Title: Selection of Foliar-Applied Potassium Fertilizer Sources and Rates of Application to Optimize Soybean Response and Weed Control with Glyphosate in a “Weed and Feed” Management System

Investigators: Peter Motavalli, Environmental Soil Science Program, University of Missouri Kelly Nelson, Dept. of Agronomy, University of Missouri, Greenley Center Gene Stevens, Dept. of Agronomy, University of Missouri, Delta Center Andy Kendig, Dept. of Agronomy, University of Missouri, Delta Center Manjula Nathan, Dept. of Agronomy, University of Missouri David Dunn, Dept. of Agronomy, University of Missouri, Delta Center

Objectives and Relevance:
Soybeans were produced on over 5 million acres in Missouri and 83% of the soybean varieties were Roundup Ready® or contained another form of transgenic herbicide resistance in 2003 (MASS, 2003). Roundup Ready® varieties allow farmers to apply Roundup® and other glyphosate-based products for broad spectrum post-emergence weed control. The incidence of K deficiency has increased in recent years due to reduced K availability under drought and areas with soil compaction, reduced applications for soybean due to low commodity prices, and higher corn grain yields and increased soybean acreage in rotation with corn increasing K fertilizer requirements (Reetz and Murrell, 1998; Fixen, 2000). Soil test K data from the University of Missouri Soil and Plant Testing Lab indicates that over 50% of the soil samples tested in the low to medium range for K (Fixen, 2002). This situation indicates that nearly 2.5 million soybean acres in Missouri could be at risk or are currently experiencing yield loss due to inadequate K soil test levels.

The proposed objectives of this study are:

1. Determine soybean yield response and salt injury from different foliar-applied potassium (K) fertilizer sources and rates of application.
2. Determine the impact of K fertilizer source and rate of application on weed control when mixed with a glyphosate-based herbicide (e.g. Roundup WeatherMAX®).
3. Evaluate the cost-effectiveness of applying K fertilization with glyphosate-based herbicides for no-till glyphosate-resistant soybean production.

Procedures:
This study will evaluate the effects of foliar-applied K fertilizer sources and rates of application on glyphosate-resistant soybean response and weed control.

- Two-year field trials will be established at the MU Greenley Center in Northeast Missouri and at the MU Delta Center in Southeast Missouri on soils with medium to low soil test K and with a diverse, high population of weeds. Roundup-Ready® soybeans will be no-till planted at 180,000 seeds/acre in 15 inch rows.

- The study will be arranged as a randomized complete block design with four replications. Treatments will consist of four rates (0, 2, 8, and 16 lb K/acre) of foliar K fertilizer sources (potassium chloride, potassium thiosulfate, potassium phosphate, Trisert K+) and
diammonium sulfate (2.6 lb/acre) either sprayed separately on plots maintained weed-free or sprayed as a mixture with a glyphosate-based herbicide (i.e. Roundup WeatherMAX® at 22 oz/acre tank mixture) on plots with weeds. The foliar K application rates that will be utilized in this research (8 to 16 lb K/acre) are based on previous research that demonstrated a consistent positive soybean yield response to foliar-applied potassium sulfate at several growth stages on a claypan soil near the MU Greenley Research Center with medium to low soil test K (Nelson and Motavalli, 2003). The lower 2 lb K/acre rate is also included because additional research by Nelson and Motavalli in 2003 indicated that mixing Roundup WeatherMAX® with K fertilizer sources increased foliar fertilizer uptake by soybean plants, possibly due to the presence of adjuvant in the Roundup. The spray mixture pH will be determined prior to the “weed and feed” application. All treatments will be applied at a standard postemergence timing for weed control at a 15 gallons/acre carrier volume.

