Project Title: Spread it and Forget it: Spoon-feeding Tall Fescue Pastures

Investigators: Robert L. Kallenbach and Brett T. Jones

Objectives and relevance of project:

Tall fescue is the predominant grass of Missouri's 11 million acres in pasture and hay. It provides forage for more than 3.5 million beef cattle in Missouri. About one-half of all tall fescue acres receive some nitrogen (N) fertilizer in spring. Most of these applications are made in March or early April. Other times in which tall fescue acres are fertilized with N are in late spring to stimulate summer regrowth and in late-summer for autumn stockpiling.

In past years, ammonium nitrate and urea have been the most popular sources of N for spring and late-summer fertilization. Ammonium nitrate is widely considered the most reliable source of N for forage production as the N in ammonium nitrate is much less likely to be lost to volatilization than that in urea. However, ammonium nitrate is being phased out in many areas due to security concerns.

Given the pricing structure and potential problems with ammonium nitrate, urea is commonly used as a N source for forage production. This is due to urea's wider availability and lower cost per N unit when compared to ammonium nitrate. In fact, in many rural areas the only source of N available for pastures is urea. While urea is a common source of N fertilizer for row crop applications in spring, its use for fertilization of pastures is problematic due to excessive nitrogen volatilization. Up to 40% of the N applied to pastures as urea can be lost due to volatilization if rainfall does not occur within 48 hours of an application. Given these problems, farmers are looking for a reliable and inexpensive source of N for pastures.

Environmentally Smart Nitrogen (ESN) is a polymer coated urea product from Agrium that offers protection from N volatilization. Additionally, N from ESN is released slowly over time and may provide a steady source of N throughout the growing season. We proposed to test an easy-management (*Spread-it-and –Forget-it*) protocol where a single application of ESN mixed with urea provides season-long N to the pasture. The ESN product has been an effective source of N for other crops, but research is needed to determine if the Spread-it-and-Forget-it program would be effective for pastures and if so, when is the ideal time(s) to apply it.

The **overall objective** is to test a simple N fertilization program that optimizes seasonal and annual production of tall fescue pasture. Specific objectives are:

Objective 1: Determine how the Spread-it-and-Forget-it program compares to fertilizing pasture with urea or ammonium nitrate.

Objective 2: Determine the best time to apply ESN/Urea mixture in the Spread-it-and-Forget-it program to optimize the slow-release characteristic of the product.

We propose a three-year experiment to evaluate forage production when N fertilization occurs at one of eight times. Fertilization timings will start in mid-March and continue at 45-d intervals, to end in late January the following year. This spectrum of N fertilization dates encompasses most cultural practices that Missouri producers employ.

Procedures:

Treatments: Eight N fertilization dates and four N sources (total of 25 treatments per block; Table 1) will be imposed on established tall fescue. The N rate will be 100 lb./acre (annual total). Soil pH, P and K levels will be maintained at those recommended by the University of Missouri Soil Testing Laboratory.

Table 1. Nitrogen fertilizer sources and application timings (45 days apart) to be applied to tall fescue pastures at the Forage Systems Research Center near Linneus, Missouri.

N Application Date	N Fertilizer Source	N from ESN	Ammonium nitrate or Urea N
		----------lb/A----------	
Mid-Mar	Urea	-	100
Late Apr	Urea	-	100
Mid-June	Urea	-	100
Late July	Urea	-	100
Mid-Sept	Urea	-	100
Late Oct	Urea	-	100
Mid-Dec	Urea	-	100
Late-Jan	Urea	-	100
Mid-Mar	Ammonium Nitrate	-	100
Late Apr	Ammonium Nitrate	-	100
Mid-June	Ammonium Nitrate	-	100
Late July	Ammonium Nitrate	-	100
Mid-Sept	Ammonium Nitrate	-	100
Late Oct	Ammonium Nitrate	-	100
Mid-Dec	Ammonium Nitrate	-	100
Late-Jan	Ammonium Nitrate	-	100
Mid-Mar	75/25% ESN/Urea	75	25
Late Apr	75/25% ESN/Urea	75	25
Mid-June	75/25% ESN/Urea	75	25
Late July	75/25% ESN/Urea	75	25
Mid-Sept	75/25% ESN/Urea	75	25
Late Oct	75/25% ESN/Urea	75	25
Mid-Dec	75/25% ESN/Urea	75	25
Late-Jan	75/25% ESN/Urea	75	25
---	Control	0	0

Location and Design: This study will be conducted on tall fescue at the Forage Systems Research Center near Linneus, MO. Each treatment is replicated six times in a randomized complete block design. Individual plots are 20 ft. x 20 ft. Plots will not be relocated when a new year starts and plots will receive the same N fertilization date and source each year. The repeated measures allow detection of cumulative and residual effects of treatments.

