Northern Missouri Research, Extension & Education Center

University of Missouri

Field Day Annual Report
August 1, 2024

Cornett Farm | Lee Greenley Jr. Memorial Farm | Thompson Farm

Grace Greenley Farm | Ross Jones Farm

NORTHERN MISSOURI RESEARCH, EXTENSION AND EDUCATION CENTER

FIELD DAY ANNUAL REPORT 2024

(Volume 3)

Editors

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Acknowledgment: We would like to thank Shannon Lay, Jeana Curtis, Teresa Lynn Bradley, Jeff Case, Northern Missouri Research, Extension and Education Center staff, and all authors for contributing to this field day annual book.

SR606 New 8/2024

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WELCOME

Jeff Case

Director, NMREEC

Welcome to the Northern Missouri Research, Extension, and Education Center (NMREEC) annual field day. The NMREEC's focus is to conduct non-biased research that is beneficial to producers and the agricultural industry. In support of this mission, we evaluate new technologies in livestock, conservation, and crop management systems to ensure that they are cost-effective and applicable to the region. This field day combines the resources of three Agricultural Experiment Stations across Northern Missouri demonstrating a sampling of the practices we evaluate. The number of projects and researchers utilizing the center has increased and will continue to grow with collaborations gained across the NMREEC locations.

This year marks the 47th annual field day at the Lee Greenley Jr. Memorial Research Farm. The Lee Greenley Jr. Memorial Research Farm is comprised of three farms in Knox and Shelby counties for a total of 1390 acres. These farms are the Lee Greenley Jr. Memorial Research Farm near Novelty, the Ross Jones Farm near Bethel, and the Grace Greenley Farm near Leonard. The Lee Greenley Jr. Research Farm was established when Miss Hortense Greenley donated the 700-acre farm to the University of Missouri in memorium of her father Lee Greenley Jr. It became a part of the University of Missouri's comprehensive out-state research program in 1969 and was dedicated on October 6, 1974. The 240-acre Grace Greenley Farm was officially deeded to the University of Missouri in 2015 from Miss Hortense Greenley's estate upon her passing in memorium to her mother Grace Greenley. Ross C. Jones left his farm to the University of Missouri in 1988 after his passing to be utilized as an Agricultural Experiment Station to "improve agriculture in this area". A key research focus has been the MU Drainage and Sub-irrigation (MUDS) project that was initiated at the Ross Jones farm in 2001. The system allows for the evaluation of a corn/soybean rotation with drainage and sub-irrigation on claypan soil that is prevalent across northern Missouri. Research is also conducted on the impact of various crop and soil management practices on crop production, soil, and water quality at different landscape positions. Our beef herd is used for research and demonstration. The herd continues to improve through estrous synchronization and artificial insemination to superior sires. We practice rotational grazing and continue to strive to reduce input costs and produce quality beef. The Greenley Farm has marketed heifers in the Show-Me-Select Replacement Heifer Program for more than 20 years.

The Cornett Research Farm (Forage Systems Research Center) located near Linneus was established in 1965 when the University of Missouri began leasing land from the Cornett family to conduct grassland and grazing research. The farm was donated to The University of Missouri in 1981 upon the death of the last Cornett family member. The Cornett farm is comprised of three separate farms: Cornett, Allen, and Hatfield formerly referred to as the Forage Systems Research Center and consists of approximately 1,200 acres. The primary research goal of the Cornett Research Farm is the development and evaluation of forage/beef systems for all classes of beef cattle. For the past 59 years, we have conducted research and delivered the findings to our stakeholders. Field days, grazing schools, focused workshops, and technical training sessions are utilized throughout the year to deliver cutting-edge technologies to our communities. Research conducted at the Cornett Research Farm is integral to developing and implementing grazing management practices eligible for state cost share. Cornett Research Farm is the primary farm associated with CAFNR's Forage-Beef Program of Distinction. The Cornett Farm is an advocate for developing and implementing best management practices for protecting and promoting our environment and natural resources. Focusing on efficient and profitable beef production systems, research is designed to investigate the cause-and-effect relationships of cattle, plants, and soil (the systems approach) in forage/beef systems. These practices include the utilization of reproductive technologies, promoting live weight gains on pasture through season-long grazing and forage finishing beef, soil fertility management, and the development/adoption of smart farm technologies. Our goal at the Cornett Research Farm is to help farmers become more profitable by producing healthier, more nutritious products while improving the environment.

Thompson Research Farm was established in 1955 through the will of Dr. George Drury, a retired dentist. His will specified that 1,240 acres of land should be given to the University of Missouri. An additional 360 acres of the original tract later was added to the gift. The terms of the will prescribed that the farm should be "dedicated to public educational purposes in memory of Eulah Thompson Drury, Guy A. Thompson, Paschall W. Thompson, and Olive F. Thompson." Initial work at Thompson Farm involved research in crop production, soils, and insect control. A full-time agronomist directed crops and soil studies from 1956 until 1978. The research efforts at Thompson Farm historically centered on conducting yield tests with corn, soybean, alfalfa, wheat and oats as well as herbicide studies in soybean and testing of Hessian fly resistance in wheat. The University of Missouri introduced beef cattle research at the farm in 1963. The first comprehensive cattle crossbreeding experiment was conducted at Thompson Research Farm under the direction of Dr. John F. Lasley. The farm was also the site of a bull progeny testing program from 1970-1990, where approximately 100 bulls were tested yearly. Current research at the Thompson Farm focuses on beef cattle production systems and forest management. The Thompson Research Farm has been instrumental in the development and testing of estrous synchronization protocols in beef cattle and is a leader in the Show-Me-Select Replacement Heifer Program.

Visitors are always welcome to visit the NMREEC, whether you are attending a tour, meeting, wedding, or just passing through. This is your research center and your suggestions often become the catalyst for projects that benefit the broader community. We encourage you to visit our Facebook page at https://www.facebook.com/MUNorthernMOREEC where you can watch for frequent center updates and see some of our day-to-day activities. We are also on Twitter at @cafnr. You can find our additional social media links on the next page.

We are grateful to the many sponsors that make this event possible, and they are mentioned on the back cover of this book. I would also like to thank the members of our Advisory Boards for their continued support and guidance and our staff who maintain the day-to-day operations of our farms. These partnerships and teams allow us to fulfill our Land Grant Mission of Teaching, Research, and Community Engagement.

We hope your time spent at the Lee Greenley Jr. Memorial Research farm of the North Missouri Research, Extension, and Education Center was both educational and enjoyable. Thank you for joining us as we "Drive to Distinction".

MU Northern Missouri REEC Social Media Links
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Monthly Newsletter

MU Northern Missouri REEC Monthly Newsletter
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2024 NMREEC FIELD DAY LIST OF TOURS AND PRESENTATIONS

Beef and Forage Management

Ticks & Missouri Cattle

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Managing Sorghum X Sudangrass for High Yield and Quality

- Dr. Carson Roberts

Validating Available Genomic Predictions Marketed for Commercial Crossbred Cattle

- Dr. Jamie Courter

Integrated Pest Management

Key to Integrated Pest Management in Soybeans

- Dr. Ivair Valmorbida

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- Dr. Kevin Bradley

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Industrial Hemp Production and Flooding Effects on Soybean

- Anjeeta Nain and Dr. Gurpreet Kaur

Updating Nitrogen Rate Recommendations for Missouri

- Dr. Gurbir Singh and Pranay Kumar Kadari

Lunch Program

The Land Grant Mission in Today's Agriculture

- Richard Fordyce

NORTHERN MISSOURI RESEARCH, EXTENSION AND EDUCATION CENTER

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Richard Fordyce Bethany	**Rep. Kurtis Gregory** Marshall	**Brooks Hurst** Tarkio
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LEE GREENLEY Jr. MEMORIAL RESEARCH FARM

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Jaime Triplett Rutledge	**Harold Trump** Luray	**Nate Walker** Kirksville
Dr. Glenn Wehner Kirksville	**Dr. Jason Weirich** Columbia	**John Wood** Monticello

CORNETT RESEARCH FARM

Dean Brookshiere Chillicothe	**Bruce Burdick** Plattsburg	**Walter Carr** Brookfield
Harry Cope Truxton	**Donald Davies** Dawn	**Dennis Jacobs** Brookfield
Ivan Kanak Maysville	**Dennis McDonald** Galt	**Bob Miller** Keytesville
Allen Powell Laclede	**Valerie Tate** Linneus	

THOMPSON RESEARCH FARM

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Stephen Eiberger King City	**Bruce Emberton** Milan	**Ethan Griffin** Trenton
Phil Hoffman Trenton	**Gregg Landes** Jamesport	**Carl Woodard** Trenton

LEE GREENLEY Jr. MEMORIAL RESEARCH FARM

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Lynn Bradley
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Assistant Professor

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Ryan Hall
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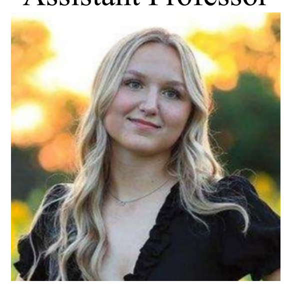

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Jennifer Allen
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THOMPSON RESEARCH FARM


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Laramie Persell
Ag Associate II


Amanda Coffman
Farm Worker II


Kyla Coffman
Temporary Technical

NMREEC GRADUATE STUDENTS

Anjeeta Nain
M.S. in Soil, Environmental, and Atmospheric Sciences (2024-2025)

Anjeeta received a B.S. in Agriculture Sciences from CCS Haryana Agricultural University, India in 2023. She started her M.S. degree in spring 2024 in the School of Natural Resources with Dr. Gurpreet Kaur. Anjeeta is working on developing agronomic management practices for industrial hemp production in Missouri. She is conducting multilocation trials in Missouri for industrial hemp variety testing and nitrogen management.

Dustin Steinkamp
M.S. in Plant, Insect and Microbial Sciences (2023-2025)

This is Dustin's second year at the Lee Greenley Jr. Memorial Farm. He graduated from Western Illinois University with his B.S. in agriculture in 2023. He is studying the effects of nitrogen loss in corn fields through leaching and gaseous emissions as well as evaluating nitrification inhibitors used with urea. He is grateful for the opportunity to continue his education and work with Dr. Kelly A. Nelson along with a very friendly and knowledgeable staff at the Greenley Research Farm.

Pranay Kumar Kadari
M.S. in Plant, Insect and Microbial Sciences (2023-2025)

Pranay graduated from Professor Jayashankar Telangana State Agricultural University in 2022 with a B.S. degree in Agricultural Sciences. He is currently a second-year master's student working with Dr. Gurbir Singh. His research focuses on studying the effects of nitrogen application timings and rates along with various nitrogen stabilizers at different topographic positions on crop production, gaseous emissions, soil and water quality. He loves learning from the expert staff at the NMREEC.

Genevieve M. VanWye
Ph.D. candidate in Animal Science (2023-2027)

Genna graduated from Iowa State University in the spring of 2020 with a bachelor's degree in animal science and started her graduate program at the University of Missouri in the fall of 2020. Her research has focused on the use of long-term progestin-based estrus synchronization protocols and optimal timing of AI with sex-sorted semen in beef heifers. She successfully defended her M.S. thesis in November of 2022 and recently started a Ph.D. In the future, Genna hopes to be an educator to both cattle producers and students in beef production and reproductive management.

Rose Paul
Ph.D. Candidate in Plant, Insect, and Microbial Sciences (2024-2027)

This is Rose's first semester at the Lee Greenley Jr. Memorial Farm. She graduated with her Master's in Agronomy from Punjab Agricultural University, India in 2023. She is studying the N response in corn with different landscape positions, biological products, and cover crops. Her focus is evaluating soil health in response to different nitrogen fertilizers in combination with nitrification inhibitors. She enjoys working with fellow graduate students and the friendly and resourceful staff at the Greenley Farm.

Charchit Bansal
M.S. in Plant, Insect and Microbial Sciences (2024-2025)

Charchit received his B.S. in agriculture from Punjab Agricultural University, India in 2023 and started his M.S. in Plant Sciences at the University of Missouri, Columbia in the spring of 2024. His research focuses on drainage water management on terraced fields with new tile inlet technologies to reduce nutrient sediment loss in water. He is very grateful for the opportunity to study and work with Dr. Gurbir Singh and Lee Greenley Jr. Memorial Research Farm staff.

Tharindu Rambadagalla
M.S. in Soil, Environmental, and Atmospheric Sciences (2023-2025)

Tharindu is a second-year master's student in the School of Natural Resources, working under Dr. Morgan Davis, Dr. Ranjith Udawatta, and Dr. Gurbir Singh. He earned his Bachelor of Science in Agricultural Technology and Management with a major in Crop Sciences from the University of Peradeniya, Sri Lanka in 2022. Tharindu is conducting field research at the Greenley Research Center focusing on evaluating the effects of winter cover crops on nitrogen dynamics in agricultural systems. His study also examines the overall performance of corn-soybean rotations when integrated with cover crops which is particularly relevant to sustainable agriculture practices. Tharindu's goal is to integrate knowledge of agronomy with principles of sustainable agriculture and natural resource management, aiming to maximize agricultural system productivity while minimizing environmental impact.

NMREEC VISITING SCHOLARS

Zakhiriddin Berdimuratov
M.S. in Soil Science

Zakhiriddin is currently a master's student in soil science at the Tashkent State Agrarian University, Toshkent, Uzbekistan. He is visiting the Lee Greenley Research Farm in the summer of 2024 to learn about the agricultural production systems in Missouri. He is getting experience in field research in agronomy, soil science, and alternative crop production. He enjoys working with the Greenley faculty, staff, and students.

Erkin Ravshanov
B.S. in Agronomy

Erkin is a bachelor's student in Agronomy at the Tashkent State Agrarian University, Toshkent, Uzbekistan. Erkin is also visiting the Lee Greenley Research farm to gain some experience with the agriculture production practices used in corn and soybean cropping systems. He enjoys working with the undergraduate and graduate students at the Greenley Research Farm on various field projects.

TERRACE CONSTRUCTION AND NEW TILE INLET TECHNOLOGY EFFECTS ON SOIL HEALTH AND WATER QUALITY

Charchit Bansal
Graduate Research Assistant

Gurbir Singh
Assistant Professor

Kelly A. Nelson
Professor

Gurpreet Kaur
Assistant Research Professor

INTRODUCTION

Greater than 60% of soybean and 70% of corn production in Missouri is in the northern region above the Missouri River (Nelson et al., 2023). This production region is dominated by loess deposits creating elevation and slopes on the cultivable terrain. The slope of a field leads to runoff issues exacerbating the nutrient sediment and herbicide losses resulting in impairment of water quality downstream (Kladivko et al., 2004; Smith & Livingston, 2013; Smith et al., 2015). Effective land improvements like terrace construction are regarded as the best management practice for ameliorating runoff issues (Skaggs et al., 1994; Wei et al., 2016). Terraces split the steep slopes into shorter runs (Stops et al., 2022) thereby reducing the effect of surface water runoff. However, terrace construction also increases the problem of waterlogging in the depressional areas within a terrace (Li et al., 2017; Adler et al., 2020). Additional drainage systems like tile drainage are generally used in the Midwestern United States for removing ponded water from fields (Smith et al., 2008; Smith et al., 2015; Stops et al., 2022). Surface inlets or tile risers, underground tile conduits, and tile outlets all together constitute the drainage system (Gupta et al., 2019). Hickenbottom (HB), the standard perforated tile riser having circular perforations along its circumference, is installed at the lowest point of the terrace (Smith & Livingston, 2013; Li et al., 2017; Kaur et al., 2023) helping with water removal at the highest rate as compared to other inlets like water quality inlets (Li et al., 2017). Recently, blind inlets (BI), surface inlets having two layers of limestone and sand/gravel, may replace traditional tile risers. Blind inlets help reduce the nutrient sediment loads involving phosphorus, nitrates, and total soluble solids (TSS) in effluent water (Smith & Livingston, 2013; Smith et al., 2015; Li et al., 2017). Feyereisen et al., (2015) reported a 60% reduction in TSS loads, and 66 and 50% total P (TP) and soluble reactive P (SRP) by using BI compared to the standard HB tile riser, respectively. Similarly, in a six-year study on BI, Gonzalez et al. (2016) found a reduction in herbicide and pesticide contents including atrazine, 2,4-D, metolachlor, and glyphosate ranging between 11 and 58% in the discharge water. Moreover, the BI does not obstruct the path of farm equipment compared to the HB tile riser (USDA-NRCS, 2011). Very few studies have investigated the soil losses caused by the construction of terraces (Foster & Highfill, 1983) for setting up tile-drained fields using different types of tile inlets in the Midwestern U.S.

OBJECTIVES

The objectives of this study were to 1) identify the significant changes in the soil properties due to terrace construction by comparing the soil from pre and post-construction of terraces, and 2) examine the effects of different terraced tile inlet technologies on sediment removal and runoff water quality.

PROCEDURES

Geo-referenced soil samples were collected at 0–6, 6–12, 12–18, and 18–24 inches depths using a Giddings probe (Giddings Machine Company, Windsor, CO) in the spring of 2022 (pre-construction of terraces), and 2023 (post-construction). Soil health parameters including bulk density (BD), volumetric water content (VWC), soil electrical conductivity (EC), and soil temperature were collected from terraces. Aggregate stability using Royal Eijkelkamp Wet Sieving apparatus, permanganate oxidizable carbon, total carbon, and total nitrogen in combination with soil-available enzymes (beta-glucosidase, beta-glucosaminidase, acid phosphatase, and arylsulfatase) will be analyzed from the collected soil samples.

In 2023, post-construction of terraces, three of the typical HB inlet risers were replaced with new tile inlet technologies including – HB with underground channel tile laterals (HRL), water quality inlet (WQ), and blind inlet (BI) with two replications in a randomized complete block design. Additionally, we kept two replications of HB inlets which are regarded as controls for the comparison of results (Figure 1). Water samples from each terrace tile outlet at the Grace Greenley Research Center near Leonard, Missouri were collected after every rain event in 2023 and the daily discharge was calculated using MX2001 HOBO data loggers (Onset HOBO Company, Bourne, MA). The collected water samples were analyzed for pH, EC, and TSS. The cumulative discharge and TSS loads were then determined for each inlet technology.

RESULTS

Pre-terrace construction soil BD at 12–18 and 18–24 inches depths was 1.30 and 1.33 g cm^{-3}, respectively, which was significantly lower than post-terrace construction soil BD at the same depths (86.77 and 93.02 lb ft^{-3}, respectively). Due to the replacement of soil after terrace construction, BD of post-construction soil samples at 0-6- and 6-12-inches depths (66.17 and 78.66 lb ft^{-3}, respectively) were significantly lower than pre-terrace construction soil BD (86.15 and 85.53 lb ft^{-3}, respectively) at the same depths. There were no significant differences in VWC and EC among pre- and post-construction soil samples ($p>0.05$). However, due to the redistribution of topsoil, post-terrace construction soil samples had 3.1°F higher soil temperature than pre-terrace construction soil samples.