- Changes in soil test K in the plow layer due to treatment application will be determined by sampling at the beginning and end of the growing season. Foliar salt injury will be rated 3, 7, 14, 21, and 28 days after application. Weed control for individual weed species will be recorded 14, 28, and 56 days after application. A biomass harvest of weeds 28 days after treatment will be utilized to evaluate weed control. Leaf samples taken at initial bloom will be used to determine crop K status in treated and non-treated plants. Soybeans will be harvested and data analyzed to determine the influence of foliar K fertilizer source on crop response, weed control, and grain yield.

- To determine the cost-effectiveness of the foliar K treatments, gross margins will be calculated as the [(grain yield * market price) – cost of foliar fertilizer and its application in the presence and absence of the herbicide] to determine the practical use of K sources in a weed and feed soybean production system.

**Current Status and Importance of Research:**

Several studies have evaluated response of soybean to foliar fertilizer mixtures (Garcia and Hanway, 1976; Haq and Mallarino, 1998; Parker and Boswell, 1980); however, no research has evaluated the interaction between macronutrient foliar fertilizers and weed control with postemergence herbicides. Potassium is an essential nutrient that increases drought tolerance, stem strength, and improves plant growth. Uptake of K is primarily by diffusion through roots and under drought conditions limited uptake may occur (Sardi and Fulop, 1994). Previous research on a farm field in Northeast Missouri by Nelson and Motavalli in 2001 and 2002 on crop response to a foliar application of K sulfate at the V4, R1-R2, or R3-R4 stages of development demonstrated that soybean grain yield increased over 10 bu/acre when compared to a non-treated or MgSO₄ control (Nelson and Motavalli, unpublished). The calculated increase in profit due to this yield increase from foliar K applications was approximately $50/acre. However, possible limitations for the use of K sulfate combined with a post-emergence herbicide application are the large carrier volume required for an optimum foliar K application and the possible incompatibility that the K fertilizer source may have when mixed with a glyphosate-based herbicide. In addition, the K source/herbicide mix must result in minimal crop injury and not affect weed control.
In 2003, Nelson and Motavalli with primary funding from the Fluid Fertilizer Foundation (a grant of $4,000), established three field trials in Northeast Missouri with initial low to high soil text K to determine the effects of mixing several K fertilizer sources with Roundup WeatherMAX® on soybean production and weed control. Observations regarding the compatibility and resulting pH of tank mixing the K fertilizer sources with Roundup WeatherMAX® were noted. Potassium sulfate and nitrate did not cause any significant leaf injury 3 or 14 days after treatment (DAT) but due to their limited solubility only a maximum of 2 lb K/acre could be applied. Most treatments had complete recovery from leaf injury by 14 DAT except K phosphate, K thiosulfate, K carbonate and Trisert K+ plus Roundup WeatherMAX®. Soybean grain yield increased 3 bu/acre at two of three sites in Northeast Missouri in 2003 when foliar potassium chloride was applied with minimal crop injury and good common lambsquarters, common waterhemp, giant foxtail, and common ragweed weed control. Further research is required to test the most promising foliar K sources at comparable rates of application and at several locations in Missouri where soybeans are grown.

**Timetable for Proposed Research:**

<table>
<thead>
<tr>
<th>Month</th>
<th>Activity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>April, 2004</td>
<td>Characterize field sites in Southeast and Northeast Missouri</td>
</tr>
<tr>
<td></td>
<td>Establish foliar K fertilizer/herbicide field experiments</td>
</tr>
<tr>
<td></td>
<td>Plant soybeans in experiments</td>
</tr>
<tr>
<td>April-Sept., 2004</td>
<td>Sample and analyze soil and plant tissue</td>
</tr>
<tr>
<td></td>
<td>Apply post-emergence K treatments</td>
</tr>
<tr>
<td>Sept./Oct, 2004</td>
<td>Harvest experiments and analyze soil and plant tissue samples</td>
</tr>
<tr>
<td>November, 2004</td>
<td>Analyze research results</td>
</tr>
<tr>
<td>December, 2004</td>
<td>Submit annual progress report</td>
</tr>
<tr>
<td>April-Nov. 2005</td>
<td>Same as 2004 for K fertilizer field experiments</td>
</tr>
<tr>
<td>December 2005</td>
<td>Submit final report</td>
</tr>
</tbody>
</table>

