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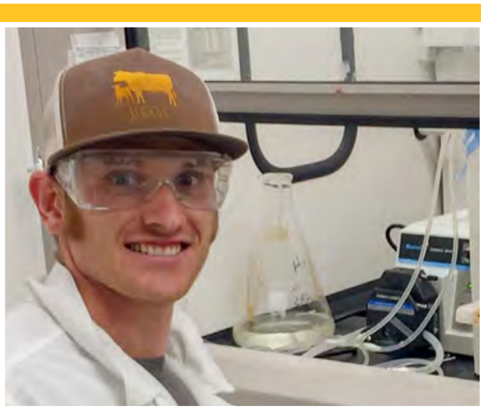
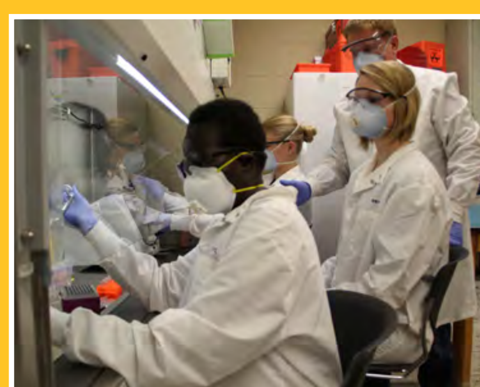
WYOMING AGRICULTURAL EXPERIMENT STATION

2018 FIELD DAYS BULLETIN





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2018 FIELD DAYS BULLETIN

WYOMING AGRICULTURAL EXPERIMENT STATION

Bret Hess, associate dean and director
John Tanaka, associate director
University of Wyoming, Dept. 3354
1000 E. University Ave.
Laramie, WY 82071-2000
contact: aes@uwyo.edu; 307-766-3667
www.uwyo.edu/uwexpstn

RESEARCH & EXTENSION CENTERS

Laramie (LREC)
Scott Lake, interim director
University of Wyoming
1174 Snowy Range Road
Laramie, WY 82070
contact: lrec@uwyo.edu; 307-766-3665
www.uwyo.edu/uwexpstn/centers/laramie

Lingle (James C. Hageman SAREC)
John Tanaka, director
2753 State Highway 157
Lingle, WY 82223-8543
contact: sarec@uwyo.edu; 307-837-2000
www.uwyo.edu/uwexpstn/centers/sarec

Powell (PREC)
Bret Hess, interim director
747 Road 9
Powell, WY 82435-9135
contact: uwprec@uwyo.edu; 307-754-2223
www.uwyo.edu/uwexpstn/centers/powell

Wyoming Seed Certification Service
Mike Moore, manager
contact: mdmoore@uwyo.edu; 307-754-9815 or 800-923-0080

UW Seed Analysis Laboratory
Pam Bridgeman, manager
contact: seed-lab@uwyo.edu; 307-754-4750

Sheridan (ShREC)
Brian Mealor, director
3401 Coffeen Ave.
Sheridan, WY 82801-9619
contact: shrec@uwyo.edu; 307-673-2856
www.uwyo.edu/uwexpstn/centers/sheridan

PREFACE

The *Field Days Bulletin* (FDB) has been published annually since 2011 by the Wyoming Agricultural Experiment Station (WAES) and its four Research and Extension (R&E) centers in Laramie, Lingle, Powell, and Sheridan. The goal is to document and make publicly available the content of ongoing and completed research projects and activities conducted or funded by WAES. This bulletin is a reflection of our commitment to document agricultural and other research at the R&E centers, at the University of Wyoming, and across the state, and these reports illustrate the diversity and breadth of the WAES research portfolio. We are devoted to making new discoveries and researching problems relevant to a wide constituency across Wyoming and the region, with the goal of helping guarantee sustainability and productivity in our state. Transferring the knowledge generated through this research is the initial step toward achieving these objectives. To that end, we are proud to present this year's *Field Days Bulletin*.

Bret Hess
Associate Dean and Director
Wyoming Agricultural Experiment Station

Editor
Robert Waggener

Project Managers
Joanne Newcomb and Robert Waggener

Layout and Design
Tanya Engel

Example of How to Cite a FDB Paper
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Contents

OFF-STATION LONG REPORTS

PREC INTRODUCTION

PREC SHORT REPORTS

PREC LONG REPORTS

SAREC INTRODUCTION

SAREC SHORT REPORTS

SARECLONG REPORTS

SHREC INTRO

SHREC SHORT REPORTS

SHREC LONG REPORTS

Introduction to the Wyoming Agricultural Experiment Station *Field Days Bulletin*

Bret Hess[1]

Introduction

Introductions in the past two editions of the Wyoming Agricultural Experiment Station (WAES) *Field Days Bulletin* mentioned historic milestones and activities celebrated by WAES. While WAES continues to enjoy the next phase of its future, it comes with announcements of the retirements, promotions to other universities, and deaths of several contributing members of our team.

Pistol and Pete's Boss Moves to Nebraska

Similar to the entire WAES team, the two-horse team of Haflingers—famously known as Pistol and Pete—were saddened by the news that their boss, Doug Zalesky, resigned his position as director of the Laramie Research and Extension Center (LREC) for a position with the University of Nebraska–Lincoln. It would be extremely difficult to argue with the suggestion that Dr. Zalesky was a great first director of LREC, having made the creation of LREC as seamless as possible. The Pistol and Pete project illustrated his commitment to serving as an ambassador for WAES, the College of Agriculture and Natural Resources, and the University of Wyoming. The University of Nebraska is fortunate to have Dr. Zalesky serve as director of its Eastern Nebraska Research and Extension (R&E) Center.

Departure of College Leaders

Professor Frank Galey announced his retirement from UW after serving for more than 16 years as dean of the College of Agriculture and Natural Resources. Dr. Galey will continue his service as executive vice president and provost at Utah State University. Our college has enjoyed tremendous support and many successes during Dean Galey's tenure. WAES and its four R&E centers will miss his support. Congratulations to Frank and very best wishes in the role of second in command at USU.

Professor Glen Whipple, associate dean and director of UW Extension, announced his retirement. Dr. Whipple has decided to enjoy a well-deserved retirement after 33 years of service, including as head of the Department of Agricultural and Applied Economics and interim dean of the then College of Agriculture. The entire WAES community appreciates the numerous contributions made by Glen, and we wish him all the best.

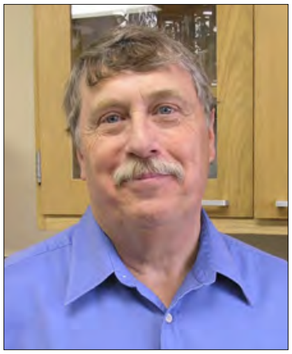
Associate Professor Bruce Cameron, head of the Department of Family and Consumer Sciences, announced he will be leaving UW for a department head position at Louisiana State University. WAES is grateful to Dr. Cameron for his contributions to WAES. Good luck Bruce, and Geaux Tigers!

Passing of Two Fellow Scientists

WAES lost two major contributing scientists this past year.

Department of Plant Sciences Assistant Professor Gustavo Sbatella, who was stationed at the Powell R&E Center, died August 2, 2017, in a motorcycle accident near Las Vegas, Nevada, while traveling to a scientific conference in California. Dr. Sbatella was dearly appreciated by those whom had the pleasure of working with him. He had a remarkable connection with the growers and industry he served. Our thoughts are extended to Gustavo's family, friends, colleagues, and students. Take care 'Boss.' More about Gustavo, including a photo, is in the Powell R&E Center introduction.

[1]*Director, Wyoming Agricultural Experiment Station.*



On March 6, 2018, Department of Animal Science Professor Stephen Paul Ford died peacefully at his home in Laramie. WAES was blessed to have a scientist of Dr. Ford's caliber as part of its team of contributing scientists. We extend our thoughts to Dr. Ford's family, friends, colleagues, and students. His dedication, talents, and service are greatly missed.

What's New?

Department of Animal Science Associate Professor Scott Lake graciously agreed to serve as interim director of LREC. Dr. Lake is rapidly learning the complexities of the center while balancing life as a faculty member. We thank Scott for stepping up, and we look forward to his leadership.

In spite of their previous boss' departure, Pistol and Pete plan to make several appearances with their new supervisor, Travis Smith. Many thanks to Travis and the team for continued efforts to represent WAES, the college, and UW across the state throughout the coming months. It is exciting to think about how such appearances will be captured in the next Pistol and Pete calendar.

Last year was one of the most well attended series of field days on recent record. We are looking forward to having audiences join us for another series of field days at R&E center locations this year: in Sheridan (Saturday, June 30), Powell (Thursday, July 19), Lingle (Wednesday, August 22), and Laramie (Saturday, August 25). Research at the four R&E centers, the UW-owned Rogers Research Site, and other locations in Wyoming are summarized in this bulletin.

Travis Smith and our famous college ambassadors, Pistol, left, and Pete.

On Tuesday, June 12, WAES is co-hosting the sixth annual Wyoming Forage Field Day at our Lingle location, the James C. Hageman Sustainable Agriculture R&E Center. More information is at www.uwyo.edu/uwe/forage-field-day/.

We are also co-hosting the Thunder Basin Research Initiative Field Day on Tuesday, August 21, in northeast Wyoming's Thunder Basin. This field day will highlight a partnership with the U.S. Department of Agriculture's Agricultural Research Service and the Thunder Basin Grasslands Prairie Ecosystem Association. For information about this event, contact UW Assistant Professor Derek Scasta at jscasta@uwyo.edu or 307-766-2337.

Acknowledgments
I wish to thank all past, present, and future employees and supporters of WAES for all the contributions over the years. Much appreciation is expressed to editors Robert Waggener and Joanne Newcomb, graphic designer Tanya Engel, as well as our R&E centers, UW Extension, UW College of Agriculture and Natural Resources, and other colleagues for continuing to make the *Field Days Bulletin* a highly professional and educational document.

Contact Information
Bret Hess at brethess@uwyo.edu or 307-766-3667.

PARP: I, II, III, IV, VI, V, VII, VIII, IX, X, XI, XII

Introduction to the Laramie Research and Extension Center

Scott Lake[1, 2]

Introduction

The Laramie Research and Extension Center (LREC) consists of the Livestock Farm west of Laramie on Highway 230, animal facilities at the Wyoming State Veterinary Laboratory, forage resources at the McGuire Ranch property northeast of Laramie, and the greenhouse complex at 30th and Harney streets in Laramie. LREC personnel (Fig. 1) and facilities provide a wide range of resources to faculty and staff members, graduate and undergraduate students, and others for teaching, research, extension, and other activities.

Sadly, we had two valued members of our team depart this year. LREC Director Doug Zalesky accepted a position as director of the University of Nebraska–Lincoln's Eastern Nebraska Research and Extension Center, located near Mead, Nebraska. Doug was an excellent director and oversaw many successful changes at LREC during his tenure here. He will be missed! Additionally, Mark Karlstrum, manager of the Cliff and Martha Hansen Livestock Teaching Arena, left UW to pursue other endeavors in St. George, Utah. We wish both of these gentlemen nothing but the best!

LREC Highlights and Accomplishments

LREC enjoyed a very successful 2017. Despite budget reductions that have been universally seen across the University of Wyoming campus, LREC continues to provide quality resources for the land grant mission, namely teaching, research, and extension activities. In addition to many of the research projects that are either finished or are ongoing, as evidenced by the number of papers in the *Field Days Bulletin*, one of the highlights continues to be the Haflinger team of horses that have become well known across the state. Pistol and Pete pull the UW College of Agriculture and Natural Resources sheep wagon through numerous parades and other events. Pistol and Pete reside at LREC, and with the help of Travis Smith and the staff at LREC we're ensured that the team makes its way across Wyoming.

The LREC **Sheep Unit** (Fig. 2) was again a very busy unit in 2017, providing animals and facilities for research projects, lab classes, outreach activities, and judging contests. The unit conducted two producer-owned ram tests (black-faced and white-faced) during 2017 and continues to collaborate with the U.S. Sheep Experiment Station (Dubois, Idaho) on feed efficiency in rams. The

Figure 1. *LREC personnel include, from left, Dave Lutterman, Landon Hoffer, Rod Rogers, Director Doug Zalesky (who accepted a position earlier this year as director of the Eastern Nebraska Research and Extension Center), Mark Karlstrum (who recently moved to Utah), Shelby Gaddis, Travis Smith, Kalli Koepke, and Ryan Pendleton.*

[1]*Interim Director, Laramie Research and Extension Center;* [2]*Department of Animal Science.*

Figure 2. *The LREC Sheep Unit provides animals and facilities for research projects, lab classes, outreach activities, and judging contests.*

sheep facility is managed by Kalli Koepke, who does an excellent job juggling the many demands of the ram tests, judging needs, research, teaching, extension, and other activities.

The LREC **greenhouse complex** is a busy facility year-round. The facility is utilized by various departments, graduate students, staff, and faculty from around the College of Agriculture and Natural Resources, UW Extension, and others. The **All-America Selections Display Garden** on campus was introduced in 2012 and continues to be a popular garden that highlights the best of the best in flowering annuals and perennials.

The LREC **Beef Unit** continues to be busy providing animals for multiple hands-on labs taught at the facility. Research continues to be in the area of feed efficiency and brisket disease (aka high-altitude disease). Brisket can lead to heart failure, and it poses most risk to cattle above 6,000 feet in elevation. Research into understanding this disease continues to be an area of emphasis (see paper titled "The effect of monensin on pulmonary arterial pressures in beef calves"). The LREC **lab animal facilities** are utilized by faculty, staff, and students in the departments of Animal Science, Veterinary Sciences, and Molecular Biology, and the Microbiology Program. The facilities house mice and rats utilized in numerous studies throughout the year.

Year in and out, the most heavily utilized LREC facility is the **Cliff and Martha Hansen Livestock Teaching Arena** and **Mary Mead Room**. Aside from being the home of the UW Rodeo Team, the facilities are also utilized by lab classes, other UW teams and organizations, and numerous groups, including 4-H clubs and FFA chapters throughout the year.

Acknowledgments
The success of accomplishing the LREC mission is totally dependent upon the quality staff and faculty at LREC, along with the support they receive from students, the management teams for each unit, and others. The entire staff and faculty work extremely hard to provide quality opportunities for students, researchers, and the general public.

Contact Information
Scott Lake at scott.lake@uwyo.edu or 307-766-3665.

PARP: I, V, VI, VIII, X, XII

The effect of monensin on pulmonary arterial pressures in beef calves

Investigators: Colby Hales, Tim Holt, and Scott Lake

Issue: Ionophores are widely used throughout the beef industry due to their ability to increase efficiency. Ionophores, including monensin, are antibiotics used to treat bacterial, fungal, and parasitic infections. There have been reports of increased heart rate and cardiac stress accompanied with the feeding of monensin, which may place cattle that are susceptible to high-altitude disease at risk, regardless of elevation (Fig. 1).

Goal: Study the effect of monensin on pulmonary arterial pressure (PAP) in beef calves fed a high-concentrate diet.

Objectives: Evaluate PAP scores in beef calves in two groups: a control (no monensin added), and the other fed a base ration combined with monensin.

Expected Impact: This study should help cattle producers and feeders further understand the potential impact of monensin on increasing susceptibility of cattle to high-altitude disease, commonly known as brisket disease.

Contact: Scott Lake at scott.lake@uwyo.edu or 307-460-8129, or Colby Hales at chales@uwyo.edu or 307-760-1315.

Keywords: monensin, brisket disease, pulmonary hypertension

PARP: V:10,13

Figure 1. *Cattle are susceptible to brisket disease at any elevation, but it is more common at higher altitudes. (Photo courtesy Robert Waggener)*

2018 All-America Selections annual and perennial flowers

Investigators: Karen Panter

Issue: All-America Selections (AAS; http://all-americaselections.org) is an international, independent, non-profit organization devoted to testing and highlighting the best of the best in flowering annuals and perennials. There are more than 70 AAS Trial Grounds plus almost 200 Display Gardens in the U.S. and Canada. The gardens at the University of Wyoming are Display (Fig. 1), and are the only AAS gardens in Wyoming.

Goal: Showcase new and improved annual and perennial flowering plants for the high-altitude Wyoming climate.

Objectives: The effect of various substrate mixes and rooting hormone concentrations on root production in goji berry hardwood cuttings will be evaluated.

Expected Impact: Test new, unsold cultivars; inform gardeners and landscapers about AAS winners; earn gardeners' and landscapers' trust in AAS winners; and determine which of the AAS selections can be successfully grown in Wyoming's climate.

Contact: Karen Panter at kpanter@uwyo.edu or 307-766-5117.

Keywords: flowers, annuals, perennials

PARP: not applicable

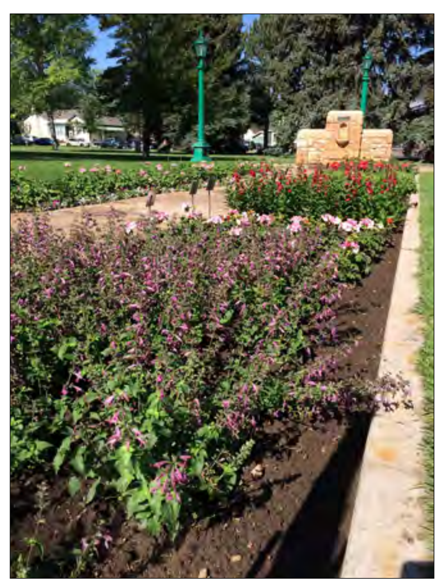


Figure 1. *There are two All-America Selections Display Gardens on the UW campus, including this one by Old Main.*

Year-round greenhouse and high tunnel specialty cut flower production

Investigators: Karen Panter

Issue: Diversification of Wyoming's economic base should include agricultural crops, including horticultural crops.

Goal: Encourage owners of greenhouses and high tunnels in Wyoming to grow specialty cut flowers for local markets.

Objectives: Demonstrate that growing fresh cut flowers is feasible in greenhouses and high tunnels, using at least five different species through 2018 and 2019 (Fig. 1).

Expected Impact: Growers and producers could adopt recommended practices and reduce production costs, diversify their operations, boost profits, and, in turn, make their operations more sustainable.

Acknowledgment: This project is funded by a grant from the Wyoming Department of Agriculture Specialty Crop Block Grant Program.

Contact: Karen Panter at kpanter@uwyo.edu or 307-766-5117.

Keywords: horticulture, cut flowers, high tunnel

PARP: I:1

Figure 1. *Flowers are grown in a high tunnel at the Laramie Research and Extension Center.*

Effects of zinc supplementation on mastitis prevalence in ewes and on lamb performance

Investigators: Whit Stewart, Dan Rule, Steve Paisley, Thomas Murphy, Bret Taylor, and Chad Page

Issue: Ewes that experience subclinical mastitis, on average, raise 19.6 to 24.6 pounds less lamb per litter than those that do not. In preliminary data, ewes that had greater serum zinc (Zn) concentrations had decreased somatic cell count in their milk, an indicator of mastitis.

Goal: Decrease prevalence and severity of mastitis, and increase lamb performance by determining optimal dietary Zn concentrations during gestation.

Objectives: Evaluate the effects of increasing Zn supplementation to pregnant ewes on mastitis and lamb performance.

Expected Impact: Supplementing Zn to ewes in pregnancy could effectively decrease prevalence of mastitis after lambing. By reducing mastitis in ewes, producers could positively affect overall lamb growth and performance in the flock.

Contact: Whit Stewart at whit.stewart@uwyo.edu or 307-766-5374.

Keywords: lamb performance, mastitis, zinc

PARP: V:10,13

Figure 1. *'Smart' feeders (those that feed automatically) at the Laramie Research and Extension Center administer zinc-fortified supplements during ewe pregnancy.*

Effects of terminal sire breed on carcass characteristics

Investigators: Whit Stewart, Warrie Means, David Notter, Bret Taylor, Bret Hess, and H. Nicole Mckibben

Issue: There are inconsistent carcass quality and yield characteristics in U.S. slaughter lambs. Utilization of terminal sire (purebred) and novel composite (hybrid) meat-producing breeds can improve efficiency of production and lamb quality, yet this needs to be evaluated prior to industry adaptation.

Goal: Evaluate breeds that produce offspring excelling in animal growth and carcass traits, thereby increasing Wyoming and U.S. lamb quality and consistency.

Objectives: Evaluate performance and lamb quality characteristics in traditional terminal sire and novel composite breeds.

Expected Impact: Determine superior breed options that will improve production efficiencies, lamb quality and consistency, and producer profitability.

Contact: Whit Stewart at whit.stewart@uwyo.edu or 307-766-5374.

Keywords: sheep breeds, carcass characteristics, growth characteristics

PARP: V:17, VIII:6

Figure 1. *Composite sheep breeds being developed for improvement of lamb quality characteristics at the Laramie Research and Extension Center.*

TRPM8 Signaling in the Ram Brain: Putative Testosterone Receptor

Robert Ziegler[1], Kathleen Austin[1], and Brenda Alexander[1]

Introduction

Testosterone traditionally signals through an intracellular mechanism and changes gene transcription, a process that takes time. A novel signal mechanism has been identified allowing a way to rapidly respond to testosterone. This mechanism is through TRPM8 channels (TRPM8 is short for transient receptor potential cation channel subfamily M member 8). This study was designed to have a better understanding of TRPM8 in the brains of sheep. Earlier research has identified the TRPM8 channels in the male prostate and the brain; however, the function of this channel is not clear. As a testosterone receptor, TRPM8 channels may be important in male reproductive tissues with implication for the expression of reproductive behavior.

Objectives

The objective of this study was to quantify TRPM8 channels in areas of the brain known to be important for reproductive performance of the ram.

Materials and Methods

Sexual activity of rams was determined by individually exposing rams to two or three ewes in estrus for 20 minutes. Rams mounting ewes within 10 minutes, achieving ≥six ejaculations in 20 minutes, and exclusively mounting females are considered high-performing, female-oriented rams. Rams failing to exhibit sexual interest toward stimulus animals, having a long latency (>10 minutes) to mount, or achieving ≤three ejaculations are considered to be low-performing or sexually inactive.

Rams were isolated from ewes, but had visual and olfactory contact with each other. Individual pens prevented physical contact. On the day of tissue collection, rams were exposed to isolated olfactory cues of estrus for one hour. This was accomplished by saturating cotton pads with urine from estrous ewes, and then inserting those pads in facemasks that were placed on the rams. After this procedure, rams were anesthetized and killed, with brains collected and preserved.

TRPM8 activity was determined in the amygdala (an area of the brain important for determining the biological significance of sensory signals) using immunocytochemistry. Cells staining positive for TRPM8 were quantified.

Results and Discussion

The amygdala has a direct connection with the olfactory bulb (the neural structure necessary for the sense of smell), but is also important in complex sensory processing. The biological significance of sensory stimuli is extracted at the level of the amygdala. The amygdala sits in the juncture between the sensory stimulus and the execution of behavior. Stimuli in an animal's environment would be relayed through the amygdala, which would then signal an appropriate response (e.g., flee vs. move closer).

The amygdala is composed of several interconnected nuclei that allow for integration of sensory stimuli. Of the amygdala nuclei, previous research identified differences in neural signaling among sexually active and inactive rams in the central nuclei. In humans, the central nucleus is required for the sense of fear. Although it may be difficult to ascribe a "sense of fear" to sheep, "fear" should be considered as a heightened sense of awareness. Increased arousal toward non-specific stimuli would be advantageous in the identification of receptive females.

Although the expression of the TRPM8 channel was similar among high and low sexually performing rams, a distinct pattern of expression was observed among the different areas of the amygdala. The central nuclei had the most robust expression of TRPM8 channels (Fig. 1), which have been shown to be a testosterone receptor. High concentrations of testosterone decrease the expression of those channels. Since testosterone is known to be important in the regulation of fear and anxiety, it is possible that the TRPM8 channels in the central nucleus of the amygdala are downregulated in males, causing a greater fear tolerance.

Expression of the TRPM8 channels in the medial and cortical nuclei of the amygdala was sparse (Fig. 1). Rams rely heavily on their sense of smell to determine when a ewe is receptive to breeding, and the medial area is important for the processing of odors. The cortical area is important for the formation of certain emotional or social memories. This area of the amygdala would be responsible

[1]*Department of Animal Science*

in forming the memory of ewes the ram has bred, so he moves on to the next ewe, increasing the number of his offspring. This area would perhaps also help recognize the significance of a predator. Numbers of TRPM8 channels in these areas were low and did not differ among high- or low-performing rams, so the TRPM8 channels in these areas are unlikely to be important for the processing of olfactory cues or social memory in the ram.

The Alexander lab is continually striving to identify the biological cause of sexual disinterest. Approximately 30% of the ram population has low sexual interest and, in turn, sire disproportionally fewer lambs than their high-performing cohorts, affecting genetic progress in the flock. Although the expression of TRPM8 channels in the ram's central amygdala may not be important for the expression of sexual behavior per se, it may be important for the integration of sensory signals and impact the interpretation of those signals. Additionally, expression of these channels may be more important in the detection of predators and the response to that threat.

Acknowledgments
This study was supported, in part, by U.S. Department of Agriculture Hatch funds.

Contact Information
Brenda Alexander at balex@uwyo.edu or 307-766-6278.

Keywords: sheep, neural signaling, reproductive performance

PARP: V:12

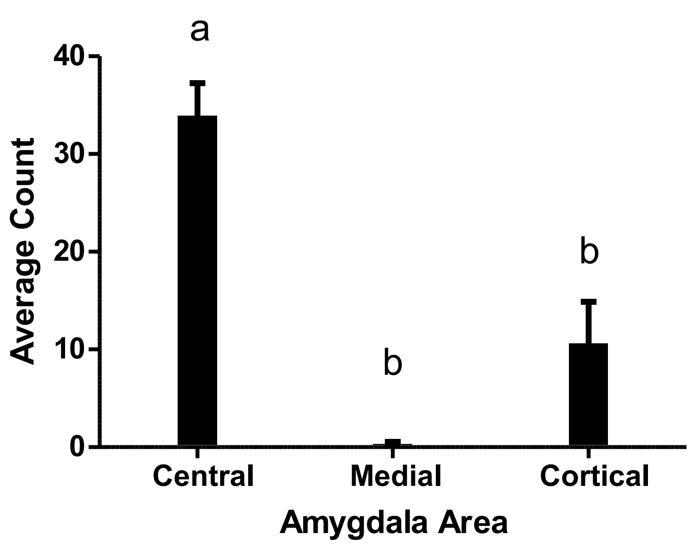


Figure 1. *Average count of TRPM8 channels in the central, medial, and cortical nucleus of the amygdala in the ram. Areas with different subscripts differ (p<0.001).*

RNA-Binding Protein RBM20 Regulates Skeletal Muscle Regeneration

Maimaiti Rexiati[1], Mingming Sun[1], and Wei Guo[1]

Introduction

Skeletal muscle injuries are extremely common during sporting events and other activities, and impaired muscle function or increased risk of recurring injury can occur following recovery. Skeletal muscle is highly adaptable tissue that can regenerate new muscle fibers after damage by injury or disease. Muscle stem cells and other cell types in skeletal muscle orchestrate the regeneration process. The first step of regeneration is associated with acute inflammation, degeneration, and removal of the damaged muscle, which is subsequently replaced by newly regenerated muscle tissue. A protein called ribonucleic acid-binding motif protein 20 (RBM20) is highly expressed in heart and skeletal muscles. RBM20 binds ribonucleic acid (RNA) and is responsible for RNA processing, but the role of RBM20 in skeletal muscle injury and regeneration is unknown.

Objectives

In this study, we evaluated whether RBM20 regulates skeletal muscle regeneration in rat muscle following an injury.

Materials and Methods

We used 9-week-old rats to study the skeletal muscle regeneration process. We injured the rat hind limb muscle tissue with an injection of chemical reagents, following University of Wyoming animal care and use policies. After this procedure, hind limb muscles were harvested at 18 hours and again at 3, 5, 7, 14, and 30 days post-injury to analyze the injured muscle tissues (Fig. 1).

Results and Discussion

Our observation indicated that muscle mass and the regenerating muscle fiber (cell) numbers were not significantly different between control and test group animals during the entire process of regeneration. The muscle fibers, however, were significantly smaller and grew slower in the test group compared to the control, indicating a delayed regeneration process in the injured muscle tissues. Additionally, we observed higher levels of fibrotic tissues in our test group, indicating damaged tissue could not be efficiently replaced with newly formed muscle fibers. We also observed that proteins essential for skeletal muscle regeneration were expressed less in the test group. We did not observe any differences in the muscle microstructure assembly process between the control and test groups. The fiber maturation process, however, was significantly delayed in the test group.

Our completed study indicates that RBM20 is essential for skeletal muscle regeneration. Without RBM20, the skeletal muscle regeneration process is delayed and injured muscle cannot efficiently substitute damaged tissues with newly formed muscle fibers. In the future, more work could be done to develop therapeutic agents that could target RBM20 to accelerate injured muscle regeneration and healing.

Acknowledgments

This work was supported by the U.S. Department of Agriculture's National Institute of Food and Agriculture, National Institutes of Health's IDeA Networks of Biomedical Research Excellence, American Heart Association's Beginning Grant-in-Aid program, and University of Wyoming's Faculty Grant-in-Aid program.

Contact Information

Wei Guo at wguo3@uwyo.edu or 307-766-3429.

Keywords: muscle injury, RNA-binding protein, skeletal muscle regeneration

PARP: not applicable

[1]*Department of of Animal Science*

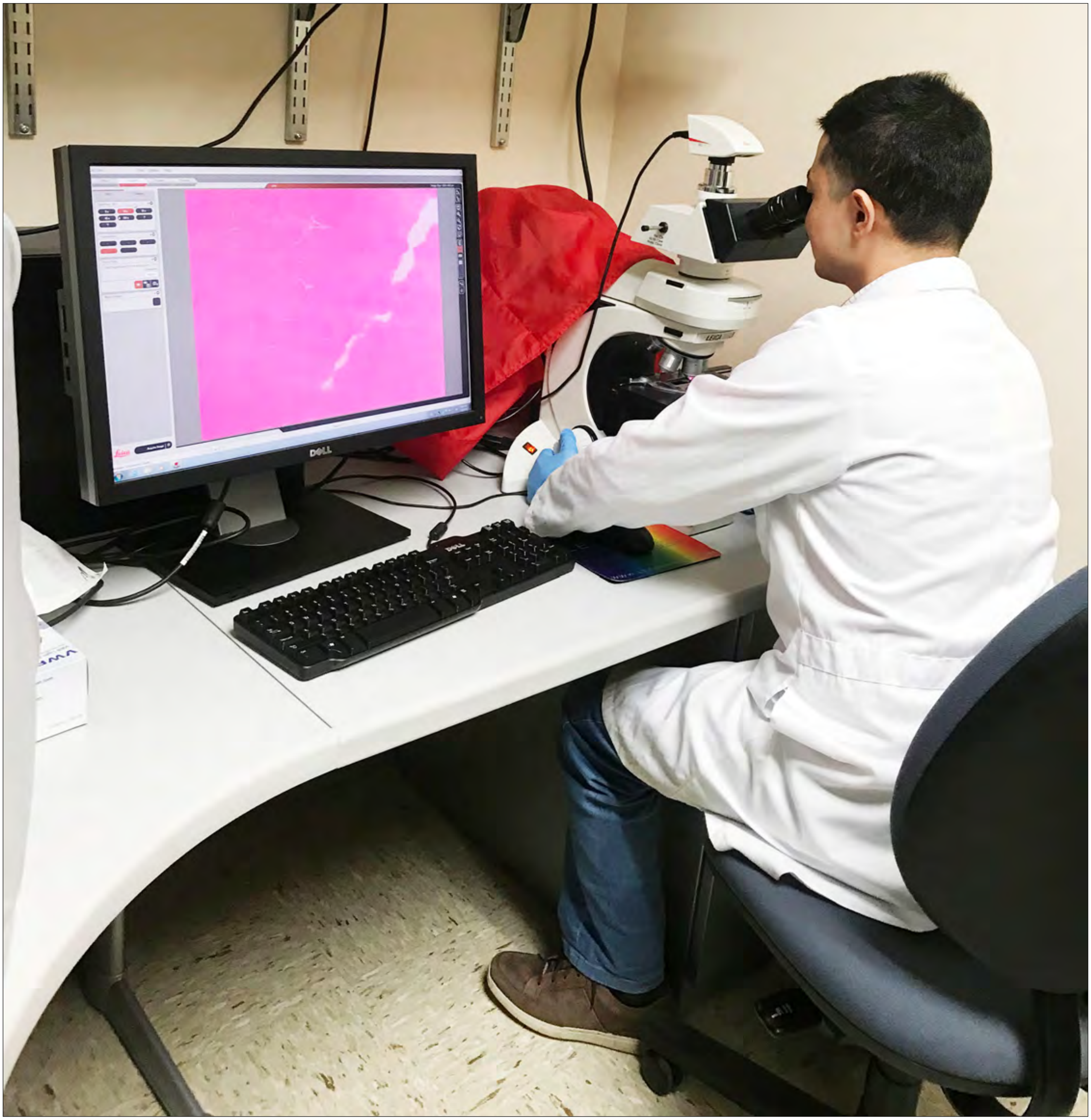


Figure 1. *Maimaiti Rexiati, a graduate student in Assistant Professor Wei Guo's lab, performs morphological analysis on injured rat muscle sections.*

RNA Binding Protein RBM20 Regulates Gene Network Associated with Heart Muscle Contraction

Wei Guo[1,2], Chaoqun Zhu[1,2], Qiurong Wang[1,2], Mingming Sun[1,2], and Marion Greaser[3]

Introduction
Ribonucleic acid-binding motif protein 20 (RBM20) is highly expressed in skeletal and heart muscles, notably the heart. RBM20 deficiency can lead to heart muscle disease known as dilated cardiomyopathy (DCM), a leading cause of heart failure and a significant source of mortality and morbidity worldwide. RBM20 helps regulate gene splicing, a process in which one gene encodes for several proteins with similar functions. Given the role of RBM20 in the regulation of gene splicing, the identification of its downstream RNAs (ribonucleic acids) would shed light on human heart failure progression and provide strategies for molecular therapy. With these efforts, more than 30 downstream RNAs of RBM20 have been identified including a major titin RNA, a gene expressed in heart muscle for muscle contractile function; however, it is unknown whether RBM20 also regulates gene expression levels or changes in the heart.

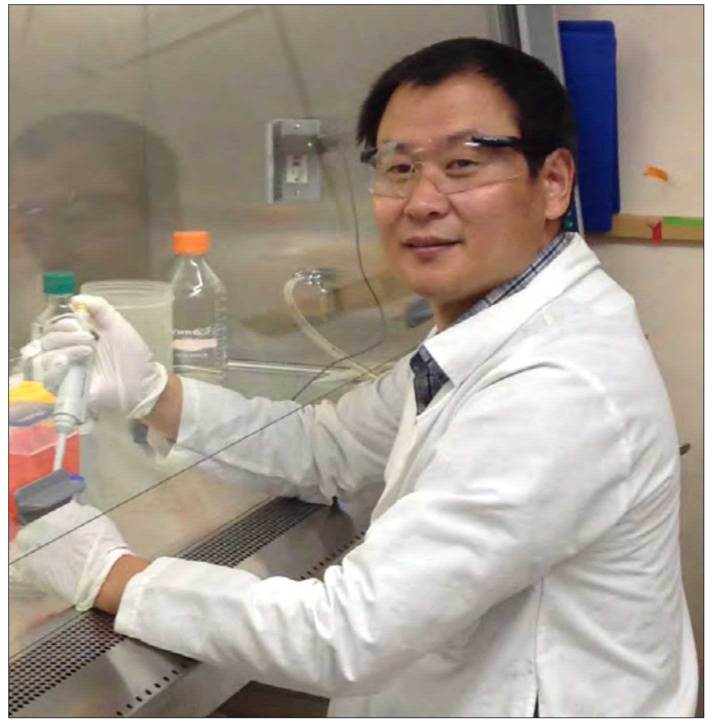


Figure 1. *Assistant Professor Wei Guo's research focus is muscle structure, muscle function, and fetal programming.*

Objectives
The objectives of this study are to investigate the expression level of how many and what genes are regulated by RBM20 in the heart muscle.

Materials and Methods
We used rats as animal models for our research. They were maintained on standard rodent feed using protocols approved by the University of Wyoming and University of Wisconsin–Madison animal use and care committees. Hearts were obtained from animals that were one, 20, and 49 days old after the animals were euthanized. The left chambers were dissected and used for this study because of their functional importance of pumping blood to peripheral tissues. RNAs and individual muscle cells were isolated from the heart tissues for gene expression and muscle cell contractile measurements (Fig. 1).

Results and Discussion
We compared gene expression in heart muscle from the rats with RBM20 expression (wild-type) and the rats without RBM20 (RBM20 knockout). We found that fewer genes are regulated by RBM20 at a younger age when compared to older ages. The expression level of about 90% of the regulated genes is increased. We also found that the upregulated genes are associated with heart failure. The proteins encoded by these upregulated genes can bind to a protein titin, a major muscle protein that can cause heart failure with changed expression level. Particularly, we revealed that RBM20 changes calcium levels in heart muscle and results in abnormal muscle contraction. These results suggest that RBM20 is important in regulating muscle gene expression, and its deficiency leads to increased gene expression in day 49 when compared to days one and 20, and, ultimately, heart failure.

Heart failure is a serious condition, and usually there is no cure. These patients normally have a weakened heart that cannot supply the body with enough blood, leading to fatigue and shortness of breath. In late stages of the disease, heart failure often leads to death. Our results provide new insights into the role of RBM20 in the progression of heart failure and novel therapeutic targets for molecular therapy; however, further study is needed to

[1]*Department of Animal Science;* [2]*Center for the Study of Fetal Programming;* [3]*University of Wisconsin–Madison.*

address the detailed mechanisms of how heart failure can be reversed by targeting RBM20.

Acknowledgments

This study was supported by the National Institutes of Health's IDeA Networks of Biomedical Research Excellence, Wyoming Agricultural Experiment Station, U.S. Department of Agriculture's National Institute of Food and Agriculture, and American Heart Association.

Contact Information

Wei Guo at wguo3@uwyo.edu or 307-766-3429.

Keywords: heart muscle disease, heart failure, gene expression

PARP: not applicable

Molecular Basis of Maternal Obesity-Induced Fetal Cardiac Contractile Dysfunction

Qiurong Wang[1,2], Stephen Ford[1,2], Peter Nathanielsz[1,2], Jun Ren[3], and Wei Guo[1,2]

Introduction

Obesity is an exponentially increasing public health and economic issue worldwide. Currently, 18–35% of pregnant women in the U.S. are obese. Epidemiological studies suggest that maternal obesity (MO), or over-nutrition during pregnancy, is associated with increased risk of heart disease. It has been shown that maternal nutrition plays an important role in fetal heart development and function. Animal studies show that MO could lead to morphological changes to the fetal heart, among them increased heart chamber weights and thickness from mid- to late-gestation. Despite these morphological changes, MO fetal heart function was impaired under stress conditions; however, it remains unclear how the molecular and cellular mechanisms lead to the impaired fetal heart function.

Objectives

The objective of this study is to examine how maternal obesity (MO) changes fetal heart muscle cell contraction.

Materials and Methods

From 60 days before and throughout pregnancy, Rambouillet/Columbia-crossed ewes were fed either 100% of National Research Council (NRC) recommendations (control, n=5) or 150% of NRC recommendations (MO, n=5). At the 135th day of gestation (approximately two weeks before the full term of sheep pregnancy), fetuses were obtained via caesarean section from ewes. The fetuses and ewes were euthanized under anesthesia following University of Wyoming animal use and care policies. The fetal hearts were quickly removed, and the individual heart muscle cells were isolated. The mechanical properties of contraction were assessed on isolated muscle cells (e.g., how much do cells contract, and how long does it take for each contraction?). Additionally, protein was extracted from fetal heart tissue to examine the expression levels of the molecules.

Results and Discussion

We assessed the contraction ability on isolated fetal heart muscle cells and found that muscle cells from fetuses of obese mothers had decreased contraction. In contracting heart muscle cells, the time for an individual cell to contract to its shortest possible length takes longer from MO fetal hearts than from the control. Also, the cells from MO fetal hearts do not contract as well as the control, as the overall change in length per contraction is lower. Meanwhile, we also found that calcium (an important ion in the cells that controls the contraction of muscle cells) was also altered in the MO fetal hearts. Further, we looked into the molecular signaling controlling the calcium levels in the muscle cells. The regulation of calcium levels in the cells is accomplished by releasing and taking back calcium from and to the calcium reservoir. There are two pumps on the calcium reservoir: a ‘releasing pump’ that pumps calcium out of the reservoir into the cells, and an ‘uptaking pump’ that pumps calcium into the reservoir. We revealed that MO changed the releasing pump, but not the one that uptakes, leading to excessive calcium in the muscle cells.

We also studied the molecules related to muscle contraction (Fig. 1). Our results showed that the molecules related to fast-speed contraction were reduced in the MO fetal heart while the molecules related to slow-speed contraction increased, which could be a possible explanation to the slower and less contraction of the muscle cells. Additionally, MO altered the protein complex, which senses the calcium level in the cells and passes the signal to the contraction unit in the muscle cells. These findings help us understand the mechanism of why the MO fetal heart is less sensitive to calcium, which, in turn, leads to weaker contractions.

These results suggest that maternal obesity alters calcium levels in offspring heart muscle cells and changes contraction-related proteins—both of which contribute to the fetus having compromised heart contractions. Further study is needed to reveal more detailed mechanisms and discover possible interventions to correct adverse effects of MO on the fetal heart.

Acknowledgments

This study was supported by the National Institutes of Health’s IDeA Networks of Biomedical Research Excellence, Wyoming Agricultural Experiment Station, U.S. Department of Agriculture’s National Institute of Food and Agriculture, and American Heart Association.

[1]*Department of Animal Science;* [2]*Center for the Study of Fetal Programming;* [3]*School of Pharmacy.*

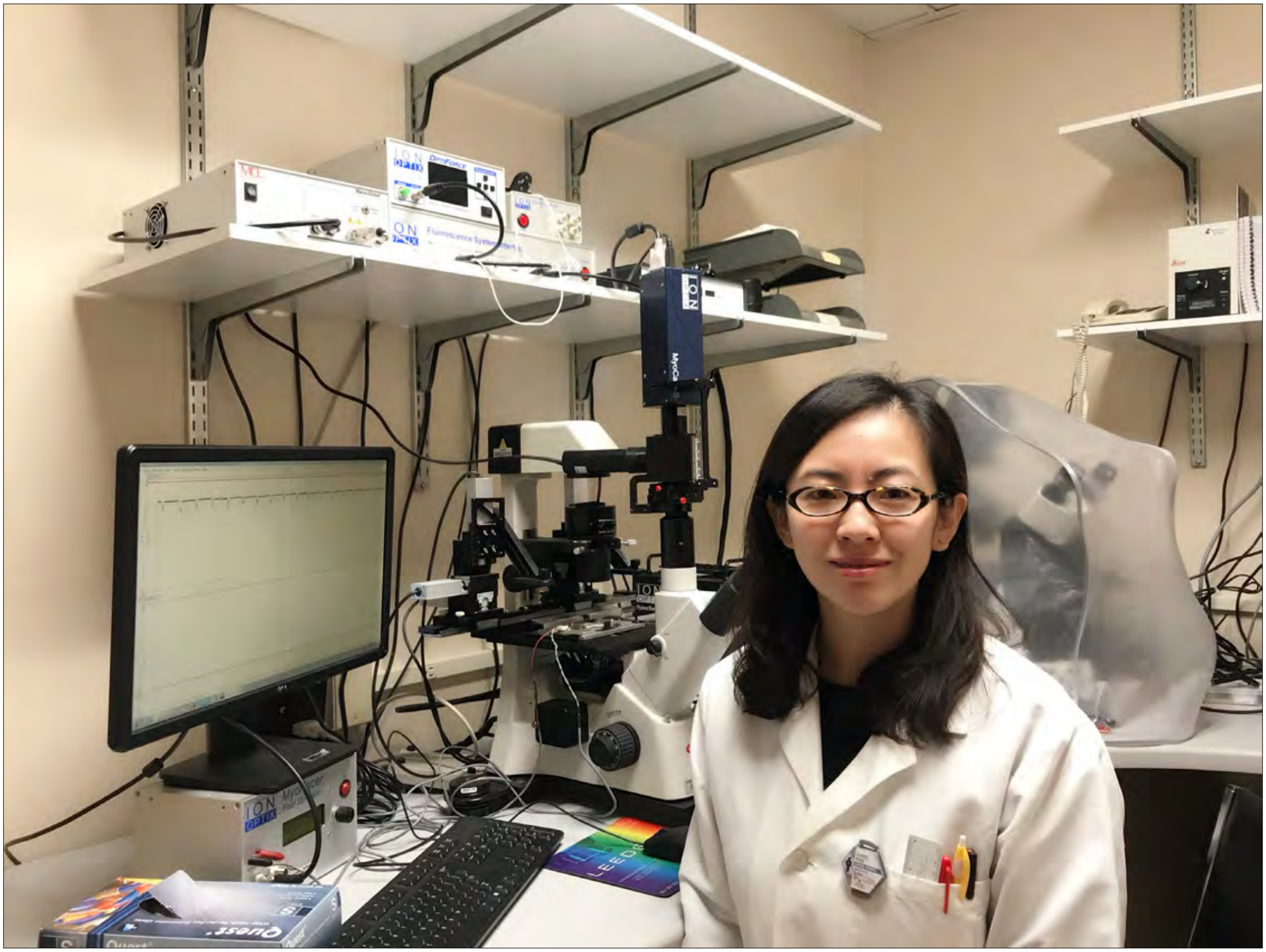


Figure 1. *Qiurong Wang is a postdoctoral fellow working on fetal programming in Assistant Professor Wei Guo's lab.*

Contact Information
Wei Guo at wguo3@uwyo.edu or 307-766-3429.

Keywords: maternal obesity, cardiovascular disease, fetal heart function

PARP: not applicable

Effect of Maternal Influence on Calf Feed Efficiency

Kelly Carpenter[1], Hannah Cunningham[1], Kathleen Austin[1], and Scott Lake[1]

Introduction

According to some cattle market experts, more pounds of beef will be produced in 2018 than any other time in U.S. history. Several factors are responsible for this record amount of production, and one is the current low price of feed. Despite this, fees associated with growing and purchasing feed over time can account for 70% of the input costs for livestock producers in Wyoming and other western states. For the cow/calf producer, selecting females based on heritable efficiency traits will positively affect future generations of the herd and, ultimately, the producer's bottom line. Feed efficiency in cattle can be attributed to the population of microorganisms (or microbiome) of the rumen. The microbiome is thought to be established at birth and to adapt through weaning. Influence on the establishment of the rumen microbiome and traits associated with it are increasing in importance for cattle producers.

Objectives

Objectives of our 60-day trial were to assess feed efficiency associated with birth and calf-rearing methods of weaned Charolais and Angus calves. We want to emphasize that the intent of this analysis was to assess feed efficiency of the two individual breeds, not to make comparisons between the breeds.

Materials and Methods

The trial was established in spring 2017 at the Laramie Research and Extension Center (LREC). Two groups of calves—one consisting of 30 Charolais and one consisting of 16 Angus—were the subjects. The Charolais group was divided into the following treatments: bottle group calves born vaginally and raised on calf milk replacer; control treatment calves born vaginally and nursed on their own mother; and caesarian-section treatment calves born by C-section and reared nursing on their own mother (Table 1). The Angus group was also divided into three treatments (Table 2). The bottle and control treatments were the same as the Charolais. Concerning the C-section treatment, too few Angus pairs survived until the beginning of this trial, so another treatment was established in its place, a probiotic treatment, in which calves were born vaginally and received probiotic paste within 24 hours of birth. The probiotic paste is similar to human probiotic supplements and encourages a healthy balance of gut bacteria. Duration of the test was 60 days on a high-concentrate GrowSafe diet.

Results and Discussion

Tables 1 and 2 display the age of calf, start weight, end weight, weight per day of age, and residual feed intake (RFI) for each treatment. It is important to understand the RFI index number each treatment reports. The treatments with negative RFI values are the most efficient, while calves with positive RFI values are less efficient. Table 1 shows the treatments for the Charolais calves (control, bottle, and C-section), while Table 2 shows the treatments for the Angus calves (control, bottle, and probiotic).

Because there is a difference in age of calves at the beginning of the study, data are also presented as weight per day of age. Angus calves fed the probiotic at weaning had greater efficiency when compared to the control calves. Bottle-fed calves did not differ between either breed. There was no difference in feed efficiency within the Charolais calves; however, due to a difference in age, start weight, and ending weight, the control calves were heavier when compared with the bottle-fed calves. This data is important for cattle producers in understanding the potential role of rumen microorganisms and maternal influence in cattle feed efficiency. This is an emerging area of interest in animal science with increasing importance to producers as they select cattle for their herds.

The variation in age, weight per day of age, and RFI encouraged us to follow this set of calves past weaning and explore possible efficiency differences as yearlings with a subsequent feed efficiency trial. This trial was repeated at the James C. Hageman Sustainable Agriculture Research and Extension Center to further examine breed and treatment group differences in fall 2017. We anticipate releasing findings from this study in the 2019 *Field Days Bulletin*.

Acknowledgments

We thank the LREC crew for their help with this project.

Contact Information

Kelly Carpenter at kthomp@uwyo.edu or 307-766-2224.

Keywords: feed efficiency, residual feed intake, microbiome

PARP: V:1,7

[1]*Department of of Animal Science*

Table 1. Charolais calves as influenced by different birth and rearing method treatments.

	Bottle	Control	C-Section[1]	Standard Error	*P*-Value
Age (days)	329.8a	339.0b	322.56ab	2.62	0.0003
Start Wt (lb)	638.7ab	752.0b	667.33a	24.59	0.0043
End Wt (lb)	780.7ab	900.27b	815.33a	28.04	0.009
Weight/day of age[2]	2.08a	2.3864b	2.2422ab	0.05	0.0257
RFI	0.1418	0.044	-.083	0.619	0.9657

Note: Charolais calves in the feed efficiency trial had different methods of birth (vaginal or caesarian section) and different rearing methods.
[1]C-Section=caesarian section
[2]Weight per day of age

Table 2. Angus calves as influenced by different rearing method treatments.

	Bottle	Control	Probiotic[1]	Standard Error	*P*-Value
Age (days)	324.57a	319.0b	290.75ab	8.08	0.0153
Start Wt (lb)	642.29	731.2	626.5	46.7	0.2040
End Wt (lb)	795.57	865.0	763.75	51.89	0.3420
Weight/day of age[2]	2.2071	2.432	2.3775	2.96	0.4189
RFI	0.5291a,b	2.722a	-0.35b	1.46	0.034

Note: Angus calves in the feed efficiency trial were all born vaginally.
[1]Probiotic is the group of calves given ruminant probiotic paste at intervals after birth
[2]Weight per day of age

2017 Fresh Cut Flower Production: Completion Report

Karen Panter[1]

Introduction

Locally grown edible horticultural crops are in demand; there are also reasons to produce ornamental crops locally. The latter can help greenhouse operators, producers, and others diversify their operations, and this, in turn, can provide additional jobs and strengthen local economies. Also, many cut flowers are grown in other countries and flown to the U.S., leaving large carbon footprints. We pursued a series of studies to determine production strategies for local fresh cut flowers. We have already successfully grown and flowered several cultivars of fresh cut sunflowers and have broadened the plant possibilities. Our goal was to develop production strategies for several species of annual cut flowers for commercial production in Wyoming greenhouses and high tunnels.

Objectives

The purposes of this project were to grow globe amaranth (*Gomphrena*), cockscomb (*Celosia*), red amaranth (*Amaranthus*), cornflower (*Centaurea*), and marigold (*Calendula*) for cut flower use and to determine which of these flowers can be successfully grown for Wyoming's markets.

Materials and Methods

Five species of annual cut flowers were grown: *Gomphrena* 'Ping Pong Mix', *Calendula* 'Princess Golden' (Fig. 1), *Centaurea* 'Classic Artist Mix', *Celosia* 'Celway Mix', and *Amaranthus caudatus* 'Red'. Seeds of each were sown March 16, 2017, in a Laramie Research and Extension Center (LREC) greenhouse. After emergence seedlings were transplanted into 1,004 cell packs (dates varied). Plants were then planted into #1 pots and placed in a LREC greenhouse and high tunnels May 26, 2017, at 12-inch spacings. All plants were fertilized three times weekly with 15-5-15 cal-mag (calcium, magnesium, and other nutrients) at 100 parts per million liquid feed and were hand-watered. Data were taken on days to harvest from seed sowing, each stem's length, and number of stems cut per plant for four months. Data were also taken from the greenhouse, the north and south sections of the east- to west-oriented high tunnel, and the east and west sections of the north- to south-oriented high tunnel.

Results and Discussion

Days to harvest from seed sowing varied by species and location where grown (Fig. 2). *Gomphrena* took between 135 and 140 days, *Calendula* from 134 to 139 days, *Centaurea* from 103 to 140 days, *Celosia* from 138 to 144 days, and *Amaranthus* from 122 to 129 days.

Stem lengths also varied by species and location (Fig. 3). For all five species, stems were longest when grown in the greenhouse. *Gomphrena* were very short, from

Figure 1. *Calendula 'Princess Golden' in the greenhouse.*

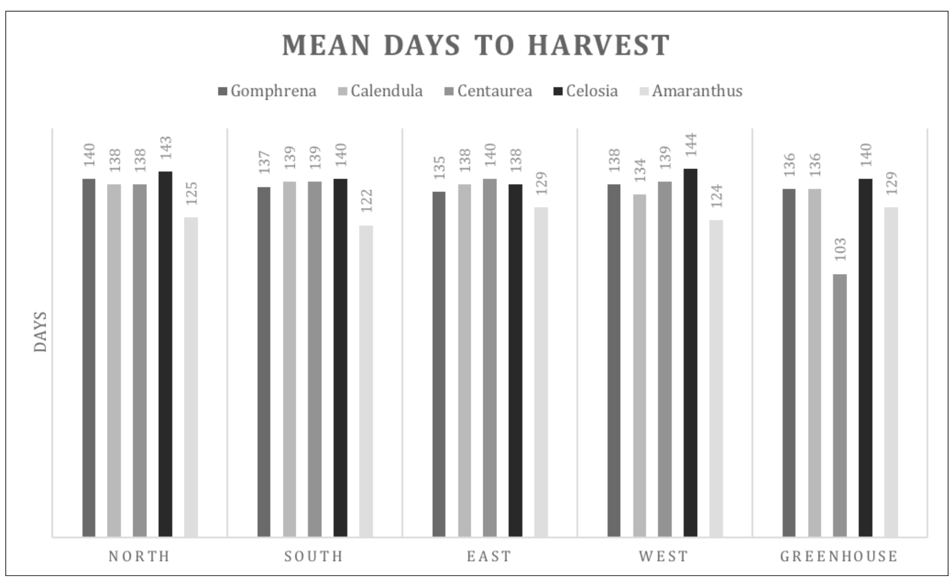


Figure 2. *Mean days from seed sowing to harvest of fresh cut flower stems of Gomphrena, Calendula, Centaurea, Celosia, and Amaranthus.*

[1]*Department of Plant Sciences*

3.8 to 4.8 inches. *Calendula* ranged from 12.0 to 14.2 inches. *Centaurea* were the longest stems ranging from 13.4 to 16.7 inches. *Celosia* stems were between 8.4 and 11.2 inches. *Amaranthus* were also short, ranging from 2.8 to 4.3 inches.

Yields per square foot for four months for *Gomphrena* were 9.3 to 12.9, for *Calendula* 14.1 to 15.8, for *Celosia* 3.3 to 14.7, and for *Amaranthus* 17.9 to 25.1. Few *Centaurea* in the greenhouse survived due to virus problems so ranged from 1.8 to 27.5 (Fig. 4).

Due to virus problems, *Centaurea* was not viewed as a viable cut flower crop when grown in the greenhouse; however, they did produce successfully in the two high tunnels. Two of the other species, *Gomphrena* and *Amaranthus*, are not recommended due to short stems. The last two species, *Calendula* and *Celosia*, produced substantial numbers of stems along with sufficient stem lengths. They are suitable for greenhouse and high tunnel production and will be grown in future cut flower studies.

Acknowledgments
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Contact Information
Karen Panter at kpanter@uwyo.edu or 307-766-5117.

