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

2. Investigator: Xi Xiong, Dan Lloyd

3. Objectives:

The primary objective of this research is to evaluate and demonstrate the phosphorus fertilizer runoff potential from turfgrass systems.

Specifically, this research will:

1) Determine surface phosphorus runoff from typical and recommended fertility programs applied to lawns with low (<40 lbs P_2O_5/acre) and high (>60 lbs P_2O_5/acre) plant available 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.

Relevance to the Missouri Fertilizer and Lime Industry:

In the United States, land occupied by managed turf including residential and commercial lawns, parks, golf courses, and athletic fields is around 40 million acres (Milesi et al., 2005). For perspective, national turfgrass production occupies three times more acreage than is used for corn production and is the single largest irrigated crop in the United States. In Missouri, approximately 850,700 acres were used for turfgrass cultivation in 2005 (Milesi et al., 2005), which according to current estimates would make turfgrass the fourth largest crop in Missouri by acreage (USDA/NASS, 2009). With a growing population and new home construction increasing, the urban landscape and turfgrass acreage will continue to expand in acreage and importance.

Turfgrass is fertilized to apply between 100-200 lbs of N/acre annually. For most agricultural systems specific attention is given to phosphorus and potassium nutrition as well as nitrogen, where as in the home lawn setting fertilizer rates are often calculated based solely on the nitrogen content. Because of the wide availability of fertilizers with 1:1:1 ratios for N-P-K analyses and because the cost savings compared to low nitrogen containing organic fertilizers, 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. According to lawn and garden soil test data compiled by the University of Missouri soil testing lab from the 275 samples submitted from Boone county, 54% and 62% were the excessive range of soil phosphorus and potassium, respectively (Nathan, 2009, unpublished data).

Typically, surface runoff on turfgrass is minimal due to its dense contiguous growth habit. However, continual fertilization of phosphorus on soils that are in excess of available phosphorus increases the likelihood of nutrient loss through surface runoff without providing an improvement in 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. This

often practiced method of excessive fertilization is economically undesirable, environmentally problematic, and agronomically ineffective. Rather than waiting for environmental agencies to completely ban the use of phosphorus in lawn fertilizers, as has already been implemented in numerous regions, the best approach is to perform anticipatory research and establish permanent demonstrations to show the runoff potential of properly fertilized turf. The objective of this research is to promote the proper use of fertilizers on home lawns and compile data so that when regulations are discussed in Missouri, informed decisions can be made based on sound research.

4. Procedure:

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)

Design: This study will be conducted as an ongoing field study on permanent demonstration plots at the turfgrass research facility at the South Farm Research Center in Columbia, MO beginning in spring of 2010. All treatments will be applied to tall fescue (*Festuca arundinacea*), the most abundant lawn grass in Missouri. Treatments will receive 150 lbs N/acre and potassium as recommended by soil test. Phosphorus will be applied to the selected treatments as monoammonium phosphate split equally into three separate applications occurring in May, September, and October as recommended by University of Missouri extension (Dunn and Ervin, 1999). Three replications will be included in a randomized complete block design. Plots measure 6x18 ft and will have a 5% slope designed to collect runoff water for nutrient and sediment analysis. Runoff will be collected using a design described by Cole et al (1997) with modifications (Figure 1). Each plot will be edged with both galvanized steel and plastic-edging borders to minimize the runoff overflow. Plots will also be equipped with flumes which direct the runoff water to the collection bins. Sample splitters will be installed for each plot to avoid overflow potential and direct runoff evenly to the collection bins. Plots will be mowed with a rotary mower at 2.5 inches on a 5-7 day interval with clippings returned. Irrigation will be applied twice per week to replace the evapotranspiration (ET) losses. A rain gauge will be installed in the center of the plots to measure the amount of water the plots received.

Measurements: Soil and tissue samples from each plot will be collected in the spring and fall each year and analyzed in the University of Missouri soil testing lab for general fertility analysis and total phosphorus. Runoff samples will be collected from all rainfall events accumulating greater than two inches. Runoff will also be collected from simulated rainfall of 2 inches applied once in the spring and fall of each year. Immediately following each rainfall or irrigation event, runoff water samples from each collection bin will be brought to the Soil Analysis Lab at the University of Missouri to be analyzed for total nitrogen, nitrate, total phosphorus, dissolved phosphorus, and

sediment through methods described by Nathan et al (2006). Weekly measurements will include turfgrass quality on a 1-9 scale and chlorophyll index using a field scout CM1000 reflectance meter (Spectrum technologies, Plainfield, IL). Normalized difference vegetation index (NDVI) will also be recorded weekly using a greenseeker (NTech Industries, Inc., Uklah, CA) to provide an unbiased assessment of turfgrass vigor.