**Strategy for Application/Transfer of Knowledge:**

The information developed from this research will assist Missouri soybean farmers to make informed decisions on how foliar K fertilizer source affects soybean response, weed control, and economic return and will determine if foliar K fertilizer can be cost-effectively integrated into a post-emergence weed control program in no-till glyphosate-resistant soybean production systems. This information will be incorporated into research and extension publications, workshops and annual field days to provide additional information to farmers and agricultural professionals on effective K fertilizer management practices.

**References:**


### Proposed Budget:

<table>
<thead>
<tr>
<th>CATEGORIES</th>
<th>YEAR ONE</th>
<th>YEAR TWO</th>
<th>TOTAL</th>
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<td><strong>A. Salaries</strong></td>
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<td>M.S. Graduate Research Assistant (50%)</td>
<td>$11,832</td>
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<td><strong>B. Fringe Benefits</strong></td>
<td>$1,218</td>
<td>$1,340</td>
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<td><strong>C. Travel</strong></td>
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<td>Travel to field sites</td>
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<tr>
<td><strong>TOTAL TRAVEL COSTS</strong></td>
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<td><strong>D. Equipment</strong></td>
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<td><strong>TOTAL EQUIPMENT COSTS</strong></td>
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<td><strong>E. Other Direct Costs</strong></td>
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<td>Laboratory reagents and supplies</td>
<td>$2,000</td>
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<td>Field supplies (Greenley and Delta Center)</td>
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<td>Soil and plant tissue analyses by MU Soil and Plant Testing Lab</td>
<td>$547</td>
<td>$547</td>
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<td><strong>TOTAL OTHER DIRECT COSTS</strong></td>
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<td>$6,047</td>
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<td><strong>TOTAL REQUEST</strong></td>
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**Justification:**

Salaries and Fringe Benefits: Funds are requested for support of a graduate research assistant (50% time) based on set rates at the University of Missouri. Fringe benefits for the graduate student cover the cost of health insurance.

Travel: Covers cost of travel to Greenley Agronomy Center and Delta Center field sites and Univ. of Missouri at Columbia at 36.5¢/mile.

Laboratory Reagents and Supplies: Covers cost of laboratory reagents, sample containers, and other materials used in soil and plant tissue analyses.

Field: Cost of fertilizer, seed, plot preparation, planting, weed control and harvesting, soil samplers, flags, pots and other field supplies and operations.

Soil and Plant Tissue Analyses: the University of Missouri Soil and Plant Testing Laboratory will characterize soil samples for soil pH, soil organic matter, extractable P, K, and exchangeable Ca and Mg taken at the beginning and end of the first growing season and also at the end of the second growing season: (64 samples x $5.70/sample x 3 samplings = $1,094).
Resume of PETER P. MOTAVALLI

Assistant Professor, Soil Nutrient Management
Dept. of Soil, Environmental and Atmospheric Sci.
School of Natural Resources
University of Missouri-Columbia
302 ABNR Bldg.
Columbia, MO 65211

EDUCATION:

Ph.D., 1989, Soil Fertility and Plant Nutrition - Cornell University, Ithaca, NY
M.S., 1984, Soil Fertility and Plant Nutrition - University of Wisconsin, Madison, WI
B.S., 1982, Agronomy - University of Wisconsin, Madison, WI
B.S.F.S., 1978, Foreign Service - Georgetown University, Washington, DC

RESEARCH, EXTENSION AND TEACHING EXPERIENCE:

University of Missouri, Columbia, MO (Mar., 1999 – present). Assistant Professor of Soil Nutrient Management in the Dept. of Soil, Environmental and Atmospheric Sci., School of Natural Resources.

