low soil P level (treatment 3). This result indicated that accumulated higher soil P level will likely increase the chance of runoff P loss. These same trends and level of significance were also measured for P dissolved in water (Table 2). In examining the sediment P levels, we observed that some differences were noted among treatments, but this was not significant. It was quite interesting to note that of the total P estimated from treatments 2 and 4 (no additional P added at day 0), 92.3% and 94.4% were represented by sediment P from treatments 2 and 4, respectively. These data suggest that some P was lost from treatments 2 and 4, but this was represented primarily by P attached to sediment. For treatments 1 and 3, only up to 34% of the P was lost in sediment. The amount of runoff was similar for the four treatments. For 5 DAT, numerical differences in total, dissolved, and sediment P were noted between treatments, but differences were not statistically significant. The impact of the P levels was influenced by the numerical differences in runoff water collected.

On a concentration basis (amount of runoff water collected taken into consideration), total P (mg/L) and total dissolved P (mg/L) were significantly higher for plots receiving P just prior to a high rainfall event (0 DAT) compared to plots that did not receive P (Figure 3A and B). At 5 DAT, levels of total P and dissolved P were quantitatively similar at both the high and low soil P levels. These data indicate that a majority of the potential P lost with high rainfall events will occur with the first event.

Mineralization of tall fescue tissue on December 9 (18 DAT) showed differences for P among treatments but not N or K (Table 3). The P (in %) in tissue samples from high P soils (treatment

1 and 2) ware significant higher than the tissue samples collected from the low soil P plots (treatment 3 and 4). This result corresponds with the soil P level presented at Figure 2.

Estimates of turf health over a 25 day period following application of P and high rainfall were similar for the four treatments (Table 4). Among all the variables of turf health, only NDVI measured at 10 DAT showed differences between treatments. Higher NDVI values would correlate with better turf color and coverage, but differences between treatments could not be associated with P levels. Our data indicate that the relative P levels in the soil did not contribute to an ability to assess the tall fescue growing in plots with that treatment as healthier.

Rainfall amounts in the experimental area were low over the duration of the study (Figure 4). As a result, the soil moisture potential was low and high rainfall events of 4 inches were necessary to induce runoff from the plots.

In summary, our preliminary data demonstrate that improper application of P fertilization does increase the chance of loss P through runoff.

Objective for year two (2012):

The second year of this experiment will be repeating the treatments and measurements as we conducted in 2011. It is important for a field-based project to validate results by collecting data from different growing seasons, as the year-to-year variance of environmental conditions are expected. This past year has been extremely dry and we were not able to collect any runoff data from natural rainfalls. In 2012, we plan to put down treatments both in spring and fall, and hopefully we are able to collect data from both simulated and natural rainfalls. For the second year of this study, we are also ready to demonstrate and present the results to the general public through the Turf and Ornamental Field day in summer, and Lawn-care workshop in spring. At the end of the second season, we are also planning to present the results to the Missouri Green Industry Conference in December.

Proposed budget for year two (2012):

Category	Year 2
Salary and benefits (20% Research Specialist)	9,373
Supplies (fertilizer, sampling bags) *	500
Soil testing services**	5,000
Total	14,873

* Supplies include fertilizer, sampling bags, seeds, pesticides, and other necessary consumables.
** Soil testing services include estimates for two soil samples, two tissue samples, and six runoff water samples in 2012 from each plot.

Figure 2. Soil phosphorus (P) concentration (lb/ac) measured by Bray I P before and after P fertilizer treatments. Soil samples were randomly taken from 5 different locations within each plot and mixed for analysis. Bars labeled by different letters before or after P treatment are not significantly different using Fisher's Protected LSD (*P*=0.05).

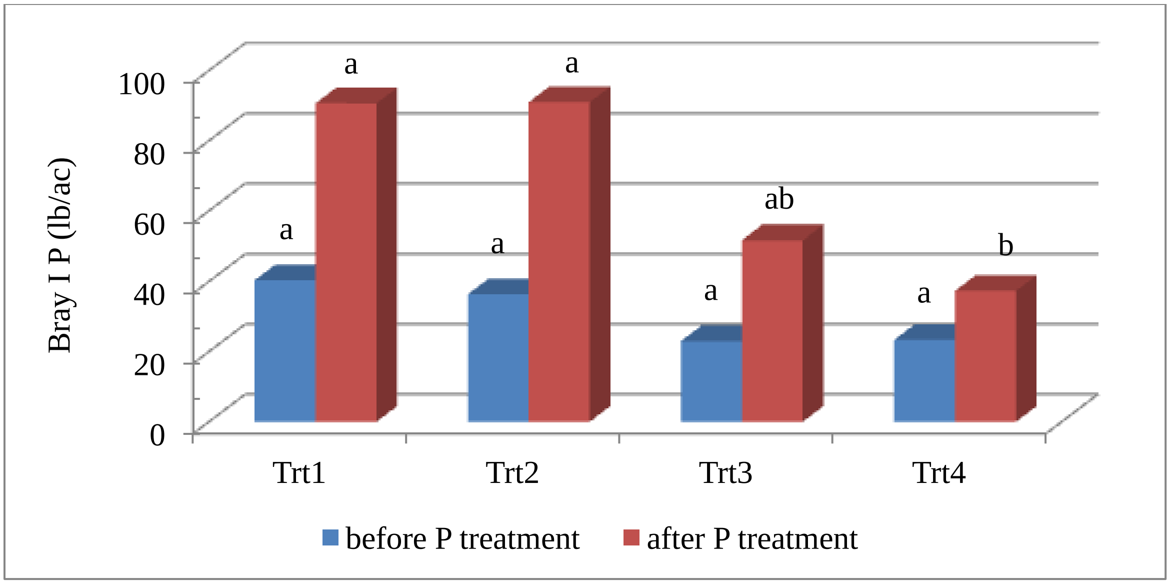
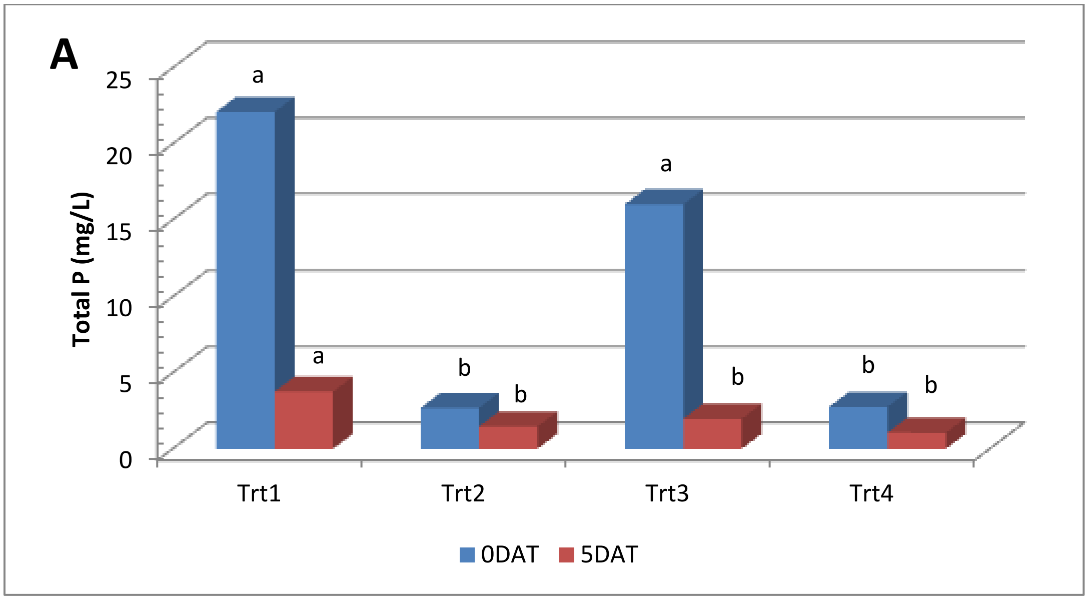


Figure 3. Concentrations of total P (mg/L) and dissolved P (mg/L) in runoff water collected at 0 (A) or 5 (B) days after the P fertilizer treatment (DAT). Bars labeled by different letters at 0 or 5 DAT are not significantly different using Fisher's Protected LSD (*P*=0.05).



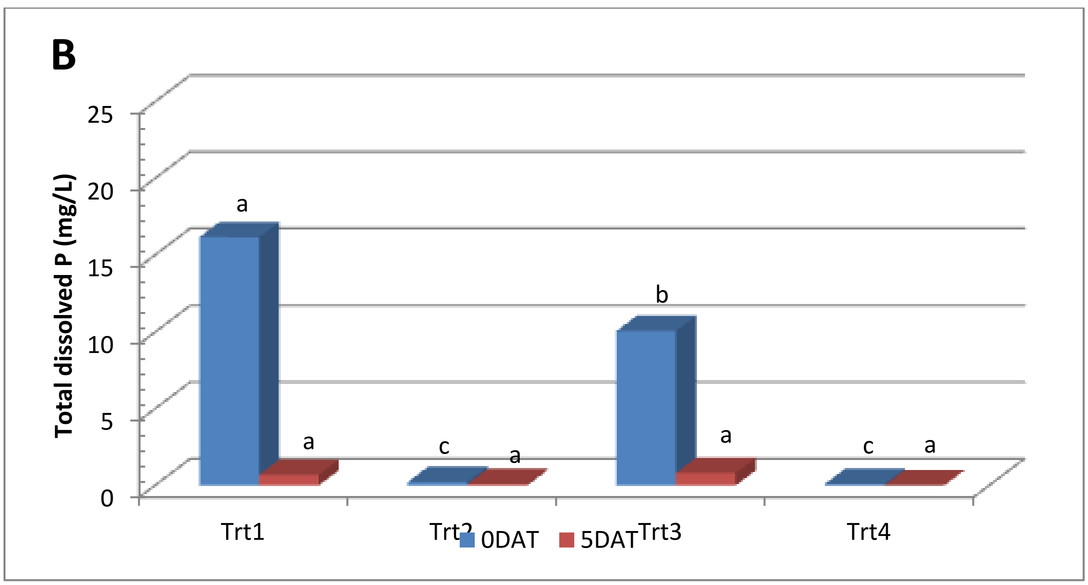


Figure 4. Precipitation (inches) at the South Farm during fall, 2011.

