1. **Project Title**: Liming to Reduce Ergovaline Concentration in Toxic Tall Fescue Pastures

2. **Investigators**: Craig Roberts, Robert Kallenbach, and John Lory

3. **Objective and Relevance to the Missouri Fertilizer and Lime Industry**

Fescue toxicosis is the most severe forage-livestock disorder in Missouri (Roberts and Andrae, 2010). It costs the Missouri beef industry $160 million each year, as toxic tall fescue reduces calf gains by 40%, milk production by 30%, and pregnancy rate in spring calving herds by up to 45%. It has an even greater impact on dairy cattle and horses.

Fescue toxicosis is caused by a toxic fungus called "the endophyte" because it resides in the tall fescue plant (Bacon et al., 1977). The endophyte produces ergovaline, a compound known to be responsible for these symptoms (Rottinghaus et al., 1991). The objective of this research is to determine the impact of liming on ergovaline concentration in tall fescue.

4. **Procedures**

Field Preparation and Design

This experiment will be conducted for three years, 2012-14, on the Tom Roberts (no relation to investigators) farm near Alton, MO. The reasons for this location are 1) the farm is located near Sarah Kenyon, an MU Extension Specialist who will be assisting in the field work, 2) the soil has been tested andhas a salt pH of 5.5, 3) the pasture has been tested for endophyte and found to contain 90% infected plants, 4) the Tom Roberts farm is typical of many Ozark beef operations, and 5) an on-farm demo will expedite the technology transfer that follows this research. In the winter of 2012, 16 plots measuring 10' x 20' will be marked, with 8 replications designated as non-treated control or and 8 treated with 2.2 tons lime/acre according to soil test. Plots will also be fertilized in the winter with nitrogen at the rate of 50 lb/acre and sprayed for broadleaf weed control.

Plant Sampling

Plots will be sampled twice each year—once in the spring and once in the fall. The spring sampling will occur in late April, after plants green up in the spring but before they reach the boot state. The fall sampling will occur in early October, after plants green up again in the fall but before the killing frost. Whole plants of tall fescue will be cut from each plot at soil level and stored in a freezer immediately upon returning from the field. After each sampling, plots will be clipped and clippings removed.

Sample Preparation and Laboratory Analysis

Frozen samples will be cut into 2" segments, beginning at the crown. The reason for this, ergovaline concentration is not always distributed evenly throughout the plant. All segmented samples will be freeze-dried and ground to 1 mm. The ground samples will be scanned with near-infrared spectroscopy (Roberts et al., 1997) and then analyzed for ergovaline by HPLC (Rottinghaus et al., 1991).

Below is a summary of the treatments:

Factor	No.	Description
Years	3	2012, 2013, 2014
Lime treatments	2	Lime, control
Cuttings/year	2	Spring, fall
Plant parts	4+	2" segments, beginning at soil level
Replications	8	

5. Current Status and Importance of Research Area

Nearly all pastures in Missouri include common tall fescue infected with the toxic endophyte, causing mild to severe cases of fescue toxicosis every year. In the 1980s, some pastures were renovated, as the toxic tall fescue was replaced with "endophyte-free" varieties. However, the endopyhte-free varieties died, as they were susceptible to drought, insects, pathogens, and overgrazing. Recently, pasture renovation has re-emerged, this time by replacing toxic tall fescue with varieties that contain endophytes that do not produce ergovaline. These new, nontoxic varieties survive much better than endophyte-free varieties. However, many fields will not be renovated, because renovation is expensive and time consuming; renovation requires two applications of glyphosate, a smother crop, and one year to complete. Many farmers continue to manage toxic pastures and fields.

Modern recommendations for tall fescue management include "alkaloid management," which involves a set of practices that reduce ergovaline ingestion in a toxic field. These practices include livestock rotation among paddocks, dilution of tall fescue in the pasture by interseeding legumes, feeding of supplements, and ammoniation of hay. Because of the importance of legumes, the practices should include liming, as good soil fertility encourages growth of clovers and alfalfa, which dilutes the toxicity of a pasture.

It may be that liming can reduce ergovaline inside the grass plant as well. Research has shown that this compound is unstable in alkaline environments. It is greatly reduced when hay is treated with ammonia (Chestnut et al., 1991; Roberts et al., 2002). It also breaks down when an alkaline reagent is used on the extract in the laboratory (Rottinghaus et al., 1991). To date, no research has reported an effect of lime on ergovaline concentrations in toxic tall fescue pastures. A reduction of ergovaline, even if small, by liming the soil would increase the net profits on the family farm and further encourage the practice of liming.

6. Expected Economic Impact of the Project

In the case of gain, it is typical to strive for 0.25 lb increase in average daily gain with every management practice adopted (Roberts and Andrae, 2010). If successful, this practice could produce an extra 37.5 lb per steer over a 150-day grazing period; this increases profits by $22.50 per steer at a 0.60 cent/lb. With a 100-steer herd, profits would be $2,250 higher on that family farm.

7. Timetable for Proposed Research

Year	Activity
2012	Layout field plots and apply lime (January)
	Sample plots (April, October)
	Samples segmented and stored in freezer
2013	Sample plots (April, October)
	Samples segmented and stored in freezer
	Ergovaline analysis (including samples from 2012)
2013	Sample plots (April, October)
	Samples segmented and stored in freezer
	Research presented at conference
	Ergovaline analysis (samples from 2013)
	Manuscript prepared for journal; findings presented via Extension

8. Strategy for Application and Transfer of Knowledge

Findings will be incorporated into the University of Missouri Extension programs that address fescue toxicosis (http://plantsci.missouri.edu/roberts/tallfescuetoxicosis.htm). Findings will be presented in both written and oral form and be shared with producers and producer groups, agency personnel, crop consultants, and colleagues in neighboring universities and states.

9. Proposed Budget

Item	Year 1	Year 2	Year 3	Total
Research Technician (25%)	$12,187	$12,187	$12,187	$36,561
Benefits	$3,900	$3,900	$3,900	$11,700
Supplies	$5,600	$2,600	$2,600	$10,800
Travel	$1,200	$1,200	$1,200	$3,600
Ergovaline analysis	$0	$13,568	$8,320	$20,928
Publications	$0	$0	$800	$800
Total	**22,887**	**33,455**	**29,007**	**85,349**

Justification: The salary and benefits for the **research technician** are based on 25% of a salary of $48,750 and 32% benefits. The research technician will be involved not only in the field and laboratory aspects of the experiment but also in the publications in year 3 and extension presentations in years 2 and 3. **Supplies** are for all laboratory and field work, including fertilizer, lime, sample bags, mower accessories, coolers and dry ice, weigh boats, clippers, freeze drier oil, grinder parts, and similar supplies; supplies in year 1 also include two chest freezers, which are required for storage of plant samples prior to ergovaline analysis. **Travel** includes 4 trips to the research site. **Ergovaline analysis** is based in a per

sample charge of $53; samples from years 1 and 2 will be analyzed in year 2 (256 samples x $53 = $13,568), and the remaining samples in year 3 (128 samples x $53 = $6,784). In year 3, ergovaline analysis also includes near-infrared scanning at a per sample charge of $4.00 (384 total samples x $4.00 = $1,536). **Publications** include a scientific journal article as well as extension bulletins.

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Chestnut, A. B., H.A. Fribourg, K.D. Gwinn, P.D. Anderson, and M.A. Cochran. 1991. Effect of ammoniation on toxicity of *Acremonium coenophialum* infested tall fescue. Anim. Feed Sci. Tech. 35:227-236

Roberts, C.A., and J.G. Andrae. 2010. Fescue toxicosis and management. ASA and CSSA, Madison, WI.

Roberts, C.A., R.E. Joost, and G.E. Rottinghaus. 1997. Quantification of ergovaline in tall fescue by near infrared reflectance spectroscopy. Crop Sci. 37:281-284

Roberts, C. A., Kallenbach, R. L., and Hill, N. S. 2002. Harvest and storage methods affect ergot alkaloid concentration in tall fescue. Online. Crop Managment. doi. 10:1094/CM-2002-0917-01-BR.

Rottinghaus, G. E., Garner, G. B., Cornell, C. N., and Ellis, J. L. 1991. HPLC method for quantitating ergovaline in endophyte-infested tall fescue: seasonal variation of ergovaline levels in stems with leaf sheaths, leaf blades, and seed heads. J. Agric. Food Chem. 39:112-115.

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EDUCATION

- Ph.D. Agronomy; Minor: Biochemistry; May 1985; University of Arkansas, Fayetteville, AR
- M.S. Agronomy; May 1982; University of Arkansas, Fayetteville, AR
- B.S. Geography; B.S. History; December 1979; University of North Alabama, Florence, AL
- A.A. Biblical Studies, May 1977; Florida College, Temple Terrace FL

EXPERIENCE

- Professor, State Forage Specialist (2005 to present); University of Missouri
- Associate Professor, State Forage Specialist (1997-04); University of Missouri
- Assistant Professor, State Forage Specialist (1991-96); University of Missouri
- Research Assistant Professor (1988-90); University of Missouri
- Postdoctoral Research Associate (1985-88); University of Illinois

HONORS & AWARDS

- Outstanding Alumnus, Crop, Soil, and Environmental Sciences, University of Arkansas (2008)
- J.W. Burch State Specialist Award for Agricultural Extension, University of Missouri (2008)
- Outstanding Contribution, Plant Sciences Faculty Fellowship, University of Missouri (2007)
- Fellow, Crop Science Society of America (2006)
- Fellow, American Society of Agronomy (2006)
- Editor-in-Chief, Crop Science Society of America Publications (2004 to 2009)
- Frank Meyer Medal for Outstanding Paper in Plant Genetic Resources, CSSA (Co-recipient, 2002)
- Senior Faculty Award for Research, Sigma Xi, Missouri Chapter (1997)
- Distinguished Appropriate Technology Award for Environmental Protection, National Center for Appropriate Technology, Butte MT (Co-recipient, 1994)
- Phi Alpha Theta, Rho-Beta Chapter (Honors History, 1987)
- Outstanding Contribution to Young Scientists Technical Program, American Forage and Grassland Council (1983)
- President, University of North Alabama Geography Club (1979)

RECENT PUBLICATIONS (2006 to present)

JOURNAL

Roberts, C.A., R.L. Kallenbach, G.E. Rottinghaus, and N.S. Hill. 2011. Ergovaline and ergot alkaloid concentrations change in conserved tall fescue forage. Online. Forage and Grazingl. doi:10.1094/FG-2011-1013-01-RS.

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Looper, M.L, R.W. Rorie, C.N. Person, T.D. Lester, D.M. Hallford, G.E. Aiken, C.A. Roberts, G.E. Rottinghaus, and C.F. Rosenkrans, Jr. 2009. Influence of toxic endophyte-infected fescue on sperm characteristics and endocrine factors of yearling Brahman-influenced bulls. J. Anim. Sci. 87:1184-1191.

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Ren, C., K.D. Bilyeu, C.A. Roberts, and P.R. Beuselinck. 2007. Factors regulating the mobilization of storage reserves in soybean cotyledons during post-germinative growth. Seed Sci. Tech. 35:303-317.

Shewmaker, G.E., H.F. Mayland, C.A. Roberts, P.A. Harrison, N.J. Chatterton, and D.A. Sleper 2006. Carbohydrate accumulations in eight tall fescue cultivars. Grass and Forage Sci. 61:413-421.

Roberts, C.A., C. Ren, P.R. Beuselinck, H.R. Benedict, and K. Bilyeu. 2006. Fatty acid profiling of soybean cotyledons by near-infrared spectroscopy. Appl. Spectrosc. 60:1328-1333.

Kallenbach, R.L., C.A. Roberts, T.R. Lock, T.R., D.H. Keisler, M.R. Ellersieck, and G.E. Rottinghaus. 2006. Performance of steers fed ammoniated straw from tall fescue seed fields. Online. Forage and Grazinglands doi:10.1094/FG-2006-0113-01-RS.

BOOKS & CHAPTERS

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Roberts, C.A., G. Lacefield, D. Ball, and G. Bates. 2009. Managing tall fescue to optimize grazing in the northern hemisphere. p. 85-99 *In* H. Fribourg et al. (eds.) Tall Fescue for the 21st Century. ASA, Madison, WI.

Bush, L.P., C.A. Roberts, and C. Schultz. 2007. Plant chemistry and antiquality components in forage. P. 509-528. *In* RF Barnes, et al. (eds.) Forages: the Science of Grassland Agriculture. 6th ed. Blackwell Publishing, Ames, IA.

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Education:
Ph.D., Agronomy, with an emphasis in statistics. 1994. Texas Tech University, Lubbock TX.
M.S., Agronomy. 1992. University of Missouri-Columbia, Columbia, MO.
B.S., Agronomy. 1989. Southwest Missouri State University, Springfield, MO.

Professional Employment and Experience (Since 1994)**:**
Professor/State Extension Specialist – Forage Crops. University of Missouri – Columbia. (60% Extension – 25% Research – 15% Service). Sep. 2009 to Present.
Associate/Associate Professor/State Extension Specialist – Forage Crops. University of Missouri – Columbia. Jan. 1998 to Sep. 2009.
Field Crops Advisor. University of California - Cooperative Extension. Oct. 1994 to Dec. 1997.

Professional Service, Honors and Awards (Since 2004)**:**
2011: C. Brice Ratchford Fellow. *(Fellowship given to one person in the MU-system annually)*
2010: Missouri Grasslander - Agency. *(Statewide award given by the Missouri Forage and Grassland Council to one agency person each year)*
2009: University of Missouri "Teamwork Extension Award". *(System wide award given to a group of faculty and regional specialists working together on innovative outreach programming.)*
2007: Donald W. Fancher Provost Award for Outstanding Achievement in Extension and Continuing Education. *(Campus-wide award given to one faculty member at the University of Missouri each year.)*
2004: Young Crop Scientist award presented by the Crop Science Society of America *(International award given to one scientist under 37 years of age annually)*
2004: J.W. Burch State Specialist Award for Outstanding Statewide Program Leadership
2004: Gamma Sigma Delta Honor Society award for Excellence in Extension Education

Membership in Professional Societies:
American Society of Agronomy, 1990 to present
Crop Science Society of America, 1990 to present
American Forage and Grassland Council, 1990 to present
Missouri Forage and Grassland Council, 1998 to present
Gamma Sigma Delta Honor Society of Agriculture, initiated in 1988

Research Activities:

Refereed Journal Articles	52
Book Chapters	2
Proceedings and Abstracts	121
Grants Dollars Awarded	$6,837,267

Extension Education:

Extension Manuals and Guides	34
Workshops and Short Courses taught	118
Extension education meetings and classes taught	302

Selected publications

Refereed Journal Articles (Since 2007):

Dierking, R.M., and R.L. Kallenbach. 2011. Mediterranean and continental tall fescue: II. Effects of cold, nonfreezing temperatures on leaf extension, proline, fructan, and abscisic acid. Crop Sci. (in press).

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Meyer, A.M., M.S. Kerley, R.L. Kallenbach, and T.L. Perkins. 2009. Comparison of grazing stockpiled tall fescue versus feeding hay with or without supplementation for gestating and lactating beef cows during winter. Profess. Anim. Sci. 25:449-458

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Casler, M.D., K.P. Vogel, C.M. Taliaferro, N.J. Ehlke, J.D. Berdahl, E.C. Brummer, R.L. Kallenbach, C.P. West, and R.B. Mitchell. 2007. Latitudinal and longitudinal adaptation of switchgrass populations. Crop Sci. 47:2249-2260.

Book Chapters:

Casler, M.D. and R.L. Kallenbach. 2007. Cool-season grasses for humid areas. *In* R.F Barnes, C.J. Nelson, K.J. Moore and M. Collins (ed.) Forages Vol II: The science of grassland agriculture, 6th ed. Iowa State Univ. Press, Ames, IA.

Cherney, J.H. and R.L. Kallenbach. 2007. Forage systems for the temperate humid zone. *In* R.F Barnes, C.J. Nelson, K.J. Moore and M. Collins (ed.) Forages Vol II: The science of grassland agriculture, 6th ed. Iowa State Univ. Press, Ames, IA.

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Education

B.S. Agronomy. 1986. Cornell University, Ithaca, NY.

M.S. Soil Science. 1990. University of Minnesota, St. Paul, MN.
Thesis title: Quantification of symbiotically fixed nitrogen in the soil surrounding alfalfa roots and nodules. Advisor: Dr. M.P. Russelle.

Ph.D. Soil Science. 1993. University of Minnesota, St. Paul, MN.
Thesis title: Management of manure-nitrogen and fertilizer-nitrogen in alfalfa-corn rotations. Advisors: Drs. M.P. Russelle and G.W. Randall.

Professional Positions

1986-1993 *Graduate Research Assistant*. University of Minnesota Department of Soil Science, St. Paul, MN.

1994-1995 *Postdoctoral Research Scientist*. USDA/ARS Soil and Water Conservation Research Unit, Lincoln, NE.

Postdoctoral project considered nitrogen loss pathways from beef cattle feedlots and methods to reduce nitrogen losses.

1996-2004 *Assistant Professor of Extension*, University of Missouri Department of Agronomy and the Commercial Agriculture Program. Columbia, MO.

2004-present *Associate Extension Professor,* University of Missouri, Division of Plant Sciences and the Commercial Agriculture Program. Columbia, MO.

Member of an interdisciplinary team of professional-track extension faculty addressing the competitiveness of Missouri agriculture. My program is focused on nutrient management planning, decision support tools for nutrient management, phosphorus loss from agricultural fields, impact of proposed regulations on concentrated animal feeding operations and predicting nitrogen need in corn using remote sensing and other tools. Audience for my program includes farmers, agricultural businesses and consultants, commodity group members and leadership, state and federal regulators and agency personnel. Key products include the Spatial Nutrient Management Planner (SNMP), the Missouri Phosphorus Index and the Animal Feeding Operation Site Evaluation Tool.

Current National, Regional and State Assignments

- SERA-IEG - 17, Minimizing Agricultural Phosphorus Losses for Protection of the Water Resource. Member, 1996-present. Current Chair.
- Interagency Technical Working Group on Animal Feeding Operations. Missouri Department of Natural Resources, Natural Resources Conservation Service, and University of Missouri. 1997-present. Revolving Chair, 2000-2001, 2009-2010..
- CREES Heartland Regional Water Quality Coordination Initiative. Missouri representative, Animal Manure Management. 2002-present.
- Missouri Department of Natural Resources CAFO Working Group. 2003-present.
- E-extension Manure Management Community of Practice, member and "ask the expert" resource person, 2007-present.
- Senior Associate Editor, Agron. J., American Society of Agronomy, 2008-2011.

Refereed Journal Publications, recent

Lory, J.A., R. Massey, and J. Zulovich. 2010. An Evaluation of the EPA Calculations of Greenhouse Gas Emissions from Anaerobic Lagoons. J. Environ. Qual. 39:776-783.

Scharf, P.C. and **J.A. Lory**. 2009. Calibrating reflectance measurements to predict optimum sidedress nitrogen fertilizer rate for corn. Agron. J. 101:615-625.

Lory, J.A., R.E. Massey, C.D. Fulhage, M.C. Shannon, R.L. Belyea and J.M. Zulovich. 2008. Comparing feed, fuel and fertilizer value of distiller's grains. Online. Crop Mgt. doi:10.1094/CM-2008-0428-01-RV.

Scharf, P.C., N.R. Kitchen, K.A. Sudduth, J.G. Davis, V.C. Hubbard and **J.A. Lory.** 2005. Field scale variability in optimum nitrogen fertilizer rate for corn. Agron. J. 97:452-461.

Lory J.A., R.E. Massey, J.M. Zulovich, J.A. Hoehne, A.M. Schmidt, M.S. Shannon and C.D. Fulhage. 2004. An Assessment of Nitrogen-Based Manure Application Rates on 39 US Swine Operations. J. Environ. Qual. 33:1106-1113.

Lory, J.A., R.E. Massey, J.M. Zulovich, J.A. Hoehne, A.M. Schmidt, M.S. Shannon and C.D. Fulhage. 2004. Feasibility and costs of phosphorus application limits on 39 US swine operations. J. Environ. Qual. 33:1114-1123.

Lory, John A. and P.C. Scharf. 2003. Yield goal versus delta yield for predicting nitrogen need in corn. Agron. J. 95:994-999.

Scharf, P.C. and **J.A. Lory**. 2002. Calibrating corn color from aerial photographs to predict sidedress N need. Agron. J. 94:397-404.

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