University of Guam, Mangilao, GU (Aug., 1994 – Mar., 1999). Associate Professor of Soil Science in the Agricultural Experiment Station, College of Agriculture and Life Sciences.


SELECTED PUBLICATIONS

Articles in Journals:


Extension Publications:


Motavalli, P.P. and T. Marler. Fertilizer facts: Number 5. Forms of fertilizers and other soil amendments. College of Agriculture and Life Sciences, University of Guam, Mangilao, Guam.

PROFESSIONAL ORGANIZATIONS:

Soil Science Society of America
American Society of Agronomy
Ecological Society of America

AWARDS AND FELLOWSHIPS:

1978 - Phi Beta Kappa
1978 - 1979 Fulbright-Hays Fellowship, Khartoum, Sudan
1998 Faculty Award for Excellence in Research, University of Guam
2003 Junior Faculty Research Award, Gamma Sigma Delta, Univ. of Missouri
Resume of KELLY A. NELSON

University of Missouri Greenley Research Center
P.O. Box 126, Hwy 156 E
Novelty, MO 63460
660-739-4410  Fax: 660-739-4500
E-mail: nelsonke@missouri.edu

EDUCATION:
Ph.D. Weed Science, Dept. of Crop and Soil Sci., Michigan State University, May 2000
M.S. Weed Science, Dept. of Crop and Soil Sci., Michigan State University, May 1997
B.S. Plant Science, Dept. of Agronomy, University of Missouri-Columbia, May 1995

PROFESSIONAL EXPERIENCE:
University of Missouri, Novelty, MO. June 2000 to present. Assistant Professor–Research Agronomist.

PUBLICATIONS:
Reviewed Publications


Extension Publications

Professional Activities:
Weed Science Society of America
North Central Weed Science Society of America
American Society of Agronomy
Crop Science Society of America
Resume of WILLIAM E. (GENE) STEVENS

Associate Professor
Department of Agronomy
University of Missouri-Delta Research Center
Portageville, MO 63873
Phone: (573) 379-5431
Fax: (573) 379-5875
Email: stevensw@missouri.edu

EDUCATION

Degree: Ph.D., Agronomy, 1992
Institution: Mississippi State University
Professor: Dr. Jac J. Varco

Degree: M.S., Plant and Soil Science, 1982
Institution: University of Tennessee-Knoxville
Professor: Dr. Donald D. Tyler

Degree: B.S., Biology, 1979
Institution: Union University

EMPLOYMENT AND EXPERIENCE

1994 – Present
University of Missouri-Delta Research Center
Portageville, MO

Associate Professor
Extension: (70%)
• Educate clientele groups on practices to improve soil management
• Help farmers increase efficiencies of fertilizers and irrigation
Research: (30%)
• Develop innovative cropping systems
• Evaluate new technologies for monitoring crop nutrients and pests

1990- 1994
Mississippi State Univ./USDA Crop Simulation Lab
Starkville, MS

Extension Soil Specialist
Extension: (100%)
• Provided technical support to cotton farmers across the United States using the GOSSYM cotton management program
• Served as liaison between state soil extension specialists and researchers developing crop simulation models
1984-1990  North Mississippi Branch Experiment Station  Holly Springs, MS

**Research Associate**
Research (100%)
- Conducted conservation tillage experiments for reducing soil erosion
- Coordinated research with agronomists at other stations and campus

1981-1994  Stevens Farm  Somerville, TN

**Farmer**
- Worked for father growing corn, cotton, and soybeans
- Developed nutrient management plans for the family farm

**AWARDS**
2001  Innovation in Agribusiness Award, presented by Monsanto Company
1998  Natural Resource and Conservation Service Partnership Award

**UNITED STATES PATENT**

**COMPUTER PROGRAMS DEVELOPED**


**PROFESSIONAL SERVICE**
2003  Chairman, University of Missouri College of Agriculture, Food, and Natural Resources Professional-Track Faculty Committee