The results of the hydrographs collected from the data loggers installed at the terrace tile outlets indicate that HRL had 35 to 58% greater cumulative discharge compared to the BI and WQ inlets (Figure 2). Cumulative TSS loss was significantly greater for HRL (137 ± 38 lb ac^{-1}) when compared to WQ (83 ± 35 lb ac^{-1}) and BI (108 ± 4 lb ac^{-1}), $p<0.05$ (Table 1, and Figure 3). Soil disturbance during the installation may have initially affected the TSS loads in the first year.

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Table 1. Total soluble solids (TSS) load from each tile inlet technology with a confidence interval of 95%.

Treatment	TSS load (lb ac^{-1})	St. Dev.	Confidence (p=0.05)
BI	108	3	4
HB	73	59	82
HRL	137	28	38
WQ	83	25	35

Abbreviations: BI, Blind inlet; HB, Hickenbottom inlet; HRL, Hickenbottom with Channel Laterals; WQ, Water quality inlet.

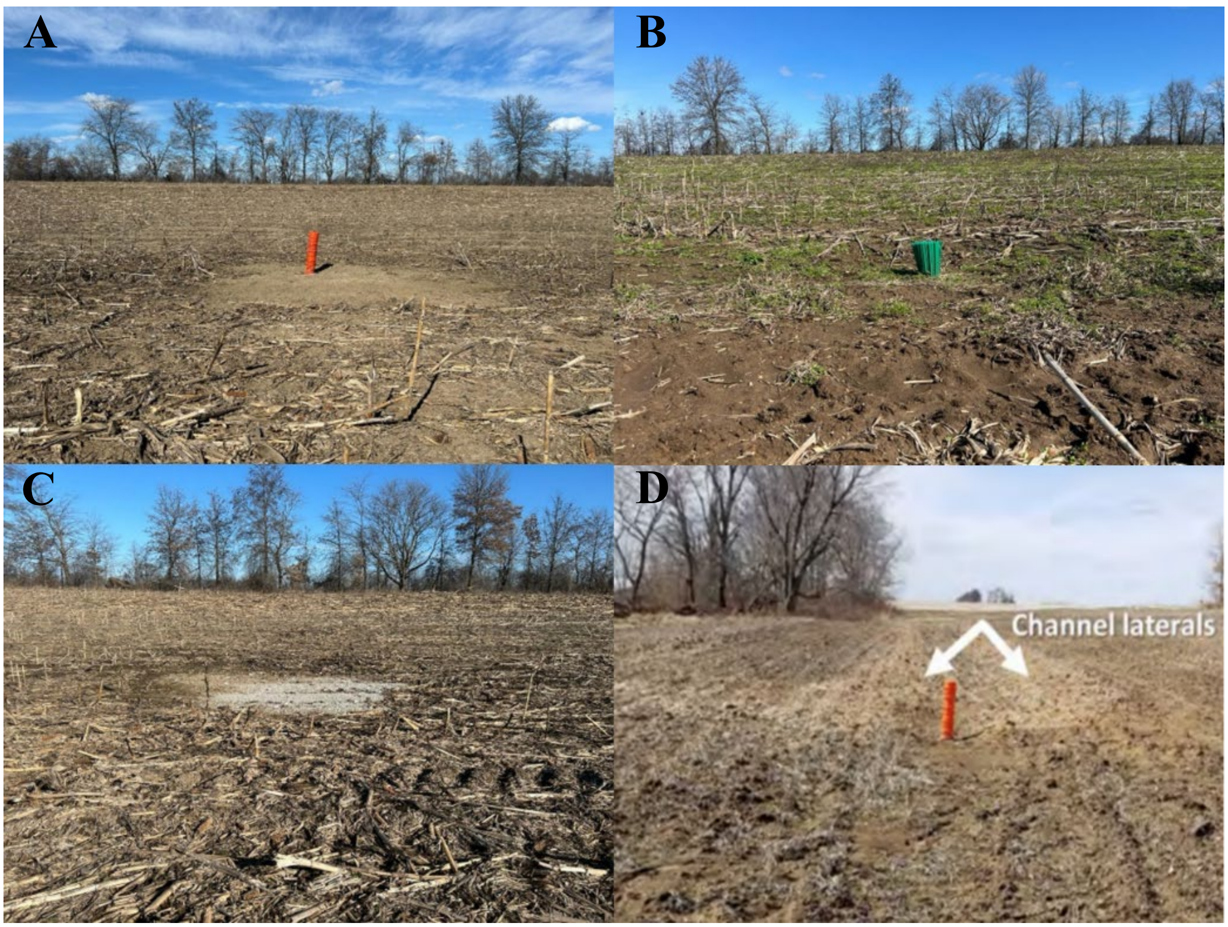

Figure 1. A) Hickenbottom Riser (HB), B) Water Quality Inlet (WQ), C) Blind Inlet (BI), D) Hickenbottom with Channel Laterals (HRL)

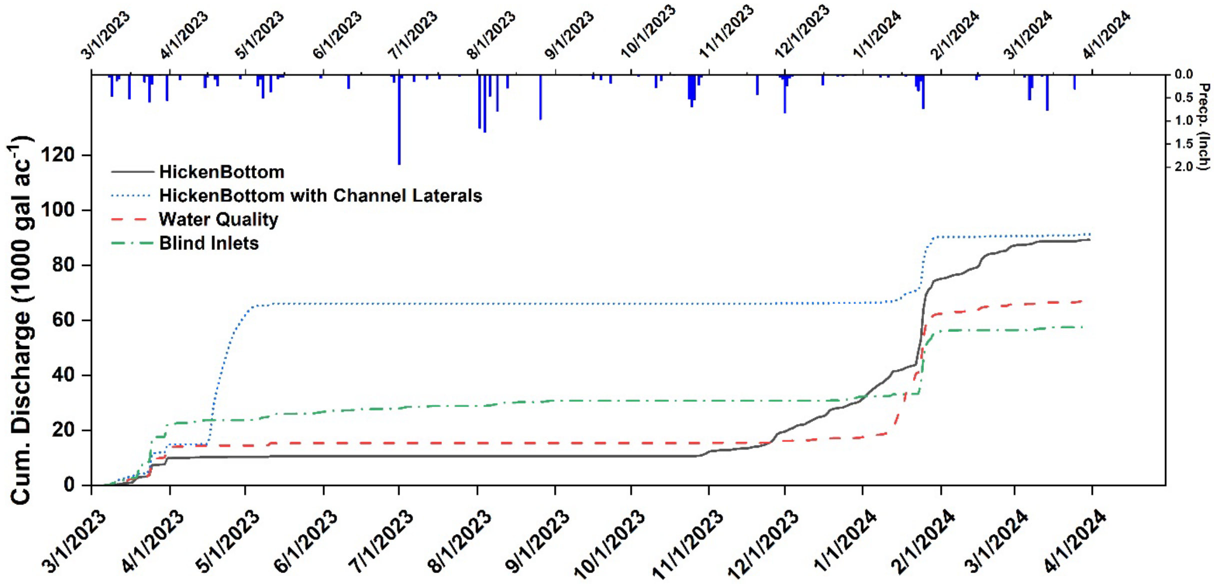

Figure 2. Cumulative daily discharge (1000 gal ac^{-1}) from individual tile technologies. Vertical bars represent the daily precipitation in inches for March 2023 to April 2024.

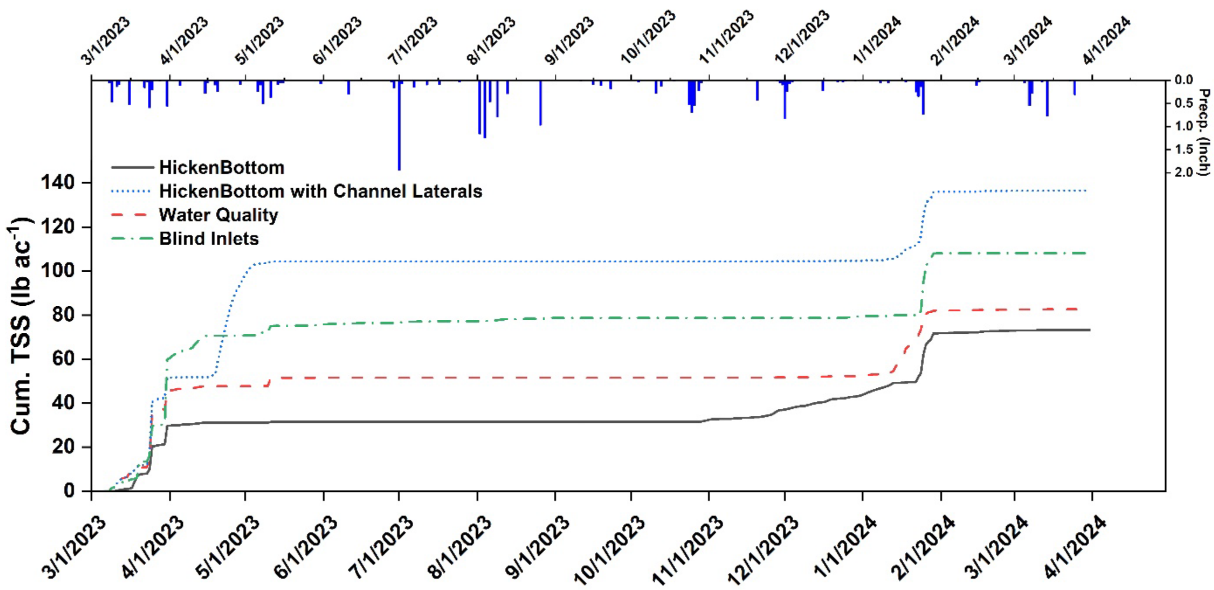

Figure 3. Cumulative daily total soluble solids (TSS; lb ac^{-1}) from individual inlet technologies. Vertical bars represent the daily precipitation (in inches) from March 2023 to April 2024.

FIELD EVALUATION OF DCD AND ENHANCED EFFICIENCY UREA FOR CORN

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INTRODUCTION

Farmers in the Midwest are facing many complex issues regarding the technical aspects of how they produce corn. For farmers to be sustainable, they must limit negative effects on the environment, continue to produce high-yielding crops that can be used by the public and create profitable farming enterprises. In a recent USDA economic analysis report from 2014 to 2022 for farmers in the Midwest U.S., they reported an average net profit of $21.41 per acre while 7 of the 9 years listed had a negative return on investment (USDA ERS, 2023). Furthermore, climate change and nutrient pollution concerns continue to linger. Leaching, denitrification, volatilization, runoff/erosion, and residue tying up plant available nitrogen (N) are the main loss mechanisms that need to be managed to avoid algae blooms in the Gulf of Mexico and enhance the nutrient use-efficiency of crops (Robertson, 1997).

Nitrogen is the mineral element most absorbed by plants under normal growing conditions and is typically the most limiting nutrient in corn production. Within the plant, N promotes leaf area, and photosynthesis, and is a constituent of essential cellular components such as amino acids, proteins, and nucleic acids (Torres-Olivar et al., 2014). Due to in-field variability and unpredictable precipitation events, successfully managing N has been a challenging problem (Rabalais et al., 2002; Scharf et al., 2005; Tremblay et al., 2012; Tao et al., 2018). Currently, many studies have shown that corn typically uses less than 40% of the fertilizer N applied (Griesheim et al., 2019).

Dicyandiamide (DCD) is a nitrification inhibitor that temporally inhibits the first stage of nitrification which is the process of oxidizing ammonia to nitrite (Amberger, 1989). A current enhanced efficiency fertilizer (EEF), SuperU™, is on the market which contains DCD at 0.85% and N-(n-butyl) thiophosphoric triamide (NBPT) at 0.06%. More research is needed on optimizing EEFs to find the optimum balance between maximizing corn yield and minimizing leaching and gaseous N loss. To increase nitrogen use efficiency and sustainability, producers will need a comprehensive N management plan that revolves around keeping inorganic N available to the plant longer in the soil. The EEFs may play an increasingly larger role in meeting these challenges. For widespread adoption to occur, data is needed that shows quantifiable reductions in nitrous oxide emissions and nitrate leaching as well as yield gains.

Research on sandy soil in the Mediterranean region evaluated nitrate leaching in maize (Diez et al., 2010). Researchers used 5% DCD mixed with ammonium sulfate and found a 32-33% reduction in nitrate concentration in the soil solution compared to nontreated ammonium sulfate (Diez et al., 2010). A study by Liu et al. (2013) was conducted in a wheat-maize rotation that included year-round gas sampling. The DCD treatment was 1.4% DCD with urea and resulted in a 35% reduction in cumulative nitrous oxide emissions compared to non-treated urea (Liu et al., 2013). Limited research is available on enhanced efficiency urea treatments for corn in poorly drained claypan soils.

OBJECTIVES
The objectives of this study are to evaluate 1) corn grain quality and yield response to enhanced efficiency urea treatments; 2) gaseous N loss of urea, DCD at 0.75%, SuperU™, and ESN®; and 3) evaluate the effects of urea, DCD at 0.75%, SuperU™, and ESN® on N leaching loss and plant N uptake.

PROCEDURES
Field research was conducted in 2023 and 2024 at the University of Missouri Lee Greenley Jr. Memorial Research Farm near Novelty. Tillage, planting, harvest date, N application, and herbicide applications are reported in Table 1. Experiments were arranged in a randomized complete block design with four replications. Plots were 10 by 40 ft. Pioneer (P1359AM) corn was planted in 30-inch-wide rows at 35,000 seeds ac^{-1}. All N fertilizers were broadcast applied to the soil surface using a hand spreader and incorporated before planting. Plant populations before harvest were determined from the entire length of the two middle rows.

Objective 1: Fertilized treatments that were evaluated for yield response included four N application rates (60, 120, 180, and 240 lbs ac^{-1}), and four dry fertilizer sources including non-treated urea, urea + DCD at 0.75%, SuperU™ (DCD at 0.85% + NBPT 0.06%; Koch Agronomic Services, Wichita, KS), and ESN® (Environmentally Smart Nitrogen, Nutrien, Saskatoon, Canada). A non-treated control that received no fertilizer was also included. Leaf greenness was determined using a SPAD chlorophyll meter (Konica Minolta, Tokyo, Japan). The center two rows of each plot were harvested at maturity for corn yield determination. Grain weight, moisture, and test weights were determined for each plot using a plot combine (Wintersteiger Delta) equipped with a HarvestMaster GrainGage. Grain yields were adjusted to 15% moisture content before analysis. Grain samples were collected and analyzed for starch, protein, and oil concentrations (Foss 1241, data not presented). Data were subjected to ANOVA and means were separated using Fisher's Protected LSD (P=0.1).

Objective 2: Fertilized treatments evaluated for gas emissions included urea treatments at 180 lbs N ac^{-1}, and a non-treated control that received no fertilizer. Nitrous oxide and ammonia (data not presented) emissions were measured weekly with a GT5000 Gasmet FTIR analyzer (Vantaa, Finland).

Objective 3: Fertilized treatments that were evaluated for leaching loss and plant N uptake included two N application rates (180 and 240 lbs N ac^{-1}), and four dry fertilizer sources (non-treated urea, urea + DCD at 0.75%, SuperU™ (DCD at 0.85% + NBPT 0.06%), and ESN®). A non-treated control that received no fertilizer was also included. In-season soil samples were collected at three depths (0-6, 7-12, and 13-18 inches) before fertilizer application and 2, 4, 6, and 8 weeks after treatment (WAT), and were analyzed for nitrate and ammonium-N. At 8 WAT, biomass was collected for the 180 lb N ac^{-1} treatments, dried, and analyzed for N concentration. At maturity, biomass was collected from the 0, 180, and 240 lb N ac^{-1} treatments and analyzed for N concentration. Post-harvest soil samples at six depths (0-6, 7-12, 13-18, 19-24, 25-30, and 31-36 inches) were collected using a Giddings probe for the 0, 180, and 240 lb N ac^{-1} treatments. Apparent recovery efficiency (ARE) was calculated as % ARE = amount of fertilizer N in biomass / total amount of N applied through fertilizer. Data were subjected to ANOVA and means were separated using Fisher's Protected LSD (P=0.05).

RESULTS

Precipitation in 2023 was below average and grain fill was affected by the dry conditions. In objective 1, there was no significant interaction between treatments and N rate (non-treated urea, DCD at 0.75%, SuperU™, ESN®) for leaf greenness (SPAD) and plant populations in 2023 (data not shown). Leaf greenness increased as N rate increased. DCD at 0.75% had the highest grain yield (129, 139, and 145 bu ac^{-1}) at the 60, 120, and 180 lbs N ac^{-1} rates, respectively, but it was similar to other treatments (Table 2). ESN® had the greatest yield (151 bu ac^{-1}) at 240 lbs N ac^{-1} which was higher than the DCD at 0.75%.

For objective 2, DCD at 0.75%, SuperU™, and the non-treated control had similar N_2O emissions and had the lowest cumulative N_2O emissions (<0.5 lbs ac^{-1}) (Figure 1). Non-treated urea had the highest N_2O cumulative emissions with almost 4 lbs ac^{-1}. DCD at 0.75% maintained soil test ammonium concentrations the longest of all treatments. DCD at 0.75% appeared to maintain more ammonia as the bulk amount of its nitrogen 8 WAT compared to six weeks for urea, SuperU™, and ESN® treatments (Table 3).

In objective 3, there were no differences between treatments for total plant N uptake for the 180 and 240 lb N ac^{-1} rates except compared to the non-treated control (Table 4). At 8 WAT biomass sampling, DCD at 0.75% had the highest biomass (1800 kg ha^{-1}) and N uptake (56 kg ha^{-1}) which was significantly greater than the NTC (1125 kg ha^{-1}, 28 kg ha^{-1}) and nontreated urea (1175 kg ha^{-1}, 31 kg ha^{-1}) (Figure 2). DCD at 0.75% was also greater than SuperU™ for plant N uptake (38 kg ha^{-1}) at this timing. DCD at 0.75% and ESN® had the highest total plant N uptake (228, and 259 kg ha^{-1}, respectively) which was greater than the NTC, but they were similar to other treatments at the 180 and 240 lbs N ac^{-1}, respectively. Apparent recovery efficiency (ARE) was non-significant among treatments for both N rates; however, DCD at 0.75% had higher efficiency (42%) compared to non-treated urea (22%) (Figure 3).

RECOMMENDATIONS

In 2023, we experienced excellent planting conditions which resulted in fast uniform corn establishment followed by a prolonged drought. Lack of adequate rainfall was the most yield-limiting factor in this study which greatly affected yield potential and made it difficult to determine the efficacy of the EEFs. However, varying environmental conditions are needed to properly evaluate new technology. Recommendations will be more conclusive following the second year of this research.

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Table 1. Field management information in 2023 and 2024.

Field Information and Management	2023	2024
N application	10 Apr.	10 Apr.
Tilloll incorporated urea	10 Apr.	10 Apr.
Planting date	11 Apr.	10 Apr.
Herbicides (PRE)	13 Apr.	10 Apr.
Glyphosate	32 fl oz ac^{-1}	32 fl oz ac^{-1}
Verdict	5 fl oz ac^{-1}	5 fl oz ac^{-1}
MSO	12 fl oz ac^{-1}	12 fl oz ac^{-1}
UAN	8 fl oz ac^{-1}	8 fl oz ac^{-1}
Herbicides (POST)	18 May.	20 May.
Roundup PowerMax 3	32 fl oz ac^{-1}	22 fl oz ac^{-1}
Bicep II Magnum	2.6 qt ac^{-1}	2.6 qt ac^{-1}
Cavallo 4SC	5 fl oz ac^{-1}	N/A
Callisto	N/A	3 oz ac^{-1}
NIS	N/A	0.25% v v^{-1}
AMS	N/A	17 lbs/100gal
Herbicides (POST)	8 June.	
Glypex 5 Extra	32 fl oz ac^{-1}	
Atrazine	32 fl oz ac^{-1}	
Armezon Pro	20 fl oz ac^{-1}	
Astute	6 fl oz ac^{-1}	
Cavallo 4SC	3 fl oz ac^{-1}	
AMS	3 lb ac^{-1}	
Harvest date	21 Sep.	

Table 2. Corn grain yield response to N fertilizer sources and rates. The last column average represents the average of all enhanced efficiency urea fertilizer treatments over each N rate.

Nitrogen rate	Urea	DCD at 0.75%	SuperU	ESN	LSD † (*P*=0.05)	Average ‡
lbs N ac^{-1}	bu ac^{-1}					
0 (NTC)	84	84	84	84	NS	84d
60	119	129	118	121	NS	119c
120	133	139	139	134	NS	137b
180	137	145	141	136	NS	140ab
240	148ab	142bc	145a-c	151a	8.5	143a
LSD (*P*=0.1)	-	-	-	-	-	4.73

†Numbers followed by the same letter are not significantly different at alpha = 0.05.
‡Numbers followed by the same letter are not significantly different at alpha = 0.10.
Abbreviations: LSD, least significant difference; NS, no significance; SuperU™ (DCD at 0.85% + NBPT at 0.06%).

Table 3. Soil test nitrate concentration at different soil depths for N sources at the 180 N rate in 2023.

Depth	0 WAP	2 WAP	4 WAP	6 WAP	8 WAP
--in--	ppm				
NTC					
0-6	5.9	10.1c-f†	18.6b-f	20.8f-h	10.4gh
7-12	3.2	3.5f	3.5g	4.3j	4.7i
13-18	2.9	2.2f	2.9g	4.7ij	4.1i
Urea					
0-6	5.9	38.6a	50.4a	130.9a	53.7b
7-12	3.2	3.8f	20.9bc	18.6f-i	14.7f-i
13-18	2.9	4.2f	5.4e-g	11.6g-j	15.6f-i
DCD at 0.75%					
0-6	5.9	23.7bc	19.8b-d	47.1e	71.5a
7-12	3.2	6.1ef	14c-g	7.4h-j	12.5f-h
13-18	2.9	3.1f	4.9fg	9.6g-j	15.5f-h
SuperU					
0-6	5.9	23.1bc	12.5c-g	69.3c	46.9b
7-12	3.2	3.1f	30b	12.8g-j	22.9e-h
13-18	2.9	3.2f	5.2e-g	9.3g-i	16.7f-i
ESN					
0-6	5.9	26ab	25b	50de	35.7c-e
7-12	3.2	3.6f	29.2b	13.5g-j	22.2e-h
13-18	2.9	3.2f	5fg	11.6g-j	24.4d-g
LSD (*P*=0.05)	14.1	14.1	14.1	14.1	14.1

†Numbers followed by the same letter are not significantly different at alpha = 0.05.
Abbreviations: DCD, dicyandiamide; SuperU™ (DCD at 0.85% + NBPT at 0.06%); ESN®, Environmentally Smart Nitrogen; ppm, parts per million.

Table 4. Total corn plant biomass, tissue N uptake (leaves, stem, cob, & husk), grain N uptake, and total plant N uptake response to urea treatments at 0 (NTC), 180 (180N), and 240 (240N) lbs N ac^{-1} in 2023.

	Total biomass		Tissue N uptake (Leaves & Stem)		Tissue N uptake (Cob & Husk)		Grain N uptake		Total plant N uptake†	
Urea treatment	180N	240N	180N	240N	180N	240N	180N	240N	180N	240N
	lb ac^{-1}		------------------------ lb N ac^{-1} ------------------------							
NTC (0 lbs N/a)	13,600c		45d		8b		74f		127e	
Urea	15,900b	17,700ab	59b-d	67a-d	12ab	11ab	95d-f	125ab	166b-e	204a-c
DCD at 0.75%	18,400ab	18,600ab	72a-c	64a-d	12ab	12ab	119a-d	123a-c	203a-c	199a-c
SuperU	16,300bc	18,600ab	50cd	65a-d	13ab	11ab	98c-f	117a-e	161c-e	194a-d
ESN	17,900ab	20,100a	78ab	87a	11ab	13ab	108a-e	132a	197a-c	232a
LSD (*P*=0.05)	3250		25.2		5.4		25.7		46.1	

†Sum of tissue N (leaves, stem, cob, & husk) and grain N uptake. Numbers followed by the same letter are not significantly different at alpha = 0.05.

Abbreviations: DCD, dicyandiamide; ESN, Environmentally Smart Nitrogen®; LSD, least significant difference; NTC, non-treated control; SuperU™ (DCD 0.85% + n-butyl, 0.06%); WAT, weeks after treatment

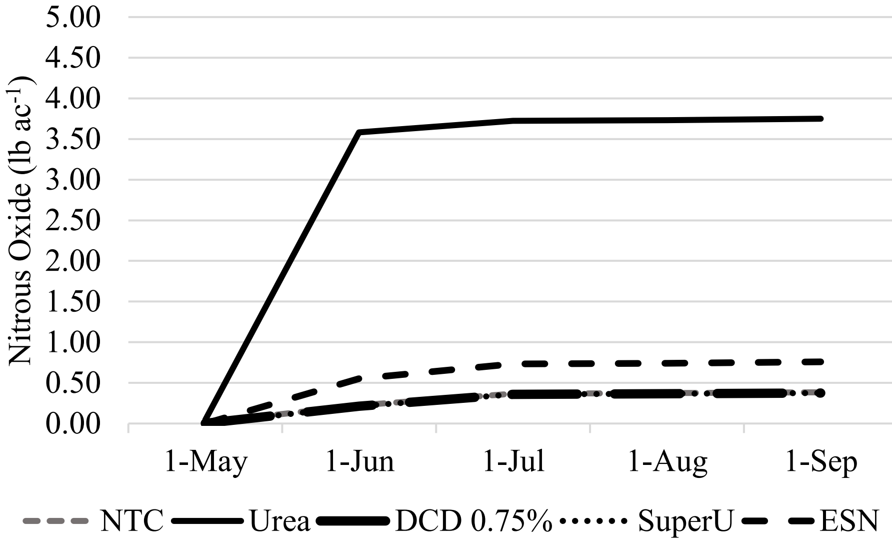

Figure 1. Cumulative nitrous oxide (N_2O) fluxes (vertical axis) for the non-treated control (NTC), enhanced efficiency urea fertilizer treatments (DCD at 0.75%, dicyandiamide; SuperU™ (DCD at 0.85% + n-butyl at 0.06%); ESN®, Environmentally Smart Nitrogen) at 180 lb N ac^{-1} in 2023.

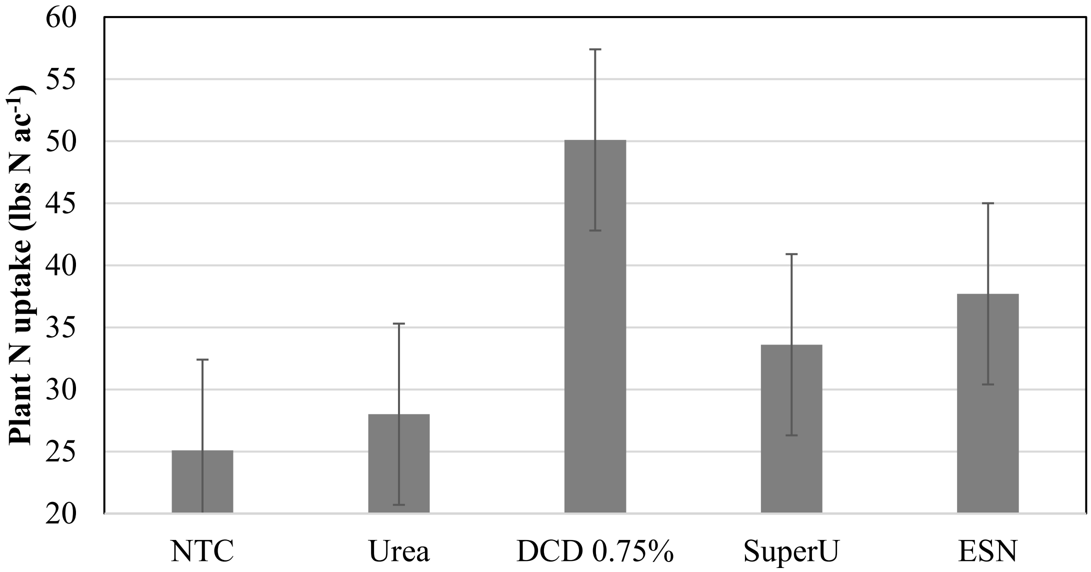

Figure 2. Corn plant N uptake 8 weeks after treatment among different N sources at the 180 lb N ac^{-1} rate. Whiskers represent LSD values (15 lbs N ac^{-1}) at *P*=0.05.

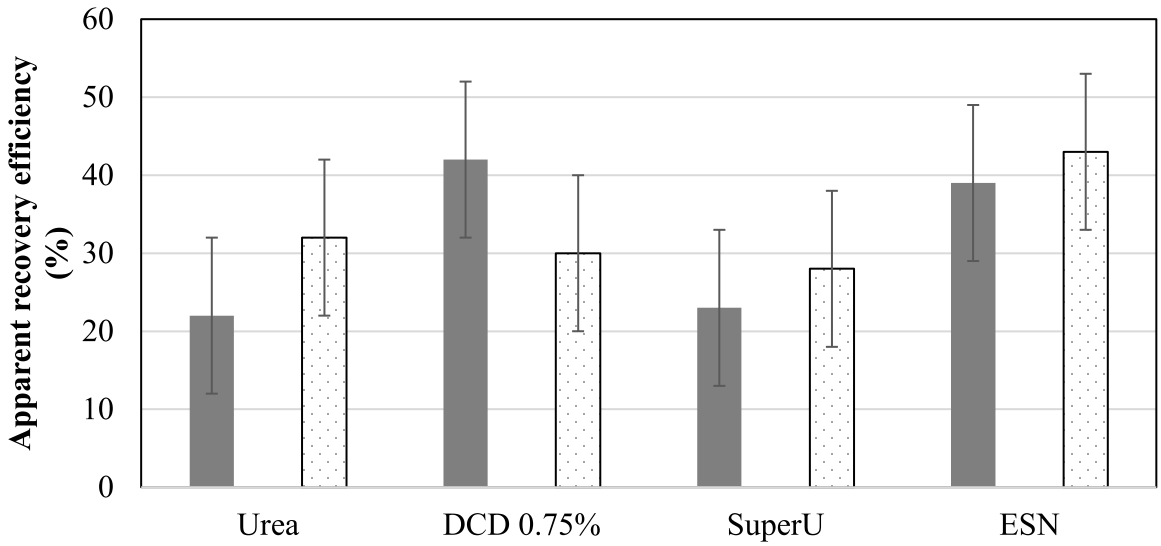

Figure 3. Apparent recovery efficiency for DCD and enhanced efficiency urea fertilizer technology treatments (DCD, dicyandiamide; DCD 0%, urea; SuperU™ (DCD at 0.85% + n-butyl at 0.06%) ESN®, Environmentally Smart Nitrogen) at the 180 (grey bar) and 240 (spotted bar) lbs N/acre. Whiskers represent the LSD at *P*=0.05.

LANDSCAPE POSITIONS AND NITROGEN TIMING AFFECT CORN YIELD AND QUALITY

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INTRODUCTION

Soil erosion on terraces causes spatial variability in soil properties and impacts nutrient cycling and crop nitrogen (N) uptake (Liu, 2011). Nitrogen is a costly input, accounting for approximately 30% of the total input costs incurred by corn growers in Missouri. Therefore, improving the efficiency of applied nitrogen is crucial to reducing fertilizer costs and increasing net returns for farmers. Applying nitrogen at crop stages with peak demands can increase N uptake and possibly ensure that most of the applied fertilizer is fixed within the plant system (Lory, 2011).

Nitrogen stabilizers are chemical additives that reduce the N dissolution rate in the soil solution and make N available for longer periods in the crop root zone. These chemicals act antagonistically to denitrifiers and thus, potentially reduce N losses to the environment including leaching and gaseous pathways (Nash et al., 2012). A split application of N at different crop growth stages, using combinations of urease inhibitors (UI) and nitrification inhibitors (NI), could enhance the longevity of N release in the soil. This approach makes N available for prolonged periods, thereby increasing corn yields and grain quality. Although extensive research has been conducted on N rates and NI's in Missouri, there is still an opportunity to study how landscape positions and split application of urea with both UI's and NI's affect corn yields and grain quality.

OBJECTIVE

The goal of this study was to evaluate N split application timing effects on corn yields, grain quality, and N uptake at three topographic positions including shoulder, backslope, and footslope.

PROCEDURES

The field experiment was established in 2023 at the Lee Greenley Jr. Memorial Research Farm (40°02'1.65'' N, 92°19'0.34'' W) near Novelty, MO. The study site represented a section of a parallel terrace that is 73 meters (240 ft) in length and was built in 1981. The dominant soil series at the study site was a Kilwinning silt loam (fine, smectitic, mesic Vertic Epiaqualfs). The terrace was classified into topographic positions based on topographic position index model values (TPI) and three slope positions i.e., shoulder (S), backslope (BS), and footslope (FS) which were described in Singh et.al. (2020). Four N application timing treatments included N applied at preplant (PP), 50% N applied at preplant and 50% at V6 (PP+V6), 50% N applied at preplant and 50% at V9 (PP+V9), and a zero N control (NTC) (Table 1). Nitrogen was broadcasted as Super-U at a rate of 210 lbs N ac^{-1}. All N treatments were replicated three times at each topographic position within plots that were 10 x 30 ft with a row spacing of 30 inches. Corn was planted on 16th April 2023, and aboveground biomass was collected at the R2 growth stage. Corn grain yield, moisture, and test weight were determined using a plot combine equipped with a harvest master grain gauge. Yield, grain quality, and N uptake data were analyzed using the GLIMMIX procedure in SAS statistical software (SAS Institute Inc., Cary, NC). The T-grouping of least-square means was used for mean comparisons at $p < 0.05$.

RESULTS

Significant effects were observed across different topographic positions which influenced corn grain yield (*p=0.0084*), test weight (*p=0.0033*), and nitrogen uptake *(p=0.0085*) (Table 2). Nitrogen timing treatments significantly affected corn grain yield (*p<0.0001*), test weight (*p=0.0043*), protein (*p<0.0001*), and nitrogen uptake (*p<0.0001*). The interaction effects of topographic positions and nitrogen timing (TP x NT) were non-significant for the measured parameters.

The footslope topographic position in 2023 yielded the highest (133 bu ac^{-1}) which was 9 and 20 bu ac^{-1} higher than backslope and shoulder topographic positions, respectively. A split application of N (PP+V6 and PP+V9) had grain yields that were 6 and 8 bu ac^{-1} higher than a single application of Super U, respectively.

Footslopes had 0.6 lb bu^{-1} and 1.8 lb bu^{-1} higher test weight than backslope and shoulder positions, respectively. Preplant N application had 0.1 and 0.2 lb bu^{-1} higher test weight than PP+V6 and PP+V9 treatments, respectively. Grain moisture varied among landscape positions and was lowest at the footslope (24.3%) and highest at the shoulder (28.6%).

The footslopes also recorded 7-14% greater plant N uptake than backslope and shoulder landscape positions. Similarly, N uptake in the PP treatment was 8% less than the split N application timing treatments.

Topographic positions and N timing did not show any impact on grain oil content. Variations in grain protein and starch content occurred only with different N application timings. The highest grain protein was found with PP+V6 and PP+V9 treatments (9.5% and 9.6% respectively), and the lowest with NTC (7.8%). Grain starch content was inversely related to protein content, with the highest starch in NTC (72.5%) and decreased by 0.9% in PP, 1.3% in PP+V6, and 0.9% in PP+V9. The first year of this research shows that changes in management over landscape position can help farmers optimize yields.

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Table 1. Landscape position and nitrogen application timing treatments.

Treatment	Landscape Position	N Application Timing†	N application rate (lb N ac^{-1})
1	Shoulder	NTC	0
2	Shoulder	PP	210
3	Shoulder	PP+V6	105 + 105
4	Shoulder	PP+V9	105 + 105
5	Backslope	NTC	0
6	Backslope	PP	210
7	Backslope	PP+V6	105 + 105
8	Backslope	PP+V9	105 + 105
9	Footslope	NTC	0
10	Footslope	PP	210
11	Footslope	PP+V6	105 + 105
12	Footslope	PP+V9	105 + 105

†Abbreviations: Super-U, urea treated with agrotain and DCD; Nitrogen, N; Pre-plant, PP; vegetative growth stage, V; non-treated control, NTC; all nitrogen (N) applied as pre-plant, PP; 50% N as pre-plant and 50% N at V6 corn growth stage, PP+V6; 50% N as preplant and 50% N at V9 corn growth stage, PP+V9.

Table 2. Average corn grain yield, grain quality parameters, and N uptake for the main effects of topographic positions and nitrogen application timing treatments. Means followed by similar letters within a column are not significantly different at $p<0.05$.

Topographic Positions (TP)	Nitrogen Timing (NT)†	Grain Yield	Test Weight	Grain Moisture	Grain Oil	Grain Protein	Grain Starch	Grain N Uptake
		bu ac^{-1}	lb bu^{-1}	--------------------------%-------------------				lb ac^{-1}
Shoulder		113 c	56.1 c	28.6 a	3.3	9.0	71.5	83.0 c
Backslope		124 b	57.3 b	25.1 b	3.33	8.8	71.9	90.1 b
Footslope		133 a	57.9 a	24.3 c	3.3	9.2	71.7	97.2 a
	NTC	81 c	55.8 c	26.6	3.32	7.8 c	72.5 a	51.7 c
	PP	133 b	57.9 a	25.3	3.34	9.1 b	71.6 b	97.2 b
	PP+V6	139 a	57.4 b	26.2	3.32	9.5 a	71.2 c	105.3 a
	PP+V9	141 a	57.3 b	25.9	3.26	9.6 a	71.6 b	105.3 a
Source of Variation	df							
TP	2	0.0084	0.0033	<0.0001	0.846	0.0902	0.2188	0.0085
NT	3	<0.0001	0.0043	0.2318	0.6127	<0.0001	<0.0001	<0.0001
TP x NT	6	0.0877	0.2977	0.6236	0.4816	0.8807	0.8006	0.0951

LANDSCAPE POSITION AND NITRIFICATION INHIBITOR EFFECTS ON CORN PRODUCTION ON CLAYPAN SOILS

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INTRODUCTION

Hardpans in Missouri soils are characterized by the presence of montmorillonitic clay subsurface Bt horizon with 35-60% clay content. These hardpans have low permeability, infiltration, and saturated hydraulic conductivity (<10 mm h^{-1}) resulting in accelerated runoff during high precipitation events (Nash et al., 2012). As the slope of the farmland intensifies, soil erosion increases which restricts agricultural suitability and influences farmers' choice of crops and conservation practices.

Several studies show a positive correlation between slope (Siswanto & Sule, 2019), rainfall intensity (Meng et al., 2021), soil erosion, and nutrient loss (Sweeney et al., 2019). Soil erosion limits corn production by affecting crop emergence, establishment, and reduced plant height, but it also reduces grain and biomass yields (Lin, 2024). Claypans with slopes can make soils more vulnerable to erosion and erosion-triggered nutrient losses (Sweeney et al., 2019). A large volume of fine micropores in claypan soils restricts the diffusion of oxygen and stimulates reduction reactions which makes these soils prone to denitrification losses during high rainfall events and volatilization during dry soil regimes in the summer and fall (Jamison & Kroth, 1958).

Nitrogen stabilizers are best known for their potential to reduce denitrification and volatilization losses with anhydrous ammonia (AA). In claypan soils, the inclusion of pronitridine (Centuro^{TM}) nitrification inhibitor with fall-applied AA had a yield advantage of over 7% and increased agronomic efficiency compared to no nitrification inhibitor (Singh & Nelson, 2019). However, spatial variability within sloped fields has been understudied for site-specific N recommendations on these soils.

OBJECTIVE

The objective of this study was to determine the optimum N application rate with and without N stabilizers for three different topographic positions (i.e., shoulder, backslope, and footslope).

PROCEDURES

A field experiment was established in 2023 at the Lee Greenley Jr Memorial Research Farm (40.02328°N, 92.19179°W) near Novelty, MO. The soil series of the experimental field is classified as Kilwinning silt loam (fine, smectitic, mesic Vertic Epiaqualfs) and Putnam silt loam (fine, smectitic, mesic Vertic Albsaqualfs). The experiment layout was a split-plot design with four replications. The main plots were three landscape positions (i.e., shoulder, backslope, and footslope), while N rate application treatments were subplots. The N source used in the study was anhydrous ammonia. The classification of landscape position was completed similarly to Adler et al. (2020). The treatments included a non-treated control (NTC, 0 lbs N ac^{-1}), 60 lbs N ac^{-1}, 120 lbs N ac^{-1}, 180 lbs N ac^{-1}, 240 lbs N ac^{-1}, 120 lbs N ac^{-1} + Centuro, 120 lbs N ac^{-1} + N-Serve, 180 lbs N ac^{-1} + Centuro, and 180 lbs N ac^{-1} + N-Serve.

Each treatment included four rows of corn, DeKalb 67-44, planted at a row spacing of 30 inches using a Kinze planter at 35,000 seeds ac^{-1}. The size of each treatment plot was 10 x 250 ft. Corn whole plant biomass samples were collected from a 4-ft length of the whole row at physiological maturity while grain samples were collected at the time of harvest and analyzed for N, P, K, Ca, Mg, Na, S, Mn, Cu, Zn, Fe, and Al. Corn was harvested using a commercial combine equipped with a yield monitor which was calibrated for weight and moisture. The yield monitor of the combine was set to collect point yield data every second. The built-in yield monitors also measure duration, swath, distance, track degree, moisture, and mass flow. Corn grain yield was adjusted to 15% moisture content before data analysis. Point yield data collected from the commercial combine was processed in AgLeader SMS software (Ames, IA, USA). The data collected during the period of study were analyzed using the GLIMMIX procedure in the SAS Statistical software v.9.4 (SAS Institute, Cary NC) at a significance level of $\alpha = 0.05$. The data were analyzed based on N rate application treatments at individual landscape positions. The average of topographic positions and interaction between landscape position and N treatments are not presented.

RESULTS

Shoulder topographic position: Grain yield (<0.0001), grain N content (<0.0001), grain protein (<0.0001), grain starch (0.0035), and harvest moisture (0.0037) were significantly affected by N treatments (Table 1). The highest grain yield at the shoulder position was obtained with N application at 120 lbs N ac^{-1} + N-Serve, which was not significantly different from treatments having N application at 180 lbs N ac^{-1}. There was no benefit of Centuro and N-Serve when applied with N at 180 lb ac^{-1} compared to the N treatments at the same rate without a nitrification inhibitor. However, N at 120 lb ac^{-1} with N-serve had 11 bu ac^{-1} greater yield than N application at the same rate without any nitrogen stabilizer.

The highest grain N (1.53%) and protein concentration (10.17%) was achieved with 240 lbs N ac^{-1}. Grain protein content was 0.14% lower with 180 lbs N ac^{-1} + Centuro and 0.23% with 180 lbs N ac^{-1} + N-serve. Grain starch content ranged between 7.02% and 7.16% with the greatest starch content at 60 lbs N ac^{-1} followed by 120 lbs N ac^{-1}. Grain moisture content was variable and generally increased with increasing N rates.

Backslope topographic position: Nitrogen rate treatments had a significant effect on grain yields (<0.0001), grain N content (<0.0009), grain protein (<0.0001), grain starch (0.010), and moisture content (0.0002) (Table 2). Similarly to the shoulder topographic position, dry matter production and oil content were not significantly affected by the N treatments.

Nitrogen applied at 180 lbs N ac^{-1} + N-Serve produced the highest yield, which was 7 bu ac^{-1} greater than the same rate with Centuro. There was no benefit of N stabilizers at the backslope position when N was applied at 120 lb N ac^{-1}. The highest nitrogen content in grains was observed for 240 lbs N ac^{-1} without a stabilizer followed by 120 lbs N ac^{-1} with no stabilizer. Grain protein concentration increased notably with higher N rates, achieving the highest value (10.30%) at 240 lbs N ac^{-1}. The highest starch content was observed in the control (0 N) treatment (7.15%), and the lowest content (7.03%) was observed for 240 lbs N ac^{-1}. Grain moisture content increased with the use of stabilizers like N-Serve and Centuro or with higher nitrogen rates. Moisture content was highest (17.77%) at 240 lbs N ac^{-1}.

Footslope topographic position: Grain yields (<0.0001), grain N content (0.0008), oil (<0.0001), protein (<0.0001), and starch content (0.010) were significantly affected by the N rate (Table 3).

The highest grain yield (148 bu ac^{-1}) was observed at 180 lbs N ac^{-1} + N-serve. Nitrogen at 180 lbs N ac^{-1} + Centuro or without a nitrogen stabilizer also showed higher yields compared to all other N rate treatments at the footslope position. The lowest yield was recorded in the control plots with no nitrogen applied (94 bu ac^{-1}).

The highest N content in the grains was recorded at 1.54% in plots treated with 180 lbs N ac^{-1} + Centuro, which was significantly higher than other N-rate treatments. This was 0.03% and 0.13% higher than those observed in plots treated with 180 lbs N ac^{-1} + N-Serve and 240 lbs N ac^{-1}, respectively.

Nitrogen at 180 lbs N ac^{-1} with or without N-Serve had a protein content of 9.87%, which was the highest among all the treatments. The highest starch content was recorded in control plots with no N applied (7.14%), and it tended to decrease with increasing nitrogen rates.

RECOMMENDATIONS

1. Each landscape position requires a different N application rate to optimize yield. Hence, considering the landscape for N recommendations would help to reduce N application rates and contribute to improved N use efficiencies and higher net profits (data not presented).
2. Utilization of N stabilizers can reduce N requirements at different topographic positions. However, the efficacy of different N stabilizers is highly dependent on environmental factors such as rainfall and available soil moisture.

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Table 1. Average corn grain yield, biomass yield, and grain quality parameters at the shoulder topographic position. Means followed by similar letters within a column are not significantly different at $p<0.05$.

N treatments	Dry biomass production	Grain yield	N	Oil	Protein	Starch	Grain moisture
	lbs ac^{-1}	bu ac^{-1}	-------------------------------	--%	--	---	------------------------
0 NA†	10924	96 d	1.11 f	4.55	7.12 h	70.8 c	14.69 d
60 NA	17318	122 c	1.16 e	4.31	7.79 g	71.6 a	14.34 d
120 NA	14483	135 b	1.36 dc	4.36	9.12 f	71.0 b	14.58 d
180 NA	14343	144 a	1.49 b	4.31	9.82 c	70.3 e	15.38 c
240 NA	12453	135 b	1.53 a	4.34	10.17 a	70.6 d	16.95 a
120 Centuro	15088	126 c	1.33 d	4.18	9.25 e	70.6 dc	16.14 b
120 N-Serve	15410	146 a	1.38 c	4.1	9.51 d	70.7 dc	14.62 d
180 Centuro	16134	138 b	1.50 ba	4.21	9.94 b	70.7 dc	15.46 c
180 N-Serve	14543	135 b	1.39 c	4.22	10.03 b	70.2 e	16.34 b
p-value	0.1208	<0.0001	<0.0001	0.1400	<0.0001	0.0035	0.0037

†non-treated control with no nitrification inhibitor, 0 NA; 60 lbs N ac^{-1} with no nitrification inhibitor, 60 NA; 120 lbs N ac^{-1} with no nitrification inhibitor, 120 NA;180 lbs N ac^{-1} with no nitrification inhibitor, 180 NA; 240 lbs N ac^{-1} with no nitrification inhibitor, 240 NA; 120 lbs N ac^{-1} + Centuro, 120 Centuro; 120 lbs N ac^{-1} + N-Serve, 120 N-Serve; 180 lbs N ac^{-1} + Centuro, 180 Centuro; 180 lbs N ac^{-1} + N-Serve, 180 N-Serve.

Table 2. Average corn grain and biomass yields and grain quality parameters at the backslope topographic positions. Means followed by a similar letter within a column are not significantly different at $p<0.05$.

N treatments	Dry biomas production	Grain yield	N	Oil	Protein	Starch	Grain moisture
	lbs ac^{-1}	bu ac^{-1}	-------------------------	-%	--	---	-----------------------------
0 NA†	8148 d	87 e	1.12 f	4.43	6.91 f	71.5 a	14.78 e
60 NA	14289 c	123 d	1.27 e	4.46	7.61 e	71.4 ba	14.09 f
120 NA	1362 c	144 c	1.47 b	4.10	8.90 d	70.6 d	15.43 d
180 NA	16383 b	150 ba	1.39 c	4.42	9.96 b	70.5 ed	16.45 cb
240 NA	14499 c	145 c	1.53 a	4.34	10.30 a	70.3 e	17.77 a
120 Centuro	16276 b	143 c	1.28 e	4.20	9.08 d	71.2 b	16.60 b
120 N-Serve	19033 a	143 c	1.34 d	4.34	9.46 c	71.0 c	15.15 ed
180 Centuro	18223 a	145 bc	1.45 cb	4.34	9.85 b	70.6 d	15.99 c
180 N-Serve	16145 b	152 a	1.42 cb	4.14	9.83 b	70.4 ed	16.83 b
p-value	0.1208	<0.0001	0.0009	0.3300	<0.0001	0.0100	0.0002

†non-treated control with no nitrification inhibitor, 0 NA; 60 lbs N ac^{-1} with no nitrification inhibitor, 60 NA; 120 lbs N ac^{-1} with no nitrification inhibitor, 120 NA;180 lbs N ac^{-1} with no nitrification inhibitor, 180 NA; 240 lbs N ac^{-1} with no nitrification inhibitor, 240 NA; 120 lbs N ac^{-1} + Centuro, 120 Centuro; 120 lbs N ac^{-1} + N-Serve, 120 N-Serve; 180 lbs N ac^{-1} + Centuro, 180 Centuro; 180 lbs N ac^{-1} + N-Serve, 180 N-Serve.

Table 3. Average corn grain and biomass yields and grain quality at the foot slope topographic position. Means followed by similar letters within a column are not significantly different at $p<0.05$.

N treatments	Dry matter production	Grain yield	N	Oil	Protein	Starch	Grain moisture
	lbs ac^{-1}	bu ac^{-1}	------------	------------	%	------------	------------
0 NA†	14120	94 g	1.25 f	4.43	7.83 e	71.4 a	14.35
60 NA	17166	119 f	1.20 f	4.47	7.68 e	71.2 b	15.73
120 NA	17525	134 cd	1.45 dc	4.10	9.02 c	71.1 b	16.52
180 NA	19726	141 b	1.41 de	4.41	9.87a	70.4 d	16.52
240 NA	15510	126 e	1.49 bc	4.34	9.82 a	70.2 d	17.04
120 Centuro	16313	133 d	1.48 bc	4.20	9.26 b	70.8 c	16.50
120 N-Serve	15774	127 e	1.39 e	4.34	8.78 d	71.0 b	15.24
180 Centuro	18292	138 cb	1.54 a	4.20	9.77 a	70.3 d	15.96
180 N-Serve	15310	148 a	1.51 ba	4.14	9.87 a	70.5 d	17.43
p-value	0.6663	<u>≤0.0001</u>	<u>0.0008</u>	0.328	<u>≤0.0001</u>	<u>0.0100</u>	0.1086

†non-treated control with no nitrification inhibitor, 0 NA; 60 lbs N ac^{-1} with no nitrification inhibitor, 60 NA; 120 lbs N ac^{-1} with no nitrification inhibitor, 120 NA;180 lbs N ac^{-1} with no nitrification inhibitor, 180 NA; 240 lbs N ac^{-1} with no nitrification inhibitor, 240 NA; 120 lbs N ac^{-1} + Centuro, 120 Centuro; 120 lbs N ac^{-1} + N-Serve, 120 N-Serve; 180 lbs N ac^{-1} + Centuro, 180 Centuro; 180 lbs N ac^{-1} + N-Serve, 180 N-Serve.

CROPPING SYSTEMS TO REDUCE RELIANCE ON SYNTHETIC NITROGEN FERTILIZER IN CORN

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INTRODUCTION

There is an increasing need for sustainable crop production systems to reduce the environmental impacts of production agriculture, increase food production, improve soil health, and reduce production costs. Cover crops provide a variety of ecosystem services and can enhance many soil properties. Previous research has found that they can improve nutrient cycling, reduce erosion, decrease soil compaction, enhance aggregate stability, moderate soil temperature, suppress weeds, and improve microbial activity which ultimately leads to healthier soil (Blanco-Canqui et al., 2015). Cover crops are generally established between the commodity crop growing seasons.

Intercropping involves growing two or more crops in a field at the same time and can have many benefits to the cropping system (Gebru, 2015). Legumes are a good option because they can fix nitrogen for the corn crop (Kocira et al., 2020). Legumes grown alongside cash crops such as corn can provide nitrogen and may reduce the amount of synthetic nitrogen fertilizer that is recommended. This could decrease input costs and increase farm profitability. Overlapping the growing seasons of two crops can lead to competition for natural resources and negatively affect the growth of both crops. It is important to determine the optimal termination timing of legume cover crops to maximize the nitrogen contribution without decreasing corn grain quality or yield through interference.

OBJECTIVES

The objectives of this research were to evaluate (1) the timing of cover crop termination at different corn growth stages on corn grain yield, (2) the effect of different intercropped legume cover crops on grain yield and quality, (3) the difference between broadcast and between row cover crop seed placement on corn response, and (4) the extent that leguminous cover crops can contribute nitrogen to a corn cropping system.

PROCEDURES

Field research was conducted in 2023 and 2024 at the University of Missouri Lee Greenley Jr. Memorial Research Farm near Novelty, Missouri (40°01’40.764” N, 92°11’24.72” W) to evaluate the effects of cover crop termination timing (V2, V4, or V8), cover crop placement (between row or broadcasted), cover crop species (non-seeded, crimson clover, red clover, or hairy vetch), and nitrogen rate (0 or 120 lbs N/acre) on corn grain yield and quality. The factorial experimental design had 52 treatments and 6 replications. We included additional nitrogen rates (60, 80, 240 and 300 lbs N/acre) to create an N response curve for predicting the N contribution from the CC treatments. Plots were 10 by 30 ft and each plot included four, 30 in wide rows of corn. Red clover (*Trifolium pratense*), Dixie crimson clover (*Trifolium incarnatum*), and hairy vetch (*Vicia villosa*) were frost-seeded on 13 March 2023. The cover crops were either broadcast seeded with an EarthWay Hand Spreader or seeded between corn rows with a two-row custom-built push planter with a 7.5-inch spacing between the two rows. Red clover was seeded at 26 lbs/acre, crimson clover was seeded at 25.6 lbs/acre, and hairy vetch was seeded at 95.8 lbs/acre. In treatments with between-row seed placement, the two-row planter made three passes through the plots to center the cover crops between rows 1 and 2, 2 and 3, and 3 and 4 of corn.

DKC67-44RIB was no-till planted at 35,000 seeds/acre on 21 April 2023 into a field that was previously soybean. At the V2 stage of development (Abendroth et al., 2011), SuperU® fertilizer (46-0-0) was applied to the plots at a rate of 0 or 120 lbs N/acre. In designated plots, cover crops were terminated at V2, V4, and V8 growth stages. Corn growth stages were determined based on a vegetative stage scale (Abendroth et al., 2011). Before termination, aboveground cover crop biomass was collected, cover crop and corn heights were recorded, and the canopy of the cover crop was visually rated on a scale from 0 (no canopy) to 100% (complete canopy cover) for each plot. To collect biomass, a 1ft^2 quadrat was randomly placed between rows two and three, and all biomass inside the quadrat was collected with handheld electric grass shearers and placed in a paper bag. The biomass was weighed, dried in an oven at 60°C for 48 hrs., and weighed again to determine dry matter production.

Cover crops were terminated with Status at 10 oz/acre, atrazine at 2 qt/acre, Roundup Powermax 3 at 1 qt/acre, Dual II Magnum at 1.33 pt/acre, ammonium sulfate at 17 lbs/100 gal, and non-ionic surfactant at 0.25% v/v. The herbicide was sprayed with a pressurized CO_2 backpack sprayer at 15 GPA. The boom was 10 ft wide with Teejet XR8002VS nozzles spaced 15 inches apart. Treatments that did not have cover crops were sprayed at V2 to maintain plots weed-free. Leaf chlorophyll measurements were recorded at VT with a SPAD meter on 21 July 2023. Ten plant readings from the ear leaves were averaged for each plot. The number of plants in one row of corn in each plot was counted to determine the plant population. Corn was harvested on 27 Sep. 2023 with a Wintersteiger Delta plot combine equipped with a Harvest Master SBDS800 to measure grain yield, test weight, and moisture for each plot. Grain yield was adjusted to 15% moisture content before analysis. A grain sample was collected and analyzed with NIR spectroscopy (Foss Infratec 1241, Eden Prairie, MN) to determine oil, protein, and starch content. Data were subjected to ANOVA and means separated using Fisher's protected LSD ($P=0.05$). Significant interactions were presented when appropriate.

RESULTS

Corn height was affected by CC species (non-seeded, red clover, crimson clover, or hairy vetch) and termination timing (V2, V4, vs. V8) with later removal timings having shorter heights. Cover crop biomass and canopy were affected by the CC species, termination timing, and seed placement (broadcast or between rows) ($P=0.0142$). Cover crop species and seed placement affected ear leaf greenness ($P<0.0001$) at VT and plant population ($P=0.0059$) at harvest.

There was a significant response of corn grain yield to applied N in 2023 (Figure 1). The agronomically optimal rate was approximately 180 lbs N/acre. The 0 and 120 lb/acre rates were in the responsive part of the curve. A nitrogen contribution from the legume CC should have been detected for a grain yield response. We estimated the N contribution from the CC based on the N response curve. Two treatments averaged a higher yield than expected on the nitrogen response curve indicating a nitrogen contribution from the cover crops. The red clover treatment planted between rows, terminated at V2, and fertilized with 0 lbs N/acre contributed approximately 18 lbs N/acre. Corn fertilized with 120 lbs N/acre with hairy vetch planted between rows and terminated at V2 contributed approximately 11 lbs N/acre to the corn crop. In general, as CC biomass increased corn grain yields decreased (Figure 2).

Corn grain yield was 12 to 24 bu/acre greater when cover crops were seeded between rows compared to broadcast seeding, but the response was affected by CC removal timing (Figure 3). The highest yields were observed when cover crops were terminated at V2 (135 to 146 bu/acre) and when cover crops were seeded between the corn rows. Grain yield decreased up to 33 bu/acre when cover crop removal was delayed from V2 to V8 for broadcast-seeded CC treatments and up to 21 bu/acre for between-row seeded CC treatments. When data were combined over nitrogen treatments and seed placement, crimson clover terminated at V2 had yields similar to the non-seeded control (Figure 4). Crimson clover terminated at V4 had yields similar to the V2 timing, but the V8 termination timing decreased yields 12 Bu/acre. All removal timings of red clover and hairy vetch reduced yields compared to the non-seeded control.

Legume cover crop selection, placement, and N rate (*P=0.0050*) affected corn yield response in 2023 (Figure 5). When averaged over all of the removal timings (V2, V4, and V8), crimson clover and red clover seeded between rows had yields that were similar to non-seeded corn at 0 lbs N/acre. This indicated that there was no significant nitrogen contribution that enhanced grain yields. All other CC treatments reduced corn grain yield. When N was increased to 120 lbs N/acre, crimson clover seeded between the corn rows had yields similar to the non-seeded control. However, crimson clover broadcast seeded, red clover broadcast and between-row seeded, and hairy vetch broadcast and between-row seeded all reduced yield. There was no effect of seed placement on corn grain yields when crimson clover was broadcast or between-row seeded at 0 or 120 lbs N/acre. However, corn grain yield increased 23 to 49 bu/acre when red clover or hairy vetch were seeded between rows compared to broadcast seeding regardless of the nitrogen rate.

Early termination of CCs was important to avoid interference that reduced corn yield in 2023. This was particularly important in a dry year when competition for moisture directly impacted corn yields (visual observation). Repeatability is important when implementing CC management systems. This research was repeated in 2024.

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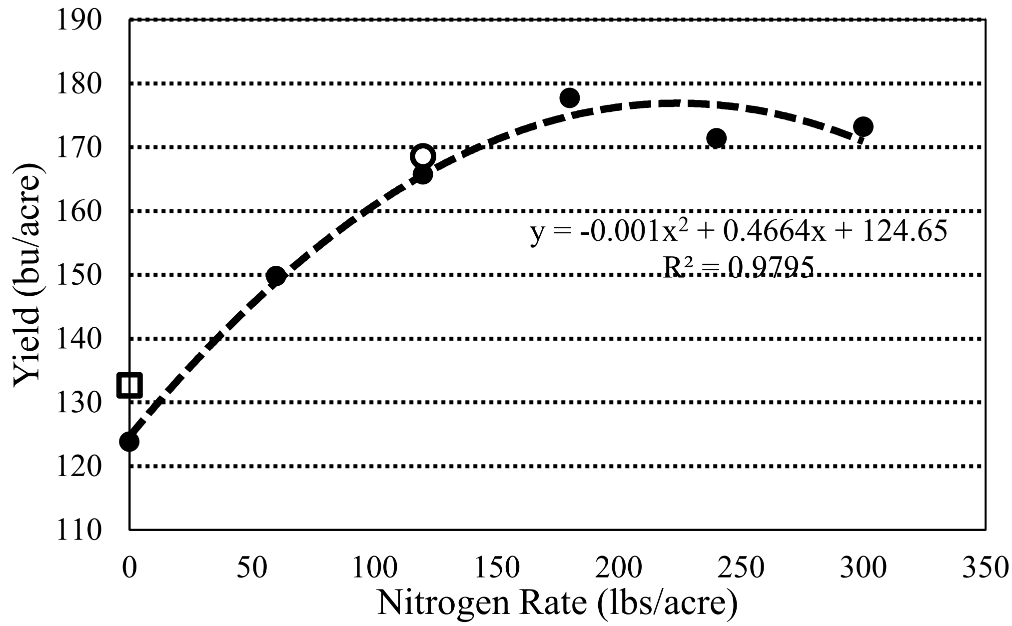

Figure 1. Corn grain yield response (dashed line) to nitrogen application rates in 2023. The open square represents the corn grain yield response to red clover planted between the corn rows with 0 N/acre and terminated at V2. The open circle represented corn grain yield response to 120 lbs N/acre with hairy vetch planted between corn rows and terminated at V2.

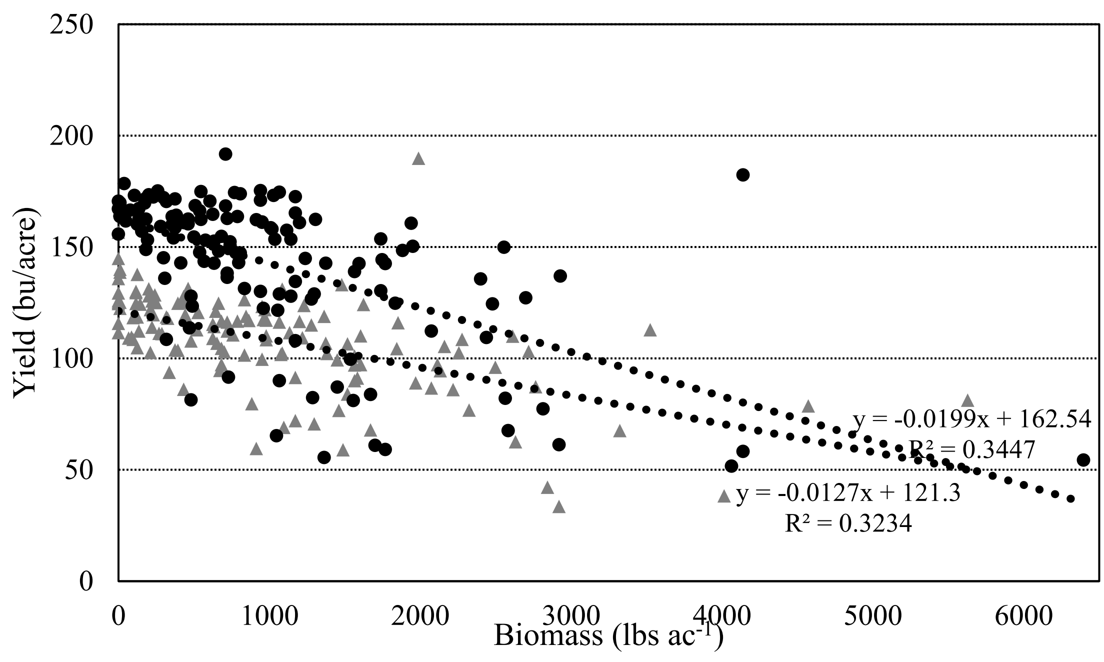

Figure 2. The effect of legume biomass at the time of cover crop termination on corn grain yield in 2023. Triangles represent treatments with 0 lbs N/acre and circle markers represent treatments with 120 lbs of N/acre.

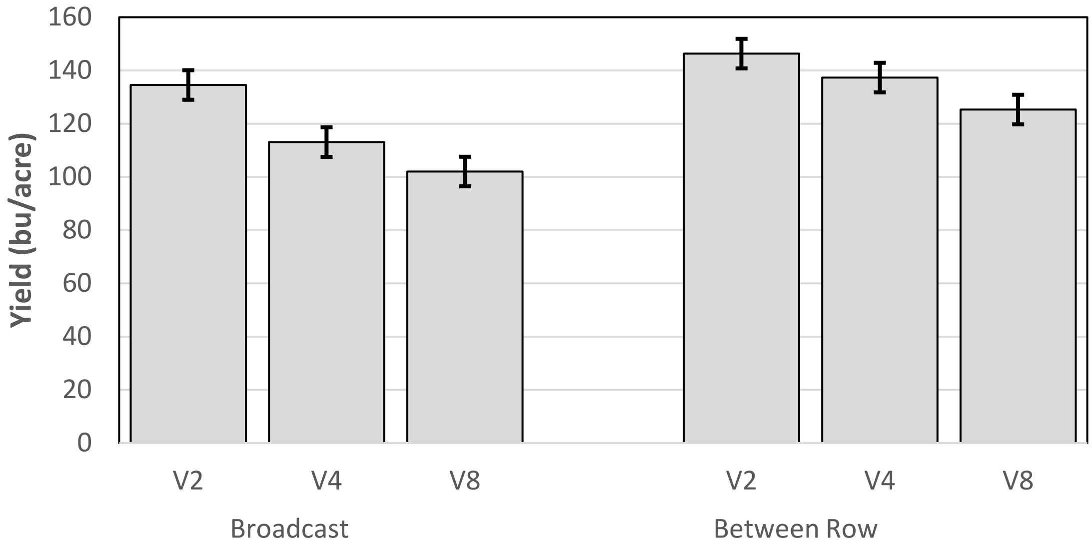

Figure 3. Cover crop seed placement (broadcast or between rows) and removal timing (V2, V4, or V8) effects on corn yield. Data were averaged over cover crop species (crimson clover, red clover, hairy vetch, and non-seeded control) and N rate (0 and 120 lbs N/acre). Whiskers represent the LSD (*P=0.05*).

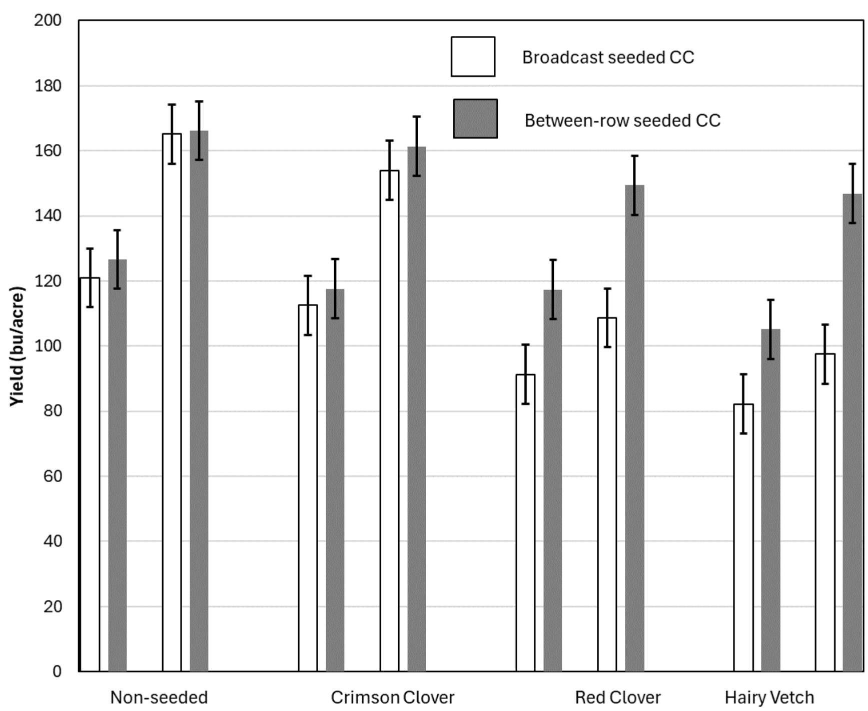

Figure 4. Corn grain yield response to legume cover crop (non-seeded control, crimson clover, red clover, or hairy vetch) seed placement (broadcast or between-rows seeding). Data were combined over N treatment and removal timing. Whiskers represent the LSD (*P=0.05*).

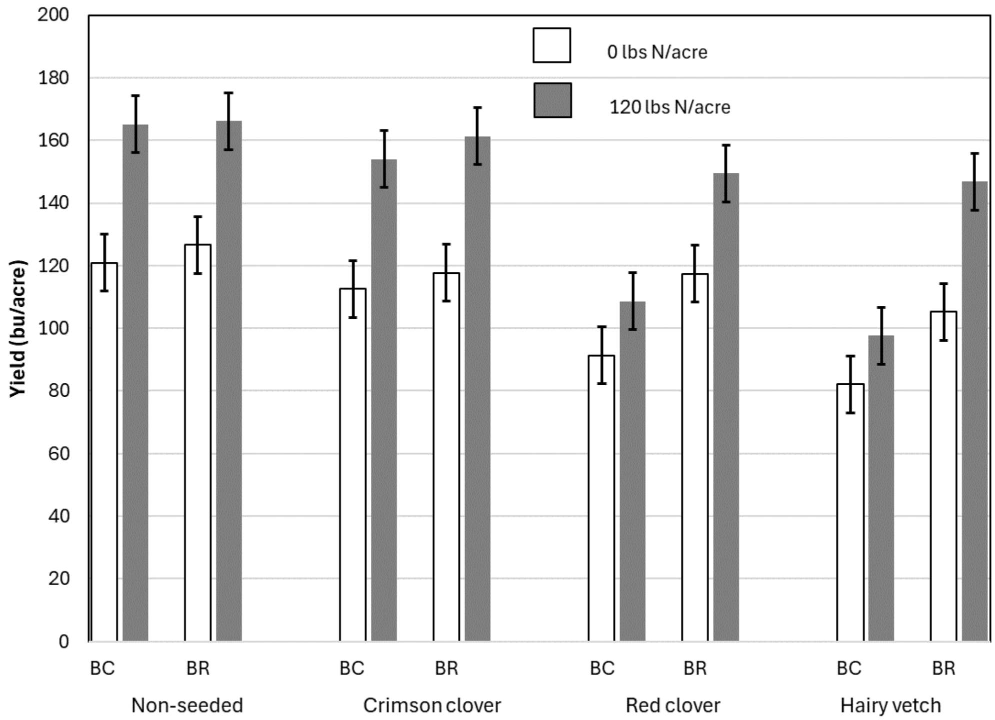

Figure 5. Corn grain yield response to legume cover crop (CC) species (non-seeded control, crimson clover, red clover, and hairy vetch) broadcast (BC) seeded and seeded in two rows between the corn rows (BR). White bars had no nitrogen applied (0 lbs N/acre) and grey bars had SuperU applied at V2. Whiskers represent LSD values (*P=0.05*). Data were combined over CC removal timing (V2, V4 and V8).

SITE-SPECIFIC SULFUR MANAGEMENT FOR CORN PRODUCTION BASED ON PRODUCTIVITY ZONES WITHIN A TERRACE

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INTRODUCTION

Sulfur (S) is an important macronutrient required for optimum corn growth and yield. Historically, atmospheric S deposition through acid rain resulted in sufficient available S in soils for major grain crops in the Midwest. In the last 2-3 decades, atmospheric S deposition has reduced to <1 lbs ac^{-1} yr^{-1} in Missouri and the S removal rate in grain has increased with the continued development of high-yielding corn hybrids. On average, 0.5 to 0.8 lbs of S per 10 bu of corn is removed by the harvested grain. Therefore, supplementing the S removal rate can help balance the soil nutrient pool.

Sulfur recommendations by the University of Missouri are based on the sulfur rating of soils (Hanson et al., 1984; Buchholz et al., 1989; Buchholz et al., 2004). According to this rating, if soil test sulfate-S (STS) extracted using 500 ppm P as monocalcium phosphate in 2N acetic acid extractant gives a value greater than 7.5 and CEC of soil is greater than 6.5 meq 100 g^{-1}, then no additional sulfur is needed by the crop. In the Midwest, positive corn grain yield responses to S have been documented with some inconsistencies (Sawyer et al. 2011; Steinke et al., 2015; Kaur et al., 2019). Most of the responsive sites for S have been documented to have coarse-textured soil, relatively low organic matter (<1.5%), and an early season low temperature with saturated conditions which results in lower mineralization of S and reduces available S pool in the soil (Tabatabai and Bremner, 1972; Rehm, 2005). Additionally, soils in critical zones that have lost the surface soil horizon due to soil erosion and have lower organic matter content can also show a response to S fertilization.

In Missouri, 60-70% of the corn production is on landscapes with significant slopes (>3%); therefore, major efforts on soil conservation have resulted in land-forming into terraces to facilitate cultivation. Landscapes with or without terraces can be classified in topographic positions leading to the development of productivity zones within a field. Major topographic positions can be classified into summit, shoulder, hillslope, foot slopes, and channels. Topographic positions, elevation, slope, aspect, curvature, upslope contributing area, flow length, flow direction, and flow accumulation are some of the landscape features that are responsible for creating corn yield variability. All the factors including low organic matter, temperature, soil loss, and saturation that regulate S supply are affected by topographic positions. Generally, footslope or channel landscape positions have higher water content in the early spring, lower temperatures, and lower organic matter which can result in S deficiency.

OBJECTIVE

The goal of this research was to evaluate S fertilizer source and rate impacts on corn yield, grain quality, and S removal at different topographic positions including the shoulder, backslope, and footslope.

PROCEDURES

The experiment was conducted at the Lee Greenley Jr. Memorial Research farm in 2023. The experiment was designed as a randomized complete block design with three replications. The treatments included in the study were topographic position (shoulder, backslope, and footslope), S sources [ammonium sulfate (21-0-0-24), TigerS or elemental S, and SymTRX 20S (16-1-0-20-2-16, N-P-K-S-Fe-Organic by dry wt.)], and S application rates (0, 5, 10, and 15 lb S ac^{-1}). Corn was planted on April 12th at 35,000 seeds ac^{-1} with a 30-inch row spacing. The plot size was 10 by 30 ft. The center two rows of each plot were harvested using a plot combine to obtain grain yield. The yield data were adjusted to 15% moisture content before analysis. Grain samples were collected at the time of harvest for grain S and grain quality parameters. The oil, protein, and starch content in corn grain was determined using the near-infrared grain analyzer (1241 Foss Infratech, Eden Prairie, MN). The S removal for corn grain was calculated by multiplying the grain S concentration and corn yield. The collected data were analyzed using the Glimmix procedure in SAS statistical software (SAS Institute Inc., Cary, NC). T-grouping of least-square means was used for mean comparisons at $P < 0.05$.

RESULTS

The main effects of topographic positions and sulfur sources were non-significant for corn grain yield, corn grain S removal, harvest moisture, and grain protein (Table 1). However, the interaction between topographic positions and sulfur rate was significant for all variables (Table 1, $p < 0.05$). The highest corn grain yield (144 bu ac^{-1}) was observed at the footslope with S at 5 lbs S ac^{-1} (Table 1). Within the footslope topographic position, the lowest yield was observed with non-treated control (0 S fertilizer) followed by 15 and 10 lbs S ac^{-1}. Based on the rate response curve, the optimum S application rate for the footslope topographic position for maximum yield was 7.7 lbs S ac^{-1} (Figure 1). A negative rate response was observed for the backslope topographic position with no difference between corn grain yield for 0 and 5 lbs S ac^{-1}. Sulfur at 10 lbs ac^{-1} had the highest yield at shoulder topographic positions and maximum corn grain yield was observed with 9.2 lbs S ac^{-1} based on the rate response curve (Figure 1).

Corn grain S removal varied between 6.31 to 8.14 lbs ac^{-1}, with the highest (8.14 and 7.89 lbs ac^{-1}) S removal at the backslope and footslope topographic positions, respectively (Table 1). On average, 0.55 lbs S was required to produce 10 bu of corn grain yield. Therefore, with a yield goal of 200 bu ac^{-1} corn, we would recommend 11 lbs of S ac^{-1}.

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Table 1. Corn grain yield, S removal, harvest moisture, oil, and protein content as affected by the interaction of S application rates and topographic positions.

Topographic position (TP)	Sulfur rate	Grain Yield	Grain S removal	Harvest Moisture	Grain Oil	Grain Protein
	lbs ac^{-1}	bu ac^{-1}	lbs ac^{-1}	----------------%----------------		
Shoulder	0	121 bc[†]	6.66 cd	18.4 cd	3.80 abc	9.24 bc
Shoulder	5	128 abc	7.29 abc	19.2 abc	3.89 a	9.22 bc
Shoulder	10	139 ab	7.71 ab	20.1 a	3.78 abc	8.99 bc
Shoulder	15	129 abc	7.50 abc	19.1 abcd	3.89 a	9.08 bc
Backslope	0	140 ab	7.69 ab	19.9 ab	3.78 abc	8.98 c
Backslope	5	148 a	8.14 a	18.1 d	3.76 bc	9.09 bc
Backslope	10	116 c	6.65 cd	19.2 abcd	3.80 abc	9.42 ab
Backslope	15	119 bc	6.74 bcd	18.6 cd	3.67 cd	9.26 abc
Footslope	0	115 c	6.31 d	18.7 cd	3.69 cd	9.34 ab
Footslope	5	144 a	7.89 a	18.7 cd	3.88 ab	8.77 c
Footslope	10	132 abc	7.31 abc	19.1 abcd	3.71 cd	9.2 bc
Footslope	15	117 bc	6.69 bcd	19.0 bcd	3.62 d	9.79 a
Source of Variation	df	-------------------------*p-values*-------------------------				
TP	2	0.7561	0.5561	0.4456	0.0016	0.5570
Sulfur Source (SS)	2	0.7404	0.5328	0.0740	0.1201	0.1193
Sulfur Rate (SR)	3	0.0251	0.0136	0.0864	0.0200	0.1601
TP x SS	4	0.6800	0.4238	0.7327	0.4453	0.7115
TP x SR	6	0.0168	0.0111	0.0154	0.0276	0.0378
SS x SR	6	0.3857	0.2372	0.1541	0.5963	0.4223
TP x SS x SR	12	0.7580	0.5171	0.7976	0.4151	0.7516

[†]Same letters within a column indicate no significant differences between means at $p < 0.05$.

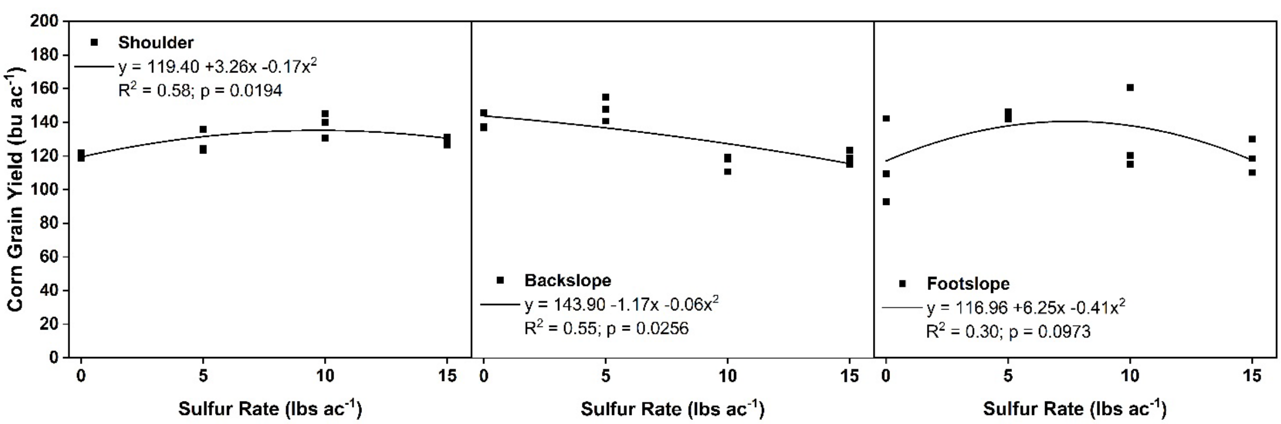

Figure 1. Corn grain yield and sulfur rate response for three topographic positions for a terraced field.

IMPACT OF FLOODING ON SOYBEAN PRODUCTION IN NORTHERN MISSOURI

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INTRODUCTION

Flooding is one of the most damaging abiotic stresses after drought (Bailey-Serres et al., 2012), which severely damages plants and causes crop production losses. "Flooding" mainly refers to the condition where the complete plant, or part of the plant, is underwater. Crop production losses due to temporarily flooded or saturated soils are a persistent problem in the Midwestern United States (Luce, 2015; Wiebold, 2015). Excessive soil moisture in the rooting zone of plants causes anoxic or hypoxic (no or low oxygen) conditions in soil which reduces crop yields, increases the risk of plant diseases and insect infestations, and off-farm loss of soil and nutrients (Morton et al., 2015). Most of the farmland in the midwestern US is classified as poorly drained (Hollinger, 1995), which can result in waterlogging or flooding of agricultural fields. This is common in most counties in northern Missouri including numerous river bottom fields and claypan soils in the region.

Claypan soils are prevalent in northern Missouri and are highly prone to waterlogging in the topsoil layers after rainfall due to poor subsoil drainage (Jamison et al., 1967; Anderson et al., 1990). Land topography is another reason for saturated soils in low-lying areas in agricultural fields which can result in total crop loss or a reduction in yield. Agricultural fields in northern Missouri have diverse topographic landscapes, which makes footslope positions highly susceptible to crop yield losses due to saturated soils.

Soybean is an important crop in Missouri with over 2.5 million acres in northern Missouri (USDA-NAAS 2019). The average yield of dryland soybean is 41 to 48 bu ac^{-1} in this region. Therefore, it is important to understand soybean response to flooding or soil waterlogging and to identify varieties that are tolerant to waterlogging to prevent yield losses. Flooding stress of soybean can cause a reduction in plant emergence, growth, plant height, branch number, pods per branch, dry matter production, seed size, N and P concentrations, a suppression in nodule nitrogenase and leaf nitrate activity, and can cause yellowing, abscission of leaves, and stomatal closure (Kaur et al., 2020). The extent of flooding injury depends upon the growth stage of the crop at the time of flooding, frequency and duration of flooding, and soil and water temperature during flooding (Kaur et al., 2020). Previous research in northern Missouri has shown a 6 to 11 bu ac^{-1} loss in corn yield with each day of saturated soils (Kaur et al., 2017). No research has been conducted on soybean with different maturity groups especially in the early stages of development when farmers may be able to replant if warranted.

OBJECTIVE

The objective of this study was to evaluate the effects of flooding stress duration during the early growth stages on commercially available soybean varieties in northern Missouri.

PROCEDURES

A field experiment was conducted at the University of Missouri's Lee Greenley Jr. Memorial Research Farm near Novelty in 2023. The experiment was designed as a randomized complete block with a split-plot arrangement and three replications. The main plots were flooding duration (0, 3, and 7 days) and varieties were subplots. Soybean was flooded at the V3-V5 growth stage for the long and short-duration flooding stress. The sub-plot size was 10 x 30 ft. The list of varieties included in the study is provided in Table 1. Soybean was planted on 24 May 2023 at 130,000 seeds per acre and row spacing of 15 inches. The flooding initiated on July 12.

Plant height was measured at the R7 growth stage and plant population was determined by counting plants from 1 row of each subplot. The pods per plant were determined by counting the number of pods per plant and the number of plants from 61 cm of row length in each subplot. Soybean was harvested using a plot combine to obtain soybean seed yield. The yield data was adjusted to 13% moisture content before analysis. Data were analyzed using the Glimmix procedure in SAS software (SAS Institute Inc., Cary, NC). T-grouping of least-square means was used for mean comparisons at $\alpha < 0.05$.

RESULTS

In 2023, in-season drought conditions delayed germination and resulted in variable emergence among different varieties. Soybean plants were at the V3-V5 growth stage at the time of flooding. Soybean plant height, plant population, pods per plant, and seed yield were significantly affected by the main effect of flooding duration. Three (32 in) and 7-days (27 in) of flooding reduced soybean plant height by 4 and 21%, respectively, compared to non-flooded soybean (34 in). Soybean plant height also varied significantly among the varieties (data not presented). When data were averaged over the varieties, flooding duration of 3 and 7 days decreased plant population than the non-flooded treatment by 23 and 38%, respectively (Figure 1). Pods per plant decreased when soybean was flooded for 7 days by 21% compared to the non-flooded soybean. Although 3-days of flooding reduced plant height and plant population, it did not impact the pods per plant and soybean seed yield. Reduced plant population and pods per plant due to 7 days of flooding resulted in a 30% reduction in soybean seed yield compared to the non-flooded treatment (Figure 1). There was a 2.9 bu ac^{-1} reduction in soybean yield with each day of flooding in 2023 (Figure 2).

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Table 1. Soybean varieties included in the flooding study in 2023.

Treatment	**Soybean variety**	**Seed treatment**	**Maturity group**
1	GH3582E3	None	3.5
2	B359EE	None	3.5
3	XO3651E	Poncho Vovito, Ilevo, Relenya, Obvious Plus	3.6
4	AG36XF	Acceleron	3.6
5	XO3752E	Poncho Vovito, Ilevo, Relenya, Obvious Plus	3.7
6	AG37XF1	Acceleron	3.7
7	B371EE	None	3.7
8	B371EE	*CruiserMaxx APX and Saltro*	3.7
9	AG38XF1	Acceleron	3.8
10	B389EE	None	3.8
11	B389EE	*CruiserMaxx APX and Saltro*	3.8
12	P38A54E	Lumigen, LumiTreo, ILEVO	3.8
13	*GH3922E3*	*CruiserMaxx APX*	3.9
14	*GH3922E3*	*None*	3.9
15	AG40XF1	Acceleron	4
16	B402EE	None	4
17	B423EE	None	4.2
18	P42A84E	Lumigen, LumiTreo, ILEVO	4.2
19	P44A91E	Lumigen, LumiTreo, ILEVO	4.4
20	P46A84E	Lumigen, LumiTreo, ILEVO	4.6

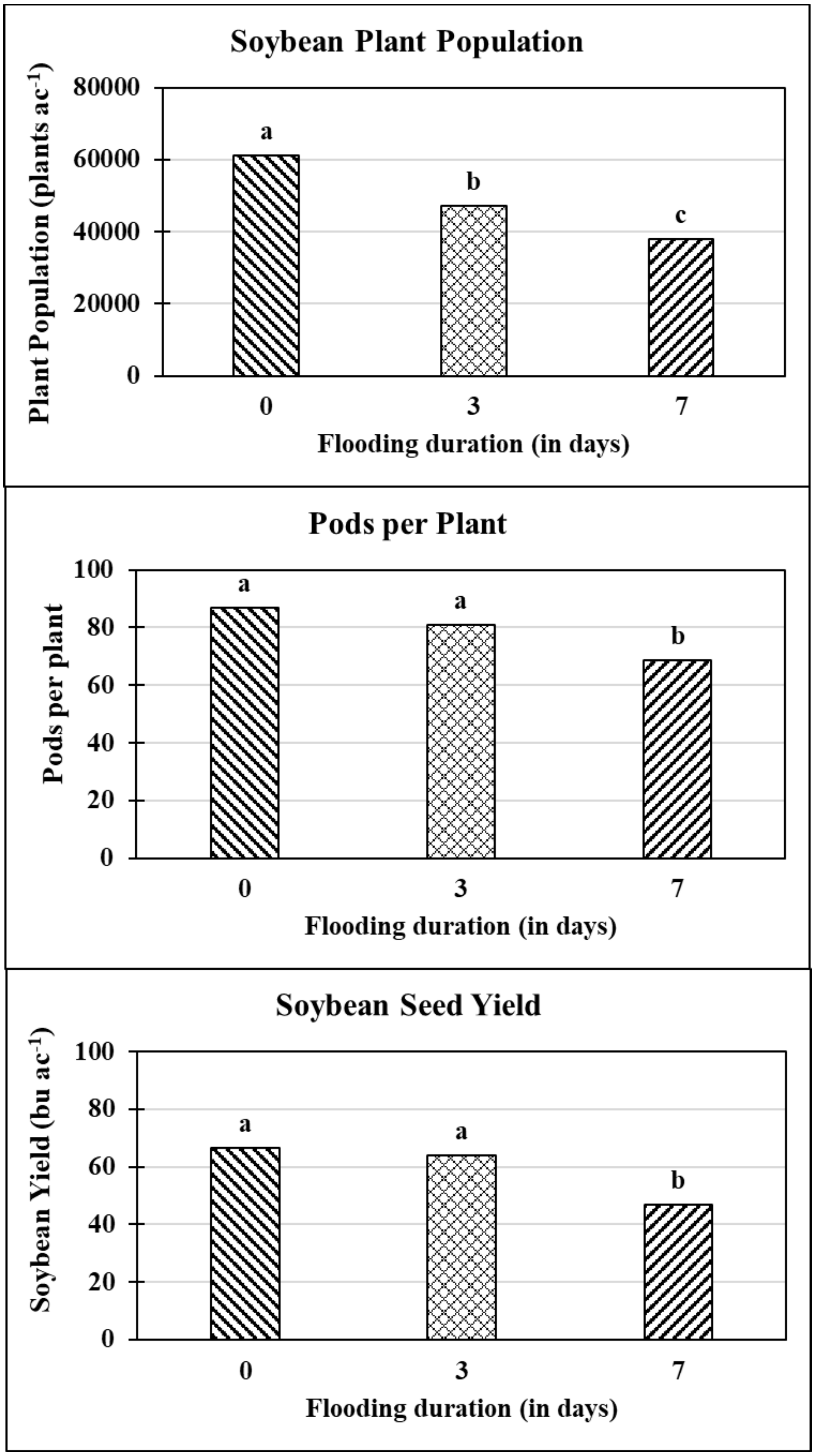

Figure 1. Soybean plant population, pods per plant, and soybean yield as affected by the flooding duration in 2023. Similar letters on bars indicated no significant difference between means at $p<0.05$.

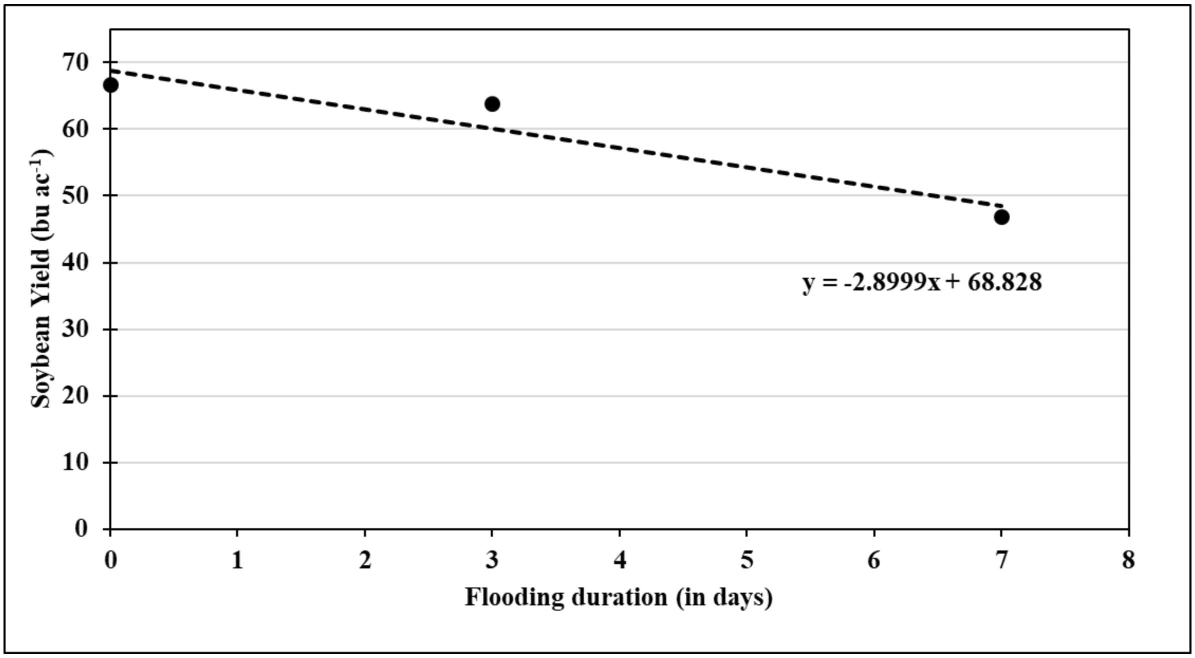

Figure 2. Soybean seed yield reduction with flooding duration.

MULTILOCATION CULTIVAR TESTING FOR INDUSTRIAL HEMP PRODUCTION IN MISSOURI

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INTRODUCTION

Industrial hemp (*Cannabis sativa* L.) is gaining attention in the U.S.A. as a valuable specialty crop, grown for its fiber, seeds, or cannabidiol content (Adesina et al., 2020). After a 45-year gap, the Agricultural Act of 2014 (Public Law 113-79) reinstated the production of industrial hemp in the U.S.A. through state pilot programs (Mark et al., 2020). The 2018 Farm Bill stipulated that cultivated hemp must contain no more than 0.3% THC (Delta-9 tetrahydrocannabinol). The U.S. Drug Enforcement Administration (DEA) strictly regulates its production, ensuring compliance with cultivation conditions (Yano & Fu, 2023). In Missouri, Senate Bill 133 was signed into law by the governor on 24 June 2019, permitting higher education institutions to research and study the growth, cultivation, or marketing of industrial hemp (Falkner et al., 2023). Although Missouri's history of hemp cultivation dates back to 1835 (USDA, 1914), the long hiatus has resulted in a significant knowledge gap regarding industrial hemp varieties and production techniques. Thus, it is crucial to evaluate new industrial hemp cultivars across Missouri to identify those best suited to local conditions and provide recommendations to growers.

OBJECTIVES

The objective of this experiment was to evaluate the effects of cultivars on industrial hemp biomass and yield production in different environments across Missouri.

PROCEDURES

Field experiments were conducted in 2023 at five locations in Missouri including the Lee Greenley Jr. Memorial Research Farm near Novelty, Hundley Whaley Extension and Education Center near Albany, Thompson Research Farm near Spickard, Fisher Delta Research, Extension and Education Center near Portageville, and Bradford Research Farm in Columbia. The experiment was set up as a randomized complete block design with four replications and the plot size was 10 by 30 feet at each location. Each plot had four rows of industrial hemp. A total of 13 varieties were evaluated at all five locations. The varieties included in the study were: Fibror 79, Futura, Jinma, Puma, Fermion, Feline 32, Orion 33, Altair, Trichomo, Rajan, Tygra, Vega, and MS-77. The hemp was planted in 30-inch-wide rows except in Portageville, MO (38 inches), and all were seeded at 30 lbs ac^{-1}.

All the varieties were tested for THC concentration. For THC analysis, the top 6 to 8 inches of flowering parts of two plants per plot were collected before harvesting for biomass. The industrial hemp samples from all replications for each variety were mixed to have only one sample per variety per location for testing of THC. The samples were sent to a laboratory (Agrozen Laboratory, Lebanon, IN) for analysis using standard methods.

The hemp plants were harvested from 10 ft of a middle row in each plot to determine biomass production and grain yield. The hemp was harvested for grain yield before full maturity to avoid shattering of seeds. The industrial hemp grain yields were adjusted to 8% moisture content before analysis. The GLM procedure in SAS statistical software (Cary, NC) was used for data analysis and means were separated by least square difference (LSD) at alpha =0.05.

RESULTS

Among all the varieties, only Jinma (0.33 to 0.49%) had a THC content higher than 0.3% at all locations, except at the Greenley Research Center, Novelty (0.29%) (data not presented). The highest biomass production for all the cultivars was present at Albany while the lowest was in Columbia (Figure 1). The MS-77 variety resulted in the highest biomass production at Albany, Columbia, and Portageville, whereas Puma had the highest biomass production at Novelty. No significant differences were found for biomass production between varieties at Columbia.

Grain yield production among locations varied by variety. The highest grain yield production was at Novelty, followed by Albany (Figure 2). At Novelty, Trihocomo was the highest yielding cultivar whereas Jinma had the lowest grain yield production. Jinma had low seed production due to the long maturity of this cultivar. The favorable climatic conditions at Albany resulted in higher biomass production. The emergence of industrial hemp was low at Columbia, which resulted in lower biomass production and grain yield. This was related to the environmental conditions at this location. The plant emergence in Spickard was good; however, soil saturation due to rainfall events resulted in crop failure at the Thompson farm in 2023. Therefore, no biomass or grain data are presented for this location. Environmental and soil conditions drastically affect the performance of different cultivars in Missouri. The study will be continued in 2024 and 2025 to provide recommendations about the suitable industrial hemp cultivars in Missouri.

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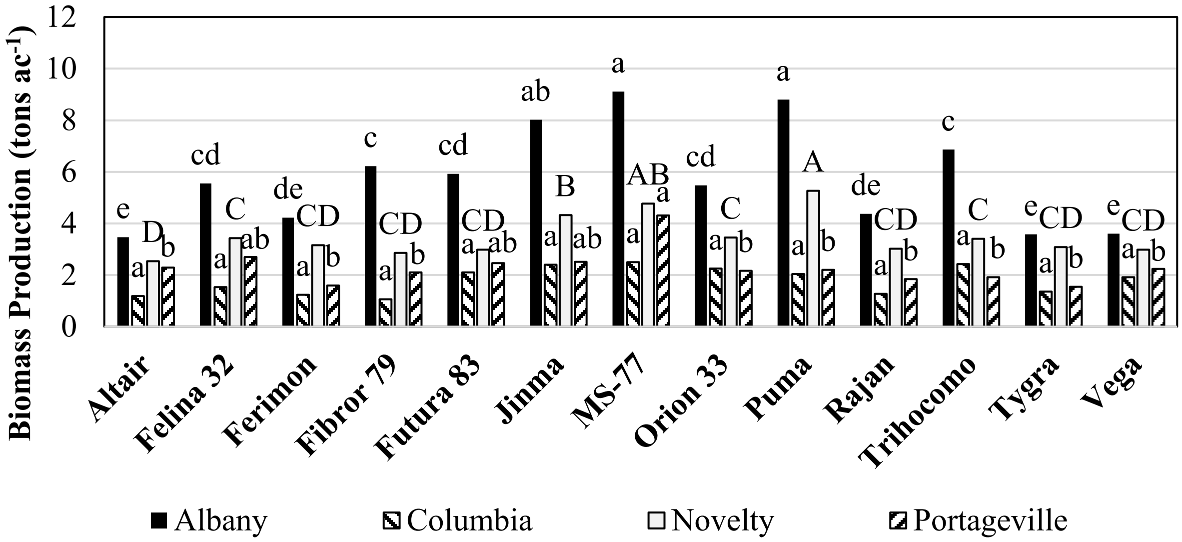

Figure 1. Biomass production of different industrial hemp varieties at four locations in Missouri in 2023. Means are compared separately for each location. Within a location, bars with similar letters indicate no significant differences between means at $p < 0.05$.

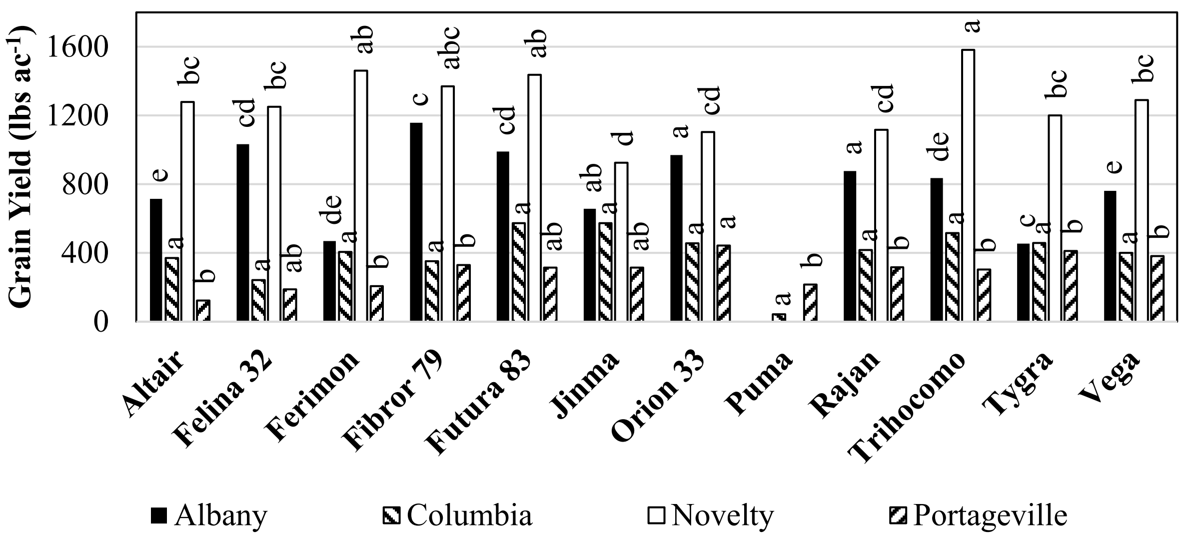

Figure 2. Grain yield production of different industrial hemp varieties at four locations in Missouri in 2023. Means are compared separately for each location. Within a location, bars with similar letters indicate no significant differences between means at $p < 0.05$.

SORGHUM SUDANGRASS HYBRID OPTIONS AND MANAGEMENT

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INTRODUCTION

Warm-season annual grasses are very productive and are suitable as stored forage and for summertime grazing. Sorghum x sudangrass and pearl millet are the most common warm season annuals available. These grasses grow quickly, usually 1-2 inches per day, and can produce as much as 8 tons of good quality forage in a single year. They are also more tolerant to drought and lower soil fertility compared to corn, but sorghum x sudangrass and pearl millet are very responsive to good management practices and improved fertility.

Traditionally, these grasses have been grown for stored feed or summer grazing. However, there is a growing interest in these grasses as a stockpiled forage for grass-fed beef. There is little information available to aid in understanding the implications of this practice. Furthermore, the genetic differences of improved varieties may perform differently in a stockpiled situation.

OBJECTIVE

Our objective is to determine the effectiveness of sorghum x sudangrass and pearl millet as a stockpiled forage.

PROCEDURES

A study is being conducted at the Cornett Research Farm in 2024 near Linneus, MO to assess the different stockpiling abilities of sorghum x sudangrass and pearl millet hybrids. Treatments were arranged in a split-plot design with four replications. The main plot consisted of two treatments, second cut and stockpiled, and the subplot treatments were twelve different hybrids and varieties of sorghum x sudangrass and pearl millet. Following the first killing frost, forage quality and yield measurements will be collected every two weeks throughout the winter. The results of this study will be presented next year.

RECOMMENDATIONS

Hybrid selection is important to maximum production and quality; improved hybrids consistently outperform conventional types. Improved genetic options include BMR, brachytic dwarf, photoperiod sensitive, and male sterile. Improved varieties can also be sown at reduced seeding rates because lower populations will not reduce quality.

Seed should be sown when soil temperatures are above 60 degrees. Seeding dates can range from mid-May to late June, and seeds should be placed ½ to 1 inch deep. Care should be taken when no-tilling into cereal rye stubble because of the allelopathic effect on the seedlings. Nitrogen fertilizer should be broadcast in a split application with 40-60 lbs/acre at emergence and 40 lbs/acre after the first cut.

Cuttings should be taken when the forage reaches 40 inches in height. Cutting height should be set at 6 inches or above the first two nodes on the plant. Sorghum x sudangrass and pearl millet can be harvested as silage, baleage, or dry hay.

Prussic acid poisoning can occur if the animals are grazed on stressed sorghum x sudangrass plants. Pearl millets do not contain prussic acid. Stress points can occur during drought or freezing temperatures. Sorghum x sudangrass should not be grazed under those conditions.

When grazing in the fall, animals should be removed when there is a chance of freezing temperatures and should not return until at least 2 weeks after the first hard frost. Both warm-season annuals can retain nitrates that cause nitrate poisoning. This is a common occurrence in drought and where excess nitrogen is available. Nitrate testing is inexpensive and should be included when high nitrates are expected.

TICKS & MISSOURI CATTLE

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INTRODUCTION

Ticks are important to the cattle industry both as nuisance pests and as vectors of diseases. The most common tick-transmitted disease of cattle in the U.S., and worldwide, is bovine anaplasmosis caused by *Anaplasma marginale*. More recently, *Theileria orientalis* Ikeda genotype has emerged as an important concern to cattle producers in the U.S., along with its tick vector, the invasive longhorned tick (also known as the Asian longhorned tick), *Haemaphysalis longicornis.*

Anaplasma marginale and *T. orientalis* are different organisms, but both infect bovine red blood cells and cause similar effects such as weight loss, spontaneous abortions, and death. On average, anaplasmosis costs U.S. cattle producers $660 per affected animal (Railey, 2021). Less data is available regarding the impact of *T. orientalis* in the U.S.; however, its significant economic cost to the cattle industries in Australia and New Zealand is well documented. Bovine anaplasmosis is often treatable with tetracycline antibiotics, but there is no approved treatment for bovine theileriosis.

Anaplasmosis can be spread by biting flies and by blood-contaminated instruments such as shared needles but is most efficiently transmitted by ticks. In the Midwest, the primary vector of bovine anaplasmosis is the American dog tick, *Dermacentor variabilis*. The major vector of *Theileria orientalis* is the longhorned tick, in its native range as well as in the U.S. (Dinkel, 2021). The longhorned tick does not transmit bovine anaplasmosis.

OBJECTIVES

This project has two major objectives. First, to estimate the proportion of American dog ticks infected with *A. marginale* on beef grazing operations in Missouri. Second, to better understand tick population dynamics on beef cattle pastures, including the potential presence of the invasive longhorned tick. Our results will contribute to better evidence-based management of tick-borne disease risk for beef producers.

PROCEDURES

Ticks are collected from March through August on five University of Missouri-owned beef grazing operations (Figure 1). Pastures are actively grazed by cattle. Ticks are collected with flannel drags over 750-meter transects according to published guidelines (CDC, 2020). Ticks are transported to the laboratory where they are taxonomically identified and subsequently stored at -80° C to await molecular analysis. Adult male American dog ticks are routinely processed and tested for the presence of *A. marginale* using real-time polymerase chain reaction (PCR) designed to detect one of the organism's specific genes (*msp1b*).

RESULTS

In 2022, ticks were collected from 79 transects on 20 days between May and August. In 2023, ticks were collected from 143 transects on 32 days between April and August. Tick collection for the spring/summer of 2024 is ongoing. So far this season, ticks have been collected from 71 transects on 18 days since March. Overall, the most common tick encountered is the lone star tick, *Amblyomma americanum* (94% of all specimens collected), with larvae being the most numerous (86% of *A. americanum* specimens collected). Details are shown in Table 1.

- Molecular analysis of American dog ticks collected in 2022 and 2023 yielded no detections of *A. marginale*, which may reflect extremely low prevalence among the tick vector and/or greater importance of other modes of transmission, such as shared needles, in our study area. Analysis of American dog ticks collected in 2024 is ongoing.
- Prior tick surveys in Missouri indicate that American dog ticks are more likely to be collected from open grassland than forested areas (Petry, 2010). Our findings are consistent with this observation.
- High numbers of *A. americanum* nymphs in 2023 may be attributable to collections made earlier in the spring when these nymphs are most abundant (Hroobi, 2021).
- We have collected nymphs of *H. longicornis* from vegetation in Linn, Boone, and Knox counties. This invasive tick has become established in many areas of the eastern U.S. and has continued to spread westward since it was first documented in 2017.

RECOMMENDATIONS

Producers can reduce the risk of tick exposure by excluding cattle from wooded areas when feasible and clearing brush regularly. Consider inspecting for ticks when handling cattle, along with checking and/or treating newly introduced animals (including dogs). Consult your local veterinarian for advice on tick control products.

For humans and pets, strategies to minimize the risk of tick bites are effective for both invasive and native ticks. Additional information is available in MU Extension's "Guide to Ticks and Tick-Borne Diseases" (IPM1032). If you suspect you have found an invasive tick, contact your local veterinarian, county extension agent, or county health department to have the tick identified.

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Table 1. Ticks collected, in total, by life stage and year of collection.

Species	Life Stage	2022 (79 transects)	2023* (143 transects)	2024** (71 transects)
Amblyomma americanum (Lone star tick)	Adult females	6	109	110
	Adult males	12	114	142
	Nymphs	108	1,509	955
	Larvae	44	18,003	396
*Dermacentor variabilis**** (American dog tick)	Adult females	37	168	444
	Adult males	28	110	437
Haemaphysalis longicornis	Adult females	0	6	0
	Nymphs	2	27	12
	Larvae	0	14	0
Miscellaneous and/or final classification pending	All Stages	0	16	11
Total		237	20,076	2,507

*Note that collection started one month earlier in 2023, and the number of collection personnel was doubled in 2022. Thus, while more ticks were collected per transect in 2023, the increase is an effect of additional effort.

**As of July 8, 2024. Tick collection is still in progress.

***Increased collections of *D. variabilis* in 2024 are largely attributable to the inclusion of a fifth field site with a higher abundance of this species.

Figure 1. Sites where ticks are collected.

Figure 3. A nymph of the invasive longhorned tick (*H. longicornis*), at approx. 45x magnification.

EVALUATING THE OPTIMAL TIMEPOINT FOR ARTIFICIAL INSEMINATION RELATIVE TO ESTRUS ONSET WHEN USING SEX-SORTED SEMEN

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INTRODUCTION

Many factors influence the pregnancy rate of artificial insemination (P/AI), including the time at which AI is performed relative to the time at which ovulation occurs (or as a proxy, the time at which expression of estrus occurred). Early research in this area, conducted by Trimberger & Davis (1943) and Trimberger (1948), determined that P/AI in dairy cattle is maximized when AI is performed during midestrus or a few hours after the end of behavioral estrus. This work led to the development of the AM-PM rule, in which cattle are bred 12-18 hours following observed estrus (Trimberger & Davis, 1943; Trimberger, 1948). More recently, research has indicated that the timing of AI impacts both fertilization rate and embryo quality (Dransfield et al., 1998; Saacke et al., 2000; Dalton et al., 2001a; Dalton et al., 2001b; Saacke, 2008). This research indicates that insemination too early relative to the time of ovulation results in high embryo quality but may reduce fertilization rates due to lower numbers of viable sperm present at the time of ovulation. Conversely, insemination too late relative to the time of ovulation results in a high fertilization rate by ensuring sufficient numbers of available sperm cells but may lead to reduced embryo quality as the oocyte ages before fertilization.

The optimal timing of insemination with sex-sorted semen may differ from conventional recommendations due to the reduced lifespan of sex-sorted sperm cells in the female reproductive tract (Maxwell et al., 2004), fewer sperm cells per insemination (DeJarnette et al., 2008), and increased incidence of precapacitation (Lu & Seidel, 2004). These factors may narrow the window of fertility with regard to the timing of insemination relative to ovulation (Sales et al., 2011; Bombardelli et al., 2016). Research in this area has explored this concept concerning the timing of ovulation and within FTAI protocols. The data obtained from these studies suggest that pregnancy rates to AI with sex-sorted semen are improved when animals are inseminated closer to the time of ovulation (Sales et al., 2011; Bombardelli et al., 2016). However, results have been mixed when delaying the timing of FTAI with sex-sorted semen until later than typically recommended when using conventional semen. Some experiments have suggested modest improvements in P/AI with sex-sorted semen when timed AI is delayed (Sales et al., 2011; Oosthuizen et al., 2021) whereas others have observed no improvement (Hall et al., 2017; Drake et al., 2020; Ketchum et al., 2021; Oosthuizen et al., 2021). The following experiments were developed with these considerations in mind, to evaluate the optimal timing of AI relative to estrus onset when using sex-sorted semen, using the CowManager system to determine the onset of estrus expression.

OBJECTIVES

1. Determine the optimal timing of artificial insemination (AI) relative to estrus onset when using sex-sorted semen following the 14 d CIDR-PG protocol in heifers and 7 & 7 Synch in cows.
2. Use data collected from this experiment to create a model to predict anticipated conception rates to AI at various fixed-time AI time points when using sex-sorted semen following a 14 d CIDR-PG in heifers and 7 & 7 Synch in cows.

PROCEDURES

Experiment 1: Among beef heifers, estrus was synchronized using the 14 d CIDR-PG protocol (Figure 1): insertion of an intravaginal progesterone-releasing insert (CIDR; 1.38 g progesterone) on Day -34 and removal on Day -20, and administration of prostaglandin $F_{2\alpha}$ (PG; 25 mg dinoprost) on Day -4. CowManager tags were inserted and the system was activated on Day -27 of the protocol to ensure adequate data collection when heifers were not in estrus. The CowManager System was used to determine if and when heifers expressed estrus following CIDR removal on Day -20 and PG administration on Day -4. Heifers were inseminated based on a split-time AI schedule, with all heifers having expressed estrus by 44 h inseminated at that time and all remaining heifers inseminated at 76 h. Heifers that failed to express estrus by 76 h were administered gonadotropin-releasing hormone (GnRH; 100 µg gonadorelin). This schedule allowed for variation in the timing of AI relative to estrus onset. All heifers that expressed estrus received sex-sorted semen, and the remaining received conventional semen collected from the same sire. Heifers were introduced to natural service sires starting 14 days after AI, and pregnancy diagnosis was performed via transrectal ultrasonography 75 days following AI.

Data collected regarding the onset of estrus relative to the timing of AI will be used to evaluate how the interval from estrus onset to AI affects conception rates to AI when using sex-sorted semen following the 14 d CIDR-PG protocol. This data will further be used to develop a model to predict conception rates to AI with sex-sorted semen based on when fixed-time or split-time AI is performed.

Experiment 2: Among beef cows, estrus was synchronized using 7 & 7 Synch (Figure 2): administration of PG (PG; 500 µg cloprostenol sodium) coincident with CIDR insertion on Day -17, gonadotropin-releasing hormone (GnRH; 100 µg gonadorelin) on Day -10, and PG coincident with CIDR removal on Day -3. CowManager tags were inserted and the system was activated on Day -17 of the protocol to ensure adequate data collection when cows are not in estrus. The CowManager System was used to determine if and when cows expressed estrus following CIDR removal and PG administration on Day -3. Cow cyclicity status was determined on D -17 by transrectal ovarian ultrasonography and based on ovarian structures present, cows were characterized as deep anestrous (no corpus luteum; CL, follicles present are less than 10 mm in diameter), superficial anestrous (no CL, follicle present that is greater than or equal to 10 mm in diameter) or cycling (CL present). Cows were blocked by cyclicity status and preassigned to receive sex-sorted or conventional semen. On Day -3, transrectal ovarian ultrasonography was performed to determine CL status and measure the largest follicle diameter (LFD). This data will be used to determine if cows that do not have a CL present at the time of PG administration express estrus earlier following PG administration and/or have reduced fertility compared to cows that have a CL present at the time of PG administration.

Data collected regarding the onset of estrus relative to the timing of AI will be used to determine an optimal timepoint for AI when using sex-sorted semen in cows following 7 & 7

Synch. This will further be used to develop a model to predict conception rates to AI with sex-sorted semen based on when fixed-time AI is performed.

RESULTS

Experiment 1**:** Estrous response of heifers treated with the 14 d CIDR-PG estrus synchronization protocol was 86% [55/64] by 76 h after PG administration. The overall pregnancy rate to AI among heifers was 64% [41/64]. Pregnancy rates to AI among heifers that received sex-sorted semen and conventional semen were 64% [34/53] and 64% [7/11], respectively.
Experiment 2: Overall estrous response of cows treated with 7 & 7 Synch was 94% [203/216] by 90 h after CIDR removal. Pregnancy rate data will be collected this summer.

RECOMMENDATIONS

Until pregnancy checks are completed, and data is analyzed, a recommendation on the optimal timing of AI based on estrus expression when using sex-sorted semen cannot be made from this research. Recommendations can be made based on previous research conducted in our lab regarding the use of sex-sorted semen.

Generally, the use of sex-sorted semen is not recommended for use in fixed-time AI protocols due to reduced pregnancy rates, especially among females who fail to express estrus. A management method used to address this challenge while maintaining the use of FTAI is limiting the use of sex-sorted semen to only cattle that express estrus by timed AI. This requires a means of determining estrous response so that all females who fail to express estrus are inseminated with conventional semen. This remains one of the most effective ways of managing the reduced P/AI associated with the use of sex-sorted semen.

Another way to improve the pregnancy rate to FTAI is to increase the proportion of females that express estrus prior to AI. Split-time artificial insemination (STAI) was developed to increase the proportion of cattle expressing estrus prior to insemination following an estrus synchronization protocol. Cattle that express estrus by the standard FTAI timepoint are serviced at that time, and insemination of non-estrous females is delayed by 20 to 24 hours. This method increases the total proportion of females expressing estrus by the time of insemination and can improve the overall pregnancy rate to synchronized estrus when using sex-sorted or conventional semen.

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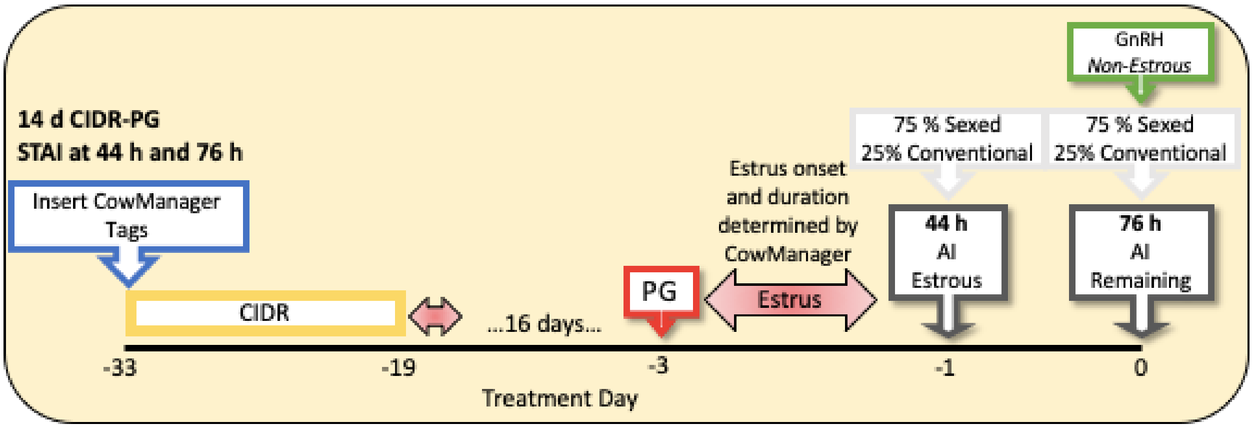

Figure 1. Experimental design for Experiment 1. Heifers were treated with the 14 d CIDR-PG estrus synchronization protocol and inseminated at 44 h or 76 h following PG administration based on the timing of expression of estrus, determined by CowManager.

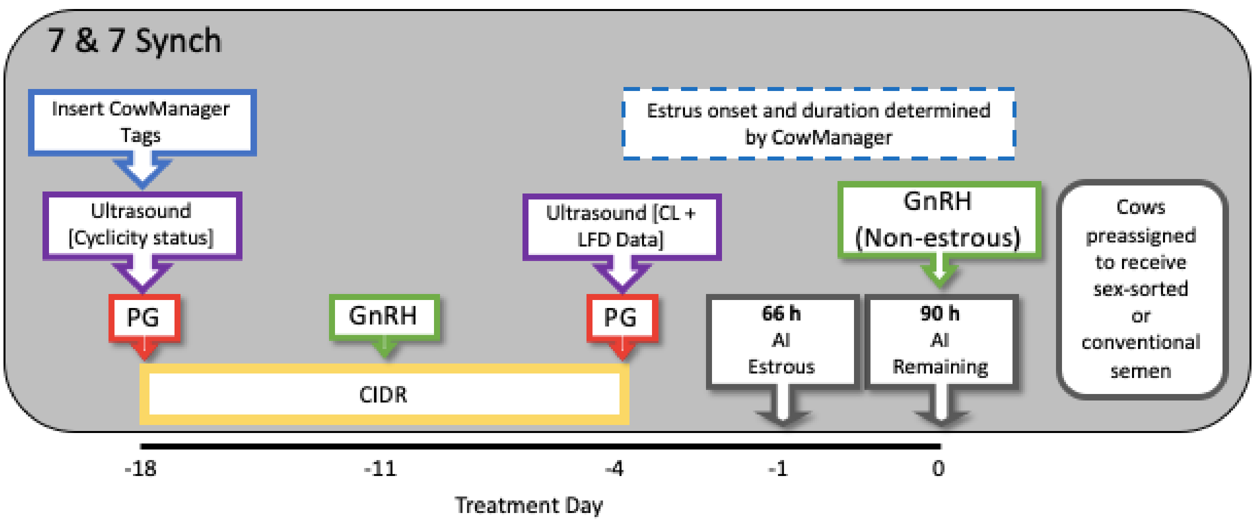

Figure 2. Experimental design for Experiment 2. Cows were treated with 7 & 7 Synch and inseminated with sex-sorted or conventional semen at 66 h or 90 h based on the timing of expression of estrus, determined by CowManager.

MISSOURI MESONET

Zachary Leasor
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INTRODUCTION

From its modest beginnings in 1992, the Missouri Mesonet has evolved from a few 3-meter-tall weather stations at University Research Centers, collecting environmental data on an hourly and daily basis, to a sophisticated network of 45 weather stations across the Show-Me State. Primary monitoring variables include temperature, relative humidity, wind speed, wind direction, solar radiation, soil temperature and rainfall. Supplemental variables include fuel moisture, leaf wetness, barometric pressure, and temperature inversion monitoring.

Missouri Mesonet is a collaborative effort among the University of Missouri Extension, the College of Agriculture, Food and Natural Resources, and the Missouri Climate Center. It provides:

- Near real-time weather (five-minute updates) and historic climate data to agriculture, energy, transportation, infrastructure, insurance, and legal sectors at the local, state, national and global levels.
- Opportunities for educational programs, teaching, research, innovation, public safety, discovery, and service to communities.

Missouri Mesonet has not only been successful in the agricultural realm, but its application has transcended numerous other vocations and interests and has become an important environmental data resource for the citizens of Missouri and beyond. In 2022 alone, Missouri Mesonet real-time web pages received over 26,000,000 hits.

In 2010, The National Oceanic and Atmospheric Administration (NOAA) implemented a multi-state project in which metadata and near real-time data were collected from various state mesonets, including the Missouri Mesonet, and used by NOAA to assess the quality of the network and improve forecasting ability. The program has since expanded and become a part of the National Mesonet Program (NMP). The Missouri Mesonet continues to be a proud partner.

For access to the Missouri Mesonet, please visit:

mesonet.missouri.edu

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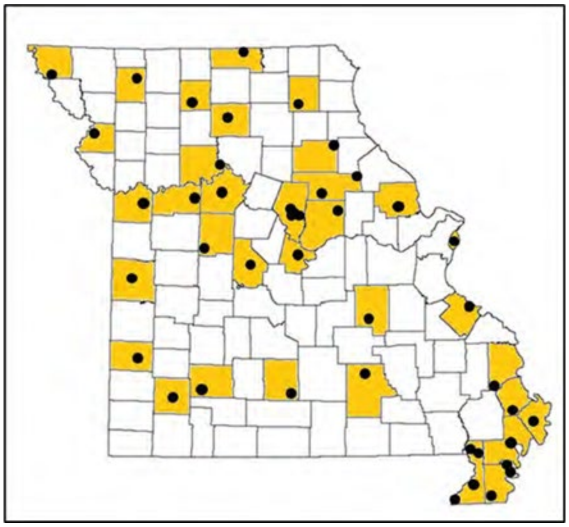
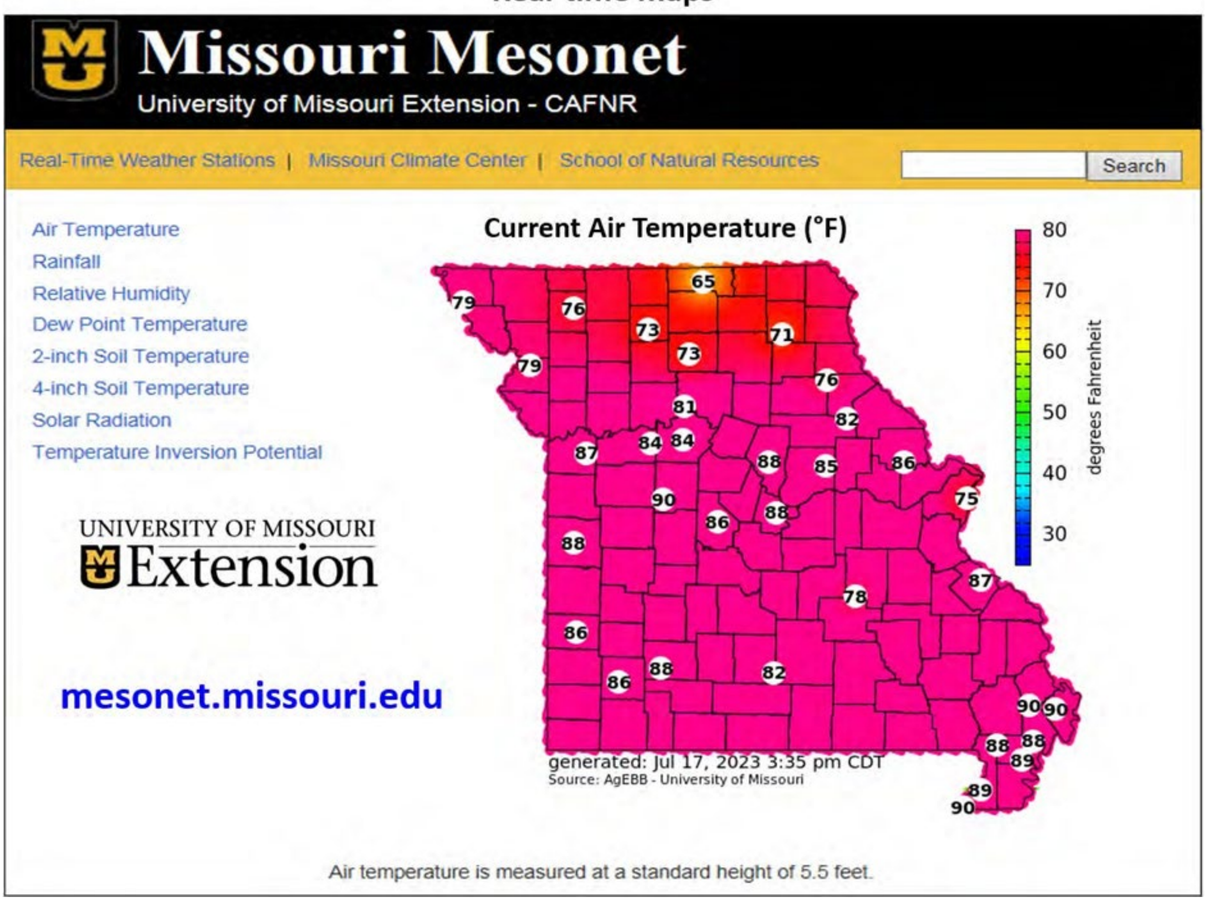


Real-time maps



WOULD YOU LIKE TO BE A VOLUNTEER WEATHER OBSERVER FOR MISSOURI? THE COCORAHS WEATHER NETWORK

Zachary Leasor
Assistant Professor

INTRODUCTION

Because of Missouri's size and topography, there is significant climatic variation within the state. Precipitation can be highly variable over short distances, especially during the summer when thunderstorm activity tends to be spotty. The hit-and-miss nature of rainfall during the growing season requires an extensive monitoring network to accurately capture precipitation patterns in the state. A large network of rain gauges across the state also provides valuable information about drought assessment, flood monitoring, prediction, research, and education.

In 2006, Missouri joined a national precipitation observation program called the Community Collaborative Rain Hail and Snow Network, or CoCoRaHS. CoCoRaHS was started in 1998 and is a grassroots volunteer network of observers who measure precipitation for their local communities. The program has been well received in Colorado and has expanded to all 50 states. As stated in their mission statement, the only requirements to join are an enthusiasm for watching and reporting weather conditions and a desire to learn more about how weather can affect and impact our lives. Additionally, to provide consistent and accurate precipitation data, all observers are required to use a particular rain gauge model, which costs $34.25 plus shipping.

Once enrolled, the weather observer is assigned a station ID and uses an interactive website to submit their observation. The website allows the observer to see their observation mapped in real-time and provides valuable information for all data users. Currently, Missouri has more than 350 regular observers participating in CoCoRaHS and data users include the National Weather Service, River Forecast Centers, Regional Climate Centers, and other stakeholders.

Participation in northeastern Missouri is not as robust as other parts of the state and we would like to increase the volume of observers for the region. If you would like to be a CoCoRaHS volunteer weather observer in northeast Missouri, please go to www.cocorahs.org for more information or contact Dr. Anthony Lupo (LupoA@missouri.edu) or one of the state coordinators for Missouri CoCoRaHS.

HORIZON POINT SITE SPECIFIC WEATHER SYSTEM

University of Missouri Extension and AgEbb

INTRODUCTION

Horizon Point is an educational program of the University of Missouri Commercial Agriculture Program that is designed to make precise weather information available to Missouri farmers in a way that assists them in managing their business. Site-specific weather reports and advisories are sent to participating farmers via quickly downloaded emails.

When farmers subscribe to Horizon Point, they provide an email address where reports are periodically sent and the precise location of their farm. The farmers also choose what advisories they want to receive and the frequency of their emailed reports.

Horizon Point is a custom weather analysis system for Missouri farmers. The weather information comes either from the National Weather Service or the Missouri Commercial Agriculture Automated Weather Station Network. The advisories process this weather information through research-based models to provide the best available, site-specific management information to farmers.

Site-specific weather information contained in Horizon Point reports include:

- Precipitation
  - Historical and Forecasted
  - Probability and Quantity
- Temperature
  - Historical and Forecasted
  - Minimum and Maximum
- Wind Forecast
  - Speed and Direction
  - 3-hour Increments

Advisories use research-based information provided by plant and animal scientists and agricultural engineers. Chosen advisories are sent only in the seasons when they are appropriate. For example, soil temperatures are important in the spring for planting and in the fall for fall-applied fertilizer management. Soil temperature advisories are not sent during the summer when they are not critical to any management decision. Current advisories available include:

- Planting Depth Soil Temperature
- Weed Scouting Aid
- Stored Grain Management Moisture Table
- Design Storm Report
- PRF Rainfall Index Monitor
- Insect Scouting Aids
- Fall Nitrogen Application Chart
- Rainfall Runoff Estimator
- Animal Comfort Indices

The emailed reports contain hyperlinks to management information such as weed seedling pictures and how to use equilibrium moisture content to maintain stored grain quality.

Horizon Point subscribers are given a secure account page where they can manage such selections as email frequency and which advisories are received. Farmers can also access archives of site-specific daily reports for the last month.

For more information about the Horizon Point system, contact us at 573-882-4827 or email us at HorizonPoint@missouri.edu

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