Keywords: annuals, specialty cut flowers, floriculture

PARP: I:1

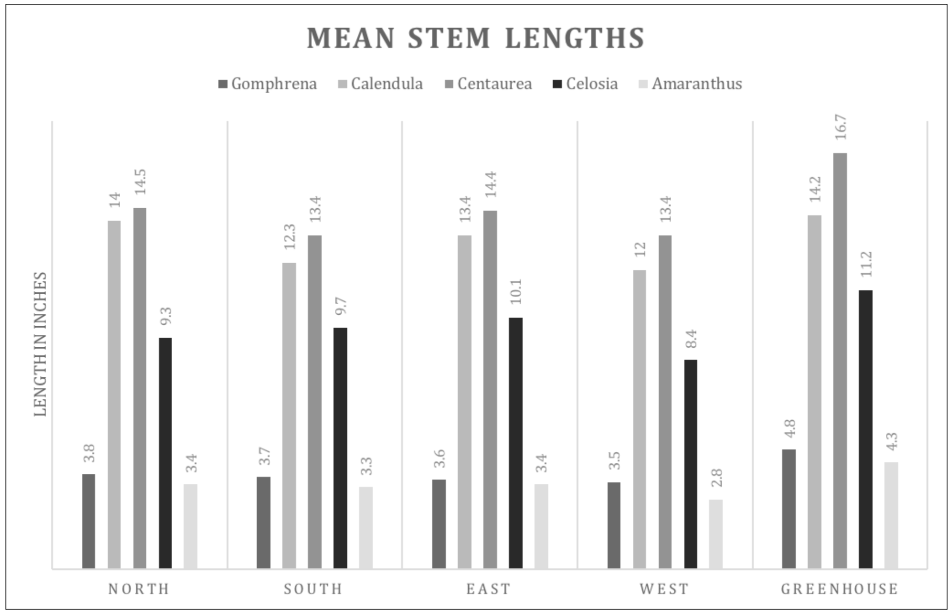

Figure 3. *Mean stem lengths in inches of fresh cut flower stems of Gomphrena, Calendula, Centaurea, Celosia, and Amaranthus.*

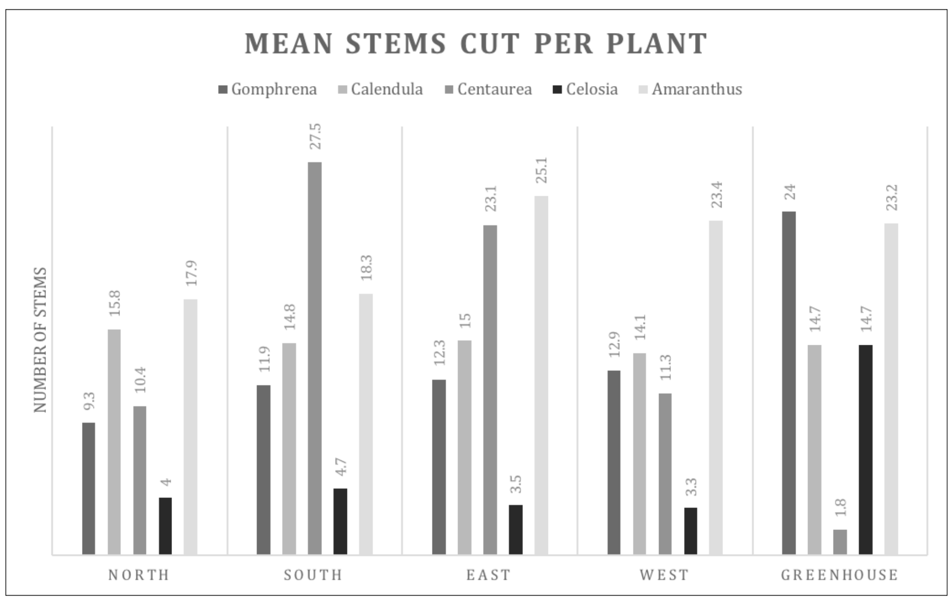

Figure 4. *Mean number of stems cut per plant of fresh cut flowers Gomphrena, Calendula, Centaurea, Celosia, and Amaranthus.*

Pronghorn Antelope Short-Term Response to a Dormant-Season Wildfire in a High-Elevation Steppe Rangeland

Derek Scasta[1]

Introduction

Fire is a natural ecological process on rangelands and can alter distribution of free-roaming livestock and wildlife. The post-fire mechanism that alters distribution of these animals is through a series of negative and positive feedbacks associated with forage and browse quality and quantity. In the case of animals being drawn to recently burned areas, the mechanism is the positive attraction to the palatable and high-quality forage and browse that regenerates after fires. While studies reporting positive attraction of cattle, big game, and other large wildlife species are well reported, there is less information in the published literature about native browsing species such as pronghorn antelope (*Antilocapra americana*). Researchers with the U.S. Department of Agriculture (USDA) Agricultural Research Service reported in 2015 that antelope were attracted to spring burned areas in the shortgrass steppe of Colorado, especially in winter. In the Colorado study, antelope density was 26 times greater in winter and seven times greater in spring. This fire–antelope interaction, however, has not been quantified in higher and colder steppe environments such as the mixed-grass prairie of southeast Wyoming.

Objectives

Our objective was to quantify short-term response of antelope to a burned area in southeastern Wyoming.

Materials and Methods

A wildfire burned February 17, 2017, approximately five miles west of Laramie. The fire burned on both sides of Highway 130, but the majority (>95%) burned on the south side of the highway on Laramie Research and Extension Center (LREC) property. We used direct visual counting in driving surveys of antelope in the approximate 80-acre burned area on LREC property and the surrounding unburned areas consisting of ~800 ac. Counting was initiated April 7, 2017, or 49 days after

Figure 1. *Antelope in the burned area April 12, 2017, just shy of two months following the fire.*

[1]*Department of Ecosystem Science and Management.*

the fire and relative to the beginning of spring-like weather and active plant growth. Surveys were conducted on the following dates: April 7, 11, 15, 19, 25, and 28; May 7, 12, 16, and 30; and June 5, 12. The 12 surveys were conducted to determine pronghorn attraction and occupancy of the burned and unburned areas. The burned and unburned areas assessed in this study were dominated by greasewood (*Sarcobatus vermiculatus*), inland saltgrass (*Distichlis spicata*), and alkali sacaton (*Sporobolus airoides*) with a minor component of western wheatgrass (*Pascopyrum smithii*) and blue grama (*Bouteloua gracilis*).

Results and Discussion

Antelope were observed actively grazing/browsing in the burned area early in the study (Fig. 1). The proportion of antelope in the burned area relative to the total number of antelope observed was greater the first seven sampling dates and lower the last four sampling dates (Fig. 2). This greater proportion of antelope in the burned area suggests an early level of attraction during early spring, but a diminishing attraction in early summer (Fig. 3). When stratified by early and late, antelope use was significantly higher early and significantly lower later (Fig. 4). Thus, burned areas known to attract cattle may also attract native species such as ungulates.

Acknowledgments

This project was supported in part by a USDA National Institute of Food and Agriculture McIntire-Stennis project grant.

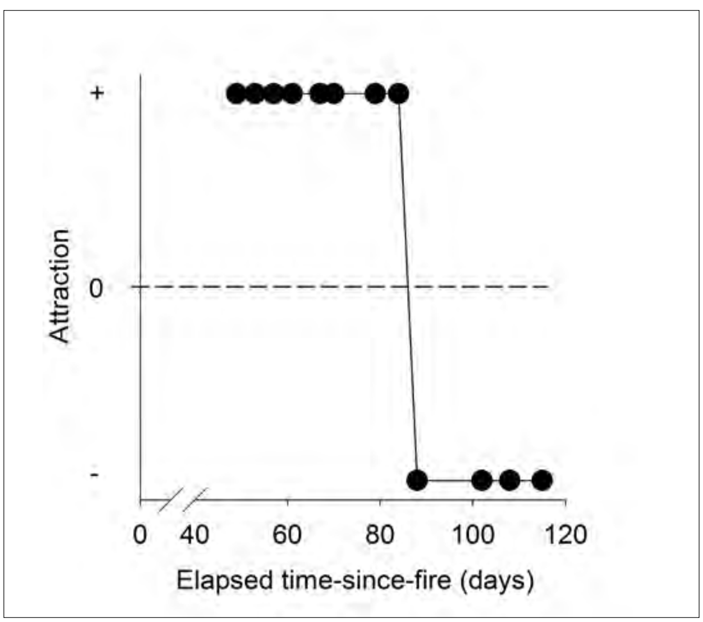

Figure 3. *Attraction to the burned area relative to time-since-fire was higher during early spring, and diminished into summer.*

Contact Information

John Derek Scasta at jscasta@uwyo.edu or 307-766-2337.

Keywords: pronghorn antelope, wildfire, fire-grazing interaction

PARP: XII:1,2

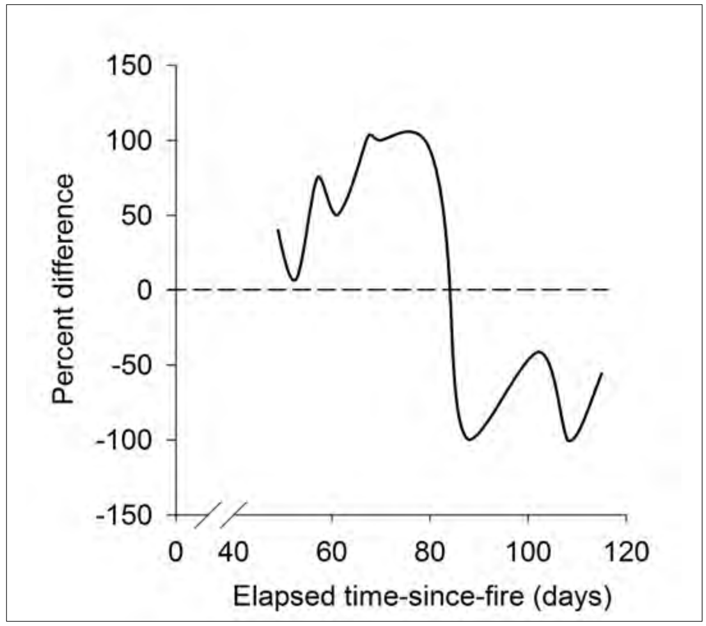

Figure 2. *Proportion of antelope in the burned area relative to the total number of antelope observed was greater initially, but then declined as spring progressed into summer.*

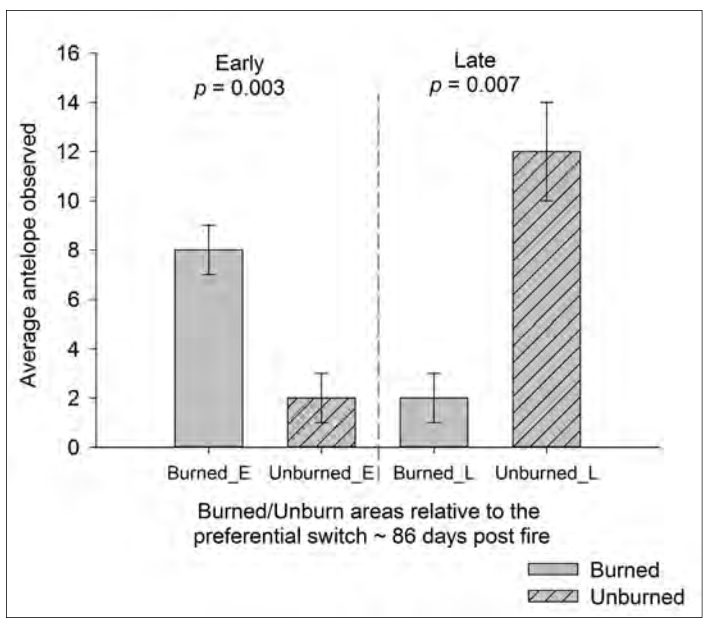

Figure 4. *When stratified by early and late, antelope use was significantly higher early and significantly lower later.*

Canopy and Soil-Surface Fire Temperatures During Small-Plot Burns in a Saline-Greasewood Ecological Site

Derek Scasta[1]

Introduction

Fire is a common occurrence on western rangelands. In Wyoming, there are many areas with saline soils and warm-season grasses such as alkali sacaton (*Sporobolus airoides*), inland saltgrass (*Distichlis spicata*), and greasewood (*Sarcobatus vermiculatus*). The resprouting nature of greasewood combined with the ability of perennial grasses to respond to fire in general are preliminary indications that these ecological sites may be adapted to fire. But the role of fire in terms of frequency, intensity, and seasonality in saline-greasewood ecological sites is largely unknown, particularly in areas with greater herbaceous biomass production due to landscape position and subsurface water dynamics. In addition, the use of fire to control greasewood may reduce the shrub dominance and enhance forage.

Objectives

Our objectives were to quantify canopy and soil-surface fire temperatures during four small-plot burns in a saline-greasewood ecological site.

Materials and Methods

In spring 2017, undergraduate and graduate students in the University of Wyoming applied fire ecology course (REWM 4440/5440) conducted a field experiment using 10-foot-square burn boxes at the Laramie Research and Extension Center (LREC) west of Laramie (Fig. 1). To measure fire temperatures and create fire temperature profiles over time, we used two type K thermocouples and a Logitech recording device. Thermocouples were placed at two positions within the fuel complex: one at the soil surface and one within the plant canopies, 14 inches above the surface. Fires were conducted using a ring-fire technique by igniting one corner of the box and then carrying fire around all four sides until returning to the original ignition point. The ignition source was a drip torch with a mixture of 50% gasoline and 50% diesel. Fires were conducted within 'safe' weather conditions, with temperatures from 46 to 52°F, wind speeds from 3.3 to 10.3 miles per hour, and relative humidity from 21.6 to 26.2%. We first graphed fire temperature relative to time of the duration of the burn. We assessed the maximum temperature measured at each thermocouple and then calculated the difference between the two maximum temperatures at each thermocouple to determine delta (ΔT_{max}).

Results and Discussion

Soil surface maximum temperatures ranged from 150°F to 511°F, with a mean of 316 ± 77°F. Canopy temperatures ranged from 238°F to 891°F, with a mean of 551 ± 138°F (Figs. 2a–d). ΔT_{max} ranged from 88°F to 638°F, with a mean of 236 ± 134°F. Thus, the temperature at the soil surface was <50% than it was within the fuel complex canopy. These fires were similar to low-fuel-load prescribed fires (~750°F; Weir and Scasta, 2014). Understanding potential maximum fire temperatures, and the difference between fire temperatures at the soil surface and the canopy of the fuel complex, is important for understanding plant and soil responses. Future studies could assess greasewood response to fire, and the use of fire as a feasible option to control greasewood without sacrificing forage and soil quality. It's our plan to start these studies in 2019.

Acknowledgments

Appreciation is extended to the students who assisted. This project was supported in part by a U.S. Department of Agriculture-National Institute of Food and Agriculture McIntire-Stennis project grant.

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Contact Information

Derek Scasta at jscasta@uwyo.edu or 307-766-2337.

Keywords: fire ecology, fire temperatures, greasewood

PARP: VI:11, X:1

[1]*Department of Ecosystem Science and Management.*

Figure 1. *UW students started fires in burn boxes to quantify canopy and soil-surface fire temperatures in a saline-greasewood ecological site in southeast Wyoming.*

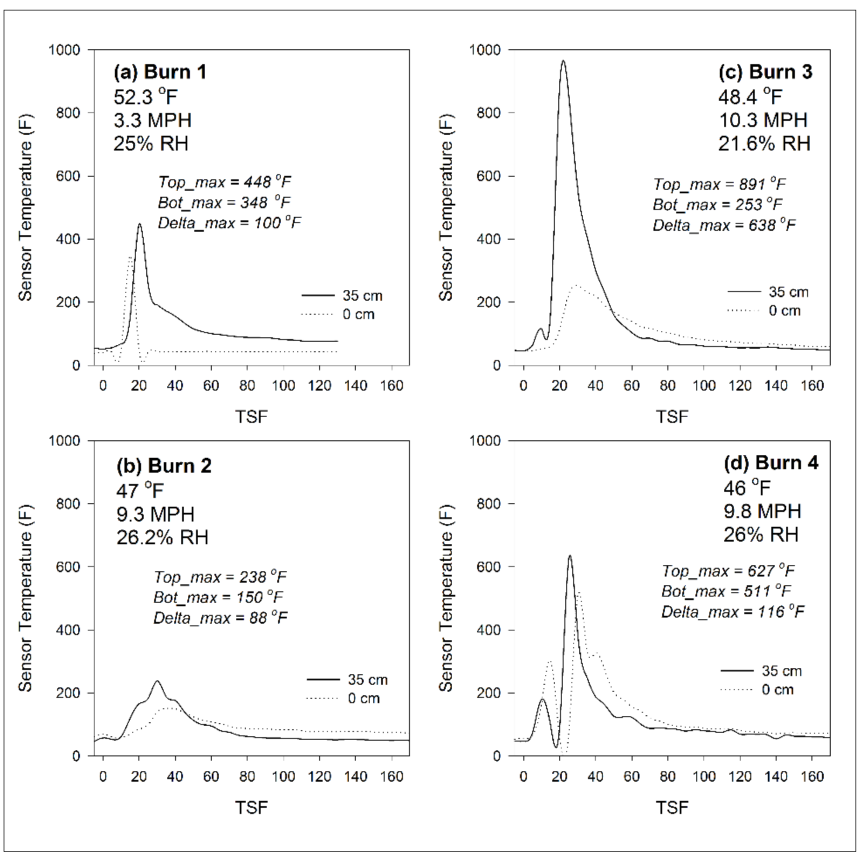

Figure 2. *Fire weather and fire temperatures at two locations in the fuel complex for four (a–d) small-plot fires in a saline-greasewood complex. Notes: °F, MPH, and RH indicate air temperatures, wind speeds, and relative humidity, respectively; 'top max' and 'bot max' indicate maximum canopy and surface temperatures, respectively, during the fires; 35 cm=14 inches); TSF=time since fire.*

Quantifying Short-Term Soil Biological and Vegetation Feedback from High-Intensity, Short-Duration Grazing Versus Conventional Grazing

Emily Bean[1] and Linda van Diepen[1]

Introduction

Debate over best grazing management has remained volatile and inconclusive for decades. Many studies have examined long-term effects of grazing management on soil and vegetation parameters, but few have monitored effects of grazing on the soil microbiological community. In addition, scientific literature presents conflicting information on the effect of animal impact on soil microbial biomass, diversity, and function. Though soil microorganisms are known to be important in all ecosystems as they are drivers of critical biogeochemical processes, e.g., carbon (C) and nitrogen (N) cycling, only recently has soil biodiversity been recognized as an important parameter of quantifying soil health for a variety of environmental, agricultural, and human health benefits; therefore, it is critical to understand how agricultural systems impact soil microbial diversity. This study addresses that knowledge gap by quantifying soil microbial and biogeochemical responses immediately following grazing and linking plant–soil–microbe interactions by integrating immediate changes in vegetation growth.

Objectives

(1) Does the soil microbial community change after grazing, and is this response different immediately after disturbance compared to longer term? (2) Does vegetation recover at different rates depending on the severity of defoliation? (3) Is there a detectable correlation between changes in soil microbial community structure, biogeochemical cycling, and vegetation recovery following disturbance?

Materials and Methods

In summer 2017, a grazing trial was implemented at the Laramie Research and Extension Center (LREC). Twelve adjacent 1/2-acre paddocks were grazed according to three treatments in a randomized complete block design: a high-intensity, short-duration treatment (HI), a low-intensity, medium-duration treatment (LO), and a no-grazing control (NG) (Fig. 1). Vegetation and soil samples were taken one week before grazing (baseline data), and 24 hours, one week, and four weeks after grazing. Microbial functional diversity was quantified by extracellular enzyme assays, which detect the activity of C, N, and phosphorus (P) cycling enzymes. Microbial biomass was measured using chloroform-fumigation incubation, and biogeochemical parameters included dissolved organic C and N, and mineral N. Vegetation biomass and recovery were monitored with a rising plate pasture meter, a manual device that uses a large metal plate to measure the density of vegetation, which, in turn, allows the user to determine forage biomass. This method is non-destructive to pasture forage so accurate measurements can be taken before and during intensive grazing.

Results and Discussion

Prelimanary results indicate that microbial biomass C differed significantly between the grazing treatments (HI and LO) and the NG control. Extracellular enzymatic activity per unit of microbial biomass C was significantly different between the grazing treatments and the control for the lignolytic (enzymes that degrade lignin) and P cycling enzymes. Microorganisms release extracellular enzymes into the soil, where they degrade organic matter and perform important nutrient-cycling functions. Measures of extracellular enzymatic activity can be used as a proxy for soil microbial activity—and an indirect glimpse of soil health. Dissolved organic N differed between the LO and the HI grazing treatments, and between the HI treatment and the control. Vegetation recovery (the growth of vegetation over time following grazing) was higher in the HI grazing treatment than both the LO treatment and control.

These results indicate that grazing may have an immediate effect—detectable after 24 hours following grazing—on soil nutrient availability and soil microbial activity, and that vegetation recovers faster following high-intensity, short-duration grazing compared to low-intensity, medium-duration grazing. These results also suggest that grazing management can have an immediate effect on soil biological parameters, which could impact producer management for short-term soil restoration goals. The

[1]*Department of Ecosystem Science and Management.*

Figure 1. *Grazing trial in action at LREC.*

grazing trials will continue in summer 2018 with a release of new data expected in the 2019 *Field Days Bulletin*.

Acknowledgments
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Contact Information
Linda van Diepen at linda.vandiepen@uwyo.edu or 307-766-2781.

Keywords: grazing management, cattle, soil microbial community

PARP: I:15, VI:5,6

Using progesterone as a management tool in captive male livestock

Investigators: Brenda Alexander, Kathleen Austin, John Blake, Andrea Cupp, Jan Rowell, Milan Shipka, and Robert Ziegler

Issue: Reindeer bucks are difficult to manage and can be dangerous to handlers during the rutting period. Progesterone agonists have been used anecdotally in the field to favorably influence buck behavior, but influence on reproductive signaling and semen production has not been determined.

Goal: University of Wyoming researchers (Fig. 1), in collaboration with the University of Alaska Fairbanks and University of Nebraska–Lincoln, are working to determine the feasibility of utilizing progesterone as a management tool in farmed reindeer.

Objectives: Evaluate the effect of progesterone on semen production and neural signaling in areas of the brain important for the expression of reproductive behavior in males.

Expected Impact: Although progesterone has been used as a management tool in captive reindeer, its influence on reproductive performance has not been evaluated. If it is determined that use of progesterone agonists does not negatively impact reproductive performance, agonists could be adopted in Wyoming and other states for use in the management of male farm and ranch animals where handler safety is a concern, e.g., farm-raised reindeer bucks, dairy and bison bulls, as well as the occasional ornery beef bull.

Contact: Brenda Alexander at balex@uwyo.edu or 307-766-6278.

Keywords: progesterone, bull management, animal behavior

PARP: not applicable

Figure 1. *University of Wyoming undergraduate student Rob Ziegler is among those working on the reindeer project.*

Genomic research and prediction technologies for beef cattle: where are the economics?

Investigators: Christopher Bastian, Timur Ibragimov, Kristi Hansen, Steve Paisley, Bridger Feuz, and Nicole Ballenger

Issue: Commercially available genomic prediction technologies, stemming from public investments in beef genomics research, may have potential to increase the economic returns from these value-adding production strategies.

Goal: Study the benefits and their distribution in the beef cattle industry stemming from the use of beef genomics to increase feed efficiency.

Objectives: Estimate the economic benefits of using beef genomics to select for increased feed efficiency in beef cattle.

Expected Impact: Results should improve understanding and communication of the potential economic effects of genomic prediction technologies aimed at increasing feed efficiency in beef cattle. Better understanding of potential benefits can assist cow-calf (Fig. 1) and feedlot operations in Wyoming and other states in determining if using beef genomics testing regarding feed efficiency is economically beneficial.

Contact: Chris Bastian at bastian@uwyo.edu or 307-766-4377.

Keywords: beef cattle, beef genomics research, genomic prediction technologies

PARP: V:1,7,8, VII:6, VIII:1,6, IX:1

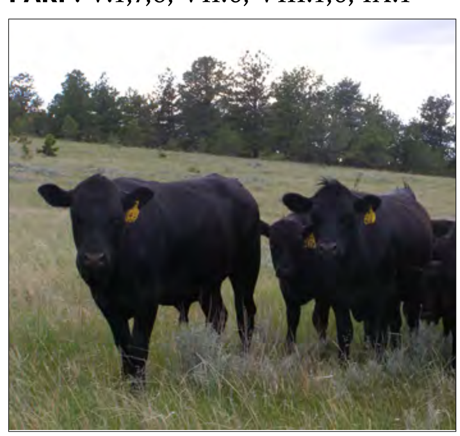

Figure 1. *Research by a University of Wyoming team could help cow-calf and feedlot operators determine if using beef genomics testing regarding feed efficiency is economically beneficial. (Photo courtesy Robert Waggener)*

Implementing a novel molecular assay in Uganda for brucellosis control

Investigators: Brant Schumaker, Ashley Smith, Noah Hull, Stella Atim, Callie Klinghagen, Sierra Amundson, and Meagan Soehn

Issue: Cattle brucellosis has been eradicated from the U.S. except for within the Greater Yellowstone Area of Wyoming, Idaho, and Montana. The African country of Uganda continuously faces loss of livestock and human illness due to brucellosis, as within-herd prevalence of this infectious disease exceeds 50% in domestic herds. Current diagnostics for brucellosis are non-ideal for the detection of infected animals within a herd. The high prevalence of disease in East Africa provides an opportunity to test our laboratory's new molecular assay for the disease.

Goal: Provide brucellosis diagnostic training to a Borlaug Fellowship Program recipient from Uganda, followed by a reciprocal visit to aid and assess the application of novel molecular techniques within the Ugandan Ministry of Agriculture, Animal Industry, and Fisheries diagnostic laboratories.

Objectives: Train a Ugandan fellowship recipient on infectious disease surveillance, detection, and diagnosis for the purpose of designing, evaluating, monitoring, and implementing brucellosis control strategies in Uganda.

Expected Impact: This project should elucidate the epidemiology of brucellosis in Uganda to identify drivers of infection within livestock populations. Identification of these drivers will help the Ugandan government make strides toward brucellosis control to reduce spillover events into livestock and human populations.

Contact: Brant Schumaker at bschumak@uwyo.edu or 307-766-9970.

Keywords: brucellosis, novel diagnostics, cattle

PARP: V:12,13

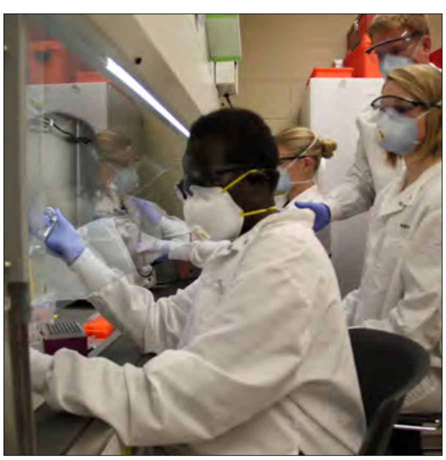

Figure 1. *Associate Professor Brant Schumaker (standing) works with Stella Atim, Ashley Smith, and Sierra Amundson (front to back) on brucellosis diagnostic test development.*

Quantifying the economic impact of excessively fat lambs in the Wyoming and U.S. lamb processing sector

Investigators: Whit Stewart, Warrie Means, and John Ritten

Issue: Recent industry-wide evaluations have identified the critical challenge that over-fat lambs pose to the industry, attributable to the seasonality of production in the Wyoming and U.S. sheep industry, but have not to date quantified these losses within the packing sectors.

Goal: Provide the Wyoming and U.S. sheep industry a quantitative assessment of what over-fat lamb is costing the meat processing sector as a basis for future assessments across other sheep industry sectors.

Objectives: Collect carcass measurements to estimate quantity and distribution of yield grades; determine fat losses in cutout data, combined labor hours, and other inputs related to trimming and disposing of fat; and use economic modeling to determine industry costs and projected improvements.

Expected Impact: The 'fat lamb project' has the potential to provide processing plant-level data creating widespread economic benefit to the Wyoming and U.S. sheep industry and all related stakeholders along with continuing momentum toward improving the quality and consistency of lamb produced in our state and country.

Contact: Whit Stewart at whit.stewart@uwyo.edu or 307-766-5374.

Keywords: over-fat lambs, lamb processing sector, lamb meat seasonality

PARP: V:16,17

The ranch economics of greater sage-grouse conservation practices

Investigators: John Tanaka, John Ritten, Kristie Maczko, Anna Maher, Nicolas Quintana Ashwell, Holly Dyer, Thomas Hilken, Holly Kirkpatrick, and Kendall Roberts

Issue: The Natural Resources Conservation Service (NRCS) has been promoting a number of ranching practices (e.g., prescribed grazing) to preserve or improve habitat for the greater sage-grouse (*Centrocercus urophasianus*), a candidate for listing under the Endangered Species Act until 2015. These ranching practices have associated costs, benefits, and incentives, which, until now, have not been thoroughly analyzed for their economic merits at the ranch level. Among the incentives are payments through the NRCS Environmental Quality Incentives Program (EQIP).

Goal: Assess the economic impact of the adoption of a set of conservation practices on four representative types of cow-calf ranching operations in at least nine major land resource areas. (MLRAs are geographically associated land resource units across the U.S. MLRA 34A, for example, generally covers much of the desert and plains of southern Wyoming, an important area for sage grouse. To learn more about MLRAs and the specific MLRAs in Wyoming, put NRCS and "Major Land Resource Area" in your Internet search engine.)

Objectives: Evaluate NRCS-promoted conservation practices in terms of their effects on cow-calf operations, forage supply, and ranch performance indicators by ranch type in each of the targeted MLRAs.

Expected Impact: Enterprise budgets developed in cooperation with university extension educators and validated by ranchers in the geographic areas of interest should assist ranchers in benchmarking their performance in the use of different forage sources and other inputs. Results from ranch economic optimization models should inform policy- and decision-makers with respect to the impact these policies would likely have on ranching operations across rangelands in Wyoming and the West.

Contact: John Tanaka at jtanaka@uwyo.edu or 307-766-5130.

Keywords: sage grouse, prescribed grazing, EQIP incentives

PARP: V:7, VI:3, VII:2,4,6,7, IX:1,3,6,7

Antimicrobial Resistant *E. coli* from European Starlings in Concentrated Animal Feeding Operations

Jennifer Anders[1], Jeff Chandler[1,2], James Carlson[2], Jeff LeJeune[3], Lawrence Goodridge[4], Baolin Wang[1], Leslie Day[5], Anna Mangan[2], Dustin Reid[2], Shannon Coleman[6], and Bledar Bisha[1]

Introduction

The use of antibiotics in animal agriculture for disease prevention, therapy, and growth promotion is generally recognized to be linked to increased antimicrobial resistance (AMR) in associated bacterial communities. A complex microbial ecology exists at the interface of livestock, with numerous inputs and outputs that contribute to AMR in these systems. Of particular interest, wildlife found in association with animal production facilities have been shown to harbor gut bacteria that have similar types of AMR to bacteria present in livestock. As a result, these wildlife species are potential reservoirs and reintroduce AMR into livestock production, and through their normal movement and migratory patterns they can spread AMR bacteria on local-to-global spatial scales.

Bird species that are in frequent contact with livestock production may play the most important role in the dissemination and propagation of AMR of any other type of wildlife given their large host ranges. European starlings (*Sturnus vulgaris*) are of particular concern, as they can congregate in large flocks in and around animal production facilities—with roosts reaching as many as 50,000 to 100,000 birds. They also travel long distances, coming in frequent contact with livestock in pastures and feedlots, especially in the absence of natural food sources.

Objectives

The objectives of this study are to (1) determine the prevalence and antimicrobial susceptibility profiles of AMR in the indicator bacteria *Escherichia coli* (*E. coli*) isolated from European starlings associated with concentrated animal feeding operations (CAFOs); and (2) establish prevalence of important genetic determinants linked to resistance of β-lactam antibiotics, which are considered priority drugs for both animal and human health.

Materials and Methods

Feedlots with severe European starling infestations (e.g., experiencing more than 10,000 starlings per day) were identified in previous studies. All feedlots were located in major beef cattle production areas in the U.S., including Colorado, Iowa, Kansas, Missouri, and Texas. Up to 30 European starlings were collected at each livestock facility. Contents of starling gastrointestinal tracts were plated onto microbiological media containing the antibiotics cefotaxime (CTX) or ciprofloxacin (CIP), which allowed our team to isolate *E. coli* resistant to these drugs (Fig 1).

Confirmation of bacteria as *E. coli* was accomplished using matrix-assisted laser desorption/ionization biotyping (MALDI-TOF MS), a method that allows for rapid identification of large numbers of bacterial isolates. Rapid identification of bacteria via MALDI-TOF MS is performed by direct comparisons of mass spectra obtained from pure isolates on agar plates to spectra from known bacterial standards contained in a mass spectral reference library. Next, susceptibility of the *E. coli* to important antimicrobials was determined using disk diffusion (a classic phenotypic method for characterizing AMR). This method involves utilization of disks embedded with antibiotics placed directly on an agar surface containing a bacterial isolate. The antibiotics subsequently diffuse into the agar. Bacteria that can grow in close proximity to the disk are generally considered resistant—because they are still able to grow when exposed to high concentrations of the antibiotic. In contrast, where there is a large zone of no bacterial growth around the disk, the bacteria are susceptible to the antibiotic—because they are not able to grow when exposed to high concentrations of the antibiotic.

In this study, determination of similarity between bacterial isolates was an important task because it allows for tracking of routes of transmission and spread of bacteria between different environments. To accomplish this, polymerase chain reaction (PCR) was used to detect genes conserved in similar isolates (phylogenetic

[1]Department of Animal Science; [2]U.S. Department of Agriculture, Animal and Plant Health Inspection Service, National Wildlife Research Center, Fort Collins, Colorado; [3]The Ohio State University, Wooster, Ohio; [4]McGill University, Montreal, Quebec, Canada; [5]University of Missouri, Columbia, Missouri; [6]Iowa State University, Ames, Iowa.

typing). PCR was also used to determine the presence of genes that encode β-lactamases, which often mediate resistance to β-lactam antibiotics in these bacteria. The β-lactam category of antibiotics includes antibiotics important in both human and veterinary medicine (e.g., penicillin).

Figure 1. *Jennifer Anders, a graduate student in the University of Wyoming animal and veterinary science degree program, processes microbiological samples in the laboratory. She is advised by Bledar Bisha, assistant professor of food microbiology in the UW Department of Animal Science.*

Results and Discussion

Of the 238 total *E. coli* isolates available in this study, most were resistant to eight or more different types of antibiotics. More than 97% of the isolates were classified as multi-drug resistant (MDR), which is defined as resistance to three or more antibiotic classes. Grouped by drug classes (14 total drug classes tested), a majority of the isolates were resistant to six or more drug classes.

The overwhelming majority of isolates were found to have AMR to penicillins (ampicillin and piperacillin), and a first-generation cephalosporin (cefazolin). Additionally, resistance to second-generation cephalosporins, third-generation cephalosporins, and monobactams (aztreonam) was observed. Cephalosporins and monobactams are β-lactam antibiotics, but due to structural differences they commonly are more resistant to most β-lactamases compared to penicillins. Genes responsible for resistance to the β-lactam antibiotics were also found in the characterized bacterial isolates, with three different types of genes that are known to easily transfer between bacteria, thereby spreading AMR in microbial communities.

This study showed that *E. coli* isolated from starlings associated with livestock production/CAFOs contain AMR phenotypes that are important in animal and human health. Among them were resistances to fluoroquinolones (ciprofloxacin and nalidixic acid) and β-lactam antimicrobials, including important classes of antibiotics such as third-generation cephalosporins. Additionally, we determined the presence of three important genes conferring resistance to β-lactams in these isolates.

European starlings are already considered invasive species, and starling control is actively being carried out on many agricultural operations; however, this study provides additional rationale for livestock producers, scientists, local, state, and federal officials, and other stakeholders to actively continue collaborating to mitigate the starling problem in CAFOs.

Acknowledgments

The authors are grateful to the Wyoming Agricultural Experiment Station for providing funding to conduct the present research. Fieldwork was made possible through the immense contributions of livestock producers, the U.S. Department of Agriculture's National Wildlife Research Center and its employees, as well as other collaborators.

Contact Information

Bledar Bisha at bbisha@uwyo.edu or 307-766-3140.

Keywords: beef cattle, concentrated animal feeding operation, antibiotic resistance

PARP: V:13, IX:2

Winter Wheat Planting Date Trial on Dryland Fields in Goshen and Laramie Counties

Carrie Eberle[1,2]

Introduction

Winter wheat performance evaluations conducted by the Wyoming Agricultural Experiment Station (WAES) are continuous and ongoing programs. WAES evaluates planting dates of winter wheat each year in cooperation with the Crop Research Foundation of Wyoming.

Objectives

Our objective was to test how planting date impacts the yield of winter wheat variety Cowboy to help growers select the planting date best adapted to the region.

Materials and Methods

The experiment was located in two dryland fields in southeast Wyoming, one on a farm in Laramie County (Fig. 1), and one in Goshen County at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). The experimental design consisted of three replications in a complete block. Measurements taken included: grain yield, test weight, and moisture (Table 1). Cowboy winter wheat was seeded on September 7, October 5, October 10, and October 14, 2016. Seeding took place in plots measuring 5 by 25 feet using a disc drill with row spacing of 7.5 inches. The seeding depth was 1.5 inches, and the seeding rate was 50 lb/ac. Plots were harvested July 21, 2017 (Goshen), using a Kincaid plot combine, and August 1, 2017 (Laramie), by hand cutting and threshing two one-meter (~3.3-foot) rows.

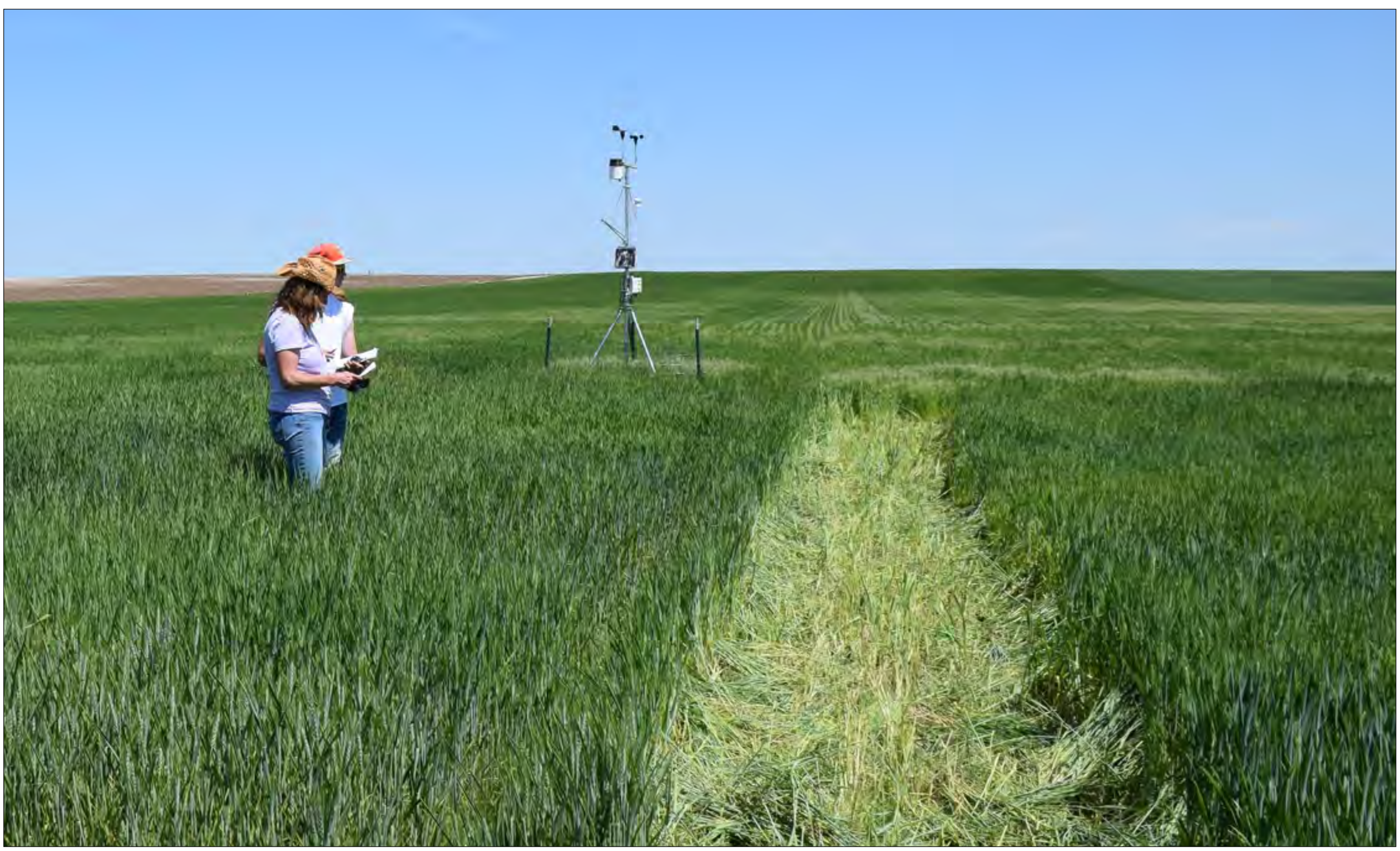

Figure 1. *Wendy Cecil and Matt Bebo collect data at a dryland wheat test site in southeast Wyoming. A weather station is in the background.*

[1]*Department of Plant Sciences;* [2]*James C. Hageman Sustainable Agriculture Research and Extension Center.*

Results and Discussion

Yield results are presented in Table 1. In both locations, the earliest planting date had the highest yield, with the yields of the later dates being lower. This is consistent with findings from previous years. There was significant weed pressure in the plots that were planted in October in Goshen County. Delayed planting of winter wheat leads to slower stand establishment and poor weed competition early in the season. Increased seeding rates and herbicide programs can be used to help manage this issue. Complete results for these trials and many others are available at www.uwyo.edu/plantsciences/uwplant/trials.html.

Acknowledgments

Appreciation is extended to the cooperator, Tim Anderson (Laramie County), who allowed us to place a trial on his farm. We also thank the farm crew at SAREC.

Contact Information

Carrie Eberle at carrie.eberle@uwyo.edu or 307-837-2000.

Keywords: winter wheat, dryland farming, yield

PARP: I:12, IX:2

Table 1. 2017 Goshen and Laramie counties dryland planting date results.

Planting Date	Yield[1] (bu/ac)		TWT[2]		% Moisture	
Goshen County Dryland (7/21/17 Harvest Date)						
9/7/2016	72.3	A[3]	59.4	A	12.6	B
10/5/2016	40.3	B	59.9	B	30.7	A
10/10/2016	48.7	B	51.3	B	30.3	A
10/14/2016	38.6	B	50.5	B	36.5	A
Average	50.0		53.5		27.5	
Laramie County Dryland (8/1/17 Harvest Date)						
9/7/2016	59.7[4]	± 25.3				
10/5/2016	39.4	± 0.6				
10/10/2016	36.9	± n/a				
10/14/2016	27.4	± 7.7				
Average	39.7[5]					

[1]Yield is for a standard 60 lb bushel and normalized to 13.5% moisture.
[2]Test weight (TWT) is given at harvest moisture.
[3]Letters indicate significant differences within each column between planting dates based on the Student–Newman–Keuls test for Goshen County.
[4]Laramie County yield was compared using the Tukey–Kramer test; there were no significant differences between planting dates.
[5]The true average (39.7) is different than the average of the four numbers presented in this column (40.9) because we rounded off the number of significant digits.

Winter Wheat Variety Trials: Laramie County Dryland and Irrigated

Carrie Eberle[1,2]

Introduction

Variety performance evaluations conducted by the Wyoming Agricultural Experiment Station (WAES) are continuous and ongoing programs. WAES evaluates many varieties/lines of winter wheat each year in cooperation with the Crop Research Foundation of Wyoming, University of Nebraska–Lincoln, Colorado State University, Montana State University, and private seed companies.

Objectives

Our objectives are to test new and existing winter wheat varieties to help growers select ones best adapted to the region.

Materials and Methods

The on-farm experiments were located on dryland and irrigated fields in Laramie County in southeastern Wyoming. The experimental design consisted of three unfertilized replications in the dryland and three fertilized replications under irrigation in a randomized complete block. Measurements taken included: grain yield, test weight, moisture, lodging at harvest (lodging is the bending over of the stems near ground-level), hail damage, stripe rust infection, and septoria/tan spot infection.

Wheat varieties were seeded in the dryland field on September 7, 2016, using a disc drill with a row spacing of 7.5 inches. The irrigated field was seeded on September 26, 2016, using a hoe drill with row spacing of 14 inches. In the irrigated trial, fertilizer was applied at a rate of 135-20-5-1 lb/ac nitrogen-phosphorus-sulfur-zinc, respectively. All plots were 5 ft by 25 ft, the seeding depth was 1.5 inches, and the seeding rates were 50 lb/ac in the dryland trial and 100 lb/ac in the irrigated trial. Dryland plots were harvested August 1, 2017, by hand cutting and threshing two one-meter (~3.3-foot) rows. Irrigated plots were harvested August 2, 2017, with a Kincaid plot combine.

Results and Discussion

Dryland yield results are presented in Table 1. This trial had issues with fall establishment and spring sawfly damage (indicated by % lodged stems). The highest yielding varieties in the dryland trial were Cowboy and Warhorse at ~66 bu/ac. Because of the large variation between plots, there were no significant differences in either yield or lodging between any of the varieties. Also, there was no significant disease occurrence.

In the irrigated trial, the experimental line CO14A065 (HT/herbicide tolerant) was the highest yielding variety at ~79 bu/ac (Table 2). The irrigated trial was adjusted for hail damage (Table 2; estimated yield lost to hail) using the protocols by Klein and Rees (2017). Like with the dryland trial, there was no significant disease occurrence.

Complete results for these trials and many others are available at www.uwyo.edu/uwexpstn/variety-trials/index.html.

Acknowledgments

Appreciation is extended to the cooperators who allowed us to place trials on their land: Tim Anderson and Theron Anderson (dryland and irrigated, respectively). We also thank William Stump and Wendy Cecil for help with disease assessment, and personnel with the James C. Hageman Sustainable Agriculture Research and Extension Center for field help. This work was funded by the Wyoming Crop Research Foundation.

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Contact Information

Carrie Eberle at carrie.eberle@uwyo.edu or 307-837-2000.

Keywords: variety trial, winter wheat, yield

PARP: I:12, IX:2

[1]*Department of Plant Sciences;* [2]*James C. Hageman Sustainable Agriculture Research and Extension Center.*

Table 1. 2017 Laramie County dryland wheat trial results. Yield ± standard deviation is based on hand-harvested samples. Lodged stems are a proxy for sawfly damage; percentage is based on a visual estimate taken at harvest.

Variety	Yield (bu/ac)			% Lodged Stems		
Cowboy	66.4	±	16.4	14.0	±	12.1
Warhorse (SS)[1]	65.6	±	19.1	2.0	±	2.6
Freeman	64.6	±	9.5	43.3	±	15.3
CO13D1783	62.1	±	18.2	40.0	±	26.5
MT1465	59.1	±	15.5	31.7	±	17.6
TAM114	57.9	±	8.8	60.0	±	10.0
Avery	54.4	±	17.7	43.3	±	35.1
CO13003C (HT)[2]	51.9	±	18.6	10.0	±	5.0
Panhandle	51.7	±	5.0	48.3	±	29.3
Robidoux	49.1	±	4.4	37.0	±	31.6
Sunshine	48.4	±	7.4	50.0	±	10.0
Langin	47.8	±	10.6	23.3	±	16.1
MT1444	46.1	±	13.3	23.3	±	23.1
Spur (SS)	44.9	±	8.7	23.3	±	5.8
Denali	44.8	±	23.4	43.3	±	35.1
WB4721	44.7	±	16.5	43.3	±	20.8
SY Wolf	43.2	±	10.7	43.3	±	15.3
MTW1491	41.9	±	12.7	8.3	±	2.9
SY Monument	41.7	±	15.3	56.7	±	11.5
Ruth	41.7	±	17.0	46.7	±	15.3
Antero	41.0	±	10.1	53.3	±	11.5
MT1348	40.3	±	6.9	8.3	±	10.4
Hatcher	39.7	±	15.7	20.0	±	26.0
CO12D1770	39.3	±	7.4	60.0	±	17.3
CO012D2011	39.2	±	10.2	60.0	±	10.0
CO14A058 (HT)	36.0	±	3.6	26.7	±	20.8
MT1471	31.6	±	7.8	3.3	±	2.9
WB4462	30.8	±	9.3	20.0	±	10.0
CO14A065 (HT)	28.7	±	4.4	26.7	±	15.3
Average	46.8	±	14.9	33.2	±	23.4

Note: Based on the Tukey–Kramer test, there was no significant difference in yield between variety or lodging of the different varieties.

[1]SS stands for solid stem.

[2]HT stands for herbicide tolerant; these varieties carry novel proprietary AXigen™ herbicide tolerance traits for winter annual grassy weed control.

Table 2. 2017 Laramie County irrigated wheat trial results. Yield is harvest yield for a standard 60 lb bushel and normalized to 13.5% moisture.

Variety	Yield (bu/ac)		TWT[1]		%M[2]		EYL[3] (bu/ac)		EMY[4] (bu/ac)	
CO14A065 (HT)[5]	79.0	A[6]	57.3	GHIJ	11.2	EFCD	30.9	AB	110.0	A
CO13D1783	77.3	AB	57.9	CDEFGH	11.1	EFCD	25.6	ABCDE	102.9	ABC
Cowboy	75.4	ABC	57.2	GHIJK	11.5	EBCD	30.4	ABC	105.8	AB
MT1444	75.0	ABC	58.8	BC	12.0	ABCD	8.0	DE	83.0	BCDE
Denali	72.7	ABCD	58.4	BCDE	11.5	EBCD	25.6	ABCDE	98.3	ABCD
MTW1491	71.5	ABCDE	58.4	BCDEF	12.1	ABC	16.0	BCDE	87.5	BCDE
MT1348	71.4	ABCDE	58.5	BCDE	11.5	EBCD	14.4	BCDE	85.8	BCDE
CO12D1770	69.2	ABCDE	59.2	AB	12.2	AB	40.5	A	109.7	A
Langin	68.2	ABCDE	56.5	IJK	11.0	EFD	32.0	AB	100.2	ABCD
Spur (SS)	66.3	ABCDEF	56.3	JK	10.4	F	9.6	CDE	75.9	DE
MT1465	65.3	ABCDEF	57.1	GHIJK	10.9	EF	7.5	E	72.8	E
CO13003C (HT)	65.2	ABCDEF	56.9	HIJK	11.1	EFCD	31.5	AB	96.7	ABCDE
MT1471	64.9	ABCDEF	58.0	CDEFG	12.1	ABC	11.2	BCDE	76.1	DE
SY Wolf	63.8	BCDEF	57.4	FGHI	12.2	AB	13.9	BCDE	77.7	DE
Hatcher	63.0	BCDEF	57.5	DEFGH	11.0	EFD	18.7	BCDE	81.6	CDE
Warhorse (SS)[7]	62.4	BCDEF	58.5	BCD	11.8	EBCD	16.0	BCDE	78.4	DE
Avery	61.0	CDEF	57.1	GHIJK	10.8	EF	24.0	ABCDE	85.0	BCDE
TAM114	60.7	CDEF	58.5	BCDE	12.7	A	23.5	ABCDE	84.1	BCDE
CO012D2011	58.1	DEF	59.8	A	12.5	AB	28.8	ABCD	86.9	BCDE
WB4721	57.5	DEF	57.5	EFGH	10.9	EF	14.4	BCDE	71.9	E
Antero	57.5	DEF	57.5	DEFGH	10.9	EF	25.6	ABCDE	83.1	BCDE
CO14A058 (HT)	56.3	EF	56.9	HIJK	11.1	EFCD	25.6	ABCDE	81.9	CDE
SY Sunrise	51.2	F	56.3	K	10.2	F	26.7	ABCDE	77.9	DE
Sunshine	51.2	F	57.7	DEFGH	11.1	EFCD	28.8	ABCD	80.0	CDE
Average	65.2		57.7		11.4		22.0		87.3	

[1]Test weight (TWT) is given at harvest moisture.

[2]Moisture (%M) is seed moisture at harvest.

[3]Estimated yield lost (EYL) from hail damage is based on number of heads damaged in a foot of row.

[4]Estimated maximum yield (EMY) is the sum of the yield and the EYL.

[5]HT stands for herbicide tolerant; these varieties carry novel proprietary AXigen herbicide tolerance traits for winter annual grassy weed control.

[6]Letters indicate significant differences between varieties based on the Student–Newman–Keuls test; varieties with the same letter are not significantly different within each column.

[7]SS stands for solid stem.

Studies of Insects Associated with Mountain Pine Bark Beetle in Limber Pine

Lawrence Haimowitz[1] and Scott Shaw[1]

Introduction

The pine forests of western North America have co-existed for thousands of years with the mountain pine bark beetle (MPBB [*Dendroctonus ponderosae*]). Although recent MPBB epidemics make this relationship look completely one-sided, the activities of native bark beetles are known to support forest health; for example, MPBB selectively kill trees that are most stressed by current conditions. Among these are drought, warming temperatures, mild winters, and extensive stands of old trees in declining health, the latter of which stems from decades of fire suppression. During periods of change, better-adapted trees are left to reproduce; thus, the beetles help forests cope with environmental changes. Through much of the 20th century, humans did everything possible to keep fires from forests, but we now realize that some fires (both wildfire and prescribed) are necessary for forest health. Forestry professionals, researchers, and others are beginning to see bark beetles in the same light. With future policies informed by new research, our forests can return to a condition in which bark beetle epidemics are more self-limited and contribute to forest health over the long-term.

Researchers have discovered that many insect species live under the bark of pines infested with bark beetles. In every kind of pine studied, these insects significantly reduce bark beetle survival by predation and competition; however, this research is devilishly difficult because these insects spend most of their lives under the bark of dead and dying trees. Past methods have been very resource intensive and have produced inconsistent results. Little of this research has been directed at MPBB in limber pine (*Pinus flexilis*) so almost nothing is known of insects that share this tree with the bark beetle. Our team has adapted new field methods for the study of bark beetles in attacked trees, which we have applied to our research of MPBB in limber pine.

Objectives

Our objectives have been to develop better tools to study MPBB and associated insects in the field, and to learn more about these insects in limber pine.

Materials and Methods

We developed two new methods for investigating insects living under the bark of beetle-infested trees. One of these is selective exclusion, a simple, direct method to measure the effect of MPBB-associated insects on bark beetle survival. Briefly described, a portion of a beetle-attacked tree trunk is protected from insects other than bark beetles, and then beetle survival in the protected portion

Figure 1. *Metal exclusion enclosure on limber pine.*

[1]*Department of Ecosystem Science and Management.*

Figure 2. *Lyctocoris okanaganus, a predator newly associated with mountain pine bark beetle.*

is compared with survival in the rest of the trunk. Our other method is a trap to capture insects as they emerge from beetle-infested trees to see what insects share the tree with MPBB. Both methods require enclosures to capture and/or exclude insects. We made enclosures with a very fine-mesh metal screen, impervious to insects, but which allow light and air to reach the bark under the enclosure. We tested these methods in the Shoshone and Medicine Bow national forests of Wyoming.

Results and Discussion

The only material tested that worked reliably for MPBB enclosures was metal screen similar to window screen, but with much smaller holes (Fig. 1). In past bark beetle research, the materials most widely used for insect enclosures were various forms of shade cloth or weed cloth. Our team found that MPBB easily chewed through these materials, but not the metal mesh. The selective exclusion experiments, carried out in 2015 to 2017, showed that natural enemies can have a very large effect on MPBB survival. These experiments prove that the method works, and they provide a blueprint for future studies by our team, if funding becomes available, and others. We plan to publish an in-depth paper describing this method; in the meantime, please contact lead author Lawrence Haimowitz if you have questions.

We captured thousands of insects with our emergence traps on limber pine and have only partially processed these samples. So far, we have discovered two predators not previously associated with MPBB in other pines: *Lyctocoris okanaganus* (Hemiptera:Lyctocoridae [Fig. 2]) and *Leptophloeus* undescribed species (Coleoptera: Laemophloeidae), both of which were recovered in large numbers. More research is needed to determine if they prey on pine beetles. Lawrence Haimowitz is now focusing his Ph.D. research on the taxonomy of the natural enemies of bark beetles, an area of study that is greatly needed.

Acknowledgments

This work is supported by the U.S. Department of Agriculture-National Institute of Food and Agriculture's McIntire-Stennis program and the Wyoming Agricultural Experimental Station Competitive Grants Program. We thank our undergraduate research technicians for help with sampling and preparing insect specimens for study and voucher, and we thank personnel with the Shoshone and Medicine Bow national forests for assistance with locating suitable study sites and for their prompt review of our research permits.

Contact Information

Lawrence Haimowitz at lhaimowi@uwyo.edu or 408-375-3783, or Scott Shaw at braconid@uwyo.edu or 307-766-5338.

Keywords: mountain pine bark beetle, limber pine, natural enemies

PARP: not applicable

Evaluating the Use of Thresholds' Concepts for Improving Habitat Through Cheatgrass Management

Clay Wood[1,2] and Brian Mealor[1,2]

Introduction

Cheatgrass (*Bromus tectorum*, aka downy brome) is an invasive annual grass that is widely distributed throughout western North America. It has the ability to alter fire frequency, leading to degradation of critical wildlife habitat and forage for livestock. Identifying thresholds in cheatgrass-invaded systems is a primary challenge for land managers as management thresholds are ill-defined for invasive species in rangelands. An ecological threshold refers to a point where there is an abrupt change in the quality or function of an ecosystem (Groffman et al., 2006), whereas other thresholds (economic, minimum response, etc.) relate to specific relationships between weed species' abundance and management implications. Increased understanding of where such thresholds occur may lead to well-informed cheatgrass-management decisions, especially at landscape scales.

Objectives

Our objective is to determine if there is a direct, predictable relationship between pre-treatment vegetation conditions and post-treatment increases in perennial grass biomass.

Materials and Methods

This study was conducted on multiple field sites throughout the state, but for this paper we only present data from sites near Pinedale (west-central Wyoming) and Saratoga (south-central Wyoming). To determine landscape variability, we mapped cover of cheatgrass and perennial grasses through ocular estimation in an approximate 50-foot grid pattern. A balanced subset of mapped points was selected for intensive sampling across each treatment area and across a range of cheatgrass and perennial grass cover. At each intensive sample location vegetation cover was measured using both transects and quadrats; additionally, all herbaceous biomass was collected from the cover quadrats.