Measurements: Grass height will be measured weekly in each plot with an ultrasonic sensor mounted to an ATV. Week-over-week measurements will allow us to determine weekly growth rates. At 5 times during the growing season, the ultrasonic sensor heights will be calibrated to dry matter yield by harvesting and weighing forage. This growth monitoring system allows us to determine 1) seasonal and annual forage production, 2) how quickly pastures respond to a fertilizer application, and 3) the dynamics of the best time to apply N fertilizer to optimize forage production

Cultural practices: Growth will accumulate until grass height reaches approximately 10 inches. At that time, all plots will be grazed at a stocking density great enough to remove accumulated forage in 48 hours. Immediately after the initial or second grazing each spring, all plots will be mowed to 2.5 inches to remove reproductive structures and allow vegetative regrowth in summer and autumn. The residue will remain on the plots. We estimate approximately 4 grazing events per year, each time grass height measured before and after the grazing event to document forage mass.

Current status/importance of research area: Profitability in forage/livestock systems is strongly correlated to stored feed costs. When pastures supply feed, production costs are lower (Poore et al.,

2000). Return on investment for fertilizer continues to be an important factor for forage/livestock managers. Managers like time-saving practices that are dependable and optimize plant growth; the Spread-it-and-Forget it program intends to make pasture fertilization easy and effective.

Previous research from our lab showed ESN had no advantage over urea, but only one fertilizer application date was utilized. However, pasture research from Georgia indicated that blending ESN with untreated urea at 50 to 75% gave optimal results (Payne, 2014). Additionally, forage fertilized with ESN had greater crude protein concentrations than when fertilized with urea and other enhanced efficiency N sources (Connell et al., 2011). Higher N concentration could be valuable to producers matching nutritive requirements of different classes of livestock to pasture resources.

Few unbiased experiments have evaluated the "Spread-it-and-Forget-it" management program. Our experimental design compares seasonal and total plant response to ESN and other N sources. Additionally, the experiment gives insight on the timing of fertilizer for pastures in Missouri.

Expected economic impact of the project: Fertilizer records from 2012-2013 indicate that in spring and fall, the top 20 Missouri counties for cattle inventory use 13% of the urea sold in Missouri. In contrast, about 45% of the ammonium nitrate sold in Missouri is used in the same counties in both spring and fall (http://aes.missouri.edu/pfcs/fert/index.stm). From this data, we conclude that if ammonium nitrate becomes unavailable, the equivalent of about 150,000 tons of urea will likely take its place. The question remains if ESN adds enough value to warrant its use on pasture. Our research will help answer questions about the reliability and response of pastures to ESN fertilization and the associated Spread-it-and-Forget-it program.

Timetable for proposed research: This study will begin in spring of 2015 and end in December of 2018 (three years of study). The table below gives a brief summary of the project's activities. (* indicates task to be done on an annual basis throughout the three-year study).

Locate and layout plot areas; take initial soil samples	2/15/2015
Apply nitrogen containing fertilizer products	*Eight times per year (45 days apart)
Measure grass height in plots with ultrasonic sensor	*Weekly all year long
Calibrate ultrasonic sensor to mechanical harvest	*April, May, June, August, October
Harvest plots with grazing cattle; determine forage mass and accumulation	*Variable based on plant growth (expect 3 to 5 harvests per year)
Prepare report to Fertilizer/Ag Lime Advisory Council	*December
Incorporate results into soil testing reports, hay school materials and forage conferences. Work with press on articles.	October 2015 through December 2018
Submit manuscript to a peer-reviewed journal	July 2019

Application/transfer of knowledge: We will transfer our results in three ways. First, we will incorporate the results and recommendations from this study into the curriculum of the grazing schools and the annual Forage Conferences held across the state. Second, we will work with the Soil Fertility Working Group and the Soil Testing Laboratory to refine the recommendations printed on soil testing results. Finally, we will prepare articles to be published in statewide and national magazines such as Missouri Ruralist, Stockman Grass Farmer and scientific (peer-reviewed) journals.