5. Current status and importance of research area:

Fertilizer restrictions are being considered and imposed in regions across the United States in attempt to protect surface water from eutrophication. As witnessed in places like Wisconsin, Minnesota, New York, and California, turfgrass is the generally the first crop to receive such restrictions as it is considered by many a luxury crop. These restrictions have often led to the removal of all phosphorus from fertilizer sold for use on turfgrass. Often times when new legislation is being discussed, quality local research can be extremely beneficial in ensuring that informed decisions are made.

6. Expected economic impact of this project:

Initially, the economic gain expected from this research will be realized by the end users, specifically homeowners. This will be achieved through the extensive outreach portion of this project that will stress the importance to homeowners of getting soil tested and changing fertilization practices accordingly. This will save money for those that have sufficient soil phosphorus and can purchase less expensive fertilizer without the additional phosphorus. Eventually, this research has potential to make a significant positive economic impact on the fertilizer producers in the event that fertilizer restrictions are discussed in Missouri. It is conceivable that the results of this research could help guide the regulations in a way that does not hastily remove all phosphorus from fertilizers used on turfgrass as has been done in other areas.

7. Timetable for proposed research:

2011 – February	Construct demonstration plots and impose soil treatments
– May – December	Begin phosphorus treatments and evaluations
2012 – May – December	Repeat treatments, collect measurements throughout the season
2013 – long term	Repeat treatments, collect measurements throughout the season, communicate results through demonstrations and extension

8. Strategy for application and transfer of knowledge:

This research will be highly visible as a demonstration experiment at the South Farm and will be discussed during various field days. Although funding is sought only through 2012, this will continue as a long term demonstration experiment. The information gained from this study will be disseminated effectively through extension avenues including an extension factsheet and the wide reaching master gardener program. Results of this research will also be available on a webpage link provided by the lawn and garden soil testing service. This research will be published in appropriate journals as well as presented at conferences and annual meetings of various societies (including the American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, and the Missouri Turf and Ornamental Council).

9. Proposed Budget

Category	Year 1	Year 2	Total
Salary and benefits (20% research specialist)	9,100	9,100	18,200
Plot construction -Galvanized steel, plastic, collections bins, pipes *-Sample splitters	 5,000 14,400		 5,000 14,400
**Supplies (fertilizer, sod)	500	500	1,000
***Soil testing services	5,000	5,000	10,000
Total	**34,000**	**14,600**	**48,600**

Budget narrative:

* Sample splitters are a necessary expense to accurately measure quantity of total runoff while eliminating the risk of overflow, cost is based on 12 sample splitters estimated at $1200 each.

** Supplies include fertilizer, sod, weed control, plot preparation, and other necessary field materials.

*** Soil testing services include estimates for two soil samples, two tissue samples, and six liquid samples annually from each plot.

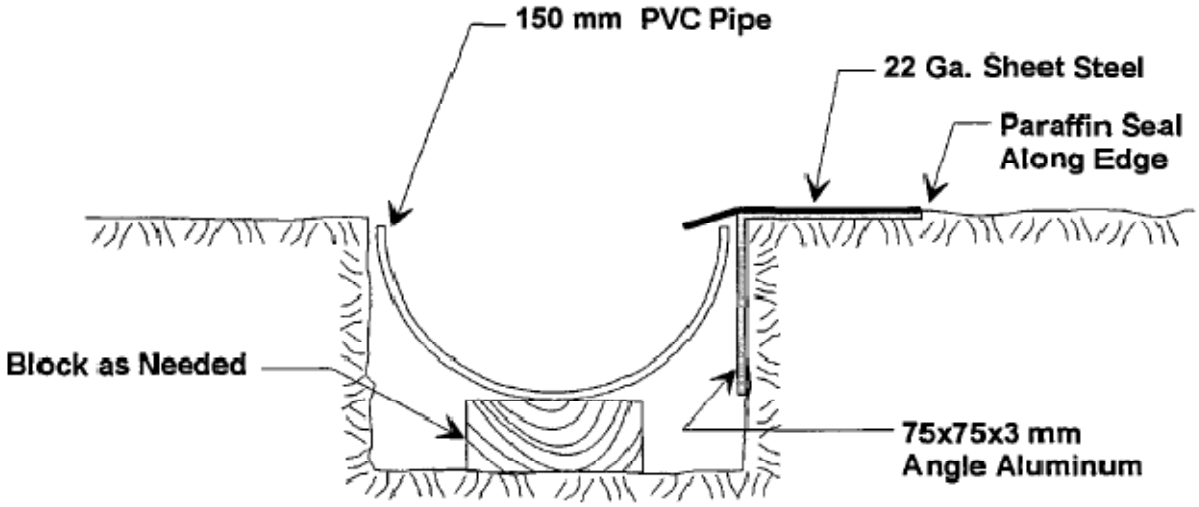

Figure 1. Cross section view of plot area (Cole et al., 1997).

References:

Cole, J.T., J.H. Baird, N.T. Basta, R.L. Huhnke, D.E. Storm, G.V. Johnson, M.E. Payton, M.D. Smolen, D.L. Martin, and J.C. Cole. 1997. Influence of buffers on pesticide and nutrient runoff from bermudagrass turf. J. Environ. Qual. 26: 1589-1598.

Dunn, J.H. and E.H. Ervin. 1999. Lawn maintenance calendar – cool-season grasses. MU Extension, University of Missouri-Columbia. G6705

Nathan, M., J. Stecker, and Y. Sun. 2006. Soil testing in Missouri. Missouri Cooperative Extension Service. EC923.

USDA/NASS – Missouri field office. 2009. Missouri current estimates. http://www.nass.usda.gov/Statistics_by_State/Missouri/Publications/Current_Estimates/

Resume of Xi Xiong

Assistant Professor of Turfgrass science
Division of Plant Sciences
University of Missouri
Columbia, MO 65211
Phone: 573-882-1824
Email: xiongx@missouri.edu

Education

Ph. D., Crop Science, Oklahoma State University, Oklahoma, 2005.
M.S., Turfgrass Science, Sichuan Agricultural University, China, 2001.
B.S.E., Horticulture, Sichuan Agricultural University, China, 1998.

Research and Professional Experience

2009-current	Assistant Professor in Turfgrass Science, Division of Plant Sciences, University of Missouri.
2008-2009	Research Assistant Professor in Turfgrass Science, Division of Plant Sciences, University of Missouri.
2005-2008	Post-Doctoral Research Associate, Laboratory of Plant Molecular Physiology, University of Florida.
2002-2005	Graduate Research Assistant, Department of Horticulture & Landscape Architecture, Oklahoma State University.
1998-2001	Graduate Research and Teaching Assistant, Department of Grassland and Turfgrass Science, Sichuan Agricultural University, Sichuan, China.

Awards and Honors

Tulsa Garden Club Scholarship, Oklahoma State University, 2004.
Huffine Memorial Distinguished Graduate Fellowship, Oklahoma State University, 2004.

Professional Affiliations

Member of Crop Science Society of America
Member of American Society for Horticultural Science
Member of Golf Course Superintendents Association of America
Member of International Turfgrass Society
Member of United States Golf Association
Member of Phi Kappa Phi Honorary Society
Member of Missouri Turfgrass & Ornamental Council

Peer Reviewed Publications (* published in Chinese)

Earlywine, D.T., R.J. Smeda, T.C.Teuton, C.E.Sams, and **X. Xiong**. 2010. Evaluation of oriental mustard (*Brassica juncea L.* Czern.) seed meal for weed control in turf. Weed Technology. 24: 440-445.

Xiong X., V.A. James, H. Zhang and F. Altpeter. 2010. Constitutive expression of the barley *HvWRKY38* transcription factor enhances drought tolerance in turf and forage grass (*Paspalum notatum* Flugge). Molecular breeding, 25 (3): 419-432.

Xiong X., G.E. Bell, J.B. Solie, M.W. Smith, and B. Martin. 2007. Bermudagrass seasonal responses to N fertilization and irrigation detected using optical sensing. Crop Science, 47: 1603-1610.

Xiong X., G.E. Bell, M.W. Smith, and B. Martin. 2006. Comparison of the USGA and airfield sand systems for sports turf construction. Online. Applied Turfgrass Science, doi:10.1094/ATS-2006-0531-02-RS.