Pre-treatment data were collected in June 2015, and pre-emergence herbicide treatments were conducted in September 2015 using two formulations of imazapic. Plateau®, a liquid formulation, and Open Range™ G, a granular formulation, were applied at a rate of 7 oz/ac and 13 lb/ac, respectively. Post-treatment data were collected in June 2016 and 2017.

Results and Discussion

Two years after the treatments, cheatgrass biomass was reduced across herbicide treatments at Pinedale relative to the untreated check (Fig. 1*a*; p=<0.001); however, at Saratoga cheatgrass biomass was not reduced relative to the check (Fig. 1*b*; p=0.405). At Pinedale, cheatgrass biomass increased in the untreated check, especially in areas with lower pre-treatment cheatgrass cover. Perennial grass biomass increased in both herbicide treatments relative to the untreated check two years after treatment, especially at sites with higher pre-treatment cheatgrass cover at both Pinedale (Fig. 1*c*; p=0.067) and Saratoga (Fig. 1*d*; p=0.018).

With further analysis of our data, we intend to determine where thresholds occur in cheatgrass-invaded rangelands. A better understanding of thresholds' concepts relating to cheatgrass management could aid in implementing landscape-scale management to reduce fire frequency, increase perennial grasses and shrubs, and improve wildlife habitat and forage for livestock.

Acknowledgments

We thank the University of Wyoming Department of Plant Sciences, Sheridan Research and Extension Center, Wilbur-Ellis, Sublette County Weed and Pest District, and Wyoming Local Sage-Grouse Working Groups for support and funding, and UW field crews for assistance.

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Contact Information

Brian Mealor at bamealor@uwyo.edu or 307-673-2647.

[1]*Department of Plant Sciences;* [2]*Sheridan Research and Extension Center.*

Keywords: cheatgrass, thresholds, imazapic

PARP: III:3,5,7, VI:3, XII:1

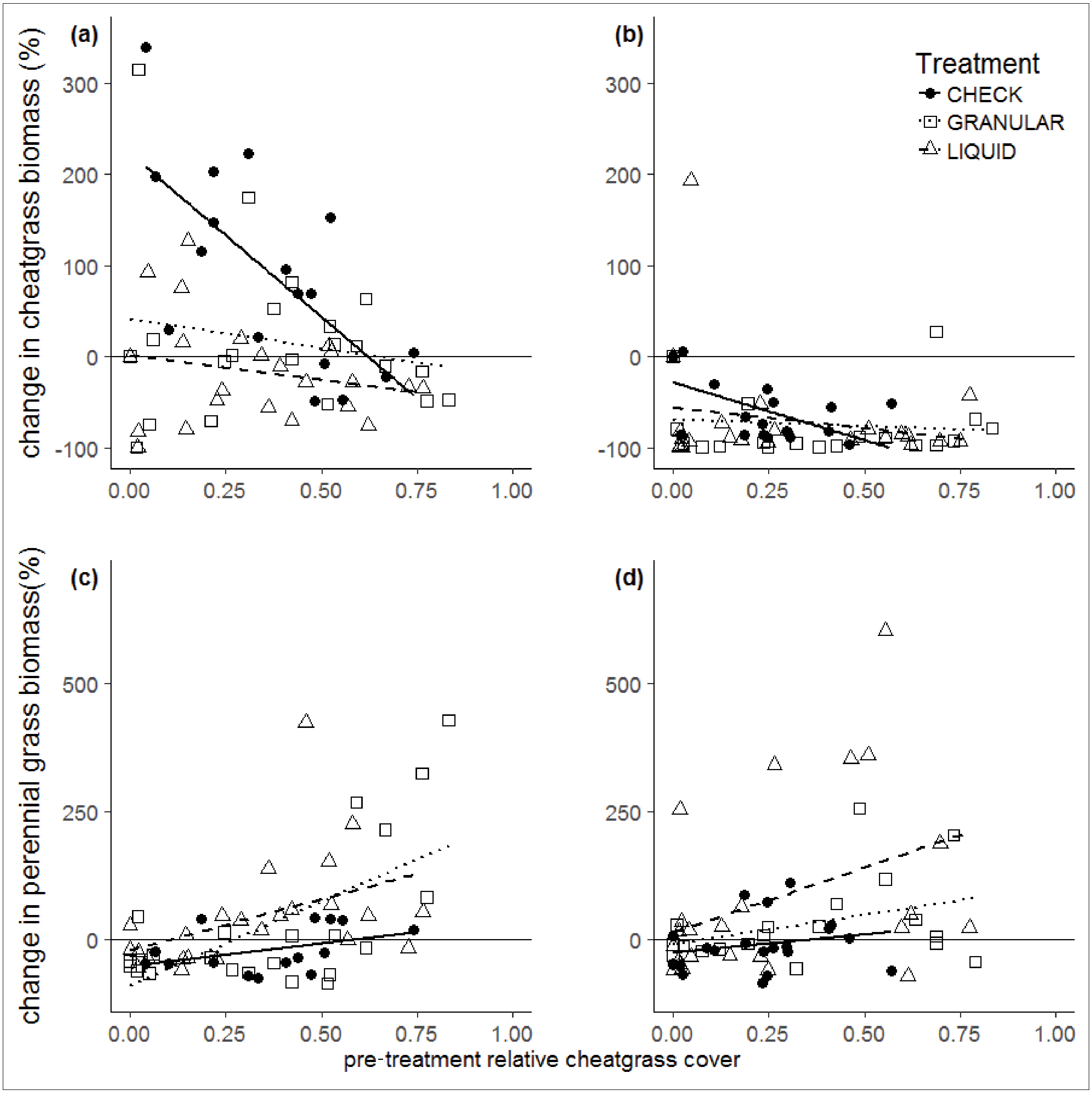

Figure 1. *Two year post-treatment changes in cheatgrass (a–b) and perennial grass (c–d) biomass at Pinedale (a, c) and Saratoga (b, d). Changes in biomass are percent change in relation to pre-treatment biomass.*

Wildfire Effects on Density and Volume of Sagebrush and Rabbitbrush in a High-Elevation Rangeland

Derek Scasta[1,2] and Bridger Feuz[2]

Introduction

Shrub succession in response to disturbance (and the associated development of novel strategies to manage shrub dominance) on western rangelands is a concern to ranchers, wildlife managers, and land-management agencies alike. How fire alters dominance of some shrubs such as sagebrush (*Artemisia* species) has been well documented. But how the fire disturbance facilitates invasion or increasing plant reproduction of other shrub species is not as well understood. Sagebrush-dominated shrub complexes have been suspected to shift to a plant community dominated by rabbitbrush (*Chrysothamnus* spp.) after fires, yet actual invasions are difficult to document due to different resprouting and structural characteristics of species within the shrub complex.

Objectives

Our objectives were to quantify density and structure of sagebrush (*Artemisia tridentata*) and rabbitbrush (*Chrysothamnus viscidiflorus*) after a wildfire in southwest Wyoming.

Materials and Methods

In September 2010, the Windmill Fire burned approximately 6,000 acres of rangeland in Uinta County. The area was dominated by perennial grasses including Indian ricegrass (*Achnatherum hymenoides*), Sandberg bluegrass (*Poa secunda*), western wheatgrass (*Pascopyrum smithii*), and a dominant shrub overstory composed of big sagebrush (*Artemisia tridentata*) with likely hybridization with mountain big sagebrush (*A. tridentata* ssp. *vaseyana*). We used paired burned-unburned belt transects on a ranch in 2015 and 2016 to determine sagebrush and rabbitbrush responses to the wildfire. Transects 50 meters (~165 feet) in length were paired based on proximal areas that burned and did not burn and were placed within 300 m (~1,000 ft) of one another. In 2015, shrub density was determined using belt transects by recording the number of each shrub species rooted in the transect 1 m (~3 ft) from one side of the transect. In 2016, height and width of shrubs were determined by measuring the first 10 individuals of each species along the same 50 m transects, and this information was used to calculate canopy volume using the conical volume formula, which is based on the circular canopy area multiplied by height and divided by 3.

Means and standard errors of density and volume for each shrub species using transect means across paired burned-unburned transects (n=4) were calculated. We conducted paired t-tests separately for each shrub species using fire (i.e., burned or unburned) to determine if shrub density and then shrub volume were different in burned areas for the two shrub species.

Results and Discussion

Density of sagebrush was significantly lower post-fire, but density of rabbitbrush was unchanged. In unburned plots, sagebrush density was 3,885 ± 767 per acre, which is four times higher than the 991 ± 385 plants per ac in burned areas. Rabbitbrush density was 2,974 ± 585 plants per ac in unburned plots and 3,055 ± 807 plants per ac in burned plots. Relative density comparisons show that sagebrush density was lower and rabbitbrush density was unchanged (Fig. 1)

The wildfire had a similar effect on shrub volume as it did on shrub density. Sagebrush volume was 5 ± 0.5 ft^3 in unburned plots, 11 times greater than the 0.5 ± 0.2 ft^3 in burned plots, suggesting that fire physically reduced sagebrush volume (p=0.029). Rabbitbrush volume was 0.2 ± 0.1 ft^3 in both the unburned plots and the burned plots. Rabbitbrush density and volume means were not significantly different between burned and unburned sites, suggesting fire did not lead to a positive or negative physical alteration of rabbitbrush volume (p=0.686).

Additional sampling in 2017 across four ecological sites further determined that rabbitbrush density was strongly explained by ecological site, not fire (Scasta and Feuz, 2017). Thus, fire in this system did reduce sagebrush, but did not increase rabbitbrush.

[1]*Department of Ecosystem Science and Management;* [2]*University of Wyoming Extension.*

Acknowledgments
Appreciation is extended to the rancher cooperators. Our study was supported in part by a U.S. Department of Agriculture, National Institute of Food and Agriculture McIntire-Stennis project grant.

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Contact Information

Derek Scasta at jscasta@uwyo.edu or 307-766-2337.

Keywords: fire ecology, plant succession, rangeland

PARP: VI:11, X:1, XII:1

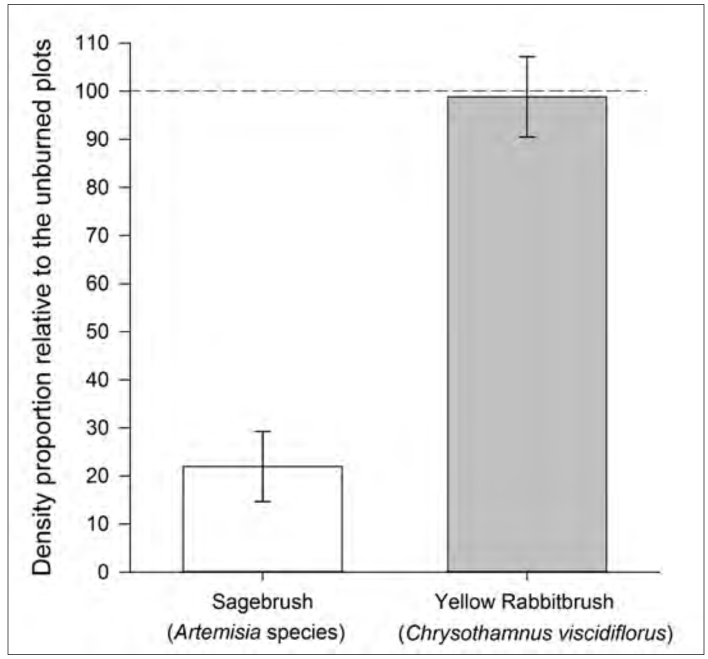

Figure 1. *Relative density of sagebrush and rabbitbrush comparing burned versus unburned area.*

Predation and Survival of Mock Sage Grouse Nests in Carbon County

Derek Scasta[1,2] and Abby Perry[2]

Introduction

The greater sage-grouse (*Centrocercus urophasianus*) is a sagebrush obligate bird that has received a lot of attention and conservation focus for many years, in part due to many petitions for listing under the Endangered Species Act between 1999 and 2015. While the causes for decline are numerous and include issues such as habitat loss, predators are also known to prey on sage grouse. Avian predators, in particular, can influence habitat selection (including how adult females select nest locations) and nest survival. Mock or dummy nests have been used to quantify survival rates and predator species of northern bobwhite quail (*Colinus virginianus*), another upland ground-dwelling bird, yet such methods have not been used to any great extent for sage grouse in the western United States. Considering that human disturbances and development can have an impact on populations of predator species, such methods may provide insight as to what predation risk is occurring in a localized area.

Objectives

Our objectives were to determine predator species and survival rates relative to expected hatch dates in south-central Wyoming using mock greater sage-grouse nests.

Materials and Methods

We assessed predator species and survival of 12 mock sage grouse nests on a ranch in Carbon County. The study area consists of semiarid, high-elevation sagebrush steppe. Each mock nest was composed of four brownish chicken eggs and placed in habitat that is hypothesized to mimic features an adult female sage grouse would use: under a Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) plant with adequate perennial grass underneath and surrounding areas. Game cameras were placed ~10 to 16 feet from each mock nest, which were established May 15–16, 2017. Nests were evaluated and cameras pulled on June 16, 2017.

Results and Discussion

Nest survival, or nests that were intact, was ~67% at the start of the expected hatch period (25 days post-placement) and 50% at the end of the expected hatch period (27 days post-placement [Fig. 1]). Of the six nests predated prior to the end of the expected hatch period, three were predated by common ravens (*Corvus corax* [Fig. 2]) (25% of the total nests), and three were predated by common magpies (*Pica pica*) (25% of the total nests). Other predators caught on camera included coyotes (*Canis latrans*) and American badgers (*Taxidea taxus*), but they were never noted to depredate a nest or only were caught after the nest was completely depredated. In one other instance, a Wyoming ground squirrel (*Urocitellus elegans*) was caught moving a single egg around, but was never caught actually eating an egg. Ravens depredated three additional nests 28, 29, and 32 days after placement, but these depredation events were not accounted for in the survival because eggs would have been expected to hatch prior to these events.

The results are somewhat surprising because our study area was ~20 miles southwest from Rawlins, and ravens were never visually noted during our brief periods in the area (i.e., so they did not visually track us placing the nests). In addition, raven density and occupation is known to be affiliated with human activity with movement by ravens beyond ~2 miles from town less likely (Bui et al., 2010). But ravens may have been attracted to our study site since there is a road corridor through the area (and associated human-related activities including road-killed animals). This information is important as multiple stressors of sage grouse populations are considered, especially if raven populations continue to increase.

Acknowledgments

Appreciation is extended to John Hansen, the owner of the ranch where our research was conducted. The study was supported in part by a U.S. Department of Agriculture, National Institute of Food and Agriculture McIntire-Stennis project grant.

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Contact Information

Derek Scasta at jscasta@uwyo.edu or 307-766-2337.

Keywords: sage grouse, avian predators, wildlife habitat

PARP: XII:2

[1]*Department of Ecosystem Science and Management;* [2]*University of Wyoming Extension.*

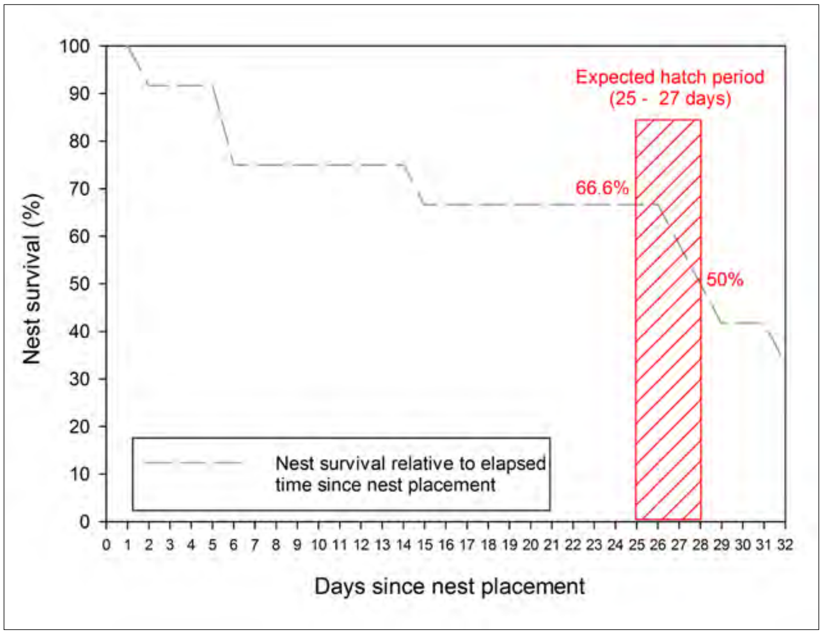

Figure 1. *Mock nest survival relative to days since placement and the expected hatch period that occurs 25 to 27 days post-placement.*

Figure 2. *Ravens predated 25% of the mock nests prior to the end of the expected hatch period.*

Wyoming Agricultural Climate Network (WACNet)

Vivek Sharma[1,2], Chris Nicholson[3], Tony Bergantino[3], Jeff Cowley[4], Bret Hess[2,5], and John Tanaka[5–7]

Introduction

Understanding the potential changes in local climate variables is critical to better understand how these changes affect agricultural and natural resource ecosystem productivity. In many cases, past, current, and future weather conditions greatly influence decisions made by producers (e.g., cattle and sheep stocking rates, irrigation, pest and disease control, land use and management). To support these decisions, the University of Wyoming, in collaboration with the Wyoming State Engineer's Office, has developed the Wyoming Agricultural Climate Network (WACNet), a network of 26 weather stations across the state (www.wrds.uwyo.edu/WACNet/WACNet.html). Most of the stations are located in the irrigated regions of the state, including the Bighorn, Green River, and Platte River basins (Figure 1). Other stations were installed to support forest and natural resource ecosystem research. For example, the weather station at the UW-owned Rogers Research Site in southeast Wyoming near Laramie Peak was added to WACNet in 2017.

Objectives

The objectives of WACNet are to monitor and provide information on climatic conditions for agricultural and natural resource applications in Wyoming.

Materials and Methods

Figure 1 shows the location of WACNet automated weather stations across Wyoming. All monitoring stations in the program provide real-time data, including air temperature, humidity, wind speed and direction, solar radiation, and precipitation. In addition to these parameters, some stations also measure soil moisture, soil temperature, atmospheric pressure, vapor pressure deficit, and reference evapotranspiration data. All of the stations are equipped with Campbell Scientific Inc. CR1000 or CR6 data loggers and sensors. The data loggers are powered by batteries that are recharged by solar energy (Fig. 2). All of the stations are integrated into a web-based platform managed by UW's Wyoming Water Resources Data System (WRDS). Raw data gathered by each weather station is communicated to WRDS through cell phone modem and internet. WRDS then processes and assesses all of the data for quality assurance/quality control and disseminates the information via the WACNet website.

Results and Discussion

For each WACNet station, information is recorded daily (every 15 minutes, hour, and 24 hours). Users can retrieve climate data (free of cost) summarizing information for the last seven and 30 days, both in graphical and table format from the WACNet website. Users can also download long-term climate data on both an hourly and daily timescale. For example, Figure 3 represents maximum and minimum temperatures for a 30-day period at the Heart Mountain weather station near Powell, while Figure 4 shows precipitation and soil moisture variation for 60 days at the same station.

Acknowledgments

We thank the Wyoming Agricultural Experiment Station and Wyoming State Engineer's Office for funding and support, and we extend our appreciation to WRDS for their work.

Contact Information

Vivek Sharma at vsharma@uwyo.edu or 307-754-2223.

Keywords: climate, weather, Wyoming Agricultural Climate Network

PARP: X:5

[1]Department of Plant Sciences; [2]Powell Research and Extension Center; [3]University of Wyoming Water Resources Data System; [4]Wyoming State Engineer's Office; [5]Wyoming Agricultural Experiment Station; [6]James C. Hageman Sustainable Agriculture Research and Extension Center; [7]Department of Ecosystem Science and Management.

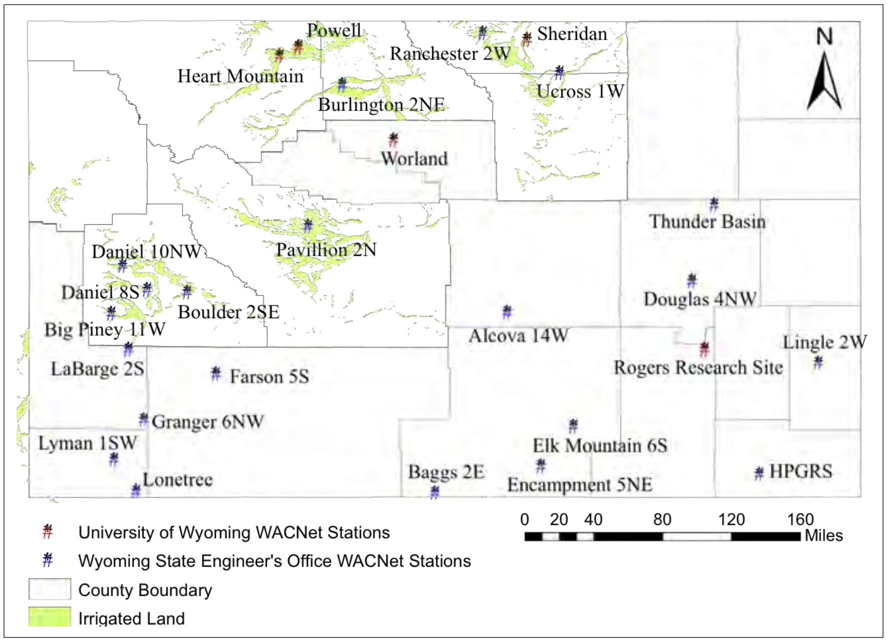

Figure 1. *The location of WACNet automated stations across Wyoming. Most of the stations are located in irrigated areas, the highlighted areas across the map. (HPGRS=High Plains Grasslands Research Station operated by the U.S. Department of Agriculture's Agricultural Research Service.)*

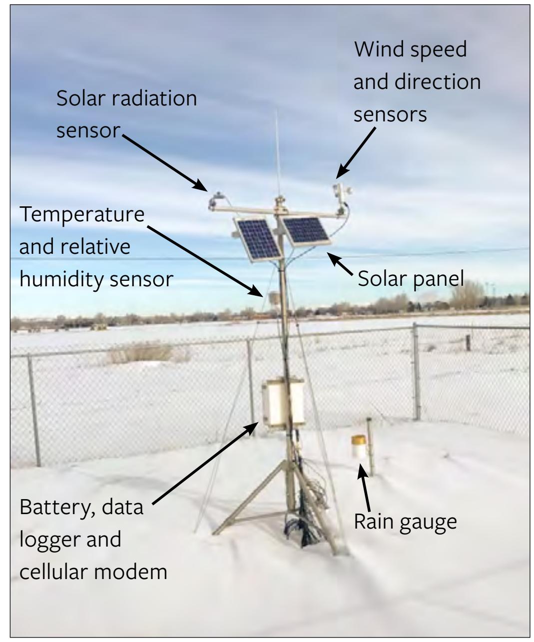

Figure 2. *WACNet automated weather station at Worland.*

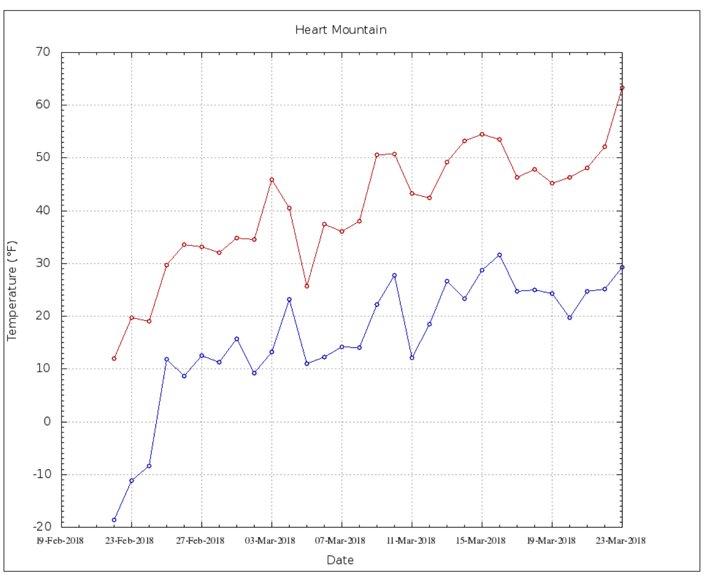

Figure 3. *Maximum and minimum temperature variations earlier this year at the Heart Mountain weather station near Powell.*

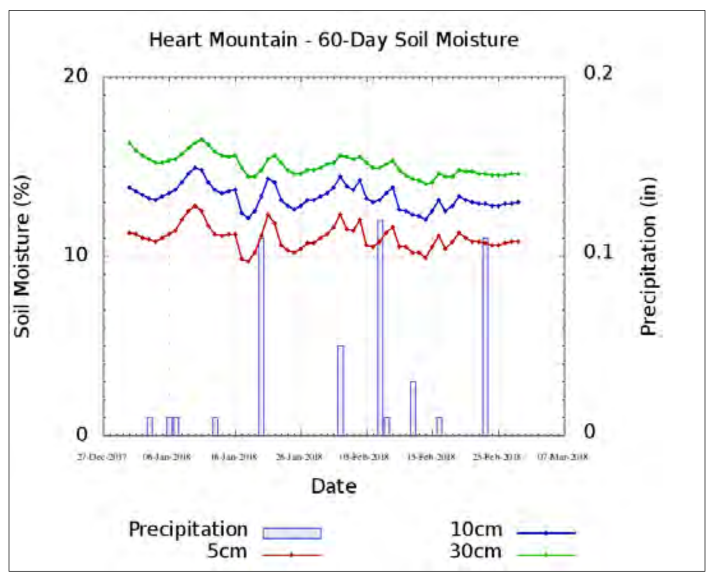

Figure 4. *Precipitation amounts along with soil moisture at different depths at the Heart Mountain station. The vertical bars show the amount of precipitation in inches. The horizontal lines show soil moisture percentage at the following depths: lower line=5 cm depth (~2 in); middle line=10 cm depth (~4 in); and top line=30 cm depth (~12 in).*

Survey of Wyoming Dry Bean Producers

John Tanaka[1–3] and Anna Collins[2]

Introduction

The Wyoming Bean Commission (wyomingbeancommission.org) was established in 2015 to collect funds and apply them to research on dry bean production. As the program began, the commission had little information on the type of research producers wanted to see done.

Objectives

The purpose of the study was to conduct a survey of Wyoming dry bean producers to ascertain what issues they would like to see addressed (e.g., disease and weed management, crop rotations, harvest methods, etc. [Table 1]).

Materials and Methods

A survey was designed and administered, and we then obtained approval from the University of Wyoming Institutional Review Board to conduct the survey. An introductory letter was sent to a random sample of dry bean growers in the state. This letter was followed-up by mailing them the survey, 'reminder' and 'thank you' postcards, and a second survey to those who had not responded.

Results and Discussion

Only 32 of 210 mailed surveys were returned and usable, implying that the results are +/-11% at the 80% confidence level. Pinto (55% of respondents) and great northern (26%) beans were stated as having the greatest research need. For those two bean classes only, the greatest research needs were harvest method (53% of respondents), applied herbicide injury (50%), weed management (50%), fertilization (47%), and disease management (31%). Table 1 presents the research needs (and associated respondent percentages) that were identified by producers for all bean classes grown in the state (pinto, great northern, navy, and other). Bean leaf hopper and grasshoppers were the only insect issues that were ranked highly as being a problem in beans. Similarly, white mold, common rust, and root rot were the most significant diseases mentioned. Nightshade was the main weed mentioned as being the most problematic.

Producers were also asked how they would like to receive research results. Extension bulletins, local newsletters, field days, classroom workshops, and websites were all deemed as good ways to relay research findings.

Results are indicative of what Wyoming bean producers believe are important research issues. Given the low response rate to the survey, the accuracy of the results may be low. Future surveys of this kind may require much more outreach to producers to get better response rates.

Acknowledgments

We thank the Wyoming Bean Commission, Wyoming Department of Agriculture Specialty Crop Block Grant Program, and Wyoming Agricultural Experiment Station for financial support.

Contact Information

John Tanaka at jtanaka@uwyo.edu or 307-766-5130.

Keywords: dry bean, research needs, Wyoming Bean Commission

PARP: I:11,14, II:2, IV:1,3, IX:3–6

[1]Wyoming Agricultural Experiment Station; [2]Department of Ecosystem Science and Management; [3]James C. Hageman Sustainable Agriculture Research and Extension Center.

Table 1. Research needs for all dry bean classes as specified by Wyoming producers.

Research Need	Respondents
Applied herbicide injury	63%
Weed management	59%
Fertilization	56%
Harvest method	53%
Disease management	38%
Frost damage	28%
Row spacing	25%
Micronutrient deficiency	25%
Hail damage	25%
Fertilizer application method	25%
Inoculation	22%
Emergence/stand	22%
Delayed planting	22%
Soil salinity	19%
Wind damage	16%
Water damage (beans still harvested)	16%
Water damage (beans drowned/not harvested)	16%
Use of ground roller	16%
Seed treatment insecticides	13%
Insect management	13%
Herbicide drift injury	13%
Drought	13%
Use of desiccants	9%
Seeding rate	9%
Fungus management	9%
Incorporating beans into a rotation	6%
Field scouting	6%
Residual herbicide	3%
Pop-up fertilizer	3%
Foliar feeding	3%
Dry-down response to water, heat, day length	3%

Alfalfa Weevil Growing-Degree Day Calculator Validation

Jeremiah Vardiman[1], Scott Schell[2], and Blake Hauptman[1]

Introduction

Alfalfa weevil (Hypera postica) continues to be a problem for Wyoming alfalfa hay producers, and the 2017 growing season was no different. Many hay producers report that spraying for the pest at least once a year is necessary to produce good alfalfa crops. At initially barely noticeable densities of just two larvae per plant stem, alfalfa weevil can cause yield losses of more than 400 lb/ac to the first and second cuttings combined. Low alfalfa weevil densities can also reduce the feed quality of hay. At high densities, you can't fail to notice them as the swather head will be covered with the wriggling green larvae.

Since alfalfa weevil grow and develop incrementally with increasing spring temperatures above 48°F, a growing degree-day (GDD) calculator can be utilized to determine the approximate dates to monitor fields for damage and time insecticide spray applications. GDD calculators are nothing new and are used widely in agriculture. In 1993, a GDD chart was published as part of a University of Wyoming Extension alfalfa weevil bulletin (type 'B-983' into the Search Publications bar at www.wyoextension.org/publications/). The bulletin includes average degree-day values for seven locations across Wyoming to give farmers approximate calendar dates to monitor for critical weevil activity. Unfortunately, the chart is not very precise because varying spring weather can change weevil development by several weeks, year to year.

Figure 1. *Three large alfalfa weevil larvae are barely visible in this photo of heavily damaged alfalfa. The weevils consume a lot of foliage and leave behind the coarse stems and leaf veins, further reducing the forage value of the hay left to harvest.*

Objectives

We are working on validating an internet-based GDD calculator to allow farmers to use their local weather station data to predict alfalfa weevil development. This would provide more accurate local sample dates and keep weevil monitoring efforts to a minimum by focusing the sample times to critical periods in the pest's lifecycle.

Materials and Methods

Validation of the GDD calculator started in 2017 and is continuing this year. We are comparing the computer's projected developmental stages for alfalfa weevil to actual developmental stages in field populations in several areas of the state. The developmental stages that will be monitored include egg hatch, instar 1, instar 4, and adult development (instar is the developmental stage of the larval forms of insects.) Collaborators collected samples of alfalfa weevils from producers' fields in the Bighorn Basin, Fremont County, and Sheridan areas. Samples were also collected from hay fields at the Sheridan Research and Extension (R&E) Center and Powell R&E Center. Sampling took place from March through late June both years.

A minimum of two fields were selected in each area to collect samples, and sampling occurred approximately four times at the designated developmental stages. Scott Schell, associate research scientist in the University of Wyoming's Department of Ecosystem Science and Management, is overseeing sample identification. The data from the samples will be compared to the growth stage predicted by the GDD model based on near real-time temperature data from numerous weather stations.

[1]*University of Wyoming Extension;* [2]*Department of Ecosystem Science and Management.*

Results and Discussion

A web-based GDD calculator has been developed, and we are now in the ‘ground-truthing’ phase of the project. This phase involves determining whether the GDD calculator is accurately predicting larval development by sampling for insects during the growing season from different regions of the state. Data from 2017 collections revealed multiple growth stages of weevils present at the sampling dates. In some instances, year-old adult weevils were found with multiple larval stages and new adults. This suggests that there are multiple hatches and an overlap of life cycles occurring, which could be part of the reason why weevil populations are now more difficult to manage in Wyoming than in the past. The final accuracy of the web-based GDD calculator in predicting important sampling dates will not be determined until after this year’s field sampling season. We anticipate releasing additional information in next year’s *Field Days Bulletin*.

Acknowledgments

We are grateful for the farmers who allowed the collection of samples from their fields. We also appreciate Allied Seed staff and personnel from the Sheridan and Powell R&E centers for their time and effort with sampling.

Contact Information

Jeremiah Vardiman at jvardima@uwyo.edu or 307-754-8836, or Scott Schell at sschell@uwyo.edu or 307-766-2508.

Keywords: alfalfa weevil, growing degree-day calculator, pest management

PARP: not applicable

Introduction to the Powell Research and Extension Center

Camby Reynolds[1] and Bret Hess[2,3]

Introduction

The Powell Research and Extension Center (PREC) is located one mile north of Powell at 747 Road 9 with an elevation of 4,378 feet. PREC has 200 irrigated acres, including 2.5 acres under on-surface drip, 1.2 acres under sub-surface drip, 112 acres under a variable-rate sprinkler, and 84 acres under surface irrigation using gated pipes and siphon tubes. Research at the center focuses on irrigation, weed control, cropping systems, variety trials, and alternative crops. We serve northwest Wyoming, including Big Horn, Fremont, Hot Springs, Park, and Washakie counties.

The faculty and staff at PREC include a researcher (Assistant Professor Vivek Sharma), a farm manager (Camby Reynolds), a research associate (Andi Pierson), two assistant farm managers (Brad May and Keith Schaeffer), and an office associate (Samantha Fulton). We are also assisted by graduate students and summer hires throughout the growing season. Bret Hess, director of the Wyoming Agricultural Experiment Station (WAES), serves as the interim director of PREC and provides administrative support mostly from the WAES office within the University of Wyoming College of Agriculture and Natural Resources in Laramie.

PREC Loses Valuable Team Member

Figure 1. *Assistant Professor Gustavo Marcello Sbatella, October 17, 1964–August 2, 2017.*

In 2017, we were saddened by the unexpected passing of UW Department of Plant Sciences Assistant Professor Gustavo Sbatella (Fig. 1). Gustavo was stationed at PREC and focused his work on irrigated crop and weed management. He was a pleasure to work with and contributed greatly to agriculture-related research and extension throughout the Bighorn Basin and Wyoming with his extensive knowledge and abundant energy. Our thoughts are with Gustavo's family, friends, colleagues, and the students he mentored.

PREC Focused on Variety Trials, Irrigation Studies

Last year was a busy year with a lot of exciting research happening at PREC and in the Bighorn Basin. We continue our efforts with trials in crops such as malt and feed barley, dry beans, corn, and sugarbeets in an effort to identify the best varieties for this region. We also have several irrigation studies designed to provide producers with more information about crop water-use requirements. To assist in this effort, Assistant Professor Vivek Sharma installed a Bowen ratio-energy balance (BREB) system. BREB measures multiple variables, among them incoming and outgoing short and longwave radiation, vapor pressure, soil heat flux, soil moisture every 12 inches to a depth of five feet, and evapotranspiration. This is an exciting addition to the research equipment at PREC. Data gained from the BREB system will be used to measure crop evapotranspiration and crop coefficients during the growing season and evaporative losses during the non-growing season. Our overall goal is to help growers and crop advisors manage irrigation water more efficiently.

2017 Growing Season

The 2017 growing season (Fig. 3) was fairly characteristic of the Powell area. We experienced large rain events in both April and September, totaling more than 1.5 inches each of these months.

Acknowledgments

We thank the PREC staff for stepping up to make sure everything was covered in a professional manner in 2017 and into this year. We appreciate your dedication to the success of the research center. We are also very appreciative of the input we receive from the PREC Advisory Board, which includes growers and industry representatives throughout the Bighorn and Wind River basins.

Contact Information

Camby Reynolds at sreynol3@uwyo.edu or 307-754-2223.

PARP: I, II, IV, VII, IX, X

[1]*Powell Research and Extension Center (PREC);* [2]*Interim Director, PREC;* [3]*Director, Wyoming Agricultural Experiment Station.*

Figure 2. *Bowen ratio-energy balance system for measuring crop evapotranspiration and crop coefficients during the growing season (A); and for measuring evaporative losses during the non-growing season (B).*

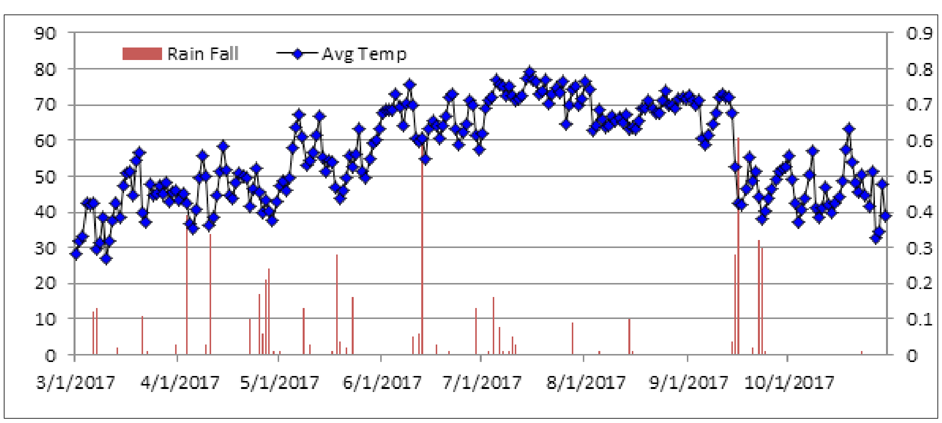

Figure 3. *Weather conditions in Powell for the 2017 growing season.*

Sugarbeet response to Insure Organics' soil enhancement

Investigators: Carrie Eberle and Caitlin Price Youngquist

Issue: Wyoming farmers need sustainable soil health programs to improve field productivity. New biological soil amendment products require testing for effectiveness and affordability for Wyoming agriculture.

Goal: Compare the effect of Insure Organics' biological soil amendment program on irrigated sugarbeets in Wyoming with the standard fertilizer programs recommended to growers.

Objectives: Measurement of stand establishment, uniformity, crop yield, sugar content, and economic cost and gains will be evaluated as well as soil health parameters.

Expected Impact: Learn if Insure Organics' program works in Wyoming to improve crop performance and soil health and if it is cost effective. Provide growers recommendations on application rates and frequency to maximize effectiveness.

Contact: Carrie Eberle at carrie.eberle@uwyo.edu or 307-837-2000.

Keywords: soil amendment, sugarbeet, sustainable farming

PARP: II:2

Figure 1. *Fall field application at the Powell Research and Extension Center. The barely visible dark bands in the field (middle and background) are where the soil amendment was applied.*

Dry bean soil-borne disease management with an integrated approach of tillage, variety, and in-furrow fungicides

Investigators: William Stump and Kyle Webber

Issue: Soil-borne dry bean diseases such as Rhizoctonia and Fusarium root rot are typically a perennial issue in dry bean production. Disease severity is dependent on environmental conditions, soil compaction, variety, and cropping history, with growers having limited options for control.

Goal: Determine if an integrated approach of a single in-furrow fungicide application at planting, varietal selection, and deep tillage to alleviate soil compaction is sufficient to protect the dry bean crop until harvest from soil-borne disease impacts.

Objectives: Evaluate an integrated approach combining different tillage options, up to five locally adapted cultivars, and in-furrow fungicides to compare the efficacy of disease control on Rhizoctonia and Fusarium.

Expected Impact: Results should assist growers in selecting the best cultivars to use in the presence of soil-borne disease, deciding whether a prescription deep tillage operation is worthwhile, and determining the most effective in-furrow fungicide treatments for season-long control.

Contact: William Stump at wstump@uwyo.edu or 307-766-2062.

Keywords: soil-borne disease, tillage, fungicide

PARP: I:11

Evaluation of goji berry as a high-value fruit crop in Wyoming

Investigators: Jeremiah Vardiman, Sadanand Dhekney, and Michael Baldwin

Issue: Some Wyoming producers, including local food producers, are always looking for alternative crops and markets to keep their operations economically viable, especially during years of poor crop prices. High-value alternative crops, such as fruit crops, can help provide economic stability and a new market to capitalize on. Unfortunately, Wyoming's climate (short growing season, early and late freezes, and harsh winters) makes fruit production difficult and inconsistent as a reliable cash crop.

Goal: Evaluate goji berry (*Lycium barbarum*) (Fig. 1) as a potential high-value crop for Wyoming and study the feasibility of organic production.

Objectives: Assess the performance of the cold-hardy (U.S. Department of Agriculture Plant Hardiness Zone 3a [-40 to -35°F) goji berry plant to determine the days required for flowering, fruiting, length of the growing season, and yield potential per plant at two locations, Powell and Sheridan, Wyoming.

Expected Impact: To date, this study indicates that goji berry plants are suitable for fruit production in some areas of Wyoming. In spring 2017, the plants broke dormancy between March 25 and April 5, which is approximately a month prior to grapevines growing within the same vineyard. The survival rate was 98%, and the total yield was 0.56 lb/plant over two harvest periods.

Contact: Sadanand Dhekney at sdhekney@uwyo.edu or 307-673-2754, or Jeremiah Vardiman at jvardima@uwyo.edu or 307-754-8836.

Keywords: goji berry, fruit, cold-hardy

PARP: I:1, X:1

Ingrid Balabanova, shutterstock.com

Figure 1. *Goji berry.*

Parasitism of Lygus Bugs in Wyoming Alfalfa

Timothy Collier[1] and Sophie DeBecquevort[2]

Introduction

Plant bugs in the genus *Lygus* are important pests of a number of different crops. In the Bighorn Basin, *Lygus* are critical pests of alfalfa grown for seed. Feeding by these bugs damages alfalfa flower buds, which dry up and often drop from the plant. Current recommendations for *Lygus* management are to spray insecticides during the bloom stage when four or more *Lygus* bugs are present in a sweep-net sample.

Management recommendations for *Lygus* in alfalfa do not, however, include numbers of natural enemies, which are sometimes included in pest management decision-making. Natural enemies that suppress *Lygus* bugs can indeed be present in alfalfa fields, but their impact has not been well studied in Wyoming. In alfalfa grown in Idaho, a species of parasitic wasp, *Peristenus howardi*, parasitizes 44–81% of the immature stages of *Lygus*, potentially providing substantial biological control of *Lygus*. In Arizona and California, a second species of parasitic wasp, *Leiophron uniformis*, has more modest effects, parasitizing a maximum of about 11% of *Lygus* in alfalfa. A potential explanation for the difference in impacts of the two wasp species is variations in their life cycles: the species from Idaho has two generations per year, whereas the species collected in Arizona and California has only one.

Objectives

The objectives of this study were to determine the levels of parasitism of *Lygus* in alfalfa at the Powell Research and Extension Center (PREC), and to determine if the apparently more effective species of parasitic wasp, *P. howardi*, is present.

Materials and Methods

Lygus bugs were collected using sweep nets on June 21 and July 18, 2017, from alfalfa fields at PREC. Of the 451 immature *Lygus* collected, 330 were reared on green beans (Fig. 1) until either pupation of the *Lygus* or emergence of wasp larvae; 121 immature *Lygus* were frozen for later dissection under a stereomicroscope.

Results and Discussion

A total of 12 wasp larvae emerged from *Lygus* immatures, indicating an overall parasitism rate of only 3.6%. All of the larvae formed cocoons, but none produced an adult wasp over the summer; therefore, none of these wasps was likely to be *P. howardi*, which would have produced a summer generation of adult wasps. Of the 121 immature *Lygus* that were dissected, 16 contained a wasp larva, indicating a parasitism rate of 13%. Parasitism rates were slightly higher in July than in June: 5% versus 3% for rearing, and 14% versus 8% for dissections, respectively. Identification of the wasp species is pending. We conclude that parasitism rates of *Lygus* at PREC were low and substantially below the rates observed in Idaho, and so did not contribute much to *Lygus* suppression. It is certainly possible that rates of parasitism are higher in other parts of the Bighorn Basin or may be higher at PREC in some years relative to 2017.

Acknowledgments

We thank Camby Reynolds and the late Gustavo Sbatella from PREC for enthusiastic assistance in identifying fields in which to sample. The study was supported by funding from the U.S. Department of Agriculture Hatch-Multistate Research Program.

Contact Information

Timothy Collier at tcollier@uwyo.edu or 307-766-2552.

Keywords: pest management, biological pest control, *Lygus* bug

PARP: I:2

[1]Department of Ecosystem Science and Management; [2]École Supérieure d'Agricultures - Angers (Higher School of Agriculture of Angers [France]).

Figure 1. *Container with green beans and newly collected Lygus bugs from the field, ready for transport to the laboratory.*

2017 Briess Barley Variety Performance Evaluation

Carrie Eberle[1], Andi Pierson[2], and Camby Reynolds[2]

Introduction

The Wyoming Agricultural Experiment Station (WAES) at Powell conducts barley variety performance trials as part of an ongoing research effort. In cooperation with private seed companies and regional small grain breeding programs, WAES evaluates a wide range of germplasm each year.

Objectives

The purpose of the trial is to evaluate the performance of new malting barley varieties against locally grown check varieties in collaboration with Briess Malt and Ingredients Co., based in Chilton, Wisconsin. With the growing number of small and craft breweries across Wyoming and the U.S., demand is increasing for new and unique malting ingredients including malt barley. The Bighorn Basin's climatic conditions vary greatly from other barley production regions, as does the performance of malting barley varieties. Data on grain yield, test weight, and plumpness are important to local and regional producers, as some malting varieties may not perform in some areas.

Materials and Methods

The experiment was located at the Powell Research and Extension Center (PREC) during 2017. Fertilizer was applied April 14 at the rate of 50 lb/ac of nitrogen, and 50 lb/ac of P_2O_5 in the form of urea (46-0-0) and monoammonium phosphate (11-52-0). The experimental design included small-plot trials conducted in randomized complete blocks with three replications and strip trials conducted in single-replicate strips.

On April 18, seven barley varieties were established in small plots 7.3 by 20 feet using double-disc openers set at a row spacing of 7 inches. On this same date, 11 barley varieties were established in strips 7.3 by 80 ft. The seeding depth was 1.5 inches, and the seeding rate was 110 lb/ac. Weeds were controlled by a post-emergence application of Husky® at 15 oz/ac. Furrow irrigations were May 16, June 5, June 19, July 3, and July 17. Measurements included height, grain yield, kernel plumpness, lodging (bending or kinking of stems at or near ground level, causing the plant to fall over), thinness (small seeds), and test weight (TWT). Plots were harvested August 24 using a Wintersteiger plot combine.

Results and Discussion

Results from 2017 are presented in Tables 1and 2. The highest yielding variety in the small-plot trial was 'Genie' at 147.7 bu/ac, which was significantly higher than the regional checks shown in bold in Table 1. Regional check varieties are AC Metcalfe, Harrington, Baronesse, and Steptoe. In the strip trial, 'Bojo' had the highest yield at 168.3 bu/ac. Complete results are posted online at www.uwyo.edu/uwexpstn/variety-trials/index.html.

Acknowledgments

Appreciation is extended to PREC staff and summer crews for their continuing support throughout the 2017 season.

Contact Information

Andi Pierson at apierso1@uwyo.edu or 307-754-2223.

Keywords: malt barley, variety trial, performance evaluation

PARP: I:12

[1]*Department of Plant Sciences;* [2]*Powell Research and Extension Center.*

Table 1. Malt barley results from 2017 small-plot trials. Each variety was replicated three times. **Bolded** varieties are regional checks.

Variety	Height (in)		Yield (bu/ac)		Plump (6/64)[1]		Plump (5.5/64)[1]		Thin[2]		Lodging (1–9)		TWT[3] (lb/bu)	
AC Metcalfe[4]	**30.3**	**A[7]**	**110.5**	**c**	**0.9**	**a**	**1.0**	**a**	**0.0**	**b**	**0.7**	**a**	**51.8**	**a**
Harrington	**30.2**	**a**	**129.1**	**abc**	**0.9**	**a**	**1.0**	**a**	**0.0**	**b**	**0.3**	**a**	**51.5**	**ab**
Baronesse	**30.3**	**a**	**126.6**	**abc**	**0.9**	**a**	**1.0**	**a**	**0.0**	**ab**	**0.3**	**a**	**51.9**	**a**
Steptoe	**27.8**	**ab**	**120.5**	**bc**	**0.8**	**b**	**0.9**	**b**	**0.1**	**a**	**0.3**	**a**	**47.5**	**d**
Genie[5]	27.8	ab	147.7	a	0.9	a	1.0	a	0.0	ab	0.7	a	50.7	ab
Acorn	27.8	ab	143.8	ab	0.9	a	1.0	a	0.0	b	0.7	a	48.9	cd
Odyssey	26.5	b	142.4	ab	0.9	a	1.0	a	0.0	b	0.0	a	50.0	bc
Mean	28.7		131.5		0.9		1.0		0.0		0.4		50.3	
LSD[6]	2.7		26.2		0.1		0.1		0.0		0.9		1.6	

[1]Plump=barley that remains on top of a 6/64 × 3/4 slotted-hole sieve and barley that remains on top of a 5.5/64 × 3/4 slotted-hole sieve;
[2]Thin=barley that passes through a 5.5/64 × 3/4 slotted-hole sieve;
[3]TWT=test weight;
[4]malt barley varieties in **bold** type are the regional checks;
[5]varieties in normal type are varieties being tested for Briess;
[6]LSD=least significant difference;
[7]varieties with the same letter are not significantly different, within each column.

Table 2. Malt barley results from 2017 strip trials. Strip trials only include one plot per variety and do not have any regional checks included.

Variety	Height (in)	Yield (bu/ac)	Plump (6/64)[1]	Plump (5.5/64)[1]	Thin[2]	Lodging (1–9)	TWT[3] (lb/bu)
Bojo	29.5	168.3	94%	98%	2%	1.0	51.3
Barke	26.5	167.8	85%	93%	7%	0.0	52.4
Manta	29.0	163.7	88%	95%	5%	0.0	50.6
Aberdeen S-3	28.0	154.6	81%	92%	8%	0.0	49.3
AC 09-668-24	29.0	153.9	92%	96%	4%	0.0	51.3
Malz	27.0	151.9	88%	94%	6%	1.0	52.0
Laudis	31.0	143.7	83%	93%	7%	0.0	50.7
Steffi	24.5	143.7	93%	97%	3%	0.0	51.7
Sangria	27.0	136.8	92%	96%	4%	1.0	52.6
Villa	26.0	134.1	94%	98%	2%	0.0	52.1
Pinnacle	32.0	128.2	96%	98%	2%	0.0	50.6

[1]Plump=barley that remains on top of a 6/64 × 3/4 slotted-hole sieve and barley that remains on top of a 5.5/64 × 3/4 slotted-hole sieve;
[2]Thin=barley that passes through a 5.5/64 × 3/4 slotted-hole sieve;
[3]TWT=test weight.

2017 Elite Malt Barley Variety Performance Evaluation

Carrie Eberle[1], Andi Pierson[2], and Camby Reynolds[2]

Introduction

The Wyoming Agricultural Experiment Station (WAES) at Powell conducts barley variety performance trials as part of an ongoing research program. In cooperation with the U.S. Department of Agriculture's Agricultural Research Service and private seed companies, WAES evaluates a wide range of germplasm each year.

Objectives

The purpose of the elite malt barley trial is to evaluate the performance of malting barley grown under variable climatic conditions. Wyoming's climatic conditions in the Bighorn Basin vary greatly from other U.S. barley growing regions, as does the performance of spring barley varieties. Data on grain yield and test weight are important to local and regional producers, as some malt varieties may not perform in some areas.

Materials and Methods

The experiment was located at the Powell Research and Extension Center (PREC) during 2017. Fertilizer was applied April 14 at the rate of 30 lb/ac of nitrogen; 25 lb/ac of P_2O_5; and 20 lb/ac of muriate of potash (MOP) in the form of urea (46-0-0), monoammonium, phosphate (11-52-0), and MOP (0-0-60), respectively. The experimental design of all trials was a randomized complete block with three replications.

On April 18, 30 barley varieties were established in plots measuring 7.3 by 20 feet using double-disc openers set at a row spacing of 7 inches. The seeding depth was 1.5 inches, and the seeding rate was 110 lb/ac. Weeds were controlled by a post-emergence application of Husky® at 15 oz/ac on June 6. Furrow irrigations were May 16, June 6, June 18, July 4, and July 18. Measurements included grain yield, test weight (TWT), height, lodging (bending or kinking of stems at or near ground level, causing the plant to fall over), and kernel plumpness. Subsamples, 5.3 by 15 feet, were harvested August 8 using a Wintersteiger plot combine.

Results and Discussion

Results from 2017 are presented in Table 1. The highest yielding malting entry was 'Merit 57' at 158 bu/ac. Entries in bold type in Table 1 are regional checks. Results are posted annually at www.uwyo.edu/uwexpstn/variety-trials/index.html.

Acknowledgments

Appreciation is extended to PREC summer crews and staff for assistance during 2017.

Contact Information

Andi Pierson at apierso1@uwyo.edu or 307-754-2223.

Keywords: malt barley, variety trial, performance evaluation

PARP: I:12

[1]*Department of Plant Sciences;* [2]*Powell Research and Extension Center.*

Table 1. Elite barley test results from 2017.

Cultivar Name	Yield bu/ac	TWT[1] lb/bu	Height in	Lodging 0/9	Plump[2] (6/64)
Merit 57[3]	**158**	**54**	**34**	**0.3**	**89%**
08ARS112-75[4]	157	53	31	0.0	87%
08ARS028-20	155	52	28	0.0	88%
2Ab08-X05M010-82	155	53	33	0.0	84%
08ARS116-91	152	53	33	0.7	91%
08ARS012-79	149	53	32	0.0	92%
11ARS183-9	148	53	33	0.0	90%
10ARS191-3	147	53	30	0.0	81%
10ARS138-9	145	54	34	0.3	93%
11ARS172-6	141	53	36	0.7	94%
2Ab08-X05M010-65	140	53	31	0.0	77%
10ARS144-1	139	52	32	0.7	88%
AC Metcalfe	**139**	**50**	**33**	**0.0**	**94%**
12ARS048-7	138	52	30	0.3	94%
11ARS162-8	137	53	31	0.0	93%
Voyager	**136**	**54**	**33**	**0.0**	**94%**
11ARS162-4	136	53	30	0.0	88%
12ARS061-2	135	53	32	0.3	96%
10ARS061-2	135	53	33	0.0	92%
2Ab08-X04M278-35	134	54	30	0.3	86%
12ARS053-6	132	51	31	0.3	85%
10ARS034-5	130	52	31	0.0	91%
M69	**129**	**53**	**27**	**0.0**	**90%**
Conrad	129	53	32	0.0	91%
10ARS110-2	128	54	27	0.0	90%
10ARS175-3	128	53	32	0.3	94%
11ARS189-5	126	52	36	0.7	92%
Harrington	**125**	**54**	**31**	**0.0**	**82%**
11ARS127-2	124	53	26	0.3	83%
CDC Copeland	**119**	**52**	**33**	**0.3**	**87%**
Location Mean	138	50	32	0	0.89
Checks Mean	133	50	32	0	0.90
LSD (.05)[5]	26.2	2.0	2.2	0.6	0.06

[1]TWT=test weight;
[2]plumpness=barley that remains on top of a 6/64 × 3/4 slotted-hole sieve, and barley that remains on top of a 5.5/64 × 3/4 slotted-hole sieve;
[3]entries in **bold** type are regional checks;
[4]entries in normal type are varieties being evaluated;
[5]LSD=least significant difference: the mean yields of any two varieties being compared must differ by at least the LSD amount shown to be considered different at the 5% level of probability of significance.

2017 Western Regional Spring Barley Nursery Performance Evaluation

Carrie Eberle[1], Andi Pierson[2], and Camby Reynolds[2]

Introduction

The Wyoming Agricultural Experiment Station (WAES) at Powell conducts malting and feed barley variety performance trials as part of an ongoing research program. In cooperation with the U.S. Department of Agriculture's Agricultural Research Service and private seed companies, WAES evaluates a wide range of germplasm each year.

Objectives

The purpose of the Western Regional Spring Barely Nursery is to evaluate the performance of malting and feed barley grown under variable climatic conditions at about 15 sites across the West (including Powell) and one site in Saskatchewan, Canada. Wyoming's climatic conditions in the Bighorn Basin vary greatly from other U.S. barley growing regions, as does the performance of spring barley varieties. Data on grain yield and test weight are important to local and regional producers, as some varieties may not perform in some areas.

Materials and Methods

Our trial was located at the Powell Research and Extension Center (PREC) during 2017. Fertilizer was applied April 14 at the rate of 50 lb/ac of nitrogen, and 50 lb/ac of P_2O_5 in the form of urea (46-0-0) and monoammonium phosphate (11-52-0). The experimental design of all trials was a randomized complete block with three replications.