References:

Connell, J.A., D.W. Hancock, R.G. Durham, M.L. Cabrera, and G.H. Harris. 2011. Comparison of enhanced-efficiency nitrogen fertilizers for reducing ammonia loss and improving bermudagrass forage production. Crop Sci. 51:2237–2248.

Payne, K.M. 2014. The effect of ESN nitrogen fertilizer on bermudagrass forage production. MS Thesis, University of Georgia, Athens GA.

Poore, M.H., G.A. Benson, M.E. Scott, and J.T. Green. 2000. Production and use of stockpiled fescue to reduce beef cattle production costs. J. Anim. Sci. 79:1-11.

Budget:

YEAR 1

Salary and Benefits	
Research Specialist (20% of $58,000)	$11,600
Benefits for Research Specialist	$3,944
Total Salary and Benefits	$15,544
Operating Expenses	
Fertilizer, bags, repair parts for harvester and other field supplies	$3,740
Travel to research location (mileage, lodging, and meals for 8 trips/yr)	$1,600
Total Operating Expenses	$5,340
Equipment	
None	$0
Total Equipment	$0
Total Proposal Request for Year #1	$20,884

YEAR 2

Salary and Benefits	
Research Specialist (20% of $59,740)	$11,948
Benefits for Research Specialist	$4,062
Total Salary and Benefits	$16,010
Operating Expenses	
Fertilizer, bags, repair parts for harvester and other field supplies	$3,740
Travel to research location (mileage, lodging, and meals for 8 trips/yr)	$1,600
Total Operating Expenses	$5,340
Equipment	
None	$0
Total Equipment	$0
Total Proposal Request for Year #2	$21,350

YEAR 3

Salary and Benefits	
Research Specialist (20% of $61,532)	$12,306
Benefits for Research Specialist	$4,184
Total Salary and Benefits	$16,490
Operating Expenses	
Fertilizer, bags, repair parts for harvester and other field supplies	$3,740
Travel to research location (mileage, lodging, and meals for 8 trips/yr)	$1,600
Total Operating Expenses	$5,340
Equipment	
None requested	$0
Total Equipment	$0
Total Proposal Request for Year #3	$21,830
GRAND TOTAL REQUEST	**$64,064**

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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)**:**
2014: National Excellence in Extension Award. (*National award given to one person annually by the American Association of Public and Land Grant Universities and the National Institute of Food and Agriculture*)
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	64
Book Chapters	2
Proceedings and Abstracts	121
Grants Dollars Awarded (last 5 years)	$4,625,299

Extension Education:

Extension Manuals and Guides	34
Workshops and Short Courses taught	148
Extension education meetings and classes taught	452

Refereed Journal Articles (Since 2010)**:**

Kallenbach, R.L. 2015. Describing the dynamic: Measuring and assessing the value of plants in the pasture. Crop Sci. *In Press. Invited Review.*

Richner, J.M., R.L. Kallenbach, and C.A. Roberts. 2014. Dual use switchgrass: Managing switchgrass for biomass production and summer forage. Agron. J. 106:1438-1444.

Roberts, C.A., D.K. Davis, M.L. Looper, R.L. Kallenbach, G.E. Rottinghaus, and N.S. Hill. 2014. Ergot alkaloid concentrations in high- and low-moisture tall fescue silage. Crop Sci. 54:1887-1892.

Fukushima, R., M.H. Ramos, M.S. Kerley, J.H. Porter, and R.L. Kallenbach. 2014. Comparison of acetyl bromide lignin with acid detergent lignin and Klason lignin and correlation with in vitro forage digestibility. Anim. Sci. Feed Tech. *In Press.*

Emerson, R., A. Hoover, A. Ray, J. Lacey, M. Cortez, C. Payne, D. Karlen, S. Birrell, D. Laird, R.L. Kallenbach, J. Egenolf, M. Sousek, and T. Voigt. 2014. Drought effects on composition and yield for corn stover, CRP mixed grasses, and *Miscanthus* as bioenergy feedstocks. Biofuels. 5:275-291.