2000  Chairman, Soil Management and Plant Nutrition Committee, Beltwide Cotton Conference, Anaheim, California

1995-1999  Farm Supervisor at Missouri Rice Research Farm

1997-2001  Editor of Missouri Rice Outlook and Research Updates
REFEREED RESEARCH PUBLICATIONS:


D. Dunn, G. Stevens, M. Aide, and J. Horn. 2002. Effect of soil pH and zinc on rice cultivars in Missouri. Trans. Missouri Acad. of Sci. pg.33-36


Resume of J. ANDREW KENDIG

Extension Associate Professor,
State Extension Weed Specialist
Commercial Agriculture Program
University of Missouri Delta Center
P.O. Box 160
147 Highway T South
Portageville, MO 63873
573/379-5431 Work
573/471-1849 Home
573/379-5875 FAX
kendigj@missouri.edu

Education:

Degree: Ph.D. 1992
Institution: University of Arkansas, Fayetteville
Major: Agronomy, Weed Science emphasis
Dissertation: Carryover of nine persistent herbicides to wheat in Arkansas
Advisor: Dr. Ronald Talbert

Degree: M.S. 1988
Institution: University of Arkansas, Fayetteville
Major: Agronomy, Weed Science emphasis
Thesis: Biology and Control of Horsenettle.
Advisor: Dr. Ronald Talbert

Degree: B.S. 1983
Institution: University of Missouri, Columbia
Major: Agriculture, Agronomy emphasis

Experience:

Extension Associate Professor, Weed Specialist 70% extension 30% research. University of Missouri Delta Center, September 2002 to present

Managed a diverse research and extension program in Weed Science. Primary focus was weed control for corn, cotton, rice and soybean. Additional efforts included weed control for grain sorghum, wheat, potatoes, watermelon, and home horticulture. Supervised an applied herbicide screening program and integrated weed management research program. Provided educational programs to growers, area extension agents, agrichemical dealerships, consultants and agrichemical sales personnel. Maintained close working relationship with agrichemical industry, extension weed specialists and researchers in Mid-South states. Coordinate two training courses for Certified Crop Advisors.
Extension Assistant Professor, Weed Specialist 70% extension, 30% research. University of Missouri Delta Center. November 1993 to September 2002

Managed a diverse research and extension program in Weed Science. Primary focus was weed control for corn, cotton, rice and soybean. Additional efforts included weed control for grain sorghum, wheat, potatoes, watermelon, and home horticulture. Supervised an applied herbicide screening program and integrated weed management research program. Increased industrial funding 50% from 1994 to 1998. Provided educational programs to growers, area extension agents, agrichemical dealerships, consultants and agrichemical sales personnel. Maintained close working relationship with agrichemical industry, extension weed specialists and researchers in Mid-South states. Established two training courses for Certified Crop Advisors.

Extension Associate, University of Missouri Delta Center July 1992 to October 1993.

Interim position at University of Missouri Delta Center. Managed a research and extension program in Weed Science. Primary focus was weed control for corn, cotton, rice and soybean. Supervised an applied herbicide screening program and integrated weed management research program. Provided educational programs to growers, area extension agents, agrichemical dealers, consultants and agrichemical sales personnel.

Graduate Assistant, University of Arkansas, January 1986 to June 1992.


Agronomist, GreenKeeper Lawn Care, Dallas, TX, January 1984 to December 1985.

Responsible for sales, customer service and application with a chemical lawn care company. Responsible for a route with 700 customers in Eastern Dallas

Professional Service:

Program chair for Beltwide Cotton Weed Science Conference for 1999 and 2000 meetings.
Program chair for Rice Technical Working Group Weed Science Conference for 2000 meeting.
Rice Federation Environmental Committee 1999 to present
Southern Weed Science Society Herbicide Resistance Committee 1994 to present (secretary in 1997, Chair 1998)
Missouri Certified Crop Advisor Board of Directors 1994 to present- (chair 2001-2002).