On April 18, 31 barley varieties were established in plots measuring 7.3 by 20 feet using double-disc openers set at a row spacing of 7 inches. The seeding depth was 1.5 inches, and the seeding rate was 110 lb/ac. Weeds were controlled by a post-emergent application of Husky® at a rate of 15 oz/ac on June 5. Furrow irrigations were May 16, June 5, July 3, and July 17. Measurements included grain yield, test weight (TWT), height, lodging (bending or kinking of stems at or near ground level, causing the plant to fall over), and plumpness. Subsamples measuring 5.3 by 15 feet were harvested August 18 using a Wintersteiger plot combine.

Results and Discussion

Results from 2017 are presented in Table 1. The highest yielding entry was 11WA-107.58 at 145 bu/ac. This entry is both a feed and malt variety and was in the bottom 25% in 2016 for yield. Entries in bold type in Table 1 are regional checks. Results are posted annually at www.uwyo.edu/uwexpstn/variety-trials/index.html.

Acknowledgments

Appreciation is extended to PREC staff and summer crews for assistance during 2017.

Contact Information

Andi Pierson at apierso1@uwyo.edu or 307-754-2223.

Keywords: barley, variety trial, performance evaluation

PARP: I:12

[1]*Department of Plant Sciences;* [2]*Powell Research and Extension Center.*

Table 1. 2017 Western Regional Spring Barley Nursery results.

Cultivar Name	Row Type	Grade	Yield bu/ac	TWT[1] lb/bu	Height in	Lodging 0/9	Plump[2] (6/64)
11WA-107.58[3]	2 row	Feed/Malt	145	53	32	0.3	96%
2B11-4949	2 row	Malt	144	52	32	0.7	93%
UTBS10905-72	6 row	Feed	144	49	33	1.0	94%
MT124677	2 row	Feed/Malt	142	52	31	0.0	93%
2B10-4162	2 row	Malt	140	51	30	0.3	77%
2B12-5582	2 row	Malt	138	51	29	0.3	92%
08ARS028-20	2 row	Malt	138	51	32	0.0	87%
CDC Fraser	2 row	Malt	137	50	32	0.3	93%
11WA-107.43	2 row	Feed/Malt	136	53	32	0.0	93%
MT090190	2 row	Feed/Malt	136	52	33	0.3	92%
2B10-4378	2 row	Malt	135	52	31	0.3	89%
08ARS112-75	2 row	Malt	134	51	30	0.3	90%
08ARS116-91	2 row	Malt	134	52	33	0.7	89%
10ARS191-3	2 row	Malt	133	51	35	0.3	87%
UTSB10902-91	6 row	Feed	132	49	34	0.7	93%
Harrington[4]	**2 row**	**Malt**	**129**	**52**	**32**	**0.3**	**92%**
MT124128	2 row	Feed/Malt	128	52	28	0.7	94%
MT124134	2 row	Feed/Malt	128	51	30	0.3	94%
BZ512-282	2 row	Feed	127	49	33	0.3	77%
Baronesse	**2 row**	**Feed**	**127**	**52**	**30**	**0.3**	**89%**
MT124112	2 row	Feed/Malt	126	52	29	0.3	96%
10WA-117.17	2 row	Feed/Malt	124	52	32	0.3	89%
10WA-106.18	2 row	Feed/Malt	124	52	33	0.7	84%
2B11-5166	2 row	Malt	124	50	31	0.7	87%
CDC Bow	2 row	Malt	123	51	33	0.7	92%
2ND32529	2 row	Malt	121	50	32	0.3	90%
Steptoe	**6 row**	**Feed**	**121**	**47**	**29**	**0.7**	**81%**
BZ512-220	2 row	Feed	120	47	31	0.0	75%
2ND33760	2 row	Malt	114	52	33	0.3	89%
12WA-120.14	2 row	Feed/Malt	114	52	34	0.7	90%
AC Metcalfe	**2 row**	**Malt**	**111**	**52**	**32**	**0.3**	**91%**
Location Mean			129	51	32	0.4	89%
Checks Mean			122	51	31	0.4	88%
LSD (0.05)[5]			20.25	1.73	1.48	0.87	0.05

[1]TWT=test weight;

[2]plump=barley that remains on top of a 6/64 × 3/4 slotted-hole sieve and barley that remains on top of a 5.5/64 × 3/4 slotted-hole sieve;

[3]entries in normal type are entries being tested;

[4]entries in **bold** type are regional checks;

[5]LSD=least significant difference: the mean yields of any two varieties being compared must differ by at least the LSD shown to be considered different at the 5% level of probability of significance.

2017 Dry Bean Performance Evaluation

Mike Moore[1], Camby Reynolds[2], Jolene Sweet[1], and Andi Pierson[2]

Introduction
The Wyoming Seed Certification Service funds and coordinates the dry bean variety performance evaluation at the Powell Research and Extension Center (PREC).

Objectives
Wyoming's climate is locally variable, as is dry bean varietal yield potential and days to maturity. Yield potential and data on days to maturity are important to producers, as moderate-and long-season bean varieties may not mature in all areas.

Materials and Methods
Weed control consisted of a pre-plant incorporated treatment of 40 oz of Eptam® and 2 pints Sonalan® per acre. The plots received 60 units of nitrogen, 30 units of phosphorous, and five units of zinc per acre. The plot design was a complete randomized block with four replications. The seeding rate was four seeds per foot of row, on 22-inch rows. The three-row by 20-foot plots were planted June 2, 2017. Visual estimates were made for the number of days to reach 50% bloom (50% of plants with a bloom) and days to maturity (50% of the plants with one buckskin pod). Subplots of one row by 10 feet were pulled by hand and threshed with a stationary plot thresher.

Results and Discussion
Stand establishment was poor due to crusting created by heavy rain after planting. While all entries matured prior to the first frost, precipitation delayed threshing, and resulted in shattering losses for some lines that may not have occurred under better harvest conditions. Producers interested in selecting varieties for their specific situation can contact the lead author (contact information below) or their crop adviser.

Acknowledgments
This study was conducted with the assistance of PREC staff.

Contact Information
Mike Moore at mdmoore@uwyo.edu, 307-754-9815, or 800-923-0080.

Keywords: dry bean, performance evaluation, yield trial

PARP: I:12

[1]Wyoming Seed Certification Service; [2]Powell Research and Extension Center.

Table 1. Agronomic data, 2017 dry bean performance evaluation, Powell, Wyoming.

Name	Market class	Bloom Days after Planting	Buckskin Days after Planting	Yield lb/ac	Seeds per Pound
PT10-12-1	pinto	53	88	3033	1299
NE2-16-33	pinto	51	88	2615	1107
Black Foot	pinto	51	81	2365	1274
Nez Perce	pinto	54	87	2335	1399
Twin Falls	pinto	56	90	2921	1339
La Paz	Pinto	56	90	3155	1210
Othello	Pinto	49	77	3096	1157
Staybright (COSD 35)	SLD[1]	54	90	3403	1268
COSD-7	SLD	51	85	2780	1262
Palomino	SLD	49	85	3264	1175
SR10-2-1	small red	52	86	2344	1177
ACUG 13-SR1	small red	57	89	2161	2245
ACUG 15-B4	black	57	93	3019	2189
ACUG 14-1	navy	50	86	1918	2086
Eclipse	Black	57	88	3026	2326
Dynasty	DRK[2]	49	91	2912	796
DRK 1	DRK	50	92	2592	980
Cornell 612	LRK[3]	49	86	1984	845
CELRK	LRK	49	81	2137	788
CO 14790-3	Pinto	54	88	2989	1253
	Mean	52	87	2702	1359
	LSD[4]	2	2	857	95
	CV[5]	2.4	1.5	19.1	4.2

[1]SLD=slow-darkening pinto;
[2]DRK=dark red kidney;
[3]LRK=light red kidney;
[4]LSD=least significant difference;
[5]CV=coefficient of variation.

Edible Dry Beans as Part of Improved Crop Rotations in Wyoming

Jay Norton[1] and Jim Heitholt[2]

Introduction
Crop rotations in Wyoming's irrigated production areas are changing rapidly as marked increases in sugarbeet yields reduce the acreage needed to supply sugar refineries. Wyoming sugarbeet acreage has declined by nearly half in recent years, while edible dry beans have seen a 20% increase in acreage from the 1990s to present. The shift in crop rotations coincides with steady transition from furrow irrigation to overhead sprinklers, which creates opportunities for conservation tillage systems; however, dry bean production practices that include undercutting for harvest are not suitable for conservation-oriented strategies. Reduced- or zero-tillage practices combined with direct harvest create much less soil disturbance than the approaches typically used in Wyoming, but information about the growth and yield of different dry bean varieties under different tillage and irrigation practices is needed.

Objectives
Our objectives are to evaluate growth and yield of four dry bean varieties within a sugarbeet–dry bean–barley rotation under (1) conservation and typical tillage management; and (2) typical full irrigation and 75% of full irrigation.

Materials and Methods
For the first year of this anticipated three-year study, four varieties of edible dry beans were planted on June 1, 2017, under a lateral-move overhead sprinkler at the Powell Research and Extension Center (PREC). One six-row strip (22-inch rows) of each variety was planted within each of four treatments: (1) conventional till/full irrigation; (2) conventional till/limited irrigation; (3) minimum till/full irrigation; and (4) minimum till/limited irrigation. The study was embedded in the bean phase of a long-term sugarbeet–bean–barley rotation study that began in 2014. Varieties included COSD-7 (now called Sundance), Windbreaker, Monterrey, and Poncho, which were selected to represent varieties known to be both suitable and unsuitable for direct harvest as part of the minimum-till system. Strips were divided into three 60-foot-long subplots within each of the two tillage-by-irrigation treatments (4 varieties × 4 treatments × 3 subplots equal 48 plots total) (Table 1; Fig. 1).

During the 2017 growing season, canopy temperature (an indicator of drought stress) was collected on July 12, and plant height and above-ground biomass were collected on August 14 and 15 (discussed below). To determine grain yield, two 10-foot sections of row were hand-harvested in each plot on September 9. In subsequent growing seasons (starting in 2018 and through the duration of the study) beans and barley will be moved to follow sugarbeet within the sugarbeet–dry bean–barley rotation. A description of tillage practices under the minimum and conventional tillage systems is included in Table 1.

Results and Discussion
Under conventional tillage, Poncho beans yielded the best under both full and limited irrigation levels (Fig. 1). Under limited irrigation in the conventional tillage treatment, Poncho exceeded yields of the other varieties under full irrigation except for COSD-7. The minimum-till plots were impacted by excessive weeds that affected growth and yield traits. Under limited irrigation, Monterrey and Windbreaker beans produced statistically similar yields in the minimum tillage treatment as they did under conventional tillage. Canopy temperatures ranged from 91 to 95°F on July 2 and were not impacted by varieties or treatments. Plant height in mid-August generally reflected yields, but was not impacted as much by tillage or irrigation level. Total above-ground plant biomass was fairly even within tillage treatments, but the weight of pods in the early maturing variety Poncho was almost twice as high as the other varieties. In summary, deficit irrigation and minimum tillage reduced grain yield in 2017. Although we expected the upright varieties (COSD-7, Monterrey, and Windbreaker) to perform better than the prostrate variety (Poncho) under minimum tillage, that was not the case.

Acknowledgments
We thank PREC field crews for plot management. The study is supported by the Wyoming Bean Commission and Wyoming Department of Agriculture Specialty Crop Block Grant Program.

Contact Information
Jay Norton at jnorton4@uwyo.edu or 307-766-5082.

Keywords: tillage, dry bean, deficit irrigation

PARP: I:1,3,7,9,13, II:6, IV:3,4, IX:1,4, X:2

[1]Department of Ecosystem Science and Management; [2]Department of Plant Sciences.

Table 1. Tillage operations in the long-term (since 2014) tillage by irrigation study at PREC in which the current dry bean variety study was embedded into the earlier study.

	Sugarbeet	**Dry Bean**	**Malt Barley**
Conventional Tillage (CT)	**Previous Fall** (after barley): Moldboard plow to ~9 inches. Level with mulcher × 2.# **Spring**: Disc to incorporate fertilizer.	**Previous Fall** (after beet): Moldboard plow to ~9 in. Deep rip following beets if compaction detected. Level with mulcher × 2. **Spring**: Incorporate fertilizer.	**Previous Fall** (after bean): Moldboard plow to ~9 in. Level with mulcher × 2. **Spring**: Disc to incorporate fertilizer.
Minimum Till (MT)	**Previous Fall**: None, or strip-till to prep seedbed. **Spring**: Strip-till following broadcast fertilizer.	**Previous Fall**: None, or strip-till to accommodate barley drill. Deep rip following beets if compaction detected. **Spring**: No-till.	**Previous Fall**: None, or strip-till to accommodate barley drill. **Spring**: No-till.

× 2 means that this operation was done twice.

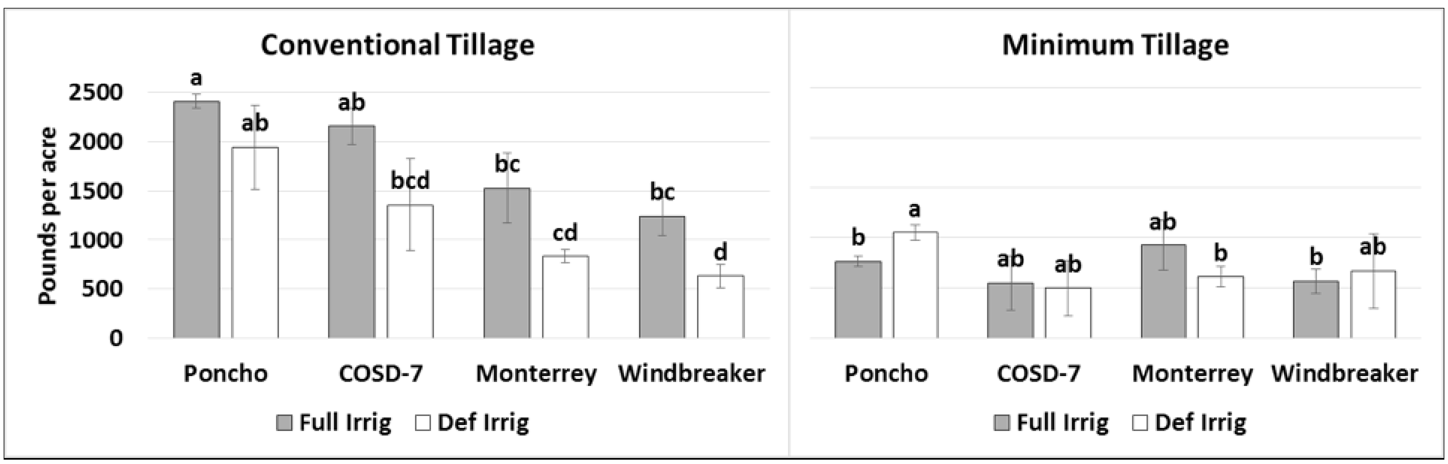

Figure 1. *Yields of variety by tillage and irrigation (full and deficit irrigation). Error bars indicate standard error (n=3). Different letters indicate significant differences within tillage levels at the p<0.1 level.*

Screening Dry Bean Genotypes for Drought Tolerance in Wyoming

Vivek Sharma[1,2] and Jim Heitholt[2]

Introduction

Sustainable dry bean production in the semiarid to arid regions of Wyoming is only possible with irrigation (surface or sprinkler), as rainfall does not supply the required amounts of water for growth. In recent years, many Wyoming dry bean production areas did not receive adequate irrigation water for the complete growing season(s), and producers are not certain that they will have adequate water to grow their bean crops in future years. Thus, profitability for Wyoming dry bean producers will require genotypes having drought tolerance.

Objectives

Our objectives are to identify dry bean genotypes that are tolerant to drought under the semiarid to arid conditions of Wyoming.

Materials and Methods

The field experiments were conducted during the 2016 and 2017 growing seasons at the Powell Research and Extension Center (PREC) and James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). This paper highlights findings from 2017 (the 2016 results are in the 2017 *Field Days Bulletin*, pages 46–47, available at www.uwyo.edu/uwexpstn/publications/index.html).

Our 2017 study was a split-plot arrangement with 36 and 25 genotypes replicated three times at PREC and SAREC, respectively. Treatments included well-watered (full irrigation treatment [FIT]) and drought stressed (65% FIT). Plots were sown on May 23 and June 6, 2017, at PREC and SAREC, respectively.

A drought susceptibility index (DSI) based on minimization of yield loss under stress conditions in comparison to optimum conditions was used to characterize relative drought tolerance of dry bean genotypes (see Fischer and Maurer, 1978). Low DSI values represent the cultivars that have less difference in yield between well-watered and drought treatments. To further identify the cultivars that have lower DSI numbers and higher average yields, the average yield for each cultivar was correlated with DSI and divided into four different groups. This division was made based on DSI (numbers less than 0.8) and the average yield of all the genotypes tested at PREC and SAREC (Fig. 1).

Results and Discussion

Average yield data from both drought-stressed and well-watered treatments were compared to assess the effect of water stress on dry bean yield (Table 1). For the 2017 growing season, yields for the wellwatered treatments were 25% and 34% higher at PREC and SAREC, respectively, than beans in the drought treatment (average for all genotypes). The difference between well-watered and drought treatment at SAREC, in part, is due to different management practices (30-inch row spacing at SAREC vs. 22-inch row spacing at PREC) and climatic conditions. The average total seasonal precipitation and air temperature at SAREC was 0.87 inches and 01.71°F greater than PREC for the 2017 growing season. The cultivars Common Red Mexican and Poncho exhibited the highest yield at PREC and SAREC.

DSI analysis showed that genotypes CELRK, Twin Falls (originally tested under the name UIP-40), CO91216-15, CO-33176-1, Talon, and CO-14790-3 were less susceptible to drought stress as indicated by their low DSI (Group A, Fig. 1). These genotypes, however, were among the lowest-yielding cultivars under full irrigation. For the Bighorn Basin growing area, our results indicate that genotypes such as Desert Song, Medicine Hat, Powderhorn, CO-46348, and Monterrey are higher yielding and ranked as drought tolerant (DSI less than 0.8; Group B, Fig. 1). For the bean growing areas of southeast Wyoming, genotypes including Poncho, Avalanche, CO-25069-2, UI-537, and CO-91216-15 are higher yielding and drought tolerant (Group B, Fig. 1).

Acknowledgments

The study is supported by U.S. Department of Agriculture Hatch funds and the Wyoming Bean Commission. The authors thank PREC and SAREC crews for help with field work.

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Contact Information

Vivek Sharma at vsharma@uwyo.edu or 307-754-2223.

Keywords: drought, irrigation, dry bean

PARP: I:12, IV:3,4, IX:4, X:1

[1]*Powell Research and Extension Center;* [2]*Department of Plant Sciences.*

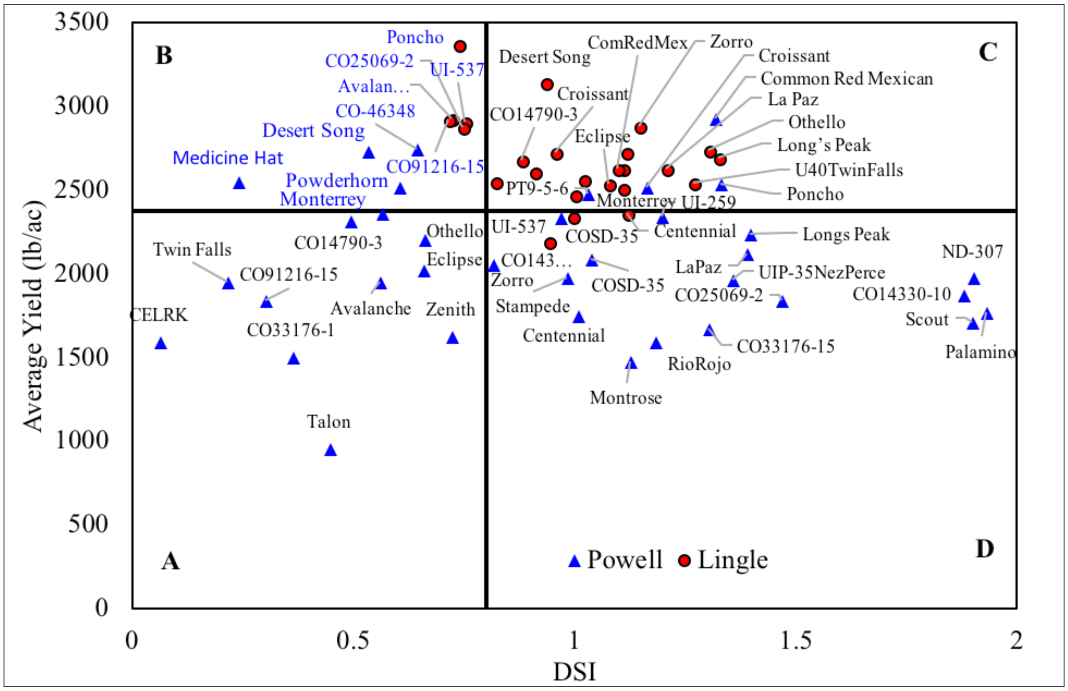

Figure 1. *Diagram showing the distribution of dry bean cultivars based on their average seed yield (across both irrigation rates) and drought susceptibility index (DSI). Horizontal and vertical lines indicate the mean average yield for 36 and 25 genotypes tested at PREC and SAREC, respectively. DSI <0.8 was used as our arbitrary cut-off for drought tolerance. Group A: genotypes that are less susceptible to drought produce lower yields. Group B: genotypes that are relatively high yielding and also less susceptible to drought. Group C: genotypes that are high yielding and more susceptible to drought. Group D: genotypes that are less yielding and more susceptible to drought.*

Table 1. Dry bean average, maximum, and minimum yield (lb/ac) under two watering regimes (well-watered and dry) during the 2017 growing season at PREC (Powell) and SAREC (Lingle).

	Treatments	Average	Max	Min
Powell, WY 2017	Well-Watered	2320 lb/ac	3565 lb/ac	1019 lb/ac
			Common Red Mexican	Talon
	Dry	1743 lb/ac	2521 lb/ac	896 lb/ac
			Desert Song	Talon
Lingle, WY 2017	Well-Watered	3244 lb/ac	3856 lb/ac	2615 lb/ac
			Poncho	CO-14339-10
	Dry	2134 lb/ac	2884 lb/ac	1774 lb/ac
			Poncho	CO-14339-10

Dry Bean Growth Dynamics in Response to Deficit Irrigation Under Surface- and Sprinkler-Irrigation Systems

Abhijit Rai[1], Jim Heitholt[1], and Vivek Sharma[1,2]

Introduction

Dry edible beans (*Phaseolus vulgaris* L.) are grown on approximately 41,000 acres in Wyoming. Dry bean yields depend largely on amount of leaf area, speed of leaf formation, plant height, and normalized difference vegetation index (NDVI; an index that relates to plant health and greenness). To achieve optimal dry bean growth, favorable irrigation amounts and timings, proper nutrient levels, and other factors come into play. In recent years, however, many Wyoming farmers have faced water availability and climate variability issues. Under these circumstances, adopting efficient irrigation-management strategies (such as deficit irrigation) is crucial to maintain high productivity. Therefore, understanding growth dynamics of dry beans in response to various irrigation levels could help producers develop more efficient irrigation strategies, which, in turn, could help them maintain or improve yields.

Objectives

This study seeks to understand the response of dry bean leaf area index (LAI), plant height, and normalized difference vegetation index (NDVI) to full and limited irrigation under surface- and sprinkler-irrigation systems.

Materials and Methods

Field experiments were conducted in 2017 at the Powell Research and Extension Center (PREC). Dry bean cultivar 'Othello' was planted in sprinkler- and furrow-irrigated fields with five irrigation treatments: full irrigation treatment (FIT), 75% FIT, 50% FIT, 25% FIT, and 125% FIT (an excess irrigation treatment) in 22-inch rows at 90,000 seeds/ac. The experiment was laid out as a randomized block design with three replications. LAI, plant height, and NDVI were measured weekly throughout the growing season and stopped when the plants were nearing maturity.

Results and Discussion

The variation in LAI, plant height, and NDVI within and between the two irrigation methods and five irrigation treatments are presented in Figure 1. As expected for both sprinkler- and surface-irrigated dry beans, LAI and NDVI increased as the canopy developed, peaked in the middle of the growing season, and then decreased as the dry beans progressed toward maturity. Plant height gradually increased as the season progressed and peaked at the reproductive stage; thereafter, plant height changed little.

In the sprinkler-irrigated fields, imposing water stress resulted in shortening of the flowering and pod periods, and it also reduced leaf formation. LAI, plant height, and NDVI were highest in FIT and lowest in 25% FIT. The excess irrigation treatment (125% FIT) did not result in any additional benefit. In surface-irrigated fields, the highest LAI, plant height, and NDVI were recorded for 50% and 25% FIT, and lowest for 125% FIT. Lower LAI, plant height, and NDVI values for 75% and FIT are likely due to floodinglike stress. No statistically significant differences were observed between the values recorded for each treatment in surface irrigation.

Our study indicates that both modes of water application (sprinkler and surface) have a significant effect on dry bean growth parameters. For the two systems, both excess and insufficient irrigation resulted in growth parameters outside the range observed within the optimal irrigations.

Acknowledgments

The study is supported by U.S. Department of Agriculture Hatch funds and the Wyoming Department of Agriculture. We thank PREC crews for help with field activities.

Contact Information

Vivek Sharma at vsharma@uwyo.edu or 307-754-2223.

Keywords: irrigation, dry bean, normalized difference vegetation index

PARP: IV:3,4, X:1

[1]*Department of Plant Sciences;* [2]*Powell Research and Extension Center.*

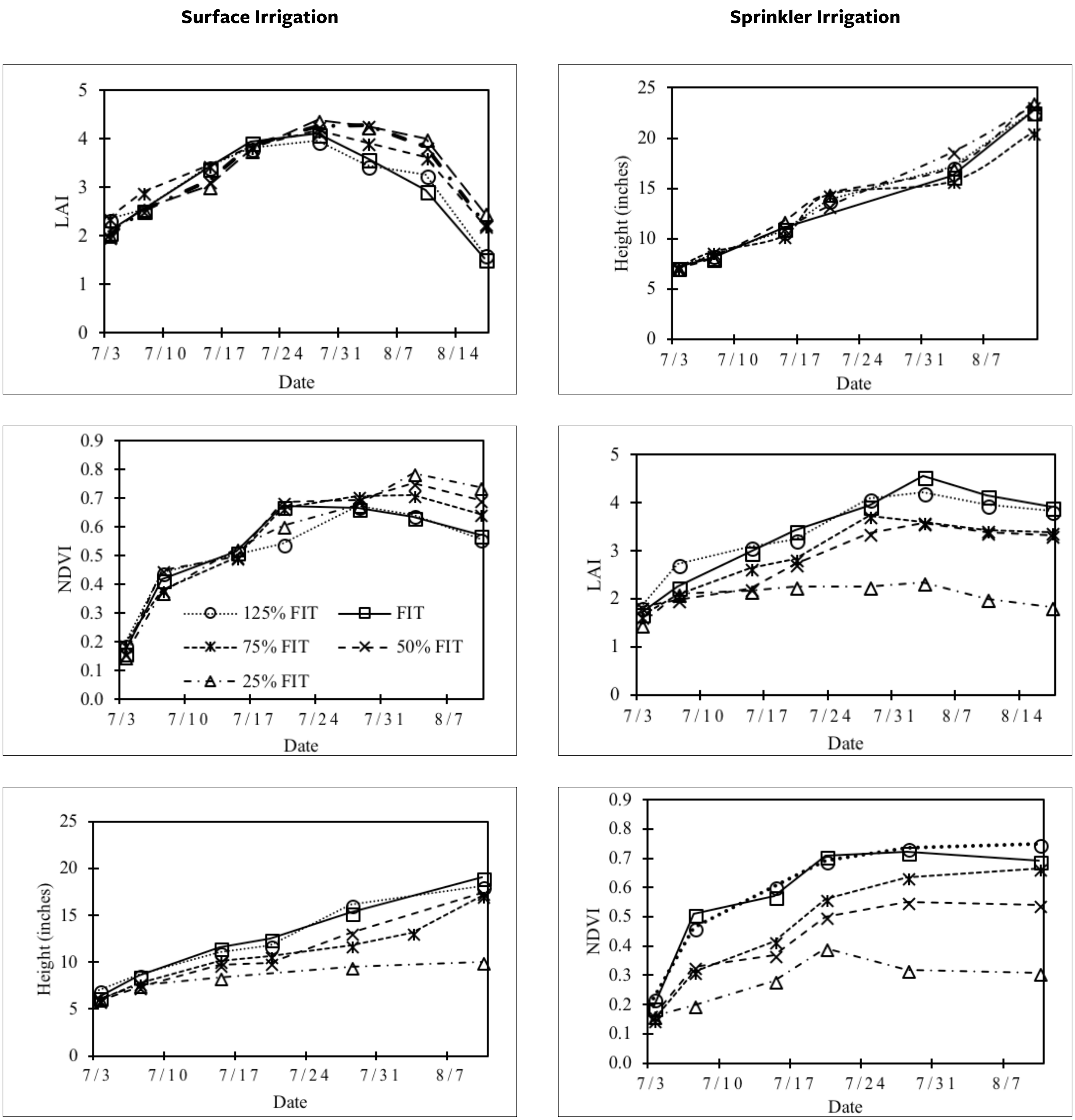

Figure 1. *Dry bean leaf area index (LAI), plant height (ht), and normalized difference vegetation index (NDVI) under FIT (full irrigation treatment), 75% FIT, 50% FIT, 25% FIT, and 125% FIT in surface- and sprinkler-irrigated fields at PREC.*

Dry Bean Yield Response to Deficit Irrigation Under Surface- and Sprinkler-Irrigation Systems

Vivek Sharma[1,2], Abhijit Rai[1], and Jim Heitholt[1]

Introduction

The aim of any crop production scheme is better quality and quantity. Dry bean is very sensitive to water deficit, which can lead to large yield reductions. The extent and duration of drought stress in dry bean are directly associated with total dry bean biomass and seed yield, number of pods and seeds per plant, root length and mass, and maturation time. In Wyoming, dry bean production is largely dependent on irrigation; however, in recent years the state has faced both water availability and climatic variability challenges. In addition, irrigation-management decisions by growers are increasingly influenced by costs associated with irrigation, e.g., labor, water, pumping, etc. Therefore, it becomes essential to understand dry bean yield response to various irrigation levels under different irrigation systems. Having a better understanding of yield dynamics should enable growers to use water more efficiently and, in turn, increase farm income.

Objectives

This study seeks to understand dry bean yield response to full and limited irrigation under surface- and sprinkler-irrigation systems.

Materials and Methods

The field experiments were conducted in 2017 at the Powell Research and Extension Center (PREC). Dry bean variety 'Othello' was planted in sprinkler- and furrow-irrigated fields under five irrigation treatments: FIT (full irrigation treatment), 75% FIT, 50% FIT, 25% FIT, and 125% FIT (an excess irrigation treatment). The experiment was laid out as a randomized block design with three replications. At maturity, an area 10 feet long by two rows wide was hand-harvested from three locations in each plot for bulk yield analysis (Fig. 1*A*). In addition, two plants and their pods were harvested separately to analyze pod harvest index, seeds per pod, and number of pods per plant (Figs. 1*B–D*, respectively).

Results and Discussion

Drought stress affected both the seed yield and yield components. Figures 1*A–D* summarize the average yield, pod harvest index (PHI), seeds per pod (SP), and number of pods per plant (PP) in response to treatments under sprinkler and surface irrigation. In the sprinkler-irrigated treatment, maximum yield (2,935 lb/ac), PHI (75%), SP (3), and PP (17) were observed for FIT. The 75% and 125% treatments produced lower yields, PHI, SP, and PP compared to FIT. Imposing more stress on the crop by further reducing the applied water to 50% and 25% of FIT resulted in a significant yield reduction and lower PP ($p<0.05$); however, no significant differences were observed in PHI and SP at 25% and 50% FIT, compared to FIT.

In the surface-irrigation treatment, the highest yield of 2,204 lb/ac and PHI of 74% were observed for 50% FIT, while the highest SP (3.7) and PP (18) were observed for 25% FIT. The lowest yield, PHI, SP, and PP were observed for the excessive irrigation treatment (125% FIT). This is due to excess water stress, which promotes early plant maturation and yield reduction. No significant difference was observed between the values recorded for each treatment in surface irrigation.

Overall, our results indicate that for FIT, dry bean performed better under sprinkler irrigation compared to surface irrigation; however, mixed responses for yield and yield components were observed for the deficit-irrigation treatment. For both the sprinkler- and surface-irrigation treatments, dry bean did not perform well with excessive irrigation. This is an ongoing study, and for 2018 we are collecting plant biomass for additional analyses to evaluate the performance of dry bean plants with different irrigation regimes.

Acknowledgments

The study is supported by U.S. Department of Agriculture Hatch funds and the Wyoming Department of Agriculture. We thank PREC crews for help with field activities.

Contact Information

Vivek Sharma at vsharma@uwyo.edu or 307-754-2223.

Keywords: deficit irrigation, dry bean, yield

PARP: IV:3,4, X:1

[1]*Department of Plant Sciences;* [2]*Powell Research and Extension Center.*

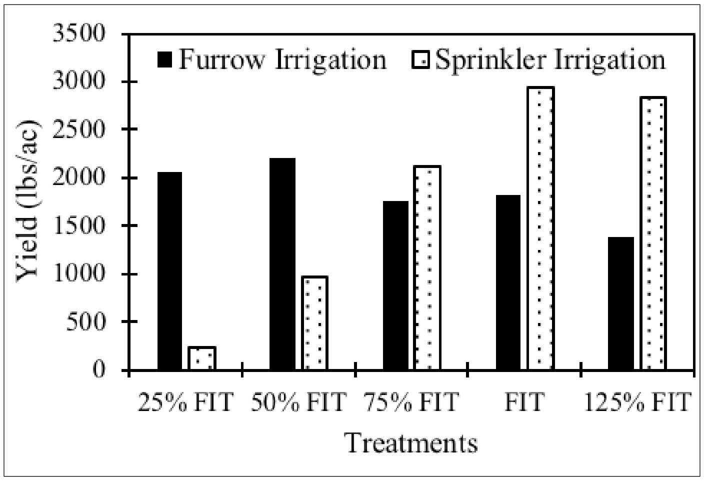

Figure 1A. *Dry bean mean yield (14% moisture content).*

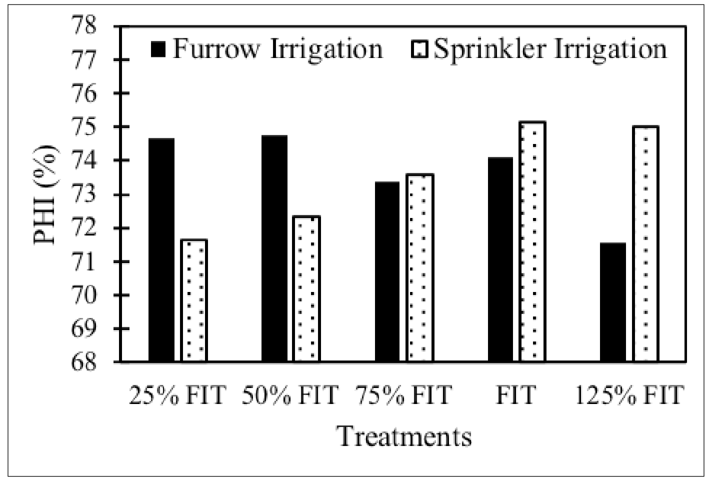

Figure 1*B*. *Pod harvest index. PHI=(seed weight)/(seed weight + pod wall weight).*

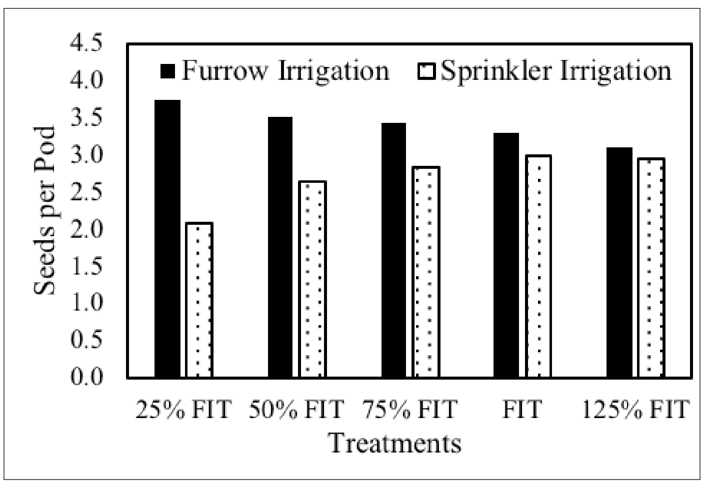

Figure 1C. *Seeds per pod (SP).*

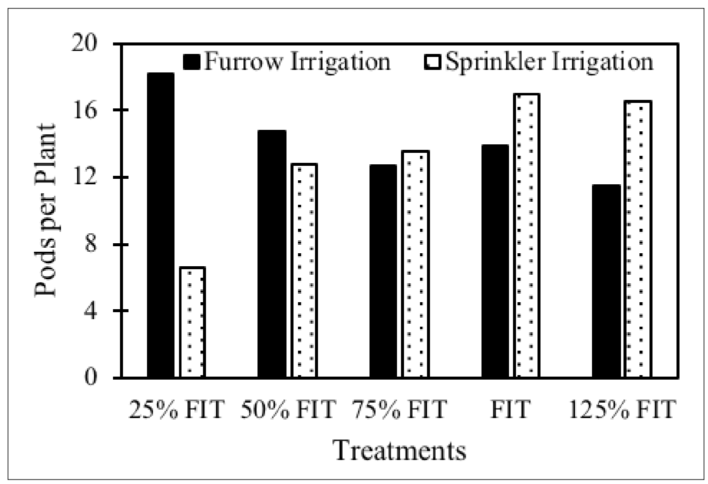

Figure 1*D*. *Pods per plant (PP).*

Quantification of Growing-Season Crop Evapotranspiration for Sugarbeet in Wyoming

Vivek Sharma[1,2]

Introduction

The sugarbeet (*Beta vulgaris*) is one of the most important irrigated row crops in Wyoming. In 2015, farmers harvested ~9.3 million tons from 31,200 acres—and the value of production was ~$41 million (Brandt and Hussey, 2016). Improving sugarbeet irrigation management can have significant impacts on both quantity and quality of sugarbeet, and it can also help producers better manager their own water needs while helping to conserve Wyoming's water resources. Efficient irrigation management in sugarbeet production requires adequate quantification of growing-season water use, i.e., crop evapotranspiration (ETc).

ETc represents direct loss of water from the field by evaporation from the soil and transpiration by plants. ETc is highly dependent on crop type, growth stages, soil management, and meteorological conditions such as air temperature, solar radiation, relative humidity, and wind speed. It is a powerful indicator of crop water productivity. A reliable estimate of ETc is also vital to develop criteria for in-season water management, particularly in the context of irrigation scheduling, water allocations, long-term estimates of water supply, and the design and management of water distribution structures (e.g., canals, reservoirs). Detailed information about ETc is in the University of Wyoming Extension Bulletin B-1293, *Evapotranspiration: Basics, Terminology and its Importance*, available at www.wyoextension.org/publications.

Objectives

The main objectives are to quantify sugarbeet daily and seasonal variation in crop evapotranspiration (ETc).

Materials and Methods

The study was conducted in 2017 at the Powell Research and Extension Center (PREC). The field was prepared with conventional tillage and fertilized with a nitrogen blend (SSN-46N and SSP 11-52-0) based on soil samples collected May 5. Eight days later, the sugarbeet hybrid 9418RR was planted at a 1-inch depth with a projected plant density of 50,000/ac. Plants emerged from May 25 to May 29, and urea-ammonium nitrate (UAN 32%) was side-dressed June 29. Irrigation was applied using a Global Positioning System-guided, variable-rate center-pivot sprinkler system. Weed and pest control was uniformly applied to the entire field as needed. Sugarbeets were harvested October 12.

BREB System Installed at PREC

A Bowen ratio-energy balance (BREB) system was installed on June 24, 2017, in the middle of the sugarbeet field (Fig. 1) to measure hourly, daily, and seasonal fluctuations of ETc and other energy balance fluxes (e.g., net radiation, soil heat flux, and sensible heat flux). BREB is an integrated system consisting of temperature-humidity sensors (at two heights above the crop canopy to measure the vertical heat and vapor gradient) and a double-sided total hemispherical radiometer (to measure longwave, shortwave, and net radiation). Also included are heat flux plates and three soil thermocouples to measure soil heat flux. In addition, rainfall and wind speed/direction are recorded using a rainfall sensor cup and an anemometer, respectively. A detailed description of the BREB system and its components is provided by Irmak (2010).

Results and Discussion

In this section, we highlight the sugarbeet ETc from June 27 to the end of sugarbeet growing season, October 15 (Fig. 2). Daily ETc varied from 0.02 inch on June 27 to 0.32 inch on July 14, while the season average was ~0.20 inch/day. The season's total ETc was ~20 inches (Fig. 2). Relative to days after planting and thermal units (an indicator for assessing crop development), sugarbeet growth can be divided into four stages: early season, development, full cover, and late season. ETc percentages during these four stages in 2017 were 2.0, 35.2, 51.3, and 11.5 of total seasonal ETc, respectively. Low ETc at the early season growth stage is due to non-availability of data before June 27. Average ETc during the early, development, full cover, and late season were 0.10, 0.23, 0.22, and 0.11 inch/day, respectively. Sugarbeet ETc data presented in this study along with soil water measurements will assist producers in managing their irrigation systems more effectively, e.g., irrigation timing and amounts. In addition, having ETc data for the entire season allows producers to better plan water needs for the full year.

[1]*Department of Plant Sciences;* [2]*Powell Research and Extension Center.*

Acknowledgments
This study is supported by U.S. Department of Agriculture Hatch funds and Western Sugar Cooperative. We thank PREC crews for their help in installing the BREB system.

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Contact Information
Vivek Sharma at vsharma@uwyo.edu or 307-754-2223.

Keywords: evapotranspiration, sugarbeet, irrigation efficiency

PARP: IV:3,4, X:1

Figure 1. *The Bowen energy balance system in a developed sugarbeet field at PREC.*

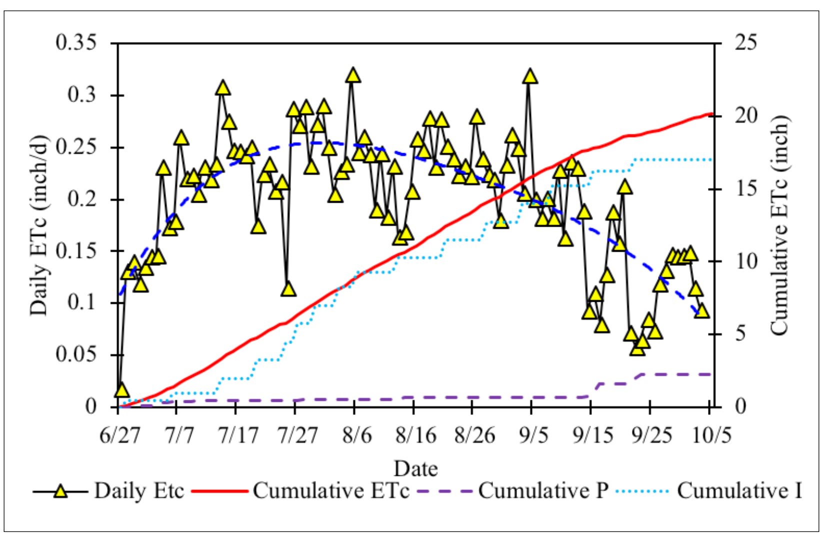

Figure 2. *Sugarbeet daily crop evapotranspiration (ETc), cumulative ETc, cumulative precipitation (P), and cumulative irrigation (I) for the 2017 growing season.*

Development of Sugarbeet Crop Coefficients

Vivek Sharma[1,2]

Introduction

Accurate quantification of crop evapotranspiration (ETc [see definition in previous paper]) is one of the critical parameters for effectively managing irrigation, especially in semiarid regions like Wyoming. In general, measuring ETc is a difficult, time-consuming process requiring advanced measurement techniques and expensive instrumentation. In many cases, ETc is estimated using the experimentally derived crop coefficient (Kc) together with reference evapotranspiration (ETref). ETref is defined as the rate of water loss by evaporation and transpiration from a healthy (free of water stress and diseases) grass or alfalfa reference surface. Detailed information on ETc, ETref, and reference surfaces are provided in the University of Wyoming Extension Bulletin B-1293, *Evapotranspiration: Basics, Terminology and its Importance,* available at www.wyoextension.org/publications. Kc, meanwhile, incorporates crop canopy characteristics and management practices. Each crop has a different set of specific Kc values used to predict water use rates at different growth stages; however, not much is known about the daily and seasonal patterns and magnitudes in daily Kc values for sugarbeet in the semiarid Wyoming growing areas.

Objectives

The objectives of this study are to develop daily alfalfa- and grass-reference crop coefficients (Kc) for sugarbeet based on days after planting (DAP) and thermal units (growing degree days, GDD) (see B-1293 for details).

Materials and Methods

A field experiment was conducted at the Powell Research and Extension Center (PREC) in 2017. A detailed description of field-management practices and ETc are provided in the previous paper. Sugarbeet Kc values based on grass (Kco) and alfalfa (Kcr) reference surfaces were calculated from ETc values obtained from the Bowen ratio-energy balance (BREB) system in the field. We then used the following formula to estimate ETref:

$$Kco = \frac{ETc}{ETo} \; ; \; Kcr = \frac{ETc}{ETr}$$

Daily grass-reference (ETo) and alfalfa-reference (ETr) evapotranspiration were computed using the standardized American Society of Civil Engineers Penman-Monteith equation (Task Committee on Standardization of Reference Evapotranspiration, 2005). GDD (°F) was calculated using daily average air temperature (Tavg) and the base temperature threshold (Tbase) for sugarbeet survival (34°F) and is expressed as:

$$GDD = \sum_{i=1}^{n} (Tavg - Tbase)$$

Results and Discussion

Grass- and alfalfa-reference crop coefficients as a function of days after planting (DAP) and growing degree days (GDD) are presented in Figures 1*A–D*. In general, Kc values were low in the early season stages, gradually increased before reaching maximum values toward the middle of the growing season, and then decreased toward the end of the season. The average Kco and Kcr values for the four growth stages are presented in Table 1.

The sugarbeet Kc values presented from our study are higher than reported by Allen et al. (1998). They reported values of 0.35 for initial stages, 1.20 for mid stages, and 0.70 for late growth (Allen et al, 1998, did not report a Kc value for the crop development stage). Higher values are largely attributed to the differences in cultivars used in our study, methods used, climatic conditions, and perhaps, more importantly, soil and crop management practices. This further justifies the significance of developing local Kc values for accurate quantification of sugarbeet water use.

The extremely low value of 0.70 at the late growth stages reported by Allen et al. (1998) is due to the fact that they reported late Kc values for no irrigation during the late growth stage. Under the semiarid conditions of the Bighorn Basin, however, four to five irrigation events generally occur from the first week of September until harvest, which resulted in higher sugarbeet Kco and Kcr values in our study. In addition, at harvest, we noticed that plant canopy coverage was still greater than 70%. Producers can use the reported Kc values to estimate actual crop water use. For example, if the ETref (based on the alfalfa reference surface) for sugarbeet mid-stage (August 15–20) is 1.20 inches and Kc is 1.15 (Table 1), the actual crop water use is 1.38 inches

[1]*Department of Plant Sciences;* [2]*Powell Research and Extension Center.*

(ETc=ETref × Kc)=1.20 × 1.15=1.38). And if the application efficiency of the irrigation system is considered to be 85%, then 1.6 inches should be applied (1.38 inches ÷ 0.8 =1.6 inches) to meet the crop water requirement and to account for irrigation application losses. (Note: an application efficiency of 85% was used as an example. It can vary among irrigation systems and how the systems are managed.)

Acknowledgments
This study is supported by U.S. Department of Agriculture Hatch funds and Western Sugar Cooperative. We thank PREC crews for help in installing the BREB system.

Literature Cited

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Task Committee on Standardization of Reference Evapotranspiration, 2005, The ASCE standardized reference evapotranspiration equation: Environmental and Water Resources Institute, American Society of Civil Engineers, *x* + 59 p.

Contact Information
Vivek Sharma at vsharma@uwyo.edu or 307-754-2223.

Keywords: sugarbeet, evapotranspiration, crop coefficient

PARP: IV:3,4, X:1

Table 1. Distribution of sugarbeet crop coefficient based on grass (Kco) and alfalfa (Kcr) reference surfaces for different growth stages at PREC, 2017.

	Initial	Crop Development	Mid Stage	Late Growth
Kco	0.57	1.04	1.43	1.40
Kcr	0.44	0.83	1.15	1.08

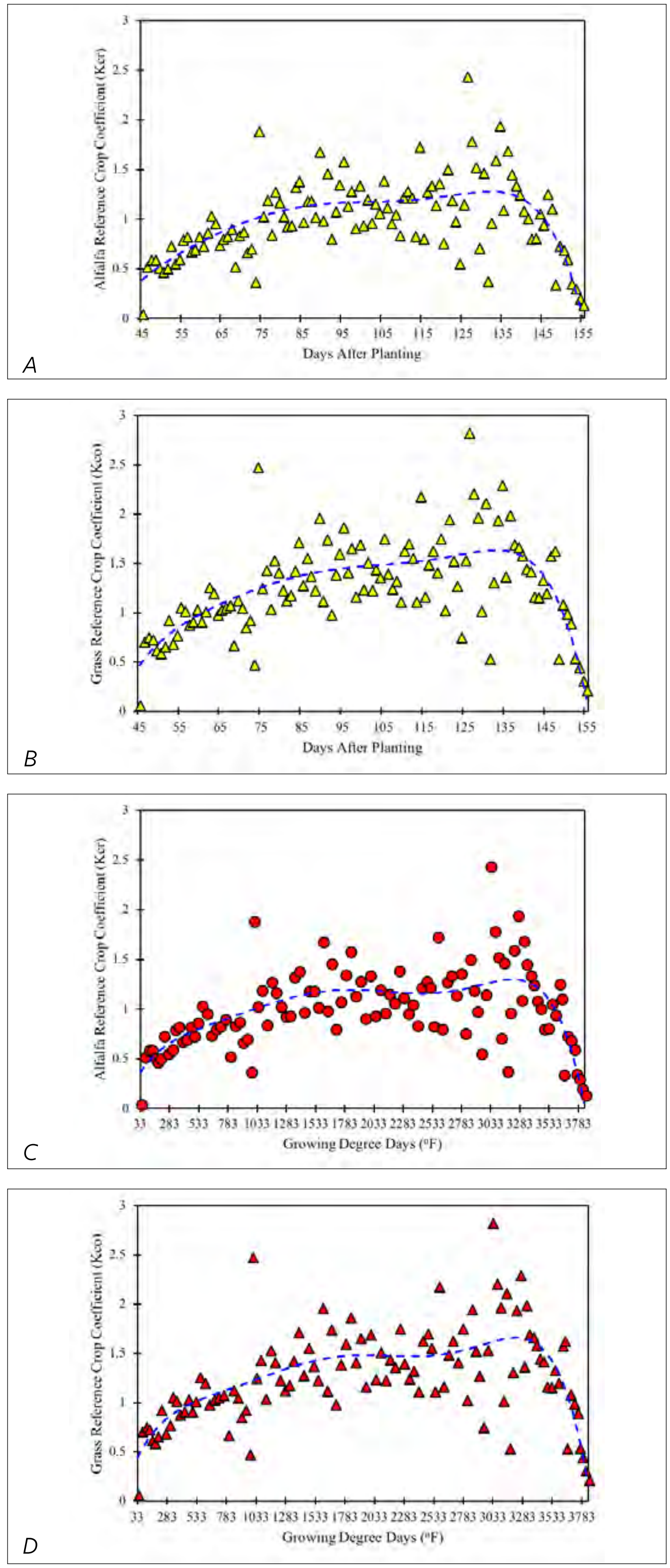

Figure 1. *Alfalfa- (**A** and **C**) and grass- (**B** and **D**) reference crop coefficients (Kcr and Kco, respectively) for sugarbeet as a function of days after planting (DAP; **A** and **B**) and growing degree days (GDD; **C** and **D**).*

Management of Rhizoctonia Root and Crown Rot Disease in Sugarbeet with a Fungicide-Herbicide Tank Mix to Improve Farm Efficiency

Stephan Geu[1] and William Stump[1]

Introduction

Treating sugarbeet seed with a fungicide prior to planting is recommended for various soil-borne diseases including those caused by Rhizoctonia. Infection by Rhizoctonia, however, can occur all season, and seed treatment is only effective for up to six weeks after planting, at which point foliar applications of fungicide may be necessary. This fungicide application typically occurs around the time the second to third application of Roundup® herbicide would be applied to the crop for weed control. Our research in 2016 investigated the potential of tank mixing Quadris®, Priaxor®, and Proline® 480 SC fungicides along with the glyphosate herbicide Roundup PowerMAX®. In 2017, we added an additional generic formulation of Quadris® fungicide called Satori® (active ingredient azoxystrobin) to the study. By combining fungicide with the herbicide application, efficacy can be improved due to reduced trips across the field.

Objectives

The objectives are to determine if co-applying fungicide and the herbicide glyphosate is a viable, crop-safe, and effective management practice for Rhizoctonia root and crown rot disease management in sugarbeets.

Materials and Methods

The second year of the study was established in 2017 at both the Powell Research and Extension Center (PREC) and James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) with four replicates. Prior to planting, plot areas were inoculated with *Rhizoctonia solani* grown on barley at two inoculum levels. Sugarbeets were planted on May 8 (PREC) and May 12 (SAREC). All seed used was treated with Kabina ST at standard rates. Foliar fungicides and Roundup PowerMAX were applied at the 8- to 10-leaf stage. Treatment structure was such that all fungicide + Roundup tank mixes were compared to a sequential application of the same fungicide-Roundup combination. All fungicides and Roundup were applied at normal field rates and compared to non-inoculated and inoculated checks. Parameters measured included weed control, crop injury, Rhizoctonia disease incidence (as measured by crop canopy cover decline), and sugar yield (Table 1).

Results and Discussion

There was no statistical evidence that co-application affected herbicide or fungicide efficacy at either site. Additionally, there was no evidence that co-application caused any crop injury at either site (data not shown in Table 1). Disease severity was lower with the fungicide treatments compared to the inoculated untreated check at both locations. There were some differences in disease severity between the different fungicides at SAREC. Weed pressure, as determined by weed counts, was higher at the SAREC location, which could have caused poor fungicide deposition in some plots due to uneven weed pressure, possibly confounding results. A majority of the treatments improved the final sugar yield compared to the inoculated check. In conclusion, based on results from the past two years, there was no evidence that tank mixing Roundup PowerMax and the four fungicides tested had any effect on weed and disease control efficacy or on crop injury.

Acknowledgments

We thank PREC and SAREC field crews for assistance in plot establishment, maintenance, and harvesting, and Western Sugar Cooperative for quality analysis. The study was supported by funding from Western Sugar Coop and the Big Horn and Wind River Basins Applied Research Fund.

Contact Information

William Stump at wstump@uwyo.edu or 307-766-2062.

Keywords: Rhizoctonia management, fungicide-herbicide co-application, sugarbeet

PARP: I:11

[1]*Department of Plant Sciences.*

Table 1. Management of Rhizoctonia root and crown rot of sugarbeet with foliar-broadcast fungicide and glyphosate treatments at PREC and SAREC in the 2017 field season.

Treatments and rates[1] (fl oz/ac)	Total weed counts (2 yd²)		Rhizoctonia disease severity (% canopy decline)		lb sugar/ac	
	PREC	SAREC	PREC	SAREC	PREC	SAREC
Non-inoculated check Roundup[2] (24)	1.1 a[3]	5.3 a	0.6 c	0.3 e	6,877.8 a	8,277.0 a
Inoculated check Roundup (24)	0.3 a	736.0 a	4.8 a	5.8 a	3,990.2 c	2,439.4 f
Priaxor (0.46) + Roundup (24) tank-mix	0.3 a	5.0 a	4.0 ab	3.5 b	4,881.4 bc	5,059.5 cd
Priaxor (0.46) Roundup (24)	0.1 a	16.8 a	3.4 ab	3.0 bc	5,482.0 b	3,068.4 ef
Proline (0.33) + Roundup (24) tank-mix	0.6 a	7.9 a	3.4 ab	2.5 bcd	5,168.4 bc	4,582.3 de
Proline (0.33) Roundup (24)	0.3 a	5.4 a	4.1 ab	1.9 d	5,500.0 b	6,431.5 bc
Quadris (10.5) + Roundup (24) tank-mix	0.8 a	7.1 a	4.3 ab	2.1 cd	5,155.6 bc	5,298.4 bcd
Quadris (10.5) Roundup (24)	0.8 a	9.3 a	3.8 ab	2.1 cd	5,245.9 b	5,795.8 bcd
Satori (10.5) + Roundup (24) tank-mix	0.4 a	5.3 a	3.4 ab	2.0 cd	5,795.9 ab	6,883.9 ab
Satori (10.5) Roundup (24)	0.6 a	8.9 a	3.9 ab	1.9 d	5,460.6 b	5,703.7 bcd

[1]Unless indicated as a tank-mix treatment, treatments were applied sequentially (after first application was dry).

[2]Roundup PowerMAX was the herbicide used, but 'PowerMAX' was deleted from this list because of space limitations.

[3]Treatment means followed by a different letter are significantly different (Fisher's protected least significant difference, $p \le 0.05$).

Introduction to the James C. Hageman Sustainable Agriculture Research and Extension Center

John Tanaka[1–3]

Introduction

The James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) was established in 2002, and research activities began fully in 2006. SAREC has 349 acres of irrigated cropland using a combination of three center pivots, a lateral-move sprinkler, and furrow irrigation (Fig. 1). There are 1,223 ac of dryland crops, primarily in wheat and corn, 2,180 ac of rangeland, and a 400-head feedlot. SAREC also oversees management of the approximate 320-ac Rogers Research Site in the North Laramie Mountains near Laramie Peak, land that was gifted to the University of Wyoming by Colonel William C. Rogers.

SAREC Personnel

We work as a team (Fig. 2) to provide the best possible research and extension activities, serving a six-county region in eastern Wyoming (Albany, Converse, Goshen, Laramie, Niobrara, and Platte), the state as a whole, and other regions with similar crop and livestock production issues. We welcome Blaine Magnuson to our team (Fig. 3). Blaine was hired as a research aide to help with all of the ongoing and future studies at SAREC. He comes to Wyoming from Nebraska, where he was running a ranch after graduating from Chadron State College. Our research includes small- to large-plots on cropland, rangeland restoration, grazing on pasture and rangelands, and feeding primarily cattle in the feedlot. Additionally, we are heavily involved in extension activities throughout the year by providing a place for hands-on demonstrations and also giving talks and writing articles of interest to a wide variety of constituents. We are highly committed to conducting research and extension activities that help solve issues for farmers, ranchers, agricultural organizations, the owners of small acreages, the managers of both public and private lands, and others.

Developments

In 2017, during a period of severe weather, we escaped the tornados, but were hit by a microburst of wind that blew apart one of our sheds (Fig. 4). We are working with UW insurance personnel to get it rebuilt. We continue to focus on maintaining what we currently have, and we have also developed a plan to upgrade and modernize our equipment over the next several years. We have installed small paddocks for long-term grazing system and soil health research.

We are improving our infrastructure to accommodate as much cutting-edge research as we can. Along those lines, we are pleased to start several new long-term projects on the center related to sustainable agriculture. Included in this effort are using carbon products to amend the soil, planting different mixes of pasture grasses, establishing an irrigated organic field, growing first grains (aka ancient grains, including spelt and emmer wheat), along with all of the novel research you will read about in the SAREC section of the *Field Days Bulletin*.

All of us are involved in outreach and engagement with farmers, ranchers, agribusinesses, and our communities. One program that was finally given a name is our Taters for Tots. SAREC assistant farm manager Al Unverzagt has taken the lead with this effort, in which we grow a patch of potatoes and invite local fourth-grade students to come out and pick some spuds. Students also go to the classroom to learn a little about agriculture.

Acknowledgments

SAREC was formed to be a place where applied research will be conducted to help agricultural production in the region become more sustainable. Our mission is to serve the citizens of Wyoming, the region, and nation by facilitating innovative discovery, dissemination, and engagement of integrated agricultural systems that are ecologically sound, economically viable, and socially acceptable. The success of SAREC depends upon the staff and faculty, and the advice we get from farmers, ranchers, and agribusinesses through our newly created SAREC Advisory Board and through more informal meetings and discussions. These efforts are among the reasons why SAREC can provide a quality location for faculty, staff, students, and others from UW and beyond to conduct their research and extension activities.

[1]*Director, James C. Hageman Sustainable Agriculture Research and Extension Center;* [2]*Associate Director, Wyoming Agricultural Experiment Station;* [3]*Department of Ecosystem Science and Management.*

Figure 1. *Overhead view of the main irrigated fields.*

Figure 2. *From left, Troy Cecil, Kevin Madden, Kelly Greenwald, Al Unverzagt, Lori Schafer, Steve Paisley, Jeff Edwards, Carrie Eberle, Kylah Meyer, Aberle Filley, Larry Miller, John Tanaka, Larry Howe, and Brian Lee.*

Figure 3. *Blaine Magnuson joined the SAREC team as a research aide. Here, he applies a carbon-based soil amendment to determine the effects of such amendments on soil characteristics and grass production.*

Figure 4. *Shed damage from the summer 2017 windstorm.*

Contact Information

John Tanaka at jtanaka@uwyo.edu or 307-837-2000.

PARP: I, II, III, IV, VI, VII, VIII, IX, X, XI, XII

Alternative winter dryland crops

Investigator: Carrie Eberle

Issue: Wyoming dryland wheat farmers need ways to increase profitability and reduce farm risk through sustainable intensification of acres, development of new cropping rotation strategies, and integrated agricultural systems.

Goal: Study the potential to grow the winter crops pea and camelina—in rotation with winter wheat—under dryland conditions in southeast Wyoming.

Objectives: Evaluate Austrian winter pea, winter pea 'WyoWinter', winter camelina 'Bison', and winter camelina 'Joelle' for stand establishment, winter survival, water use, and seed and biomass production when seeded into standing wheat stubble and prepared dryland fields.

Expected Impact: Results should provide growers information on planting management and production potential of alternative crops for dryland production.

Contact: Carrie Eberle at carrie.eberle@uwyo.edu or 307-837-2000.

Keywords: winter pea, winter camelina, dryland farming

PARP: I:1,2,5,9, X:1

Figure 1. *Winter pea 'WyoWinter" on October 11, 2017, at the James C. Hageman Sustainable Agriculture Research and Extension Center.*

Pulse crops as a possible rotation with dryland winter wheat

Investigators: Amberle Filley and Carrie Eberle

Issue: A large portion of winter wheat is cropped in a wheat–fallow rotation, but volatile markets and low rotation diversity make this an unsustainable rotation. With more demand for high-protein crops worldwide, this project looks to help provide High Plains' producers the information needed to grow pulse crops and take advantage of markets, diversify their rotation, and increase soil fertility.

Goal: Determine if pulse crops can be incorporated into the dryland winter wheat rotation to improve the overall sustainability of farming in southeast Wyoming and surrounding areas.

Objectives: Evaluate guar, dry pea, lentil, and chickpea yield, water use, and nitrogen (N) fixation in dryland conditions.

Expected Impact: Results of this trial should provide information to producers on when to plant, what N gains can be expected in the soil, whether early termination is a viable option (which may be necessary during drought years), and what yield expectations they can have for southeast Wyoming.

Contact: Carrie Eberle at carrie.eberle@uwyo.edu or 307-837-2000.

Keywords: dryland farming, pulse crops, sustainable farming

PARP: I:1,2,5,9, II:5,7,9, X:1

Use of pyrolized coal and biochar as a soil amendment

Investigators: Peter Stahl, Carrie Eberle, Anowar Islam, Jay Norton, and Roger Coupal

Issue: Wyoming farm and ranch operations need sustainable soil management options to improve soil conditions and productivity. Carbon-based soil amendments provide an opportunity for sustainable uses of coal to maintain one of the state's most important industries, coal mining.

Goal: Determine the effects of carbon-based soil amendments (pyrolized coal and biochar) on soil characteristics, perennial grass production, and soil microbial growth.

Objectives: Conduct an approximate five-year field trial evaluating the impacts of pyrolized coal and biochar on soil characteristics, microbial biomass production, and growth of forage plants in sandy soil (Fig. 1). The impacts of pyrolized coal will be compared to results obtained with use of biochar.

Expected Impact: We hypothesize that carbon-based soil amendments will increase the water- and nutrient-holding capacities of the sandy soil in which the field trial is being conducted and will have a positive influence on microbial productivity and plant growth.

Contact: Peter Stahl at unclem@uwyo.edu or 307-766-2179.

Keywords: soil health, pyrolized coal, forage production

PARP: IV:6, XI:1

Figure 1. *University of Wyoming researchers in spring 2018 began applying carbon-based soil amendments to this field at the James C. Hageman Sustainable Agriculture Research and Extension Center as part of a long-term study.*

Evaluating chickpea cultivars for forage and grain production in Wyoming

Investigators: Anowar Islam, Dennis Ashilenje, and Michael Baidoo

Issue: Chickpea is a relatively cheap source of crude protein; hence, it is among the most-valued pulse crops in the U.S. This crop is adapted to cool conditions and can mature earlier when supplied with moderate levels of nitrogen (N) fertilizer; however, there is limited information concerning its use as a forage crop.

Goal: Identify chickpea cultivars adapted to Wyoming conditions for forage and grain production.

Objectives: Evaluate forage yield, grain yield, and nutritive value of different chickpea cultivars under different rates of N fertilizer; and screen different lines of chickpea for potential use as a forage crop.

Expected Impact: Results from preliminary studies in 2017 show that chickpea cultivars have potential to produce up to four and six tons/ac of grain yields and forage dry matter, respectively. Nutritive values of both forage and feed are being analyzed. Figure 1 shows chickpea cultivar Desi Kala Chana, which flowered early and had the highest forage and grain yields. Based on results from 2018 and later growing seasons, producers could decide whether to adopt chickpea as an alternative, multi-purpose rotational crop to fit into traditional grain–fallow systems.

Contact: Anowar Islam at mislam@uwyo.edu or 307-766-4151.

Keywords: chickpea, forage production, grain production

PARP: I:2,6,9,12, II:2, VIII:5, X:1

Figure 1. *Chickpea cultivar Desi Kala Chana at pod development stage, September 9, 2017. The trial is at the James C. Hageman Sustainable Agriculture Research and Extension Center.*

Evaluation of forage sorghum under irrigated and dryland conditions in Wyoming

Investigators: Anowar Islam, Dennis Ashilenje, and Michael Baidoo

Issue: Forage sorghum could potentially supply enough crude protein and energy to increase the performance of cattle. In areas with marginal rainfall for corn production in Wyoming and surrounding states, sorghum could potentially thrive because of its ability to withstand drought.

Goal: Identify cultivars of forage sorghum suitable for production under irrigated and dryland conditions in Wyoming.

Objectives: Determine dry matter yield and nutritive value of different cultivars of forage sorghum grown under irrigated and dryland conditions at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC).

Expected Impact: Results from preliminary studies in 2017 indicate the potential for sorghum cultivars to produce similar forage yields in both dryland and irrigated conditions. Among these are Sweetleaf II, NK300, SP4555, and Nutri-King BMR (Fig. 1). These cultivars also had higher yields and similar crude protein as corn silage in both cropping systems. Trials will continue in 2018 to identify cultivars with consistently high yields and forage nutritive value. Well-adapted cultivars could be used to sustain cattle production when conditions are not favorable for other forage crops.

Contact: Anowar Islam at mislam@uwyo.edu or 307-766-4151.

Keyword: sorghum, yield, nutritive value

PARP: I:2,12,15, II:2,12,15, IV:3,4, VI:1,3

Figure 1. *Dennis Ashilenje standing in sorghum cultivar Nutri-King BMR at milk stage in a dryland system at SAREC on September 7, 2017.*

Flow meter and electric meter installation on SAREC irrigation pivots

Investigators: Kevin Madden, John Tanaka, Kristi Hansen, and Brian Lee

Issue: Irrigation systems are common in the major agricultural production areas of Wyoming to produce irrigated crops. Unlike some states including Nebraska, irrigation metering is not required in Wyoming; therefore, water use is assumed to be less than efficient in a production setting. The James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC), in collaboration with others, wants to better understand the electrical costs and water consumption associated with current pumping practices for future management consideration.

Goal: Install water flow and electric meters on the irrigation systems at SAREC to better understand and evaluate the center's water use (Fig. 1); and collaborate with local producers and the University of Nebraska's Panhandle Research and Extension Center (UNL-PREC) in this project.

Objectives: Become more efficient and accurate with water placement at SAREC, UNL-PREC, and cooperator fields.

Expected Impact: Disseminate results to producers across Wyoming and western Nebraska to help them better understand water usage, how to use water more efficiently, and how to lower irrigation costs, including electrical usage.

Contact: Brian Lee at blee@uwyo.edu or 307-837-2000.

Keywords: irrigation efficiency, flow meter, water use

PARP: I:1, IV:1,3,4

Figure 1. *A center pivot at SAREC is being equipped with water flow and electric meters (photographed March 2018).*

Taters for Tots education program at SAREC

Investigators: SAREC faculty and staff

Issue: Community outreach and youth education are among the goals of the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Among the specific goals is to educate elementary school students about the importance of agriculture to our state, nation, and world.

Goal: Host area school groups to SAREC each fall to teach them about agriculture in our area.

Objectives: Educate local youths about agriculture, in general, and potato production, specifically, through a hands-on program titled Taters for Tots, in which students work with adults to harvest potatoes.

Expected Impact: Teaching area youths about agriculture will inform them about the importance of this industry to our communities in terms of jobs and economic sustainability, and it's our hope that such education will encourage young people to pursue careers directly or indirectly related to agriculture.

Contact: Brian Lee at blee@uwyo.edu or 307-837-2000.

Keywords: potato, youth education, community outreach

PARP: IX:5,7

Figure 1. *SAREC faculty and staff help students gather potatoes on one of many visits to the research farm by elementary classes.*

Evaluating biochar in a high tunnel environment

Investigators: Brian Lee, Jeff Edwards, and John Tanaka

Issue: Growing crops in high tunnels can be an efficient means to expand food production by extending the growing season; however, growing successive crops in high tunnels takes more fertilizer and other inputs to maintain soil health. Biochar—a sustainable carbon byproduct produced from plant matter—could help producers increase production.

Goal: Evaluate biochar and compost mixtures in high tunnels at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC [Fig. 1]), Goshen County Resource Center, and Eastern Wyoming College. The mixes will consist of 2% biochar/98% compost, 5% biochar/95% compost, and 100% compost. A small, measured amount of fertilizer will also be added.

Objectives: Evaluate the use of biochar mixed with compost to determine its effect on vegetable production and quality in a high tunnel setting.

Expected Impact: Results could help producers improve vegetable, fruit, and herb production in high and low tunnels, and the project will also provide the opportunity for students to work in the high tunnels and carry out research.

Contact: Brian Lee at blee@uwyo.edu or 307-837-2000.

Keywords: high tunnel, vegetable production, horticulture

PARP: I:2, II:5,8, VII:1, IX:9, X:1

Figure 1. *The SAREC high tunnel will be one of the sites for a vegetable production research project evaluating compost and biochar in 2018.*

Response to Late-Season Hail Damage in Irrigated Corn

Carrie Eberle[1,5], Steve Paisley[2,5], Brian Lee[3,5], John Tanaka[4,5], and Kevin Madden[5]

Introduction

After a hail event, decisions on how to manage a field to reduce economic loss and prepare for the next year's crop can be complicated. Unfortunately, hail damage in crop fields is not a novel occurrence for growers in Wyoming. A team of researchers at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) decided to take advantage of a 2016 hail storm and designed a study in hailed-out irrigated corn to evaluate impacts of different management responses.

Objectives

The objectives of this study were to: (1) determine the best practice to manage hail-damaged corn stalks; (2) evaluate winter cereal cover crops sown into hail-damaged corn fields; (3) measure the impact that management decisions have on the next year's corn crop; and (4) calculate the economics for each treatment.

Materials and Methods

On July 27, 2016, SAREC was hit with a hail storm that resulted in a complete loss of the irrigated corn crop. On August 12 and 17, four corn-management treatments were applied to the hailed-out corn on two center-pivot irrigated fields (Table 1). Cereal cover crops were seeded on August 18 and 20 across all corn-management treatments (Table 2). Cattle were grazed from November 2016 through February 2017, and exclusion zones were set up in each treatment to compare grazing impact. Above-ground biomass of cover crops was sampled in grazed and ungrazed areas on October 10, 2016 (before grazing) and March 25, 2017 (after grazing). Biomass samples were analyzed for forage quality as well as dry matter produced on a per-acre basis. Soil nitrogen (N) was measured across all treatment combinations (corn management × cover crop × grazing) in the top 10 inches on March 25, 2017, followed by field cultivation. Corn was sown on May 11, 2017, and harvested November 20, 2017, with a Kincaid plot combine. Two 25-foot corn rows were harvested for each treatment combination. Each treatment was replicated twice, with three sample plots in each replicate. Equations to calculate N credits (non-fertilizer N available to the corn crop), cover crop animal feed value, and corn yield value can be found in Table 3.

Results and Discussion

Across all combinations, the most cost-effective treatment was to shred the hailed corn stalks, plant winter wheat, and winter graze the field. This treatment combination only lost, on average, $169/ac (Table 4). Without incorporation of grazing, cover crops increased cost by an average of $50 to $150/ac (Table 4, Ungrazed). When livestock are incorporated into the field, winter wheat, rye, and triticale at a 1/2-seeding rate are all economically competitive with fallow (Table 4, Grazed). No-till and cover crop treatments also have the added value of reducing wind erosion and contributing to soil organic matter.

Acknowledgments

We thank the SAREC crew for assistance during the project. The study was supported by the Wyoming Agricultural Experiment Station Rapid Response Agricultural Research Fund and by U.S. Department of Agriculture Hatch funds.

Contact Information

Carrie Eberle at carrie.eberle@uwyo.edu or 307-837-2000.

Keywords: hail, forage, grazing

PARP: I:3,6,15, X:1

[1]Department of Plant Sciences; [2]Department of Animal Science; [3]Department of Agricultural and Applied Economics; [4]Department of Ecosystem Science and Management; [5]James C. Hageman Sustainable Agriculture Research and Extension Center.

Table 1. Corn stalk management treatments (Management) and associated cost of operation (Cost). Cost includes field operations and herbicide application.

Management	Description	Cost[1]
Drill	Corn stalks left standing, glyphosate applied	$13.93
Shred	Corn stalks shredded, glyphosate applied	$24.73
Disc	Two field passes with a tandem disc	$17.84
Shred/Disc/LS	Corn stalks shredded, followed by a single pass with a tandem disc, followed by a single pass with a Landstar (LS) finishing cultivator.	$24.59

[1]*William F. Lazarus, University of Minnesota Extension, machinery cost estimator*

Table 2. Winter cereal cover crop treatments, seeding rates, and associated operation costs.

Cover Crop	Fallow	Sorghum	Wheat	Rye	Triticale	Triticale(1/2 rate)
Cultivar	n/a	Grazex III	SY Wolf	Guardian Fall	Fridge Beardless	Fridge Beardless
Seeding Rate	n/a	30 lb/ac	120 lb/ac	120 lb/ac	120 lb/ac	60 lb/ac
Operation Costs	$0.00	$40.38	$37.98	$54.78	$78.78	$48.78

Table 3. Equations to calculate system credits.

Rotation Credits	Equation
Soil Nitrogen (N) Credit	Spring Soil N (lb/ac) × Price of Urea ($0.36/lb) × 2.2[1]
Cover Crop N Credit	Spring Biomass PAN[2] (lb/ac) × Price of Urea ($0.36/lb) × 2.2
Cover Crop Feed Value	Spring Biomass (ton/ac dry wt) × Price of Silage ($42.60/ton)
2017 Corn Grain Yield Value	Corn Yield (bu/ac) × Local Cash Price ($3.15/bu)

[1]*2.2 is the constant used to convert urea to N;* [2]*PAN is plant-available N*

Table 4. Value of each management combination ($/ac). Costs include fall corn management (Table 1), cover crop seed and planting (Table 2), and conventional corn production ($736/ac). Credits include those presented in Table 3, calculated for each management by cover crop by grazing combination.

UNGRAZED	Fallow	Sorghum	Wheat	Rye	Triticale	Triticale(1/2)
Drill	-$252	-$282	-$276	-$331	-$377	n/a
Shred	-$324	-$314	-$349	-$386	-$435	-$423
Disc	-$233	-$356	-$287	-$422	-$464	-$425
Shred/Disc/LS[1]	-$211	-$261	-$309	-$251	-$350	-$268
GRAZED	**Fallow**	**Sorghum**	**Wheat**	**Rye**	**Triticale**	**Triticale(1/2)**
Drill	-$225	-$323	-$213	-$256	-$279	n/a
Shred	-$201	-$291	-$169	-$264	-$247	-$226
Disc	-$284	-$292	-$281	-$279	-$369	-$256
Shred/Disc/LS[1]	-$239	-$331	-$281	-$200	-$237	-$201

[1]*Corn stalks shredded, followed by a single pass with a tandem disc, followed by a single pass with a Landstar (LS) finishing cultivator.*

Planting Date and Variety Effect on Winter Camelina Production

Carrie Eberle[1,2]

Introduction

Camelina is an oilseed crop that has had limited success in the U.S. over the last two decades (Sindelar et al., 2015). With continued interest in renewable energy and healthy oils there have been new efforts to incorporate camelina into crop rotations. Camelina oil can be used to produce fuel (Moser, 2010), healthy edible oils, and supplemental livestock feed. Winter camelina is seeded in September and harvested around mid-June, is relatively drought tolerant, and is a winter annual that has potential to fit into dryland or irrigated rotations in Wyoming.

Objectives

The objectives were to determine if planting date and planting method affect the plant stand and seed yield of winter camelina.

Materials and Methods

We evaluated the performance of two winter camelina varieties, 'Bison' and 'Joelle', across four planting dates (September 7 and 19, and October 5 and 18, 2016) using two different seeding methods (disc drill and shoe drill). The trial was conducted under irrigation, but only received a one-time irrigation of 0.3 inches on September 14, 2016. Natural rainfall accumulation was 1.9 inches and 9.8 inches in the 2016 to 2017 phase of the trial, respectively. We used a randomized complete block design with three replications. Plots were 5 feet wide by 20 feet long. The disc drill seeded 7 rows on 7.5-inch spacing, and the shoe drill seeded 4 rows on 12-inch spacing. Seed was planted at 7 lb/ac at a depth of 1/2 to 1 inch. Stand counts were taken in the fall (November 12, 2016) and at harvest (June 29, 2017) in the same 3.3-foot row for each plot. The crop was harvested by hand cutting two 3.3-foot rows from each plot, and samples were threshed using a HALDRUP thresher with a 6-millimeter (~0.04-inch) screen.

Results and Discussion

Crop stands were highly variable (Fig. 1) across all varieties, planting dates, and seeding methods. Fall crop stands, harvest crop stands, and seed yield are reported in Table 1. Seed planted on October 18 had almost no fall germination, but those seeds germinated in the spring and still produced high seed yields. Seed yield was most consistent for Bison and Joelle when seeded with the disc drill on September 19 and later dates (Table 1). Both Bison and Joelle had treatments with seed yields of more than 1,000 lb/ac. At these yields winter camelina has the potential to be a competitive crop in Wyoming (Eberle et al., 2015). It is clear that planting date and seeding method impacted winter camelina yield. Preliminary results indicate that winter camelina may be the most productive when disc drilled later in the season and allowed to germinate during winter and spring. More work is needed to determine optimum seeding practices to ensure a consistent crop yield. Economic markets will also need to be created to make this crop a viable option for producers. Dryland trials are underway to better understand the feasibility of winter camelina in Wyoming.

Acknowledgments

We thank the SAREC crew for support.

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Contact Information

Carrie Eberle at carrie.eberle@uwyo.edu or 307-837-2000.

Keywords: winter camelina, planting date, crop rotation

PARP: I:3,6,12,15, X:1

[1]*Department of Plant Sciences;* [2]*James C. Hageman Sustainable Agriculture Research and Extension Center.*

Table 1. Stand counts (plants per 3.3 feet) and seed yield (lb/ac) for winter camelina varieties 'Bison' and 'Joelle' planted in early fall 2016. Fall stand counts were taken on November 12, 2016, in one 3.3-foot row of each plot. Harvest stand counts were taken June 29, 2017, in the same row as fall stand counts. Yield is based on two 3.3-foot row hand samples.

	Bison			Joelle		
Planting Date	**Fall Stand**	**Harvest Stand**	**Seed Yield (lb/ac)**	**Fall Stand**	**Harvest Stand**	**Seed Yield (lb/ac)**
Disc Drill						
9/7/2016	2.0	1.3	390 ± 676	0.0	0.0	0
9/19/2016	18.0	22.3	1,651 ± 862	12.3	7.7	1,076 ± 538
10/5/2016	29.7	16.7	1,113 ± 450	0.0	0.3	500 ± 440
10/18/2016	1.7	13.3	1,201 ± 406	0.0	22.7	1,201 ± 170
Shoe Drill						
9/7/2016	26.3	16.3	1,038 ± 726	11.0	14.0	1,332 ± 1166
9/19/2016	0.7	1.0	0	0.0	0.0	0
10/5/2016	0.0	0.0	0	0.0	0.7	0
10/18/2016	1.0	35.7	602 ± 58	0.0	26.3	663 ± 312

Figure 1. *Stand variation of winter camelina in spring 2017.*

Post-Grazing Vegetation Structure and Ground Surface Temperature Responses to Grazing Intensity in a Rangeland Soil Health Experiment in a Wyoming Mixed-Grass Prairie

Timm Gergeni[1] and Derek Scasta[1]

Introduction

Producers are increasingly making grazing-management decisions based upon projected impacts to soil health, but disagreement persists regarding the direction and magnitude of potential soil health changes. Previous research has indicated potential negative effects of grazing management intensification on soil health in low-productivity environments. Other studies suggest that more intensive, short-duration grazing benefits soil health, while others yet have shown no change in these properties. These inconsistencies demand more empirical assessments of the top-down effects of grazing management on soil health.

To better understand the effects of grazing on the soil health of Wyoming's rangelands, we established an experiment in a mixed-grass prairie at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC [Fig. 1]). Baseline soil analyses (e.g., organic matter, nitrogen content, and microbiological parameters) and forage data (e.g., biomass and composition) were taken prior to grazing and will be presented after our research concludes in summer 2019. Other soil and vegetation observations that were more likely to be effected in the short term (e.g., ground surface temperature and grazing height) were taken post-grazing in 2017, year one of the three-year grazing experiment, and these results are reported in this paper (Figs. 2–3).

Objectives

Our specific objectives are to (1) determine how grazing intensity, or complete exclusion, alters soil health properties; (2) quantify both the direction (positive, negative, or neutral) and magnitude (great or small relative to change) of any soil health alterations relative to grazing management; and (3) relate the soil health feedbacks associated with grazing management to vegetation responses.

Materials and Methods

This study was established in June 2017 at SAREC (Fig. 1). Twelve, one-acre paddocks were utilized, and each grazing treatment was replicated four times in a randomized complete block design. Three grazing treatments were utilized one time annually: (1) no grazing (NG); (2) moderate rotational grazing (MRG) consisting of four, 1,200-pound heifers (or 4,800 lb/acre) spending from four to nine days in the paddocks; and (3) ultra-high-density (UHD) grazing consisting of 33 cow/calf pairs and two bulls (60,500 lb/ac) spending seven to 25 hours in the paddocks.

Due to the natural variation in forage production across the 12 paddocks, pre-grazed forage height and biomass were used to determine grazing time in each paddock, with grazing time calculated for 50% utilization. Vegetation height was recorded post-grazing. To quantify the short-term treatment effect on litter accumulation and soil microclimate, soil surface temperatures were taken post-grazing at eight intervals along a 240-foot transect in each paddock. Surface temperatures were recorded using a Performance Tool W89722 Infrared Thermometer at waist height (~3 ft) above ground and relativized to a reference temperature taken at each point using a white sheet of

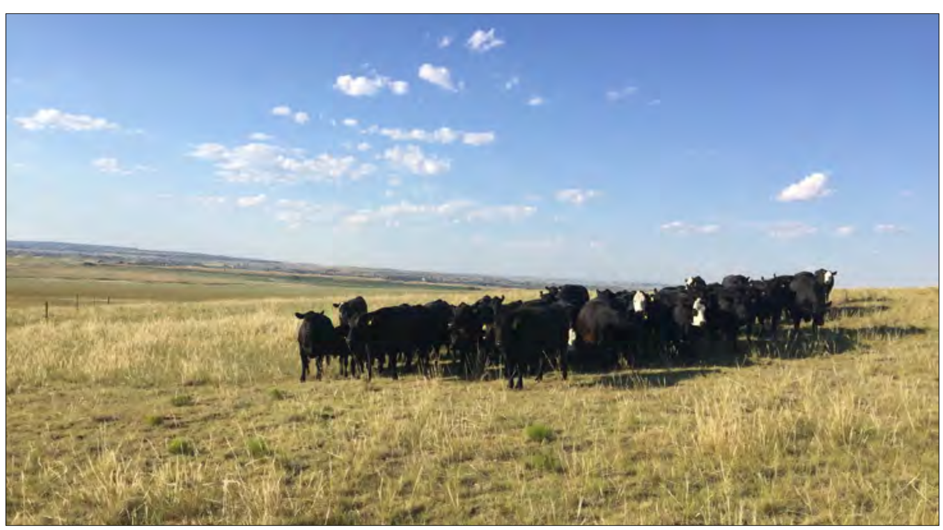

Figure 1. *Ultra-high density herd (60,500 lb/ac).*

[1]*Department of Ecosystem Science and Management.*

paper following Twomey et al., 1986. Surface temperature readings began at 11:30 a.m. with an air temperature of 86°F. Statistical analyses were performed on vegetation and temperature data to address any differences in surface temps between grazing treatments and to identify if uniform forage utilization was accurately achieved.

Results and Discussion

Post-grazing ground surface temperatures did not differ statistically relative to treatment (Fig. 2), potentially indicating that adequate forage cover was left in each paddock. Post-grazing forage height did differ statistically relative to treatment (Fig. 3). As expected, the NG paddocks had the greatest post-grazing height; meanwhile, the UHD and MRG paddocks were found to be statistically similar to one another, but statistically different from the NG paddocks (Fig. 3).

The importance of this early result is that we can confirm that our predicted grazing times in paddocks for the two grazing treatments achieved similar utilization rates with different stock densities and time in paddocks. Baseline soil sampling occurred prior to grazing treatments and will be repeated at the conclusion of the study (summer 2019). This should allow us to identify any changes to soil health in response to grazing treatments.

Acknowledgments

We thank SAREC field crews for constructing the grazing paddocks. This study is funded by the Sustainable Rangelands Roundtable (www.sustainablerangelands.org).

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Contact Information

Derek Scasta at jscasta@uwyo.edu or 307-766-2337.

Keywords: grazing management, rotational grazing, soil health

PARP: I:15, VI:3,5,6

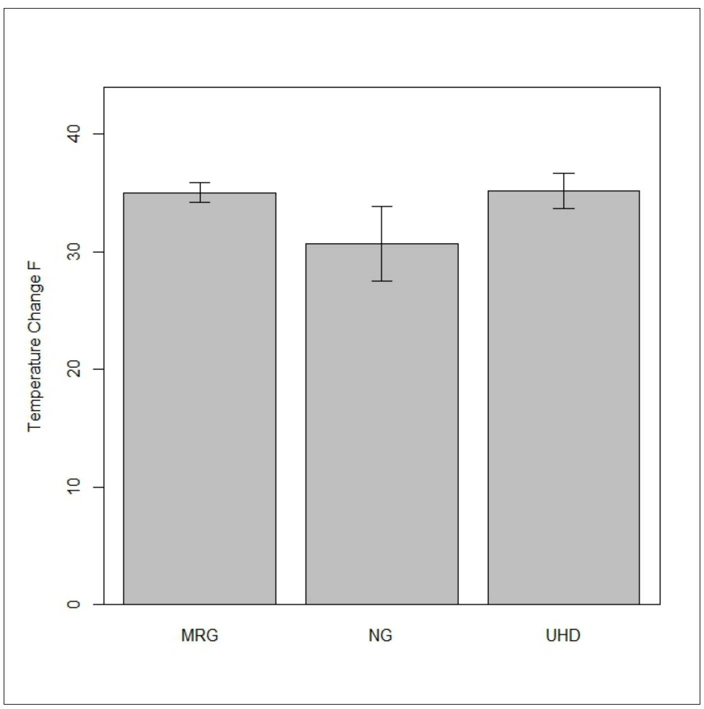

Figure 2. *Change in surface soil temperature (°F) relative to treatments post-grazing (p=0.272). UHD=ultra-high-density grazing (60,500 lb/ac), MRG=moderate rotational grazing (4,800 lb/ac), and NG=no grazing.*

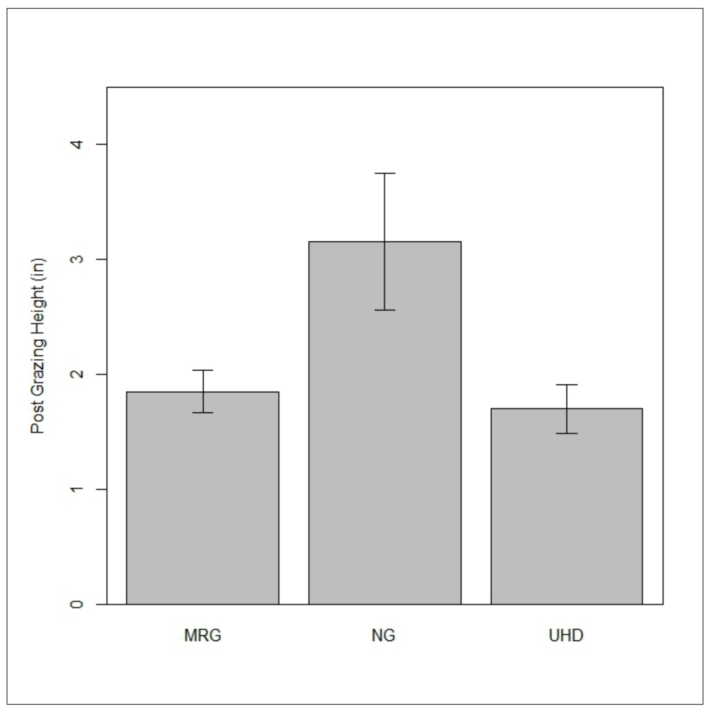

Figure 3. *Post-grazing height (p=0.0127).*

2017 Dry Bean Performance Evaluation

Jim Heitholt[1], Ali Alhasan[1], Azize Homer[1], and Kevin Madden[2]

Introduction

Southeast Wyoming bean producers seek performance data on recently released varieties.

Objectives

The University of Wyoming obtained funds for conducting this trial from the Wyoming Bean Commission so that growers and seed companies have dry bean performance data for the southeast Wyoming climate.

Materials and Methods

A three-acre tract at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) was used for this study and several others. It was disced multiple times and fertilized with 50 pounds nitrogen and 40 pounds sulfur per acre in April 2017. Seeds of 20 dry bean (*Phaseolus vulgaris* L.) cultivars were sown on June 6 at 100,000 seeds/ac using 30-inch rows and four-row plots (Table 1). Weed control consisted of a pre-emerge application of 21 oz Outlook® and 32 oz Prowl® H2O followed by routine hand-hoeing throughout the growing season. Irrigation was provided at 0.50 inch per week through June and 0.75 inch per week in July and August. The plot design was a complete randomized block with four replications. Visual estimates were made for the number of days to reach 50% bloom (50% of plants with a bloom), and plant height was recorded in early September. Prior to harvest, lodging/upright rating was recorded (Table 1). During September and October, whole plants from subplots (eight feet from each of the two center rows) were pulled by hand and threshed with a Haldrup LT-35 stationary plot thresher. Subsamples of 100 seeds were weighed to calculate seed/lb.

Results and Discussion

Stand establishment was excellent, and no anomalies were encountered during the growing season. Cultivars varied significantly in all measured traits. Two pinto and one black-seeded line exceeded a yield of 3,000 lb/ac.

Acknowledgments

This study was conducted with the assistance of SAREC staff. The authors thank Carrie Eberle for use of the thresher. This work is also supported by U.S. Department of Agriculture-National Institute of Food and Agriculture projects WYO-562-16 and WYO-558-15.

Contact Information

Jim Heitholt at jim.heitholt@uwyo.edu or 307-766-3104.

Key words: dry bean, performance evaluation, yield trial

PARP: I:12

[1]*Department of Plant Sciences;* [2]*James C. Hageman Sustainable Agriculture Research and Extension Center.*

Table 1. Agronomic data, 2017 cooperative dry bean nursery at SAREC. Yields are corrected to 14% moisture, and seeds/lb values are based upon 6% moisture.

Name	Market Class	Bloom Days after Planting	Plant Height (inches)	Yield (lb/ac)	Seeds per Pound	Lodging/ Upright Rating**
PT10-12-1	pinto	51	23	2870	1420	8.2
NE2-16-33	pinto	48	31	3160	1210	2.0
Blackfoot	pinto	48	19	2430	1330	6.7
Nez Perce	pinto	48	28	2850	1470	6.0
Twin Falls	pinto	56	26	2680	1530	9.2
La Paz	pinto	56	31	2810	1350	6.7
Othello	pinto	47	24	2970	1260	3.5
Staybright*	SLD pinto	51	29	2910	1450	8.0
Sundance*	SLD pinto	47	30	2900	1370	5.7
ND-Palomino	SLD pinto	47	29	3480	1270	4.2
SR10-2-1	small red	50	27	2880	1350	6.5
ACUG 13-SR1	small red	52	25	2870	2530	9.2
ACUG 15-B4	black	56	22	3100	2640	8.0
ACUG 14-1	navy	47	27	2890	2300	8.0
Eclipse	black	56	22	2690	2560	9.2
Dynasty	DRK	48	22	2440	920	7.5
DRK 1	DRK	52	18	2680	1170	6.7
Cornell 612	LRK	48	17	1720	1160	7.5
CELRK	LRK	47	16	2560	840	7.7
CO 14790-3	pinto	49	28	2840	1310	8.2
	Mean	50	25	2702	1526	7.0
	LSD	3	4	601	111	1.3
	CV	4	12	15	5	13
	p-value	0.001	0.001	0.002	0.001	0.001

**Staybright aka COSD 35; Sundance aka COSD 7*
*** Upright rating was 10 for completely upright plants and 0 for completely prostrate plants.*

Effect of Potassium on Yield of Newly Released Alfalfa Cultivars

Michael Baidoo[1] and Anowar Islam[1]

Introduction

Alfalfa (*Medicago sativa* L.) is among the most valuable forage crops in Wyoming and the nation. Many cultivars are released every year with improved traits, including the potential to produce higher yields. Reduced-lignin alfalfa is among the newly released cultivars. It has the potential to offer higher yield and more harvest flexibility than conventional cultivars (non-reduced lignin) without compromising forage quality. To produce high yields, alfalfa requires high amounts of potassium (K) in the soil; however, intensive alfalfa production over many years generally leads to a reduction of K in soils unless sound soil-management practices are implemented. Currently, recommended K application rates to replenish this essential nutrient for high alfalfa yields are based on older cultivars. Further, limited information is available about K effects on the newly released cultivars.

Objectives

The objective of the study is to determine the effects of K on two newly released alfalfa cultivars at different harvest times.

Materials and Methods

The study was established at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) in 2016. The three treatments included (1) two recently released alfalfa cultivars: 'Hi-Gest 360' (reduced lignin) and 'AFX 457' (non-reduced lignin); (2) four K rates: 0, 50, 100, and 150 pounds K_2O per acre; and (3) two harvest times: early harvest (late bud to early [10%] bloom), and late harvest (7 days after early harvest). The experiment was set up in a 2 × 2 × 4 factorial arrangement in a randomized complete block design with four replications under irrigation. This resulted in a total of 64 plots, each measuring 5 × 20 feet.

Soils from the plots were sampled and analyzed to determine initial soil nutrient status, especially K level, during final land preparation. The initial level of K was medium (~155 parts per million). Potassium was hand-applied and incorporated into the soil by raking, and other nutrients were managed for adequacy before planting. Inoculated alfalfa seeds were planted at a seeding rate of 20 pounds pure live seed per acre on September 8, 2016. Four harvest periods were set from June to October (at 30-day intervals) in 2017. Forage samples collected were oven dried for 72 hours at 140°F to determine forage yield on a dry matter basis. After the final harvest, soil samples were collected from individual plots to determine residual K. Data were analyzed using SAS 9.4.

Results and Discussion

Forage yield was affected by the interaction effect of K, cultivar, and number of harvests. When results from all four harvests were combined over the two harvest times (early and late), Hi-Gest 360 produced the highest total yield (8,372 lb/ac) under the 150 pounds K_2O per acre rate, whereas AFX 457 produced the highest total yield (8,283 lb/ac) when treated with 100 pounds K_2O per acre (Table 1). This indicates that a moderate level of K is needed for a high yield of AFX 457, while a high level of K is needed for similar yields of Hi-Gest 360. Overall, Hi-Gest 360 and AFX 457 produced similar total yield. Compositional differences (e.g., genetics) in both cultivars and their influence might have contributed to the yield difference.

Compared to the first and second harvests, the third and fourth harvests produced higher yields in both cultivars (Table 1). The lower yields in the earlier harvests could be due to climatic conditions (hot and dry) during the growing season, which might have affected the ability of alfalfa plants to uptake K. Preliminary observations in 2017 suggest that K in conjunction with harvest frequencies and weather play a major role for alfalfa growth and productivity. The study is ongoing, and we will continue monitoring K levels both in the soil and in the alfalfa to further explore K uptake and its effects on alfalfa growth, yield, quality, and persistence. This information could be useful to growers in their efforts to improve soil fertility, harvest management programs, alfalfa yields, and, ultimately, the sustainability of their operations.

Acknowledgments

We thank SAREC crews, Alforex Seeds, and University of Wyoming forage agronomy laboratory members for assistance. The project is funded by a grant from the U.S. Department of Agriculture-National Institute of Food and Agriculture's Alfalfa and Forage Research Program.

[1]*Department of Plant Sciences.*

Contact Information
Anowar Islam at mislam@uwyo.edu or 307-766-4151.

Keywords: alfalfa, potassium, time of harvest

PARP: I:1,2, II:2, IX:2

Table 1. Potassium and cultivar effects on dry matter yield of alfalfa at different harvests, SAREC 2017.

Dry matter yield† (pounds per acre)										
Treatment	Hi-Gest 360					AFX 457				
K_2O	1‡	2	3	4	Total	1	2	3	4	Total
0	1603b§	1158b	2227c	2048c	7036c	1781a	1069b	2316c	2227c	7393c
50	1603b	1158b	2583b	2138b	7482b	1781a	1158a	2316c	2316b	7571b
100	2049a	1247a	1870d	2138b	7304b	1692b	1069b	2850a	2672a	8283a
150	1870ab	1069c	3028a	2405a	8372a	1514c	1158a	2494b	2361b	7527b
Average	1781	1158	2427	2182	7549	1692	1114	2494	2394	7694

†Values are averaged over two harvest times (early; late)
‡Harvest number:
1=May 30 (early harvest), June 6 (late harvest);
2=July 10 (early harvest), July 17 (late harvest);
3=August 18 (early harvest), August 25 (late harvest);
4=September 29 (early harvest), October 6 (late harvest).
§Within column, means followed by same lower-case letter are not significantly different at $p < 0.05$.

Seed Removal of Broadcast-Seeded Cover Crops Into Standing Corn

Randa Jabbour[1], Sara Carabajal[1], and Andrew Kniss[1]

Introduction
Using cover crops is a strategy to promote plant diversity and environmental benefits. One potential application of cover crops is use as supplemental forage for grazing livestock during fall and winter if interseeded with corn. But the best methods associated with interseeding cover crops are not thoroughly understood, especially in semiarid climates like those found in Wyoming's major crop-producing areas. Broadcast seeding causes less soil disturbance and larger areas can be seeded in less time, but seeds broadcast onto the soil surface could have patchier establishment and potentially leave seeds vulnerable to seed predators. Seed predators include insects like ground beetles and ants, as well as larger animals like rodents and birds. In addition, planting cover crops as either monocultures or polycultures can impact cover crop success.

Objectives
Our objectives were to test whether cover crop seed is removed by invertebrates or vertebrates, and whether it varies by seed species or application in mixtures.

Materials and Methods
We broadcast seeded cover crops in standing corn at the V6 stage of growth on June 24, 2016, at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). There were seven treatment groups: a monoculture of Austrian pea, turnip, and winter wheat, two three-species mixtures, one six-species mixture, and a control plot with no cover crop.

Seed assays were used to estimate levels of seed predation between vertebrate and invertebrate seed predators. These were installed in the field following seeding of the site. In 2016, seed assays were placed in the field on June 27 and collected June 29. The assays contained 60 seeds of either a single species or a mixture. Single-seed species included purple top turnip, Austrian pea, and winter wheat. Two three-species mixtures included 20 seeds each of either a turnip-clover-wheat or rapeseed-pea-triticale mixture. The six-species mixture contained 10 seeds each of all six species. Seed treatments were counted and pressed onto inverted petri dishes covered with double-sided tape. Seeds were distributed evenly throughout the plate, and sand was poured on the sticky portions of the seed plate to prevent seed predators from sticking to the seed assays.

To account for vertebrate and invertebrate seed predator presence, we used two different treatments: exclosure and open assays. For the open treatment, seed dishes were accessible to both vertebrates and invertebrates and had no barriers to seed access. For the exclosure treatment, seed dishes had mesh wire surrounding the seed dish with small (one-inch square) holes only accessible by invertebrates. Seed dishes surrounded with tight mesh wire that restricted access to seed by both sets of predators served as the control. Seed dishes (single species or mixed) correlated with the seeding treatment of each plot. Seed assays were excluded from control plots.

Results and Discussion
As illustrated in Figure 1, seed removal from the experimental dishes varied according to both the species mix or individual plant species and the exclosure type. More seeds were removed from the mixtures (specifically the three-species mixes including rapeseed, clover, and triticale, as well as the six-species mix), closely followed by the single species application of turnip. In general, seed removal was lower for larger seeds like wheat and winter pea than small seeds such as turnip, rapeseed, and clover. Next, note that for most of the plant species, more seeds were removed from the open dishes than the exclosure treatment, which only allowed removal by insects. This indicates that non-insects, likely small mammals or birds, are removing more broadcast seeds than insects are.

This research shows that there is seed removal by animals occurring in the two-day window following broadcast seeding of cover crops in corn. Management implications may include adjusting seeding rates to account for this removal. Future research will focus on better understanding if this removal varies across different fields and different seeding dates.

Acknowledgments
Thanks to Makenzie Pellissier, Trevor Alm, Drew Carollo, Derek Pieper, and McKenna Pieper for field experiment support, and to Jenna Meeks for experimental design advice. Thanks to Kevin Madden and the SAREC crew for field-management activities.

[1]*Department of Plant Sciences.*

Contact Information

Randa Jabbour at rjabbour@uwyo.edu or 307-766-3439.

Keywords: cover crops, beneficial insects, interseeding

PARP: I:6, II:5,7

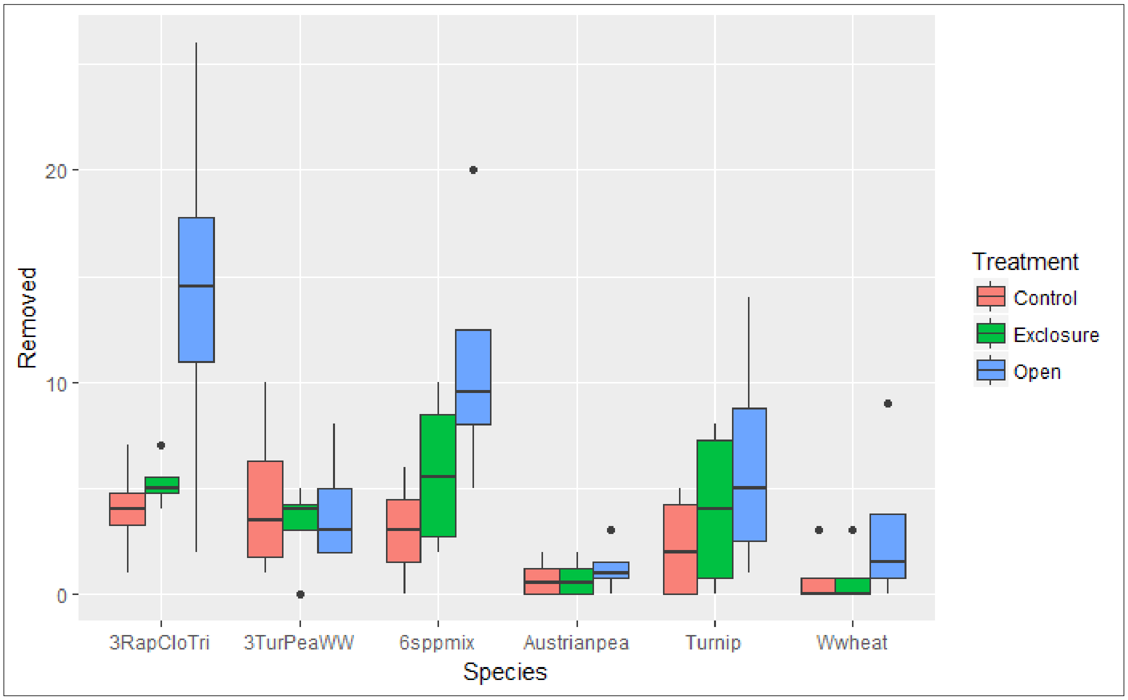

Figure 1. *Seed removal across cover crop species and removal treatments in 2016. The species mixes are referred to as 3RapCloTri (mixture of rapeseed, clover, and triticale), 3TurPeaWW (mixture of turnip, pea, and winter wheat), 6sppmix (includes the six species from each three-species mix), and Austrian pea, turnip, and winter wheat. The control, exclosure, and open treatments impacted which type of predator could access the seed. Exclosure was available to only insects, whereas the open treatment was available to larger animals as well.*

Effect of Direct-Fed Microbials on Weaned Calf Performance

Colby Hales[1] and Scott Lake[1]

Introduction

Direct-fed microbials (DFMs) are feed supplements that have been used as replacements to fed antibiotics that inhibit gastrointestinal infection (Seo et al., 2010). In addition, ruminant animals fed DFMs have been reported to have increased feed efficiency. DFMs create an optimal environment for microbial activity within the rumen. While there are several classes of DFMs in regard to their use, the main classes are lactic acid-producing bacteria and lactic acid-utilizing bacteria. These two classes of microbes have a drastic effect on reducing lactic acidosis when compared with calves fed diets without DFMs.

Propionibacterium acidipropionici, the primary ingredient in the direct-fed microbial Direct Pro™, is a lactic acid-utilizing bacteria that converts lactic acid to the volatile fatty acid (VFA) propionate and decreases acetate (Seo et al., 2010). This leads to an increase in efficiency due to the more efficient conversion of propionate to glucose. Additionally, when cattle are fed low-quality forages, *Propionibacterium acidipropionici* has been shown to increase digestibility, allowing DFMs to act similarly as ionophores through altering fermentation. Unlike ionophores, DFMs can be fed without a veterinary prescription and can be fed in an all-natural protocol.

Objectives

The objective of this study is to determine the effect of the direct-fed microbial Direct Pro on feed efficiency in weaned beef calves.

Materials and Methods

The study was established in 2017 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Calves (150 total; 75/treatment) were all fed a similar weaning ration consisting of corn silage, corn, and soybean meal. The two treatments were a control diet (no added DFMs) and a DFM group (with DFMs poured directly onto the standard ration in the bunk). Weights were taken on the first day of the study, again on day 21, and on day 42, the last day of the study (Table 1).

Results and Discussion

The hypothesis of this study was that Direct Pro as a supplement would increase the efficiency of weaned beef calves. There were no differences between treatments during the first 21 days. DFM-fed calves, however, had a greater (p=0.04) average daily gain (ADG) from days 21–42 of the study and tended (p=0.12) to have greater total weight gain over the course of the entire study (Table 1). It has been shown through this study that Direct Pro had significant impact on gain during the last 21 days of the study. Similar in response to ionophores, *Propionibacterium acidipropionici* reduces the acetate-to-propionate ratio and increases total VFA concentration, which is consistent with increased gain and the potential for increased efficiency as demonstrated in this study.

Acknowledgments

We thank SAREC crews for help with this study.

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Contact Information

Scott Lake at scott.lake@uwyo.edu or 307-766-3892.

Keywords: direct-fed microbials, feed efficiency, beef calves

PARP: V:1,2,7,10

[1]*Department of Animal Science.*

Table 1. Effects of DFMs on weaned calf performance.

	Treatment			
Item	**Control**	**DFM[1]**	**SEM[2]**	***p*-Value**
Initial wt, lb	540	539	7.6	0.89
Final wt, lb	670	674	8.0	0.69
Days 1–21 ADG[3]	78.6	77.7	2.6	0.80
Days 21–42 ADG	2.43	2.76	2.3	0.04
Total weight gain	129.8	135.7	2.7	0.12

[1]DFM=direct-fed microbial; [2]SEM=standard error of the mean; [3]ADG=average daily gain.

Planting Cover Crops After Compost Application in Winter Wheat Fallow in Eastern Wyoming: Soil Moisture, Weed Competition, and Crop Yield Responses

Mavis Badu[1], Urszula Norton[1], and Jay Norton[2]

Introduction

Cover crops planted in the fallow phase of the winter wheat–fallow rotation have shown to provide multiple benefits including improved soil health and increased soil organic matter (SOM) in many wheat producing regions. But in areas of very low precipitation, such as eastern Wyoming and western Nebraska, cover crop adoption is low due to the negative effect on soil water remaining in the profile for the succeeding winter wheat (*Triticum aestivum* L.). Planting cover crops in conjunction with composted feedlot manure (compost) can be a viable alternative to improve on soil properties, which, in turn, can increase water storage and other nutrient and non-nutrient benefits.

Objectives

Our objectives were to assess the effects of cover crops planted after compost on weed growth, soil moisture, and subsequent wheat yield.

Materials and Methods

Treatments

A field experiment was conducted at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). In September 2015, compost at 0, 6, 12, and 18 ton/acre—an equivalent of 0, 13, 26, and 39 lb/ac nitrogen (N)—was applied in the fallow phase and in strips from where winter wheat was harvested in July 2015. In May 2016, a mixture of 29 lb/ac of Austrian winter pea and 50 lb/ac of oats was planted to one-half of the fallow plots and tilled in mid-June 2016. In October 2016, inorganic fertilizer at a rate of 79 lb/ac mono-ammonium phosphate and 107 lb/ac ammonium sulfate (a total of 39 lb N/ac) were applied to non-compost amended plots in the fallow. Winter wheat was planted after cover crop termination.

Data Collection

Measurements included (1) weekly monitoring of soil moisture (between May and August of 2016 and May and August of 2017); (2) one time weed density estimates in the fallow phase (July 2016) and succeeding wheat phase (July 2017); and (3) a determination of winter wheat yield (July 2017). Data were subjected to a two-factor (compost and cover crops) factorial analysis of variance, and means were separated by Fischer's least significant difference at $p \leq 0.05$ (soil water content and weed density) and at $p \leq 0.1$ (winter wheat yield).

Results and Discussion

Weed Density

In 2016, no statistical differences between treatments were observed (Fig. 1). In 2017, weed density was reduced in the wheat phase by ~27–81% in plots planted to cover crops in the preceding year. The biggest differences were observed at 6 and 18 tons/ac (Fig. 2).

Soil Moisture and Wheat Yield

In 2016, cover crops reduced soil moisture by ~3% during cover crop growth; however, the differences between cover crop and no cover crop fallow treatments were no longer present on the day winter wheat was planted. Winter wheat yield increased by ~13% and 28% in the cover crop treatments (Fig. 3). The largest yield increases were observed at 12 and 18 ton/ac compost with cover crops (yields increased from 60 bushels to 90 bushels/ac).

Conclusions

Planting cover crops after a one-time application of compost show successful weed control and improved winter wheat yield, with no reduction in soil moisture within the first two years of the adoption of this practice. This may be a viable practice by winter wheat organic farmers having a readily available, relatively inexpensive supply of weed-free compost.

Acknowledgments

We thank the entire SAREC crew and Brandon Fulcher, Anna Rachocki, Katherine Hunley, and Erin Rooney. This project was funded through grants from the U.S. Department of Agriculture (USDA) Organic Transitions, USDA Hatch funds, and the Wyoming Department of Agriculture.

Contact Information

Urszula Norton at unorton@uwyo.edu or 307-766-5196.

Keywords: organic farming, winter wheat, soil amendment

PARP: I:3, II:5,8, III:3

[1]*Department of Plant Sciences;* [2]*Department of Ecosystem Science and Management.*

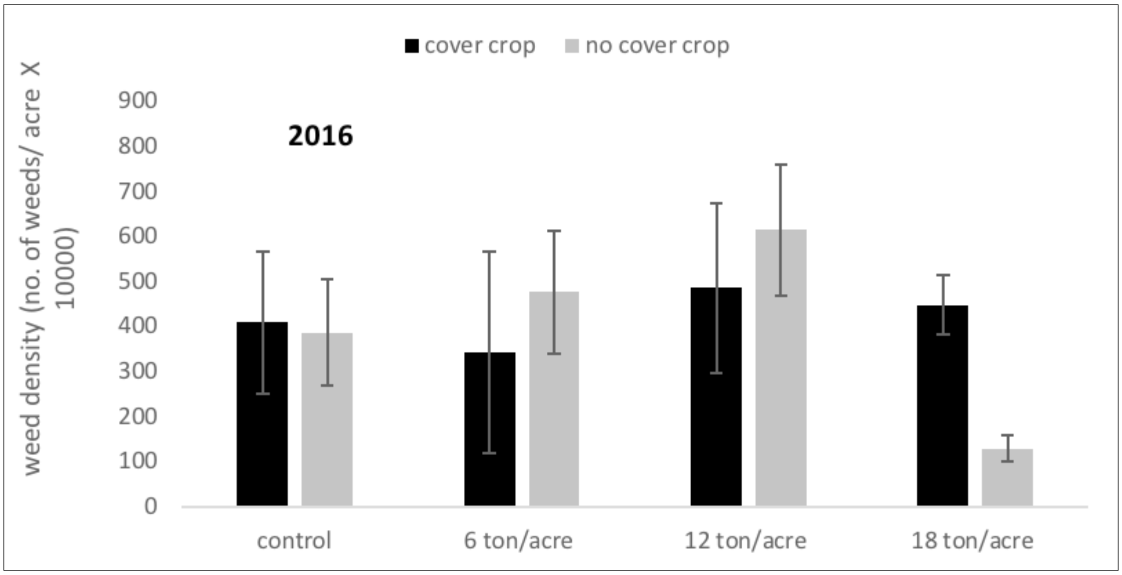

Figure 1. *Weed density in the cover crop and no cover crop plots in the fallow phase (2016).*

Error bars represent standard errors of a mean (n=8).

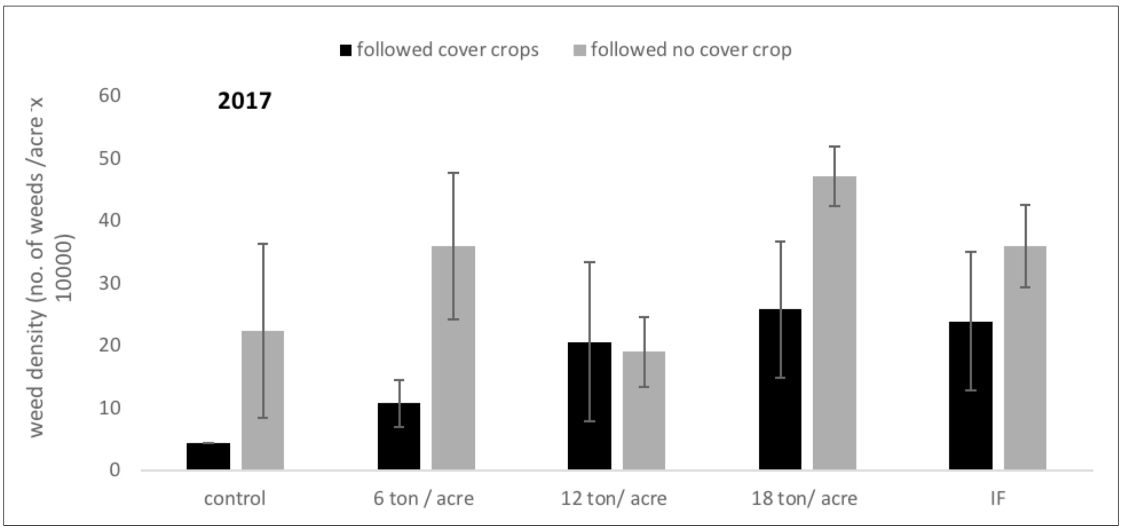

Figure 2. *Weed density in the winter wheat phase preceded by the cover crop and no cover crop planted fallow.*

Error bars represent standard errors of a mean (n=8). Means attached by different letters are statistically different at p≤0.05.

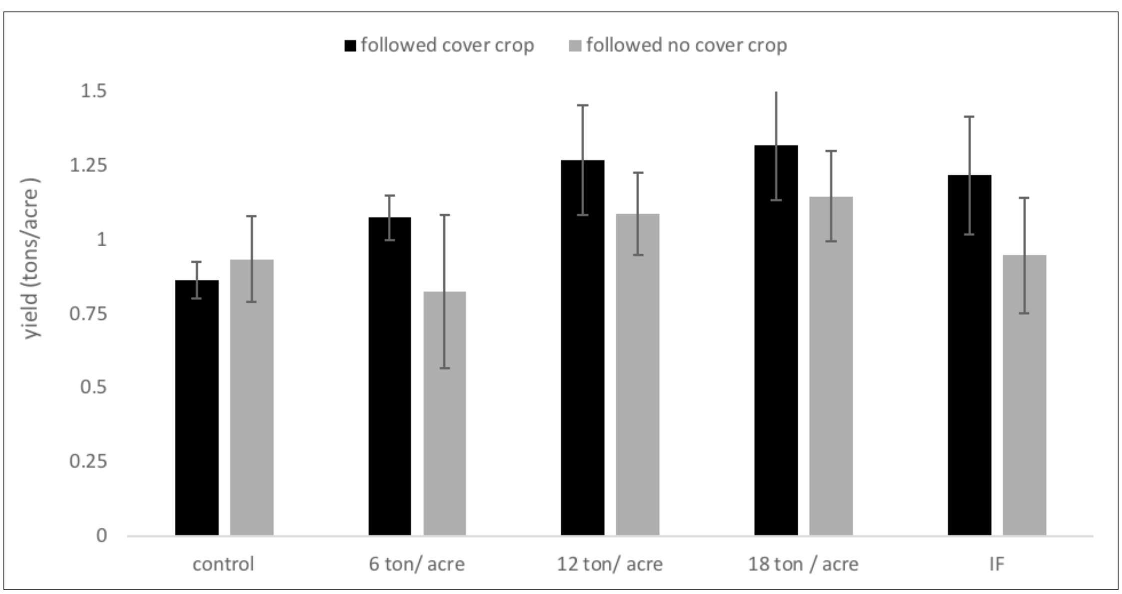

Figure 3. *Wheat yield after cover crop or no cover crop fallow (2017).*

Error bars represent standard errors of a mean (n=8). Means attached by different letters are statistically different at p≤0.05.

Soil Carbon and Nitrogen Responses to High Rate of Compost in Dryland Winter Wheat During the First Two Years

Mavis Badu[1], Urszula Norton[1], and Jay Norton[2]

Introduction

Application of composted feedlot manure ("compost") to dryland winter wheat may deliver much needed soil nutrients, and improve soil properties like water holding capacity, soil structure, and cation exchange capacity (CEC). But anecdotal evidence shows that farmers who apply small amounts of compost every three to four years do not obtain desired benefits in yield. A one-time high rate application may bring the desired effects of compost. Reeve et al., 2012, observed higher soil organic carbon (C) and microbial properties in amended plots than control plots, 16 years after a one-time application of 20 ton/acre compost on a dryland wheat field near Snowville, Utah. Could a one-time high rate compost application bring similar benefits to dryland wheat fields in southeast Wyoming?

Objectives

Our objectives were to determine the influence of a one-time high rate of compost application on soil C, soil nitrogen (N), and greenhouse gas (GHG) emissions.

Materials and Methods

The research was a field experiment conducted at the dryland organic section of the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). We applied 18 ton/ac composted feedlot manure and 79 lb/ac inorganic fertilizer to the field in September 2015. The compost supplied 41 lb N/ac, while the inorganic fertilizer (79 lb/ac mono-ammonium phosphate and 107 lb/ac ammonium sulfate) supplied 44 lb N/ac. The compost was raked into the soil at a depth of ~2 inches.

Soil samples were collected six times in 2016 and 2017 and were analyzed for dissolved organic C and inorganic N (sum of nitrates and ammonium). Polyvinyl chloride (PVC) rings 9.8 inches in diameter and 3.9 inches high were used as the bottom of the GHG collection chambers. These were installed at a depth of ~2 inches. The tops of the chambers, also made of PVC pipes, were used to cover the installed bottoms when collecting gas samples. Gas samples were analyzed for nitrous oxide (N_2O) at every sampling date. Data were subjected to a one-factor analysis of variance, and significant means were separated by Fischer's least significant difference at $p \leq 0.05$.

Results and Discussion

Higher dissolved organic C (DOC) in the compost treatment compared to the control and inorganic fertilizer indicates enhanced nutrient release from compost, which served as a substrate for microbes (Fig. 1). Compost supplied N amounts comparable to inorganic fertilizer during wheat green-up and rapid plant growth—anywhere between 25–40% more than the control (Fig. 2). Lower N_2O emissions from compost in May 2017 (Fig. 3) show more efficient N uptake by plants and microbes in compost-amended soil compared to inorganic fertilizer.

These results indicate a one-time high rate compost application can yield early benefits in southeastern Wyoming such as (1) enhanced microbial activity as shown by soil DOC; and (2) more efficient use of soil N as shown by plant and microbe-available N and lower N losses to N_2O.

Acknowledgments

We thank the entire SAREC crew and Brandon Fulcher, Anna Rachocki, Katherine Hunley, and Erin Rooney. This project was funded through grants from the U.S. Department of Agriculture (USDA) Organic Transitions, USDA Hatch funds, and the Wyoming Department of Agriculture.

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Contact Information

Urszula Norton at unorton@uwyo.edu or 307-766-5196.

Keywords: organic farming, nutrient mineralization, trace gas emission

PARP: I:3, II:5,8, III:3

[1]*Department of Plant Sciences;* [2]*Department of Ecosystem Science and Management.*

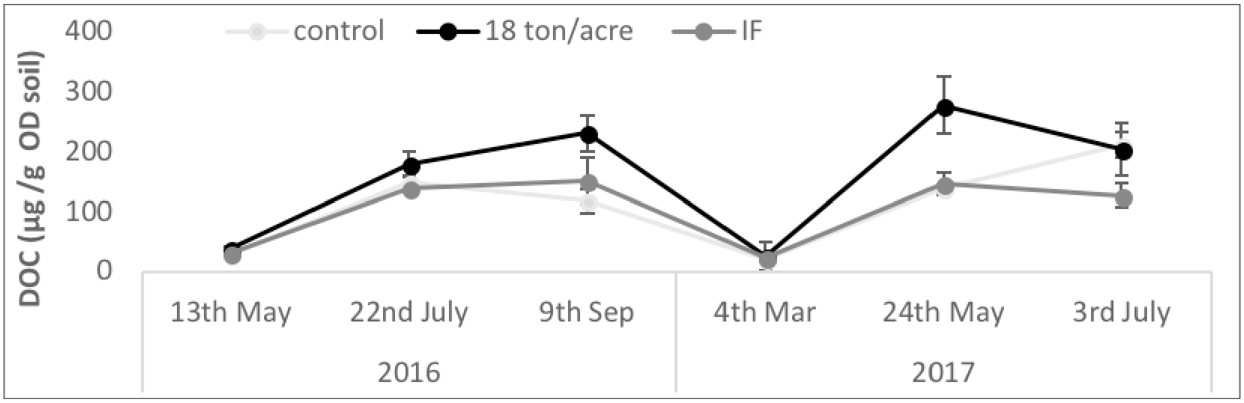

Figure 1. *Dissolved organic carbon concentration of the soil during the wheat phases of the 2016 and 2017 growing seasons.*

µg/g OD soil=microgram dissolved organic C per 1 gram of oven dried soil (1 gm=~0.04 oz); IF=inorganic fertilizer; error bars represent standard errors of a mean (n=8); asterisks indicate statistical difference between means across treatments at p≤0.05.

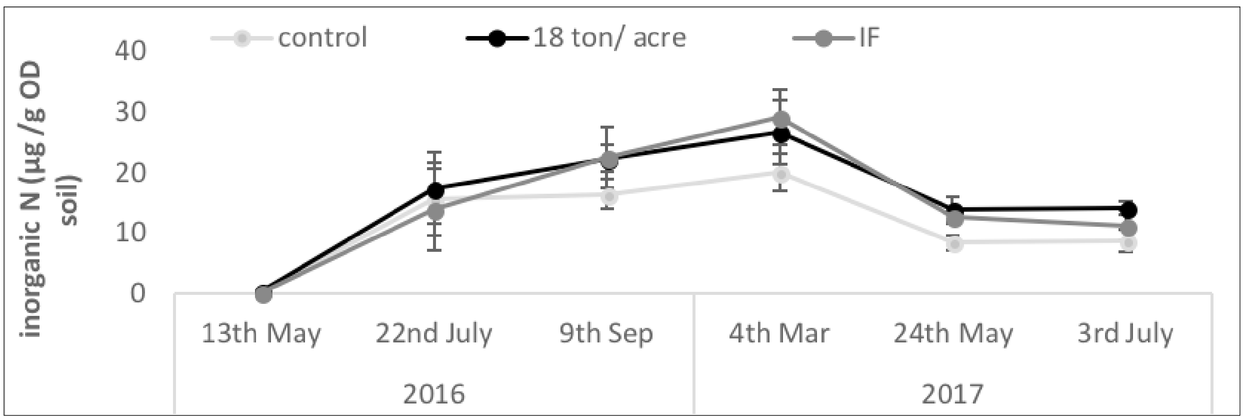

Figure 2. *Inorganic N concentration of the soil during the wheat phases of the 2016 and 2017 growing seasons.*

µg/g OD soil=microgram inorganic N per 1 gm of oven dried soil; IF=inorganic fertilizer; error bars represent standard errors of a mean (n=8); asterisks indicate statistical difference between means across treatments at p≤0.05.

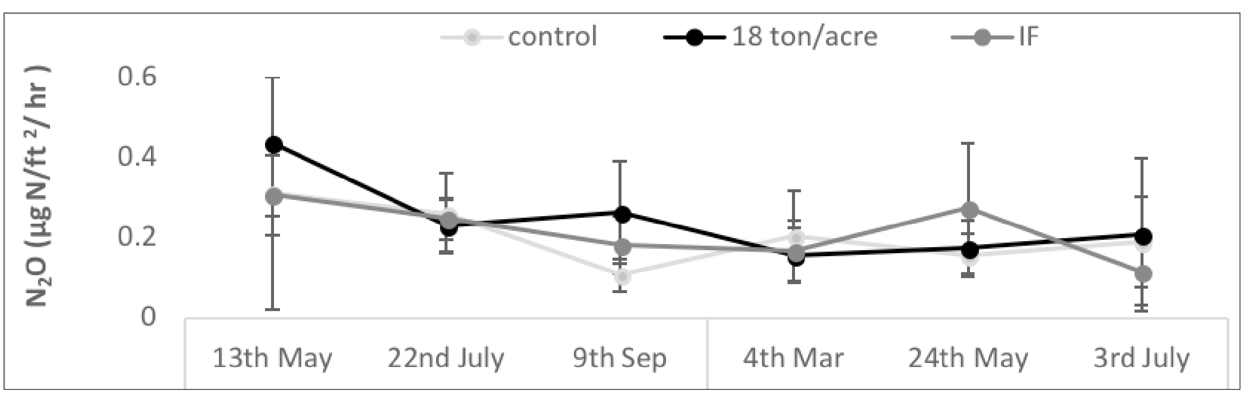

Figure 3. *Nitrous oxide emission from wheat phases of the 2016 and 2017 growing seasons. Error bars represent standard errors of a mean (n=8). Asterisks indicate statistical difference between means across treatments at p≤0.05.*

µg N/ft²/hr=microgram inorganic N per one square foot land area per one hour; IF=inorganic fertilizer; error bars represent standard errors of a mean (n=8); asterisks indicate statistical difference between means across treatments at p≤0.05.

Management of Root Rot Diseases of Dry Bean with In-Furrow Fungicides

William Stump[1] and Wendy Cecil[1]

Introduction

Soil-borne dry bean diseases such as Rhizoctonia and Fusarium root rot are common issues in dry bean production with disease severity dependent on environmental conditions, variety, cropping history, and other factors. Growers in the past have had limited options addressing these issues, but new-generation fungicides and in-furrow placement have shown promise in reducing these disease impacts.

Objectives

A study was conducted to compare the relative efficacy of fungicides applied in-furrow at planting on management of soil-borne diseases, specifically those caused by Fusarium and Rhizoctonia.

Materials and Methods

Research plots were established on June 5, 2017, at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Six in-furrow fungicide treatments were compared to non-treated inoculated and non-treated non-inoculated checks (Table 1). A randomized complete block design with four replicates was established. Each treatment plot was 20 feet long and four rows wide with a five-foot in-row buffer between plots. Plots relied on natural soil populations of *Rhizoctonia solani* and *Fusarium* spp. The planting date was June 5 with pinto bean variety Othello, and in-furrow applications were made prior to row closure. The field plot area received fertility, weed control, and irrigation appropriate for dry bean production. Parameters measured were stand counts, plant vigor, percent stand decline due to disease, incidence of root rot, and bean yield (Table 1).

Results and Discussion

No effect on crop emergence or phytotoxicity due to treatments was observed on the dry bean crop (data not shown). Effects of in-furrow fungicide applications on the bean crop and root rot are shown in Table 1. Most treatments improved plant vigor as measured on July 5, compared to the non-treated inoculated check. The exceptions were the treatments of Velum® Prime and Serenade® ASO, which resulted in plant vigor similar to the non-treated/inoculated check. Only the in-furrow treatment of Proline® had comparable vigor to that of the non-treated/non-inoculated check. All treatments except Velum Prime and Serenade ASO had less stand decline than the non-treated/inoculated check, while the Proline treatment resulted in the least amount of stand decline and was similar to the non-treated non-inoculated check.

Toward the end of the season plants were pulled to rate for root disease, and all treatments except Quadris® and Headline® had less diseased root surface than the non-treated inoculated check. Proline resulted in the least amount of disease compared to all other treatments. Due to late-season weed pressure bean yields were highly variable, and there were no significant statistical differences in yield. Results show that there is some potential of some fungicides applied in-furrow at planting to protect against the effects of soil-borne diseases.

Acknowledgments

We thank SAREC field crews for assistance in plot establishment, maintenance, and termination. The study was supported by funding from Bayer Crop Science, the U.S. Department of Agriculture Hatch program, and the Wyoming Bean Commission.

Contact Information

William Stump at wstump@uwyo.edu or 307-766-2062.

Keywords: dry bean, soil-borne disease, fungicide efficacy

PARP: I:11

[1]*Department of Plant Sciences.*

Table 1. Management of stem and root rot diseases of dry bean with in-furrow fungicides.

Treatment and rate/ac#	Plant vigor (1–10)##	% stand decline	Root disease rating (0–11)*	Bean seed yield (lb/ac)
	July 5	Aug. 24	Aug. 29	Aug. 6
Non-treated non-inoculated check	9.0 a**	0.5 c	7.0 a	2,380.2 a
Non-treated inoculated check	4.8 c	31.0 a	6.8 a	2,272.3 a
Proline (5 fl oz)	9.0 a	0.5 c	4.0 c	1,638.3 a
Velum Prime (3 fl oz)	5.5 c	2.0 a	5.0 bc	2,800.0 a
Propulse (6 fl oz)	7.3 b	4.0 b	5.5 b	1,966.5 a
Serenade ASO (32 fl oz)	5.0 c	28.0 a	5.5 b	2,178.3 a
Quadris (8.7 fl oz)	7.3 b	3.0 b	7.0 a	1,881.5 a
Headline (10.4 fl oz)	7.0 b	5.0 b	7.0 a	1,906.3 a

#Treatment rates (per acre) were concentrated in-furrow.

##Plant vigor rating scale (1–10) where 1=no stand and 10=best stand in the replicate.

*Based on visual estimates of root surface affected with disease of 10 plants. Root disease rating scale (0–11) where 0=no disease and 11=root 100% affected with disease.

**Means followed by the same letter were not significantly different ($p \leq 0.05$).

Management of Potato Early Dying Syndrome with In-Furrow Fungicide/Nematicides and Foliar Nematicide Combinations

William Stump[1] and Wendy Cecil[1]

Introduction

Potato early dying (PED) syndrome is due to a complex of various disease agents, but the major pathogens include Verticillium (a soil-borne fungal pathogen) and lesion nematodes. As the name implies, this disease complex causes the potato crop to senesce (die-back) earlier than normal, negatively impacting yields due to a shortened season. Among the treatment options are biofungicides and nematicides. Serenade® ASO is a biofungicide used to manage certain soil-borne fungal pathogens like Verticillium. A specific strain of the bacteria, *Bacillus subtilis*, forms an exclusion zone around the potatoes as they develop root systems, thereby protecting against fungal invasion. The numbered compound QST713 is a fermented bacterial formulation. Additionally, the remaining treatments were insecticide/nematicide products used to target the nematodes.

Objectives

The objective of this study is to determine the effects of in-furrow biofungicide and nematicide application combinations on management of PED syndrome.

Materials and Methods

The research plot was established in 2017 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Six in-furrow treatments and an in-furrow plus a foliar treatment were compared to a non-treated control for the management of PED syndrome. A randomized complete block design with four replicates was established. Each treatment plot was 20 feet long and four rows wide with a 5-foot non-treated, in-row buffer between plots. On May 25, cultivar 'Atlantic' potato seed-pieces were planted at 12-inch spacing with 36-inch row centers in an open furrow. After seed placement, treatments were applied in-furrow in a 5- to 7-inch band over the seed (Table 1). After application, the furrows were closed with the planter closing discs. The foliar broadcast nematicide treatment was applied July 10 and 24 with the aid of a CO_2-pressurized backpack sprayer (Table 1). The plot received fertility, weed control, and irrigation appropriate for potato production.

Results and Discussion

Parameters measured were final stand counts, % stand decline, and final yield (Table 1). We collected the stand count data on June 19 from the middle two rows of each plot (40 row ft in total). Treatments had no significant effects on the count. On August 28, there was visible necrosis (death of tissue in the potato due to disease) in the crop as it began to decline. Treatments of Serenade ASO (biofungicide), FLU + CTD (biofungicide), and Velum® Prime (nematicide) + Movento® HL (insecticide/nematicide) + DYNE-AMIC® (surfactant) had significantly less percentage of foliar necrosis than the non-treated check. By September 5, however, there were no significant differences in terms of foliar necrosis across all treatments. On October 12, two rows by 10 feet were harvested with a two-row mechanical digger. Treatments had no significant effect on overall tuber yields.

Acknowledgments

We thank SAREC field crews for assistance in plot establishment, maintenance, and harvesting and Western Potatoes Inc., Alliance, Nebraska, for the seed. The study was supported by Bayer Crop Science, U.S. Department of Agriculture Hatch funds, and the Colorado Potato Administrative Committee, Area 3.

Contact Information

William Stump at wstump@uwyo.edu or 307-766-2062.

Keywords: lesion nematodes, potato early dying syndrome, fungicide

PARP: I:11

[1]*Department of Plant Sciences.*

Table 1. Management of potato early dying syndrome with in-furrow and foliar treatments.				
Treatment, rate (product/ac), and timing[1]	**Stand count (40 ft row)**	**Potato early dying (% foliar necrosis)**		**Total[2] tuber yield (cwt/ac)**
	June 19[3]	Aug 28	Sept 5	
Non-treated check A	32.5 a	28.0 a	65.0 a	208.4 a
Serenade ASO (OMRI[4]) (2 qt) A	34.5 a	8.5 c	50.0 a	174.2 a
QST713 HICFU 150FS (12.8 fl oz) A	36.6 a	28.0 a	50.0 a	199.7 a
Velum Prime (6.5 fl oz) A	35.0 a	21.0 ab	50.0 a	181.5 a
Serenade ASO (OMRI) (2 qt) + Velum Prime (6.5 fl oz) A	33.8 a	28.0 a	56.0 a	178.6 a
FLU + CTD (15 fl oz) A	34.5 a	12.0 bc	31.0 a	210.5 a
Velum Prime (6.5 fl oz) + TI435 600SC (4.7 fl oz) A	35.0 a	23.5 a	56.0 a	180.0 a
Velum Prime (6.5 oz) A + Movento HL (2.5 oz) + DYNE-AMIC (0.25% v/v)[5] B, C	34.3 a	12.0 bc	46.0 a	176.4 a

[1]Treatment applications dates (A–C, respectively) were: May 25 (in-furrow), July 10 and 24 (foliar broadcast nematicide treatment). Listed in-furrow rates were adjusted to rates per 1000 row ft. with 36-in. row spacing.

[2]cwt=hundredweight.

[3]Treatment means followed by different letters differ significantly (Fisher's protected LSD, $p \leq 0.05$).

[4]OMRI means that this plant protectant is listed under the Organic Materials Review Institute.

[5]v/v=volume/volume.

Management of Potato Early Blight with Foliar Fungicide Programs

William Stump[1] and Wendy Cecil[1]

Introduction

Early blight of potato (*Solanum tuberosum*) caused by the pathogen *Alternaria solani* is a disease of concern for growers in the High Plains region, including southeast Wyoming. If left uncontrolled, the disease can cause severe defoliation, resulting in reduced tuber size and number. Foliar fungicides are the primary means of early blight management on potato in the United States.

Objectives

The objectives of this study are to determine the effect of foliar fungicides on early blight development and yield for potato.

Materials and Methods

Field plots were placed at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) in 2017. The experimental design was a randomized complete block design with four replications. Plots were four, 20-foot-long rows (36-inch row centers), with a 5-foot in-row buffer. Plots were planted on May 25 with cultivar 'Atlantic'. Emergence was observed June 12. After irrigation on July 25, *Alternaria solani* conidia (spores produced asexually by various fungi [concentration not determined]) were applied along the length of two center rows of each plot. This was to insure uniform disease pressure across the experiment. Foliar fungicide treatments were applied on July 24, and August 1, 8, and 15 (Table 1). Fungicides were applied with a CO_2-pressurized backpack sprayer. Early blight disease severity was measured by calculating the average number of lesions per leaflet (Table 1). Six leaves were randomly selected from each treatment plot: two leaves each from the top, middle, and bottom third of the canopy. The number of lesions was counted on up to seven leaflets from each of the six leaves. Leaves were collected on July 17, 24, and 31, and on August 7, 14, and 21. Two rows by 10 feet were harvested with a two-row mechanical digger on October 12.

Results and Discussion

Disease initiated late and progressed slowly throughout the season resulting in moderate disease by season-end. No phytotoxicity due to foliar treatment was observed in the potato crop. Early blight was first confirmed in the plots on July 24, before inoculation on July 25. Fungicide treatments reduced overall disease by an average of 80–96% as measured by the area under the disease progress curve (AUDPC), compared to the non-treated check. Increased treatment differentiation occurred when evaluating foliar necrosis at the end of the season. All fungicide treatment programs reduced foliar necrosis compared to the non-treated check (Table 1). In general, the Proline® treatment and the protectant fungicide program of Echo® ZN and Dithane™ Rainshield™ were not as effective as the other fungicide treatments in reducing foliar necrosis. Fungicide programs had no significant effect on yield, most likely due to the late developing disease pressure (Table 1).

Acknowledgments

We thank SAREC field crews for assistance in plot establishment and harvesting, and Bayer Crop Science, Colorado Potato Administrative Committee, Area 3, and Western Potatoes Inc., Alliance, Nebraska, for support.

Contact Information

William Stump at wstump@uwyo.edu or 307-766-2062.

Keywords: potato, early blight, fungicide

PARP: I:11

1Department of Plant Sciences.

Table 1. Early blight management in potatoes with fungicide programs, effects on disease, and crop yield.					
Treatment, rate (product/ac), and timing[1]	**Ave # lesions per leaflet**		**AUDPC[2]**	**% canopy necrosis**	**Total tuber yield[3] (cwt/ac)**
	Aug. 7	**Aug. 21**		**Aug. 24**	
Non-treated check	18.4 a[4]	77.1 a	561.6 a	86.0 a	224.9 a
Luna Tranquility (11.2 fl oz) + Induce A, B Scala 60 SC (7 fl oz) + Echo ZN (24 fl oz) C Echo ZN (32 fl oz) D	0.6 b	2.7 b	34.9 b	8.5 c	211.5 a
Luna Tranquility (11.2 fl oz) + Induce A, C Scala 60 SC (7 fl oz) + Echo ZN (24 fl oz) B, D	0.9 b	5.3 b	27.6 b	12.0 c	252.3 a
Luna Tranquility (11.2 fl oz) + Induce A, C Serenade ASO (1 qt) B Scala 60 SC (7 fl oz) + Echo ZN (24 fl oz) D	0.5 b	2.5 b	23.7 b	21.0 b,c	249.1 a
Proline 480 SC (4.3 fl oz) + Induce A–D	3.4 b	5.9 b	66.2 b	31.0 b	235.9 a
Echo ZN (32 fl oz) A, C Dithane Rainshield (32 oz) B, D	3.3 b	17.9 b	111.0 b	31.0 b	223.2 a
Echo ZN (32 fl oz) A Endura 70WG (4 oz) B, D Headline (6 fl oz) C	4.5 b	7.0 b	75.9 b	8.5 c	228.8 a

[1]Application dates were as follows: A=July 24, B=Aug. 1, C=Aug. 8, and D=Aug. 15. For each fungicide treatment, the spray adjuvant Induce was applied at 0.5% v/v (volume/volume).

[2]AUDPC=area under the disease progress curve for data collected from July 17 through August 21. The AUDPC is an estimate of season-long early blight disease severity in the plant canopy.

[3]cwt=hundredweight.

[4]Treatment means followed by different letters are statistically different (Fisher's protected LSD, $p \leq 0.05$).

Potato Early Blight Management with In-Furrow Fungicide Combinations

William Stump[1] and Wendy Cecil[1]

Introduction

Foliar fungicides are the primary means of early blight management on potato in the U.S.; however, fluopyram, the active ingredient in Velum® Prime, has fungicidal as well as nematicidal activity. Because of this, it has shown to have activity on early blight when applied in-furrow at planting for nematode management. Velum Prime is marketed both as a nematicide and fungicide.

Objectives

The objectives of this study are to determine the effects of an in-furrow application of Velum Prime at planting with and without additional foliar fungicides on early blight development and yield for potato.

Materials and Methods

Field plots were placed at the James C. Hageman Sustainable Agriculture Research and Extension Center in 2017. The experimental design was a randomized complete block design with four replications. Plots were four, 20-foot-long rows (36-inch row centers), with a 5-foot in-row buffer. In-furrow treatments were applied to open furrows over planted seed on May 25. Emergence was observed on June 12. After irrigation on July 25, *Alternaria solani* spores (concentration not determined) were applied along the length of two center rows of each plot. Foliar fungicide treatments were applied July 24 and 31, and August 8 and 15 with a backpack sprayer. Data collected included early blight disease severity and potato yields (Table 1).

Results and Discussion

Early blight was first confirmed in the plots on July 24. After inoculation the disease progressed, resulting in visible necrosis (death of tissues in the potato due to disease) in the non-treated check by late August. Effects of fungicide applications on early blight disease are shown in Table 1. There were significant differences in lesion numbers for treatments. The area under the disease progress curve (AUDPC), a measure of season-long foliar disease, revealed that only the two in-furrow treatments of Velum Prime reduced overall foliar disease significantly compared to the non-treated check. This effect was also apparent in severity ratings of percent foliar necrosis with these two treatments having noticeably less canopy necrosis than the non-treated check and the Echo® ZN/Dithane® program. The addition of the Echo ZN/Dithane foliar sprays to the Velum Prime in-furrow did not significantly change effects on disease suppression. Fungicide programs had no significant effect on yield. A single application of Velum Prime in-furrow at planting for nematode management has the potential to provide significant season-long management of potato early blight under Wyoming's growing conditions.

Acknowledgments

We thank SAREC field crews for assistance in plot establishment and harvesting, and Bayer Crop Science, Colorado Potato Administrative Committee, Area 3, and Western Potatoes Inc., Alliance, Nebraska, for support.

Contact Information

William Stump at wstump@uwyo.edu or 307-766-2062.

Keywords: potato, early blight, in-furrow fungicide

PARP: I:11

[1]*Department of Plant Sciences.*

Table 1. Potato early blight management with in-furrow fungicide combinations.					
Treatment, rate (product/ac), and timing[1]	**Ave # lesions per leaflet**		**AUDPC[2]**	**% canopy necrosis**	**Total tuber yield[3] (cwt/ac)**
	Aug. 7	Aug. 21		Aug. 24	
Non-treated check	9.0 a[4]	10.4 a	358.7 a	88.00 a	188.8 a
Velum Prime (6.8 fl oz) A	0.2 b	1.6 a	9.6 b	17.00 b	229.4 a
Velum Prime (6.8 fl oz) A Echo ZN (1 pt) BD Dithane DF (2 lb) C	0.3 b	1.9 a	10.4 b	8.5 b	228.0 a
Echo ZN (1 pt) BD Dithane DF (2 lb) CE	10.6 a	21.6 a	203.4 ab	80.5 a	236.0 a

[1]Fungicide applications dates (A–E, respectively) were: May 25 (in-furrow), July 24 and 31, and August 8 and 15 (foliar fungicide). Listed fungicide rates were adjusted to rates per 1,000 row ft with 36-in row spacing.

[2]AUDPC=area under the disease progress curve for data collected from August 22 through September 10. The AUDPC is an estimate of season-long early blight disease severity in the plant canopy.

[3]cwt=hundredweight.

[4]Treatment means followed by different letters differ significantly (Fisher's protected LSD, $p \leq 0.05$).

Management of Rhizoctonia Root and Crown Rot Disease in Sugarbeet with Bio and Conventional In-Furrow and Foliar-Banded Fungicide Applications

William Stump[1] and Wendy Cecil[1]

Introduction

Rhizoctonia root and crown rot (RRCR) of sugarbeet is considered the number one disease issue for sugarbeet production in the High Plains, including southeast Wyoming. Conventional and biofungicides continue to be explored as a disease management option for sugarbeet growers. In-furrow applications of these fungicides made at planting have shown promise in managing RRCR season-long.

Objectives

The objectives are to determine if a biofungicide applied in-furrow and/or in combination with conventional fungicides can provide season-long RRCR management.

Materials and Methods

The study was established in 2017 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Seven in-furrow with +/- sequential foliar-banded fungicide treatments were compared to a non-treated inoculated check (Table 1). A randomized complete block design with four replicates was established. Each plot was 20 feet long and four rows wide with a five-foot, non-treated, in-row buffer between plots. Prior to planting, the plot area was inoculated with *Rhizoctonia solani* grown on barley. Sugarbeet was planted on May 12, and in-furrow treatments were made at this time. Serenade® ASO and Serenade QST 713 (a more concentrated version of ASO) were applied as an in-furrow treatment alone or in combination with Quadris®, a conventional fungicide, both as a tank-mix partner. Some of these treatments were followed with a foliar-banded Proline® 480 SC fungicide application applied at the 8-leaf stage on June 12. The field plot area received fertility, weed control, and irrigation appropriate for sugarbeet production. All data were collected from the middle two rows of each plot (40 row ft in total). Parameters measured included final crop stand, RRCR disease severity (percent canopy decline), and sugar yield (Table 1).

Results and Discussion

Based on 4-inch soil temperatures, conditions were too cool for Rhizoctonia activity until mid-June; therefore, seedling damping off was not an issue and treatments had no significant effect on stand counts (Table 1). RRCR development was slow initially, but by late summer the inoculated check plot canopies were greater than 80% reduced due to disease. By late-season, treatments did have a significant effect on disease severity as measured by percentage canopy declines. Treatments that had Quadris as one of the in-furrow fungicides with the foliar band application had significantly less disease severity (on average 72% less disease) than the check and in-furrow-only treatments. There were no differences in disease suppression between the in-furrow plus foliar-banded treatments. In-furrow-only treatments were not different from the non-treated inoculated check for severity, indicating that the in-furrow biofungicide treatments made at planting did not provide season-long control for RRCR and resulted in crop failure. The in-furrow plus foliar-band treatments provided full-season disease control, resulting in sucrose yields that were significantly better than the in-furrow-only treatments. Based on the results, there is not much evidence the biofungicides had any influence on RRCR management.

Acknowledgments

We thank SAREC field crews for assistance in plot establishment, maintenance, and harvesting, and Western Sugar Cooperative for quality analysis. The study was supported by Bayer Crop Science and U.S. Department of Agriculture Hatch funds.

Contact Information

William Stump at wstump@uwyo.edu or 307-766-2062.

Keywords: Rhizoctonia management, biofungicide, sugarbeet

PARP: I:11

[1]*Department of Plant Sciences.*

Table 1. Management of Rhizoctonia root and crown rot (RRCR) of sugarbeet with in-furrow and foliar-banded fungicide treatments.

Treatment, product rate/ac, and timing[1]	Beet stand (40 row ft) June 12	RRCR severity (% canopy decline) Aug. 24	Extractable sucrose lb/ac Sept. 22
Non-treated inoculated check	62.3 a[2]	86.0 a	516.0 b[3]
Serenade ASO (1 qt) A	56.5 a	88.0 a	668.0 b
Serenade ASO (2 qt) A	58.3 a	88.0 a	1,559.0 b
Serenade QST 713 (6.4 fl oz) A	54.3 a	83.0 a	630.0 b
Serenade QST 713 (12.8 fl oz) A	51.8 a	91.5 a	42.0 b
Serenade ASO (1 qt) + Quadris (9.2 fl oz) A Proline 480 SC (5.7 fl oz) B	56.3 a	6.0 b	7,305.0 a
Serenade ASO (2 qt) + Quadris (9.2 fl oz) A Proline 480 SC (5.7 fl oz) B	56.3 a	8.5 b	7,147.0 a
Quadris (9.2 fl oz) A Proline (5.7 fl oz) B	57.8 a	7.5 b	7,820.0 a

[1]Application timing: A=in-furrow at planting; rate listed concentrated in a 7-in furrow. B=foliar banded (5–7 in) at 8-leaf stage.
[2–3]Treatment means followed by different letters differ significantly (Fisher's protected least significant difference, $p \leq 0.05$).

Management of Cercospora Leaf Spot with Foliar Fungicide Programs

William Stump[1] and Wendy Cecil[1]

Introduction

Cercospora leaf spot (CLS) is the most important foliar disease of sugarbeets wherever they are grown. Growers typically manage this disease with foliar applications of fungicide. With emerging fungicide resistance in most production areas, research continues to explore new chemistries and fungicide rotations for CLS control.

Objectives

The objective is to determine the efficacy of foliar fungicide programs for Cercospora leaf spot management.

Materials and Methods

The study was established in 2017 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Seven foliar fungicide programs were compared to a non-treated check (Table 1). A randomized complete block design with four replicates was established. Each plot was 20 feet long and four rows wide with a five-foot, non-treated, in-row buffer between plots. On August 14, foliar inoculations with *Cercospora beticola* spores and associated hyphae (amounts not determined) were made on the two middle rows of each plot. Parameters measured included CLS severity (an area under the disease progress curve [AUDPC]) and sugar yield (Table 1).

Results and Discussion

Cercospora leaf spot development was low to moderate severity in 2017. No fungicide treatments caused any apparent phytotoxicity in the beet crop. All fungicide programs reduced AUDPC (measure of overall CLS disease) equally compared to the non-treated check. Despite CLS disease pressure, treatments had no effect on sugar yield (Table 1). Proline® 480 SC tank mixes with the biofungicides Serenade® ASO, Sonata® ASO, and QRD484.033 resulted in equivalent disease control as the three sequential applications of Proline treatment (QRD484.033 is an experimental compound). Results from this trial indicate a biofungicide can potentially replace at least one conventional fungicide application for the same level of disease control.

Acknowledgments

We thank the SAREC field crews for assistance in plot establishment, maintenance, and harvesting, and Western Sugar Cooperative for quality analysis. The study was supported by Bayer Crop Science and U.S. Department of Agriculture Hatch funds.

Contact Information

William Stump at wstump@uwyo.edu or 307-766-2062.

Keywords: biofungicide, Cercospora leaf spot, sugarbeet

PARP: I:11

[1]*Department of Plant Sciences.*

Table 1. Management of Cercospora leaf spot of sugarbeet with foliar fungicide programs.

Treatment, product/ac, and timing[1]	AUDPC[2]	Extractable sucrose lb/ac
Non-treated check	190.2 a[3]	6,191 a
Proline 480 SC (5 fl oz) A–C	7.0 b	7,683 a
USF 0728 325 SC (11 fl oz) A–C	24.3 b	7,746 a
Proline 480 SC (5 fl oz) + Serenade ASO (2 pt) A–C	11.3 b	7,524 a
Proline 480 SC (5 fl oz) + Sonata ASO (2 pt) A–C	12.7 b	6,768 a
Proline 480 SC (5 fl oz) A Super Tin® 4L (8 fl oz) + Topsin® 4.5FL (20 oz) B Gem™ 500 SC (3.6 fl oz) C	65.9 b	7,923 a
Proline 480 SC (5 fl oz) + Serenade ASO (2 pt) A Super Tin 4L (8 fl oz) + Topsin 4.5FL (20 oz) + Serenade ASO (2 pt) B Gem 500 SC (3.6 fl oz) + Serenade ASO (2 pt) C	83.1 b	8,622 a
Proline 480 SC (5 fl oz) + QRD484.033 (273.7 fl oz) A–C	27.1 b	8,616 a

[1]Application dates were as follows: A=Aug. 7, B=Aug. 21, and C=Sept. 5. All treatments except the check included the surfactant Induce® 90 SL at 25.66 fl oz/ac.

[2]AUDPC=area under the disease progress curve. AUDPC is a measure of season-long disease control. Smaller values equate to less disease.

[3]Treatment means followed by different letters differ significantly (Fisher's protected least significant difference ($p \leq 0.05$).

Management of Sugarbeet Cyst Nematode with In-Furrow and Foliar-Banded Nematicides

William Stump[1] and Wendy Cecil[1]

Introduction

Sugarbeet cyst nematode (SBCN) can negatively affect sugarbeet production in Wyoming and other production areas, and the nematode is difficult to manage. Newer nematicides are becoming available to manage SBCN, but require field testing to determine efficacy, application method, and crop safety over a wide range of agricultural environments.

Objectives

Our objectives were to compare the efficacy of new nematicide treatments on sugarbeet cyst nematode and determine effects on the sugarbeet crop. We tested a (1) new nematicide applied in-furrow (Velum® Prime) in combination with a foliar-banded application of Movento® HL insecticide/nematicide; (2) foliar-banded-only application of Movento HL; and (3) foliar-banded-only application of Movento 240 SC.

Materials and Methods

The study was established in 2017 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Two foliar application programs (#2–3, Table 1) and an in-furrow plus two foliar-application treatments (#4, Table 1) were compared to a non-treated check for the management of SBCN (Table 1). A randomized complete block design with four replicates was established on May 16. Each plot was 20 feet long and four rows wide with a five-foot, non-treated, in-row buffer between plots. Parameters measured included treatment effects on crop health and final stands of sugarbeet, SBCN severity, and sugar yield (Table 1). All data were collected from the middle two rows of each plot (40 row ft in total).

Results and Discussion

On June 19, the in-furrow treatment of Velum Prime + the foliar-banded application of Movento HL resulted in less than half the sugarbeet stand compared to the foliar-banded-only treatments and non-treated check (Table 1). Additionally, this treatment exhibited significantly more phytotoxicity compared to the other treatments. Phytotoxicity in the treatments was characterized by plant distortion, but plants recovered within several weeks. An August 29 survey revealed that SBCN infestations were apparent throughout the plot area. On this date, the Velum Prime + Movento HL treatment had significantly lower SBCN cyst rating than the treatments of just the Movento foliar-banded applications and the non-treated check. At harvest, however, there were no significant differences between treatments for cyst ratings or sugar yield.

Acknowledgments

We thank SAREC field crews for assistance in plot establishment, maintenance, and harvesting, and Western Sugar Cooperative for quality analysis. The study was supported by Bayer Crop Science and U.S. Department of Agriculture Hatch funds.

Contact Information

William Stump at wstump@uwyo.edu or 307-766-2062.

Keywords: sugarbeet, sugarbeet cyst nematode, nematicide timing

PARP: I:11

[1]*Department of Plant Sciences.*

Table 1. Management of sugarbeet cyst nematode in sugarbeet with in-furrow and foliar-banded nematicide treatments.

Treatment, rate, and timing[1]	**% Phytotoxicity**	**Stand count (40 ft)**	**Cyst rating late season (0–3)**[2]	**Cyst rating at harvest (0–3)**[2]	**Lb sucrose/ac**
	June 12	June 19	Aug. 29	Sept. 18	
1. Non-treated check	0.0 a[3]	69.8 a	3.0 a	3.0 a	2,781.0 a
2. Movento HL (2.5 oz/ac) B,C + DYNE-AMIC[4] (0.25% v/v*) B,C	12.5 a	67.3 a	2.6 a	3.0 a	2,833.6 a
3. Movento 240 SC (5 oz/ac) B,C + DYNE-AMIC (0.25% v/v) B,C	8.3 a	67.3 a	2.8 a	2.9 a	3,235.6 a
4. Velum Prime (3 oz/ac) A + Movento HL (2.5 oz/ac) B,C + DYNE-AMIC (0.25% v/v) B,C	41.7 b	30.3 b	1.3 b	2.8 a	3,304.6 a

[1]In-furrow application rate was adjusted for 30-inch rows. Application dates were as follows: A=May 13 (in-furrow), B=July 10, C=July 17. Foliar treatments were applied as a 7-inch foliar band.

[2]Cyst rating scale is as follows: 0=none, 1=1–10 cysts/root, 2=11–100 cysts/root, 3=>100 cysts/root.

[3]Means followed by different letters are statistically different; Fisher's protected least significant difference ($p \leq 0.05$).

[4]DYNE-AMIC® is a surfactant.

*v/v=volume/volume.

Management of Stripe Rust in Irrigated Winter Wheat

William Stump[1] and Wendy Cecil[1]

Introduction

Stripe rust occurs worldwide and is likely the most damaging cereal crop rust in the U.S. The fungus causes damage to leaves when rust pustules erupt through the leaf surface, reducing the photosynthetic area. This, in turn, results in lower grain yield and quality. The primary method of management is the use of stripe rust resistant varieties in low-input wheat production, which is the most effective and economical means of control. In irrigated wheat, however, foliar fungicide treatments are used to control the disease with success. This study looks at alternative timings of fungicide applications.

Objectives

A study was conducted comparing earlier vs later fungicide application timings to determine effects on stripe rust disease management in irrigated winter wheat.

Materials and Methods

Research plots were established in 2016 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). 'SY Wolf' winter wheat was seeded at a rate of 120 lb/ac on October 13. Overhead sprinkler irrigation was applied as needed for the growing season. The field relied on endemic stripe rust. A randomized complete block design with four replicates was established, and plots were 20 × 10 feet. All treatments were made to and data collected from the center 8 feet. The early fungicide treatments were applied to wheat at the tillering stage, while later treatments were applied at the flag leaf stage. Disease incidence was rated on 10 plants randomly selected from each plot. Severity was an estimate of the percentage of total foliage affected with stripe rust pustules. A 5- by 20-foot area from each plot was harvested on July 19, 2017.

Results and Discussion

Stripe rust was first observed in the plots on May 26, and disease developed to moderate severity by season-end. Disease ratings are presented in Table 1. All treatments resulted in significantly less disease than the non-treated check (48–99% disease severity reduction), and the treatments differentiated according to application timing and frequency. The treatments that were applied at tillering only resulted in disease reductions of 48–51% compared to the non-treated check. The best disease suppression (97–99%) was with the treatments applied at the tillering stage followed by a treatment applied at the flag leaf stage, or as a single application at the tillering stage. For all fungicide treatments except for Tilt® and Trivapro®, treatments resulted in higher plot yields than the non-treated check. Despite improved disease suppression with treatments that had later application timing, yields were statistically similar among the fungicide treatments. The exception was Priaxor® applied at flag leaf, which led to greater plot yield than Tilt and Trivapro applied at tillering.

Results indicate that under moderate disease pressure, fungicide treatments will reduce stripe rust disease and improve yields compared to the untreated check. Applications made at tillering (which coincide with a final herbicide application) reduce stripe rust disease 50%, on average, and was not as effective as fungicides applied at the flag leaf stage. For the Alto® 100 SL treatment, however, yield was equivalent to treatments that received both timings or the later timing. Having split applications of treatment at tillering and at flag leaf did not improve disease suppression compared to the flag leaf applications only.

Acknowledgments

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Contact Information

William Stump at wstump@uwyo.edu or 307-766-2062.

Keywords: winter wheat, stripe rust, fungicide timing

PARP: I:11

[1]*Department of Plant Sciences.*

Table 1. Management of stripe rust of irrigated winter wheat effects on disease incidence, severity, and wheat yield.

Treatment, rate/ac, and timing[1]	**Disease Incidence (10 max)**[2]	**Disease Severity (%)**[3]	**Plot grain weight**[4] **(lb/100 sq ft)**
Non-treated check	10.00 a[5]	18.5 a	12.21 c
Tilt 3.6EC (2 fl oz) A	9.25 a	5.5 b	14.01 bc
Alto 100 SL (4 fl oz) A	8.25 ab	5.0 b	15.16 ab
Trivapro (9.4 fl oz) A	6.75 b	5.0 b	14.09 bc
Alto 100 SL (4 fl oz) A Trivapro (13.7 fl oz) B	0.25 c	0.0 c	15.20 ab
Trivapro (9.4 fl oz) A Trivapro (13.7 fl oz) B	0.50 c	0.0 c	15.45 ab
Priaxor (9 fl oz) B	1.00 c	0.0 c	16.12 a
Twinline® (9 fl oz) B	0.50 c	0.0 c	15.27 ab

[1]Application dates were: A=May 1, 2017, and B=May 26, 2017. All treatments except the check included the surfactant Induce® 90 SL @ 25.66 fl oz/ac.

[2]The number of plants infected with stripe rust out of 10 random plants per plot.

[3]Disease severity was percentage of total foliage affected with stripe rust.

[4]Plot yield included an area of 5 × 20 feet harvested.

[5]Treatments followed by different letters differ significantly (Fisher's protected least significant difference, $p \leq 0.05$).

Evaluating Bioherbicide Efficacy on Invasive Winter Annual Grasses

Daniel Tekiela[1]

Introduction

Invasive winter annual grasses are one of the greatest threats to rangeland ecosystems in the western U.S. In particular, cheatgrass (*Bromus tectorum*, aka downy brome) has been shown to, for example, lessen plant biodiversity, decrease forage quality, reduce fire-cycle intervals, and modify ecosystem function. Unfortunately, there is a very limited suite of tools that *may* offer long-term control of cheatgrass and other invasive annual grasses; therefore, there has been significant interest in the recent production of bioherbicides labeled for annual grass control.

What is referred to as "bioherbicide" for annual grass control is really a few particular strains of the ubiquitous soil bacteria *Pseudomonas fluorescens*. Previous studies have suggested that in laboratory conditions the presence of these strains decrease the vigor and growth of some invasive annual grasses by invading the intercellular space of root structures and reducing root growth. As a result, these strains have been mass produced for application to invaded soils. Unfortunately, there are few field trials that show the efficacy of these products—and none particularly in Wyoming's many unique environments. This control information is critically important, notably for a biological product that must remain living during the application process. Similar studies are being performed in other areas of the West where cheatgrass is problematic.

Objectives

The objectives of this study are to determine if various bioherbicides alone or in combination with synthetic herbicides are a viable tool for cheatgrass management in Wyoming's environmental conditions.

Materials and Methods

The study was established in fall 2016 as cheatgrass was germinating. The four study locations include the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) and three sites in Albany, Fremont, and Laramie counties. Various rates and combinations of bioherbicides and common synthetic herbicides were utilized for cheatgrass control (Table 1). Three different carrying agents (i.e., solutions) were used to harbor the bacteria and are referred to as D7-1, D7-2, and D7-3. Ideally, these applications would have occurred prior to germination, but due to the application requirements for bioherbicides (cool temperatures, overcast skies, and imminent rain), there was no ideal application time prior to germination for any of the locations; thus, some cheatgrass had already germinated. Cheatgrass cover was visually estimated in summer 2017 to determine herbicide efficacy.

Results and Discussion

In 2017, bioherbicides, regardless of their carrier, did not reduce cheatgrass cover when looking at all four sites. Only synthetic herbicides were able to reduce cheatgrass cover to significant levels (Table 1, Fig. 1). Specifically, imazapic (Plateau®) was most effective at control, reducing cheatgrass cover by more than 50%. Additionally, combinations of synthetic and bioherbicides did not see any increased control, and synthetic herbicides appear to drive the cheatgrass cover response. Because minor germination occurred at some sites prior to application, better control may be observed in 2018 since these products are all intended to be pre-emergent applications (i.e., before germination). This study will be monitored into the future to determine if bioherbicides need an establishment time to be effective, or if they are not a viable option for much of Wyoming and areas in surrounding states having similar climatic conditions. More information about this research is in the author's University of Wyoming Extension bulletin B-1296, *Use of Pseudomonas fluorescens as a bioherbicide for cheatgrass and other invasive winter annual grass control*, available at www.wyoextension.org/publications/

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Contact Information

Daniel Tekiela at drtekiela@gmail.com or 540-553-5471.

Keywords: cheatgrass, bioherbicide, invasive species

PARP: III:5,9,11

[1]*Department of Plant Sciences.*

Table 1. Herbicide treatments and first-year cover of cheatgrass due to treatments for all four study locations.

Treatment[1]	Cheatgrass Cover (%)
D7-2 1.0x	63.2 A[2]
D7-3 2.0x	64.0 A
D7-1 0.5x	61.5 AB
D7-1 2.0x	62.0 AB
D7-2 2.0x	60.5 AB
D7-3 0.5x	62.3 AB
Untreated	56.0 ABC
D7-1 1.0x	55.0 ABC
D7-2 0.5x	54.0 ABC
D7-3 1.0x	55.1 ABC
Indazaflam	53.5 ABC
D7-1+Ind	49.4 ABCD
D7-2+Ind	47.8 ABCD
D7-3+Ind	46.0 ABCD
D7-3+Ima	35.5 BCD
D7-1+Ima	30.8 CD
D7-2+Ima	25.8 CD
Imazapic	24.6 D

[1]D7-1 through D7-3 are different carrying agents for the bioherbicide. Rates following treatment are the application rate relative to standard applications (i.e., a 1x rate was 1 oz/ac). Combinations are all 1.0x rates of both synthetic and bioherbicides based on regional recommendations.

[2]Letters shared by treatments are not statistically different.

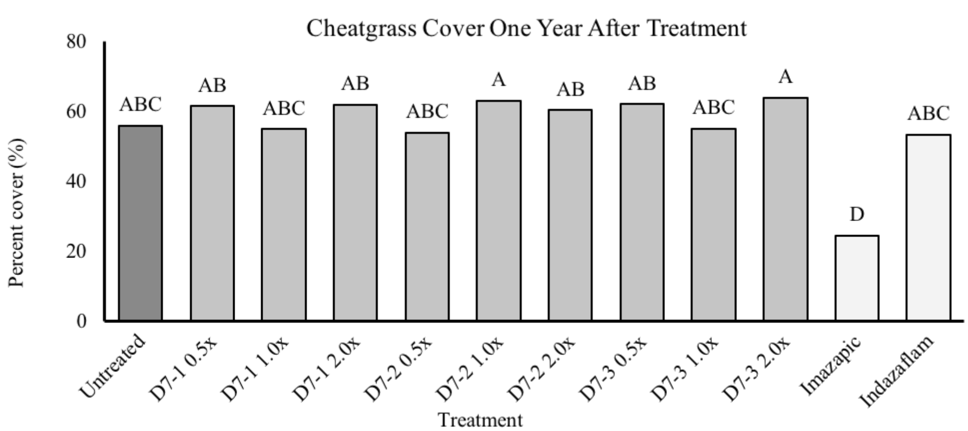

Figure 1. *Effect of each treatment on cheatgrass cover across four sites. Letters signify significant differences among treatments. Only imazapic reduced cover. Combination herbicide + bioherbicide plots were visually excluded; however, all results were driven by presence of imazapic regardless of combination. See Table 1 for treatment details.*

RRS Bulletin 1: *Introduction to the University of Wyoming's Rogers Research Site, North Laramie Mountains, Wyoming*

Stephen Williams[1,2] and Robert Waggener[3,4]

Introduction

In 2002, the Triple R Ranch in southeast Wyoming was bequeathed to the University of Wyoming in the amended will of Colonel William C. Rogers (Fig. 1). The property passed to the UW College of Agriculture and Natural Resources by 2005. The 320-acre parcel—which officially became known as the Rogers Research Site (RRS) in memory of Colonel Rogers—is now a component of the Research and Extension (R&E) centers through the Wyoming Agricultural Experiment Station (WAES). Overseeing management of RRS is the James C. Hageman Sustainable Agriculture R&E Center (SAREC) near Lingle.

In his will, The Colonel, as he was known by friends, stated that the land should be used by UW and others, in part, to conduct research relating to the improvement of forestry and wildlife resources. RRS is near the prominent Laramie Peak, and at the time UW received the gift the site was predominately covered by ponderosa pine (*Pinus ponderosa*). The area is home to a rich array of resident and migratory wildlife species. In summer 2012, during an extreme drought, the Arapaho Fire burned ~98,000 acres in the north Laramie Mountains, including RRS lands. The blaze killed nearly 95% of the ponderosa pine on the site and surrounding lands.

Objectives

The overall objective is to conduct research relevant to the University of Wyoming at RRS while honoring the wishes of Colonel Rogers. Among the specific objectives are to conduct research relating to the improvement of forestry and wildlife resources at the site and on surrounding lands in the Laramie Mountains, which are predominately composed of U.S. Forest Service, private, and State of Wyoming lands.

Materials and Methods

A variety of materials and methods have been used to conduct several completed and ongoing projects at the site, including soils and vegetation mapping, ponderosa pine restoration and erosion control following a high-severity fire, and pre- and post-fire soils research (Fig. 2). A summary of some of that research, along with planning for the future of RRS, is contained in the eight papers that follow this introduction.

Results and Discussion

Fortunately for current and future researchers, much baseline data was compiled prior to the Arapaho Fire, including soils and vegetation mapping (Fig. 2). A great deal of planning has also taken place both before and after the fire. This has included a formal survey of 50 people who attended an open house at RRS in 2005, informal comments submitted by participants of another field day in 2009, work of the RRS Management Committee in 2010 and 2011, a forest audit conducted at RRS in 2011, and work of an ad hoc committee that formed in 2012 following the wildfire.