Campbell, B.T., C.J. Kojima, T.A. Cooper, B.C. Bastin, L. Wojakiewicz, R.L. Kallenbach, F.N. Schrick and J.C. Waller. 2014. A single nucleotide polymorphism in the dopamine receptor D2 gene may be informative for resistance to fescue toxicosis in Angus-based cattle. Animal Biotech. 25:1-12.

Hamilton, S.A., R.L. Kallenbach, G.J. Bishop-Hurley and C.A. Roberts. 2013. Stubble height management changes the productivity of perennial ryegrass and tall fescue pastures. Agron. J. 105:557-562.

Sather, B.C., R.L. Kallenbach, W.J. Sexten, and K.W. Bradley. 2013. Evaluation of cattle grazing distribution in response to weed and legume removal in mixed tall fescue [Schedonorus phoenix (Scop.) Holub] and legume pastures. Weed Technol. 27:101-107.

Lee, D.K., E. Aberle, C. Chen, J. Egenolf, K. Harmoney, G. Kakani, R.L. Kallenbach, and J.C. Castro. 2013. Nitrogen and harvest management of conservation reserve program (CRP) grassland for sustainable biomass feedstock production. GCB Bioenergy. 5:6-15

Houx, J.H., III., R.L. McGraw, H.E. Garrett, R.L. Kallenbach, F.B. Fritschi and W.M. Rogers. 2013. Extent of vegetation-free zone necessary for silvopasture establishment of eastern black walnut seedlings in tall fescue. Agroforest. Syst. 87:73-80.

Kallenbach, R.L., R.J. Crawford, Jr., M.D. Massie, M.S. Kerley, and N.J. Bailey. 2012. Integrating bermudagrass into tall fescue-based pasture systems for stocker cattle. J. Anim. Sci. 90:387-394.

Dierking, R.M., and R.L. Kallenbach. 2012. Mediterranean and continental tall fescue: II. Effects of cold, nonfreezing temperatures on leaf extension, proline, fructan, and abscisic acid. Crop Sci. 52:460-469.

Dierking, R.M., C.A. Young, and R.L. Kallenbach. 2012. Mediterranean and continental tall fescue: I. Effects of endophyte status on leaf extension, proline, mono- and disaccharides, fructan, and freezing survivability. Crop Sci.52:451-459.

Houx, J.H., III, R.L. McGraw, H.E. Garrett, R.L. Kallenbach, F.B. Fritschi, and M.A. Gold. 2012. Temperate silvopasture tree establishment and growth as influenced by forage species and cultural management practices. J. Agric. Sci. 4:20-30.

Kumar, S., S.H. Anderson, R.P. Udawatta, and R.L. Kallenbach. 2012. Water infiltration influenced by agroforestry and grass buffers for a grazed pasture system. Agroforest. Syst. 84:325–335.

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 Grazinglands doi:10.1094/FG-2011-1013-01-RS.

Rogers, W.M., C.A. Roberts, J.G. Andrae, D.K. Davis, G.E. Rottinghaus, N.S. Hill, R.L. Kallenbach, and D.E. Spiers. 2011. Seasonal fluctuation of ergovaline and total ergot alkaloid concentrations in tall fescue regrowth. Crop Sci. 51:1291-1296.

Udawatta, R.P., H.E. Garrett, and R.L. Kallenbach. 2011. Agroforestry buffers for non point source pollution reductions from agricultural watersheds. J. Environ. Qual. 40:800-806.

Rogers, W.M., C.A. Roberts, R.L. Kallenbach, G.E. Rottinghaus, N.S. Hill, W.E. McClain, and D.G. Blevins. 2010. Poultry litter and its chemical equivalent can affect ergot alkaloid concentrations in tall fescue. Online. Forage and Grazinglands doi:10.1094/FG-2009-0129-01-RS.