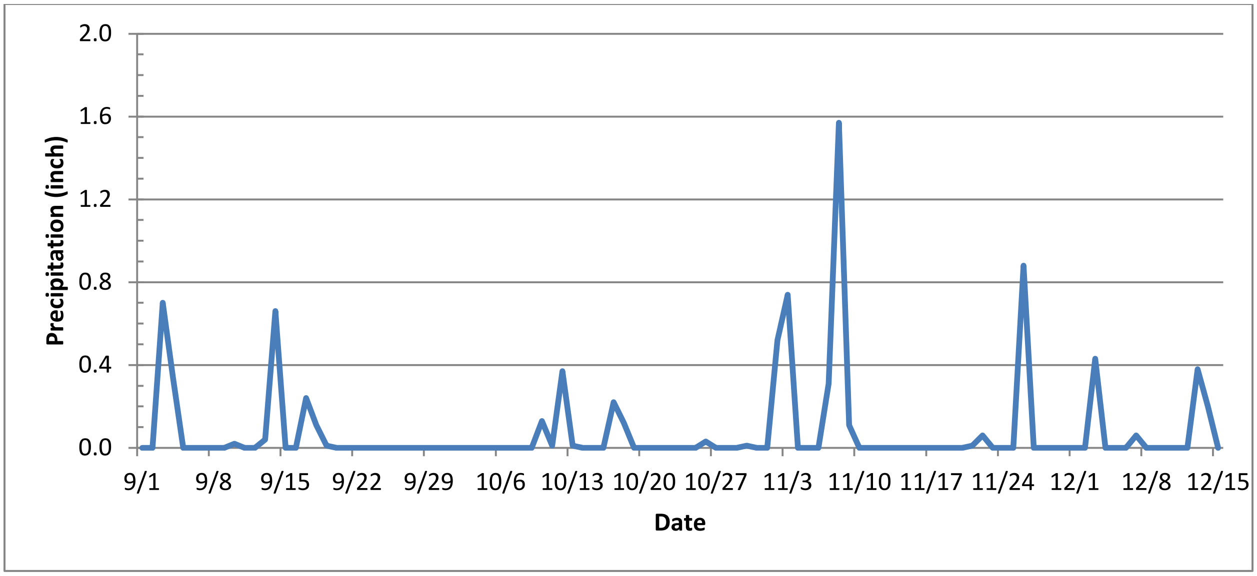


Table 2. Total phosphorus loss in the runoff water from the plot area affected by the P fertilizer treatments at the different days after treatments (DAT). Data included are total P (mg), dissolved P (mg), sediment P (mg), and the total runoff (L) from the plot area.

Trt #	Soil P	Practice	---Total P (mg) ---		--Dissolved P (mg) ---		---Sediment P (mg)* ---		-----Runoff (L) -----	
			0DAT	5DAT	0DAT	5DAT	0DAT	5DAT	0DAT	5DAT
1	High P	Home owner	333.9a**	371.8	237.9a	93.7	96.0	278.0	16.4	98.1
2	High P	Soil test	48.1c	85.3	3.7c	6.0	44.4	79.3	15.9	58.4
3	Low P	Soil test	199.9b	157.3	132.0b	67.8	67.9	89.5	12.7	71.2
4	Low P	Restricted use	28.4c	106.6	1.6c	2.1	26.8	104.5	14.9	97.1

*Sediment P (mg) is indirectly presented by the difference between the total P and dissolved P.
**Mean separation is conducted only when significant differences were found by ANOVA. Means within a column followed by the same letter are not significantly different using Fisher's Protected LSD (*P*=0.05).

Table 3. Turfgrass tissue mineral concentrations, percent nitrogen (N%), phosphorous (P%), and potassium (K%) influenced by the P fertilizer treatments.

Trt #	Soil P	Practice	N%*	P%	K%
1	High P	Home owner	2.22	0.36a	1.70
2	High P	Soil test	1.85	0.32b	1.33
3	Low P	Soil test	1.87	0.29c	1.49
4	Low P	Restricted use	2.04	0.29c	1.56

*Clipping samples were collected from the plot area and analyzed in the Soil and Plant Testing Laboratory and reported as percent (%) dry matter.

Table 4. Turf quality, canopy chlorophyll index, and Normalized Difference Vegetation Index (NDVI) affected by P fertilizer treatments. Data were collected at different days after treatments (DAT).

Trt #	Soil P	Practice	-----------Turf quality*-----------				--------Chlorophyll Index**--------				----------NDVI†----------		
			1DAT	10DAT	19DAT	25DAT	1DAT	10DAT	19DAT	25DAT	10DAT	19DAT	25DAT
1	High P	Home owner	7.0	7.3	7.2	7.0	240.7	205.7	234.0	204.3	0.79a‡	0.67	0.73
2	High P	Soil test	7.2	7.2	7.0	7.0	213.0	197.0	215.7	183.3	0.63b	0.59	0.63
3	Low P	Soil test	7.2	7.2	7.0	7.0	220.3	196.7	217.0	189.7	0.69ab	0.64	0.69
4	Low P	Restricted use	7.3	7.5	7.2	7.0	234.7	210.0	235.0	200.0	0.72ab	0.68	0.76

*Turf quality were visually assessed at 1-9 scale where 9 represents ideal turf, 1 represents dead turf, and 6 represents minimally acceptable turf quality;

**Chlorophyll index were collected by using a field scout CM1000 reflectance meter (Spectrum technologies, Plainfield, IL) and averaged three random readings per plot;

†Normalized difference vegetation index (NDVI) were recorded using a GreenSeeker (NTech Industries, Inc., Uklah, CA);

‡Means followed within a column followed by the same letter are not significantly different using Fisher's Protected LSD (*P*=0.05).