In 2016, WAES devoted funding to publish bulletins relating to planning, research, extension, and teaching at RRS. RRS bulletins 1 through 4 have been published, bulletins five through eight will be published in the coming weeks and months, and we anticipate publishing a ninth bulletin detailing the ongoing ponderosa pine restoration and related soils research. The bulletins are summarized in this section of the *Field Days Bulletin*.

The RRS bulletin series is being posted on the SAREC website at http://bit.ly/RogersResearchSite. Each bulletin contains a story about Colonel Rogers and some of the history behind the land in the Laramie Mountains, where he spent much of his retirement before passing away in 2003 at age 96.Acknowledgments

Funding and support for research at RRS and the subsequent bulletins were provided by WAES and the U.S. Department of Agriculture McIntire-Stennis program. More than 100 people have helped in our efforts to publish the bulletins, and they are and will be acknowledged in the respective bulletins.

Contact Information

Robert Waggener at robertw@uwyo.edu.

[1]*Department of Ecosystem Science and Management;* [2]*now retired;* [3]*Wyoming Agricultural Experiment Station;* [4]*James C. Hageman Sustainable Agriculture Research and Extension Center.*

Keywords: Colonel William C. Rogers, Rogers Research Site, forestry research

PARP: X:1

Figure 1. *Colonel William C. Rogers spent much of his retirement on the 320-acre Triple R Ranch he purchased in the north Laramie Mountains. This photo was taken in 1995. At the time, The Colonel, as friends knew him, would have been 89 years old. (Photo courtesy Colleen Hogan)*

Figure 2. *UW student Michael Curran excavates a soil pit at one of the research plots at RRS. This photo was taken June 22, 2012, just two weeks before the lightning-caused Arapaho Fire burned across RRS and surrounding lands. Fortuitously, soils and vegetation mapping were completed prior to the fire. (Photo by Claire Wilkin)*

RRS Bulletin 2: *Wide Constituency Guides Early Activities and Research at Rogers Research Site, North Laramie Mountains, Wyoming*

Robert Waggener[1,2]

Introduction

Early research projects and activities at the University of Wyoming's Rogers Research Site (RRS) have been guided by a wide constituency. This has included public input, suggestions by a number of UW, state, and federal employees, work by two ad hoc RRS planning committees, and decision-making by UW officials. Also factoring into the early studies at RRS were particular research interests of faculty, staff, and students in the UW College of Agriculture and Natural Resources, Wyoming Agricultural Experiment Station (WAES), and Wyoming Geographic Information Science Center (WyGISC).

In 2005, the 320-acre property in the north Laramie Mountains near Laramie Peak passed to the UW College of Agriculture and Natural Resources. RRS was subsequently put under management of WAES and one of its four Research and Extension (R&E) centers in Wyoming, the James C. Hageman Sustainable Agriculture R&E Center (SAREC) near Lingle.

Objectives

Early objectives were to seek input from a wide constituency in an effort to help guide site planning and research potential, and a more recent objective was to compile the outcomes of those activities and studies into WAES-published bulletins for future reference.

Materials and Methods

In 2005, WAES and SAREC hosted an open house at RRS, which attracted 70 people, including area ranchers, farmers, cabin owners, landowners, and UW, state, and federal employees (Fig. 1). Each attendee received a questionnaire to help determine priorities for the site. One of the most important questions posed in the survey was: "What activities should be undertaken on the Rogers' property?"

Results and Discussion

Fifty people, or 71% of those in attendance, filled out the survey. Respondents were asked to rank what they believed were the most important activities at RRS, from highest priority to lowest. Forty-four of the 50 respondents (88%) ranked "forestry research" as the top priority, while "wildlife/habitat research" was ranked a close second, and "student education" third (Table 1).

Early studies and other activities at RRS have focused on forestry, vegetation, wildlife, soils, and other natural resources. Factoring heavily into this decision-making were (1) the wishes of Colonel William C. Rogers, who bequeathed the land to UW; (2) survey responses from those attending the 2005 open house; (3) feedback from participants in other field days at RRS, including one in 2009; (4) input from the 2010–2011 RRS Management Committee; (5) recommendations from the 2011 Wyoming Forestry Best Management Practices Audit Team; (6) suggestions from the 2012 RRS Ad Hoc Committee; (7) discussions by UW officials; and (8) particular research interests of UW faculty, staff, and students. Details about RRS planning and early research are summarized in the next seven papers in this section.

Bulletin 2 and other bulletins in the RRS series are and will be posted on the SAREC website at http://bit.ly/RogersResearchSite.

Acknowledgments

Appreciation is extended to those who attended open houses at RRS and offered input on site planning and research. The author also thanks UW faculty, staff, and students who have conducted studies at RRS, as their work will provide important baseline data for future research. Many thanks go to WAES and SAREC for providing support. More than 100 people have assisted in efforts to publish these bulletins, and they are acknowledged in the respective publications.

Contact Information

Robert Waggener at robertw@uwyo.edu.

[1]*Wyoming Agricultural Experiment Station;* [2]*James C. Hageman Sustainable Agriculture Research and Extension Center.*

Table 1. Results from survey filled out by 50 people who attended 2005 open house at Rogers Research Site, listed from highest priority to lowest.

	of 50 respondents	
Forestry research	44	88%
Wildlife/habitat research	40	80%
Student education	33	66%
Water and watershed research	32	64%
Weed control and research	31	62%
Adult outdoor education	28	56%
Range ecology research	23	46%
Livestock research/grazing	22	44%

Keywords: Rogers Research Site, forestry research, planning

PARP: X:1

Figure 1. *Beautiful weather and scenery greeted the approximate 70 people who attended the 2005 open house on the Rogers' property, which was bequeathed to UW for research, extension, and teaching. Here, open house attendees tour a small reservoir that was constructed while Colonel Rogers owned the property. (Photo by Jim Freeburn)*

RRS Bulletin 3: *A Conceptual Framework to Guide Research and Teaching at Rogers Research Site, North Laramie Mountains, Wyoming*

Stephen Williams[1,2] and Robert Waggener[3,4]

Introduction

During the early 2000s, there was an effort to organize a forestry-related component of the Wyoming Agricultural Experiment Station (WAES). This effort was made possible due to an endowed gift of 320 acres of forested land in southeast Wyoming by Colonel William C. Rogers. The parcel, which has become known as the Rogers Research Site (RRS), is located in the Laramie Mountains, approximately five miles southeast of the prominent Laramie Peak and 25 miles northwest of Wheatland, Wyoming.

Objectives

Objectives were to prepare RRS for research, outreach, and teaching activities both within and outside of the University of Wyoming community, and a more recent objective was to compile the outcomes of that planning and early research into WAES-published bulletins for future reference.

Figure 1. *Among those attending the 2009 field day were, from left, in foreground, Martin Hicks, WGFD wildlife biologist; Steve Paisley, UW Extension beef cattle specialist; Jim Waggoner, UW Department of Ecosystem Science and Management associate professor (now retired); and Ryan Amundson, WGFD habitat biologist. In the background are representatives from UW Real Estate Operations, from left, Doug Haggerty, Eric Sneesby, Josh Decker, and Kendra Hamel. (Photo by Kelly Greenwald).*

Materials and Methods

WAES Director Bret Hess and many others worked to address short- and long-term planning items for RRS from 2009 through 2012. The five key components to these undertakings included (1) input gathered during a 2009 field day at RRS (Fig. 1); (2) recommendations from the RRS Management Committee; (3) a forestry audit (Fig. 2); (4) a project to collect baseline data at RRS; and (5) planning meetings following the 2012 Arapaho Fire.

Results and Discussion

In 2010, the RRS Management Committee formed to develop short- and long-term goals for RRS. Active members included Ryan Amundson, Wyoming Game and Fish Department (WGFD) statewide habitat biologist; Bryan Anderson, district forester with the Wyoming State Forestry Division; Jim Freeburn, former director of the James C. Hageman Sustainable Agriculture Research and Extension Center, which manages RRS; Bob Shoemaker, warden of the Laramie Peak Fire Zone; and Steve Williams, lead author of RRS Bulletin 3. They released a final report in 2011, which, in part, provided recommendations on how to encourage research, teaching, and extension at RRS.

In 2011, RRS was selected as one of five sites in the state to undergo an audit through the Wyoming Forestry Best Management Practices (BMPs) Audit program. The audit team, which consisted of representatives from a variety of agencies and organizations (Fig. 2), found that best management practices were well maintained at RRS with a few minor departures.

In early 2012, a project was proposed to inventory soils, plants, and animals at RRS, research nitrogen fixation by plants, and monitor weather at the site. This research was approved by the U.S. Department of Agriculture-National Institute of Food and Agriculture's McIntire-Stennis

[1]*Department of Ecosystem Science and Management;* [2]*now retired;* [3]*Wyoming Agricultural Experiment Station;* [4]*James C. Hageman Sustainable Agriculture Research and Extension Center.*

program. Since then, a weather station with remote accessibility was installed at RRS and vegetation and soils were mapped. The mapping projects are summarized in two papers within this section of the *Field Days Bulletin* (*FDB*).

In summer 2012, the high-intensity Arapaho Fire burned through the area, killing most of the ponderosa pine (*Pinus ponderosa*), which dramatically changed many of the objectives developed by both the RRS Management Committee and Wyoming Forestry BMPs Audit Team. In response, the RRS Ad Hoc Committee formed in late summer 2012 to address the impacts of the fire and to develop a list of possible post-fire research topics. Since then, UW faculty, staff, and students (both graduate and undergraduate) have carried out several research projects involving soils and post-fire ponderosa pine restoration. Those projects are summarized in four papers in this section of the *FDB*.

RRS Bulletin 3 and other bulletins in the series are and will be posted on the SAREC website at http://bit.ly/RogersResearchSite.

Acknowledgments
We thank the many people who have been involved in developing short- and long-term goals for RRS, and who have carried out research at the site.

Contact Information
Robert Waggener at robertw@uwyo.edu.

Keywords: Rogers Research Site, forestry research, planning

PARP: III:5 X:1, XII:1

Figure 2. *Wyoming Forestry Best Management Practices Audit Team members and local residents work together to score RRS in terms of best-management criteria. Pictured are, from left, Melissa Dempsey, U.S. Forest Service (USFS); Colin Tierney, WGFD, red shirt; George Portwood, Laramie Peak resident, red/blue shirt, in background; Bonnie Parker, Laramie Peak resident, blue shirt, in background; Carson Engelskirger, Black Hills Forest Resource Association, now with Wyoming State Forestry Division, yellow shirt; Bob Means, Bureau of Land Management (Bob passed away suddenly in 2015), gray vest; Carol Purchase, USFS; and Stephen Williams, far right. (Photo by Jim Freeburn)*

RRS Bulletin 4: *Vegetation Mapping of Rogers Research Site, North Laramie Mountains, Wyoming, Using High Spatial Resolution Photography and Heads-Up Digitizing*

Mathew Seymour[1,2], Kenneth Driese[3], and Robert Waggener[4,5]

Introduction

The Rogers Research Site (RRS) is a 320-acre parcel of forested land in the Laramie Mountains of southeast Wyoming that was bequeathed to the University of Wyoming in 2002 by Colonel William C. Rogers. The site was donated to UW, in part, for forestry- and wildlife-related research.

Objectives

Our primary objective was to create a vegetation map using high spatial resolution AEROCam photography and heads-up digitizing. The goal was to provide an accurate inventory of existing vegetation within RRS and lands immediately surrounding the site.

Materials and Methods

The project was launched in 2006 to produce an accurate land-cover map of RRS using high spatial resolution (3.3–6.6 ft), multispectral (blue, green, red, and near-infrared bands) AEROCam photography and a procedure called “heads-up digitizing.” The latter involves manually interpreting the photography to infer vegetation classes. The mapping effort was led by the lead author of this paper, Mathew Seymour, a UW undergraduate student during the project, and his mentor, Ken Driese, a member of the UW Department of Botany faculty who specializes in vegetation ecology and remote sensing of vegetation.

Results and Discussion

When we conducted our mapping in 2006, RRS and surrounding lands in the Laramie Mountains were covered predominately by sparse and thick stands of ponderosa pine (*Pinus ponderosa*) forest in various age classifications. Specifically, our vegetation map (Fig. 1) shows that 80% of RRS lands were covered by ponderosa pine, with mixed grass and shrublands occupying about 10% of the site and quaking aspen (*Populus tremuloides*) 4%. Other features included rock outcroppings, cabins and outbuildings, and a small reservoir.

In 2012, during an extreme drought, a significant natural event occurred: the lightning-caused Arapaho Fire burned approximately 98,000 acres in the Laramie Mountains, including RRS. The thick-barked ponderosa pine has evolved to survive frequent, low-intensity ground fires, but the Arapaho burned with such intensity that it killed the majority of ponderosa in the area. Our vegetation map is, therefore, of great importance for future work associated with RRS and nearby lands. Specifically, for researchers and land managers planning to assess temporal changes in habitat structure and land cover, the map will be invaluable.

RRS Bulletin 4 is available on the James C. Hageman Sustainable Agriculture Research and Extension Center website at http://bit.ly/RogersResearchSite.

Acknowledgments

Funding and support for the project was provided by the Wyoming Agricultural Experiment Station through the U.S. Department of Agriculture. Additional funding came from WyomingView, AmericaView, and the U.S. Geological Survey. Numerous other acknowledgments are listed in RRS Bulletin 4.

Contact Information

Mathew Seymour at m.seymour@bangor.ac.uk, or Ken Driese at kdriese@uwyo.edu or 307-766-3975.

Keywords: Rogers Research Site, vegetation mapping, high spatial resolution photography

PARP: X:1

[1]University of Wyoming student; [2]now with Bangor University, Bangor, Gwynedd, United Kingdom; [3]Department of Botany; [4]Wyoming Agricultural Experiment Station; [5]James C. Hageman Sustainable Agriculture Research and Extension Center.

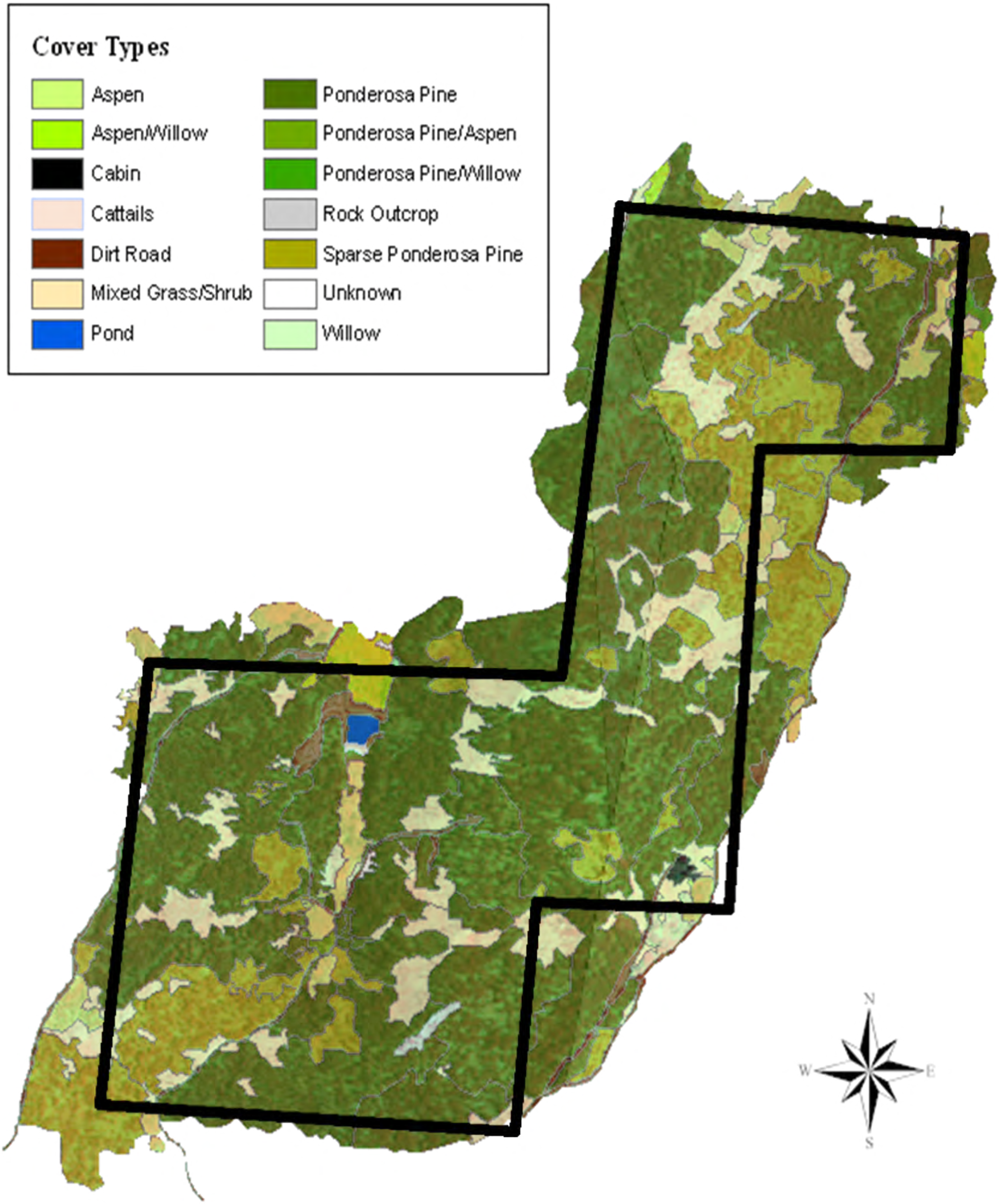

Figure 1. *Land-cover map of the Rogers Research Site in 2006. It shows that 80% of RRS lands were covered by ponderosa pine. A more detailed map, many other figures, and much more information is presented in RRS Bulletin 4. (Map by Mathew Seymour).*

RRS Bulletin 5: *Restoration of Ponderosa Pine Following High-Intensity Fire, Rogers Research Site, North Laramie Mountains, Wyoming*

Mollie Herget[1,2], Stephen Williams[1,3], Linda van Diepen[1], Stephanie Winters[1], and Robert Waggener[4,5]

Introduction

In 2012, a high-intensity wildfire burned ~98,000 acres in the north Laramie Mountains in southeast Wyoming, killing the majority of ponderosa pine (*Pinus ponderosa*) in the area of Laramie Peak. While ponderosa has evolved to withstand low-intensity surface fires, high-intensity fires like the Arapaho Fire, which occurred during an extreme drought and reached temperatures upwards of 900°F, can leave the majority of these thick-barked trees dead. Research is still evolving to determine best management practices (BMPs) for restoring ponderosa pine forests after such fires.

Objectives

To contribute to this ongoing research movement, we set out to investigate the impacts of different restoration treatments applied to the post-fire landscape at the 320-acre University of Wyoming Rogers Research Site, which is located within the 2012 burn area.

Materials and Methods

To determine which BMPs are most effective in restoring a ponderosa pine forest following a high-intensity fire, four replicated blocks were established within RRS in 2015, each located in a unique watershed. Within each experimental block, 18 plots were established, and all plots were 50 × 50 meters (~164 × 164 ft).

Each plot received different combinations of each of the three treatments, which included (1) which cutting treatment is most effective for ponderosa forest regeneration: no cutting; cut all standing trees and remove slash from the site; or cut all standing trees and remove saw wood, but leave slash behind; (2) which method of introducing ponderosa to the burned site is most effective for forest regeneration: natural regeneration, planting seedlings, or planting seed; and (3) whether seeding a native grass mixture on the burned site will help to reestablish ponderosa pine.

Results and Discussion

By 2017, only 146 of the 2,400 seedlings were still alive, meaning that only 6.1% of the seedlings survived their two years in the ground. There was *no statistical difference* between cut treatments and erosion-control treatments. Despite this lack of statistical difference, there was a *trend of higher survival* in the cut-and-remove treatment compared to the two other cutting treatments (no cutting and cut-and-leave slash) as well as a trend of higher survival in plots having an erosion (native grass) treatment.

Mesh guards placed around 10% of the seedlings in each plot did not result in higher survival rates. Of the 240 seedlings with these guards, only 10 were still alive by late summer 2017, two full years after planting. This is only a 4.2% survival rate, nearly identical to the overall survival rate of 6.1%.

Data analysis is continuing, an effort led by UW Assistant Professor Linda van Diepen and her graduate student, Stephanie Winters. To better understand the BMPs for ponderosa pine seedling survival, a three factor factorial complete randomized design will be analyzed using a two-way analysis of variance (ANOVA), with cutting treatment and native grass treatment as factors. For natural pine seedling regeneration, a three-way ANOVA will be used with cutting treatment, planting treatment, and native grass treatment as factors.

Additionally, the 2017 pine seedling survival data will be further analyzed by including information on slope and aspect in an effort to better understand effects of erosion and soil moisture potential, solar radiation, soil, etc., on seedling survival (slope is the steepness or the degree of incline of a hillside, while aspect is the orientation of the slope). For more information about the ongoing study, see the paper by van Diepen and Winters at the end of this section.

To learn about the ponderosa pine restoration project in detail, see RRS Bulletin 5 on the James C. Hageman

[1]Department of Ecosystem Science and Management; [2]now with the Natural Resources Conservation Service, Elsberry Plant Materials Center, Elsberry, Missouri; [3]now retired; [4]Wyoming Agricultural Experiment Station; [5]James C. Hageman Sustainable Agriculture Research and Extension Center.

Figure 1. *Stephanie Winters, left, and Kristina Kline were among the UW graduate and undergraduate students, along with faculty mentors, who conducted ponderosa pine seedling survival surveys at RRS in 2017.*

Sustainable Agriculture Research and Extension Center website at http://bit.ly/RogersResearchSite.

Acknowledgments
We are grateful for the weather information provided by longtime Laramie Peak-area resident George Portwood, who has been tracking weather at sites near RRS since the 1970s (weather and climate change are an important part of this study, and the weather information is in RRS Bulletin 5). Funding and support for the project are provided by the Wyoming Agricultural Experiment Station and U.S. Department of Agriculture McIntire-Stennis program. Many others helped in our efforts to publish RRS Bulletin 5, and they are acknowledged in the bulletin.

Contact Information
Linda van Diepen at linda.vandiepen@uwyo.edu or 307-766-2781.

Keywords: ponderosa pine, wildfire, post-fire restoration

PARP: III:5 X:1, XII:1

RRS Bulletin 6: *Soils of the University of Wyoming Rogers Research Site, North Laramie Mountains, Wyoming*

Larry Munn[1,2], Stephen Williams[1,2], Michael Urynowicz[3], and Robert Waggener[4,5]

Introduction

When Colonel William C. Rogers bequeathed his "Triple R Ranch" to the University of Wyoming in 2002, he stated in his will that the 320-acre parcel of forested land in southeast Wyoming's Laramie Mountains should be used, in part, for research relating to the improvement of forestry and wildlife resources (Rogers, 2002). One could argue that such research begins with the study of air, water, and soil—three natural resources that wildlife and forests depend upon.

This paper summarizes Rogers Research Site (RRS) Bulletin 6, which focuses on soil as a natural resource. Understanding the ability and capacity of soil to support an ecosystem plays an important role in land-management decisions (U.S. Forest Service, 2017), including those involving both forestry and wildlife resources.

Objectives

Our objectives were to map the soils of RRS to provide important baseline data for future studies at the site that will be carried out by UW faculty and staff members, undergraduate and graduate students, and others.

Materials and Methods

Soil inventory efforts began in 2009 and continued after the 2012 Arapaho Fire, which burned ~98,000 acres in the north Laramie Mountains near Laramie Peak, including RRS lands. The high-intensity fire killed the majority of ponderosa pine (*Pinus ponderosa*), and also changed soil characteristics, which are discussed in other papers in this section.

Lead author Larry Munn completed his field work in 2014, using standard mapping methods to map the soils of RRS. In 2018, Munn and co-author Robert Waggener worked with Shawn Lanning in the Wyoming Geographic Information Science Center (WyGISC) to create five digital soils maps, including the one in this paper (Fig. 1). Backdrop images for the maps were taken in 2009, three years before the Arapaho Fire, and in 2015, three years after the fire. Munn also created a schematic cross-section of ridge showing representation of common locations of soil mapping units on slope positions at RRS.

Results and Discussion

RRS has (1) thin to moderately deep and coarse-textured soils, which support coniferous forests on hillsides and ridge tops; and (2) thick, dark, fine-textured soils in areas where the water table is high, which support herbaceous vegetation in meadows and riparian zones. The representative soils for mapping units at RRS are classified as the following four series: Alderon (RRS-01, an Alfisol), Cathedral taxajunct (RRS-02, an Entisol), Dalecreek (RRS-03, a Mollisol), and Kovich (RRS-04, a Mollisol) (Fig. 1).

See RRS Bulletin 6 to learn more about the soils at RRS, including a discussion that addresses the question: why these soils? The publication is available on the James C. Hageman Sustainable Agriculture Research and Extension Center website at http://bit.ly/RogersResearchSite.

Acknowledgments

Much appreciation is extended to Shawn Lanning, a Geographic Information System research scientist and data manager with WyGISC, for working with our team to create the digital soils maps. Funding and support for the lead author's soil mapping project at RRS were provided by the Wyoming Agricultural Experiment Station and U.S. Department of Agriculture McIntire-Stennis program. Many others helped in our efforts to publish RRS Bulletin 6, and they are acknowledged in the bulletin.

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Contact Information

Robert Waggener at robertw@uwyo.edu.

Keywords: Rogers Research Site, soils mapping, forestry research

PARP: X:1

[1]*Department of Ecosystem Science and Management;* [2]*now retired;* [3]*Department of Civil and Architectural Engineering;* [4]*Wyoming Agricultural Experiment Station;* [5]*James C. Hageman Sustainable Agriculture Research and Extension Center.*

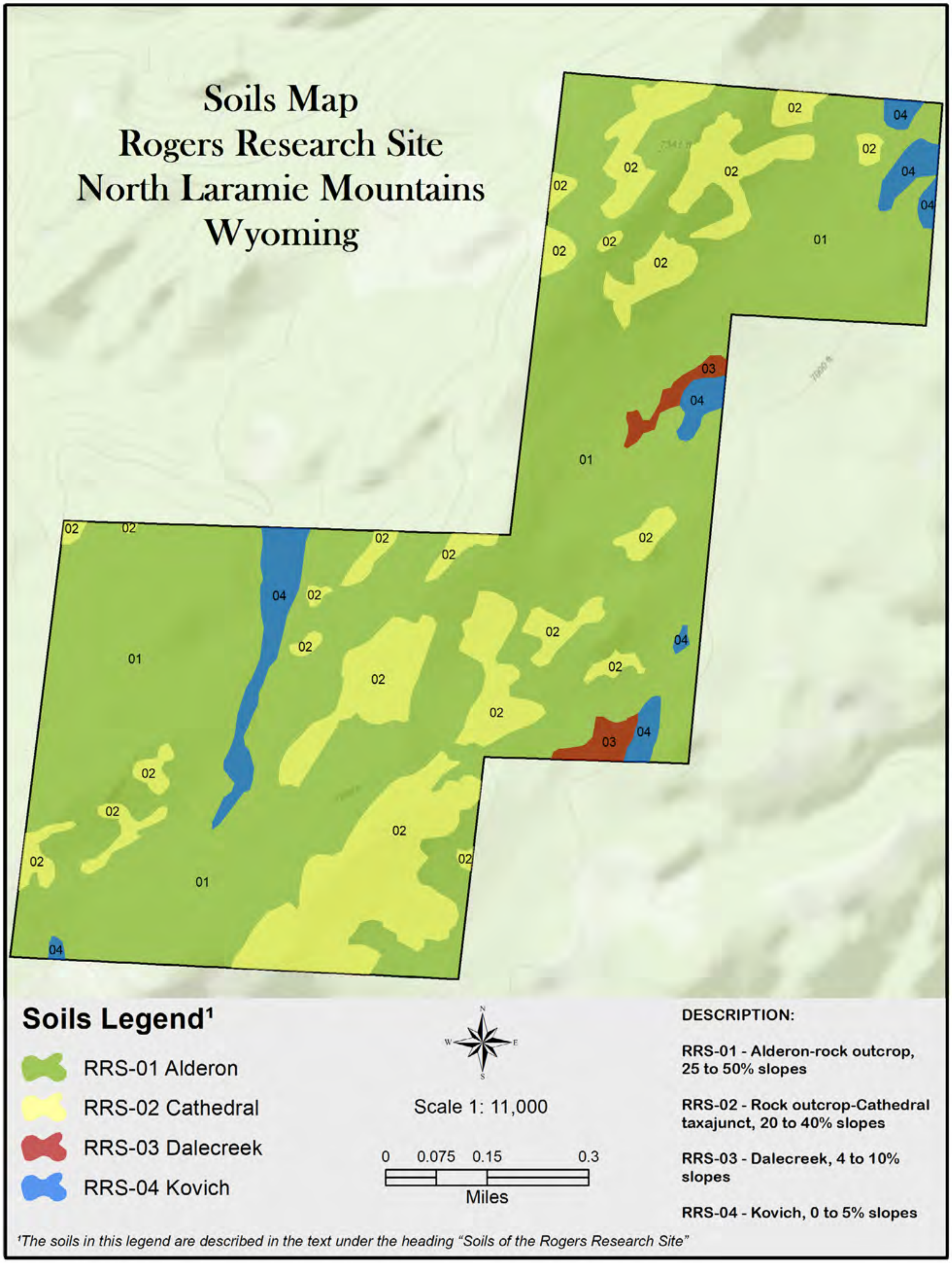

Figure 1. *General soils map of the Rogers Research Site, showing the boundaries of the Alderon, Dalecreek, and Kovich soils, and the Cathedral taxajunct. (Soils mapping by lead author Larry Munn; digital GIS and cartography work by Shawn Lanning, WyGISC; base map from Esri World Topographic Map).*

RRS Bulletin 7: *Pre- and Post-Fire Soil Comparisons, Rogers Research Site, North Laramie Mountains, Wyoming*

Stephen Williams[1,2], Claire Wilkin[3,4], Larry Munn[1,2], Michael Urynowicz[5], and Robert Waggener[6,7]

Introduction

Soil microbiological and chemical properties change under the influence of fire. These changes vary significantly based on the intensity of the fire, site location, and micro- and macro-topographic and climatic variations (Certini, 2005). Soil property affects can include soil carbon (C) content, pH, electrical conductivity (EC), and the concentrations of major cations and anions including nitrate nitrogen (NO_3-N), ammonium nitrogen (NH_4-N), phosphate phosphorus (PO_4-P), calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na). Microbial community composition and the relative abundance of different microbe taxonomic groups are common points of focus as soil microorganism responses to fire, particularly with regard to re-vegetation, decomposition, and recovery.

Figure 1. *Larry Munn obtains Global Positioning System coordinates at one of the sites at RRS where soil samples were collected. Fortuitously, these samples were collected shortly before the 2012 Arapaho Fire; thus, the samples provided important baseline data for post-fire studies. (Photo by Steve Williams)*

In summer 2012, the Arapaho Fire in southeast Wyoming's Laramie Mountains burned approximately 98,000 acres of wildland, including the 320-ac Rogers Research Site (RRS), which is owned by the University of Wyoming and managed by the Wyoming Agricultural Experiment Station. Fire modifies ecosystems very quickly, allowing some organisms that have been dormant to become active and others to decrease or disappear. As such, understanding how fire impacts microbial organisms and other soil properties is paramount to understanding the ponderosa pine (*Pinus ponderosa*) system at RRS and surrounding lands.

Objectives

Objectives were to (1) determine if important nutrients in the surface soil would be available in higher concentrations following this high-intensity burn; (2) whether pH and EC would reflect this; and (3) if the surface soil microbial biomass would be significantly changed.

Materials and Methods

As part of an original study to document soils at RRS, eight monitoring plots were established in spring 2012 (Fig. 1). Soil samples were collected from a soil pit excavated at the center of each square plot in June—work that occurred, fortuitously, just days and weeks before the lightning-caused fire started on June 27. To address fire effects, additional soil samples were collected in late July 2012. A subsample of each soil horizon sample was placed on dry ice. From these subsamples, NO_3-N and NH_4-N were extracted using 2M KCl (2-molar potassium chloride) and analyzed using BioTek™ colorimetric assays. Microbial biomass and community composition were estimated using phospholipid fatty acid analysis (PLFA).

Results and Discussion

All fatty acid signatures demonstrated a post-fire reduction compared with pre-burn samples. Data had a high standard error, so significant differences for an alpha of 0.05 were only observed in the actinomycetes

[1]*Department of Ecosystem Science and Management;* [2]*now retired;* [3]*University of Wyoming graduate student;* [4]*now with WSP, San Jose, California;* [5]*Department of Civil and Architectural Engineering;* [6]*Wyoming Agricultural Experiment Station;* [7]*James C. Hageman Sustainable Agriculture Research and Extension Center.*

and protozoans. Both arbuscular mycorrhizal fungi and ectomycorrhizal fungi showed significant differences at an alpha of 0.10. Post-fire soils were substantially richer in available base cations and phosphate phosphorus, and surface soil properties were more severely altered as compared to the subsurface.

The pH of surface soils increased by 1.22 units, on average, across the eight sites sampled, while Ca, Mg, K, Na, EC, and PO_4-P all increased significantly following the fire (Table 1). Weight %N and %C both increased, apparently indicating that the fire at RRS did not heat the soil long enough or at high enough temperatures to volatilize significant amounts of biomass litter N and C. Our study also showed that NH_4-N increased significantly, while NO_3-N increased significantly when comparing surface soils only (Table 1). After observing marked soil chemical and biotic changes following the fire, we became interested in exploring the subsequent effect these changes might have on the soil microbial communities, including how the addition of external soil amendments affect the system. The results of this study are summarized in the next paper in this section.

RRS Bulletin 7 is nearing completion and will be posted on the James C. Hageman Sustainable Agriculture Research and Extension Center website at http://bit.ly/RogersResearchSite.

Acknowledgments
Support for this research came from the Wyoming Agricultural Experiment Station, UW College of Agriculture and Natural Resources, and UW Department of Civil and Architectural Engineering. Many people assisted with statistical design, field and laboratory work, and the development of RRS Bulletin 7, and they are acknowledged in the bulletin.

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Contact Information
Robert Waggener at robertw@uwyo.edu.

Keywords: Rogers Research Site, pre- and post-fire soil comparisons, soil microbial community

PARP: X:1

Table 1. Pre- and post-fire soils data from eight 50 m × 50 m (164 ft × 164 ft) plots at Rogers Research Site.

horizon	NO3 - N (mg/kg)		NH4 - N (mg/kg)		Ca (meq/L)		Mg (meq/L)		K (meq/L)		Na (meq/L)	
	pre fire	post fire	pre fire	post fire	pre fire	post fire	pre fire	post fire	pre fire	post fire	pre fire	post fire
A	8.8	28.0*	6.6	16.7*	1.5	8.2*	0.6	3.5*	0.3	0.9*	0.7*	0.3
B	7.5	10.9	7.4	5.1	0.8	1.5	0.3	0.5	0.2	0.2	0.8*	0.5
Overall	8.3	22.9	6.9	13.3*	1.2	6.2*	0.5	2.6*	0.3	0.7*	0.8*	0.4

horizon	pH		EC		SAR		PO4-P (mg/kg)		Wt% N		Wt % C	
	pre fire	post fire	pre fire	post fire	pre fire	post fire	pre fire	post fire	pre fire	post fire	pre fire	post fire
A	6.0	6.6*	0.3	1.0*	0.9*	0.2	30.9	90.0*	0.2	0.4*	3.4	5.7*
B	5.9	5.9	0.2	0.3	1.2*	0.5	18.9	25.6	0.1	0.2	0.8	2.0
Overall	6.0	6.4	0.2	0.7*	1.0*	0.3	26.2	71.0*	0.2	0.3*	2.4	4.6

NO_3-N (nitrate nitrogen), NH_4-N (ammonium nitrogen), and PO_4-P (phosphate phosphorus) are in milligram/kilogram (mg/kg) dry soil. All cations are in milliequivalents per liter (meq/L), a chemical unit commonly used to characterize salt concentration in solutions. Ca=calcium, Mg=magnesium, K=potassium, Na=sodium, EC=electrical conductivity, SAR= sodium adsorption ratio, Wt%N=nitrogen content, Wt%C=carbon content. An asterisk (*) denotes a significantly higher variable response between a single soil horizon and its paired counterpart, $\alpha<0.05$.

RRS Bulletin 8: *Nutrient Additions and Soil Microbial Community Recovery Following High-Severity Forest Fire, Rogers Research Site, North Laramie Mountains, Wyoming*

Claire Wilkin[1,2], Stephen Williams[3,4], Michael Urynowicz[5], Larry Munn[3,4], and Robert Waggener[6,7]

Introduction

In summer 2012, the Arapaho Fire burned approximately 98,000 acres in the north Laramie Mountains of southeast Wyoming, including the Rogers Research Site (RRS). The 320-ac parcel is owned by the University of Wyoming and managed by the Wyoming Agricultural Experiment Station. A study was performed at RRS to investigate the effectiveness of soil amendments (compost tea, 'traditional' compost, and ammonium nitrate [NH_4NO_3]) fertilizer for re-establishing the soil microbial community and hastening the recovery of the site to a healthy successional environment following the high-severity fire. The long-term goal of this effort is restoration of the burned forest stand; however, this study was directed toward an evaluation of the below-ground ecosystem and, specifically, the microbial communities in the soil on short time scales.

Objectives

Objectives were to (1) determine how the microbial community structure and chemical properties changed from a pre-fire, semiarid ponderosa pine (*Pinus ponderosa*) stand to the post-fire environment; (2) compare treatment impacts on soil community recovery to that of the control; and (3) monitor belowground community and inorganic nitrogen (N) nutrient dynamics over a nine-month period after treatment.

Materials and Methods

The post-fire soil amendment study included six treatments across seven blocks for a total of 42 treatment plots. The treatments included two steeping times of compost tea, NH_4NO_3, traditional compost, water-only control, and blank control. The treatments were applied in a randomized complete block design using seven replicates. Four sample sets were collected: one day prior to the November 13, 2012, treatments, and approximately one week (November 25, 2012), six months (May 14, 2013), and nine months (August 14, 2013) post-treatment. These sample dates are referred to as pre-treatment, and post 1, 2, and 3, respectively.

Site-wide soil samples collected pre- and post-fire (Fig. 1) were frozen and subsequently extracted for phospholipid fatty acid (PLFA) signatures. These samples were run for pH, electrical conductivity (EC), calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), sodium adsorption ratio (SAR), and phosphate phosphorus. Ammonium (NH_4) and nitrate (NO_3) concentrations were also determined.

Results and Discussion

The NH_4 and NO_3 measurements, carried out over the four sample dates, demonstrated a strong seasonal trend. The pre-treatment measurement did not show any statistical differences across the 42 plots for either ammonium nitrogen (NH_4-N) or nitrate nitrogen (NO_3-N). Following treatment, the fertilizer plots showed a significant spike in NO_3-N, not unexpected after the addition of NH_4NO_3 as fertilizer. This spike disappeared by the post-2 measurement; there was not a similar spike in the NH_4 data. What was most interesting was the nearly fourfold increase in both NH_4-N (Fig. 2)

Figure 1. *On July 18, 2012—just over two weeks after the Arapaho Fire burned across RRS and surrounding lands—Steve Williams collects soil samples as part of a multi-pronged soil study detailed in RRS Bulletins 7 and 8. (Photo by Stanley Bellgard)*

[1]University of Wyoming graduate student; [2]now with WSP, San Jose, California; [3]Department of Ecosystem Science and Management; [4]now retired; [5]Department of Civil and Architectural Engineering; [6]Wyoming Agricultural Experiment Station; [7]James C. Hageman Sustainable Agriculture Research and Extension Center.

and NO_3-N at the post-3 sample date. This increase in both inorganic N values may coincide with seasonal environmental changes, as summer 2013 was relatively wet and mild, especially in the week prior to the August 14 sampling. This may also reflect loss of the conifer canopy and subsequent reduced water uptake after the fire.

RRS was significantly affected by the Arapaho Fire, and likely this ecosystem will take many decades to recover to pre-fire levels of ponderosa pine production. The release of organic-bound nutrients and the charring of woody materials may have long-term effects on soil bacteria populations. The addition of organic amendments, in the form of compost and its aerated teas, may have stimulated ammonification and fungal activity and narrowed fungi:bacteria ratios over the short-term. The observed changes in PLFA signatures in the experimental surface soils were typically variable and non-significant as the seasons changed and different environmental conditions allowed microbial communities to wax and wane. The addition of N fertilizer, in the form of NH_4NO_3, stimulated bacterial populations to higher levels compared to controls. A longer-term study at RRS with an emphasis on characterization of post-fire vegetation development and well-defined functional groups of microorganisms (e.g., N-fixing bacteria and mycorrhizal fungi) is recommended to understand the full implication of external amendment addition to this fire-impacted forest ecosystem.

RRS Bulletin 8 is nearing completion and will be posted on the James C. Hageman Sustainable Agriculture Research and Extension Center website at http://bit.ly/RogersResearchSite.

Acknowledgments
Many people assisted with statistical design, field and laboratory work, and the development of RRS Bulletin 8, and they are acknowledged in the bulletin. The Wyoming Agricultural Experiment Station, UW College of Agriculture and Natural Resources, and UW Department of Civil and Architectural Engineering provided financial support.

Contact Information
Robert Waggener at robertw@uwyo.edu.

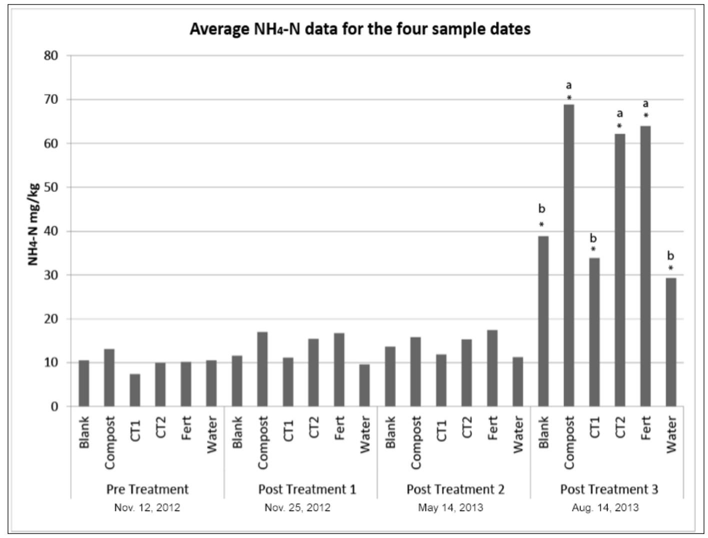

Figure 2. *Ammonium nitrogen (NH_4-N) average responses for pre- and post-treatment analyses. Nitrate nitrogen [NO_3-N] showed a similar response.*

NH_4-N mg/kg: ammonium nitrogen in milligram/kilogram dry soil. Example: 50 mg/kg of NH_4-N=100 lb of NH_4-N per acre in a layer 8 inches thick, the latter of which is commonly called an acre furrow slice (AFS) The assumption for AFS is that the soil has an average bulk density of 1.33 g/cm^3 (~50% pore space by volume). The result is 100 lb NH_4-N in an AFS that weighs 2 million pounds.

Different letters indicate significant differences between treatments on a single sample date ($p<0.05$). An asterisk (*) indicates significantly higher response for a single treatment compared with other sample dates.

The four sample sets include: one day prior to the November 13, 2012, treatment (pre-treatment), and approximately one week (post 1), six months (post 2), and nine months (post 3) post-treatments. Blank=blank control; compost=traditional compost; CT1=compost tea aerated and steeped at a ratio of one part compost to five parts water (v/v) for one day; CT2=compost tea aerated/steeped for two days; Fert=ammonium nitrate (NH_4NO_3) fertilizer; water=water-only control.

Keywords: Rogers Research Site, post-fire soil amendment study, soil microbial community

PARP: II:8, X:1, XII:1

Linking Ponderosa Pine Ecosystem Restoration with Soil Ecology Following a High-Intensity Wildfire at Rogers Research Site, North Laramie Mountains, Wyoming

Stephanie Winters[1] and Linda van Diepen[1]

Introduction

Warming temperatures associated with climate change have increased wildfire intensity and frequency. Ponderosa pine (*Pinus ponderosa*) regeneration following high-intensity wildfire is limited in mid-elevation, lower montane, xeric (dry) forests in the Rocky Mountain region. This is due to a reduction of seed supplies from living trees, warm temperatures, and limited precipitation. Though low-intensity fires are common in ponderosa pine forests, there is currently no best management practices for restoration of ponderosa pine forests post high-intensity wildfire. In July 2012, a lightning strike started the Arapaho Fire in the north Laramie Mountains, burning ~98,000 acres. The Rogers Research Site (RRS)—a University of Wyoming-owned and Wyoming Agricultural Experiment Station-managed property—experienced ~95% ponderosa pine mortality due to the high-severity fire, which burned during an extreme drought and unusually warm temperatures.

Objectives

Our study aims to bridge the gaps in knowledge regarding best restoration practices for ponderosa pine forest regeneration post-wildfire and how soil ecology (e.g., soil chemical and physical characteristics, and soil microbial community function and composition) correlates with ponderosa pine survival and regeneration.

Materials and Methods

An earlier research team implemented a block design within RRS in 2015 to determine the best combination of management treatments for ponderosa pine restoration (this is covered in the paper summarizing RRS Bulletin 5). Four blocks were established with each comprising 18 plots of 164 × 164 feet, or 0.62 acre in size. Each block received different combinations of pine planting treatment (hand-planted seedlings, hand-seeding ponderosa pine seed, and natural regeneration), cutting treatment (cut and remove slash, cut and leave slash, no cutting/leave all dead material in plot), and erosion treatment (seeding with a native grass mix, no seeding) for a total of 72 plots across all four blocks. In 2017, ponderosa pine seedling counts were performed in all treatment plots as well as vegetation species composition using Daubenmire quadrats along 50-m (~165-ft) transects (Fig. 1). The Daubenmire method uses cover classes to estimate the percentage cover of plant functional groups or specific plant species. Soil ecology measurements to be taken in summer 2018 include carbon and nitrogen pools, microbial activity through enzymatic analysis, and microbial community analysis using molecular methods.

Results and Discussion

Mean live pine seedling density was significantly higher in the planted seedling treatment at 34 seedlings per acre compared to 0.8 and 0.4 seedlings per acre for natural regeneration and hand-seeded treatments, respectively. The combination treatment of 'hand-planted' and 'cut/remove slash' resulted in the highest stem density at 55 seedlings per acre.

Vegetation cover was dominated by perennial forb lifeforms for all cut treatments. Two subshrubs, fringed sage (aka prairie sagewort/*Artemisia frigida* Willd.) and white sagebrush (*Artemisia ludoviciana* Nutt.), and two shrub lifeforms, Fendler's ceanothus (*Ceanothus fendleri* A. Gray) and snowbrush ceanothus (*Ceanothus velutinus* Douglas ex Hook.), had the second highest cover in 'cut/remove slash' and 'no cutting/leave all dead' treatments. Two perennial grasses, rough bentgrass (*Agrostis scabra* Willd.) and green needlegrass (*Nassella viridula* [Trin.] Barkworth), and sub-shrub lifeforms had the second highest cover in the 'cut/leave slash' treatment.

Cheatgrass (aka downy brome/*Bromus tectorum* L.) was the most abundant invasive species present in all cut treatments. Canada thistle (*Cirsium arvense* [L.] Scop.) was most abundant in the 'cut/leave slash' treatment compared to the other cut treatments. The native grass seeding slightly reduced invasive species abundance, but the reduction was not statistically significant. The planned soil ecology research for summer 2018 will determine how restoration treatments post-wildfire affect soil biogeochemistry and the microbial community,

[1]*Department of Ecosystem Science and Management.*

Figure 1. *Field assistants Tiffany Simpson, left, and Kristina Kline count ponderosa pine seedlings at one of the restoration treatment plots at Rogers Research Site.*

and if there is a correlation with ponderosa pine forest restoration success.

Acknowledgments

Great thanks go to Department of Ecosystem Science and Management field assistants Kristina Kline, a UW agroecology undergraduate, and Tiffany Simpson, a UW alum who earned a B.S. in rangeland ecology and watershed management, for help with counting ponderosa pine seedlings and performing vegetation surveys. The study is supported by a U.S. Department of Agriculture, National Institute of Food and Agriculture McIntire-Stennis award.

Contact Information

Linda van Diepen at linda.vandiepen@uwyo.edu or 307-766-2781.

Keywords: ponderosa pine, wildfire, post-fire restoration

PARP: III:5, X:1, XII:1

Introduction to the Sheridan Research and Extension Center

Brian Mealor[1,2]

Introduction

The mission of the Sheridan Research and Extension Center (ShREC) is to serve Wyoming's applied research, education, and extension needs in horticulture, rangeland restoration, and forage science. Our team (Fig. 1) seeks to continually improve our performance in all aspects of this mission. Our extension and outreach efforts have significantly increased over the past few years and have included target-specific field days, intensive multi-day workshops, and one-on-one consultations with local producers, land managers, and those who live on small acreages and in the city. With two field locations (Wyarno, east of Sheridan, and the Adams Ranch, just south of Sheridan College), a research greenhouse, two high tunnels (Fig. 2) and state-of-the-art laboratory space, we are able to facilitate studies ranging from highly technical to very applied. While a lot of research occurs on these sites, ShREC also serves as home base for additional research and educational endeavors around the state and region.

Highlights

Our research approach spans a broad range of methods, ranging from purely basic science to strongly applied science that is directly related to clientele needs. The use of precision breeding, biotechnology, molecular genetics, and conventional plant propagation facilitate the exploration of genetic diversity and novel combinations to enhance performance or diversity of plant materials. Greenhouse evaluations of growth, competitive ability, stress tolerance, and other characteristics further refine our understanding of how plant materials may perform under controlled conditions. Field evaluations of plant materials, management methods, water regimes, agricultural practices, harvest approaches, and other ways in which plants interact with their environment further advance development of management recommendations for our region.

The research enterprise at ShREC continued to mature and diversify in 2017. As you will see from other articles in this section of the *Field Days Bulletin*, research topics spanned grass, alfalfa and mixed hay production, native plant production for reclamation, precision breeding of grapes, cover crops for soil health and grazing, and projects related to weed science.

The first grape harvest from the research vineyard took place in 2017. Although birds found the grapes to their liking before harvesting was complete, more than 100 pounds of grapes from 18 varieties were collected and evaluated for various quality characteristics. Sadanand Dhekney's team cooperated with University of Wyoming Extension's Kentz Willis and Lori Dickinson to prepare grape jelly. Taste and color varied widely across jellies depending on the variety of grape.

Thanks to a partnership with the Laramie Research and Extension Center, sheep made their return to the Wyarno farm in 2017 as part of a cover crop project. The last record we could locate of sheep grazing research at ShREC was in the 1950s. The small flock helped with ground maintenance in the orchard and among the windbreaks when they were grazing cover crops. They also spent some time at Adams Ranch managing vegetation along a portion of the irrigation system.

As part of our commitment to providing research experience for undergraduate students, we expanded our internship program in 2017 to explore a pilot project that will allow undergraduate interns to seamlessly transition into a master's of science degree program with UW. After spending a year experiencing hands-on research opportunities as an undergraduate intern, they can return for multiple years as interns to work on a specified research program or topic. Those summer projects will aggregate over several years into the core of an M.S. thesis. This program, in cooperation with the UW Department of Plant Sciences, will provide research-minded students an efficient and effective way to further their education in an increasingly competitive job market.

Resource Stewardship

The Adams Ranch is a direct result of partnership among UW, Sheridan College, and Whitney Benefits. While Whitney Benefits owns the real estate, we conduct research and educational activities within the terms of a multi-year lease. As part of our ongoing stewardship of the property, we made significant improvements to the irrigation infrastructure in 2017. We installed flow meters on all three center-pivot irrigation systems and a side-roll irrigation system to allow for better accounting of water use on both research and production fields. In preparation

[1]*Director, Sheridan Research and Extension Center;* [2]*Department of Plant Sciences.*

for the pending widening of Coffeen Avenue (on the west boundary of Adams Ranch south of Sheridan), we modified the controls and sprinkler system on one of the center pivots—a change that will allow us to minimize watering over future rights of way and walking paths. Additionally, our 2017 summer interns waged a campaign against Russian olives, a state-designated noxious weed species, by using cut-stump herbicide treatments on almost every tree on the Adams Ranch.

Figure 1. *The ShREC team includes, from left, Sadanand Dhekney, Brian Mealor, Mike Albrecht, Dan Smith, Rochelle Koltiska, Beth Fowers, and Clay Wood.*

Figure 2. *The ShREC team installs a cover on one of the two high tunnels.*

Acknowledgments
Members of the ShREC team strive to provide a setting where faculty and staff members, students, and other partners have access to high-quality research and learning opportunities. Our partnerships with Whitney Benefits, Sheridan College, UW Extension, the ShREC Advisory Board, and others expand our ability to serve the needs of stakeholders in Sheridan County and north-central and northeast Wyoming. We also thank other entities that have provided direct support in multiple forms over the past year: Monsanto Co., Wilbur-Ellis, Plank Stewardship Initiative, Sheridan County CattleWomen, Alforex™ Seeds, Allied Seed LLC, Granite Seed Company, Corteva™ Agriscience, Bayer Crop Science, Bureau of Land Management, and others.

Contact Information
Brian Mealor at bamealor@uwyo.edu or 307-673-2647.

PARP: I, II, III, IV, VI, VII, VIII, IX, X, XII

Establishment of native species for commercial seed production

Investigators: Brian Mealor, Beth Fowers, and Jaycie Arndt

Issue: Some native species are highly desirable in reclamation and restoration settings; however, availability of seed is often very limited. Seed production and availability may be negatively impacted because species are challenging to establish and grow or because their seeds are difficult to efficiently and effectively harvest.

Goal: Evaluate methods for increasing seed availability of desirable, but largely unavailable, native plant species.

Objectives: In 2016–2017 we initiated a long-term project to evaluate growth and production of grasses and forbs including: Letterman's needlegrass (*Achnatherum lettermanii*), western wheatgrass (*Pascopyrum smithii*), green needlegrass (*Nassella viridula*), prairie sandreed (*Calamovilfa longifolia*), desert biscuitroot (*Lomatium foeniculaceum*), sulphur-flower buckwheat (*Eriogonum umbellatum*), scarlet globemallow (*Sphaeralcea coccinea*), and fourwing saltbush (*Atriplex canescens*). Work on these species is ongoing with first seed collection projected to occur at the earliest in 2018, but some species require three or more years before seed production occurs.

Expected Impact: Identifying the best methods for germination and growth for each species will allow that information to be shared, and seed production at the Sheridan Research and Extension Center will proceed as a first step in increasing seed availability.

Contact: Brian Mealor at bamealor@uwyo.edu or 307-673-2647.

Keywords: native species, seed production, plant establishment

PARP: IX:6, XII:1

Figure 1. *Scarlet globemallow (Sphaeralcea coccinea). (Photo courtesy Katie Estep)*

Evaluation of Table, Wine, and Juice Grape Cultivars in Wyoming

Sadanand Dhekney[1] and Jeremiah Vardiman[2]

Introduction

The acreage under grape production in Wyoming is increasing as producers seek alternative crops to diversify farm operations, and more and more homeowners are planting grapes as well. However, low winter temperatures, late spring frosts, and a short growing season limit the cultivation of popular bunch grape cultivars in the state. With the development of new cold-hardy grape cultivars, the scope for grapevine production in colder regions of the U.S., including Wyoming, is expanding. Grape production and quality is governed, in part, by the complex interaction of cultivar with prevailing soil and climatic conditions. Thus, cultivar choice is a critical factor for successful vineyard establishment. Hot and dry weather conditions during the growing season can ensure vigorous, disease-free vine growth and high-quality fruit production if suitable cultivars for the state can be identified.

Objectives

The objectives of the study are to evaluate table, wine, and juice grape cultivars for cold-hardiness, yield, and fruit quality under short growing seasons.

Materials and Methods

A grapevine cultivar evaluation trial (Fig. 1, *A–B*) was established in 2013 at the Sheridan Research and Extension Center (ShREC), which has an elevation of 3,750 feet and growing season of 120–130 days. A germplasm comprising 30 cultivars was established in a greenhouse at ShREC. Year-old vines were transplanted into the vineyard in May 2013. Grapevines were trained to a high-wire cordon and irrigated using drip irrigation. Grapevines were spur-pruned in the second week of May by retaining two spurs (nodes) from dormant canes from the previous season. Any vines exhibiting dead cordons were retrained by allowing two vigorous suckers to grow to the top of the wire. Grapevines were covered with netting in August to minimize fruit loss from bird feeding. Data were collected on bud break, number of flowers per vine, yield per vine, number of clusters, cluster weights, individual berry weights, and total soluble solids (sugar concentration). Grapevines were harvested between August 30 and September 13, 2017.

Results and Discussion

Despite our efforts to protect the vines with netting, a significant amount of bird damage was observed in Marquette, Osceola Muscat, and St. Croix—with total loss of fruit in Marquette. Harvesting was carried out early to avoid complete depredation of fruit from birds. Frontenac, Frontenac Gris, and Osceola Muscat were the highest yielding cultivars (Table 1; data from vines where the fruit was not eaten by birds). Most *Vitis labrusca* hybrids such as ‘Elvira’, ‘Concord’, ‘Ives’, and ‘Fredonia’ are extremely late-maturing and ripening for the Sheridan area and not suitable for production due to the risk of the crop being lost to an early fall freeze. We continue to screen additional cultivars for their suitability under short growing seasons. The study should provide information to commercial growers, small-acreage owners, and backyard gardeners on grape cultivars that can be successfully grown for fresh fruit, juice, and wine production in Wyoming and surrounding areas having similar climates.