Kallenbach, R.L., E.B.Venable, M.S. Kerley, and N.J. Bailey. 2010. Stockpiled tall fescue and livestock performance in an early stage Midwest silvopasture system. Agroforest. Syst. 80:379–384.

Bailey, N.J. and R.L. Kallenbach. 2010. Economic favorability of feeding distillers dried grains with solubles and round-bale silage to stocker cattle. Profess. Anim. Sci. 26:375-379.

Udawatta, R.P., H.E. Garrett, and R.L. Kallenbach. 2010. Agroforestry and grass buffer effects on water quality in grazed pastures. Agroforest. Syst. 79:81–87.

Bradley, K.W., R.L. Kallenbach, and C.A. Roberts. 2010. Influence of seeding rate and herbicide treatments on weed control, yield, and quality of spring-seeded glyphosate-resistant alfalfa. Agron. J. 102:751-758.

Dierking, R.M., R.L. Kallenbach, and I.U. Grün. 2010. Effect of forage species on fatty acid content and performance of pasture finished steers. Meat Sci. 85:597-605.

Bailey, N.J. and R.L. Kallenbach. 2010. Comparison of three tall fescue-based stocker systems. J. Anim. Sci. 88:1880–1890.

Dierking, R.M., R.L. Kallenbach, and C.A. Roberts. 2010. Fatty acid profiles of orchardgrass, tall fescue, perennial ryegrass, and alfalfa. Crop Sci. 50:391-402.

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Education

PhD	2017 (IP)	Plant, Insect, and Microbial Sciences University of Missouri Dissertation: Response of beef cattle selected for tolerance to tall fescue toxicosis Advisor: Dr. Robert Kallenbach
BS	2012	Plant Science, Crop Management emphasis University of Missouri Minors: Agriculture Economics and Animal Sciences GPA: 3.71

Employment

2012 to Present	Graduate Research Assistant Division of Plant Sciences, University of Missouri Supervisor: Dr. Robert Kallenbach
2012	Lab Assistant Division of Plant Sciences, University of Missouri Supervisor: Dr. Robert Kallenbach
2011	Maize Product Development Intern Pioneer Hi-Bred International, Inc., Miami, Missouri Supervisor: Tiffany Thorton
2009 to 2012	Undergraduate Research Assistant Division of Plant Sciences, University of Missouri Supervisor: Dr. Robert Kallenbach

Presentations

July 27, 2013	GrowSafe Research presented to the Ecology of Grazing Lands System Course in Mt. Vernon, MO.
August 24, 2013	GrowSafe Research presented to the Southwest Research Center Beef Field Day in Mt. Vernon, MO.
September 11, 2014	Tall Fescue Toxicosis presented to the Southwest Research Center Ag Education Field Day in Mt. Vernon, MO.
September 12, 2014	Influence of Cattle Genetics on Tall Fescue Toxicosis presented to the Southwest Research Center Field Day in Mt. Vernon, MO.
November 3, 2014	Polymorphisms at DRD2 Gene Affect the Gains of Cow-Calf Pairs on Tall Fescue Pasture presented at the 2014 ASA, CSSA, SSSA Annual Meeting in Long Beach, CA.
January 12, 2015	Polymorphisms at DRD2 Gene Affect the Gain and Intake of Heifers fed Tall Fescue Silage presented at the 2015 American Forage and Grasslands Council Annual Conference in St. Louis, MO

Grants & Gifts

Fall 2014	Division of Plant Sciences Travel Fund – Graduate Student Travel Grant $750

Teaching

Fall 2013	Forage Crops – Plant Sciences 3270 Instructor: Dr. Jeanne Mihail and Dr. Michael Collins

Publications

Jones, B.T., R.L. Kallenbach, and C.J. Kojima. 2014. Polymorphisms at DRD2 Gene Affect the Gains of Cow-calf pairs on Tall Fescue Pasture. Online. *In* 2014 Crop Sci. abstracts. CSSA, Madison, WI.

Jones, B.T., R.L. Kallenbach, and C.J. Kojima. 2014. Polymorphisms at DRD2 Gene Affect Dry Matter Intake and Weight Gain of Heifers Fed Tall Fescue Silage. Online. *In* 2015 American Forage and Grasslands Council abstracts. AFGC, Berea, KY.