Xiong X., Y. Wu, and X. Li. 2001. Progress of physiological and biochemical research on bermudagrass related to cold tolerance. Pratacultural Science. (3): 39-41. *

Xiong X., Y. Wu, and X. Li. 2001. Preliminary research of determination technology on bermudagrass in relation to cold tolerance. Pratacultural Science. (2): 32-35, 38. *

Xiong X., Y. Wu, K Mao, and Y. Cheng. 2001. The preliminary study on formation speed and quality evaluation of native bermudagrass in Minjiang River basin. Sichuan Animal and Veterinary Sciences. (4): 18-20. **

Wu Y., L. Liu, **X. Xiong,** X. Xie, Z. Wang, and Y. Yan. 2001. Utilization and evaluation of native germplasm of bermudagrass in Sichuan. Grassland and Turf. (3): 32-34. *

Xiong X., Y. Wu, L. Liu, and X. Li. 2000. The present investigation report on turfgrass development in Yibin City. Journal of Sichuan Grassland. (3): 39-42. *

Li X., K. Mao, **X. Xiong,** and S. Li. 2000. Progress in research on cold tolerance of warm-season turfgrass. Grassland of China. (4): 53-58. *

Book Chapter

Gregory E. Bell and **Xi Xiong.** 2008. The History, Role, and Potential of Optical Sensing for Practical Turf Management. In: Handbook of Turfgrass Management & Physiology. (M. Pessarakli, Ed.). CRC Press, Taylor & Francis Publishing Company, Florida.

Resume of Dan Lloyd

Research specialist
Division of Plant Sciences
110 Waters Hall
University of Missouri
Columbia, MO 65211

phone: 573-239-2757
fax: 573-874-1601
email: lloyddt@missouri.edu

Education

B.S. in Soil Science, University of Wisconsin – Madison, 2007
M.S. in Soil Science, University of Wisconsin – Madison, 2009
- Research focus: Low-temperature N uptake and utilization of cool season turfgrass using ^{15}N

Academic Experience

2009- present — Turfgrass research Specialist
University of Missouri, Division of Plant Sciences
Responsibilities:
- Assist Dr. Xi Xiong and students with ongoing research
- Manage field operations at the turf research facility
- Conduct product evaluations
- Supervise greenhouse and laboratory methods

2007-2009 — Graduate research fellow
University of Wiscosin – Madison, Department of Soil Science
Responsibilities:
- Designed, implemented and executed a two year turfgrass research project involving greenhouse and field research in Wisconsin and Minnesota
- Managed, scheduled and trained five employees in field and laboratory methods
- Communicated research objectives and results through publications and presentations at conferences and seminars
- Gained proficiency in experimental design and statistical analysis using statistical software packages SAS and JMP

2008 — Teaching assistant
University of Wisconsin – Madison, Department of Horticulture
Responsibilities:
- Taught the laboratory section for “Introduction to turfgrass management”

2009-present Research Specialist
University of Missouri, Division of Plant Sciences
Responsibilities:

- Coordinate research trials at South Farm turfgrass research facility
- Fungicide, herbicide, and insecticide product evaluations
- Teach lab section of "Introduction to Turf Management"
- Assist with laboratory and greenhouse research for Dr. Xiong's research program

Affiliations:

Golf Course Superintendents Association	2005- present
Wisconsin Golf Course Superintendent's Association	2005- present
Crop Science Society of America	2007- present
American Society of Agronomy	2007- present
Soil Science Society of America	2007- present

Selected Publications and Presentations:

Lloyd, D. T., 2009. Is Fall *really* the most important time for N fertilization of turfgrass? Missouri turf and ornamental conference

Lloyd, D.T.; D.J. Soldat; T. Balser. 2009. Understanding Microbes Helps Explain Nutrient Cycling. Golfdom. February, 2009. p. 50-52.

Lloyd, D.T., 2008. Late-Season Nitrogen Fertility on Putting Greens – A Wisconsin Survey The Grass Roots, vol. 37, issue 4. July/August

Lloyd, D.T.; D. J. Soldat, T. Balser. 2008. Soil physical and biological diversity of lawns in Dane County, Wisconsin. ASA-CSSA-SSSA 2008 International meetings.

Lloyd, D.T. 2005. Biostimulants for turfgrass use. Golf Course News website.