Acknowledgments

The study was supported by the Wyoming Department of Agriculture Specialty Crop Block Grant Program. We thank ShREC crews for assistance with vineyard establishment and maintenance.

Contact Information

Sadanand Dhekney at sdhekney@uwyo.edu or 307-673-2754.

Keywords: grape, cold-hardy, viticulture

PARP: I:2,12, IX:9

[1]*Department of Plant Sciences,* [2]*University of Wyoming Extension.*

Figure 1. ***A–B****, Views of the test plot in Sheridan. Netting was used in an effort to protect vines from hungry birds, but the birds still managed to wreak havoc on several grape varieties.*

Table 1. Evaluation of cold-hardy grapevine cultivars in Wyoming.

Cultivar	Yield per vine (lb)	No. of clusters	Cluster weight (lb)	Berry weight (g)*	TSS** (sugar level)
Brianna	8.36	34.0	0.370	1.92	20.60
Elvira	2.80	27.3	0.110	1.70	16.00
Edelweiss	8.20	43.0	0.393	1.90	16.40
Frontenac	9.31	59.3	NA#	0.97	20.30
Frontenac Gris	9.10	58.0	0.250	1.09	20.50
Foch	4.78	26.6	NA	1.10	20.00
Osceola Muscat	9.30	45.5	0.150	1.37	23.38
Swenson White	2.80	16.0	0.175	1.60	13.42
Swenson Red	3.20	24.6	0.130	1.42	18.23
St. Croix	3.10	32.5	0.100	1.15	20.00

*1 gram=~0.04 ounces; **TSS=total soluble solids; #NA=not available.

Perennial Cool-Season Grasses Under Irrigation for Hay Production and Fall Grazing

Blaine Horn[1], Anowar Islam[2], Dan Smith[3], Valtcho Jeliazkov[4], and Axel Garcia y Garcia[5]

Introduction

Perennial cool-season grasses comprise nearly 25% of hay field acreage in north-central and northeast Wyoming. The most popular grasses used for hay production under irrigation in this region have been smooth brome (Bromus inermis) or meadow brome (Bromus riparius). Although these two grasses are productive with good stand persistence, they generally reach anthesis (optimum stage for hay harvest) by mid-June most years in northern Wyoming. For operations with significant acreage this could result in some of the hay being lower in quality than what a lactating beef cow or sheep ewe requires due to the maturity of the grasses at harvest. Likewise, small hay operations dependent upon custom harvesters can have their fields harvested when these grasses are at a later maturity than desired. The opportunity to select perennial cool-season grasses with varying maturity dates could benefit hay producers in being able to furnish good quality hay for their own livestock as well as to their clients.

Objectives

Objectives of this study were to assess (1) late spring/early summer hay yields of perennial cool-season grasses; (2) regrowth yields of these grasses for fall grazing; and (3) forage quality of the hay and regrowth.

Materials and Methods

Fourteen perennial cool-season introduced grasses were seeded into eight plots at the Sheridan Research and Extension Center (ShREC) in September 2014. The plots received 150 lb of nitrogen and 50 lb of phosphate per acre in mid-April 2017. To assess hay yields, the plots were either harvested on June 15, 2017 ('Manchar' and 'Carlton' smooth brome, 'Paddock' and 'MacBeth' meadow brome, 'Latar' and 'Profile' orchardgrass, and 'Fawn' and 'Texoma MaxQ II' tall fescue) or June 30, 2017 ('Luna' and 'Manska' pubescent wheatgrass, 'Oahe' and 'Rush' intermediate wheatgrass, and 'Climax' and 'Tuukka' timothy). Desired stage of maturity for harvest was post-flowering to visible seed development. Regrowth of all the grasses underwent a harvest on September, 28, 2017. Grass material from all harvests was analyzed for crude protein (CP), macro- and micro-minerals, and net energy maintenance (NEm), the amount of energy available to the animal to maintain bodily functions.

Results and Discussion

The intermediate and pubescent wheatgrasses produced an average of one ton/ac more hay compared to the other grasses (Table 1); however, they produced the least amount of late summer/early fall regrowth among the grasses along with 'Carlton' smooth brome. 'Latar' orchardgrass yielded the highest amount of regrowth, averaging 500 lb/ac more dry matter forage compared to the other grasses. With regard to quality, hay of all the grasses contained an adequate amount of CP to meet the needs of a 1,200-pound beef cow at peak lactation, except for 'Oahe' and 'Manska', and an adequate amount of NEm. In addition, late summer regrowth of the grasses contained adequate amounts of CP and NEm for a beef cow at all production stages as well as for weaned calves. Hay from the grasses contained adequate amounts of calcium (Ca), phosphorus (P), potassium (K), and sulfur (S) for a beef cow, whereas magnesium (Mg) and manganese (Mn) contents were only sufficient in hay from the grasses harvested on June 15 (data not shown). Iron (Fe) content of the hay from all the grasses was borderline sufficient, while the amounts of copper (Cu) and zinc (Zn) were inadequate. Late summer regrowth of the grasses contained adequate amounts of Ca, P, K, Mg, S, and Fe, but not enough Cu or Zn. Only 'Latar', 'Profile', and 'Carlton' contained sufficient amounts of Mn.

For a mid-June hay crop either 'Carlton' smooth brome or 'Paddock' meadow brome would be recommended; whereas, for a late June harvest any of the four wheatgrasses would be suggested. For early fall grazing, 'Latar' or 'MaxQ II' would be suggested.

Acknowledgments

We thank ShREC field crews for assistance in harvesting. The study was supported by the Wyoming Department of Agriculture's Agriculture Producer

[1]University of Wyoming Extension; [2]Department of Plant Sciences; [3]Sheridan Research and Extension Center (ShREC); [4]previously at ShREC/now at Oregon State University; [5]previously at Powell Research and Extension Center/now at University of Minnesota.

Research Grant Program and the Wyoming Agricultural Experiment Station.

Contact Information

Blaine Horn at bhorn@uwyo.edu or 307-684-7522.

Keywords: cool-season grass, hay production, regrowth yields

PARP: I:2,12, IV:4, VI:1,3

Table 1. Hay yields (12% moisture) for the June harvests and regrowth dry matter yields for the September harvest of the cool-season perennial grasses and crude protein (%CP) and net energy maintenance (NEm) in mega-calories per pound (Mcal/lb) contents of the hay and regrowth. Harvest dates were June 15 for the bromes, orchard, and tall fescues, and June 30 for the wheatgrasses and timothies.

Grass	Variety	June 15 and 30 harvest			September harvest		
		Ton/ac	%CP*	NEm**	Lb/ac	%CP*	NEm**
Smooth brome	Carlton	3.7 d	12.9 ab	0.65 a	145 e	10.1 a	0.69 ab
	Manchar	4.0 cd	13.8 a	0.65 a	365 cde	9.5 a	0.69 ab
Meadow brome	MacBeth	3.9 cd	10.2 ab	0.60 bc	765 b	9.8 a	0.67 bc
	Paddock	3.9 cd	9.0 b	0.59 c	590 bcd	9.6 a	0.67 bc
Orchard	Latar	4.4 c	12.8 ab	0.62 ab	1595 a	10.4 a	0.70 ab
	Profile	3.7 d	9.8 ab	0.60 bc	890 b	10.5 a	0.70 ab
Tall fescue	Fawn	3.9 d	10.2 ab	0.62 ab	600 bcd	9.1 a	0.69 ab
	Texoma MaxQII™	4.3 d	11.7 ab	0.63 ab	820 b	9.5 a	0.70 ab
Intermediate wheatgrass	Oahe	5.0 ab	8.6 b	0.60 bc	330 de	9.8 a	0.65 c
	Rush	5.0 ab	9.1 b	0.60 bc	415 cde	9.8 a	0.65 c
Pubescent wheatgrass	Luna	5.1 ab	9.0 b	0.60 b	185 e	10.5 a	0.71 a
	Manska	5.2 a	8.4 b	0.60 bc	280 de	10.2 a	0.70 ab
Timothy	Tuukka	4.5 bc	10.1 ab	0.63 ab	685 bc	10.9 a	0.68 bc
	Climax	3.7 d	10.5 ab	0.63 ab	545 bcd	10.7 a	0.67 bc

Note: column means followed by same letters do not differ at $p<0.05$.

*CP=crude protein

**NEm=net energy maintenance

Species Composition and Nitrogen Fixation Affect Forage Yield and Nutritive Value of Irrigated Meadow Brome-Legume Mixtures

Dennis Ashilenje[1] and Anowar Islam[1]

Introduction

Forage species in mixtures are known to make complementary use of mineral nutrients, water, and light, thus enhancing productivity. Alfalfa, bird's-foot trefoil (BFT), and sainfoin are popular forage legumes in Wyoming that can be grown in mixture with meadow brome, a cool-season perennial grass. Unlike alfalfa, sainfoin and BFT do not cause bloat problems and are not susceptible to alfalfa weevil. Despite the benefits of these legumes in mixtures, they usually have poor growth and persistence because they are shaded by grass and exploited for fixed nitrogen (N). However, changes may occur in species biomass, allowing legumes to dominate at different times compared to grass, thus reducing competition. In such circumstances, legumes have improved growth and N fixation, which can contribute to higher forage yields and nutritive values for mixtures compared to monocrops.

Objectives

The objectives of this study were to determine compositional changes in species biomass that influence forage yield and nutritive value for irrigated meadow brome-legume mixtures.

Materials and Methods

The field experiment started in September 2013 at the Sheridan Research and Extension Center (ShREC). The trial consisted of 15 treatments, including alfalfa (cultivar 'WL363HQ'), sainfoin ('Shoshone'), and BFT ('Norcen') monocrops; nine different grass-legume mixtures; and meadow brome ('Fleet') supplied with 0, 50, and 100 lb N/ac (Table 1). Plant samples were evaluated for forage dry matter (DM) yield and forage nutritive value, which can boost milk production in dairy animals and promote weight gain and milk production in beef animals. These samples were taken in June, August, and October 2015, 2016, and 2017. Grass-alfalfa mixtures were also analyzed for N fixation.

Results and Discussion

Grass-legume mixtures significantly affected ($p<0.0001$) cumulative forage DM yield and nutritive value from 2015 to 2017 (Table 1). The 50:50 mixture of meadow brome-alfalfa and 50:25:25 mixture of meadow brome-alfalfa-BFT had 17 tons of DM per acre, which was ~30% more than the grass monocrop supplied with 100 lb N/ac. The lowest DM-producing mixtures were the 50:50 and 70:30 meadow brome-sainfoin, both of which produced 9 tons/ac. Overall, mixtures composed of meadow brome, alfalfa, and BFT had improved forage crude protein (CP,16–18%), acid detergent fiber (ADF, 32–35%), neutral detergent fiber (NDF, 53–55%), in vitro dry matter digestibility (IVDMD, 65–67%), and relative feed value (RFV, 128–133) compared to corresponding values (14%, 35%, 60%, 66%, and 113, respectively) for the grass monoculture supplied with 100 lb N/ac. In the mixed cropping, alfalfa fixed a total of 90–144 and 161–191 lb N/ac in 2016 and 2017, respectively. As a result, this N fixation enhanced forage nutritive value for mixtures despite dominance of grass biomass. Overall, mixtures of meadow brome-alfalfa and meadow brome-BFT improved yield and forage nutritive value, which is beneficial to livestock DM intake, growth, and milk production. Grass-sainfoin mixtures may be more beneficial if alfalfa is included in the mixture.

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Contact Information

Anowar Islam at mislam@uwyo.edu or 307-766-4151.

Keywords: species composition, grass-legume mixtures, forage yield

PARP: I:2, II:2, VI:1, VII:1

[1]*Department of Plant Sciences.*

Table 1. Cumulative forage dry matter (DM) yield and nutritive value of grass-legume mixtures and grass with N fertilizer from 2015 to 2017 at ShREC.

Treatments†	**DM**‡	**CP**	**ADF**	**NDF**	**IVDMD**	**RFV**
	ton/ac		%			
Alfalfa monocrop	12	24	28	47	69	168
Sainfoin monocrop	4	19	29	47	62	172
BFT monocrop	10	22	29	47	65	174
MB + alfalfa (50:50)	17	18	33	53	67	129
MB + alfalfa (70:30)	16	18	32	55	66	133
MB + sainfoin (50:50)	9	14	34	56	64	122
MB + sainfoin (70:30)	9	13	35	55	64	118
MB + BFT (50:50)	13	17	34	55	65	128
MB + BFT (70:30)	14	17	33	55	66	129
MB + alfalfa + sainfoin (50:25:25)	13	16	34	53	68	125
MB + alfalfa + BFT (50:25:25)	17	18	33	54	68	131
MB + alfalfa + BFT + sainfoin (50:16.7:16.7:16.7)	15	17	32	52	67	133
MB monocrop without N	8	12	37	60	65	104
MB + 50 lb N/ac	10	13	37	60	67	101
MB + 100 lb N/ac	12	14	35	60	66	113
Mean	12	17	33	54	66	132
p-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
least significant difference (LSD 0.05)	2.2	1.3	1.5	2.0	2.4	10.2

†MB=meadow brome; BFT=bird's-foot trefoil.

‡DM=cumulative forage dry matter yield of three years; CP=crude protein; ADF=acid detergent fiber; NDF=neutral detergent fiber; IVDMD=in vitro dry matter digestibility; RFV=relative feed value.

Evaluating Establishment and Forage Production of Various Cover Crops in a Dryland Setting

Tyler Jones[1], Beth Fowers[1,2], Caitlin Price Youngquist[3], Blake Hauptman[3], and Brian Mealor[1,2]

Introduction

Cover crops have made their way into many farmers' crop rotations. They provide soil cover between cash crop plantings, and seed mixes can be formulated to address potential soil health concerns. Cover crops are widely used in irrigated systems, and as such the benefits they provide continue to be shown; however, it remains unclear how cover crops fit into a dryland system where moisture can be a primary limiting factor.

Objectives

Our objectives were to evaluate the establishment and forage production of four cover crop seed mixes in a dryland setting in north-central Wyoming.

Materials and Methods

We drill-seeded four cover crop seed mixes (Table 1) in spring 2017 across three replicated blocks at the Sheridan Research and Extension Center (ShREC) property east of Sheridan near Wyarno, Wyoming. Seed mixes one and two (primarily cool-season plants) were planted on May 15, and seed mixes three and four (primarily warm-season) were planted on May 26. Plot sizes measured 60 × 300 feet. On July 3, we visually estimated canopy cover in each plot within multiple 0.25m² (2.7ft²) quadrats (Fig. 1). All emerging plants that were not part of the seed mix were considered other species, and the seeded cover crops were considered forage species.

We collected biomass on July 19, 2017, from five frames in each plot. Biomass samples were clipped, dried, and weighed, and the data from the five frames within each plot were combined. On July 24, we terminated cover crop growth when half of each plot was mowed, while the other half was grazed by a flock of 30 sheep. We analyzed all data using a one-way analysis of variance.

Results and Discussion

Overall establishment was consistent across species mixes, with adequate stands of each mix establishing early in the season. Mid-summer forage production varied among seed mixes (Table 1; $p=0.018$). Non-forage biomass (largely composed of annual weeds) was statistically consistent across treatments (Table 1), although the less diverse warm-season mix provided the lowest forage production in conjunction with a relatively high weed population. Although we did not quantify regrowth following grazing or mowing, we observed noticeable regrowth in the warm-season mixes, suggesting a later termination date may have been more appropriate for such crops. Turnips and radishes were severely impacted by flea beetle herbivory. This pilot project indicates that diverse cover crop mixes can be grown under dryland conditions in north-central and northeast Wyoming, but there is much more to learn about the benefits and challenges of incorporating them into management programs. Additional research is planned to further investigate the use of cover crops in our region.

Acknowledgments

We thank ShREC interns for their help with data collection, Allied Seed LLC for providing seed for the research, and the Laramie Research and Extension Center for providing sheep.

Contact Information

Brian Mealor at bamealor@uwyo.edu or 307-673-2647.

Keywords: cover crops, soil health, forage production

PARP: I:3,6,12,15, II:10

[1]Sheridan Research and Extension Center; [2]Department of Plant Sciences; [3]University of Wyoming Extension.

Table 1. Biomass of seeded forage and non-forage plants collected July 19, 2017, from four cover crop mixes grown on dryland at ShREC's Wyarno facility east of Sheridan.

Species mix#	Forage biomass (lb/ac)##	Other biomass (lb/ac)##
1 forage barley, forage pea	468 (81)	30 (13)
2 oats, forage pea, deep-root radish, bulb turnip	451 (79)	56 (30)
3 sorghum × Sudangrass, leaf turnip, sainfoin	92 (49)	93 (27)
4 millet, sunn hemp, phacelia, buckwheat, teff	112 (25)	66 (21)

#Seed mixes 1 and 2 are primarily cool-season plants; mixes 3 and 4 are primarily warm-season plants.

##The first number is the mean; the second number (in parentheses) is the standard error.

Figure 1. *From left, Tyler Jones, Jaycie Arndt, and Beth Fowers evaluate one of the cover crop mixes at Wyarno.*

Relative Competitive Abilities of Bulbous Bluegrass and Cheatgrass with Perennial Grasses

Jordan Skovgard[1], Beth Fowers[1,2], and Brian Mealor[1,2]

Introduction
Bulbous bluegrass (*Poa bulbosa*) is an introduced, cool-season grass that is widely distributed across much of Wyoming. Although often found in disturbed sites, it also invades rangelands and improved pastures. It is a poor forage species, dries up early in the spring, and may compete with more desirable perennial grasses for resources. In spite of its relatively long history in our region, little is known about the ecology of bulbous bluegrass in rangelands or natural areas.

Objectives
Our objective was to evaluate the competitive ability of bulbous bluegrass as compared to the known highly competitive invasive grass downy brome (aka cheatgrass/*Bromus tectorum*) when grown with various perennial grasses.

Materials and Methods
We conducted a greenhouse experiment at the Sheridan Research and Extension Center (ShREC) in 2016. This involved establishing a replacement series design where we adjusted the proportional density of each species grown in sets of eight individuals across various ratios: 0:8, 2:6, 4:4, 6:2, and 8:0. All mixtures were grown in field soil and replicated five times. After 12 weeks, we harvested, dried, and weighed above-ground biomass to calculate relative yield for each species at each proportional density. Relative yield (RY) compares the amount of biomass produced by a species in mixture compared to that species when grown alone. RY gives a standardized 'index' by which to compare relative competitive effects across multiple species. Species included one undesirable perennial, bulbous bluegrass; one undesirable annual, cheatgrass; and five desirable perennial grasses, western wheatgrass (*Pascopyrum smithii*), crested wheatgrass (*Agropyron cristatum*), bluebunch wheatgrass (*Pseudoroegneria spicata*), Idaho fescue (*Festuca idahoensis*), and squirreltail (*Elymus elymoides*).

Results and Discussion
All species were suppressed when grown with cheatgrass, both individually and when pooled across species, but the competitive effects of bulbous bluegrass varied across species. Western wheatgrass, squirreltail, and crested wheatgrass were not suppressed by bulbous bluegrass, indicating that they might be good choices for reclamation or rangeland improvement projects where bulbous bluegrass is a concern. Bluebunch wheatgrass and Idaho fescue both exhibited poor competitive ability against cheatgrass and bulbous bluegrass.

Figure 1. *Bulbous bluegrass (Poa bulbosa) reproduces from bulblets instead of seed.*

When all perennial grasses were pooled together, competitive effects of bulbous bluegrass were essentially neutral, suggesting a lack of strong competitive interactions. When cheatgrass and bulbous bluegrass were grown together to compare their interactions, cheatgrass

[1]Sheridan Research and Extension Center; [2]Department of Plant Sciences.

was the superior competitor. Although bulbous bluegrass does not appear to be as strong a competitor as cheatgrass, it may competitively displace some perennial grasses depending on species composition and other factors (e.g., grazing management, drought). We plan to repeat this greenhouse study in 2018 to improve the confidence in our results.

Acknowledgments
We thank ShREC interns for help with data collection.

Contact Information
Brian Mealor at bamealor@uwyo.edu or 307-673-2647.

Keywords: invasive species, weed management, rangeland restoration

PARP: III:5

Evaluating New Herbicide Mixtures for Rangeland Cheatgrass Management

Brian Mealor[1,2], Sara Eller[1], and Beth Fowers[1,2]

Introduction

Although current chemical methods for controlling downy brome (aka cheatgrass/*Bromus tectorum*) are fairly effective, they require relatively frequent re-treatment to maintain cheatgrass suppression on infested sites. Some herbicides not previously used in rangeland settings may provide longer-term control with a single application. Additional tools for suppressing or controlling cheatgrass may improve the ability of ranchers, farmers, land managers, reclamation personnel, and others to restore cheatgrass-impacted rangelands while diminishing potential for developing herbicide-resistant cheatgrass populations by repeated applications of herbicides with the same mechanism of action.

Objectives

The objectives are to evaluate seven herbicide mixtures at two different timings for their effectiveness in reducing cheatgrass and their impacts on associated vegetation.

Materials and Methods

We applied seven herbicide mixtures at two different timings in 2016 (March and April) with a total volume of 20 gallons per acre with a CO_2-pressurized sprayer and a 10-foot boom with six 8002 nozzles. Treatments were implemented in 10- by 30-foot plots set in a randomized complete block design with three replicates and a replicated, non-treated check. Treatments included Olympus™ (1.2 oz/ac) and Plateau® (7 oz/ac), alone and combined; and Esplanade® 200 SC (5 and 7 oz/ac) combined with Roundup WeatherMAX® (16 oz/ac) or combined with Olympus™ (1.2 oz/ac).

Applications on March 3 occurred with a 54°F air temperature, 38% relative humidity, 41°F soil temperature at 2 inches deep, and 5–8 mph wind. Cheatgrass on-site varied from the 1–3 leaf growth stage, and roughly half the plants were purple due to semi-dormancy from cold weather. Applications on April 21 occurred with a 60°F air temperature, 54% relative humidity, 48°F soil temperature at 2 in deep, and 3 mph wind. Cheatgrass was 2–3 in tall and actively growing. On May 31, 2017, we collected plant biomass from three 0.25 m^2 (2.7ft^2) quadrats from each plot at the same time, and separated this into cheatgrass, bulbous bluegrass (*Poa bulbosa*), and desirable perennial plants (Table 1).

Results and Discussion

Plant biomass production approximately 13 months after herbicide application varied among treatments (Table 1). Treatments with Esplanade reduced cheatgrass biomass and completely controlled bulbous bluegrass when compared to the other treatments. These reductions in weedy grass biomass were accompanied by an increase in desirable perennial plant biomass production (Table 1). Currently, Esplanade is not registered by the U.S. Environmental Protection Agency (EPA) for use in rangelands or pastures. Based on this study and other research, Esplanade is effective for managing annual grasses and will be an important tool in range and pasture settings upon EPA approval.

Acknowledgments

Thanks to Bayer Crop Science for funding support and to ShREC summer interns for assistance.

Contact Information

Brian Mealor at bamealor@uwyo.edu or 307-673-2647.

Keywords: cheatgrass, weed management, invasive species

PARP: III:3,5,7,8, VI:3, XII:1

[1]*Sheridan Research and Extension Center;* [2]*Department of Plant Sciences.*

Table 1. *Cheatgrass, bulbous bluegrass, and perennial plant biomass collected May 31, 2017, across multiple herbicide treatments at the ShREC property east of Sheridan.*

			Biomass (lb/ac)		
Herbicide	**rate (oz/ac)**	**application time**	**cheatgrass**	**bulbous bluegrass**	**perennial plants**
Untreated	n/a	n/a	1716	278	165
Olympus	1.2	March 3, 2016	1486	90	264
Plateau	7	March 3, 2016	1838	188	272
Plateau	7	March 3, 2016	1890	37	386
Olympus	1.2				
Esplanade	5	March 3, 2016	358	0	643
Roundup Wmx	16				
Esplanade	7	March 3, 2016	297	0	746
Roundup Wmx	16				
Esplanade	5	March 3, 2016	230	0	988
Olympus	1.2				
Esplanade	7	March 3, 2016	179	0	286
Olympus	1.2				
Olympus	1.2	April 21, 2016	1582	29	277
Plateau	7	April 21, 2016	2087	90	433
Plateau	7	April 21, 2016	1722	36	355
Olympus	1.2				
Esplanade	5	April 21, 2016	322	0	890
Roundup Wmx	16				
Esplanade	7	April 21, 2016	520	0	522
Roundup Wmx	16				
Esplanade	5	April 21, 2016	152	0	852
Olympus	1.2				
Esplanade	7	April 21, 2016	109	0	874
Olympus	1.2				

Evaluating Herbicide Mixtures and Seeding of Cheatgrass-Dominated Sites

Brian Mealor[1,2]

Introduction

Invasive annual grasses, such as downy brome (aka cheatgrass, *Bromus tectorum*), have broad-reaching impacts for agriculture and conservation across Wyoming and the West. Sites that have been affected by both annual grass invasion and repeated surface disturbances may have severely depleted perennial plant communities.

Objectives

The objectives of this project are to evaluate various herbicides within a restoration setting for their ability to reduce cheatgrass competition and facilitate desirable native species establishment.

Materials and Methods

On April 21, 2016, we applied 10 different herbicide treatments plus a non-treated check to 10- by 60-foot plots replicated three times in a randomized complete block design. The study is at the Sheridan Research and Extension Center (ShREC) property east of Sheridan near Wyarno, Wyoming. Herbicides included Esplanade 200SC®, Method 240SL®, Accord XRT®, Lambient™, and Plateau®. We seeded five perennial grasses in late November 2016 and seeded the same species in spring 2017 to evaluate effects of different delay times between herbicide application and seeding. Grass species include western wheatgrass (*Pascopyrum smithii*), Indian ricegrass (*Achnatherum hymenoides*), green needlegrass (*Nassella viridula*), blue grama (*Bouteloua gracilis*), and crested wheatgrass (*Agropyron cristatum*). We evaluated plots May 30, 2017, for cheatgrass control, and we estimated seeding success on July 28, 2017, using emergence (%).

Results and Discussion

Most herbicides exhibited greater than 90% cheatgrass control (Fig. 1); however, emergence and establishment of all seeded species were very low (<10%). If we can identify methods for reestablishing desirable species in cheatgrass-dominated areas, this information can help land managers increase the carrying capacity for livestock, improve habitat for wildlife species, and reduce wildfire risk. We anticipate that future data collection should show additional seeded-species establishment.

Acknowledgments

We thank ShREC field crews for assistance in data collection and Bayer Crop Science for funding support.

Contact Information

Brian Mealor at bamealor@uwyo.edu or 307-673-2647.

Keywords: cheatgrass, weed management, invasive species

PARP: III:3,5,7, VI:3, XII:1

[1]*Sheridan Research and Extension Center;* [2]*Department of Plant Sciences.*

Figure 1. *Seedling native grasses (foreground) establish in an area with successful cheatgrass control. Non-treated plot visible in background.*

Indaziflam Effects on Seed Production and Viability for Various Rangeland Grasses

Beth Fowers[1,2], Hannah Ostheimer[1], and Brian Mealor[1,2]

Introduction

Annual weeds negatively impact grass seed production by directly competing for resources and by contaminating seed lots. Herbicide options in grasses grown for seed are relatively limited; further, for an herbicide to be useful it must provide acceptable weed control with little reduction in seed production and viability. Indaziflam controls annual grasses and other weeds, but little is known about how it affects seed production and germinability.

Objectives

Our objectives were to evaluate the effects of the herbicide indaziflam on seed production and germinability across a range of established perennial grasses.

Materials and Methods

Seventeen grass species/varieties were seeded in a randomized complete block design with four replicates in 2013 at the Sheridan Research and Extension Center (ShREC) property east of Sheridan near Wyarno, Wyoming. We applied Esplanade 200 SC® (5 oz/ac) plus Roundup WeatherMAX® (12 oz/ac) to one-half of each grass plot on March 27, 2017, leaving the other half as a non-treated control. Cheatgrass (aka downy brome, *Bromus tectorum*) and several of the perennial grasses were actively growing at the time of application. We harvested, counted, and weighed mature inflorescences (seedheads) on July 3, 2017, from three bunchgrasses per grass + herbicide plot or, if the species was rhizomatous, from three 0.25 m^2 ($2.7ft^2$) frames within each grass plot. We evaluated cumulative germination using 50-seed lots in petri dishes with filter paper in a growth chamber set at 70°F daytime and 50°F nighttime temperatures for one month. We analyzed data as a two-way analysis of variance with plant material and herbicide as the two treatments.

Results and Discussion

While herbicide application controlled annual grasses across the site ($p<0.0001$), it also negatively impacted some of the perennial grasses. Responses varied highly among grass species/varieties. Inflorescence number was reduced for several wheatgrasses, several wildryes, and one bluegrass ($p=0.0001$; Figure 1). 'Bozoisky-Select' Russian wildrye showed more than a 60% reduction in inflorescence number while 'Mankota' Russian wildrye exhibited more than a 90% reduction. Other impacted species expressed mild differences between treated and untreated inflorescences while the majority of species were not affected by herbicide application. Similar trends were observed with inflorescence weight, including large negative impacts to Russian wildye (>90% reduction) and Siberian wheatgrass (>45% reduction), but most other species were not affected by the herbicide.

Total number and weight of inflorescences have a direct relationship to seed production. Because germination was decoupled from overall seed production, we can determine germination regardless of the total amount of seed produced. While herbicide application affected overall germination ($p=0.01$), germinability of most species was not impacted (Figure 2). Herbicides noticeably reduced germination in two varieties: 'Opportunity' Nevada bluegrass (100%) and 'Washoe' basin wildrye (>50%; $p<0.0001$).

First-year herbicide impacts on seed production and germinability should be interpreted cautiously since we could not separate glyphosate from indaziflam effects in this year. The two species with the greatest impact on inflorescence number are also species that begin active growth very early in spring—indicating that they may have been most susceptible to glyphosate damage at the time of application. Continuing data collection will allow us to determine impacts of indaziflam alone on seed production and germination of established species.

Acknowledgments

We thank ShREC interns for their help with data collection and Bayer Crop Science for funding support.

Contact Information

Brian Mealor at bamealor@uyo.edu or 307-673-2647.

Keywords: indaziflam, perennial grass, seed production

PARP: III:5,7,11

[1]*Sheridan Research and Extension Center;* [2]*Department of Plant Sciences.*

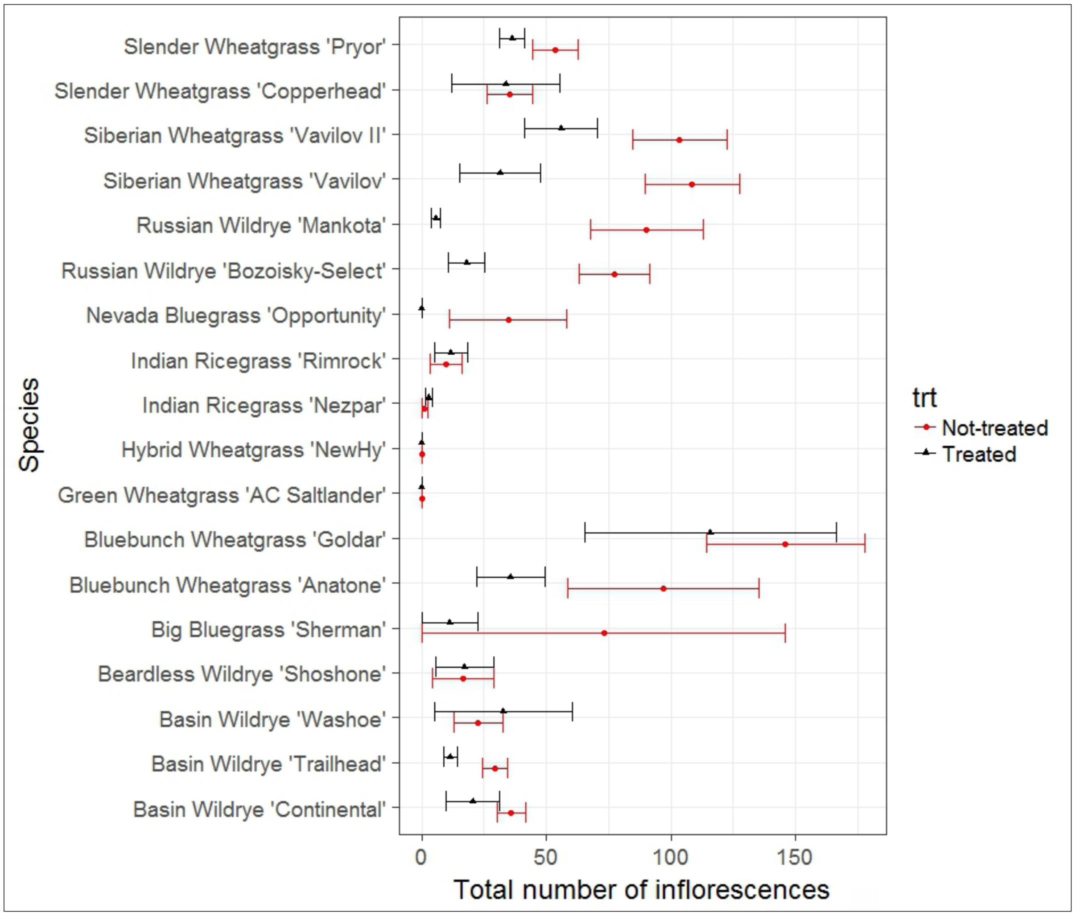

Figure 1. *Inflorescence number by grass species/variety and herbicide treatment.*

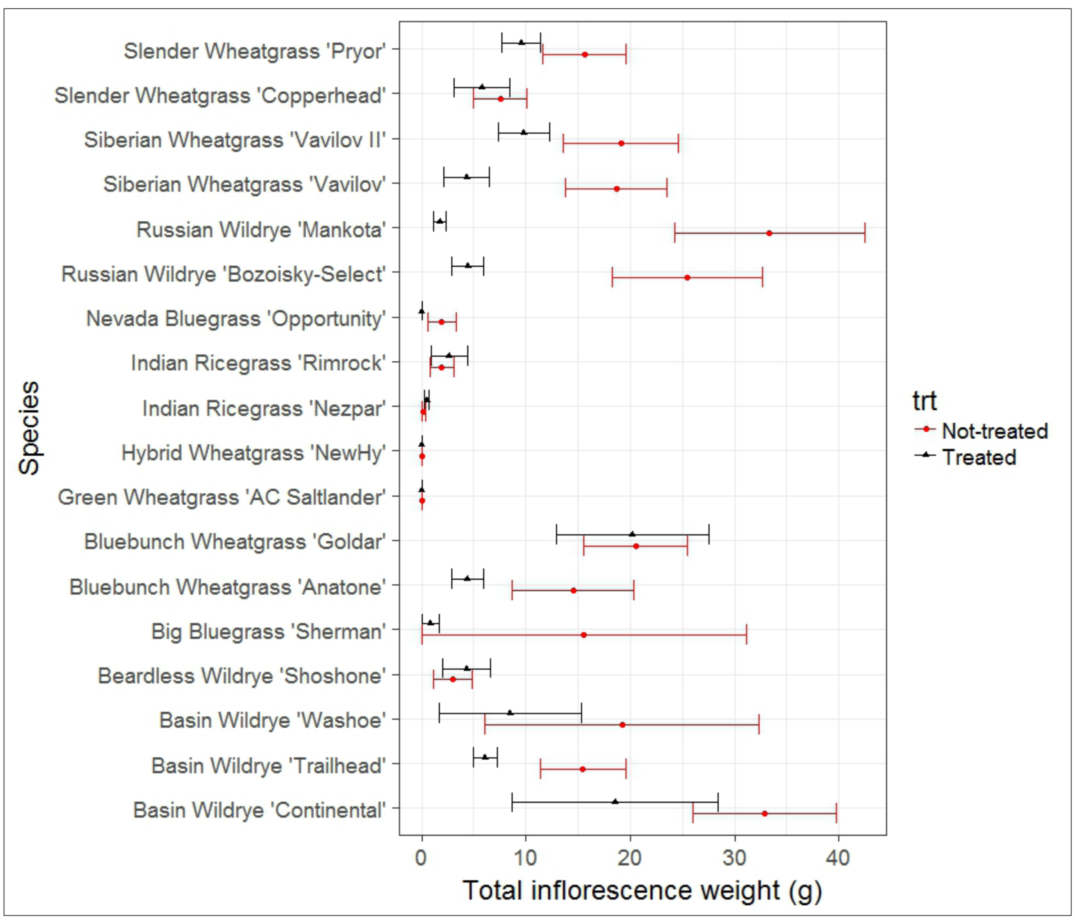

Figure 2. *Germination by grass species/variety and herbicide treatment.*

Evaluating Herbicide Effectiveness for Russian Olive Management

Brian Mealor[1,2] and Beth Fowers[1,2]

Introduction

Russian olive (*Elaeagnus angustifolia*) is an introduced invasive tree that is on the noxious weed list in Wyoming and several other states, including Colorado. It causes ecological damage by competitively excluding native species, is a heavy water user, and negatively affects wildlife species through habitat changes. It also has economic impacts because of possible livestock or tire damage from the thorns along with the costs for managing the species. Herbicides may be the best option for Russian olive management, but research continues to determine the most successful treatment options for control.

Figure 1. *Jordan Skovgard applies herbicide to Russian olive regrowth at ShREC.*

Objectives

The objective is to evaluate four different herbicide applications for their effectiveness in controlling Russian olive.

Materials and Methods

Herbicide application occurred November 3, 2016, using handheld spray bottles on a previously existing population of Russian olives at the Sheridan Research and Extension Center (ShREC [Fig. 1]). The study was applied to 10- by 15-foot plots set in a randomized complete block design with four replicates and a replicated non-treated check. Individual treatments were Garlon™ 480 EC at 25% volume, and Method® 240SL at three concentrations: 1.67%, 6.67%, and 10% volumes. Herbicide was applied to each tree within the plot up to two feet from the base on the stems or trunks so that there was a thorough coverage of the chemical. The mixtures also included a 75% volume/volume addition of basal oil surfactant to increase the effectiveness of the herbicides. Russian olive trees in the area had been cut the previous year, so all new growth treated was less than 2 inches in diameter. Russian olive control (% visual relative to non-treated) was evaluated June 26, 2017, along with damage to perennial grasses.

Results and Discussion

All herbicide mixtures damaged Russian olive trees (Fig. 1). While all treatments showed significant damage compared to the control ($p<0.0001$), there was little difference between the herbicides. Garlon and the higher rates of Method, however, may show increased effects on Russian olive. Perennial grass damage was also apparent with all herbicides ($p=0.0066$) and was greatest with increasing rates of Method. First-year impacts of herbicide on a tree species like Russian olive may not be long-term. At the time of evaluation, while damage was apparent, it was not clear if that damage would be long-term or if the trees were already beginning to recover from the herbicide application.

[1]Sheridan Research and Extension Center; [2]Department of Plant Sciences.

Additional monitoring of the plots in 2018 may begin to show if long-term effectiveness of the herbicides occurs. Currently, one of the most common treatments is the cut-stump method. Trees are cut down and the stumps are sprayed or painted with an herbicide to prevent re-sprouting. This is a labor intensive and time sensitive method as it is critical to apply the herbicide within 10 minutes after cutting to be effective. Even then, complete suppression of resprouts is not always achieved. If the herbicides and methods in this project (herbicide application without cutting) are effective at controlling Russian olive, they would be a beneficial option for land managers, weed and pest personnel, and others.

Acknowledgments
We thank Jordan Skovgard, Clay Wood, and Hannah Ostheimer for assistance.

Contact Information
Brian Mealor at bamealor@uwyo.edu or 307-673-2647.

Keywords: weed management, Russian olive, invasive species

PARP: III:3,5,7,11

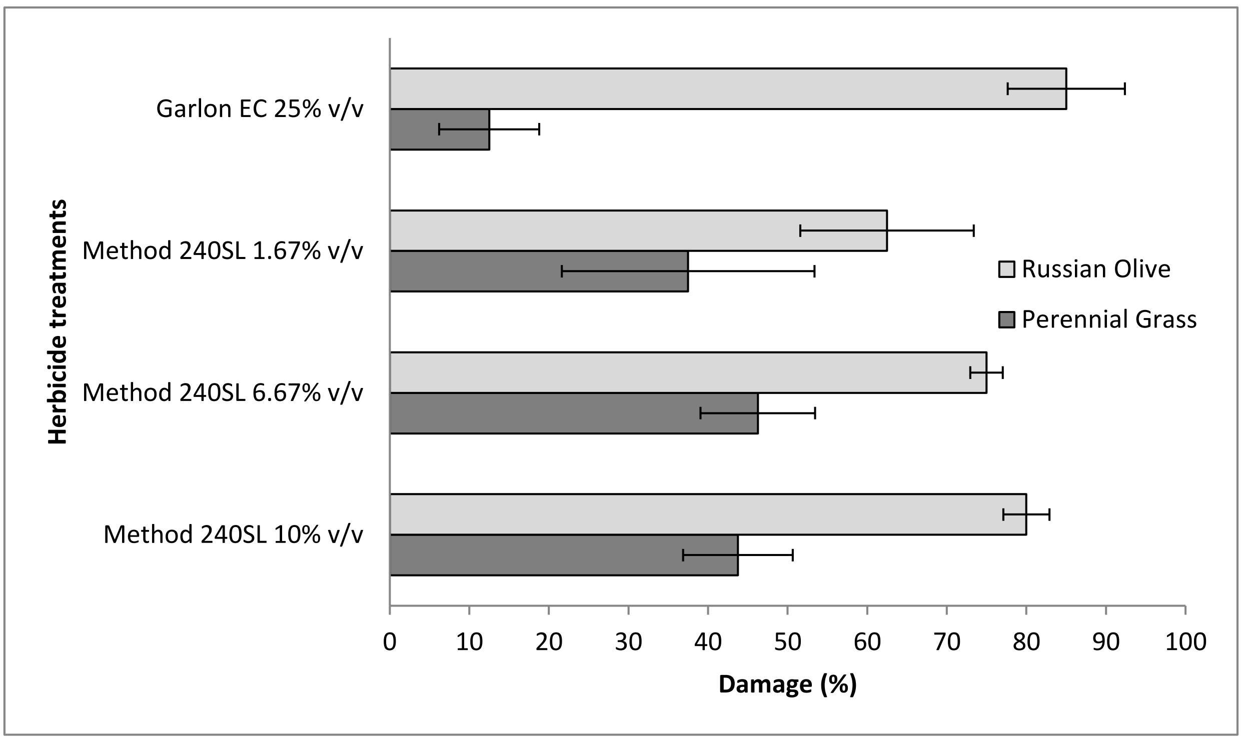

Figure 2. *Herbicide effects damage to Russian olive regrowth and perennial grasses (v/v=volume/volume).*

Using Molecular Methods to Identify Historic Apple Cultivars in 100-Year-Old Orchards in Wyoming

Steven Miller[1], Jonathan Magby[1], and Gayle Volk[2]

Introduction

The last remnants of 19th- and early 20th-century apple plantings struggle to survive in isolated, nearly forgotten, or abandoned orchards, and the identity of most of these varieties has been lost. Molecular techniques offer powerful methodologies for the identification of heirloom, historic, and novel apple cultivars in apple orchards planted in the late 19th and early 20th centuries in Wyoming. In addition, there have been no efforts to grow or maintain important apple cultivars in a centralized location to preserve the germplasm for future generations. An apple germplasm repository orchard was planted in spring 2017 at the Sheridan Research and Extension Center (ShREC).

Objectives

Our objectives are to (1) investigate the use of molecular genotyping techniques to identify heirloom, historic, and novel apple cultivars in approximate 100-year-old orchards in Wyoming; and (2) establish a germplasm repository orchard at ShREC.

Materials and Methods

The present study is using a comparative approach to identify heirloom, historic, and novel apple cultivars in Wyoming. DNA is extracted from trees of unknown cultivars located in historic orchards or from individual trees remaining in historic farmsteads around Wyoming. Microsatellite or simple sequence repeats (SSRs)—types of molecular fingerprints (aka genetic markers)—are compared with those from the Germplasm Resources Information Network (GRIN) database operated by the U.S. Department of Agriculture (USDA) Agricultural Research Service. Pieces of woody growth collected from the trees were grafted onto Antonovka rootstock (*Malus antonovka* helps to create a hardy, full-sized tree from the heirloom/historic/novel cultivars). In 2017, two- to four-year old saplings were planted into a newly established germplasm repository orchard at ShREC (Fig. 1).

Results and Discussion

The final total for Wyoming trees sampled was 993. We also included 450 additional cultivars mentioned in early Wyoming Horticultural Society bulletins and other apple books, journal articles, and private lists that were not previously in the GRIN database. We were able to obtain comparator reference samples of these 450 cultivars from the USDA-managed apple orchard in Geneva, New York, and the Seed Savers Exchange in Decorah, Iowa. Thirty cultivars were positively identified from Wyoming, with 58% of the samples directly matching comparator genotypes in the GRIN database. Because identifications were based on a comparison of microsatellite loci with known cultivars, this suggests that additional reference samples are needed for comparison. It also may suggest that there are a number of novel cultivars derived from incidental crosses between apples in some of the larger orchards in the past 100 years.

Information on more than 200 apple trees found still living in Wyoming can be found on our website at www.wyomingappleproject.com. On our website you'll find (1) *City Pamphlets*, which include apple information for numerous locations around Wyoming; (2) *Apples of Wyoming: Lost and Found*, which lists all cultivars; (3) the *Wyoming Apple Key*, which has more than 400 drawings and photos of apples collected from USDA watercolor drawings and the GRIN database to help apple enthusiasts narrow down which cultivars they may have; and (4) information on the history of the apple cultivars, local homesteads, orchards, and nurseries.

Acknowledgments

We thank all of the orchardists and individuals who allowed access to their apple trees in Wyoming. We thank Brian Mealor and the ShREC field crews for assistance in plot establishment and harvesting. The study is supported by the Wyoming Agricultural Experiment Station, USDA Hatch funds, and the Wyoming Department of Agriculture Specialty Crop Block Grant Program.

Contact Information

Steve Miller at fungi@uwyo.edu or 307-766-2834.

Keywords: apples, cultivars, molecular techniques

PARP: VIII:1, IX:9, X:1

[1]*Department of Botany;* [2]*U.S. Department of Agriculture-Agricultural Research Service, Fort Collins, Colorado.*

Figure 1. *ShREC students and field crews plant bench-grafted apple trees from Wyoming orchards into the new germplasm repository orchard at ShREC in spring 2017.*

Wyoming Production Agriculture Research Priorities—Updated June 2016

GRAND CHALLENGE—Enhance the competitiveness, profitability, and sustainability of Wyoming agricultural systems.

Goal 1. Improve agricultural productivity considering economic viability and stewardship of natural resources.
Goal 2. Develop new plant and animal production systems, products, and uses to increase economic return to producers.

Following are producer recommendations developed from statewide listening sessions:

I. Production Systems Objectives

1. Develop and maintain baseline agriculture production systems to evaluate effects of innovations on the natural resource base, sustainability, and profitability. (2014)
2. Develop best-agronomic management practices for alternative crops such as sunflower seed production and various forages (e.g., perennial and annual legumes, grasses, and legume-grass mixtures) and other oilseed crops. (2014)
3. Identify synergistic effects among crops to improve crop rotation systems. (2014)
4. Develop methods to deal with residue when establishing new stands in crop rotation systems. (2014)
5. Evaluate effects of legumes in dryland wheat production systems. (2014)
6. Evaluate incorporating crops and crop aftermath into livestock production systems. (2014)
7. Evaluate and compare no-till versus tillage techniques. (2014)
8. Identify improved harvesting techniques. (2014)
9. Evaluate the use of legumes in rotational cropping systems. (2014)
10. Identify causes for annual losses of bees and other pollinators, and develop management procedures that minimize their loss. (2015)
11. Develop best management practices to control diseases in crops. (2015)
12. Conduct crop variety trials to identify varieties best suited to Wyoming localities. (2015)
13. Identify optimal crop rotations for sugarbeet producers. (2015)
14. Identify seed treatments that optimize sugarbeet and dry bean production. (2015)
15. Devise integrated cropping/grazing systems that optimize crop and livestock production with soil health. (2015)

II. Soil Fertility Management Objectives

1. Develop methods to ameliorate poor soil pH for crop production. (2014)
2. Investigate effects of fertilizer type, placement, and timing on crop production (e.g., sugarbeets, cereal grains, dry beans, and forages). (2014)
3. Evaluate the efficacy of managing soil nitrogen applied by pivot irrigation. (2014)
4. Determine and categorize nitrogen (N) release times for varied forms of N. (2014)
5. Discover methods to reduce dependence on commercial fertilizers. (2014)
6. Develop tillage systems that minimize soil disturbance. (2014)
7. Develop cheaper alternatives to commercial fertilizer (e.g., cover crops, legumes). (2014)
8. Test the ability of compost and manure to enhance soil fertility. (2014)
9. Identify plants such as legumes that enhance soil fertility. (2014)
10. Identify crops and varieties that perform best in varied soil types and elevations. (2015)
11. Evaluate effects of aerators on soil productivity. (2015)
12. Identify soils best suited for farming or grazing. (2015)

III. Weed Control Objectives

1. Develop control methods for weeds resistant to glyphosate or other herbicides, especially in sugarbeet and dry bean production. (2014, revised 2015)
2. Develop methods to control weed emergence that can be applied in the fall. (2014)
3. Improve procedures to control noxious weeds, especially milkweed, knapweed, whitetop, curly dock (aka sour dock), and thistle. (2014, revised 2015)
4. Evaluate the efficacy of weed-control chemicals applied before planting in dry bean fields. (2014)
5. Develop chemical and non-chemical methods to control cheatgrass and other noxious weeds. (2014)
6. Coordinate application of glyphosate with precision agriculture. (2014)
7. Optimize use of herbicides economically and environmentally. (2014)
8. Facilitate access to chemicals needed for special uses. (2015)
9. Discover viable alternatives to pesticides. (2015)

10. Determine chemical carryover in no-till production. (2015)
11. Continually monitor unintended consequences of weed control on plants and animals. (2015)

IV. Irrigation Objectives

1. Test and develop surge-, pivot-, and drip-irrigation techniques for specific crops, especially alfalfa, alfalfa seed, dry beans, and sugarbeets. (2014, revised 2015)
2. Test the ability and reliability of moisture monitors to indicate timing of irrigation. (2014)
3. Conduct irrigation management studies to optimize water use for specific crops (e.g., alfalfa seed, dry beans, sugarbeets) and soils. (2014, revised 2015)
4. Develop methods to maximize (optimize) production with less water. (2014)
5. Improve irrigated pasture production at high elevations. (2014)
6. Test the ability of soil additives (e.g., surfactants) to affect water absorption and retention. (2015)

V. Livestock Objectives

1. Develop strategies to enhance the efficiency of feed utilization. (2014)
2. Evaluate effects of additives or chemicals to feeds to influence forage and/or weed consumption. (2014)
3. Train livestock to consume alternative feeds such as brush and weeds. (2014)
4. Determine heifer development strategies that optimize reproduction, foraging ability, and cow longevity to maximize profitability. (2014)
5. Identify strategic supplementation protocols that optimize animal production traits with costs of production. (2014)
6. Develop improved methods to control flies. (2014)
7. Determine how to minimize feed costs and maximize profit per unit of production. (2014)
8. Develop genetic markers for feed efficiency, and determine their ramifications on important production traits such as reproduction, milk production, pounds of calves produced, and carcass characteristics. (2014, revised 2015)
9. Develop practical estrous synchronization methods for commercial producers. (2014)
10. Determine cumulative effects of minerals, ionophores, worming, and implants on animal productivity. (2014)
11. Provide cost-benefit information on grazing of irrigated pastures. (2014)
12. Determine direct and indirect effects of disease and predators on livestock production. (2015)
13. Develop best methods to ameliorate existing and emerging diseases in livestock. (2015)
14. Optimize breeding of first-calf and re-breeding of second-calf heifers. (2015)
15. Develop breeding strategies that maximize the beneficial effects of heterosis in livestock. (2015)
16. Develop criteria for lamb carcasses to decrease variability and increase consumer satisfaction. (2015)
17. Identify and eliminate causes for consumers having poor eating experiences with lamb. (2015)

VI. Grazing Management Objectives

1. Develop improved forage-based livestock production systems (e.g., grass/legume mixtures). (2014, revised 2015)
2. Demonstrate and evaluate benefits of strip grazing corn stalks. (2014)
3. Increase the carrying capacity of range and pastureland. (2014)
4. Evaluate effects of multi-species grazing on forage utilization and range health and productivity. (2014)
5. Develop alternative grazing strategies to enhance rangeland health. (2014)
6. Evaluate Management-intensive Grazing (MiG) and rotational grazing strategies in dry environments. (2014)
7. Identify optimum grazing height for alfalfa aftermath and effects of grazing on stand longevity. (2014)
8. Develop forage species that are drought resistant. (2014)
9. Investigate ways to optimize wildlife-livestock interactions and receipt of value for hunting and tourism. (2014, revised 2015)
10. Provide new information on meadow management and irrigated-pasture grazing in higher elevations. (2014)
11. Develop economically feasible methods to control sagebrush and greasewood. (2015)

VII. Production Economics Objectives

1. Determine the cost-effectiveness of fertilizer alternatives. (2014)
2. Determine the economics of alternative grazing systems. (2014)
3. Determine the cost-effectiveness of vaccines, mineral supplements, and pour-ons in livestock production systems. (2014)
4. Develop practical methods to assign economic values to ecological management procedures. (2014)
5. Identify obstacles and evaluate options and opportunities for marketing Wyoming-produced meat and other products to consumers. (2014, revised 2015)

6. Determine impacts of alternative management strategies on whole-ranch/farm economics. (2014)
7. Provide information on costs per unit of production. (2014)
8. Identify capital management alternatives for new and expanding producers. (2015)
9. Provide tools to facilitate record keeping. (2015)
10. Determine economic potentials for alternative crops (e.g., soybeans, oil crops, forage beets) and varied crop production methods (e.g., organic, no-till, conventional) in specific Wyoming localities. (2015)
11. Determine economic impacts of grazing vs. harvesting of alfalfa and winter wheat in the fall. (2015)

VIII. Crop and Animal Genetics and Biotechnology Objectives

1. Improve marker-assisted selection procedures to identify plants and animals with desired production traits. (2014)
2. Develop and evaluate genetically modified organisms that enhance desired production traits. (2014)
3. Identify optimum cow size for Wyoming environments. (2014)
4. Increase longevity and production persistence of forage legumes. (2014)
5. Develop viable alternatives for legumes (especially alfalfa) at high elevations. (2015)
6. Develop methods to identify cattle and sheep seed stock that possess desired economic traits. (2015)

IX. Rural Prosperity, Consumer and Industry Outreach, Policy, Markets, and Trade Objectives

1. Analyze economic impacts of farming/ranching management decisions, and consider input costs, budgets, and market risks by region and crop. (2014)
2. Conduct applied research studies with producers, and develop demonstration trials with cooperators to facilitate adoption of new or changing technologies. (2014)
3. Increase dissemination of research results (*Wyoming Livestock Roundup*, radio programs, etc.). (2014)
4. Work with commodity groups to enhance adoption of new technologies. (2014)
5. Conduct hands-on classes at Research and Extension centers or with cooperators for young/new producers. (2014)
6. Provide science-based information needed by policymakers to make informed decisions. (2015)
7. Educate the public about the impacts of agricultural practices. (2015)
8. Develop alternative markets and uses for agricultural by-products. (2015)
9. Investigate methods for, and impacts of local food production. (2015)
10. Develop local processing and marketing opportunities for Wyoming livestock and crops. (2015)
11. Form venues to sell Wyoming products in international markets. (2015)
12. Enhance communication between producers, research entities, and regulatory agencies. (2015)

X. Responding to Climate Variability Objectives

1. Consider regionally unique environmental conditions when designing research studies. (2014)
2. Conduct integrated agricultural systems research that links environment and conservation to production and profitability. (2014)
3. Develop drought-resistant plants that fit the extreme environmental conditions of Wyoming. (2014)
4. Devise drought-management strategies that minimize detrimental effects of grazing. (2015)
5. Determine effects of climate variability (e.g., lack of freeze vs. hard winter) on plant and livestock diseases and production. (2015)

XI. Sustainable Energy

1. Conduct research on bioenergy/biofuels and bio-based products that are suitable to Wyoming's environment. (2014)

XII. Landscape-Scale Conservation and Management

1. Develop improved methods to reclaim disturbed lands. (2014)
2. Evaluate water, soil, and environmental quality using appropriate organisms as indicator species. (2014)
3. Present educational programs on environmental and societal impacts of agricultural innovations. (2015)
4. Develop methods to ameliorate the detrimental effects of poor quality water on crop and livestock production. (2015)

INDEX

A

B

C

D

E

F

G

H

I

Y

Z

PARP

I ♥ Pistol & Pete 2018–2019 Academic Year Calendar

The I ♥ Pistol & Pete calendar is available at the R&E Center Field Days
or through the Wyoming Agricultural Experiment Station.
Contact WAES at aes@uwyo.edu or 307-766-3667.
Download these images as desktop wallpapers at www.uwyo.edu/uwexpstn/calendar
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