Hosted 2000 Southern Weed Science Society Graduate Student Weed Contest. In this event, 46 graduate students from eight universities came to the University of Missouri Delta Center to participate in a one-day exercise that tested the students ability to identify weeds and, herbicides, calibrate sprayers and diagnose problems with field crops.

Membership in Professional Societies

Southern Weed Science Society
Weed Science Society of America
National Cotton Council
Rice Technical Working Group
Missouri Ag Industries Council

Selected Publications:


Resume of MANJULA V. NATHAN

Director of Soil and Plant Testing Laboratory  Tel.: (573) 882-3250 (work)
(100% Extension)  FAX: (573) 884-4288
Dept. of Agronomy  Email: nathanm@missouri.edu
University of Missouri
23 Mumford Hall
Columbia, MO 65211

EDUCATION:

Ph.D. in Agronomy (1989), South Dakota State University
Major: Soil Fertility, Minor: Chemistry
M.Phil. in Agric. (1981), University of Peradeniya, Sri Lanka
Major: Soil Chemistry, Minor: Statistics
B.S. (Hons.) in Agric. (1978), University of Peradeniya, Sri Lanka
Major: Agronomy, Specialization: Soil Science

EXPERIENCE:

Director/Extension Asst. Professor, MU, USA  1994 - to date
Associate Soil Scientist, NDSU, USA  1992- 1994
Postdoctoral Associate, UMN, USA  1990-1992
Postdoctoral Research Fellow: MU, USA  1989-1990
Graduate Research Assistant, SDSU, USA  1985-1989
Asst. Lecturer, Univ. of Peradeniya, Sri Lanka  1978-1979

SELECTED RESEARCH PUBLICATIONS:

   Ag. Expt. Station SB 1001, Univ. of Missouri-Columbia.
   22: 449-463
   rates and irrigation frequency on growth and yield of chilies on Calcic Red Latosols.

PROFESSIONAL SERVICE AND ACTIVITIES:

State Representative for NCR-13 Committee on Soil and Plant Analysis
Soil Testing and Plant Analysis Council Member
Board of Directors, Soil Testing and Plant Analysis Council
Director Missouri Soil Testing Association Accreditation Program
North American Proficiency Testing Program QA/QC Committee
AOAC Method Verification Committee

MEMBERSHIPS AND AFFILIATIONS:

American Society of Agronomy
Soil Science Society of America
Soil Testing and Plant Analysis Council
Sigma Delta Epsilon
Gamma Sigma Delta
AOAC International
Resume of DAVID J. (Dave) DUNN

University of Missouri
Delta Center, P. O. Box 160
Portageville, MO 63873
Phone (573) 379-5431
dunnd@missouri.edu

EDUCATION:

Degree: M.S. Geology (with emphasis in soils development) 1985
Institution: Iowa State University
Professor: Dr. Carl F. Vondra

Degree: B.S. Geology, 1980
Institution: Iowa State University

PROFESSIONAL EXPERIENCE:

Supervisor: Soil Testing Lab 1997-present
University of Missouri-Delta Center, Portageville, Missouri

Iowa State University, Ames, Iowa

Iowa State University, Ames, Iowa

PROFESSIONAL SERVICE:

1998- present University of Missouri Soil Testing Lab Advisory Committee.

1997- present University of Missouri Soil Test Recommendations Review Committee.

1997- present University of Missouri Soil Fertility Working Group.

1999-2001 Editor of Missouri Rice Research Update.

PROFESSIONAL SOCIETY MEMBERSHIPS:

American Society of Agronomy
Soil Science Society of America
Rice Technical Work Group
RECENT PUBLICATIONS:

Refereed Publications:


D. Dunn, G. Stevens, M. Aide, and J. Horn. 2002. Effect of soil pH and zinc on rice cultivars in Missouri. Trans. Missouri Acad. of Sci. pg.33-36


Agricultural Bulletins:

Crop Management Computer Programs:


Invited Workshops: