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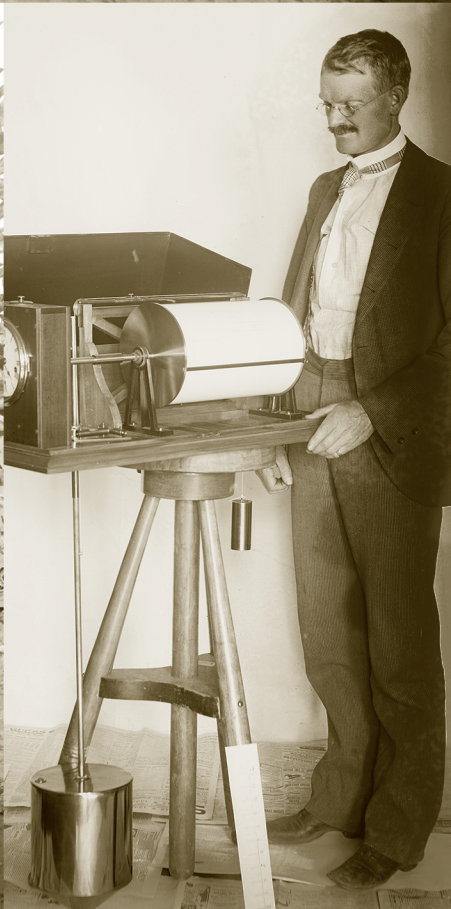
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# Field Days Bulletin

## W A E S 2 0 1 6





# Field Days Bulletin 2016

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# Introduction to the Sixth Edition of the Wyoming Agricultural Experiment Station *Field Days Bulletin*



*B.W. Hess*<sup>1</sup>

## Introduction

It is truly an honor to present the 2016 edition of the Wyoming Agricultural Experiment Station (WAES) *Field Days Bulletin*. It is an honor because I have the distinct privilege of serving as WAES director at a pivotal juncture in its history. This year, WAES is celebrating 125 years of research service to the great state of Wyoming.

## The Kick-Off Event

WAES kicked off its 125-year anniversary celebration during its annual University of Wyoming Research and Extension (R&E) Center planning conference in February. The College of Agriculture and Natural Resources' newly refurbished sheep wagon sported a banner with "Ag Research Transforms Life" while it was parked in the Simpson Plaza throughout the opening day of the conference on the UW campus. Siting the wagon at this location served as a perfect backdrop for a group photo of conference attendees (Figure 1). This location also was ideal for the many students, staff and faculty members, administrators, and visitors to sneak a peek as they strolled by on their way to and from the UW Union. In addition to a keynote address from then UW President Dick McGinity at the awards and appreciation banquet, the crowd was treated to a short video clip highlighting the existence and mission of WAES over the course of time. This video clip may be viewed by clicking on the 125th anniversary YouTube video on the main page of the WAES website (<http://www.uwyo.edu/uwexpstn/>).

## The Sheep Wagon

The refurbished sheep wagon will be pulled by a two-horse team of Halfingers at various events around

the state throughout the year. Doug Zalesky and his team at the Laramie R&E Center have been working hard to prepare the horses and wagon to offer rides while they are at various locations.

Offering rides in the sheep wagon will be one of many features at each of the R&E center field days this summer. Attendees of the field days and possibly other events will have an opportunity to view a display containing videos to celebrate the WAES 125th anniversary. In addition to the video previously mentioned, a short video clip is planned for highlighting each of the four R&E centers.

## Documenting WAES History

The video clips about each R&E center will be based upon information contained in a new book written by David Kruger, UW library liaison to the College of Agriculture and Natural Resources. David has done a remarkable job of detailing the history of WAES and its affiliated R&E centers in a reader-friendly format. Look for a synopsis of the book's content in the 2016 issue of the college's research magazine, *Reflections*. The book, which includes a forward by new UW President Laurie Nichols, also should be available at the various events where the Halfinger team is pulling the sheep wagon.

## Field Days

Join us for field days at R&E center locations in Powell (July 19), near WYarno east of Sheridan (July 20), near Lingle (August 25), and in Laramie (August 27) to take a ride in the sheep wagon, learn about our rich history, and gain insight into current and future research endeavors. Each R&E center also will be celebrating its history and contributions to WAES over the years. In

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<sup>1</sup>Director, Wyoming Agricultural Experiment Station.

addition to the sheep wagon and short video mentioned previously, each center has special events planned to complement the WAES celebration.

### **WAES Field Days Bulletin**

Similar to the previous five years, hardcopies of the 2016 *Field Days Bulletin* will be available to attendees of the field days. WAES publishes the annual bulletin in an effort to make our constituents aware of research and other activities being conducted at the R&E centers, in the College of Agriculture and Natural Resources, and at other locations around Wyoming, including on-farm trials. The bulletin is one of several vehicles WAES uses to disseminate results of its investigations to the public. Persons unable to attend the field days can locate electronic copies of past and current issues of the bulletin at <http://www.uwyo.edu/uwexpstn/publications/>.

### **Conclusion**

To circle back to my opening sentence, I am proud to be WAES director at this moment in history. It has been a

pleasure serving in this capacity, and I look forward to the many exciting developments in years to come.

### **Acknowledgments**

I wish to thank all past, present, and future members of WAES for keeping up the tradition of a vibrant WAES. Members of our sister organization, UW Extension, are also thanked for their endless assistance. A special acknowledgment is extended to David Kruger for documenting the rich history of WAES! A special heartfelt recognition goes out to all WAES supporters who have contributed in many ways. Thank you also to all the contributors to WAES bulletins. Finally, many thanks to editors Joanne Newcomb and Robert Waggener for making the *Field Days Bulletin* a highly professional document, to David Perry for his help organizing bulletin peer reviews, and to Tanya Engel for graphic design.

**Contact:** Bret Hess at [brethess@uwyo.edu](mailto:brethess@uwyo.edu) or 307-766-3667.



**Figure 1.** Participants in the 2016 WAES planning conference stand around the College of Agriculture and Natural Resources newly refurbished sheep wagon. Kneeling, from left, Dan Smith, Larry Miller, Kalli Koepke, Leslie Montoya, Gustavo Sbatella, Brian Mealor, John Tanaka, and Mike Moore. Standing in front of sheep wagon, from left, Dale Hill, Cath Harris, Denny Hall, Dave Lutterman, Troy Burke, Rochelle Koltiska, Larry Howe, Kelly Greenwald, Mark Karlstrum, Rod Rogers, Andi Pierson, Doug Zalesky, David Perry, Julie Daniels, Mary Kay Wardlaw, Travis Smith (cowboy hat), Steve Paisley, and Bret Hess. Back, left of sheep wagon, from left, Brad May, Carrie Eberle, and Mike Albrecht.

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# Introduction to the Laramie Research and Extension Center

*D. Zalesky<sup>1</sup>*

## Introduction

The Laramie Research and Extension Center (LREC) consists of the greenhouse complex at 30th and Harney streets, the livestock farm west of Laramie on Highway 230, animal facilities at the Wyoming State Veterinary Laboratory on Laramie's West Side, and lab animal facilities and forage resources at the University of Wyoming's McGuire Ranch northeast of Laramie.

LREC provides a wide range of resources to faculty and staff members, graduate students, and others for research, teaching, and outreach efforts.

## LREC Highlights and Accomplishments

LREC had another busy year, which included some changes that we believe are positive and indicative of the increased use of the center.

We installed two weather stations that provide current and historical weather data. Both stations can be accessed on the Internet to view real-time weather information. One station was installed at the LREC greenhouse complex ([www.weatherlink.com/user/uwgreenhouse](http://www.weatherlink.com/user/uwgreenhouse)), and the other was installed at the livestock center ([www.weatherlink.com/user/lreclivestock](http://www.weatherlink.com/user/lreclivestock)). If you are interested in historical weather data, please contact the LREC office (307-766-3665).

Another highlight for 2015 was development of new LREC office space. We outgrew the old office, but were able to utilize some existing room at the livestock center to develop new offices in the wool building west of Laramie. We completed the move in August 2015.

A new event—the LREC Family Farm Day—kicked off in September 2015. The purpose is to showcase resources

and activities of the LREC livestock farm. Displays, presentations, tours, and activities for children and their families were held. Attendance exceeded expectations, and we're calling the event "extremely successful." We're hosting the annual Family Farm Day on Saturday, August 27, at LREC facilities west of Laramie, and this year's event will feature more activities.

The **LREC Sheep Unit** (Figure 1) was busy again in 2015 providing animals and facilities for research projects, lab classes, outreach activities, and judging contests. The unit also conducted two producer-owned ram tests (black-faced and white-faced) during 2015.

The **LREC Swine Unit** provides resources for teaching and outreach activities throughout the year. The Swine and Sheep units worked together to complete another successful pig and lamb sale, which is conducted annually for local 4-H and FFA students.

The **LREC greenhouse complex** is a hub of activity year-round. Faculty and staff members along with graduate students from several departments within the College of Agriculture and Natural Resources utilize the facility. A recent addition to the greenhouse complex is the All-America Selections' display garden (Figure 2).



**Figure 1.** Lambing time at the LREC Sheep Unit.

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<sup>1</sup>Director, Laramie Research and Extension Center.



**Figure 2.** All-America Selections' display garden.

The garden is devoted to testing and highlighting the best of the best in flowering annuals and perennials.

Those involved with the **LREC Beef Unit** have been busy this past year conducting research related to feed efficiency and brisket disease (high-altitude sickness) in cattle. Feed efficiency is an important trait due to the high cost of feed. Brisket disease, which can lead to heart failure, poses most risk to cattle above 5,000 feet, though studies indicate cattle as low as 3,000 to 4,000 feet can show symptoms. Research into the molecular biology of brisket disease and developing better diagnostic tools to identify early stages continues. The unit also had a busy year providing animals and facilities for a variety of Department of Animal Science classes and other activities.

The **LREC lab animal facility** is utilized by faculty and staff in the departments of animal science, veterinary sciences, and molecular biology and the program in microbiology. The facilities house mice and rats utilized in numerous studies throughout the year.



**Figure 3.** Cliff and Martha Hansen Livestock Teaching Arena and Mary Mead Room.

One of the busiest and most heavily utilized facilities at LREC is the **Cliff and Martha Hansen Livestock Teaching Arena and Mary Mead Room** (Figure 3). Aside from being the home of the UW Rodeo Team, it is also utilized to conduct lab classes, provide a practice arena for other UW teams and organizations, as well as host numerous outreach events and meetings. This past year saw a renovation of the arena floor in addition to the replacement of the old rodeo equipment and panels.

### **Acknowledgments**

The mission of LREC is to provide quality resources for research, teaching, and outreach. The success of accomplishing this mission is totally dependent upon the quality staff at LREC. Their efforts are what make it possible to provide these resources for the faculty, staff, and students of UW as well as the people of Wyoming and beyond.

**Contact:** Doug Zalesky at [dzalesky@uwyo.edu](mailto:dzalesky@uwyo.edu) or 307-766-3665.



# Short Reports

## 1. Does Dalmatian toadflax alter soil microbe communities to the detriment of a native rangeland grass?

**Investigators:** Timothy Collier

**Issue:** Understanding the mechanisms by which invasive, non-native weeds detrimentally affect native rangeland plant species could provide insight into the variability of weed management success. A potentially important—but under-studied—mechanism of invasion is that invasive weeds inhibit soil microbes that are beneficial to native plants.

**Goal:** Determine whether an invasive plant species, Dalmatian toadflax (*Linaria dalmatica*), alters soil microbes in a way that reduces the growth of a native grass species, western wheatgrass (*Pascopyrum smithii*).

**Objectives:** Use a new experimental design to evaluate the effect of toadflax on the growth of western wheatgrass both in the presence and absence of soil microbes in the greenhouse. A previous experiment with a different design showed no effect of microbes.

**Impact:** Understanding what might be called “microbially mediated” invasion by non-native weeds is potentially important for evaluating the success of different weed management strategies. A key question is which management strategies better promote the benefits that soil microbes provide to native grasses.

**Contact:** Tim Collier at [tcollier@uwyo.edu](mailto:tcollier@uwyo.edu) or 307-766-2552.

**Keywords:** soil microbial effects, weed invasion, Dalmatian toadflax

**PARP:** III:3,5

## 2. Maternal and genetic influences on offspring rumen microbes and performance

**Investigators:** Hannah Cunningham, Kathleen Austin, and Kristi Cammack

**Issue:** Feed costs are typically the largest expense for beef producers, and improving feed efficiency provides a way to reduce input costs or increase stocking rates without compromising performance. Microbes in the rumen convert feedstuffs into usable energy for the host animal; it is logical, therefore, that these microbes play an important role in feed efficiency.

**Goal:** Study the importance of breed and mother on the composition of the rumen microbial population in offspring.

**Objectives:** (1) Determine the maternal and genetic influences on establishment of the rumen microbial population in offspring; and (2) determine how the rumen microbial population influences post-weaning feed efficiency of offspring.

**Impact:** Results could help to establish if post-weaning feed efficiency can be improved by manipulation of the rumen microbial population at an early age. Improvements in feed efficiency could lead to reduced feed inputs and/or better stocking rates.

**Contact:** Kristi Cammack at [kcammack@uwyo.edu](mailto:kcammack@uwyo.edu) or 307-766-6530.

**Keywords:** cattle, feed efficiency, microbes

**PARP:** V:1

### 3. Molecular mechanisms mediating the effects of maternal obesity on cardiac function and development in fetuses and offspring of obese mothers

**Investigators:** Wei Guo, Stephen P. Ford, and Jun Ren

**Issue:** Obesity is a major public health issue. Nearly one-third of women are overweight or obese at child-bearing age in Wyoming and the United States. Maternal obesity gives rise to adverse effects such as cardiovascular disease on both maternal health and fetal development, which can result in harmful, persistent effects in offspring.

**Goal:** Study the molecular and cellular mechanisms behind altered cardiac structure and function of offspring subjected to maternal obesity.

**Objectives:** Examine the effect of maternal obesity on gene expression in the heart muscle of fetus and offspring and evaluate heart physiological function at both the cell and organ level.

**Impact:** Results could provide an increased understanding for the progression of heart disease in offspring of obese and overweight mothers. Furthermore, the manipulation of gene expression levels based on potential knowledge obtained from this study may provide insight for the development of therapeutic strategies to treat chronic heart failure.

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

**Keywords:** maternal obesity, fetal programming, heart disease

**PARP:** not applicable

### 4. Valuation of residual feed intake as a selection tool for northeast Wyoming range sheep producers

**Investigators:** Kate Harlan, John Ritten, Ben Rashford, and Kristi Cammack

**Issue:** In Wyoming, feed costs constitute roughly 40% of sheep producers' total expenses. Using feed efficiency as a selection criterion in ewe replacement decisions should help reduce the forage demand of the entire flock over time, resulting in either reduced feed costs or the ability to increase ewe numbers, resulting in increased profitability.

**Goal:** Examine the feasibility of selecting for feed-efficient ewes in a range flock setting.

**Objectives:** Determine if selecting replacement ewes with a desirable residual feed intake (RFI) value is a profitable sheep production strategy for Wyoming range-flock producers (this will be determined using a genetic test).

**Expected Impact:** Preliminary results suggest a minor benefit to producers by using RFI as a selection tool when making female replacement decisions. Economic benefits of using RFI as selection criteria are dependent on both flock size and current utilization of forage resources.

**Contact:** John Ritten at jritten@uwyo.edu or 307-766-3373.

**Keywords:** sheep, RFI, forage utilization

**PARP:** V:1,7,8, VII:6

## 5. Nitrogen fertilization of dry bean: A search for greater efficiency going forward

**Investigators:** Jim Heitholt, Ali Alhasan, and Gerry Andrews

**Issue:** Because of the weak fixation potential of nitrogen gas (N<sub>2</sub>), dry bean producers often apply 40 to 80 pounds nitrogen (N) per acre to their crops. These N applications, although profitable, are potentially undesirable environmentally due to their potential to add N to the groundwater; thus, our labs are working to find novel approaches to minimize N application rates.

**Goal:** Reduce fertilizer N rates applied to dry bean without reducing yield and/or producer profit.

**Objectives:** Identify more effective combinations of rhizobia strain and dry bean genotypes. Current combinations are considered rather inefficient, and if better combinations are discovered, producers may be able to reduce application rates of N fertilizer.

**Expected Impact:** Results that could affect the producer will take significant time because we have only conducted preliminary tests so far; however, we expect to continue conducting greenhouse and field tests by inoculating with novel combinations of rhizobia and dry bean genotypes. Ultimately, we expect that producers will be able to maintain yields and profits while reducing fertilizer N rates, the latter of which could potentially reduce N in groundwater.

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

**Keywords:** dry bean, crop management, profitability

**PARP:** Goals 1 and 2

## 6. All-America Selections' annual and perennial flowers

**Investigators:** Karen Panter

**Issue:** All-America Selections (AAS) is an international, independent, non-profit organization devoted to testing and highlighting the best of the best in vegetables and annual and perennial flowers. There are approximately 85 AAS trial grounds plus almost 200 display gardens in the U.S. and Canada; the display gardens at the University of Wyoming are the only AAS gardens of either type in Wyoming.

**Goal:** Showcase new and improved annual and perennial flowers for the high-altitude Wyoming climate (no vegetables are being tested at UW this year).

**Objectives:** 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 in general and Laramie's climate more specifically.

**Expected Impact:** Since its inception at UW in 2012, the UW AAS Display Gardens have been viewed by thousands of students, faculty and staff, and members of the public. This year we are growing AAS annual and perennial flowering plants in raised beds just outside the greenhouses at the Laramie Research and Extension Center (LREC) and in front of Old Main; both will be showcased during the August 27 LREC Field Day.

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

**Keywords:** annuals, perennials, flowers

**PARP:** not applicable

## **7. In vitro assessment of effects of dietary forage quality on ruminal bypass of calcium salts of long-chain omega-3 fatty acids for cattle**

**Investigators:** Daniel C. Rule and Paul A. Ludden

**Issue:** We recently determined that forage quality influenced the amount of long-chain omega-3 fatty acids in blood plasma of heifers supplemented with calcium salts of fish oil fatty acids and fed either ‘Garrison’ creeping foxtail, brome, or alfalfa hays. The amount of fish oil calcium salts fed for optimal bypass of omega-3 fatty acids through the rumen of cattle would need to be greater when provided to cattle fed forages of greater digestibility.

**Goal:** Determine the extent of degradation of omega-3 fatty acids of fish oil calcium salts using an in vitro (test tube) model in which three forages of differing quality are used as primary feed substrate.

**Objectives:** Determine how the rate of omega-3 fatty acid degradation is affected by the quality of dietary forage when fish oil calcium salts are incubated in tubes with ruminal fluid along with either creeping foxtail, brome, or alfalfa hays.

**Expected Impact:** Results should help producers (1) determine how much fish oil calcium salt supplement to feed for optimal delivery of important fatty acids in grass fed-beef; and (2) improve reproductive efficiency in beef females maintained on forage-based diets.

**Contact:** Daniel Rule at [dcrule@uwyo.edu](mailto:dcrule@uwyo.edu) or 307-766-3404.

**Keywords:** dietary forage, omega-3 fat supplementation, cattle

**PARP:** V:1,5

# Rumen Microbes Associated with Response to High-Sulfate Drinking Water in Lambs

*A. Abrams<sup>1</sup>, K.J. Austin<sup>1</sup>, and K.M. Cammack<sup>1</sup>*

## Introduction

Water is the most important nutrient because it is involved directly or indirectly in almost every physiological process essential to livestock health. Range livestock frequently only have access to water sources that are less than ideal due to a combination of drought, urbanization, and mineral extraction, coupled with Wyoming's semiarid environment (Figure 1). Ruminant livestock are particularly susceptible to high dietary sulfur, which can cause health problems and reduced performance. Elevated levels of sulfur are often encountered in the form of high-sulfate drinking water in the western U.S. Microbes in the rumen use the sulfate to produce hydrogen-sulfide (H<sub>2</sub>S) gas, and when the host ruminant consumes high-sulfate drinking water, overproduction of H<sub>2</sub>S occurs. The H<sub>2</sub>S can be eructated and re-inhaled by the animal. The inhaled H<sub>2</sub>S acts as a neurotoxin and can lead to reduced health and performance as well as irreversible brain damage. Unfortunately, there has been limited success in treating ruminants affected by



**Figure 1.** Range livestock in Wyoming, including lambs, frequently only have access to less-than-ideal water for a variety of reasons, including semiarid conditions and drought. This photo shows typical sheep range in southwest Wyoming near Rock Springs.

high-sulfate water. This is partly due to an inadequate knowledge of the role that rumen microbes play in the host response to this water. Determination of rumen microbial species important in the response to high-sulfate water may lead to development of successful treatments and prevention strategies.

## Objectives

The objective of this study is to determine changes in the rumen microbial population in response to administration of high-sulfate water in growing lambs.

## Materials and Methods

Growing Hampshire and Hampshire-cross lambs (n=12) were individually penned for a 35-day trial period in 2015 at the Laramie Research and Extension Center (LREC) to enable collection of individual daily water and feed intake. They were administered high-sulfate drinking water for 28 days and then administered low-sulfate drinking water for the final seven days of the trial. Rumen fluid was collected and body weights were recorded on days 0, 7, 28, and 35. Rumen fluid samples from eight lambs over the four time points were used for DNA sequencing to determine microbial species and quantity (32 samples in total).

## Results and Discussion

There were 287 microbial species present in at least one of the eight lambs over the four time points. Of those species, 32 changed in abundance over time. A number of species increased in abundance after administration of the high-sulfate water and then returned to baseline abundance, suggesting that these species may be capable of adapting to a high-sulfate environment. In addition, some species that increased in abundance are classified as cellulolytic bacteria, which are known to utilize sulfur

<sup>1</sup>Department of Animal Science.

to produce amino acids. The next step in this study is to further elucidate the roles these microbes may play in the host response to high-sulfate water. Identification of microbial species instrumental in this response may pave the way for development of treatments for affected ruminants.

### **Acknowledgments**

We thank LREC for assistance with the animal trial. This study is supported by grants from the Wyoming Water Research Program (administered by the

University of Wyoming's Office of Water Programs) and the U.S. Geological Survey.

### **Contact Information**

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**Keywords:** microbes, sheep, sulfate

**PARP:** not applicable

# Effect of Soil Nitrogen Rate on Leaf Chlorophyll and Vegetative Growth of Dry Bean

A. Alban<sup>1</sup> and J. Heitbold<sup>1</sup>

## Introduction

Dry beans are considered an important source of protein in legume crops for humans because of their relatively high protein concentration (20–25%) compared with cereal crops (Majnoun, 2008). In contrast to other legumes, however, nitrogen (N) fertilizer is routinely applied to dry bean because that practice typically increases yield and profitability. Recently, Franzen (2013) reviewed factors that affect N fertility recommendations for dry bean production in North Dakota. These include: cropping history, yield goal, soil type, bean price and price of N fertilizer, rain and irrigation management, cultivar, maturity date, and, of course, rhizobia inoculation and soil N status. But unless we have an understanding of how these factors interact, we will be unable to help producers increase profits.

## Objectives

Because there are few data on dry bean response to soil N rate in the Intermountain West, including Wyoming, two of our first goals are to characterize dry bean growth and leaf chlorophyll responses to six soil N levels.

## Materials and Methods

A completely randomized design field experiment was conducted at the Laramie Research and Extension Center (LREC) by hand-sowing ‘Maverick’ dry bean on June 29, 2015. The resulting 30-sq-ft “micro-plots” were in three rows (6 feet long with 20-inch row spacing) and were inoculated with a *Rhizobium* strain to simulate conditions in a typical bean field. At 21 days after planting (DAP), 0, 20, 40, 60, 80, and 100 lb N/ac (as  $\text{NH}_4\text{NO}_3$ ) were surface applied and immediately irrigated. This source of N was used to minimize potential volatility losses that occur with N sources such as urea. In-season data collected included plant height, leaf

chlorophyll (using a chlorophyll meter on third uppermost trifoliolate), aboveground biomass, and canopy closure (%). Although the crop did not have time to mature naturally, yield and yield component data were collected prior to the first fall frost. The yield compounds include: pod number per unit area, seed number per unit area, seed size, and pod harvest index (seed weight/[pod wall + seed weight]). All data were subjected to a non-linear analysis procedure of SAS (version 9.1, SAS Institute Inc., Cary, North Carolina) with the equation  $Y=a \times \exp(b \times \text{NLevel})$ .

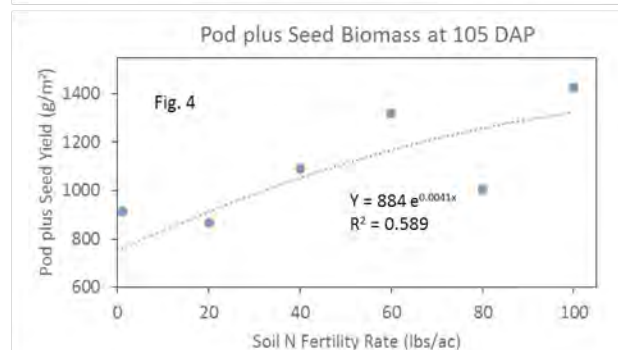
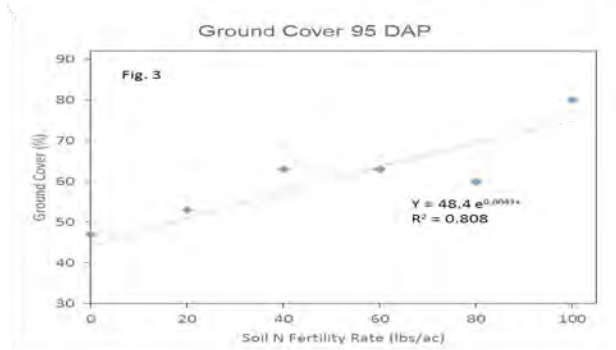
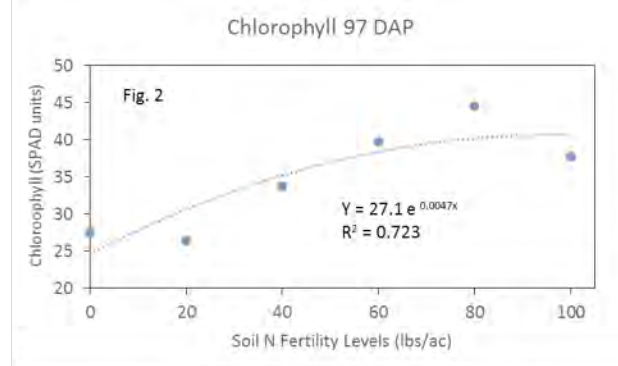
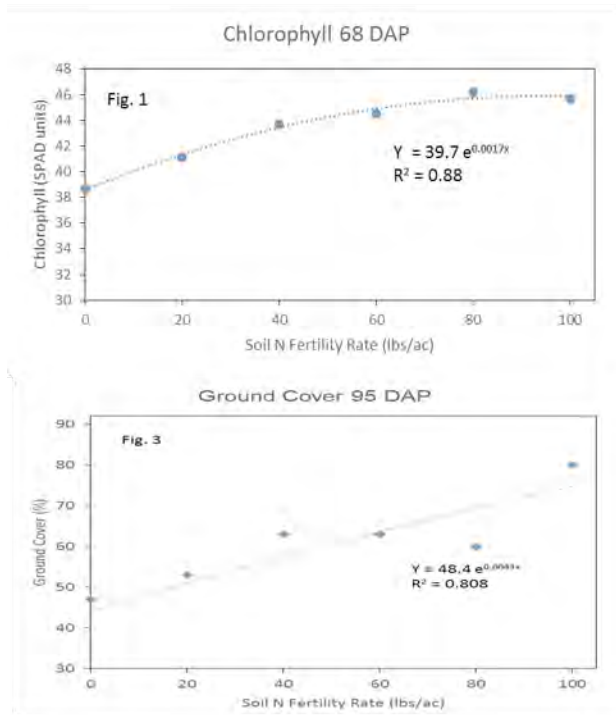
## Results and Discussion

Nitrogen levels had a significant curvilinear association with leaf chlorophyll at 68 and 97 DAP (Figures 1–2). Ground cover (Figure 3) responded to N level as did pod plus seed biomass at 105 DAP (Figure 4).

Starting with a soil having 10 parts per million nitrate-N and a soil-test recommendation of 65 pounds N, we demonstrated that there were benefits to dry bean vegetative growth and leaf chlorophyll by adding 60 lb N/ac just after planting. Our results support the report of Franzen (2013), which indicated benefits from 60 lb N/ac—but not beyond that. We also reemphasize the unfortunate situation that dry bean crops do not fix  $\text{N}_2$  efficiently.

Our study, though, must be interpreted with caution due to being grown in Laramie with a relatively late-maturing cultivar and not in Wyoming’s dry bean production areas, including the Bighorn and Wind River basins and the major crop-producing counties of southeast Wyoming. Despite this concern, our report is one of the first to quantify the effects of soil N rate on leaf chlorophyll and biomass. Additionally, our response to N rate

<sup>1</sup>Department of Plant Sciences.



**Figures 1–4.** Effect of soil N application rate on leaf chlorophyll (Figures 1–2), ground cover (Figure 3), and aboveground biomass (Figure 4). SPAD is the unit displayed from the Spectrum Technologies SPAD 502 chlorophyll meter.

results will provide guidance for our 2016 research in Goshen County, in which we intend to screen dry bean genotypes for improved N-use efficiency.

### Acknowledgments

The authors thank David Claypool, Osama Saleh, and Ethan Walter from LREC for technical support.

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**Keywords:** dry bean, nitrogen rate, leaf chlorophyll

**PARP:** Goals 1,2

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Majnoun Hosseini, N., 2008, Grain legume production, Tehran, Iran, Jahad Daneshgahi Publication, University of Tehran, 283 p. (in Persian).



# Effect of Two Nitrogen Levels and Cultivars on Growth Traits of Nine Dry Bean Cultivars in the Field

A. Albanan<sup>1</sup>, A. Piccorelli<sup>2</sup>, and J. Heitbold<sup>1</sup>

## Introduction

Compared with other legume crops, dry bean (*Phaseolus vulgaris* L.) relies on a combination of nitrogen (N) and N<sub>2</sub> fixation to grow optimally (Hardarson, 1993). N<sub>2</sub> fixation is a process by which atmospheric molecular nitrogen gas is converted into ammonium ions that are ultimately incorporated into amino acids. Agricultural systems that utilize N<sub>2</sub> fixation have the potential to reduce N fertilizer use. Unfortunately, N applications have the potential to cause contamination of ground and surface water with nitrate and increase producer input costs.

## Objectives

The objective of this study was to identify dry bean genotypes with improved N-use efficiency.

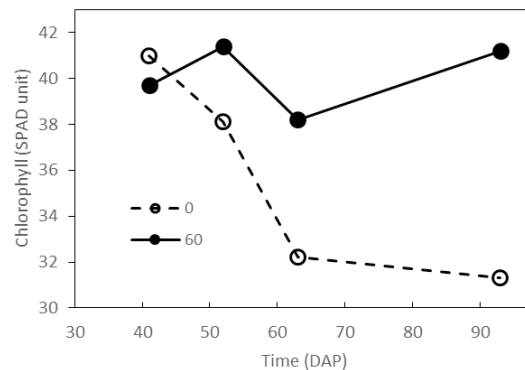
## Materials and Methods

A field experiment was conducted at the Laramie Research and Extension Center (LREC) to screen nine dry bean cultivars across four market classes in small plots. The study was sown on July 4, 2016, and all seed were inoculated with a commercial rhizobia to mimic conditions a producer would experience. Each plot consisted of three rows with a 20-inch row space, and the plot size was 30 sq. ft. The experiment used a split-plot design with two N levels (main factor) and two replications of the cultivars (subplot). The N treatments (0 and 60 lb N/ac) were applied 33 days after planting (DAP). Because the crop did not have time to mature naturally, yield and yield component data were not (and could not be) collected. Data collected included plant height, leaf chlorophyll, ground cover, and aboveground biomass.

## Results and Discussion

Although traits differed significantly among cultivars and N levels, no significant interactions were observed. Averaged across cultivars, leaf chlorophyll declined in the zero N treatment during the study, but remained steady with the treatment of 60 lb N/ac (Figure 1). Chlorophyll was measured with a Spectrum Technologies SPAD 502 chlorophyll meter. Aboveground biomass was significantly greater in the 60 lb N treatment at 75 DAP, but not at 110 DAP even though it was 34% greater (Figure 2).

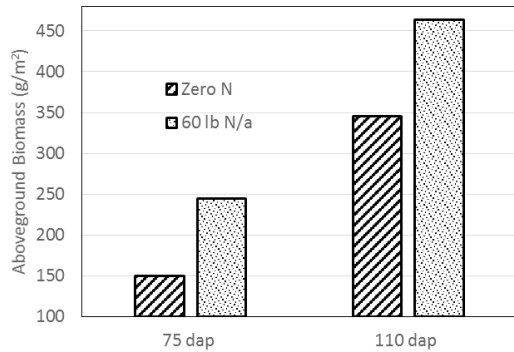
Averaged across cultivars, ground cover at 74 DAP was 57% for the 60 lb N rate and 48% for the zero N rate ( $p=0.182$ ). At 90 DAP, however, ground cover was similar to that achieved at 74 DAP, but remained significantly greater ( $p=0.037$ ) in the 60 lb N rate (58 vs. 49%). Plant height tended to be higher in the 60 lb N/ac treatment, but values were not significant (11 vs. 9 inches at 65 DAP and 18 vs. 14 at 90 DAP).



**Figure 1.** Effect of N rate (lb/ac) on leaf chlorophyll concentration of the third uppermost trifoliolate as a function of time. *P*-values at 41, 52, 63, and 93 DAP were 0.401, 0.061, 0.072, and 0.088, respectively. Data are averaged across nine cultivars.

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Differences among cultivars were found for several variables (Table 1). Despite being an early maturing cultivar, CO-46348 exhibited the highest ground cover at 75 DAP whereas Stampede exhibited the least. For height at 90 DAP, Croissant was the tallest cultivar while Stampede was the shortest. Height can be an important factor because studies often show it to be positively



**Figure 2.** Aboveground biomass as affected by N rate. *P*-values at 75 and 110 DAP were 0.009 and 0.104, respectively.

**Table 1.** Ground cover (75 DAP), plant height (90 DAP), and leaf chlorophyll (averaged across 41, 52, and 63 DAP) in nine cultivars grown in Laramie. Data are averaged across two N levels (0 and 60 lb N/ac).

Cultivar	Ground Cover	Height	Chlorophyll
	%	inches	SPAD units
Bill-Z	50	19	42
Croissant	57	21	40
CO-46348	62	19	46
Long's Peak	52	18	37
ND-307	50	15	35
Rio Rojo	45	12	36
Stampede	42	11	33
Talon	60	14	36
UI-537	52	15	40
LSD (0.05)	11	5	4

correlated to dry bean grain yield. As we have observed in other field and greenhouse studies, CO-46348 exhibited the highest leaf chlorophyll.

Because we conducted this study in Laramie and not in the dry bean production areas of Wyoming (notably the Bighorn and Wind River basins and the major crop-growing areas of southeast Wyoming), the data must be interpreted with caution. However, the consistent differences between the two N levels support the idea that most—if not all—dry bean cultivars benefit from N applications of 60 lb/ac. Our results support the idea that cultivar differences in traits related to N use might be useful in plant breeding programs. Due to the failure to detect significant cultivar-by-N level interactions, however, it appears that our future studies will require a set of genotypes with greater diversity than studied here. Future studies of this type begin in 2016 at the James C. Hageman Sustainable Agriculture Research and Extension Center near Lingle.

### Acknowledgments

The authors thank Osama Saleh and Ethan Walter for technical assistance.

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307-766-3104.

**Keywords:** genetic diversity, nitrogen uptake, *Rhizobium etli*

**PARP:** Goals 1,2

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# Alfalfa Growth Forms, Light Capture, and Nitrogen Fixation Interact to Influence Durability of Legume in Meadow Bromegrass Mixtures

*D.S. Ashilenje<sup>1</sup> and M.A. Islam<sup>1</sup>*

## Introduction

The role of legumes in symbiotic nitrogen (N) fixation and forage nutritive value is limited by their depreciation in mixtures with grasses, which are more competitive for sunlight. In addition grasses exploit legumes by their tendency to absorb great amounts of mineral N from legume root zones. However, beneficial interactions have been observed in similar mixtures. For example, the legume clover typically has enhanced growth because it fixes more N under conditions of low soil mineral N, which is increasingly taken up by the grass counterpart. In contrast, grasses typically experience greater relative growth when soil mineral N is high because legumes don't take up as much of this form of N. Considering the contribution of forage legumes to overall feed value and fixed N, it is crucial that the density and biomass quality of legumes in mixtures be maintained along with grass stands in mixtures. This is possible by understanding interactions between legumes and grasses with respect to absorption of sunlight and N. As a result, it is important to analyze how plants process and distribute carbohydrate and protein compounds leading to maximum growth, high nutritive value, and elongated crop life span.

## Objectives

The aims of this experiment are to determine the growth and canopy formation of grass while relating this to shading of legumes, N fixation, and crop lifespan for a legume (alfalfa) growing in mixtures with meadow bromegrass.

## Materials and Methods

In this study, a preliminary experiment was conducted from October to December 2015 at the Laramie

Research and Extension Center (LREC) greenhouse complex. A continuation of the project has been underway since February 2016 and will run until September of this year. This is hand-in-hand with simulations in the field for the ongoing grass-legume mixture research at the Sheridan Research and Extension Center. (There is a separate article in this bulletin on the research at ShREC on pages 143–144).

The experiment constitutes plants in a set of five pots arranged in a randomized complete block design with five treatments (Table 1) repeated four times. Treatments include meadow bromegrass at varied rates of N and in different ratios of mixture with alfalfa. Plants growing under greenhouse receive lower-light intensities for shorter periods than the natural conditions in the field. Therefore, in this experiment plants are artificially supplied with wavelengths of light required by plants for active photosynthesis ( $2,000 \text{ mol m}^{-2} \text{ s}^{-1}$  of photosynthetic photon flux density) for 16 hours a day using metal halide grow lamps. Alfalfa test plants were inoculated with N-fixing bacteria to ensure effective N fixation leading to desirable plant growth. Plant architectural characteristics being determined include shoot density, height of the primary axis, leaf count, and leaf area. Interactions between light absorption, N fixation, and distribution of carbohydrates and protein compounds at different plant canopy levels and their overall influence on forage performance and quality will be described. Measurements in the greenhouse study will be repeated in a related field experiment at ShREC in plots with 50:50 and 70:30 grass-alfalfa mixtures. Plant counts will be conducted to determine the number of individuals of each species in mixtures

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<sup>1</sup>Department of Plant Sciences.

along a 15-m (49.2-ft) transect line represented by scoring the occurrence of each plant species at the 1-m (3.3-ft) mark of a tape measure.

## Results and Discussion

Results from the preliminary study showed that alfalfa responded to shading by grass in mixtures by having less leaves despite larger leaflet area (0.9 inch<sup>2</sup>) compared to monocrop (0.6 inch<sup>2</sup>). Similarly, after eight weeks of growth, the average number of nodules per plant in alfalfa growing in a mixture was only seven ( $p=0.03$ ), which was half that counted on plants in monocrop. Grasses displayed superior competitive ability in mixtures by positioning their largest leaf area at a higher level than alfalfa. N supplied at recommended rates of 50 lbs/ac significantly ( $p<0.05$ ) increased individual leaf areas (1.8 to 2.0 inch<sup>2</sup>) in meadow bromegrass monocrop compared to control (1.4 inch<sup>2</sup>). These findings show possible characteristics of grass in cropping mixtures to negatively influence light absorption and growth and nodulation for alfalfa, which has negative implications on the legume’s capacity to fix N, on stand persistence, and on forage quality. But it will be of great interest to understand the exact way by which these relationships in light use can sustain crop stands for both species in different mixtures as well as continued

N fixation by legumes. This should be revealed at the end of the current greenhouse experiment. Since conditions in the greenhouse may give different results than those expected from field conditions, the findings in the greenhouse study will be verified upon similar cropping patterns being tested at the ShREC field site.

## Acknowledgments

We thank LREC staff for installing appropriate equipment for the experiment. The study is supported by a grant from Western SARE (Sustainable Agriculture Research and Education) and funds from the Wyoming Agricultural Experiment Station and Department of Plant Sciences.

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**Keywords:** plant architectural traits, resource capture and nitrogen fixation, alfalfa-meadow bromegrass mixtures

**PARP:** I:2, II:2, VII

**Table 1.** Treatment descriptions and codes for the greenhouse study at LREC greenhouse complex.

Treatment number	Treatment description	Treatment code
1	Meadow bromegrass without N	MB100 N0
2	Meadow bromegrass with 50 lbs of N/ac	MB100 N50
3	Alfalfa monocrop without inoculation	A0 <sub>Reference</sub>
4	Alfalfa monocrop inoculated	A100
5	50:50 ratio alfalfa-meadow bromegrass mixture	A50:MB50

# Rumen Microbes Associated with Feed Efficiency in Lambs

*M.J. Ellison<sup>1</sup>, K.J. Austin<sup>1</sup>, and K.M. Cammack<sup>1</sup>*

## Introduction

The rumen contains a large number of microbes that ferment a variety of feedstuffs into metabolites that can be used by the host ruminant. The makeup of the microbial population influences the host animal's maintenance, growth, and performance. In turn, the host animal provides an environment in which the microbes can thrive. The understanding of how rumen microbes influence the host animal's feed efficiency is important because of the economic relevance of this trait. Improvements in feed efficiency can reduce feed input costs and/or increase stocking rates for producers; however, measuring feed efficiency is time consuming and expensive. Identification of rumen microbes that

influence the host animal's feed efficiency may lead to new ways to improve feed efficiency or identify feed-efficient individuals.

## Objectives

The objective is to identify rumen microbes with abundance differences in lambs that are divergent for feed efficiency (i.e., either highly feed efficient or lowly feed efficient).

## Materials and Methods

The study was conducted at the Laramie Research and Extension Center. Growing Targhee ewe lambs (n=78) were fed a forage-based pelleted diet in a GrowSafe



**Figure 1.** Lambs on the GrowSafe feeding system.

<sup>1</sup>Department of Animal Science.

system to allow for individual feed intake measurements over a 70-day trial period (Figure 1). Body weights were collected at the beginning, middle, and end of the trial. Residual feed intake was calculated as the difference between actual and expected feed intake and was used as the measure of feed efficiency. A lower residual feed intake value is preferable because the animal is consuming less feed than expected for its maintenance and performance. Lambs were ranked on their residual feed intake values, and rumen fluid was collected from the eight most feed-efficient and eight least feed-efficient lambs. The DNA was extracted from those samples and then sequenced for microbial species identification and quantification.

### **Results and Discussion**

There were 306 microbial species present in at least one of the lambs, and 19 of those species had differences in abundance between the highly feed-efficient lambs and the lowly feed-efficient lambs. The most abundant microbial species overall was *Prevotella ruminicola*. This species is commonly reported to be the most abundant in ruminant studies, likely because it can utilize a wide variety of carbohydrates. There were other *Prevotella* species with abundance differences between high and

low feed-efficient lambs, along with *Ruminococcus* and *Clostridium* species. Many of these are fiber-degrading bacteria and are important to volatile fatty acid production and, hence, energy production for the host animal.

We are now determining (1) the role that these microbial species may play in the regulation of host feed efficiency; and (2) if some of these microbial species could effectively predict host animal feed-efficiency status (i.e., high or low feed efficiency).

### **Acknowledgments**

We thank LREC for assistance with the animal trial and the use of the GrowSafe system. We especially thank Bob Innes for the use of his lambs. This study is supported by U.S. Department of Agriculture, National Institute of Food and Agriculture Grant 2011-02678.

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**Keywords:** feed efficiency, microbes, sheep

**PARP:** V:1

# Irrigating Chives in a Greenhouse and Two High Tunnels—Completion Report

T. Gergeni<sup>1</sup> and K. Panter<sup>1</sup>

## Introduction

Since 2011, we have been conducting research into specialty crop production in the greenhouse and two high tunnels at the Laramie Research and Extension Center (LREC) greenhouse complex. Interest in local production of horticultural commodities is increasing in Wyoming. Much of the discussion centers on edible crops, including fresh herbs.

One purpose of this project was to determine water-use characteristics in the greenhouse and in two high tunnels using garlic chives as the test plant. Another was to make these irrigation findings available to Wyoming growers.

## Objectives

The main objective was to determine comparative differences in soil-moisture levels among the two high tunnels and the greenhouse. The aim is to encourage responsible irrigation practices on specialty crops that can be grown in Wyoming for sale at local venues such as farmers' markets.



**Figure 1.** Drip-irrigated chives in the greenhouse, summer 2015.

## Materials and Methods

Garlic chives (*Allium tuberosum*) were grown in the greenhouse and two high tunnels at LREC's greenhouse complex. Seeds for the spring greenhouse study were sown December 11, 2014, and transplanted to 6-inch pots on January 26, 2015. Half the pots were watered by hand, and half were watered by a drip system (Figure 1). Chives were harvested and weighed May 6, 2015.

The summer 2015 greenhouse and high-tunnels' study began March 8 when seeds were sown; seedlings were transplanted in the greenhouse and two high tunnels May 22. Plants in the high tunnels and on benches in the greenhouse were hand watered; the other greenhouse plants were drip irrigated. All plants were harvested and weighed September 10. Four soil-moisture monitoring sensors were placed in each of the six test plots.

## Results and Discussion

Even with similar soil-moisture contents, greenhouse-grown chive plants watered with drip irrigation were lower in fresh weight than those watered by hand (Table 1). All pots were treated with a slow-release fertilizer placed on the growing medium surface. The slow-released nutrients may not have been released as easily in the drip system as in the hand-watered pots.

In the high tunnels, fresh weights were highest in the east, north, and south locations and were higher than

**Table 1.** Average fresh weights of chive plants grown in a greenhouse in spring and summer under either drip irrigation or hand watering.

	Hand watered	Drip irrigated
Spring 2015	0.22 oz	0.07 oz
Summer 2015	0.32 oz	0.01 oz

<sup>1</sup>Department of Plant Sciences.

those found in the greenhouse. Soil-moisture levels were similar among the high-tunnel locations and were higher than in the greenhouse. This was probably due to differences in soil water-holding capacities. Results over four years have shown highest yields in general on the east side of the north–south-oriented tunnel. Morning sun seems to be very important for high-tunnel production, and higher soil moisture may also be a factor.

### **Acknowledgments**

Funding was provided by the Wyoming Agricultural Experiment Station.

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**Keywords:** irrigation, high tunnel, greenhouse

**PARP:** not applicable



# Sun Exposure in Growing Pigs Increases the Vitamin D Nutritional Quality of Pork

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## Introduction

Vitamin D is known for its critical role in maintaining bone health. Increasing evidence also suggests that vitamin D plays a role in the prevention of many chronic diseases. Of the 30 leading causes of death in the U.S. in 2010, 19 were linked to low vitamin D status (Baggerly, 2015). At the same time, a high prevalence of vitamin D insufficiency worldwide has been identified.

Vitamin D is unique among vitamins in that it can be obtained from diet as well as synthesized in the body from exposure to ultraviolet-B (UVB) radiation from sunlight. Compared to what is typically consumed in the diet, higher amounts of vitamin D can be synthesized from exposure to sunlight. It is estimated that a single 10- to 15-minute exposure during peak sunlight in July will produce between 10,000 and 20,000 IU (international units) of vitamin D; however, concerns of increased risk of skin cancer and skin aging keep many people out of the sun. To achieve sufficiency, these individuals must obtain vitamin D through diet and/or supplementation.

Meat, in general, is not considered a good source of vitamin D. The vitamin D content of pork may be particularly low due to traditional husbandry practices, which limit exposure to sunlight. Furthermore, the U.S. Department of Agriculture (USDA) nutrient database only evaluates pre-vitamin (D3 and D2) content of food sources. Synthesized vitamin D3 and supplemental D2 is modified in the liver to form 25(OH)D, the primary circulating form of vitamin D. Heaney et al. (2009) suggest that vitamin D content in meat products is underestimated due to failure to consider the 25(OH)D content, which is estimated to be about five times as potent as vitamin D3 in increasing serum concentration

of vitamin D. Vitamin D3 is readily sequestered by adipose tissue, while 25(OH)D is distributed throughout the body and taken up by skeletal muscle tissue.

Although swine are generally raised in confinement, they, like other agricultural animals, have the capacity to synthesize vitamin D. Sun exposure, therefore, has the potential to increase the vitamin D content of pork products.

## Objectives

The objective of this experiment is to determine the effects of sunlight exposure in pigs on lean and subcutaneous fat content of vitamin D in pork products.

## Materials and Methods

This study was established in 2014 at the Laramie Research and Extension Center (LREC). Landrace-Duroc-Yorkshire-cross grower pigs aged  $81 \pm 16$  days and weighing  $69.7 \pm 3.7$  pounds were assigned at random to sunlight exposure or to remain in standard confinement housing. Sun-exposed pigs were exposed to sunlight for one hour at solar noon for 10 days as growers and for another 10 days just prior to slaughter. Pigs were slaughtered in July and October 2014 following sun exposure during the summer solstice and fall equinox, respectively.

## Results and Discussion

Pig growth performance, including average daily gain, did not differ among pigs regardless of sun exposure. Back fat thickness at the first and last ribs and percentage fat-free lean tissue were similar among control and sun-exposed pigs. Serum concentrations of 25(OH)D were similar among pigs prior to sun exposure, but increased ( $p < 0.001$ ) with sun exposure. Sun

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exposure increased ( $p < 0.001$ ) 25(OH)D content of muscle and subcutaneous fat tissue while vitamin D3 content only increased in the lean tissue.

Many people in the U.S. and worldwide fail to maintain adequate concentrations of vitamin D. To achieve optimal vitamin D status, additional dietary sources of vitamin D may be necessary. Strategies to fortify or naturally add vitamin D to the food supply are currently being explored. Green and colleagues (2013) suggest that a greater range of food vehicles other than dairy, margarine, and cereals may be necessary to improve the vitamin D status of populations. Increased vitamin D may also be achieved by enhancing the natural vitamin D content of foods, termed bio-addition. Altering modern agricultural practices to allow pigs exposure to sunlight may be an effective means to naturally increase the vitamin D content of pork products.

In a previous study, analysis of vitamin D content of pork cuts from conventionally raised pigs yielded a vitamin D3 and 25(OH)D content of 1.6 and 2.0 IU/3.5 oz serving in the lean loin tissue, respectively, and 5.7 and 3.5 IU/oz in the fat rind (Clausen et al., 2003). Sun-exposed pigs in the present experiment had an average D3 content of 28.5 IU/3.5 oz in the lean and 52.2 IU/ oz in the fat rind of the loin. This is a near 18-fold increase of D3 in lean tissue and a nine-fold increase in subcutaneous fat. 25(OH)D content averaged 11.2 IU/3.5 oz serving in the lean and 9.2 IU/ oz in the fat rind of the loin from sun-exposed pigs.

The USDA nutrient database reports the vitamin D3 content of a raw, lean center loin to be 14 IU/3.5 oz, but does not include the 25(OH)D content of meat products. To compare, a 3.5 oz serving of lean with one ounce of fat from a sun-exposed pig would provide approximately 100 IU of vitamin D, which is similar to the vitamin D content in an 8 oz serving of vitamin D-fortified

milk. Considering that 25(OH)D is present in natural animal-based sources of vitamin D and has five times the biological activity of vitamin D3, 25(OH)D should be measured and accounted for in future vitamin D analysis of animal products.

### **Acknowledgments**

This study was funded by the Wyoming Agricultural Experimental Station.

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**Keywords:** pigs, vitamin D, sun exposure

**PARP:** I:1, V:5

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# Nuclear Size Regulation by NTF2 in Melanoma Cancer Cells

*D.L. Levy<sup>1</sup>, P. Jevtic<sup>1</sup>, L. Vukovic<sup>1</sup>, and K. White<sup>1</sup>*

## Introduction

The nucleus is the compartment within each cell that contains the genetic information directing how the cell grows and behaves. Although pathologists use an enlarged nucleus to diagnose cancer and determine what stage it has reached, we presently know very little about what causes large nuclear size or what the consequences are for the cancer patient. Our lab studies nuclear size in the model organism *Xenopus* (African clawed frog). Similar systems regulate cell growth in humans and frogs. In fact, proteins from human cells often work in frog cells. *Xenopus* research has been important in studying cancer as well as congenital heart disease, progeria, and Fanconi anemia, to name a few. To translate our findings in *Xenopus* to humans, we propose to directly alter nuclear size in cancer cells. To our knowledge for the first time, we will directly test if reducing the size of the nucleus slows cancer cell growth and metastatic potential. Our studies should shed light on how nuclear size contributes to cancer development and progression.

## Objectives

The objective of this study is to use information we have gained from the *Xenopus* system about mechanisms of nuclear size control to test if reducing nuclear size in human cancer cells affects their growth properties. Importantly, these basic studies in cell biology should provide the necessary information to develop novel methods to control cancer.

## Materials and Methods

We previously identified a protein involved in nuclear transport (NTF2) that regulates nuclear size in *Xenopus*. To examine if NTF2 levels change during cancer progression, we obtained a melanoma tissue microarray (ME1004c, US Biomax Inc.) and measured

NTF2 levels by immunohistochemistry. To test the effect of NTF2 expression on nuclear size, we (1) transiently transfected (the process of deliberately introducing nucleic acids into cells) two primary human melanoma cell lines (WM3211 and WM35) with an NTF2 expression plasmid; and (2) quantified the effects on nuclear size using a Hoechst stain, which is part of a family of blue fluorescent dyes used to stain DNA.

## Results and Discussion

We found that nuclei in melanoma cells are larger than nuclei found in benign nevi (an atypical mole) (Figure 1). Nuclear enlargement in melanomas correlated with a reduction in NTF2 expression levels (Figure 1), consistent with our data in *Xenopus* showing that NTF2 levels negatively regulate nuclear size. Transient over-expression of NTF2 in two different primary melanoma cell lines led to a reduction in nuclear size (Figure 2). These data indicate that NTF2 may be a novel cancer biomarker and potential therapeutic target. Future studies will address whether reducing nuclear size in melanoma cells impacts cell proliferation, apoptosis (the death of cells), and cell migration.

## Acknowledgments

We thank members of the Levy lab for helpful advice. This study is supported by the Wyoming Agricultural Experiment Station Competitive Grants Program.

## Contact Information

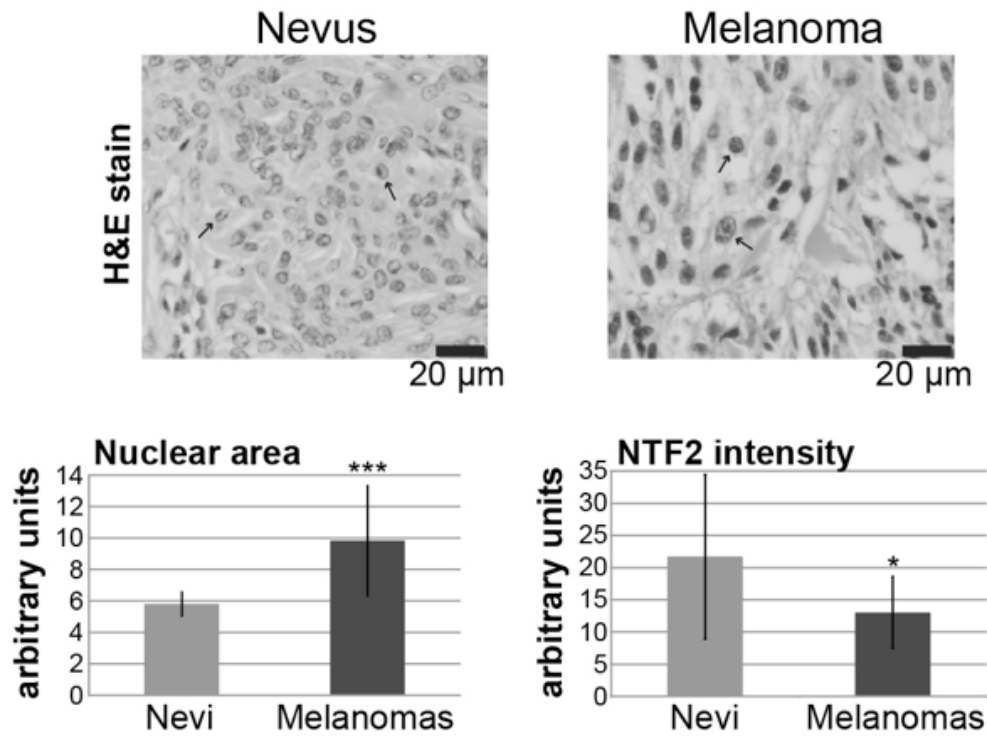
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**Keywords:** nuclear size, cancer cell biology, health

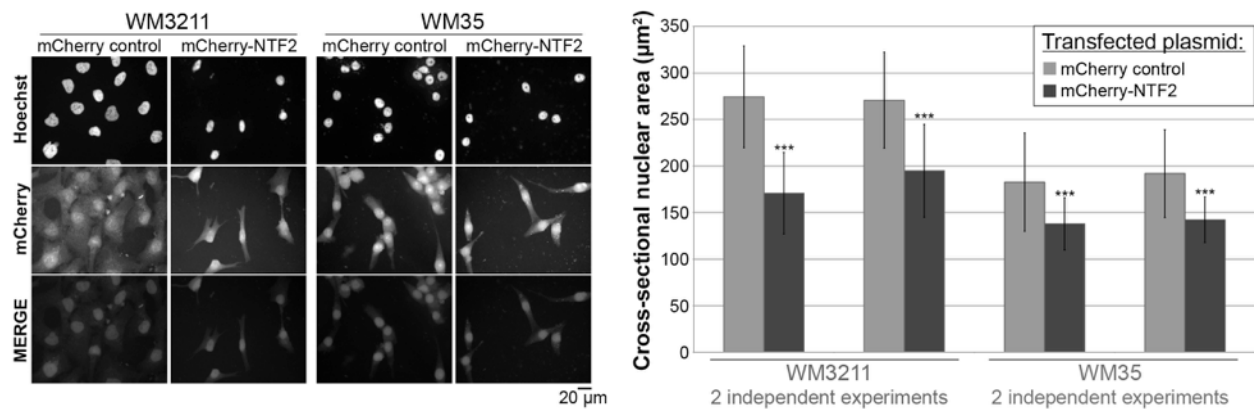
**PARP:** not applicable

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**Figure 1.** Nuclear size increases and NTF2 expression decreases in melanoma. Nuclear cross-sectional areas and NTF2 staining intensities were measured from a melanoma tissue microarray (ME1004c, US Biomax Inc.). One representative image each of a nevus (i.e., benign melanocytic proliferation) and a melanoma (i.e., primary malignant melanocytic lesion) is shown, and representative nuclei are indicated with arrows. The left graph shows average nuclear areas for 12 nevi and 12 melanomas. The right graph shows the average NTF2 staining intensities for those same samples. Error bars are SD. \*  $p < 0.05$ , \*\*\*  $p < 0.001$ .



**Figure 2.** NTF2 overexpression decreases nuclear size in melanoma cell lines. Primary radial growth phase melanoma cell lines (WM3211 and WM35) were transiently transfected with plasmids expressing mCherry alone as a control or mCherry-NTF2. Forty-eight hours after transfection, cells were fixed and stained with Hoechst. Representative images are shown. Nuclear cross-sectional areas were quantified from Hoechst-stained cells that were identified as being transfected by mCherry expression. For each bar, the cross-sectional areas of 88-223 nuclei were measured and averaged. Error bars are SD. \*\*\*  $p < 0.001$ .

# Vegetables and Herbs Under High and Low Tunnels

*K. Panter<sup>1</sup>, S.A. Dhekney<sup>1</sup>, A. Erickson<sup>2</sup>, C. Hilgert<sup>1</sup>, and J. Heitbold<sup>1</sup>*

## Introduction

Fresh, locally grown produce may not be as readily available in Wyoming as in other states for reasons including short growing season, adverse climatic conditions, and high altitude. Growing vegetables and herbs in unheated high tunnels, either alone or in combination with low-tunnel row covers, may help producers overcome some of these obstacles. The goal of this project is to successfully grow fresh tomatoes, chili peppers, green beans, and basil in two high tunnels—one situated in a north–south (NS) direction and one east–west (EW), with and without low-tunnel row covers.

## Objectives

Our main objective is to determine any differences in yields when vegetables and an herb were grown under high tunnels alone or with low-tunnel row covers within the high tunnels. Another objective was to determine any differences in yields depending on location within each of the two high tunnels.

## Materials and Methods

Three species of vegetables and one herb were grown in each of the two high tunnels at the Laramie Research and Extension Center greenhouse complex. ‘Ace 55’ tomato, ‘Anaheim Chili’ pepper, and ‘Thai Asian’ basil seeds were sown in the greenhouse April 6, 2015, and were transplanted to the high tunnels May 29, 2015. Seeds of ‘Earliserve’ green beans were directly sown into the high tunnels May 29, 2015.

Three tomatoes, four peppers, 10 bean seeds, and five basil plants were planted in northeast, southeast, northwest, and southwest locations within each high tunnel. All plants in the NE and NW sections of the NS tunnel and the NE and SE sections of the EW high tunnel were covered with white fabric low-tunnel row covers

suspended over metal hoops (Figure 1). The plants in the other sections were left uncovered.

Yield data collected were tomato, pepper, and green bean fruit weights per plant (fruit were harvested as needed all summer). Yield data on basil was the fresh weight of each plant, harvested August 24, 2015.

## Results and Discussion

The location with the highest average basil fresh weights was under the low-tunnel row cover in the NE area of the NS high tunnel (4.3 oz). Highest average per-plant yield of green beans was in the SE section of the NS high tunnel, not covered with a low-tunnel row cover (1.8 oz). For chili peppers, highest average per plant yield was in the NE section of the NS high tunnel, which was covered with low-tunnel row cover fabric (0.43 oz). Tomato yields were highest in the row-covered NE section of the NS high tunnel (41.7 oz) (Figure 2).

Results indicated yields were generally higher in the NS tunnel than the EW tunnel. Low-tunnel row covers did seem to help increase yields in the NS tunnel more than the other tunnel. Exposure to morning sun on the east side of the NS tunnel may have been the reason.

## Acknowledgments

Funding was provided by the Wyoming Department of Agriculture Specialty Crop Block Grant Program.

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**Keywords:** vegetables, high tunnel, low tunnel

**PARP:** not applicable

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**Figure 1.** Low-tunnel, row-covered plants in the NS high tunnel (uncovered for photo).



**Figure 2.** 'Ace 55' tomatoes harvested from plants grown under a white fabric low-tunnel row cover.

# Optimization of a Non-Surgical Artificial Insemination Technique Utilizing Estrous Synchronization and Frozen-Thawed Ram Semen

P.H. Purdy<sup>1</sup>, K. Koepke<sup>2</sup>, and S. Lake<sup>3</sup>

## Introduction

There is a common misconception that fertility cannot be achieved with frozen ram semen and non-surgical artificial insemination (AI). Over the past years, we (NAGP<sup>1</sup>, LREC<sup>2</sup>, Department of Animal Science, and Desert Weyr LLC of Paonia, Colorado) have achieved varying levels of fertility, but it has not improved to a level and consistency that makes it appealing to sheep producers. The reason that these results are variable is due to the inconsistency in the time of ovulation as a response to the estrous synchronization protocol, the quality of the frozen-thawed semen, and the type of extender used to freeze the semen. Understanding and controlling these factors should result in greater fertility that is acceptable to a commercial sheep producer.

## Objectives

To identify and demonstrate a simple, cost-effective method of non-surgical AI with frozen-thawed ram semen that can be utilized by sheep producers.

## Materials and Methods

Since 2004 we performed comparisons of estrous synchronization protocols, types of semen freezing extenders, and methods of AI. Computer automated sperm motion analysis, flow cytometry, and fertility trials were performed to identify optimal producer-friendly methods.

## Results and Discussion

Rambouillet and Hampshire flocks were utilized at LREC, and Black Welsh Mountain sheep were utilized from a private producer's flock (Desert Weyr LLC). Based on our fertility rates with these flocks, we have the following conclusions and recommendations:

### *Estrous synchronization:*

A comparison of progesterone-impregnated sponges and CIDRs<sup>®</sup> revealed that both devices satisfactorily synchronize the estrous cycles of mature ewes. The CIDRs, however, are the optimal choice because insertion and removal are much easier to perform, and they result in minimal discomfort to the ewes.

### *Semen freezing extenders:*

Evaluation of the three most commonly used extenders (TRIS 300, TRIS 200, and skim milk-egg yolk [aka SMEY]) demonstrated that the highest post-thaw motility is achieved with the most commonly used ram semen extender (TRIS 300), but use of this extender results in unacceptable levels of fertility when used for non-surgical artificial insemination (Table 1). Use of the other two extenders, however, results in similar post-thaw motility rates, levels of sperm intracellular calcium (an indicator of sperm fertilizing ability and function), and fertility (Table 1) making either extender (TRIS 200 or SMEY) an acceptable choice. We are optimistic that fertility rates will increase with the TRIS 200 when double inseminations are used because the fertility we achieved with this extender was a low dose, single insemination (one-third of a normal dose), which was utilized to identify suboptimal AI times.

### *AI methods:*

Laparoscopic surgical AI results in reasonable levels of fertility (Table 1), but the expenses to perform the inseminations are prohibitive for most producers.

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<sup>1</sup>U.S. Department of Agriculture, Agricultural Research Service, National Animal Germplasm Program (NAGP), Fort Collins, Colorado; <sup>2</sup>Laramie Research and Extension Center (LREC); <sup>3</sup>Department of Animal Science.

Non-surgical AI that opens the ewe's cervix did not result in acceptable fertility rates (Table 1).

Non-surgical AI that does not open the cervix has resulted in fertility approaching that of the laparoscopic AI (Table 1). The quality of the ram semen has tremendous impact on the resulting fertility, and when high quality semen is used we have observed fertility rates as high as 75% with the Black Welsh Mountain breed. Consequently, we believe that this is the most desirable AI method because it does not require opening the ewe's cervix, is easy to learn, and can be performed quickly. Additional fertility trials will be performed in fall 2016 to improve our techniques. Furthermore, we plan to publish the methods for these techniques with full

descriptions and diagrams in trade and technical journals so that they can be readily utilized by producers.

### Acknowledgments

We thank the students and crews of LREC for assistance with semen collections and artificial insemination. The study is supported in part by the Colorado Sheep & Wool Authority.

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**Keywords:** artificial insemination, sheep, estrous synchronization

**PARP:** V:9

**Table 1.** Post-thaw ram sperm characteristics and resulting fertility by freezing extender.

Extender	Post-thaw motility	Calcium activity <sup>a</sup>	Fertility	AI dose <sup>b</sup>	Number of AI/ewe <sup>c</sup>
TRIS 300	45%	15%	10-15%	100	2
TRIS 200	30-35%	45%	33%	70	1
SMEY	30-35%	45%	40%	100	2

<sup>a</sup>The proportion of sperm capable of accumulating intracellular calcium as determined via in vitro testing; <sup>b</sup>millions of sperm; <sup>c</sup>per estrus.



# Quantitative Variation in the Circadian Clock Affects Plant Performance

M. Salmela<sup>1</sup>, K. Greenham<sup>2</sup>, P. Lou<sup>2</sup>, C.R. McClung<sup>2</sup>, B.E. Ewers<sup>1,3</sup>, and C. Weinig<sup>1,3,4</sup>

## Introduction

Due to the Earth's rotation around its axis, 24-hour days with predictable light–dark and temperature cycles characterize most environments, resulting in various optimal times for biological processes over the course of a day. The circadian clock is thought to have evolved as a timekeeping system in response to cycling environments in diverse organisms from bacteria to plants to mammals. Based on stimuli from the surrounding environment, the clock contributes to the regulation of various biological phenomena from gene expression to behavior and maintains 24-hour cycles in these traits. With intact clocks, these rhythms will persist in constant conditions, while disruptions of the circadian clock may lead to altered rhythms or even arrhythmia (the absence of rhythmic patterns).

Despite the occurrence of circadian clocks in diverse organisms, little is known about how much circadian rhythms vary among individuals in field environments or about how circadian variation affects agronomically important traits.

## Objectives

The overarching objective of this research is to quantify variation in the circadian rhythms in a Wyoming native plant species that is related to many mustard crops. The performance of wild species may identify opportunities for genetic improvement of related crops. Our specific goals were to: (1) quantify circadian rhythms in the Wyoming native plant *Boechea stricta* (common name Drummond's rockcress); and (2) ascertain if circadian variation affects performance including growth, allocation, and fruit set, which are all relevant targets of crop improvement.

## Materials and Methods

We used leaf movement as a means to estimate circadian rhythms (Figure 1). We also measured a range of growth, size, and allocation traits in plants collected from across an altitudinal gradient in Wyoming, including in the Medicine Bow Mountains and Laramie Mountains in southeast Wyoming. Among other analyses, we tested for correlations between circadian period (described in Figure 1) and growth and allocation traits.

## Results and Discussion

We found that differences among sites were comparatively small (less than one hour) in comparison to the diversity within each population (2.7–3.5 hours among families sampled within several hundred meters) (Figure 2). Notably, our within-population variation captured significant proportions of circadian period variation previously documented among plants sampled across much larger geographic areas; for example, the range of 3.5 hours within South Brush Creek (SBC) in the Medicine Bow Mountains accounted for 54% of the variation in period of leaf movement among 150 globally sampled populations of a commonly studied plant species, *Arabidopsis thaliana* (mouse-ear cress). We further observed that growth and relative root:shoot allocation were strongly associated with circadian period, suggesting that the clock may affect traits important to human crop production. These results were recently published in the journal *Plant, Cell & Environment* (<http://onlinelibrary.wiley.com/doi/10.1111/pce.12670/full>).

## Acknowledgments

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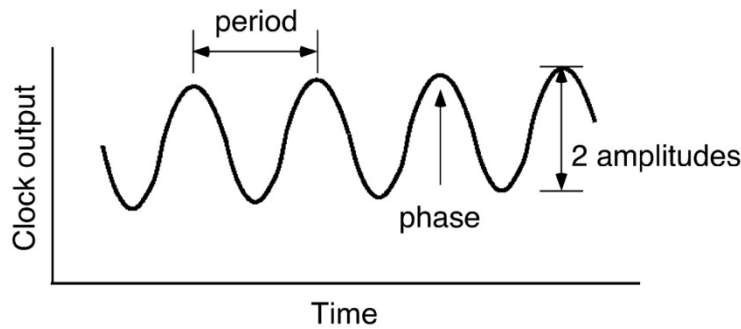
greenhouse and field conditions. This work was supported in part by grants from the National Science Foundation (IOS-0923752 and IOS-1025965 to Cynthia Weinig, C. Robertson McClung, and Brent Ewers).

**Keywords:** *Boechera stricta*, circadian rhythms, plant growth and allocation

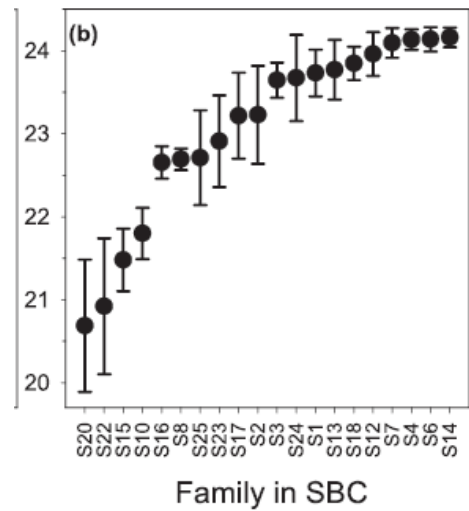
**PARP:** VIII:1

**Contact Information**

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**Figure 1.** Circadian rhythms are internal repeating rhythms with cycles close to 24 hours. The figure illustrates the circadian traits of period (duration of one cycle), phase (the timing of peak outputs such as maximal gene expression), and amplitude (the range of values achieved in a 24-hour cycle).



**Figure 2.** Diverse genetic lines (or families) from a Wyoming population of *Boechera stricta* at South Brush Creek (SBC) express a wide range of circadian periods. The x-axis of this figure shows individual genetic families, assigned numerical identifiers. The y-axis shows the duration of the circadian period.

# Influence of Ewe Breed and Age on Sheep Ked (*Melophagus ovinus* [L.]) Infestations

J.D. Scasta<sup>1</sup> and K. Koepke<sup>2</sup>

## Introduction

Sheep keds (*Melophagus ovinus* [L.]) are an external parasite of sheep. Sheep that graze in high elevations may be at greater risk of ked infestation than sheep at low elevations. Ked infestations can have negative economic consequences due to reductions in weight gain and wool production. Keds reduce animal performance because sheep become irritated, causing rubbing, scratching and a loss of blood. The influence of sheep breed and age appear to influence ked migration, infestation, and treatment decisions. The movement of keds from ewes to lambs has been suggested to decrease infestations of older sheep as new ked generations migrated while older keds remained on ewes. Sheep ked populations typically increase in the fall, and sampling at the time of shearing has been suggested to be an opportune time for detection. Moreover, sheep wool type and length can influence the susceptibility of a sheep to ked infestation.

## Objectives

Sheep producers and wool commodity organizations have expressed concern about ked infestations of sheep on high-elevation rangelands. Furthermore, the potential influence of ewe breed and age on ked infestation levels could lead to new approaches to managing keds. We measured the influence of breed and age in a commercial sheep production scenario. Our main objectives were to determine if sheep keds discriminate between three of the most common sheep breeds in Wyoming (Rambouillet, Hampshire, and Suffolk) and to explain how ewe age affects ked parasitism based on host-parasite ecology. Finally, we wanted to determine if and how ewe breed and age interact to explain ked infestations.

## Materials and Methods

We assessed ked infestations on commercial ewes from the Laramie Research and Extension Center (LREC) Sheep Unit west of Laramie. The study area consists of semiarid, high-elevation, native and improved rangeland. The plant community is dominated by perennial grasses including blue grama, crested wheatgrass, and western wheatgrass. Ewes were examined for keds at the time of shearing in October 2015. The total number of keds per ewe, breed, and age of each ewe were recorded. Rambouillet, Hampshire, and Suffolk breeds with 18 ewes in each breed group were examined. Age sub-groups within breeds were 1, 2, and 3+ years of age. Time since the last shearing was 12 months for 2 and 3+ year old ewes and 9 months for yearlings. The last application of a parasite control product was 10 months prior to sampling with a drenching of Ivomec®. We conducted a one-way analysis of variance for ked density and conducted a generalized linear model for the binary (ked presence/absence) data with ewe breed and age as separate independent variables. Finally, we conducted a mixed-effects model to determine if there was a breed-age interaction.

## Results and Discussion

Ked density was the highest on Rambouillet ewes, the lowest on Suffolk ewes, and intermediate on Hampshire ewes (the latter was not statistically different from the other breeds [ $p=0.0327$ ;  $F=3.66$ ]). Frequency of keds was the highest on Rambouillet ewes while both medium wool breeds had significantly lower presence (Figure 1;  $p=0.0075$ ;  $\chi^2=9.80$ ). Ewe age alone was not significant for ked density or presence across breeds. The interaction between breed and ewe age was significant for ked presence ( $p=0.0078$ ;  $\chi^2=20.78$ ), but not for ked density ( $p=0.0886$ ;  $F=1.87$ ). This discrepancy of statistical

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<sup>1</sup>Department of Ecosystem Science and Management; <sup>2</sup>Laramie Research and Extension Center Sheep Unit.

significance for the breed-age interaction is attributed to the high level of ked infestations on Rambouillet ewes and the variability of ked dynamics within individual breeds. For example, the greatest density of keds was on a 1-year-old Rambouillet ewe while all 3-year-old Rambouillet ewes had keds; however, no yearling Suffolk ewes had any keds, and less than a third of 3-year-old Suffolk ewes had keds. These results indicate that keds do discriminate by breed due to preference for a dense and long-stapled wool-environment. This type of wool-environment is optimal on Rambouillet ewes. This information can be used to develop integrated pest management strategies that manipulate this host-parasite ecology by selecting sheep breeds to mitigate ked parasitism. Moreover, insecticide applications could be strategically targeted within breeds on ewes of susceptible ages. An applied example of this strategic

manipulation of host-parasite ecology could be targeting all Rambouillet ewes regardless of age for treatment and only treating Suffolk ewes older than 2 years.

### Acknowledgments

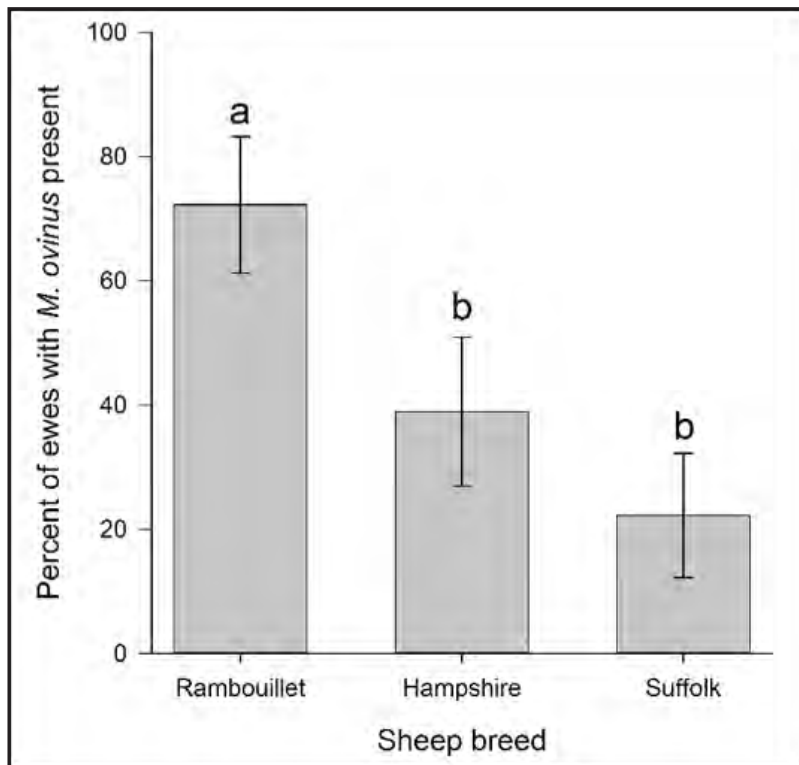
Appreciation is extended to LREC staff, student workers, and the sheep shearer for assistance. A full manuscript from this study was published in the journal of *Livestock Science*. For a copy of the paper, please contact the author.

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**Keywords:** sheep, parasites, rangeland

**PARP:** I:1, V:7, VI:1



**Figure 1.** Ked presence frequency on three sheep breeds in Wyoming. Bars with different letters indicate breeds are significantly different at the 95% confidence level.

# Strategic Sheep Grazing Effects on Yellow Sweetclover (*Melilotus officinalis* [L.] Lam.) Dominance and Structure

J.D. Scasta<sup>1</sup> and K. Koepke<sup>2</sup>

## Introduction

Yellow sweetclover (*Melilotus officinalis* [L.] Lam.) is a non-native legume introduced from Europe and Asia to the United States as a forage crop. As a legume, this plant has a symbiotic relationship with *Rhizobium* bacteria, which allows it to fixate atmospheric nitrogen. Ecologically, yellow sweetclover can dominate plant communities by invading and out-competing other herbaceous plants for resources. Currently, yellow sweetclover is listed as “invasive” in 26 states, including Wyoming, by the Plant Conservation Alliance’s Alien Plant Working Group. The use of strategic grazing with sheep has been suggested as a strategy to reduce invasion and dominance of invasive plants; however, no data exists documenting the preferential selectivity of sheep on sweetclover and the changes of sweetclover dominance and structure relative to other types of plants.

## Objectives

Our primary objective was to determine how intensive sheep grazing using different sheep breeds influenced selectivity and dominance of sweetclover in a high-elevation, semiarid rangeland situation.

## Materials and Methods

We applied grazing treatments using commercial ewes from the Laramie Research and Extension Center Sheep Unit west of Laramie (elevation 7,200 feet). We used two breed groups: (1) fine wool (FW) ewes of the Rambouillet breed; and (2) medium wool (MW) ewes of the Hampshire and Suffolk breeds. There were 24 ewes with lambs in each breed group. Sheep were placed in the first set of paired eight-acre paddocks on June 1, 2015. Prior to the rotation to the second set of paired paddocks on June 16, 2015, we conducted the first round of vegetation sampling (Pre) using four

step-point transects at four permanently marked intervals across the short axis of each paddock. Each transect was 75 meters (~82 yards) in length, and at every other step we noted the nearest grass, sweetclover, forbs, and cactus. Because our study was not fully replicated, we used the means for each transect as pseudo-replicates and calculated standard errors of the means accordingly. When sheep were moved out of the paddocks on July 22, 2015, we conducted a second round of vegetation sampling (Post) using the same method described above. At this time we also sampled our control pasture, which was immediately adjacent to the sheep-grazed pastures to the north. The only notable herbivory in the control pasture was by free-ranging pronghorn antelope. We assigned the sheep breed and sampling interval as the fixed effects (i.e., MW-Pre, MW-Post, FW-Pre, FW-Post, Control-Pronghorn-Post), and the relative proportion of grass or sweetclover were used as independent variables for statistical analyses. We used a generalized linear model using a grass analysis first followed by a sweetclover analysis. Finally, we measured sweetclover plant height, the number of flowering stems per plant, and the relative proportion of leaf location on 10 sweetclover plants along the long-axis of the three paddocks/pastures by identifying basal leaves versus aerial leaves on vertical stems.

## Results and Discussion

Prior to sheep grazing (Pre), the relative proportion of grass and sweetclover was similar in the respective paddocks:  $56 \pm 3\%$  and  $38 \pm 4\%$  for MW sheep paddock and  $60 \pm 3\%$  and  $34 \pm 3\%$  for FW sheep paddock (Figure 1). After sheep grazing (Post), the relative proportion of sweetclover had been reduced and the relative proportion of grass had been increased with no difference between the two breed groups (Figure 1). In

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the MW paddock, the relative proportion of grass was  $81 \pm 1\%$  and the relative proportion of sweetclover was  $14 \pm 2\%$  after grazing. In the FW paddock, the relative proportion of grass was  $79 \pm 1\%$  and the relative proportion of sweetclover was  $11 \pm 1\%$  after grazing (Figure 1). There were no differences between breeds in how they selected and altered the relative dominance of sweetclover. The control pasture had  $45 \pm 3\%$  grass and  $50 \pm 2\%$  sweetclover without intensive sheep grazing or  $>3.5$  greater relative sweetclover dominance (Figure 1). Our sampling has not yet been able to ascertain sweetclover mortality, but we have noted a change in the physical structure of sweetclover plants. In the intensively grazed sheep paddocks, the mean maximum heights were 8.7 to 9.4 inches, the basal leaf to aerial leaf ratios were from 4:1 to 11:1, and the numbers of flowering stems per plant were 0.2 to 0.3. In the control, the mean maximum

height was 22.8 inches (or  $>2$  times taller), the basal leaf to aerial leaf ratio was  $<1:100$ , and the number of flowering stems per plant was 12. These preliminary results indicate that well-managed sheep grazing can reduce the dominance and structure of sweetclover. Long-term reductions of sweetclover will be tracked in future years.

### Acknowledgments

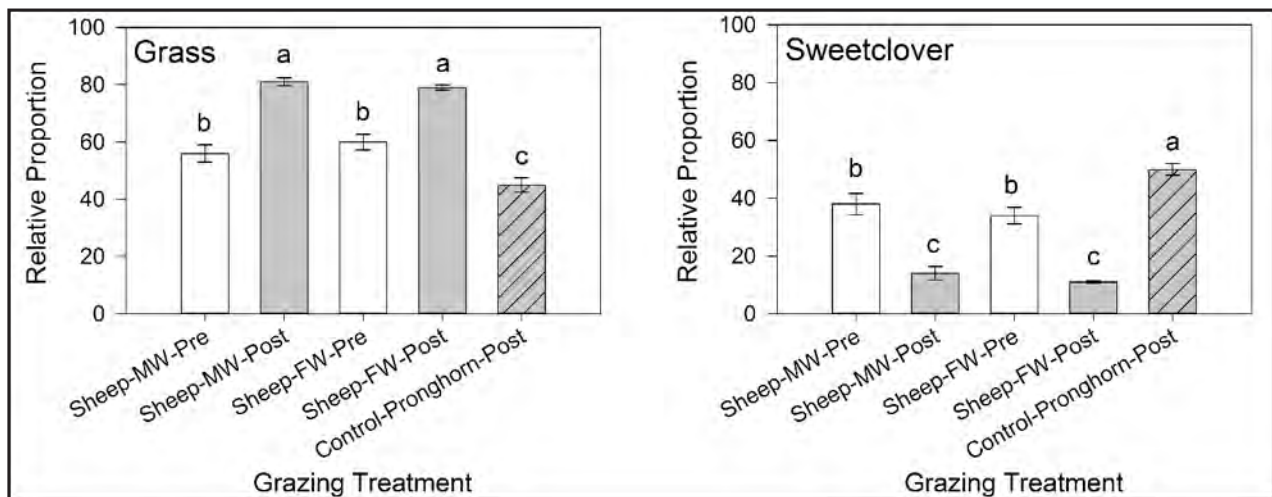
Appreciation is extended to LREC staff for coordination and assistance.

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**Keywords:** sheep, invasive plants, rangeland

**PARP:** I:1, V:3, VI:4,5,6



**Figure 1.** Proportion (%) of grass and sweetclover before (Pre) and after (Post) intensive sheep grazing with medium wool (MW) and fine wool (FW) sheep, or no sheep grazing (Control). Bars with different letters indicate significant differences at the 95% confidence level.

# Myxobacteria as Biocontrol Agents against Crop Pathogens

D. Wall<sup>1</sup>

## Introduction

There are approximately 2.1 million farms in the U.S. that annually generate around \$400 billion in agricultural sales, including crops and livestock. One ongoing threat to the agricultural industry is pathogens that destroy crops. One category of pathogens is microbes, which cause tens of billions of dollars in crop damage annually. A number of methods are used to control crop disease; chemicals, such as fungicides, are a major strategy. Although generally effective, the use of chemicals is problematic because they are expensive and can be harmful to humans, wildlife, and the environment, and pathogens can develop resistance. An alternative approach is biocontrol, where naturally occurring microbes in the soil are used to control crop diseases. Biocontrol stems from the long-known observation that some soils are naturally suppressive to crop pathogens, while other soils are conducive to diseases. That is, soil contains thousands of different microbial species—and some of these species inhibit the growth of pathogens. Many farmers have known this fact for some time, and for this reason commercial biocontrol products are used. Although these biocontrol agents are useful, their overall effectiveness is limited because little is known about these microbes and how they work.

This project was initiated with the hypothesis that myxobacteria can be used as effective biocontrol agents. This idea was based on the fact that myxobacteria are natural soil predators that kill and consume other microbes while not harming plants. During the course of our earlier studies, we found that myxobacteria kill microbes by two mechanisms. One is dependent on the secretion of products (such as antibiotics) that kill other microbes. We found that a second mechanism depends on cell–cell contact, but the details were not known.

## Objectives

Myxobacteria are promising biocontrol agents to help control crop diseases because they, in part, kill other microbes without hurting plants and causing potential harm to humans and the environment. Here we sought to understand the molecular mechanism of cell–cell contact-dependent killing.

## Materials and Methods

This study was conducted in the University of Wyoming laboratory of the investigator, who used microbiology, molecular biology, bioinformatics, and microscopy methods.

## Results and Discussion

We sought to identify genetic determinants that myxobacteria use to kill competitors. We did this to better understand how myxobacteria might be used as biocontrol agents and how they might be optimized. In prior work, we showed that one mechanism of killing involves the secretion of antibiotics. Since then, we discovered that a second system involves cell–cell contact. By using genetic and bioinformatic methods we discovered that myxobacteria contain a protein delivery system that transfers toxins to adjacent cells (Figure 1). Killing is effective and depends on the delivery genes (*tra*) and the toxin genes because when either of these components is knocked out by genetic methods, the killing trait is abolished (Figure 1). We further discovered that at least three different toxins are transferred. The toxins are proteins that act as enzymatic poisons that degrade DNA and RNA in the inflicted cells. This work was published in the American Society for Microbiology's *Journal of Bacteriology* in March 2016 (<http://jb.asm.org/content/early/2016/01/12/JB.00964-15.abstract>). In ongoing work we have also characterized a second system involved in cell–cell delivery of toxins; it is called

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<sup>1</sup>Department of Molecular Biology.

the type VI secretion system. This work has broadened our understanding into how myxobacteria kill and has added insight into how they might be genetically manipulated to serve as improved biocontrol agents. Future studies with myxobacteria are needed to test our laboratory findings in field-model systems for protecting crops from disease.

### Acknowledgments

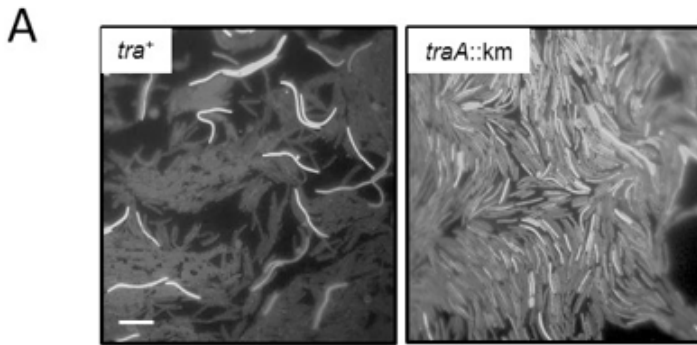
This study was supported in part by U.S. Department of Agriculture Hatch funds.

### Contact Information

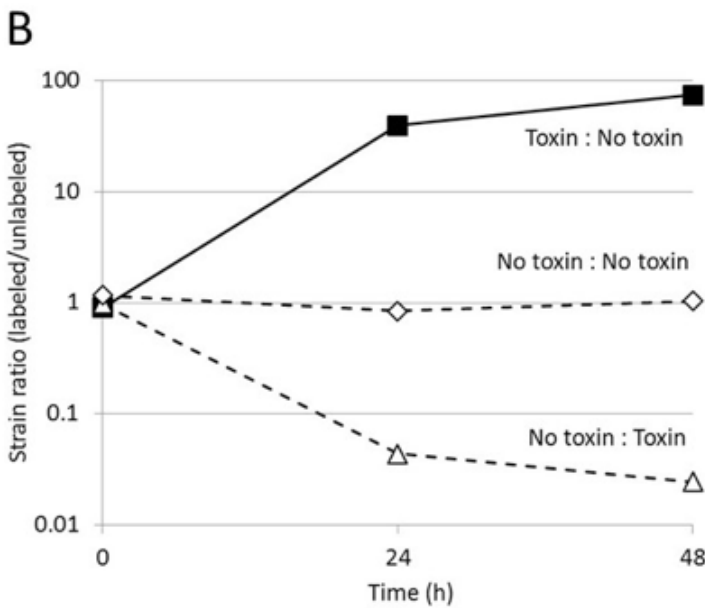
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**Keywords:** biocontrol, myxobacteria, pathogens

**PARP:** VIII:2



**Figure 1.** Cell killing depends on toxin transfer. A) Target cells (white) mixed at a 10:1 ratio with a killer strain (gray) and examined by microscopy after one day. Left, toxin transfer kills target strain or they become filamentous, while a *traA* mutation (right) blocks toxin transfer and killing. B) In competition experiments killing depends on the toxin gene.





# Evaluating the Efficacy of Two Imazapic Formulations and Sagebrush Canopy Effects on Cheatgrass Control under Greenhouse Conditions

*C.W. Wood<sup>1</sup>, B.A. Meador<sup>1,2</sup>, and A.R. Kniss<sup>1</sup>*

## Introduction

Cheatgrass (*Bromus tectorum*) is an invasive annual grass that is widely distributed throughout much of the western United States. Many efforts have been made using herbicides to restore cheatgrass-dominated rangelands to native perennial grass- and shrub-dominated communities. Imazapic is a commonly used herbicide to manage annual grasses in rangelands while providing limited negative impacts to established native grasses. One confounding factor of herbicide applications in shrubland ecosystems is the potential for physical interception of liquid herbicides by shrub canopies.

## Objectives

Our objectives were to compare the efficacy of two formulations of imazapic (Plateau<sup>®</sup>, a liquid formulation, and Open Range<sup>™</sup> G, a granular formulation) with and without a shrub canopy and to determine if herbicide rate affects cheatgrass control.

## Materials and Methods

In a 2015 greenhouse experiment at the Laramie Research and Extension Center (LREC), we established a complete randomized block design with five replicates to compare the efficacy of both imazapic formulations (Table 1)—with and without a simulated sagebrush canopy cover. Field soil was placed in six-inch-diameter pots with 10 cheatgrass seeds planted at a depth of approximately 0.4 in. Plateau was applied in a spray chamber delivering 20 gal/ac at 40 PSI. Open Range G was applied using a Scotts<sup>®</sup> Turf Builder<sup>®</sup> Classic Drop Spreader (22-in application width) using the lowest available setting. Mortar sand was sieved to approximately the same particle size as the Open Range

G granules to adjust application rates appropriately. We simulated sagebrush canopy by digging live sagebrush plants and placing them in pots above the cheatgrass pots during herbicide application.

We conducted the study over a six-week period and counted seedlings daily for the first two weeks then every other day for the remaining four weeks. We measured height of longest leaf at two-week intervals and collected biomass six weeks after treatment. Biomass samples were dried in a forced air oven at 140°F for 72 hours and weighed to the nearest milligram (one milligram equals approximately 3.5 ounces).

## Results and Discussion

Differences among imazapic formulation and canopy cover treatments were not observed under greenhouse conditions. Cheatgrass biomass, height, and seedling number decreased as herbicide rate increased ( $p < 0.0001$  for all measurements), and biomass results became more consistent with increasing herbicide rates (Figure 1).

Our results suggest that, under greenhouse conditions, Plateau and Open Range G provide similar reductions in cheatgrass biomass, height, and seedling number—irrespective of shrub canopy.

## Acknowledgments

We thank the University of Wyoming Department of Plant Sciences, Wilbur-Ellis, Sublette County Weed and Pest District, and sage grouse local working groups for support and funding and UW students and LREC greenhouse staff for assistance.

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**Keywords:** cheatgrass (*Bromus tectorum*), canopy interception, imazapic

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

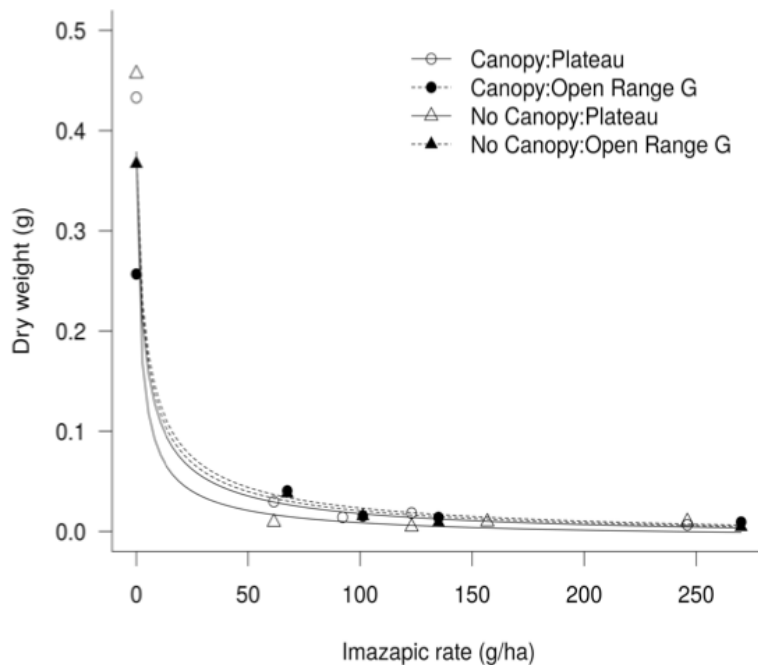
**Table 1.** Herbicide treatments (formulation and rates) evaluated for cheatgrass control with and without sagebrush canopies under greenhouse conditions.

Treatment <sup>1</sup>	Herbicide	Rate (g ai/ha) <sup>2</sup>	Rate (product/acre)
Control	Plateau	NA	NA
Control	Open Range G	NA	NA
0.5x	Plateau	61.5	3.5 fl. oz.
0.5x	Open Range G	67.5	6.5 lbs.
0.75x	Plateau	92.25 <sup>3</sup>	5.25 fl. oz.
0.75x	Open Range G	101.25	9.75 lbs.
1x	Plateau	123	7 fl. oz.
1x	Open Range G	135	13 lbs.
2x	Plateau	246	14 fl. oz.
2x	Open Range G	270	26 lbs.

<sup>1</sup>All treatments were conducted with and without shrub canopy cover.

<sup>2</sup>g ai/ha=gram active ingredient per hectare (1 g=3.53 oz; 1 ha=2.47 acres)

<sup>3</sup>No canopy treatment was applied at 156.8 g/ha due to calibration error.



**Figure 1.** Effects of imazapic rate (g/ha) on cheatgrass biomass dry weight (g) across herbicide and shrub canopy treatments. As herbicide rate increases, cheatgrass biomass decreases and results become more consistent. (See conversions for gram/oz and hectare/acre under Table 1.)

# Targeted Sheep Grazing for Dalmatian Toadflax and Geyer's Larkspur Management

*J.M. Workman<sup>1</sup> and B.A. Meador<sup>1,2</sup>*

## Introduction

Targeted grazing is a land-management tool that can be used for weed control. Managers may manipulate defoliation timing, intensity, and frequency to maximize negative effects on weeds and minimize native plant community impacts. Effective perennial weed control generally requires multiple defoliations separated by periods of regrowth.

Dalmatian toadflax (*Linaria dalmatica*) is a noxious, competitive forb found in Wyoming and across the West (it's one of 26 plants on the state's "designated noxious weeds" list). *L. dalmatica* reduces desirable forage when present. Repeated grazing is predicted to reduce toadflax density over time, but clipping studies have shown mixed results.

Geyer's (plains) larkspur (*Delphinium geeyeri*) is a native forb of the High Plains of the Intermountain West that is toxic to cattle. Historically, managers used sheep, which are more resistant to alkaloids, to graze dense larkspur patches to reduce subsequent cattle poisoning; however, this practice has not been well researched for Geyer's larkspur.

## Objectives

Objectives of this study are to quantify effects of targeted sheep grazing and herbicides on Dalmatian toadflax, Geyer's larkspur, and the native plant community.

## Materials and Methods

We established four experiment sites in 2014 on a northern mixed-grass prairie at the U.S. Department of Agriculture's High Plains Grasslands Research Station near Cheyenne. Two herbicide treatments, four grazing treatments, and a non-treated check were applied

in a randomized complete block design to 30- x 60-ft cells, with each site serving as a block. Herbicide treatments—Perspective® (4.5 oz/ac) and Escort® (0.5 oz/ac)—were applied June 19, 2014, when both target species were flowering. Grazing treatments varied in density and timing with annual stocking rate held constant at 1.6 animal unit months (AUM)/ac in 2014 and 0.9 AUM/ac in 2015. Two treatments received their entire annual stocking rate in the spring: (1) the highest-density (HD) treatment, which used 40 sheep and was grazed only in 2014; and (2) the 1x grazing treatment, which held 20 sheep (as did all other grazing treatments) and was grazed in both 2014 and 2015. Grazing was distributed throughout the growing season in our two other grazing treatments. The 2x grazing treatment received half its annual stocking rate in spring and half in summer, while 3x grazing had the annual stocking rate distributed evenly among spring, summer, and fall grazing events.

We estimated initial weed density by counting live toadflax stems in a belt transect and larkspur plants in the entire cell. We counted both species again after grazing. Toadflax stems showing signs of grazing or trampling were excluded from post-grazing counts. We also measured plant biomass by growth form (i.e., grass, forb, shrub) at midsummer and after each grazing event.

## Results and Discussion

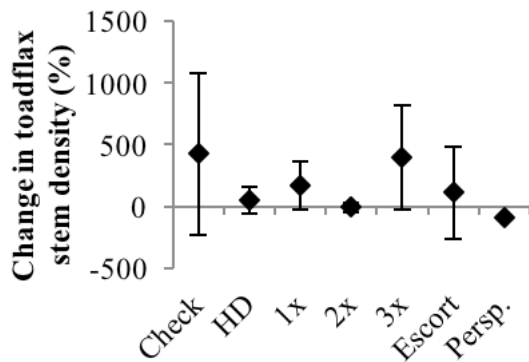
Sheep utilization of both toadflax and larkspur increased with increasing grazing intensity in 2014 and 2015; however, toadflax density was similar across all treatments after any period of regrowth in 2014. Prior to the spring 2015 grazing event, Perspective was the only treatment to reduce toadflax stem density relative to spring 2014 values (Figure 1). Toadflax stem density

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<sup>1</sup>Department of Plant Sciences; <sup>2</sup>Sheridan Research and Extension Center.

increase appeared to be reduced by the 2x grazing treatment, but additional years of treatment may be needed to determine whether this trend continues. We saw high utilization of perennial grasses in all of our grazing treatments. Midsummer 2015 perennial grass biomass was similar to the check in all our grazing treatments, but repeated heavy utilization over time may put desirable species at a competitive disadvantage.

Grazing treatments greatly reduced larkspur density for the duration of the growing season in both years, but impacts of 2014 treatments carried over into 2015 only for the herbicide treatments, particularly Perspective (Figure 2). We believe that a lower grazing intensity may satisfactorily reduce larkspur within the season of treatment while retaining greater perennial grass biomass.



**Figure 1.** Percent toadflax stem density change between spring 2014 (pre-treatment) and spring 2015 (following one year of treatment).

### Acknowledgments

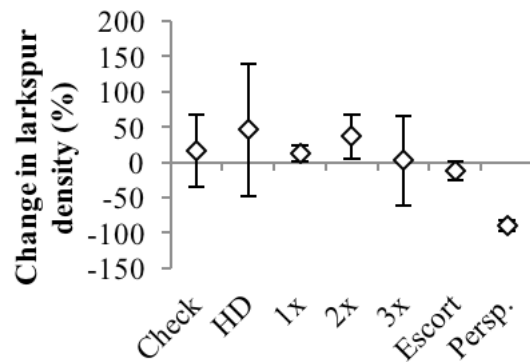
This project was supported by funding from a University of Wyoming Minority and Women’s Graduate Assistantship Program and from the Department of Plant Sciences, with sites provided by the High Plains Grasslands Research Station and animals by the Laramie Research and Extension Center. Special thanks go to the UW weed science club for project assistance.

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**Keywords:** weed management, rangelands

**PARP:** III:3,5, V:3, VI:5



**Figure 2.** Percent larkspur density change between spring 2014 (pre-treatment) and spring 2015 (following one year of treatment).

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# Introduction to the Powell Research and Extension Center

*C. Reynolds<sup>1</sup>, A. Pierson<sup>1</sup>, and B.W. Hess<sup>1,2</sup>*

## 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 142 acres under surface irrigation using gated pipe and syphon tubes, 54 acres under sprinkler (Figure 1), 2.5 acres under on-surface drip, and 1.2 acres under sub-surface drip. Research at the center focuses on irrigation, weed control, cropping systems, variety trials, and alternative crops. We serve northwest Wyoming, including Bighorn, Fremont, Hot Springs, Park, and Washakie counties.

Full-time PREC employees housed on-site include farm manager Camby Reynolds, research associate Andi Pierson, assistant farm managers Brad May and Keith Schaefer, and office associate Samantha Fulton. The center also houses two faculty members who have academic homes in the University of Wyoming's Department of Plant Sciences. Assistant Professor Gustavo Sbatella, an irrigated crop and weed management specialist, has been a valuable member of the PREC team for two years. And we are very excited to welcome our new plant sciences faculty member, Assistant Professor Vivek Sharma, who started as UW's

irrigation and agronomy specialist April 4, 2016. We look forward to working with Dr. Sharma. In addition, the site serves as home for the Wyoming Seed Certification Service and Wyoming Seed Analysis Laboratory.

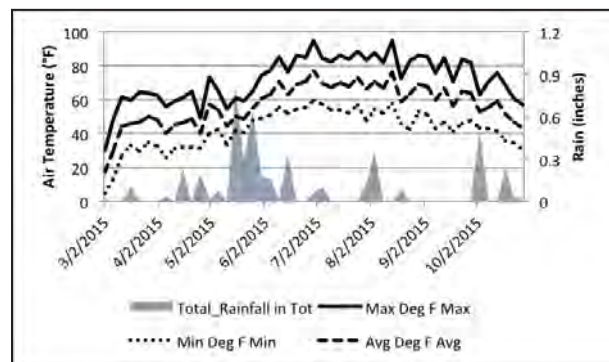
There have been other recent changes at PREC as well. After 10 months of providing service to the center, Professor John Tanaka, associate director of the Wyoming Agricultural Experiment Station (WAES), has turned over administrative support duties to Professor Bret Hess, WAES director and associate dean of the UW College of Agriculture and Natural Resources. Dr. Hess has been working as a member of the PREC team since late February 2016 while Dr. Tanaka has assumed director duties at the James C. Hageman Sustainable Agriculture Research and Extension Center near Lingle. We have also been fortunate enough to make several technology purchases to upgrade equipment, which improves our research capabilities substantially.

## 2015 Growing Season

The 2015 growing season was uncharacteristically long with 164 frost-free days (Figure 2). The average



**Figure 1.** Linear sprinkler at PREC.



**Figure 2.** Temperatures and rainfall recorded at PREC during the 2015 growing season.

<sup>1</sup>Powell Research and Extension Center; <sup>2</sup>Wyoming Agricultural Experiment Station.

frost-free period for the Powell area is about 123 consecutive days. The growing season started early with the last frost occurring on May 11 and went much later than usual with the first frost occurring on October 23. We experienced a wet spring with 40% of the annual rainfall occurring in May. Overall the 2015 growing season was exceptional, producing high yields for many producers.

### **Acknowledgments**

We would like to thank PREC staff and faculty members along with employees of the Wyoming Seed

Certification Service and Wyoming Seed Analysis Laboratory for their dedication to the work they perform on a daily basis (Figure 3).

### **Contact Information**

Camby Reynolds at [sreynol3@uwyo.edu](mailto:sreynol3@uwyo.edu) or 307-754-2223.



**Figure 3.** Powell Research and Extension Center, Wyoming Seed Certification Service, and Wyoming Seed Analysis Laboratory faculty and staff include, from left, Debbie Hufford, Tonya Espinosa, Crystal May, Jolene Sweet, Brad May, Mike Moore, Denny Hall, Andi Pierson, Camby Reynolds, Bret Hess, Keith Schaefer, Vivek Sharma, Gustavo Sbatella, and Samantha Fulton. Jill Rice not pictured.



# Short Reports

## 1. MillerCoors variety trial

**Investigators:** Andi Pierson, Camby Reynolds, and Carrie Eberle

**Issue:** The Wyoming Agricultural Experiment Station (WAES) at Powell conducts barley variety trials as part of an ongoing research effort. Malting barley is grown throughout the western United States and Canada, and breeders, industry, and producers need guidance on variety performance across environments.

**Goal:** Conduct spring barley variety trials in coordination with MillerCoors to evaluate production characteristics.

**Objectives:** Collect data on production characteristics on spring malting barley varieties grown in northern Wyoming for MillerCoors.

**Expected Impact:** Malting barley trials should assist with selection of high performing varieties for MillerCoors production in the Bighorn Basin.

**Contact:** Carrie Eberle at [carrie.eberle@uwyo.edu](mailto:carrie.eberle@uwyo.edu) or 307-837-2000.

**Keywords:** malting barley, variety trial

**PARP:** VIII

## 2. Intercropping cover crop mix with confection sunflowers

**Investigators:** Camby Reynolds

**Issue:** Producers are being encouraged to plant cover crops in their sunflower fields to help build a diversity of plants and roots in the soil. Ideally, this should improve soil health without harming the sunflowers; however, this is a relatively new process, and the effects are not well known.

**Goal:** A demonstration plot was planted in 2015 at the Powell Research and Extension Center to help producers determine what they can expect if they interplant cover crops in sunflowers.

**Objectives:** The effects and management practices of interplanting cover crops in sunflower need to be understood to help producers determine if this will be a beneficial practice.

**Expected Impact:** Producers should be able to refer to this plot when making decisions about implementing this cropping practice on their farms.

**Contact:** Camby Reynolds at [sreynol3@uwyo.edu](mailto:sreynol3@uwyo.edu) or 307-754-2223.

**Keywords:** sunflower, cover crop

**PARP:** I:2

### 3. Impact of cultural and chemical practices on soil-borne pathogens of sugarbeet in the Bighorn Basin

**Investigators:** William Stump, Gustavo Sbatella, Matt Wallhead, and Wendy Cecil

**Issue:** Weed management is a key aspect of managing *Rhizoctonia* root and crown rot of sugarbeet because the pathogen that causes the disease (*Rhizoctonia solani*) has a broad host range that includes many species of weeds and other crops. Conservation tillage systems have many benefits; however, under conservation tillage conditions, some diseases will increase in severity whereas others will decrease.

**Goal:** Study the feasibility of co-applying Roundup® and foliar fungicides for the management of *Rhizoctonia* root and crown rot of sugarbeet.

**Objectives:** Investigate the effects of tillage (minimum vs. conventional) and tank-mixed fungicide and herbicide applications on soil-borne diseases of sugarbeet in the Bighorn Basin.

**Expected Impact:** By altering production practices, crop losses due to soil-borne pathogens may be minimized, enhancing crop health and increasing yields and profitability. Cultural and chemical management practices that minimize losses due to soil-borne pathogens and/or extreme weather events will help maintain productivity.

**Contact:** William Stump at [wstump@uwyo.edu](mailto:wstump@uwyo.edu) or 307-766-2062.

**Keywords:** sugarbeet, *Rhizoctonia solani*, fungicides

**PARP:** I:7, II:6, III:6, X:2

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

**Investigators:** Jeremiah Vardiman, Sadanand Dhekney, and Michael Baldwin

**Issue:** Goji berry contains up to 20 amino acids, is an excellent source of vitamin C and antioxidants, and has a host of other compounds beneficial to good health. The fruit is currently imported from China to satisfy U.S. demand, but there is potential to meet some (and perhaps much) of this demand by growing the crop in the United States, including Wyoming.

**Goal:** Preliminary studies at the Sheridan Research and Extension Center indicate that goji berry (*Lycium barbarum*) could be a viable high-value crop for some areas of Wyoming, and we will continue evaluations to help determine its non-organic and organic production potential in the state.

**Objectives:** Evaluate the performance of the cold-hardy goji berry plant to determine days required for flowering, fruiting, and good yield potential at two study locations, Powell and Sheridan.

**Expected Impact:** The potential economic impact would include development of a new cold-hardy crop suitable for Wyoming growing conditions. The project could benefit backyard growers as well as farmers wishing to diversify their operations.

**Contact:** Sadanand Dhekney at [sdhekney@uwyo.edu](mailto:sdhekney@uwyo.edu) or 307-673-2754.

**Keywords:** goji berry, fruit, cold-hardy

**PARP:** I:1, X:1

# Growth and Pod Traits Correlate with Grain Yield among 50 Dry Bean Cultivars

*J. Heitholt<sup>1</sup>, A. Pierson<sup>2</sup>, C. Reynolds<sup>2</sup>, and A. Piccorelli<sup>3</sup>*

## Introduction

Identifying morphological and physiological traits associated with dry bean grain yield may benefit breeders and facilitate the development of higher-yielding genotypes.

## Objectives

The objectives of this study were to quantify mid-season and late-season physiological and morphological variables among a diverse range of dry bean cultivars and determine the correlation(s) of those variables to yield and each other.

## Materials and Methods

This experiment was located at the Powell Research and Extension Center (PREC) in 2015. The soil of the experiment area is classified as Garland clay loam (fine, mixed, mesic: Typic Haplarid). The site was worked by a roller harrow, leveled, and then bedded up in preparation for planting in the spring. Fertilizer application took place on March 31, 2015, at a rate of 80 pounds/ac of urea (46-0-0), 20 pounds/ac of mono-ammonium phosphate (11-52-0), and 5 pounds/ac of zinc. Weeds were controlled with the incorporation of a preplant herbicide treatment consisting of a tank mixture of ethalfuralin (2 pts Sonalan<sup>®</sup>) and dimethenamid-P (1 pt Outlook<sup>®</sup>) on April 7.

On June 3, seed of 50 diverse dry bean cultivars across several market classes were sown in plots measuring 3.7 (two rows) by 20 feet using International Harvester Cub 185 planter units with cone attachments set on a row spacing of 22 inches. The experimental design was a split plot with two water treatments (main factor), cultivars (subplot), and two replications. Irrigation was applied using furrow/flood method. All plots were well

watered until the first cultivar flowered. After that, fully irrigated plots received water every 10 days. Limited-irrigated plots received water every 14 days. Total water applied was not estimated. Data collected included days to bloom, plant height (late-season), days to maturity, yield (5-feet from each of the two rows), and yield components. The yield components included: pod number per unit area, seed number per unit area, seed size, pod harvest index [seed weight/(podwall+seed weight)], and number of aborted seed from a hand-shelled subsample of at least 25 pods per plot.

## Results and Discussion

Due to August rainfall, the differences for most traits between the fully irrigated and limited-irrigated plots were rather small and statistically insignificant. Averaged across all 50 cultivars, however, seed size was significantly higher in the fully irrigated compared to the limited-irrigation treatment (0.0126 vs. 0.0122 oz per seed). Otherwise, there were no other effects of the irrigation treatments, and additionally, there were no noteworthy irrigation-by-cultivar interactions. Cultivars, however, varied significantly for nearly every trait. Yields (corrected to 14% moisture) ranged from 4,790 lbs/ac for Othello to 2,070 lbs/ac for UCD0908. Using the mean values (average of the four observations for each cultivar), yield was correlated positively to seed per pod, pod harvest index, and plant height (Table 1). Other interesting associations were: pod harvest index (PHI) and maturity (earlier cultivars had higher PHI), plant height and seed size (taller plants had smaller seed), and pod harvest index and the number of seed per pod (number of seeds per pod increased as PHI increased). The number of aborted seed per pod and number of aborted seed per seed were both greater as seed size increased and as individual pod size increased.

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<sup>1</sup>Department of Plant Sciences; <sup>2</sup>Powell Research and Extension Center; <sup>3</sup>Department of Statistics.

As expected, there was a strong negative correlation between seed size and number of seed per pod.

Our results support previous findings in the literature as far as the relationship between yield and pod harvest index (Beebe et al., 2013). The correlations between yield and height and between pod harvest index and maturity were not particularly surprising given the literature. One correlation, the positive relationship between pod harvest index and the number of seed per pod, is challenging to interpret, but could involve seed size, which itself was negatively correlated with seed per pod. Physiological reasons that might facilitate the ability of small-seeded cultivars to partition a greater percentage of their pod biomass to seed vs. carpel (a simple pistil) could involve the need for larger-seeded cultivars to have a stronger pod wall. Because this is just one year of data, we cannot make major claims as to whether plant height, pod harvest index, or seed per pod would be effective variables from which to base selection of experimental lines within a breeding program. Nevertheless, if these results are substantiated in 2016 and beyond, then we may utilize these traits as part of a selection strategy.

## Acknowledgments

We thank the staff at PREC for assistance in irrigating and weed control and Jolene Sweet and Mike Moore for help packaging seed. The study was supported in part by U.S. Department of Agriculture Hatch funding.

## Contact Information

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

**Keywords:** dry matter partitioning, pod harvest index

**PARP:** Goals 1,2

## Literature Cited

Beebe, S. E., Rao, I. M., Blair, M. W., and Acosta-Gallegos, J. A., 2013, Phenotyping common beans for adaptation to drought, *Frontiers in Physiology*, v. 4, p. 1–20, doi: 10.3389/fphys.2013.00035.

**Table 1.** Correlations ( $r$ ) and significance ( $p > F$ ) of traits from 50 dry bean cultivars grown in Powell in 2015. Pod harvest index, number of seed per pod, aborted seed per pod, and maturity are designated as PHI, NSPP, ASPP, and Mat, respectively. Lower left ( $p$ -value); upper right ( $r$ ).

Trait	Yield	PHI	Height	Seed Size	NSPP	ASPP	Mat
Yield	na	0.643	0.385	-0.074	0.350	-0.111	-0.193
PHI	0.001	na	0.378	-0.348	0.561	-0.054	-0.364
Height	0.006	0.007	na	-0.350	0.308	-0.042	0.097
Seed Size	0.742	0.013	0.013	na	-0.774	0.499	-0.079
NSPP	0.013	0.001	0.030	0.001	na	-0.383	-0.071
ASPP	0.444	0.710	0.771	0.001	0.006	na	-0.004
Mat	0.180	0.009	0.502	0.587	0.622	0.979	na

# 2015 Dry Bean Performance Evaluation—Market Class Data Other Than Pinto

*M. Moore<sup>1</sup>, C. Reynolds<sup>2</sup>, J. Sweet<sup>1</sup>, and A. Pierson<sup>2</sup>*

## Introduction

The Wyoming Seed Certification Service funds and coordinates the dry bean variety performance evaluation at the Powell Research and Extension Center (PREC). A wide range of germplasm is evaluated, assisting producers in selecting varieties.

## Objectives

Wyoming's climate is locally variable, as is 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

The experiment was conducted at PREC. Weed control consisted of a preplant-incorporated treatment of 2 pints Sonalan<sup>®</sup> and 1 pint Eptam<sup>™</sup>. Plots received 65 units of nitrogen, 50 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 4, 2015. 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 Wintersteiger small-plot thresher.

## Results and Discussion

Stand establishment was very good. Summer temperatures and precipitation were moderate, and all entries matured prior to frost. Data for pinto bean and slow-darkening pinto bean varieties can be found on pages 63–64.

## Acknowledgments

This study was conducted with the assistance of PREC staff.

## Contact Information

Mike Moore at [mdmoore@uwyo.edu](mailto:mdmoore@uwyo.edu), 307-754-9815, or 800-923-0080.

**Keywords:** dry bean, performance evaluation, yield trial

**PARP:** II

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<sup>1</sup>Wyoming Seed Certification Service; <sup>2</sup>Powell Research and Extension Center.

**Table 1.** Agronomic data, 2015 cooperative dry bean nursery, Powell.

Name	Yield lb/ac	Seeds per pound	Days to 50% bloom	Pod maturity days after planting	Market* class
Zorro	3,361	2,366	43	83	black
Eclipse	3,119	2,385	44	80	black
T39	2,552	2,455	51	87	black
Zenith	2,258	2,256	45	83	black
Dynasty	3,072	910	46	83	DRK
Majesty	2,199	810	40	78	DRK
Talon	1,593	1,024	41	84	DRK
Desert Song	2,346	1,518	40	81	FDJ
Gypsy Rose	3,698	1,733	38	80	FDM
GN10-5-6	3,570	1,378	38	82	GN
Powderhorn	3,269	1,451	37	83	GN
GN10-17-4	3,221	1,388	39	84	GN
UCD 0701	1,972	834	42	86	Holstein
UCD 0908	1,904	888	40	79	JC
Inferno	2,716	878	43	78	LRK
Rosie	2,554	998	43	81	LRK
CELRK	1,722	880	38	85	LRK
T-9905	3,332	2,424	43	79	navy
Mist	2,780	2,386	39	83	navy
Fathom	2,661	2,237	39	77	navy
ISB96-3156	2,638	2,013	49	85	navy
Alpena	2,557	2,566	39	79	navy
ISB2884-4	2,439	2,273	40	82	navy
ISB13-796	2,853	1,417	46	84	pink
Yeti	2,518	983	42	86	WK
Snowdon	1,602	857	44	83	WK
Mean	3,016	1,463	42	82	
LSD	781	145	7	9	
CV	16	6	11	7	

\*Abbreviations: dark red kidney, DRK; Flor de Junio, FDJ; Flor de Mayo, FDM; great northern, GN; Jacob's cattle, JC; and light red kidney, LRK

# 2015 Dry Bean Performance Evaluation—Pinto Bean and Slow-Darkening Pinto Bean

*M. Moore<sup>1</sup>, C. Reynolds<sup>2</sup>, J. Sweet<sup>1</sup>, and A. Pierson<sup>2</sup>*

## Introduction

The Wyoming Seed Certification Service funds and coordinates the dry bean variety performance evaluation at the Powell Research and Extension Center (PREC). A wide range of germplasm is evaluated, assisting producers in selecting varieties.

## Objectives

Wyoming's climate is locally variable, as is 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

The experiment was conducted at PREC. Weed control consisted of a preplant-incorporated treatment of 2 pints Sonalan<sup>®</sup> and 1 pint Eptam<sup>™</sup>. Plots received 65 units of nitrogen, 50 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 4, 2015. 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 Wintersteiger small-plot thresher.

## Results and Discussion

Stand establishment was very good. Summer temperatures and precipitation were moderate, and all entries matured prior to frost. Data for market classes other than pinto bean can be found on pages 61–62.

## Acknowledgments

This study was conducted with the assistance of PREC staff.

## Contact Information

Mike Moore at [mdmoore@uwyo.edu](mailto:mdmoore@uwyo.edu), 307-754-9815, or 800-923-0080.

**Keywords:** dry bean, performance evaluation, yield trial

**PARP:** II

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<sup>1</sup>Wyoming Seed Certification Service; <sup>2</sup>Powell Research and Extension Center.

**Table 1.** Agronomic data, 2015 cooperative dry bean nursery, Powell.

Name	Yield lb/ac	Seeds per pound	Days to 50% bloom	Pod maturity days after planting	Market class
Othello	4,042	1,305	39	83	pinto
UIP-46	3,864	1,237	40	80	pinto
11303	3,839	1,396	45	85	pinto
Lapaz	3,668	1,433	43	83	pinto
Vibrant	3,668	1,360	45	81	pinto
11278	3,621	1,255	42	83	pinto
Monterrey	3,582	1,442	41	80	pinto
Eldorado	3,476	1,133	40	84	pinto
Windbreaker	3,467	1,255	39	77	pinto
13-7013	3,428	1,287	45	85	pinto
PT9-5-6	3,424	1,577	51	88	pinto
Santa Cruz	3,355	1,438	39	81	pinto
ISB1259-60	3,354	1,232	43	83	pinto
13-7014	3,257	1,391	44	83	pinto
6206	3,240	1,409	39	74	pinto
UIP-35	3,197	1,761	39	79	Pinto
Sinaloa	3,122	1,410	42	80	pinto
10305	3,104	1,437	42	80	pinto
ISB1173-1	3,083	1,273	48	82	pinto
UIP-40	3,060	1,434	37	81	pinto
Centennial	2,898	1,275	43	82	pinto
ISB1231-1	2,643	1,252	52	86	pinto
SF103-8	3,470	1,266	42	84	pinto sd*
COSD-44	3,393	1,384	43	83	pinto sd
23ST-27	3,359	1,343	46	87	pinto sd
COSD-7	3,294	1,213	39	80	pinto sd
COSD-3	3,252	1,441	39	82	pinto sd
COSD-35	3,230	1,438	37	75	pinto sd
COSD-25	2,995	1,188	43	84	pinto sd
Mean	3,016	1,463	42	82	
LSD	781	145	7	9	
CV	16	6	11	7	

\*pinto sd denotes slow-darkening lines



# Effect of Irrigation on Physiological Traits of Corn for Silage Grown under On-Surface Drip-Irrigation System

*A. Nilabyane<sup>1</sup>, M.A. Islam<sup>1</sup>, and A. Garcia y Garcia<sup>2,3</sup>*

## Introduction

Corn for silage requires adequate amounts of water, nutrients, and good management practices for profitable production. In arid and semiarid regions, including growing areas in northwest Wyoming, proper irrigation is required to achieve high corn yield and quality. Corn is more susceptible to water stress during early reproductive stages of development. Water deficit, which usually occurs during a period of high air temperature and drought, can cause severe yield reduction. Physiological parameters are often described to be affected by water reduction in corn plants. Among the parameters are photosynthesis (production of food from water and carbon dioxide by using sunlight), stomatal conductance (rate of carbon dioxide entering or water vapor exiting the leaf), transpiration (evaporation of water from plants), and other physiological processes.

## Objectives

The objective of this study was to investigate the effect of water stress on physiological attributes of corn grown in a semiarid environment under an on-surface drip-irrigation system.

## Materials and Methods

The study was conducted in 2014 at the Powell Research and Extension Center (PREC) on a clay loam soil. Almost half of the average rainfall per year (6.9 inches) is received during the growing season of May to August in a typical year. Managed with an on-surface drip irrigation system, the hybrid 'P8107HR' corn was grown under four levels of irrigation: 100 ETc (crop evapotranspiration), 80 ETc, 60 ETc, and no water from V9 to R3 stages. The V<sub>n</sub> stage is when the collar of the *n*th leaf is visible, and the R<sub>n</sub> is the reproductive stages

(the *n*th leaf is the number of leaves that are completely developed).

The study used a complete randomized design with three replications. An infrared gas analyzer (LI-COR Inc.) was used to obtain photosynthesis, stomatal conductance, transpiration, and intrinsic water-use efficiency (the ratio of photosynthesis and stomatal conductance) from August 10 to August 28 when corn was at its maximum water requirements (V14–R2) stage. Data were analyzed using the statistical software SAS.

## Results and Discussion

Photosynthesis and transpiration rates were greatly affected by water deficit; both were maximum for 100 ETc and minimum for no water treatment (Figure 1). This could be the result of low stomatal conductance due to water stress (Figure 1). The highest level of stomatal conductance was observed under 100 ETc; thereby, photosynthesis and transpiration were high. Although no differences were observed among irrigation levels, there was an increasing trend of intrinsic water-use efficiency with increasing water deficit. This indicates that the late vegetative-growth stages might be the most critical period under water stress. Results showed that water stress during a period of high water requirements at V9–R3 stage affected corn photosynthesis and transpiration rates. Irrigation timing seems to be a key factor affecting corn physiology and growth.

## Acknowledgments

We thank field and lab assistants at PREC. This project was supported by the Department of Plant Sciences and Wyoming Agricultural Experiment Station.

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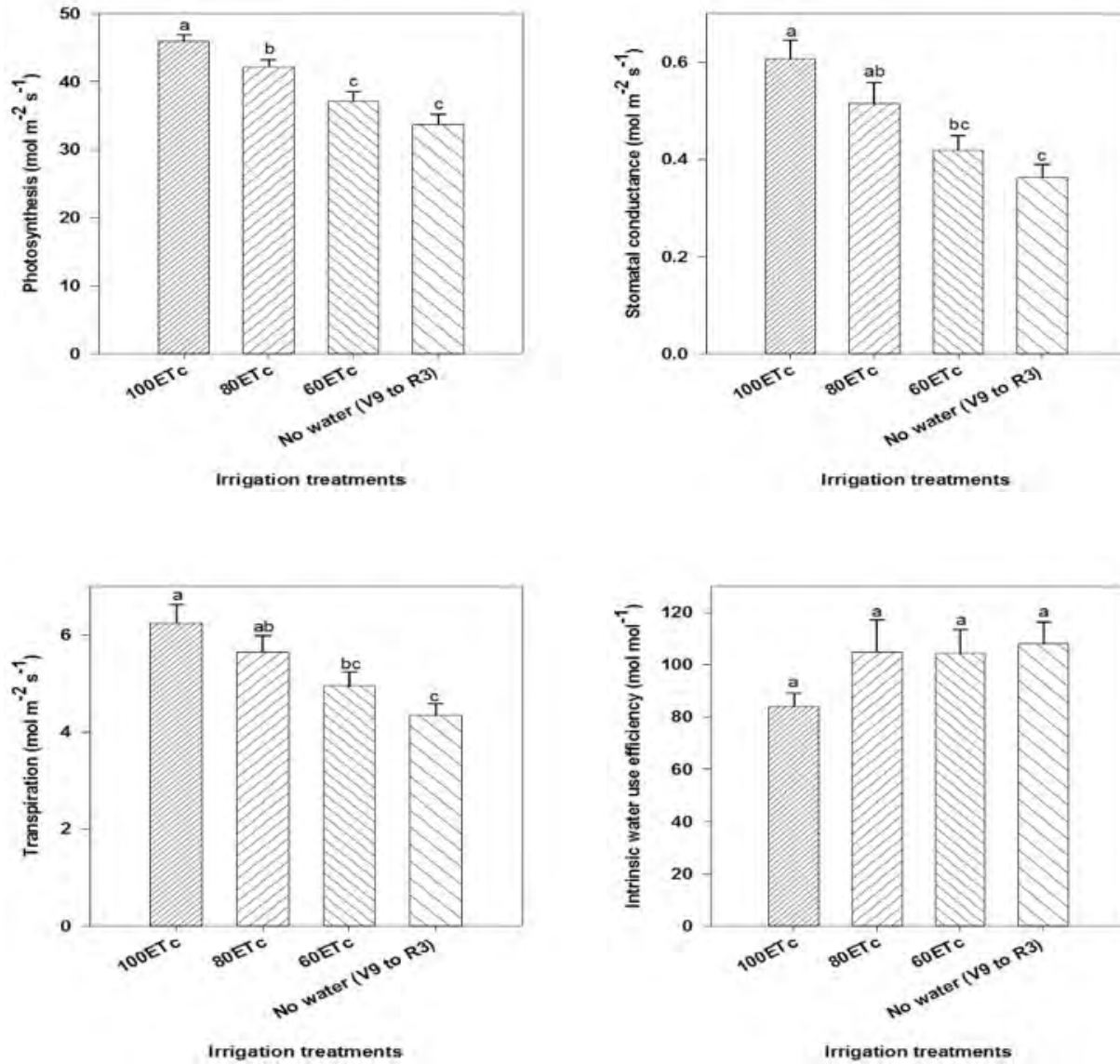
<sup>1</sup>Department of Plant Sciences; <sup>2</sup>Powell Research and Extension Center; <sup>3</sup>Now at Department of Agronomy and Plant Genetics, University of Minnesota.

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**Keywords:** irrigation, corn, physiology

**PARP:** I:2, IV:1,3,4



**Figure 1.** Physiological response of corn to different irrigation levels. Treatments with the same letter do not differ at  $p < 0.05$ .

# Quality Response of Irrigated Silage Corn under On-Surface and Sub-Surface Drip Irrigation Systems

*A. Nilabyane<sup>1</sup>, M.A. Islam<sup>1</sup>, and A. Garcia y Garcia<sup>2,3</sup>*

## Introduction

In the semiarid growing areas of northwest Wyoming, high yields and quality of corn for silage can be obtained if irrigation and nitrogen (N) are properly applied. Silage corn has been reported to have high irrigation requirements; however, the challenge is to increase silage corn production and quality with less water use. Increments in N fertilization increase whole plant crude protein (CP) concentration and corn dry matter (DM) yield by influencing leaf area and photosynthetic efficiency. It has also been reported that there is positive effect of N on DM yield and forage quality traits.

## Objectives

The objectives of this study were to determine the effects of irrigation and N on quality of silage corn grown under on-surface drip irrigation (ODI) and sub-surface drip irrigation (SDI) systems.

## Materials and Methods

The study was conducted at the Powell Research and Extension Center (PREC). The study area is characterized by a semiarid climate with an average temperature of 44°F and average annual precipitation of 6.9 inches. The hybrid Pioneer 'P8107HR' was planted in 2014 and 2015 in two separate field studies under ODI and SDI systems. Each experiment consisted of three irrigation treatments: 100%, which is equivalent to 10 inches of water applied during the growing season, 80% (8 inches), and 60% (6 inches) ETc (crop evapotranspiration). ETc is the demand of atmosphere to remove water from the ground through the processes of evaporation and transpiration, assuming no control on water supply.

The experiments also consisted of five N rates: 0, 80, 160, 240, and 320 pounds N per acre of a

urea-ammonium-nitrate aqueous solution. Both studies were laid out as a randomized complete block design in a split-plot arrangement with three replications in the ODI system and four replications in SDI. The quality parameters were determined at harvest. Data were analyzed using the statistical software SAS.

## Results and Discussion

In both studies, irrigation and N did not greatly affect the quality of silage corn. Under the ODI system (Table 1), high values of ADF and NDF were obtained for the 60 and 80 ETc treatments while low values were observed for the TDN when the plant is much stressed. Nitrogen did not affect any of the quality parameters, but there was an increasing trend of CP with increasing N. Under the SDI system (Table 2), similar trends were observed in all measured quality parameters. The results showed slightly high ADF and NDF values for low N rates. Under both irrigation systems, when the plant is water stressed, it tends to invest more energy in the fiber structures to face the limited water conditions. This explains the high values of ADF for the 60 ETc in both years. Since N is one of the major elements of the protein structure, the high CP and TDN with increasing N rates are expected. The quality parameters of silage corn are related to the genetics of the plant; hence, irrigation and N have minimal effects on the quality of silage corn.

## Acknowledgments

Appreciation is extended to the lab assistants at PREC. This project was supported by the Department of Plant Sciences and the Wyoming Agricultural Experiment Station.

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<sup>1</sup>Department of Plant Sciences; <sup>2</sup>Powell Research and Extension Center; <sup>3</sup>Now at Department of Agronomy and Plant Genetics, University of Minnesota.

**Contact Information****PARP:** I:2, II:2, IV:3,4

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

**Keywords:** corn, nitrogen, irrigation**Table 1.** Forage nutritive value as influenced by irrigation and N application under an ODI system at PREC in 2014–2015. Means followed by same letters do not differ at  $p < 0.05$ .

Factor	levels	ADF (%)		NDF (%)		CP (%)		TDN (%)	
		2014	2015	2014	2015	2014	2015	2014	2015
Irrigation	60 ETc	30.3a	32.1 a	57.4 a	56.2 a	12.4 a	11.1 a	61.5 a	59.4 b
	80 ETc	30.2 a	31.9 ab	56.6 a	55.7 a	11.7 a	10.9 a	61.6 a	59.8 ab
	100 ETc	29.9 a	30.4 b	57.0 a	53.5 a	12.0 a	11.1 a	62.0 a	61.4 a
	<i>P</i> -value	0.09		0.13		0.47		0.09	
Nitrogen (pounds/ acre)	0	30.2 a	31.4 a	57.3 a	54.9 a	11.7 a	10.7 a	61.6 a	60.3 a
	80	30.5 a	31.5 a	57.0 a	55.2 a	11.7 a	11.0 a	61.3 a	60.1 a
	160	30.0 a	31.3 a	56.5 a	55.5 a	11.9 a	11.1 a	61.9 a	60.3 a
	240	30.1 a	31.7 a	57.2 a	54.6 a	12.4 a	11.3 a	61.7 a	60.0 a
	320	30.0 a	31.2 a	57.1 a	55.4 a	12.4 a	11.0 a	62.0 a	60.5 a
	<i>P</i> -value	0.97		0.99		0.67		0.97	

**Table 2.** Forage nutritive value as influenced by irrigation and N application under SDI system at PREC in 2014–2015. Means followed by same letters do not differ at  $p < 0.05$ .

Factor	levels	ADF (%)		NDF (%)		CP (%)		TDN (%)	
		2014	2015	2014	2015	2014	2015	2014	2015
Irrigation	60 ETc	27.6 a	31.2 a	51.6 a	54.0 a	11.4 a	10.4 a	64.7 a	60.4 a
	80 ETc	28.5 a	31.2 a	53.6 a	55.3 a	11.3 a	10.5 a	63.6 a	60.4 a
	100 ETc	27.7 a	31.2 a	52.4 a	55.6 a	11.8 a	10.4 a	64.5 a	60.4 a
	<i>P</i> -value	0.43		0.07		0.80		0.43	
Nitrogen (pounds/ acre)	0	28.7 a	32.4 a	53.0 a	56.2 a	11.0 a	9.2 b	63.3 a	59.1 b
	80	27.2 a	31.9 ab	51.6 a	56.0 a	11.8 a	9.8 b	65.1 a	59.7 ab
	160	27.8 a	31.1 ab	52.4 a	54.1 a	11.5 a	10.4 ab	64.4 a	60.6 ab
	240	27.9 a	30.3 b	53.5 a	53.4 a	12.0 a	11.0 ab	64.3 a	61.5 a
	320	28.0 a	30.6 ab	52.3 a	55.2 a	11.2 a	11.8 a	64.1 a	61.2 ab
	<i>P</i> -value	0.03		0.67		0.01		0.03	

# 2015 Briess Variety Performance Evaluation

*A. Pierson<sup>1</sup>, C. Reynolds<sup>1</sup>, and C. Eberle<sup>2</sup>*

## 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 for Briess Malt & Ingredients Co. With the growing number of small and custom breweries along with homebrewers across the United States, demand is increasing for new and unique malting ingredients including malt barley. The Bighorn Basin region's climatic conditions vary greatly as does the performance of malting barley varieties. Data on grain yield, test weight, and protein 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 2015. Fertilizer was applied March 23 at the rate of 120 lb/ac of nitrogen (N) and 50 lb/ac of P<sub>2</sub>O<sub>5</sub> in the form of urea (46-0-0) and monoammonium phosphate (11-52-0). The experimental design of all trials was randomized complete block with three replications. On March 27, eight barley varieties were established in plots 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 100 pounds of seed per acre. Weeds were controlled by continual hand rouging throughout the growing season. Furrow irrigations were May 5, June 8, June 19, June 23, July 4, and July 15. Measurements included height, heading date, lodging, grain yield, test weight (TWT), kernel plumpness, and protein (lodging is the bending or kinking of stems at or near ground level causing the plant to fall over). Subsamples, 5.3 by 15 feet, were harvested August 10 using a Wintersteiger plot combine.

## Results and Discussion

Results from 2015 are presented in Table 1. The highest yielding entry was Merit 57 with 130.9 bu/ac. Annual field trial results are posted at <http://www.uwyo.edu/uwexpstn/variety-trials/index.html>.

## Acknowledgments

Appreciation is extended to PREC staff and summer crew for their continuing support throughout the 2015 season.

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**Keywords:** malting barley, variety trials

**PARP:** VIII

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**Table 1.** 2015 Briess malting barley variety performance trial results.

Variety	Height (in.)	Heading Date	Lodging (1/9)	Yield (bu/ac)	TWT (lb/bu)	Plump (% above screen)		Protein (%)
						6/64	5/64	
Merit 57	34.3	June 17	0	130.9	50.2	91.8	97.2	10.2
Meredith	35.0	June 16	2	109.3	49.7	92.2	97.0	10.4
Conrad	35.3	June 16	1	109.0	52.5	94.7	98.1	11.1
Newdale*	30.3	June 26	1	105.6	50.9	93.5	96.5	n/a
Synergy	39.7	June 15	2	105.5	51.6	96.9	98.6	10.9
S2	34.0	June 18	0	101.5	50.6	92.0	96.8	12.0
S1	35.0	June 16	3	96.8	48.7	92.5	98.1	10.7
Full Pint	35.3	June 15	4	82.9	48.8	84.4	95.8	10.7
Mean	34.8	June 17	2	104.5	50.2	92.0	97.3	
CV	7.7			18.3	3.5	5.1	1.3	

\*Newdale was planted April 6, 2015

# 2015 Elite Malt Barley Variety Performance Evaluation

*A. Pierson<sup>1</sup>, C. Reynolds<sup>1</sup>, and C. Eberle<sup>2</sup>*

## 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 nursery and private seed companies, WAES evaluates a wide range of germplasm each year.

## Objectives

The purpose of this nursery is to evaluate the performance of malting barley grown under many climatic conditions from the Pacific Northwest to the northern Great Plains, including Wyoming. Our state's climatic conditions vary greatly as does spring barley variety performance. Data on grain yield, test weight, and protein 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 2015. Fertilizer was applied March 23 at the rate of 120 lb/ac of nitrogen (N) and 50 lb/ac of P<sub>2</sub>O<sub>5</sub> 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 March 25, 30 barley varieties were established in plots 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

100 pounds of seed per acre. Weeds were controlled by a post application of pyrasulfotole and bromoxynil octanoate (11 fl. oz Huskie®) broadcast at 0.026 and 0.15 pounds active ingredient/ac on June 4. Furrow irrigations were April 16, June 11, July 3, July 16, and July 27. Measurements included grain yield, test weight (TWT), height, lodging, kernel plumpness, and protein (lodging is the bending or kinking of stems at or near ground level causing the barley plant to fall over). Subsamples (5.3 by 15 feet) were harvested August 5 using a Wintersteiger plot combine, and later sent off for protein analysis.

## Results and Discussion

Results from 2015 are presented in Table 1. The highest yielding malting entry was 2Ab04-X01084-27 at 131.9 bu/ac. Entries in bold in Table 1 are regional checks. Results are posted annually at <http://www.uwyo.edu/uwexpstn/variety-trials/index.html>.

## Acknowledgments

Appreciation is extended to PREC staff and summer crew for assistance during 2015.

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**Keywords:** malt barley, variety trial

**PARP:** VIII

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<sup>1</sup>Powell Research and Extension Center; <sup>2</sup>James C. Hageman Sustainable Agriculture Research and Extension Center.

**Table 1.** Agronomic performance of malt barley genotypes grown at PREC during 2015.

Variety	Yield (bu/A)	TWT* (lbs/bu)	Height (in.)	Lodging (0/9)	Plump (6/64)	Protein (%)
2Ab04-X01084-27	131.9	47.4	28.3	0.7	95.0	9.0
08ARS112-75	123.5	51.8	28.7	0.3	94.2	8.9
2Ab08-X05M010-65	121.9	51.2	31.7	0.7	94.7	8.6
08ARS035-47	120.3	51.8	31.7	0.3	96.6	9.5
Merem	120.0	50.2	36.7	1.7	92.4	8.9
2Ab08-X05M010-62	115.3	52.1	30.7	0.7	95.3	8.5
08ARS031-16	115.3	53.1	34.3	0.0	97.5	9.4
05ARS023-16	113.9	51.0	29.3	0.3	92.5	9.2
2Ab08-X05M010-82	113.5	52.9	33.7	1.0	93.3	8.9
<b>CDC Copeland</b>	<b>111.6</b>	<b>53.1</b>	<b>34.0</b>	<b>0.0</b>	<b>97.7</b>	<b>9.4</b>
08ARS012-79	110.5	51.1	30.7	0.0	91.4	9.3
<b>Merit 57</b>	<b>110.4</b>	<b>50.2</b>	<b>32.7</b>	<b>0.7</b>	<b>94.8</b>	<b>9.0</b>
2Ab08-X04M282-48	110.4	52.6	30.0	0.3	88.4	8.9
08ARS028-20	109.9	51.5	27.3	0.3	94.4	9.1
08ARS043-28	109.8	50.0	31.3	1.0	94.9	9.0
08ARS116-91	109.4	51.0	31.3	1.7	92.8	9.2
<b>Harrington</b>	<b>109.3</b>	<b>52.1</b>	<b>34.3</b>	<b>0.7</b>	<b>97.7</b>	<b>9.2</b>
08ARS035-7	108.7	52.0	31.3	0.7	97.7	9.8
05ARS050-14	108.5	51.2	29.7	0.7	91.5	8.6
08ARS018-8	108.1	52.7	29.3	0.3	96.9	9.9
08ARS116-6	107.8	53.0	30.3	0.3	95.5	10.0
2Ab07-X031098-31	106.4	52.0	30.3	0.3	94.9	9.6
08ARS114-68	105.2	52.8	32.7	0.3	95.8	9.5
2Ab08-X04M278-35	105.1	50.7	31.0	0.0	95.6	9.3
<b>AC Metcalfe</b>	<b>104.9</b>	<b>52.3</b>	<b>32.0</b>	<b>0.3</b>	<b>95.6</b>	<b>10.0</b>
<b>Conrad</b>	<b>103.5</b>	<b>51.7</b>	<b>30.0</b>	<b>0.3</b>	<b>97.0</b>	<b>9.5</b>
08ARS068-5	102.8	50.8	34.0	2.0	96.3	9.4
08ARS039-50	95.9	52.9	31.3	1.0	96.6	9.5
<b>M69</b>	<b>90.1</b>	<b>49.1</b>	<b>23.3</b>	<b>0.0</b>	<b>93.3</b>	<b>8.5</b>
<b>Voyager</b>	<b>89.4</b>	<b>52.2</b>	<b>27.3</b>	<b>0.3</b>	<b>98.3</b>	<b>9.0</b>
GRAND MEAN	109.8	51.6	31.0	0.6	94.9	9.2
CV %	11.7	2.2	4.2	11.6	1.4	3.8
LSD	17.6	1.5	1.8	0.9	1.8	0.5

\*TWT=test weight



# Broadleaf Weed Control in Barley

*G. Sbatella*<sup>1,2</sup>

## Introduction

Broadleaf weeds in barley can reduce crop yields and affect the quality of the harvested grain. Early weed control in barley is critical because this is the time when the crop is less competitive, and yield components can be affected.

## Objectives

Assess herbicide efficacy and crop safety of post-emergence herbicides for broadleaf weed control in barley.

## Materials and Methods

Barley variety Moravian 153 was drill planted at a rate of 60 lb/ac on March 25, 2015, at the Powell Research and Extension Center (PREC). The soil at the site is a Garland loam (soil organic matter: 1.3%, pH: 7.8) and was broadcast fertilized with 120 lbs nitrogen and 50 lbs phosphorous per acre prior to planting. The trial was furrow irrigated, and water was supplied according to crop needs. Herbicide treatments were applied with a CO<sub>2</sub> pressurized knapsack sprayer delivering 8 gallons of total volume per acre at 40 psi with a TeeJet® 8001-DG. Crop stage was two tillers with three leaves, and weed height was between 1 and 2 inches at time of herbicide application. The entire research area was sprayed with Axial® XL at 14.6 oz/ac for control of grass weeds. Plots were 11 feet wide by 30 feet long and arranged in a randomized complete block design with four replications. Herbicide treatments, adjuvants, and rates are detailed in Table 1. Weed control was estimated by counting weeds present in a 5.4 ft<sup>2</sup> quadrant

20 days after treatment (DAT). Barley yields were estimated by mechanically harvesting a 120-ft<sup>2</sup> section from each plot.

## Results and Discussion

Low levels of crop injury (yellowing) were observed five DAT in all treatments with the exception of Affinity® tank mixed with Huskie™. Barley quickly recovered from this initial injury, which was not perceivable 14 DAT. Kochia, common lambsquarters, and wild buckwheat were the main weeds present. The excellent weed control provided with all treatments was reflected in the barley yields, which were similar between treatments and higher than the non-treated checks (Table 1).

## Acknowledgments

The author would like to thank personnel from PREC, University of Wyoming graduate students, and development scientist Pete Forster for their contributions during this project.

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**Keywords:** barley, broadleaf, weed management

**PARP:** III:1,7

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**Table 1.** Weed control 20 days after treatment for herbicide treatments applied to dormant barley at PREC in 2015.

Treatment	Rate	Unit	# plants/5.4 ft <sup>2</sup>						Barley Yield (lb/ac)			
			Kochia <sup>1</sup>		Common lambsquarters		Wild buckwheat			Total <sup>2</sup> weeds		
1 Non-treated check			3	a	4	a	15	a	25	a	4,164	b
2 Huskie	11	fl oz/ac	0	b	0	b	2	b	2	b	5,601	a
Axial XL	16.4	fl oz/ac										
NIS <sup>3</sup>	0.25	% v/v*										
AMS <sup>4</sup>	1	lb/ac										
3 Affinity	0.6	oz wt/ac	0	b	0	b	0	b	2	b	5,242	a
Starane	0.6	pt/ac										
Axial XL	16.4	fl oz/ac										
NIS	0.25	% v/v										
AMS	1	lb/ac										
4 Affinity	0.6	oz wt/ac	0	b	0	b	3	b	3	b	5,467	a
Huskie	8.5	fl oz/ac										
Axial XL	16.4	fl oz/ac										
NIS	0.25	% v/v										
AMS	1	lb/ac										

<sup>1</sup>means followed by same letter do not differ at  $p < 0.05$ ; <sup>2</sup>total weeds includes kochia, common lambsquarters, and wild buckwheat, as well as other weeds counted in the plots; <sup>3</sup>NIS, non-ionic surfactant; <sup>4</sup>AMS, ammonium sulfate; \*volume/volume

# Effects of Limited Irrigation on Herbicide Efficacy and Herbicide Carryover

*G. Sbatella<sup>1,2</sup> and A.R. Kniss<sup>1</sup>*

## Introduction

A major challenge in the future for sustainable agriculture is to increase crop production with limited resources, particularly water.

But decreased soil moisture can result in extended herbicide carryover with an increased potential for crop damage in the following rotation.

## Objectives

Determine the impact of limited irrigation on efficacy, soil persistence, and carryover (herbicides remaining in the soil from the previous growing season) of soil-applied herbicides commonly used in corn and dry bean production.

## Materials and Methods

This is an ongoing project that began in spring 2015 at the Powell Research and Extension Center (PREC), where corn and dry beans were planted and pre-emergence herbicides were applied. The study is organized in a randomized complete block design with three replications. Plots are 110 by 132 ft. Herbicide treatments were assigned to five randomized strips within each plot measuring 22 by 132 ft. Herbicide treatments and rates for each crop are detailed in Table 1. Crops were grown under three irrigation levels: 100%, 85%, and 70% of the required water needs. Soils were sampled before and after herbicide applications. Yields were estimated by harvesting a 55 ft<sup>2</sup> area from each plot.

## Results and Discussion

Crop yields were affected by irrigation levels as expected (Table 2). After herbicide application, soil was sampled

at regular intervals according to sampling schedule. The collected samples will be tested in a laboratory to determine herbicide dissipation in spring 2016. Another set of soil samples will be used in spring 2016 to conduct a greenhouse bioassay. This bioassay will consist of planting rotational crops (sugarbeet, dry bean, corn, and sunflower) into the collected soil samples to detect possible crop injury from herbicide carryover (this will take place in a greenhouse). Next year, plots will be planted to sugarbeet, sunflower, dry bean, or corn depending on previous crop, and they will be grown under the same irrigation levels as in year one (2015). Crop yields will be determined at the end of the growing season to establish the effects of potential herbicide carryover in crop yields. Field results will be correlated to the greenhouse bioassay to determine the feasibility of this method to predict crop injury due to herbicide carryover.

## Acknowledgments

The authors thank personnel from PREC and University of Wyoming graduate students for their contributions during this project.

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**Keywords:** herbicides, carryover, efficacy

**PARP:** III:4,7, X:1

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**Table 1.** Herbicide treatments and rates applied in corn and dry beans, and herbicide plant-back restrictions.

	Rate	Plant-back restriction (months)		
		Sugarbeet	Barley	Dry bean
<b>Corn treatments</b>				
Atrazine (positive control)	64 fl oz/ac	2CS*	2CS	2CS
Verdict™	15 fl oz/ac	NCS**	NCS	NCS
Zidua®	3 oz/ac	12	18	11
Prequel®	1.66 oz/ac	10	9	10
Non-treated				
		Sugarbeet	Barley	Corn
<b>Dry bean treatments</b>				
Pursuit® (positive control)	6 oz/ac	40	9.5	8.5
Prowl® H2O	2 pt/ac	12	4	0
Sonalan®	2 pt/ac	8	Not specified	Not specified
Treflan™	1 pt/ac	12	0	12
Non-treated				

Abbreviations: \*2CS, two cropping seasons; \*\*NCS, next cropping season

**Table 2.** Corn and dry bean yields as affected by irrigation level at PREC, 2015.

Irrigation level	Yield			
	Corn (bu/ac)*		Dry bean (lb/ac)*	
Full (100%)	109	a	1,980	a
Moderate (85%)	74	b	1,097	b
Low (70%)	41	c	464	c

\*means followed by same letter do not differ at  $p < 0.05$

# Intercropping Forage Legumes with Grain Corn for Late-Season Forage Production

*G. Sbatella<sup>1,2</sup> and C. Reynolds<sup>2</sup>*

## Introduction

Corn stubble remaining after grain harvest is often used as a source of forage late in the fall. In general, corn stover is low in quality, particularly protein. Annual legumes such as forage soybeans can be interplanted with grain corn with the objective to increase quality of late-season forage.

## Objectives

A trial was conducted at the Powell Research and Extension Center (PREC) to evaluate the impacts that interplanting forage soybeans with grain corn have on grain yield and forage quantity and quality.

## Materials and Methods

On June 2, 2015, forage soybean Eagle Seed Large Lad RR (Roundup Ready<sup>®</sup>), group VII, was drill planted at 54, 27, 14, and 7 lb/ac. On June 5, Pioneer<sup>®</sup> 8107HR hybrid corn was planted at a rate of 42,000 seeds/ac with a John Deere MaxEmerge<sup>™</sup> planter at 22-inch row spacing. Plots consisting of only corn and forage soybean stands were included as checks. Previous to planting, soybean seeds were treated with Stamina<sup>®</sup> fungicide seed treatment at 0.4 fl oz/100 lb of seed and inoculated with N-Dure<sup>™</sup> at 2.5 oz/50 lb of seed (this treatment promotes rhizobia root nodulation, which helps with nitrogen fixation). Trial was furrow irrigated, and water was supplied according to crop needs. Roundup WeatherMAX<sup>®</sup> at 32 oz/ac was applied twice for weed control. Plots were 22 feet wide by 50 feet long and arranged in a randomized complete block design with four replications. Grain yields were estimated by harvesting 10 feet from the two center rows from each plot on November 4. Corn stubble production was calculated by harvesting the above-ground biomass from two quadrants with a 21.5 ft<sup>2</sup> area. The harvested biomass

was grinded, and a subsample weighing approximately one pound was sent for quality analysis.

## Results and Discussion

Although the established corn plant population was close to the desired 42,000 plants per acre (Table 1), differences in plant stands between treatments were enough to affect corn grain yields. The forage soybean plant populations were significantly lower than planned. Even though we expected to lose plants after corrugating the field for irrigation and planting corn, stand counts suggest that the real seeding rate delivered by the drill was considerably less than desired for all treatments.

The interplanting of forage soybeans with grain corn had no impact in corn stubble biomass quantity produced (Table 1), and it is worth mentioning that the stubble biomass of pure stands of forage soybeans was significant at the time when samples were collected (10,446 lb/ac). Grain corn yields were affected when forage soybeans were growing with corn, with grain losses ranging from 34 to 50 bu/ac (these losses were determined by subtracting 141 and 125, respectively, from 175 [Table 1]). While results suggest that the interspecific competition affected corn yields, the differences on corn plant densities were also a contributing factor affecting grain yield. The established forage soybean plant stands were not high enough to have an impact on the quality of the post-harvest stubble, measured as the protein content or total digestible nutrients (TDN) (Table 1).

Overall, the results of this initial study are encouraging because forage soybeans showed a high yield potential for the area. There are plans to continue further research

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<sup>1</sup>Department of Plant Sciences; <sup>2</sup>Powell Research and Extension Center.

on improving forage quality by intercropping corn with forage soybean during the 2016 growing season.

### Acknowledgments

The authors thank personnel from PREC and UW grad students for their contributions during this project.

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**Keywords:** corn, forage legumes, interplanting

**PARP:** I:3,6,9

**Table 1.** Corn and forage soybean plant density, stubble biomass after harvest, corn grain yield, protein content, and TDN at PREC in 2015.

		Plant density/ac		Stubble (lb/ac)*	Grain (bu/ac)	Protein (%)	TDN (%)
		Desired	Obtained				
1	Corn	42,000	43,500	13,228 ab	175 a	2.33 b	38.7 b
2	Corn	42,000	42,100	15,201 a	126 b	2.48 b	39.9 ab
	Soybean	170,000	29,000				
3	Corn	42,000	40,400	13,532 ab	141 b	2.35 b	36.4 b
	Soybean	127,500	15,100				
4	Corn	42,000	39,100	14,367 a	125 b	2.23 b	35.2 b
	Soybean	85,000	14,500				
5	Corn	42,000	40,400	14,139 a	134 b	2.35 b	37.4 b
	Soybean	42,500	30,300				
6	Soybean	170,000	40,400	10,446 b	NA	5.5 a	42.7 a

\*means followed by same letter do not differ at  $p < 0.05$

# Evaluating Crop Safety of Herbicides Applied Preplant in Sugarbeet

*G. Sbatella<sup>1</sup> and A.R. Kniss<sup>2</sup>*

## Introduction

The spread of glyphosate-resistant kochia represents a challenge for sugarbeet growers in the West because other herbicide options are limited. Since kochia seeds germinate early in the growing season, controlling kochia previous to crop planting could be an option.

## Objectives

The objective of this trial at the Powell Research and Extension Center (PREC) was to evaluate crop safety to pyraflufen ethyl (Vida<sup>®</sup>) and other preplant options as potential alternatives for weed control in sugarbeet.

## Materials and Methods

Sugarbeet variety 9036 RR (Roundup Ready<sup>®</sup>) was planted at 22-inch row spacing at a rate of 41,000 seeds/ac on April 28, 2015. The trial was under furrow irrigation. Herbicide treatments were applied with a CO<sub>2</sub>-pressurized knapsack sprayer delivering 16 gallons of total volume per acre at 40 psi with TeeJet<sup>®</sup> 8002-DG nozzles. Plots were 11 feet wide by 25 feet long and arranged in a randomized complete block design with three replications. Herbicide treatments, adjuvants, and rates are detailed in Table 1. Crop injury was evaluated 15 days after treatment. Sugarbeet yields were estimated by harvesting the two center rows.

## Results and Discussion

No crop injury was observed when Vida<sup>®</sup> was applied preplant alone or when tank mixed with Paraquat<sup>®</sup> or Roundup PowerMAX<sup>®</sup>, but was significant when Command<sup>®</sup> 3ME was applied (Table 1). Crop injury persisted throughout the growing season in these treatments. Herbicide effects on sugarbeet plants were independent of the type of surfactant used. Crop injury by the application of Command 3ME resulted in lower sugarbeet yields, but no differences were observed between the other treatments. No impacts were recorded on % sugar and sugar loss molasses (SLM).

## Acknowledgments

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**Keywords:** sugarbeet, preplant, weed control

**PARP:** III:1,7

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<sup>1</sup>Department of Plant Sciences; <sup>2</sup>Powell Research and Extension Center.

**Table 1.** Sugarbeet injury, yield, percent sugar, and sugar loss to molasses (SLM) at PREC in 2015.

	Treatment	Rate	% injury <sup>1</sup>	yield (ton/ac)	sugar %	SLM
1	No PRE <sup>2</sup>		0 b	23.2 ab	16.9 a	0.72 a
2	Vida	2 fl oz/ac	0 b	23.6 ab	16.8 a	0.74 a
	Hel-Fire® surfactant	2 qt/100 gal				
3	Vida	2 fl oz/ac	0 b	20.7 ab	16.7 a	0.72 a
	Hel-Fire	2 qt/100 gal				
	NIS <sup>3</sup>	0.25 % v/v <sup>5</sup>				
4	Vida	2 fl oz/ac	0 b	19.5 ab	16.7 a	0.77 a
	Hel-Fire	2 qt/100 gal				
	COC <sup>4</sup>	2 qt/ac				
5	Paraquat	21 fl oz/ac	0 b	22.1 ab	16.7 a	0.8 a
	NIS	0.25 % v/v				
6	Vida	2 fl oz/ac	0 b	25.1 a	16.1 a	0.83 a
	Paraquat	21 fl oz/ac				
	NIS	0.25 % v/v				
7	Vida	2 fl oz/ac	0 b	20.1 ab	16.3 a	0.67 a
	Paraquat	21 fl oz/ac				
	COC	2 qt/ac				
8	Roundup PowerMAX	32 fl oz/ac	0 b	22.9 ab	16.4 a	0.72 a
	Hel-Fire	2 qt/100 gal				
9	Vida	2 fl oz/a	0 b	19.9 ab	16.6 a	0.73 a
	Roundup PowerMAX	32 fl oz/a				
	Hel-Fire	2 qt/100 gal				
10	Command 3ME	12 fl oz/ac	75 a	17.7 ab	16.2 a	0.82 a
11	Vida	2 fl oz/ac	82 a	14.9 b	16.8 a	0.81 a
	Command 3ME	12 fl oz/ac				
	Hel-Fire	2 qt/100 gal				
12	Vida	2 fl oz/ac	73 a	14.6 b	16.3 a	0.9 a
	Command 3ME	12 fl oz/ac				
	Hel-Fire	2 qt/100 gal				
	NIS	0.25 % v/v				
13	Vida	2 fl oz/ac	67 a	15.5 b	16.6 a	0.73 a
	Command 3ME	12 fl oz/ac				
	Hel-Fire	2 qt/100 gal				
	COC	2 qt/ac				

<sup>1</sup>means followed by same letter do not differ at  $p < 0.05$ ; <sup>2</sup>no preplant herbicide; <sup>3</sup>non-ionic surfactant; <sup>4</sup>crop oil concentrate; <sup>5</sup>volume/volume



# Testing for Suitable Soybean Maturity Group for the Bighorn Basin

G. Sbatella<sup>1,2</sup> and C. Reynolds<sup>2</sup>

## Introduction

Hairy nightshade (*Solanum sarrachoides*) weed control is becoming increasingly difficult in fields with a long history of dry bean production in the Bighorn Basin. Glyphosate-resistant soybeans are an alternative that would allow better hairy nightshade control while keeping the benefits of having an annual legume in the crop rotation.

## Objectives

A trial was conducted at the Powell Research and Extension Center (PREC) in 2015 to evaluate the yield potential of glyphosate-resistant soybean varieties from different maturity groups.

## Materials and Methods

The soil at the site is a Garland loam (soil organic matter: 1.6%, pH: 8.1) and was broadcast fertilized with 50 lbs. nitrogen and 20 lbs. phosphorous per acre previous to planting. On June 8, Asgrow<sup>®</sup> soybean varieties AG0333, AG0430, AG0735, AG0835, AG0934, and AG1135 were planted with a John Deere MaxEmerge<sup>™</sup> planter at 22" row spacing. Previous to planting, seeds from varieties AG0333, AG0934, and AG1135 were treated with Stamina<sup>®</sup> fungicide seed treatment at 0.4 fl oz/100 lb of seed. All varieties were inoculated with N-Dure<sup>™</sup> at 2.5 oz/50 lb of seed (this treatment promotes rhizobia root nodulation, which helps fix nitrogen). The trial was furrow irrigated, and water was supplied according to crop needs. Roundup WeatherMAX<sup>®</sup>, at 32 oz/ac, was applied twice for weed control (Outlook<sup>®</sup> herbicide, at 14 oz/ac, was tank mixed with the second application). Two weeks after crop emergence, Endura<sup>®</sup> fungicide was broadcast applied at 3.5 oz/ac. Herbicide and fungicide treatments

were applied with a CO<sub>2</sub>-pressurized knapsack sprayer delivering 16 gal of total volume per acre at 40 psi with TeeJet<sup>®</sup> 8002-DG nozzles. Plots were 22 feet wide by 50 feet long and arranged in a randomized complete block design with five replications. Yields were estimated by harvesting the six middle rows of each plot on October 22.

## Results and Discussion

Soybean varieties based on growth and development are grouped in maturity groups. The higher the number of the maturity group, the longer the growing season of the variety. To obtain maximum yields, the correct maturity group has to be determined for a location. In this study, maturity groups 0.3, 0.4, 0.7, 0.8, 0.9, and 1.1 were tested for the Powell area. The number of plants per acre and weight of 100 seeds are important yield components, and for that reason they were recorded in the study. Plant populations after emergence ranged between 139,300 and 158,200 plants per acre (Table 1). Differences in weight of 100 seeds were recorded between varieties. AG0333 had the heaviest weight of 100 seeds at 0.57 oz, while AG0835 had the lightest at 0.44 oz (Table 1). Grain moisture was close to 14% at time of harvest on October 22. The highest yields were recorded for varieties AG1135, AG0934, and AG0333 with 38.8, 37.9, and 37.2 bu/ac, respectively (Table 1). Results suggest that the maturity group to which the variety belonged was not the main factor determining soybean yields in the Powell area. Varieties AG0430 and AG0835 were shorter in height, and plants exhibited yellowing during the growing season. Since all varieties had vigorous and active root nodules, nitrogen was probably not a limiting factor. Variety tolerance to high soil pH is a factor that needs further evaluation.

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<sup>1</sup>Department of Plant Sciences; <sup>2</sup>Powell Research and Extension Center.

## Acknowledgments

The author thanks personnel from PREC, UW grad students, and Ryan Rapp and David Heimkes of Monsanto for their contributions during this project.

## Contact Information

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**Keywords:** soybean maturity group, alternative crop

**PARP:** I:9, II:9

**Table 1.** Soybean plant population, yield, and weight of 100 seeds for six maturity groups planted at PREC in 2015.

Variety	Maturity group	Population/ac*	Yield (bu/ac)	Weight 100 seeds(oz)
AG0333	0.3	142,400 b	37.2 a	0.57 a
AG0430	0.4	145,200 b	15.1 b	0.49 bc
AG0735	0.7	151,100 ab	22.8 b	0.51 b
AG0835	0.8	151,300 ab	23.4 b	0.44 c
AG0934	0.9	139,300 b	37.9 a	0.53 ab
AG1135	1.1	158,200 a	38.8 a	0.49 bc

\*means followed by same letter do not differ at  $p < 0.05$

# Weed Control in Dormant Alfalfa

G. Sbatella<sup>1,2</sup>

## Introduction

Herbicide applications to dormant alfalfa allow the use of active ingredients that otherwise would injure the crop if applied during vegetative growth. But new herbicides have to be tested for efficacy and crop safety before labeled for use. Indaziflam is a new active ingredient that controls annual broadleaf and grassy weeds in perennial crops. Weed control efficacy and crop safety of indaziflam on alfalfa have not been established.

## Objectives

Evaluate weed control efficacy and crop response of indaziflam when applied to dormant established alfalfa.

## Materials and Methods

Alfalfa variety Vernal was drill planted at the Powell Research and Extension Center (PREC) at a rate of 8 lb/ac in spring 2014. Trial was furrow irrigated, and water was supplied according to crop needs. Herbicide treatments were applied with a CO<sub>2</sub>-pressurized knapsack sprayer delivering 16 gallons of total volume per acre at 40 psi with TeeJet® 8002-DG nozzles. Plots were 11 feet wide by 30 feet long and arranged in a randomized complete block design with four replications. Herbicide treatments and rates are detailed in Table 1. Visual evaluations for weed control and crop injury were assessed

120 days after treatment (DAT). Crop height was also measured 120 DAT to quantify crop injury. Alfalfa hay was cut June 12, 2015, and August 6, 2015, and fresh and dry biomass production was estimated by harvesting a 2.7 ft<sup>2</sup> area before each cut.

## Results and Discussion

Indaziflam provided excellent weed control that extended for the duration of the growing season. No crop injury was observed at any of the tested rates, and alfalfa hay yields were similar between treatments.

## Acknowledgments

The author thanks personnel from PREC, University of Wyoming graduate students, and Charles Hicks of Bayer CropScience for their contributions during this project.

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**Keywords:** dormant alfalfa, weed management

**PARP:** III:2,7

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<sup>1</sup>Department of Plant Sciences; <sup>2</sup>Powell Research and Extension Center.

**Table 1.** Weed control, crop injury, and height 120 days after treatment and dry hay yield for herbicide treatments applied to dormant alfalfa at PREC in 2015.

	Treatment	Rate	Control* (%)	Injury %	Height (in)	First cut	Second cut
			120 DAT			Yield (ton/ac)	
1	Untreated Check	0 fl oz/ac	0 b	0 b	13.1 a	4 a	2.9 a
2	Alion™	1 fl oz/ac	99 a	0 b	13 a	4.3 a	2.7 a
3	Alion	2 fl oz/ac	99 a	0 b	13.2 a	3.6 a	2.7 a
4	Alion	3 fl oz/ac	99 a	0 b	13.1 a	4.5 a	2.9 a
5	Alion	4 fl oz/ac	99 a	0 b	13 a	4.4 a	2.7 a
6	Alion	5 fl oz/ac	99 a	0 b	13.4 a	4.3 a	2.4 a
7	Chateau®	2 oz wt/ac	99 a	5 a	13.3 a	3.9 a	2.6 a

\*means followed by same letter do not differ at  $p < 0.05$

# Weed Control in Dry Beans

*G. Sbatella*<sup>1,2</sup>

## Introduction

Environmental conditions in northwest Wyoming growing areas are optimal for dry bean seed production. But weed control is critical to minimize yield reductions due to competition and to avoid loss of seed quality at harvest. For these reasons, it is important to explore herbicide combinations and application rates to determine which provide the best season-long weed control while protecting the bean crop from those applications.

## Objectives

A trial was conducted at the Powell Research and Extension Center (PREC) in 2015 to evaluate weed control efficacy and crop response to different herbicide programs for dry beans.

## Materials and Methods

Great northern beans ('Powder Horn') were planted with a John Deere MaxEmerge™ planter at 22-inch row spacing at a rate of 58,000 seeds per acre on June 1. The trial was furrow irrigated. Herbicide treatments were applied with a CO<sub>2</sub>-pressurized knapsack sprayer delivering 16 gallons of total volume per acre at 30 psi. Experimental plots were 11 feet wide by 30 feet long and arranged in a randomized complete block design with three replications. Weed counts from a 2.7 ft<sup>2</sup> area were recorded per plot—before post application, 20 days after treatment (DAT), and before harvest. Dry bean

yields were estimated by harvesting a 10 ft. length from the two middle rows of each plot on September 11.

## Results and Discussion

Preplant, pre-emergence, and post-emergence treatments helped reduce the total number of weeds when compared to the non-treated check as indicated on the weed counts (Table 1), but no differences were observed between treatments. Kochia was the most prevalent weed species and the most difficult to control. Kochia plants grew large in size and interfered with harvest, increasing losses. Crop injury was observed (>5%) after the POST application of Raptor® + Basagran®, but was temporary and uniform across all treated plots. Dry bean yields were higher for all herbicide applications when compared to the untreated check.

## Acknowledgments

The author thanks personnel from PREC, University of Wyoming graduate students, and Jared Unverzagt (BASF) for their contributions during this project.

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**Keywords:** dry beans, weed management

**PARP:** III:4,7

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<sup>1</sup>Department of Plant Sciences; <sup>2</sup>Powell Research and Extension Center.

**Table 1.** Weed control before and 21 days after POST applications and before harvest, and dry beans yield for herbicide treatments at PREC in 2015.

	Treatment	Rate	Unit	Ap <sup>a</sup>	Before POST*	21 Days After POST	Before harvest	Yield (lb/ac)
1	Non-treated				12 a	10 a	6 a	216 c
2	Outlook <sup>®</sup>	14	fl oz/ac	B	3 b	0 b	1 b	1,304 a
	Prowl <sup>®</sup> H2O	2	pt/ac	B				
	Raptor	4	fl oz/ac	C				
	Basagran <sup>b</sup>	21	fl oz/ac	C				
3	Outlook	14	fl oz/ac	B	4 b	2 b	2 b	1,370 a
	Prowl H2O	2	pt/ac	B				
	Raptor	4	fl oz/ac	C				
	Basagran <sup>b</sup>	21	fl oz/ac	C				
4	Outlook	7	fl oz/ac	C	4 b	1 b	1 b	986 ab
	Eptam <sup>™</sup>	3	pt/ac	A				
	Sonalan <sup>®</sup>	2	pt/ac	A				
	Basagran <sup>c</sup>	1.5	pt/ac	C				
5	Raptor	4	fl oz/ac	C	1 b	0 b	2 b	894 b
	Eptam	3	pt/ac	A				
	Sonalan	2	pt/ac	A				
	Outlook	7	fl oz/ac	C				
6	Basagran <sup>c</sup>	1.5	pt/ac	C	1 b	1 b	1 b	1,143 a
	Raptor	4	fl oz/ac	C				
	Eptam	3	pt/ac	A				
	Sonalan	2	pt/ac	A				
	Outlook	14	fl oz/ac	C				
	Basagran <sup>c</sup>	1.5	pt/ac	C				
	Raptor	4	fl oz/ac	C				

\*means followed by same letter do not differ at  $p < 0.05$

<sup>a</sup>Application timings: A, preplant-incorporated; B, pre-emergence; C, post-emergence

<sup>b</sup>Surfactant: MSO, methylated seed oil + UAN, urea ammonium nitrate

<sup>c</sup>Surfactant: NIS, non-ionic surfactant + UAN, urea ammonium nitrate

# Weed Control in Seedling Alfalfa

*G. Sbatella<sup>1,2</sup>*

## Introduction

Weed control in seedling alfalfa is critical to ensure long-term productivity. Seedling alfalfa plants can be very sensitive to herbicide applications, but this differs with the active ingredients in herbicides that are applied.

## Objectives

Assess herbicide efficacy and crop safety of herbicides applied to seedling alfalfa for weed control.

## Materials and Methods

Alfalfa variety RR (Roundup Ready<sup>®</sup>) NemaStar was drill planted at a rate of 8 lb/ac on April 28, 2015, at the Powell Research and Extension Center (PREC). Herbicide treatments were applied with a CO<sub>2</sub>-pressurized knapsack sprayer delivering 16 gal/ac at 40 psi with TeeJet<sup>®</sup> 8002-DG nozzles. Herbicide treatments, adjuvants, rates, and application timings are detailed in Table 1. Weed control and crop injury were evaluated 21 days after treatment (DAT) with post-emergence applications. Weed control was assessed by counting the number of weeds present in a 2.7 ft<sup>2</sup> section. Alfalfa hay was cut on July 10 and August 20,

and wet and dry biomass production was estimated by harvesting a 2.7 ft<sup>2</sup> area before each cut.

## Results and Discussion

Warrant<sup>®</sup> herbicide applied at pre-emergence improved early redroot pigweed, but weed control 21 days after post-emergence application did not differ between treatments (Table 1). Crop injury (stunting) was observed in all plots treated with Raptor<sup>®</sup> herbicide. As a result of no major differences in herbicide efficacy between treatments, alfalfa hay yields were similar for both hay cuts.

## Acknowledgments

The author thanks PREC personnel, University of Wyoming graduate students, and Ryan Rapp of Monsanto for their contributions during this project.

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**Keywords:** seedling alfalfa, weed management

**PARP:** III:7

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<sup>1</sup>Department of Plant Sciences; <sup>2</sup>Powell Research and Extension Center.

**Table 1.** Alfalfa injury, weed control, and dry hay yield for herbicide treatments applied for weed control in new seedling alfalfa at PREC in 2015.

Treatment	Rate	Unit	Appl <sup>I</sup>	21 DAT*		Yield <sup>II</sup> ton/ac	
				Injury %	Weeds pl/ft <sup>2</sup>	First cut	Second cut
1 Roundup PowerMAX®	32	oz/ac	B	0 b	2 c	1.7 a	3.3 a
2 Warrant®	3	pt/ac	A	0 b	1 c	1.8 a	3.2 a
Roundup PowerMAX	32	oz/ac	B				
3 Warrant	6	pt/ac	A	0 b	2 c	1.9 a	3.1 a
Roundup PowerMAX	32	oz/ac	B				
4 Roundup PowerMAX	32	oz/ac	B	0 b	4 b	1.5 a	3.0 a
Warrant	3	pt/ac	B				
5 Roundup PowerMAX	32	oz/ac	B	0 b	3 bc	1.7 a	2.9 a
Warrant	6	pt/ac	B				
6 Roundup PowerMAX	32	oz/ac	B	0 b	2 bc	1.7 a	3.1 a
Warrant	3	pt/ac	C				
Roundup PowerMAX	32	oz/ac	C				
7 Roundup PowerMAX	32	oz/ac	B	0 b	2 bc	1.7 a	2.9 a
Warrant	6	pt/ac	C				
Roundup PowerMAX	32	oz/ac	C				
8 Select Max®	12	oz/ac	B	11 a	2 bc	1.7 a	2.5 a
Raptor®	6	oz/ac	B				
MSO**	1.5	% v/v	B				
NIS***	1	% v/v	B				
9 Warrant	3	pt/ac	B	10 a	4 b	1.4 a	3.0 a
Raptor	6	oz/ac	B				
NIS	1	% v/v	B				
10 Non-treated check				0 b	9 a	1.1 a	2.5 a

\*means followed by same letter do not differ at  $p < 0.05$

<sup>I</sup>Application timings: A, pre-emergence; B, post-emergence; C, 15 days after first cut.

<sup>II</sup>Dry matter yield

Abbreviations: \*\*MSO, methylated seed oil; \*\*\*NIS, non-ionic surfactant.



# A Comparison of Foliar-Banded Fungicide Treatments for the Management of Rhizoctonia Root and Crown Rot of Sugarbeet

M. Wallhead<sup>1</sup> and W. Stump<sup>1</sup>

## Introduction

Sugarbeet (*Beta vulgaris*) represents an important crop for Wyoming farmers with approximately 31,400 acres harvested in Wyoming in 2015. The estimated value of the crop was \$46.3 million, according to the U.S. Department of Agriculture's National Agricultural Statistics Service. Rhizoctonia crown and root rot (RRCR)—caused by the pathogenic fungus *Rhizoctonia solani*—is the number one disease affecting sugarbeet across the growing region with losses up to 50% having been reported. The disease is estimated as threatening or affecting economic returns on 24% of the acres sown to sugarbeet in the U.S.

Treating seed with a fungicide prior to planting is recommended. Penthiopyrad (Kabina<sup>®</sup> ST) is a new succinate dehydrogenase inhibitor (SDHI) fungicide that has been shown to provide good levels of protection. Seed treatment is effective for up to six weeks after planting, at which point foliar applications of fungicides may be necessary. Growers in the region tend use the fungicide Quadris<sup>®</sup> (azoxystrobin) exclusively for RRCR management. But over reliance on one fungicide is not recommended due to potential for the development of resistance.

## Objectives

The objectives of this study are to determine the efficacy of various foliar fungicides compared to Quadris on Rhizoctonia root and crown rot disease and sugarbeet yield.

## Materials and Methods

Field plots were established in 2015 at the Powell Research and Extension Center (PREC). The

experimental design was a randomized complete block with four replications; plots were 6 rows (22-in row centers) by 20-ft long, with a 10-ft in-row buffer. Plots were inoculated with *Rhizoctonia solani*-infested barley at a rate of 45 lb per plot. Inoculum was broadcast with a cyclone spreader and then incorporated into the soil. All seed used in this study was treated with Kabina ST at standard rates. Stand counts were determined per 10 ft of row on May 22. Foliar fungicides were applied at the 12-leaf stage on June 18. Fungicides were applied with the aid of a CO<sub>2</sub> backpack sprayer in a total volume 0.42 gal per 400 ft of row at 40 psi. Incidence was the average number of plants showing RRCR symptoms (4 rows x 20 ft). Disease severity is presented as percent canopy decline. Both incidence and disease severity were determined August 26. Two rows by 20 ft were harvested September 11 using a mechanical beet harvester. Percent RRCR severity on beet roots was measured on a 0–100 scale at harvest. Mean separation was tested using Fisher's protected least significant difference (LSD) ( $p \leq 0.05$ ).

## Results and Discussion

All fungicide treatments significantly reduced incidence, percent canopy decline, and RRCR levels compared to the inoculated check ( $p \leq 0.05$ ). Data is summarized in Table 1. Proline<sup>®</sup> applied at 0.33 fl oz/1,000 ft of row also had incidence levels and percent canopy decline similar to that of the non-inoculated check. The Quadris treatment also was similar to the non-inoculated check in terms of % canopy decline. All fungicide treatments significantly increased yield and pounds of extractable sucrose per acre compared to the inoculated check ( $p \leq 0.05$ ). Results demonstrate that seed treatment along

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<sup>1</sup>Department of Plant Sciences.

with foliar-banded fungicides can provide season-long RCRR management and that there are viable fungicide alternatives to Quadris.

### Acknowledgments

We thank Wendy Cecil and PREC field crews for assistance in plot establishment and harvesting. Also, we thank Betaseed® for supplying the Kabina treated seed.

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**Keywords:** sugarbeet, *Rhizoctonia solani*, fungicide

**PARP:** I:1, X:3

**Table 1.** Fungicide effects on Rhizoctonia root and crown rot and yield of sugarbeet.

Treatment and Rate (fl oz)/1,000 ft <sup>1</sup>	Incidence <sup>2</sup>		% Canopy Decline <sup>3</sup>		RCRR <sup>4</sup>		Yield <sup>5</sup>	
Non-inoculated check	0	c <sup>6</sup>	0	c	0	b	12	a
Inoculated check	86	a	74	a	40	a	6	b
Quadris 0.6	29	b	16	cb	1	b	12	a
Proline 0.33	10	bc	7	cb	0	b	16	a
Priaxor 0.46	34	b	26	b	2	b	13	a
Vertisan 1.2	28	b	25	b	11	b	15	a
LSD ( $p \leq 0.05$ )	24		24		26		3	

<sup>1</sup>All seed was treated with Kabina ST. Treatments were applied at the 12-leaf stage using a single-nozzle sprayer at 40 psi.

<sup>2</sup>Incidence was determined August 26 and is represented as average number of RCRR-infected plants per plot.

<sup>3</sup>Percent canopy decline (disease severity) was determined August 26.

<sup>4</sup>Ten beets per plot were rated for percent surface area showing discoloration at harvest.

<sup>5</sup>Beet root weight in ton/ac.

<sup>6</sup>Treatment means followed by different letters differ significantly ( $p \leq 0.05$ ).

# James C. Hageman Sustainable Agriculture Research & Extension Center (SAREC)

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

*J.A. Tanaka<sup>1</sup>*

## Introduction

The James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle 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. SAREC also has (1) 1,523 acres of dryland crops, primarily in wheat and corn; (2) 1,880 acres of rangeland; and (3) a 400-head feedlot. Additionally, there are 320 acres of forested land at the Rogers Research Site near Laramie Peak.

We have had some employee changes in the past year. Assistant Professor Carrie Eberle started as a systems agronomist in the University of Wyoming's Department of Plant Sciences. Jerry Nachtman retired at the end of last summer (Figure 1), Bob Baumgartner resigned in early fall, and Jim Freeburn decided to go full-time with the Western Sustainable Agriculture Research and Education (SARE) program and moved to an office in Torrington. John Tanaka started as director



**Figure 1.** Jerry Nachtman retirement at 2015 SAREC Field Day.

of SAREC in spring 2015. Others located at SAREC include Steve Paisley (Department of Animal Science), Brian Lee (Department of Agricultural and Applied Economics), Jeff Edwards and Lori Schafer (UW Extension), assistant farm managers Larry Howe, Larry Miller,

Al Unverzagt, and Troy Cecil, and administrative assistant Kelly Greenwald.

We work as a team to provide the best possible research and extension activities serving six eastern Wyoming counties (Albany, Converse, Goshen, Laramie, Niobrara, and Platte), the state as a whole, and other regions with similar crop and livestock production issues. Our research includes small to large plots on cropland, rangeland restoration, pasture and rangeland grazing, and feeding primarily cattle in the feedlot. We are also heavily involved in extension activities throughout the year by providing a place for hands-on demonstrations and talks and by writing articles of interest to a wide range of constituents. We are highly committed to conducting research and extension activities that help solve issues for farmers, ranchers, and agricultural organizations such as the Wyoming Wheat Growers Association, Wyoming Stock Growers Association, Wyoming Farm Bureau Federation, Wyoming Bean Commission, and others.

The new Wyoming Restoration Challenge got off to a great start last year with teams from throughout the region establishing their treatments. The event was designed to allow citizens, students, and professionals come up with innovative solutions to controlling cheatgrass, a troublesome weed across Wyoming, the West, and other areas of the country. Groups such as the Nebraska Section of the Society for Range Management toured the challenge (Figure 2).

## Facility Improvements

While there were no major changes in our facilities over the past year, we have been focusing on upgrading and maintaining what we currently have. We are learning

<sup>1</sup>Director, James C. Hageman Sustainable Agriculture Research and Extension Center.

to use the variable-rate irrigation systems installed on a center pivot and on the lateral-move sprinkler. Both of these have enabled us to more precisely control water use and, in the case of the lateral-move sprinkler, establish plots of different crops and studies with different water requirements. We also made infrastructure improvements to our office and housing with higher speed Internet and cell phone boosters, which allow our employees, visiting scientists, and the public to better use our facilities.

We planted pubescent wheatgrass on a highly erodible piece of dryland cropland (Figure 3). The intent was to establish permanent cover and prevent wind erosion. This area can be used for grazing research in the future.



**Figure 2.** Tour of the Wyoming Restoration Challenge.



**Figure 3.** Highly erodible cropland was planted to permanent cover.

The UW-owned and SAREC-managed Rogers Research Site near Laramie Peak had several forest restoration treatments established following the 2012 forest fire (Figures 4–5). Trees were removed by different methods in established plots in burned areas, and reestablishment of trees was done by planting one-year-old tublings (seedlings grown in small tubes), using seed, and allowing natural regeneration. These plots will be available to researchers trying to answer different forest restoration questions. Grasses (mountain brome, Idaho fescue, green needlegrass, and slender wheatgrass) were planted for erosion control. In addition, treatments of removing all burned saw wood and slash, removing only the saw wood and leaving the slash, and untreated controls were established.



**Figure 4.** The burned forest in 2015 following the 2012 Arapahoe Fire on Laramie Peak.



**Figure 5.** Establishing a forest restoration treatment on the Rogers Research Site.

## **2015 at SAREC**

From a production standpoint, 2015 was a bit of a challenge. Rain came in the spring (4.78 inches above average for April and May) affecting planting and then again in the fall affecting harvest. Winds and hail also returned during harvest creating more challenges. We lost some research plot results because of all this. Generally, precipitation measured at SAREC was 18.53 inches—4.69 inches over the 30-year average.

## **Acknowledgments**

SAREC was formed to be a place where applied research will be conducted to help agricultural production become more sustainable. Its mission is to serve the

citizens of Wyoming, 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 wholly upon the staff, faculty, and students. Their efforts are the reason SAREC can provide a quality location for faculty, staff, and students from UW and elsewhere to conduct research and extension activities.

## **Contact Information**

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# Short Reports

## 1. Impact of chemical practices on soil-borne pathogens of sugarbeet in the High Plains

**Investigators:** William Stump, Gustavo Sbatella, Matt Wallhead, and Wendy Cecil

**Issue:** Fungicides are a key aspect of managing *Rhizoctonia* crown and root rot (RCRR) of sugarbeet. In addition to applying fungicides, weed management plays an important role in managing RCRR as the pathogen causing the disease has a broad host range that includes many species of weeds and other crops.

**Goal:** Study the feasibility of co-applying Roundup® and foliar fungicides for the management of *Rhizoctonia* root and crown rot (RRCR) of sugarbeet, which could reduce trips across the field and improve efficiency. (RRCR is caused by the pathogen *Rhizoctonia solani*.)

**Objectives:** Investigate the effects of tank-mixed fungicide and herbicide applications on soil-borne diseases of sugarbeet in the High Plains.

**Expected Impact:** Chemical management practices that minimize losses due to soil-borne pathogens will help maintain farm productivity. By co-applying herbicides and fungicides, crop losses due to soil-borne pathogens may be minimized, increasing yields and profitability.

**Contact:** William Stump at [wstump@uwyo.edu](mailto:wstump@uwyo.edu) or 307-766-2062.

**Keywords:** sugarbeet, *Rhizoctonia solani*, fungicides

**PARP:** III:6



# Evaluation of Quinoa and Fenugreek in Wyoming Conditions

*S. Baskota<sup>1</sup> and M.A. Islam<sup>1</sup>*

## Introduction

Fenugreek and quinoa are both annual, specialty crops having potential for multi-purpose use. For starters, they are highly nutritious. High fiber and protein content and presence of bioactive compounds help make fenugreek a nutritious crop (Meghwal and Goswami, 2012). Fenugreek also has been used as a medicinal plant to help treat hyperglycemia, hyperlipidemia, and disorders of the gastrointestinal and cardiovascular systems (Sangeetha, 2010). Quinoa, meanwhile, is a specialty crop containing vitamins, minerals, protein, fiber, and essential amino acids. In addition to its nutrition values for humans, quinoa is gluten free, meaning it can be consumed by people with celiac disease, and it can also be used for animal feed and green fodder (Jacobsen, 2003). As a legume crop, fenugreek fixes atmospheric nitrogen and enriches soil by supplying nitrogen to the soil pool. Both crops can sustain in a wide range of climatic and soil conditions. Because of this, they are cultivated in different parts of the world, and both have high commercial value.

Fenugreek and quinoa have further potential as a possible forage crop. In places like Wyoming, where the growing season is short across much of the state and feed is usually scarce during winter and early spring, these annual crops may be useful in supplementing animal feed. Although many studies have been conducted in Europe, Canada, and other parts of the world, limited information is available whether these crops can be grown for their full growth potential in states having less-than-ideal growing conditions, such as Wyoming.

## Objectives

The objectives of this study are to evaluate different genotypes/cultivars of fenugreek and quinoa for growth and yield potential.

## Materials and Methods

The study was conducted at the Laramie Research and Extension Center (LREC) and James C. Hageman Sustainable Agriculture Research and Extension Center

(SAREC) near Lingle in 2015. One cultivar and four genotypes of fenugreek ('Tristar', 'F96', 'LRC3375', 'LRC3708', and 'F75') and six cultivars of quinoa ('Cherry Vanilla', 'Mint Vanilla', 'Red Head', 'Oro de Valle', 'Brightest Brilliant Rainbow', and 'French Vanilla') were tested at both locations. Fenugreek seeds were inoculated with *Rhizobium* bacteria to enhance the nodulation for fixing nitrogen prior to seeding. Seed sowing took place May 18 at LREC and June 3 at SAREC. There were three replications for each treatment, and each plot size was 100 square feet. Planting was done in rows 9 inches apart. The experiments were conducted under irrigated conditions to provide "optimum" growing conditions. Irrigation amount for each plot at one location was the same. The soil at both locations was slightly alkaline (pH 8.1). Nitrogen was applied in quinoa at 134 pounds per acre, but not to fenugreek as this plant can fix atmospheric nitrogen on its own. Biomass data were collected on August 19 at LREC and August 21 at SAREC. Seed yields were also recorded for all genotypes/cultivars.

## Results and Discussion

Among the quinoa cultivars planted at SAREC, Red Head produced the highest dry matter (DM) yield (1,990 lbs/ac) while Brightest Brilliant Rainbow produced the highest seed yield (351 lbs/ac) (Figures 1 and 3). At LREC, Mint Vanilla produced the highest DM (520 lbs/ac) while Brightest Brilliant Rainbow produced the highest seed yield at 284 lbs/ac. Among fenugreek genotypes/cultivars, F96 produced the highest DM and seed yields at both LREC (1,499 and 288 lbs/ac, respectively) and SAREC (3,522 and 1,602, respectively) (Figures 2 and 4).

The variation in DM and seed yields at Laramie and Lingle was primarily due to (1) the elevation difference between the two locations (SAREC is 4,173 feet above sea level while LREC is 7,200 feet); and (2) climatic variations as Laramie received high natural precipitation in July (2.81 inches) and October (2.67 inches). The unexpected high precipitation at the time of plant establishment at LREC in July created very wet soils,

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<sup>1</sup>Department of Plant Sciences.

which ultimately led to some lodging effect. Concerning the latter, many plants from some cultivars/genotypes for both fenugreek and quinoa fell to the ground, reducing the number of plants per plot. Additional heavy precipitation in October at LREC caused seeds to shatter, which affected seed yield. However, quinoa cultivar Red Head and fenugreek genotype F96 performed well at both locations, indicating their growth potential in Wyoming conditions. It is clear that there is genotypic variance in these two cultivar/genotypes, which makes them perform better even in wet conditions. The study is being repeated in 2016, and additional agronomic data including planting time and fertilization effects and forage quality will be measured.

### Acknowledgments

We thank Dhruva Dhakal, Dennis Ashilenje, Sayantan Sarkar, and LREC and SAREC staff for assistance in experimental set-up and data collection. The study is supported by grant funds from the Wyoming Department of Agriculture's Agriculture Producer Research Grant Program and the Specialty Crop Grant Program and Hatch funds from the U.S. Department of Agriculture.

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**Keywords:** fenugreek, quinoa, forage potential

**PARP:** I:2, II:2, VI:1,8

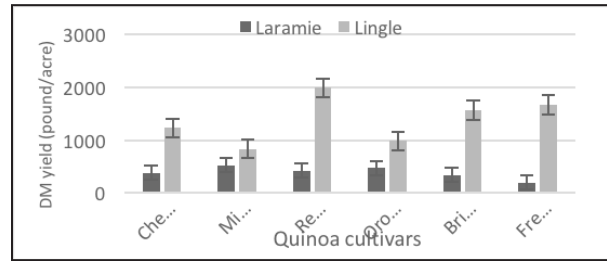
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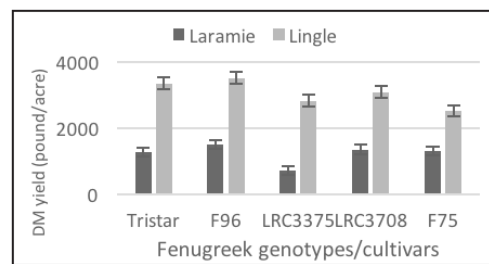
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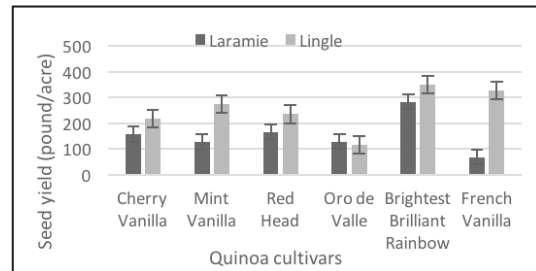
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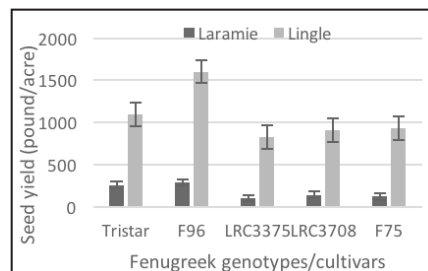
**Figure 1.** Dry matter (DM) yield of different cultivars of quinoa at Laramie and Lingle. Line associated with the bars is standard error.



**Figure 2.** Dry matter (DM) yield of different genotypes /cultivars of fenugreek at Laramie and Lingle. Line associated with the bars is standard error.



**Figure 3.** Seed yield of different cultivars of quinoa at Laramie and Lingle. Line associated with the bars is standard error.



**Figure 4.** Seed yield of different genotypes of fenugreek at Laramie and Lingle. Line associated with the bars is standard error.

# Drought Susceptibility Index and Canopy Traits of 49 Dry Bean Genotypes Subjected to Water Stress

*J. Heitholt<sup>1</sup> and B. Baumgartner<sup>2</sup>*

## Introduction

Although many dry bean farms in the Intermountain West, including Wyoming, are managed with full irrigation, genotypes possessing drought tolerance are still sought. Morphological and physiological traits that confer drought tolerance vary depending on the production environment.

## Objectives

The objectives of this study were to determine drought tolerance in a diverse group of dry bean genotypes and plant responses to drought.

## Materials and Methods

Forty-nine genotypes of dry bean across multiple market classes were sown in a field June 19, 2015, at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle. The soil is a Haverson and McCook loam. Experimental design was a split plot with irrigation level the main plot and genotypes assigned to subplots.

Irrigation levels were (1) full vs. (2) partial drought—full irrigation pre-bloom and approximately 50% crop evapotranspiration (ET<sub>c</sub>) post-bloom. After factoring in atmospheric data and assuming soil moisture is not limiting, ET<sub>c</sub> is the estimate of combined water loss from a crop canopy by two processes: (1) evaporation of water directly from soil; and (2) transpiration (the loss of water directly from plant tissues such as leaves).

Two replicates were used, and subplots were one row each 25 feet long with 30-inch row spacing. Seeding rate was approximately 87,000 seeds/ac. An herbicide application of 24 oz Roundup PowerMAX® and 12 oz Outlook® was applied June 22. A second herbicide

application of 4 oz Raptor® and 16 oz Basagran® was applied July 16.

The irrigation was applied through a lateral-move sprinkler utilizing Valley® variable-rate irrigation technology to adjust the amount of water applied to the fully irrigated plot in comparison to the limited-irrigation plot. The fully irrigated plot received 6.09 inches of supplemental water while the limited plot received 2.38 inches of supplemental water (irrigation was performed weekly). The field also received 4.77 inches of natural moisture from June through August and another 2.37 inches in September. Canopy temperature was collected August 9. At maturity, plant height and yield (15-feet of row) data were collected. Just prior to harvest, two plants and their pods were harvested from each plot for determination of yield components.

## Results and Discussion

At Lingle, mid-day canopy temperature readings during reproductive growth were unaffected by irrigation with stressed plots averaging 79°F and well-watered averaging 77°F. The water-by-genotype interaction on canopy temperature was not significant, but genotype effects were ( $p=0.001$ ). A water-by-genotype interaction affected plant height ( $p=0.002$ ). Maturity was not affected by irrigation (98 vs. 96 days after planting [DAP] for well-watered vs. drought) nor by the water-by-genotype interaction, but genotype effects were found ( $p=0.001$ ).

As expected, genotypes such as Othello, CO-46348, Croissant, and Bill-Z (78–82 DAP) were among the earliest maturing, and UCD0908, Mist, Dynasty, and Rosie (93–100 DAP) were among the latest. Seed yields—although not affected by the main effect

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<sup>1</sup>Department Plant Sciences; <sup>2</sup>Wyoming Weed and Pest Council.

of irrigation—tended to be greater in the well-watered plots (1,130 and 622 lb/ac for the well-watered and drought-stressed plots, respectively). For yield, no genotype-by-water interaction effect was detected. Genotypes varied in yield ( $p=0.001$ ) with four experimental lines from the University of Nebraska breeding program ranking in the top five. Seed size, seed per pod, and pod harvest index all tended to be higher (2–8%) in the well-watered plots than drought stressed, but the differences were not significant. Genotype effects for all these traits were detected. Using  $n=49$ , yield was negatively correlated with canopy temperature and maturity within each irrigation level and when irrigation levels were combined (three data sets). Yield was positively correlated with plant height, again across all three data sets. Correlations with each water regime are provided in Tables 1–2.

Our results indicate that many mid-season and end-of-season traits were correlated with yield in both drought and well-watered environments. It remains to be seen whether these traits could provide an efficient short-cut in breeding programs seeking to develop

higher-yield genotype, where thousands of progeny plots are being evaluated. Regardless, traits such as canopy temperature and plant height could definitely be considered as “tie-breakers” in breeding programs where all of the top-yielding lines cannot be statistically separated from each other. Note: for results of the 49 different genotypes, please contact the lead author (contact information is below).

### Acknowledgments

The authors thank Jerry Nachtman and employees of SAREC for technical support. The study was supported in part by U.S. Department of Agriculture Hatch funding.

### Contact Information

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**Keywords:** carpel, *Phaseolus* (dry bean), yield stability

**PARP:** Goals 1,2

**Table 1.** Correlation coefficients and significance level of dry bean traits grown under well-watered conditions near Lingle, 2015. Lower left ( $p$ -value), upper right ( $r$ ).  $n=49$ . Correlation of a variable with itself equals 1.0, and, thus, “na” is placed in those cells.

Trait	Yield	Maturity	Canopy Temp	Height
Yield	na	-0.421	-0.737	0.630
Maturity	0.003	na	-0.421	-0.068
Canopy Temp	0.001	0.008	na	-0.429
Height	0.001	0.643	0.002	na

**Table 2.** Correlation coefficients and significance level of dry bean traits grown under drought conditions near Lingle, 2015. Lower left ( $p$ -value), upper right ( $r$ ).  $n=49$ . Correlation of a variable with itself equals 1.0, and, thus, “na” is placed in those cells.

Trait	Yield	Maturity	Canopy Temp	Height
Yield	na	-0.596	-0.616	0.365
Maturity	0.001	na	0.392	-0.351
Canopy Temp	0.001	0.005	na	-0.145
Height	0.010	0.013	0.325	na

# Wyoming Restoration Challenge Focuses on Restoring Weed-Infested Pastures

*B.A. Meador<sup>1,2</sup>, J.M. Workman<sup>1</sup>, B. Fowers<sup>1</sup>, and C.W. Wood<sup>1</sup>*

## Introduction

Millions of acres of Western rangelands are negatively impacted by invasive species, and cheatgrass (*Bromus tectorum*) is one of the most widespread. Also known as downy brome, its ability to alter species composition and ecological functions negatively impacts habitat quality for livestock and wildlife alike. Hundreds of research papers have been published on its ecology and management, yet land managers in Wyoming and around the West are still uncertain of the most effective, cost-efficient methods to restore cheatgrass-dominated systems to a higher-functioning status. The Wyoming Restoration Challenge is a land-restoration competition where 13 teams are implementing their own strategies to restore a cheatgrass-dominated pasture to a more diverse, productive state.

## Objectives

Objectives of this project are to: (1) increase land managers' knowledge about techniques for restoring weed-dominated pastures; (2) build awareness of the importance of managing invasive weeds in general; (3) evaluate various methods for restoring degraded pasture infested with cheatgrass and other annual weeds; (4) share information with various audiences on those methods and their relative performance; and (5) encourage friendly competition among teams.

## Materials and Methods

We issued an open invitation through various outlets for teams to enter into the competition. Each team was assigned one of 13 quarter-acre plots by drawing plot numbers from a hat. Teams were given access to plots at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) in April 2015 and will be evaluated annually through fall 2017.

Any legal methods for removing cheatgrass and reestablishing a diverse, desirable plant community are allowed. Teams will be evaluated on multiple categories including vegetation productivity, plant species diversity, costs of implementation, ability to scale the methods to large landscapes, and educational program development. As approaches are implemented, the site becomes analogous to a traditional extension demonstration plot, with side-by-side cheatgrass restoration tactics available for direct comparison. The most efficient way to follow the competition is at [www.facebook.com/WYrestorationchallenge/](http://www.facebook.com/WYrestorationchallenge/).

## Results and Discussion

Twelve Wyoming-based teams and one from Nebraska registered for the challenge, including community college and university faculty and staff members, county weed and pest control district personnel, Extension educators, ranchers, government agency employees, and graduate, undergraduate, and high school students (Figures 1–3). During the first year of competition,



**Figure 1.** Julia Workman and Clay Wood, along with fellow members of the University of Wyoming Weed Control Freaks team, inspect their Restoration Challenge plot at SAREC. Workman and Wood are both graduate students in the Department of Plant Sciences.

<sup>1</sup>Department of Plant Sciences; <sup>2</sup>Sheridan Research and Extension Center.

teams assessed their plots, devised strategies, and began implementation. Integrated weed-management strategies were abundant as teams implemented high-intensity, short-duration grazing, multiple herbicide applications, mowing, burning, tillage, cover crops, and weed-suppressive bacteria applications. Cheatgrass canopy cover ranged from 5% in the University of Nebraska–Lincoln’s plot to more than 60% in the plots of several other teams. Overall plant species’ richness was relatively low in all plots, ranging from 3–11 species present. Most teams have implemented direct-seeding of desirable plants or plan to do so in 2016.

### Acknowledgments

Many thanks go to the Wyoming Agricultural Experiment Station and the SAREC crew, including Bob Baumgartner, for their support of the challenge; our partners who helped publicize the event; the Wyoming Society for Range Management and Wyoming Weed and Pest Council; and the University of Wyoming range weed science team for assistance and participation.

### Contact Information

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**Keywords:** cheatgrass, rangeland restoration, participatory learning

**PARP:** III:3,5,7, VI:3,4, IX:2,3,4,5, XII:1



**Figure 2.** Brian Connely, center, district supervisor of Natrona County Weed and Pest, discussed his team’s approach to managing cheatgrass with Nebraska Extension Educator Gary Stone, left, and others attending a cheatgrass field day at SAREC.



**Figure 3.** Glendo, Wyoming, rancher Larry Cundall explains his team’s approach to restoring rangelands infested by cheatgrass. On his team are employees of the Cundall ranch, Glendo rancher Tim Millikin, and representatives of the Natural Resources Conservation Service in Platte County.

# Determining the Effects of Climate Variables and Maternal Antibody on the Natural Transmission of Bluetongue Virus in Range-Pastured Beef Cattle

*M. Miller<sup>1</sup> and A. Suluburic<sup>1</sup>*

## Introduction

Bluetongue virus (BTV; genus *Orbivirus*, family *Reoviridae*) is an insect-transmitted virus that causes highly fatal disease in deer and pronghorn antelope, and it can cause severe disease in sheep if the flock is naïve (antibody negative). In cattle, infection does not typically result in disease, but economic impacts can be severe for breeders of registered cattle due to export restrictions if the animals test BTV antibody positive. The geographic distribution of BTV has greatly expanded in the past 12 years, including 10 new serotypes now in the U.S. that were previously found only in Central America and the Caribbean Islands. This expansion of BTV into new geographic regions has been largely attributed to a warming climate, but other factors may also play a role such as management changes and livestock movement. In Wyoming, BTV distribution is limited by elevation (<7,000 ft), and it can be predicted that warmer weather will allow infections to occur in higher landscapes.

Eastern Wyoming uniquely has the highest incidence of BTV infection in the state, and most cattle in this region are positive for BTV antibodies preventing livestock owners from exporting semen or embryos. Cows at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle were found to be 100% positive for BTV antibodies in 2015. The offspring of these cows acquire this antibody after drinking the mother's milk. This maternal antibody provides temporary protection from BTV infection, but will gradually decay and disappear over the course of 4–6 months. Our study will follow antibody-positive SAREC calves and a second group of cows and calves from the Laramie Research and Extension Center

(LREC) that is antibody negative. Both groups will be kept on the same dryland pasture at SAREC and allowed to have natural exposure to BTV.

Our study will take place over the course of three summers and will compare the transmission dynamics (time of onset and virus concentration) between treatment groups and seasonal weather conditions. The insect vector will be trapped to determine abundance and the presence of the virus. The results of our study are needed to develop predictive models for BTV outbreaks and define the impact of maternal antibodies. Such models can help producers plan for preventative strategies such as the need for vaccination and vector-control programs. They can also help to predict the effect of a warming climate on the geographic distribution of the virus. Knowing the BTV serotypes currently in the state is needed to recognize the incursions of new strains into Wyoming.

## Objectives

The objectives our study are to (1) identify climate variables correlated to vector abundance and BTV transmission in beef calves fed on dryland pasture; (2) determine the impact of maternal antibody on transmission dynamics; and (3) identify BTV serotypes currently at SAREC.

## Materials and Methods

Spring-born calves positive and negative for maternal BTV antibodies will be kept on open pasture at SAREC where natural exposure to BTV is likely. Blood samples will be collected every 2–4 weeks from May–October and tested for antibody concentration and presence of the virus. Viruses isolated will be identified as

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<sup>1</sup>Department of Veterinary Sciences.

to serotype. Local weather data will be collected, and the insect vector will be trapped to assess abundance and the presence of the virus. The time-of-onset and intensity of BTV transmission between summers and treatment groups will be analyzed for correlations with climate factors and the presence or absence of maternal antibody.

### Results and Discussion

Preliminary results are available for the first year of the study, 2015. That spring and summer was unusually cool up to August and unusually wet up to July as compared to the 15-year average (Figure 1). The first BTV infections were detected in mid-September and continued through the first half of October. The infection rate for 2015 was 37% and was not significantly different between calves antibody positive or negative for maternal antibody. Based on historical reports of disease, hot and dry years are associated with severe outbreaks of disease. We hypothesize that insect vector

transmission of BTV (time-of-onset and infection rate) for 2015 was delayed and below-average due to the cool and wet conditions of the spring, and this late onset of infection occurred after full decay of maternal antibody so that both treatment groups were equally susceptible to infection.

### Acknowledgments

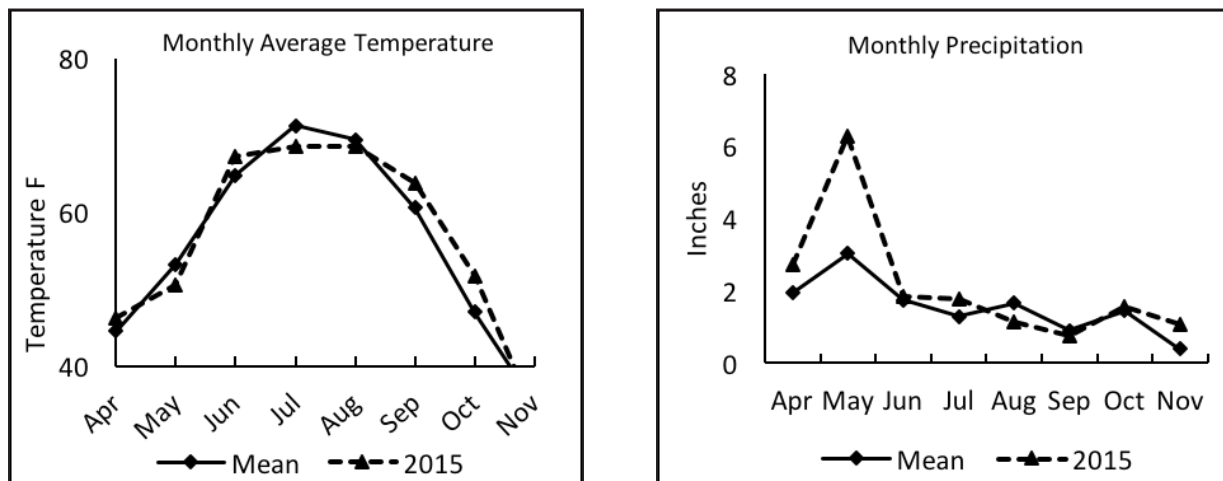
This study is currently supported by a Wyoming Agricultural Experiment Station grant. We greatly appreciate the assistance and support of the staffs at SAREC and LREC.

### Contact Information

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**Keywords:** cattle, disease, bluetongue

**PARP:** V:6, X:1



**Figure 1.** The 15-year mean monthly average temperature and precipitation for Lingle are compared to the conditions in spring/summer/fall 2015.



# Winter Wheat Planting Date Trial: Platte County Dryland

*J. Nachtman<sup>1</sup> and C. Eberle<sup>1</sup>*

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

## Materials and Methods

The experiment was located in a dryland field in Platte County, southeastern Wyoming. The experimental design consisted of three replications in a randomized complete block. Measurements taken included: heading date, plant height, grain yield, test weight, protein content, and moisture. Fertilizer was applied at 19-31-6 NPS lb/ac (19% nitrogen/31% phosphorus/6% sulfur). Goodstreak winter wheat was seeded on September 17, September 24, October 7, and October 21, 2014. The seeding depth was 1.5 inches, and the seeding rate was

50 lb/ac. Plots were harvested July 22, 2015, using an ALMACO plot combine.

## Results and Discussion

Yield results are presented in Table 1. The typical planting date for the area—September 24—resulted in the highest yield and bushel weight, 41 bu/ac and 59.3 lb/bu. Complete results for these trials and many others are available at: <http://www.uwyo.edu/plant-sciences/uwplant/trials.html>.

## Acknowledgments

Appreciation is extended to the cooperators: Newton Russell, who allowed us to place trials on his land south of Wheatland, and Panhandle Coop Association, Scottsbluff, Nebraska, for donating fertilizer for this trial.

## Contact Information

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**Keywords:** winter wheat, variety trials

**PARP:** VIII

**Table 1:** Platte County dryland winter wheat planting date study, 2015.

Planting date: Goodstreak	Fertilized grain yield (bu/ac)	Test weight (lb/bu)	Heading date (days from Jan 1)
September 17, 2014	39	58.2	151
September 24, 2014 (typical)	<b>41</b>	<b>59.3</b>	151
October 7, 2014	37	55.9	157
October 21, 2014	19	39.3	163
Average	34	53.2	155.5

<sup>1</sup>James C. Hageman Sustainable Agriculture Research and Extension Center.



# Winter Wheat Variety Trial Nurseries: Eastern Wyoming Dryland and Irrigated

*J. Nachtman<sup>1</sup> and C. Eberle<sup>1</sup>*

## 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 objective is to test new and existing winter wheat varieties to help growers select ones best adapted to the region.

## Materials and Methods

The experiments were located in Crook (dryland), Goshen (dryland), Laramie (dryland and irrigated), and Platte (dryland) counties in eastern Wyoming. The experimental design consisted of six replications in the dryland plots and five replications in the irrigated plots in a randomized complete block. Measurements taken included: heading date, plant height, grain yield, test weight, protein content, and moisture. Fertilizer was applied to three of the six reps in each dryland location at 19 pounds nitrogen (N), 31 pounds phosphorus (P), and six pounds sulfur (S) per acre. In the irrigated study, fertilizer was applied at a rate of 135 lbs N, 20 lbs P, five lbs S, and one lb zinc per ac. Twenty-seven winter wheat varieties were seeded September 18, 2014, in Crook County; 26 varieties were seeded September 17 in Platte County; and 22 varieties were seeded September 24 in Laramie County. (Please see note in Results and Discussion about the Goshen and Laramie County dryland trials.)

Seedings took place in plots 5 by 25 feet using a hoe drill with a row spacing of 14 inches. The seeding depth was 1.5 inches, and the seeding rate was 50 lb/ac. Plots were harvested August 4, 2015 (Crook), July 22 (Platte), and August 3 (Laramie County irrigated) using an ALMACO plot combine.

## Results and Discussion

In 2015, the dryland trials in Goshen and Laramie counties were lost to winterkill and sawfly/cheatgrass, respectively.

Yield results in the producing trials are presented in Table 1. Variety MT 0978 had the highest yield with the exception of the Platte County fertilized trial, in which Antero had the highest yield. The average yield of the fertilized trials was 5 bu/ac higher than the unfertilized trial in Crook County and 6 bu/ac higher in Platte County. In Platte, the addition of fertilizer increased the overall protein content by 0.5% and increased the per-acre bushel weight by 1.1 lbs.

Results for these trials and many others are available at: <http://www.uwyo.edu/plantsciences/uwplant/variety-trials/wheat.html>.

## Acknowledgments

Appreciation is extended to the cooperators who allowed us to place trials on their land: Whalen Farms (Crook), Herb Mattson (Laramie-dryland), Theron Anderson (Laramie-irrigated), and Newton Russell (Platte). The Goshen County trial was conducted at the James C. Hageman Sustainable Agriculture Research and Extension Center.

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<sup>1</sup>James C. Hageman Sustainable Agriculture Research and Extension Center.

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**Keywords:** winter wheat, variety trials

**PARP:** VIII

**Table 1.** 2015 eastern Wyoming dryland and irrigated winter wheat variety test. **Bold-shaded values** indicate the highest yielding variety within a location and fertilizer treatment.

Entry	Crook Co Dryland		Platte Co Dryland		Laramie Co Irrigated
	Fertilized grain yield (bu/ac)	Unfertilized grain yield (bu/ac)	Fertilized grain yield (bu/ac)	Unfertilized grain yield (bu/ac)	Fertilized grain yield (bu/ac)
MT 0978	<b>51</b>	<b>43</b>	48	<b>47</b>	<b>91</b>
Judee (SS)	<b>51</b>	40	40	31	81
SY Wolf	<b>51</b>	37	43	31	87
MTS 1024 (SS)	46	38	35	27	83
MT 1078	45	41	32	24	78
Robidoux	44	31	44	41	67
Warhorse (SS)	44	39	40	31	80
MT 1113	43	34	45	35	88
Hatcher	42	30	47	42	69
SY Monument	42	36	50	40	n/a
Cowboy	40	37	49	40	76
MT 1138	40	30	49	39	86
Antero (W)	39	42	<b>53</b>	42	86
Denali	38	41	49	39	78
NE10589	37	33	40	34	68
CO011D446	36	34	50	48	80
Sunshine (CO09W293)	36	30	40	34	79
CO011D346	34	32	51	43	69
Byrd	33	31	48	45	75
CO011D174	33	29	51	42	78
Panhandle (NE 05548)	32	29	40	37	n/a
Brawl CL Plus	31	30	30	30	65
Bearpaw (SS)	29	33	34	31	77
Settler CL	29	29	40	33	78
Goodstreak	25	21	41	36	n/a
Centurk	18	18	n/a	n/a	n/a
Buckskin	16	15	34	27	
average	37	32	43	37	78
LSD0.05	6	6	5	5	5

(W) hard white winter wheat; (SS) solid stem for sawfly resistance; (LSD) least significant difference

# Unraveling the Mystery: Measuring Digestibility of Different Types of Baling Twine

*T.S. Paisley<sup>1</sup>, S.I. Paisley<sup>2</sup>, and E. Van Kirk<sup>2</sup>*

## Introduction

When feeding hay bales to livestock, most ranchers remove the twine from the bale; however, some of the twine can be left on and potentially consumed by livestock. The concern is that the twine can affect the health of the animal when ingested. Consequently, the purpose of this experiment is to measure the digestibility of polypropylene, sisal, and sun-biodegradable (Clearfield™) baling twines in the rumen of beef cattle. The hypothesis is that the (1) sisal twine will be significantly more digestible than the other twines; (2) sun-biodegradable twine will be the second most digestible; and (3) polypropylene twines will be the least digestible. This project is important because many ranchers feed cattle baled hay during late fall, winter, and early spring, and the cattle may accumulate baling twine in their rumen, affecting overall rumen volume and potentially reducing the amount of feed that an animal can consume and digest. Understanding the digestibility characteristics of different types of twine may help ranchers make more informed management and purchasing decisions when managing their own livestock.

## Objectives

Because ingesting baling twine could be potentially hazardous for cattle, the study measures the ruminal digestibility of different types of baling twine.

## Materials and Methods

This study was conducted at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle. The standard protocol for measuring in vitro dry matter disappearance (IVDMD) was followed, utilizing the SAREC forage analysis laboratory and an existing ruminally cannulated cow (a cow that had previously been fitted with a porthole-like device allowing researchers access to the rumen). Samples of thick polypropylene, thin polypropylene, sisal, and Clearfield sun-biodegradable twines were

cut into half-inch lengths, dried, and evaluated for IVDMD along with an alfalfa hay standard. Twine and alfalfa samples were placed in mesh bags and incubated in rumen fluid for 0, 12, 24, and 48 hours to determine the rate of disappearance (digestibility) during incubation.

## Results and Discussion

After 48 hours incubation, the sisal baling twine was the most digestible with 15.82% disappearance. Both polypropylene twine samples as well as Clearfield all had minimal disappearance of only 0.27 to 1.55% (Table 1, Figure 1). While minimal digestion of polypropylene twine was expected, the Clearfield results were surprising because it naturally decomposes in sunlight, but remained indigestible in the incubation study. Final disappearance of the alfalfa hay standard resulted in the correct 58% disappearance (Table 1, Figure 1), confirming that the IVDMD procedure was conducted correctly.

Sisal twine is a natural fiber and is partially digestible in the rumen, but is more expensive than polypropylene twines. Poly twines are stronger, cheaper, and stay intact during storage, making transportation and feeding easier. Producers need to be aware of the potential feeding hazards of polypropylene and Clearfield twine if ingested by livestock.

## Acknowledgments

Thanks to SAREC, Department of Animal Science, and Wyoming Agricultural Experiment Station for use of the cow and forage lab facilities.

## Contact Information

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**Keywords:** baling twine, digestibility, beef cattle

**PARP:** V:1,7

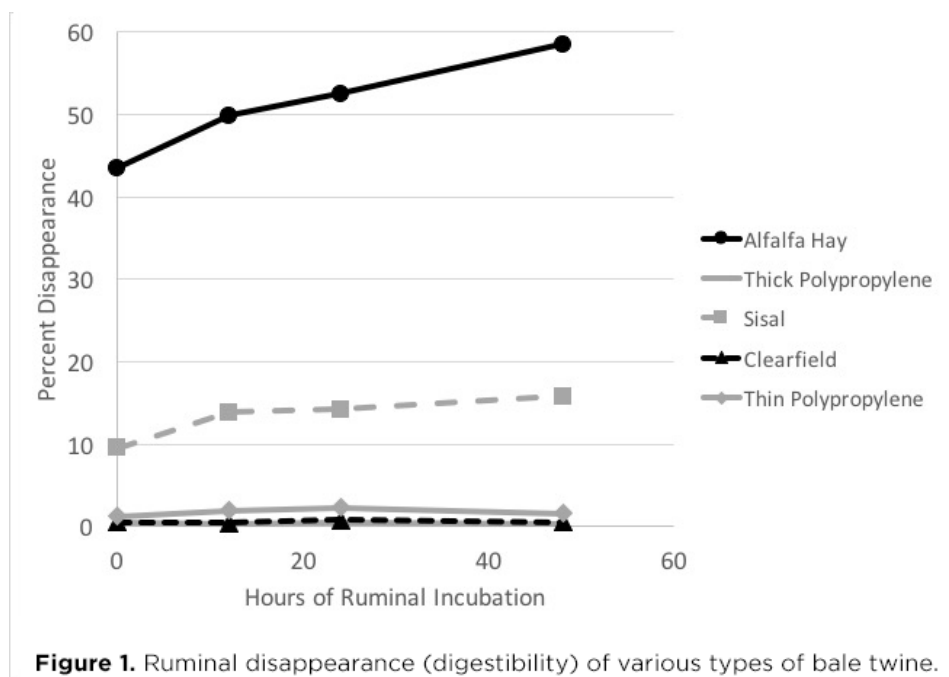
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<sup>1</sup>Wheatland Middle School (8th grade science project); <sup>2</sup>Department of Animal Science.

**Table 1.** Ruminal disappearance values, bale twine study.

Sample	Hours of Rumen Incubation			
	0	12	24	48
Alfalfa Hay	43.55 <sup>a</sup>	49.84 <sup>a</sup>	52.57 <sup>a</sup>	58.51 <sup>a</sup>
Sisal	9.50 <sup>b</sup>	13.87 <sup>b</sup>	14.17 <sup>b</sup>	15.82 <sup>b</sup>
Thin Polypropylene	1.26 <sup>c</sup>	1.94 <sup>c</sup>	2.27 <sup>c</sup>	1.55 <sup>c</sup>
Clearfield	0.47 <sup>c</sup>	0.44 <sup>c</sup>	0.74 <sup>c</sup>	0.52 <sup>c</sup>
Thick Polypropylene	0.47 <sup>c</sup>	0.33 <sup>c</sup>	0.53 <sup>c</sup>	0.27 <sup>c</sup>

<sup>a,b,c</sup>Columns with different superscripts differ ( $P < .05$ )



**Figure 1.** Ruminal disappearance (digestibility) of various types of bale twine.

# Use of Perennial and Annual Flowers to Attract Beneficial Insects to Alfalfa

*M. Pellissier<sup>1</sup> and R. Jabbour<sup>1</sup>*

## Introduction

Intensification of cropland has lowered habitat diversity in agricultural landscapes, leading to fewer alternative resources for natural enemies of agricultural pests. Natural enemies are an important way to reduce pest populations and improve crop yields. Alternative habitats near or bordering agricultural fields can provide overwintering habitat, refuge from management disturbances, and additional food sources important for many types of natural enemies. Alfalfa weevil and aphids are major pests of alfalfa hay in Wyoming. Beneficial insects that can kill these pests may increase in numbers in response to increased flower resources. Subsequently, their pest-control activities could also increase.

## Objectives

We tested whether planting strips of perennial and annual flowers in alfalfa fields attract beneficial insects. We are also interested in the suitability of these plants for southeastern Wyoming's climate. The goal of flower habitats is to try to provide nutrition to adult wasps and other predators that can then move into alfalfa to kill weevils and aphid pests.

## Materials and Methods

The field site for this experiment is located at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle. Twenty-five-foot x 25-ft plots of alfalfa were adjacent to either a perennial flower strip, an annual flower strip, or a control strip of fescue grass. Perennial flowers were planted in 2014 and annuals in 2015. The species used for each treatment are listed in Figures 1 and 2. Annual species were chosen based on their use in previous habitat-management studies while perennial species were sourced regionally when possible. Plots and treatments were vacuum

sampled, and the collected arthropods were then counted and sorted. Data on plant characteristics such as number of open blooms and vegetation heights were also collected.

## Results and Discussion

We found that the perennial flower habitats bloom throughout the entire growing season, compared to the annual flower habitats, which did not bloom in the early season (Figures 1 and 2). This delay in bloom for annual habitats is critical because alfalfa weevil and their parasitoids are most active in May and June. Additionally, frosts early in the growing season may limit the success of planting annual flowers. Therefore, established perennial flower habitats may be a better option for supporting natural enemies of alfalfa weevil in southeastern Wyoming. We would like to note that we did not monitor the potential "weediness" of these species in future years, and weed management, both within flower habitats and of the flowers themselves, is an area needing further investigation.

## Acknowledgments

We are grateful to Bob Baumgartner, Zoe Nelson, Allison Jones, Jemma Woods, Alanna Elder, and Preston Hurst for assistance in maintaining plots. Casey Delphia and Brett Blaauw advised on experimental design.

## Contact Information

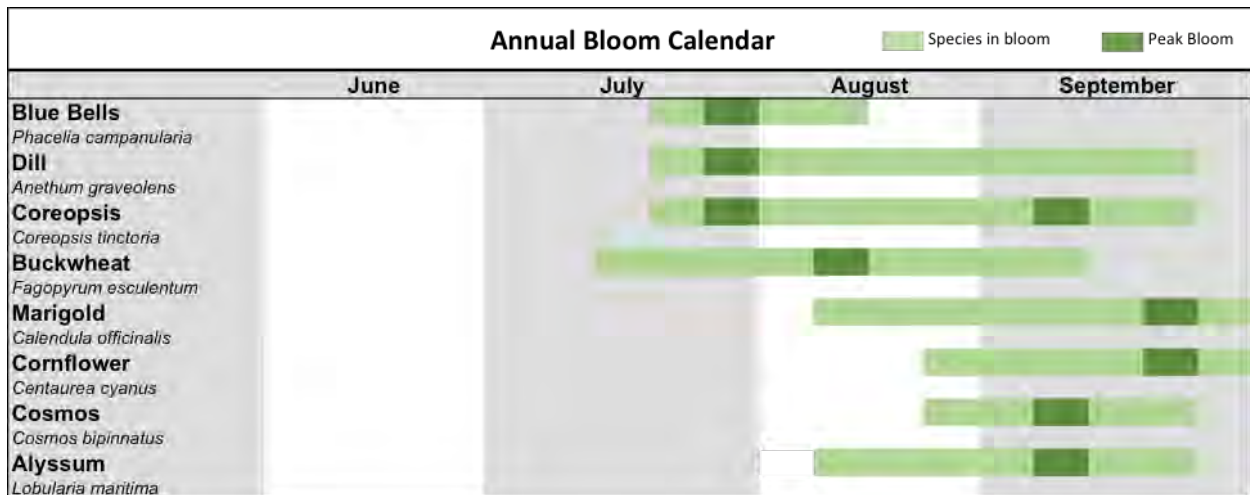
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**Keywords:** alfalfa, biological pest control, flowering strips

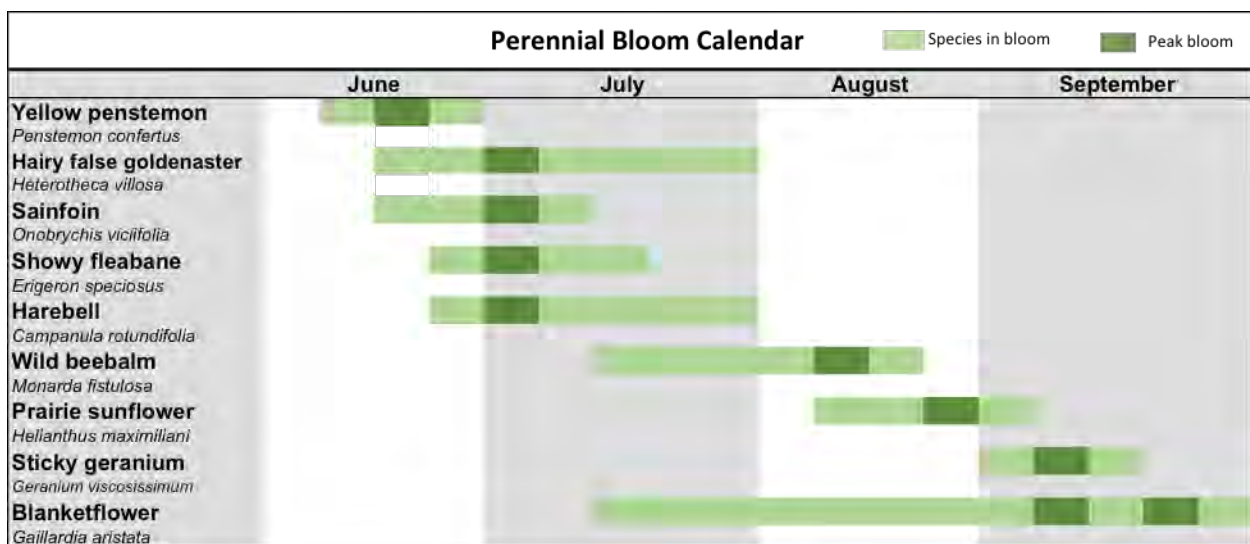
**PARP:** I:1,2, X:2

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<sup>1</sup>Department of Plant Sciences.



**Figure 1.** Bloom calendar for the flower species in the annual treatment in 2015. Lighter bars show when flowers are in bloom while dark bars show peak bloom.



**Figure 2.** Bloom calendar for the flower species in the perennial treatment in 2015. Lighter bars show when flowers are in bloom, while dark bars show peak bloom.



# Bird's-foot Trefoil Response to Planting Method and Harvesting Frequency

*S. Sarkar<sup>1</sup> and M.A. Islam<sup>1</sup>*

## Introduction

Bird's-foot trefoil is a promising forage legume that has potential to increase quality and production of livestock in the U.S., including Wyoming. It can be used as an alternative to alfalfa due to its non-bloating property, high persistence, and improved forage quality. Though bird's-foot trefoil cannot replace alfalfa, it can reduce the pressure on alfalfa as an alternative forage legume. It can be grown and grazed as a single crop as well as in mixture with grasses, and it has shown to increase milk and meat quality of cattle and feed-use efficiency. Planting bird's-foot trefoil with a companion crop helps in reducing weed competition. Bird's-foot trefoil can also be seeded with stubble of a previous crop to help prevent weeds and save resources on seed-bed preparation. Some studies suggest that fewer harvests can be economical for bird's-foot trefoil as the total yield compared to forage quality remains the same due to quality deterioration by the end of growing season. Bird's-foot trefoil production, however, is limited due to lack of information on its agronomic management and practices.

## Objectives

The objectives of the study are to determine the effects of planting methods, harvesting frequency, and different cultivars on yield and quality of bird's-foot trefoil.

## Materials and Methods

The study was conducted at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle. The study had 81 plots arranged in a randomized complete block design, and planting took place in June 2015. Each plot has a combination of three distinct treatments. The first involved planting three different bird's-foot trefoil cultivars: 'Leo',

'Norcen', and 'Bruce'. The second treatment involved different planting methods: clean-tilled planting, planting in standing wheat, and planting in wheat stubble. The third treatment was harvesting frequency, which included either harvesting once, twice, or three times during the growing season.

Data collection included seedling emergence, plant height, crop canopy coverage, and weed coverage. All plots were mowed twice (last week of July and September) to help control weeds and enhance establishment of bird's-foot trefoil. Dry matter (DM) yield was estimated at the end of the growing season by clipping each plot. Forage quality was also determined using the clipped samples. The samples were dried and ground, and then forage quality was analyzed using near-infrared spectroscopy (NIRS) in the University of Wyoming forage agronomy lab.

## Results and Discussion

Variations were observed among treatments in all growth and quality parameters. Initially, the seedling emergence was about 80% for all treatments; however, it started to decline with advancement of time (data not shown). The highest decline was in the standing-wheat plot, which later declined to zero, followed by less decline in the other two plots. Additional growth parameters (height and canopy coverage) were higher for bird's-foot trefoil planted in clean-tilled plots than in plots with wheat stubble (data not shown). Dry matter yield was greatly affected by planting methods (Figure 1). No bird's-foot trefoil survived in standing-wheat planting, whereas clean-tilled and stubble planting produced similar DM yield. Cultivar performance was not much different within planting method. Norcen did the best in clean-tilled plots as well as in wheat stubble. The relative feed

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<sup>1</sup>Department of Plant Sciences.

value (RFV) of bird's-foot trefoil in clean-tilled plots was slightly better than in wheat stubble, but there were some RFV variations among cultivars (Figure 2). Bruce had the highest RFV in clean-tilled plots, whereas Leo had the best RFV in wheat stubble. These preliminary results suggest that bird's-foot trefoil can be successfully established both in clean-tilled and stubble.

**Acknowledgments**

We thank SAREC crews and UW forage agronomy laboratory members for assistance. The study is supported by the Wyoming Department of Agriculture's

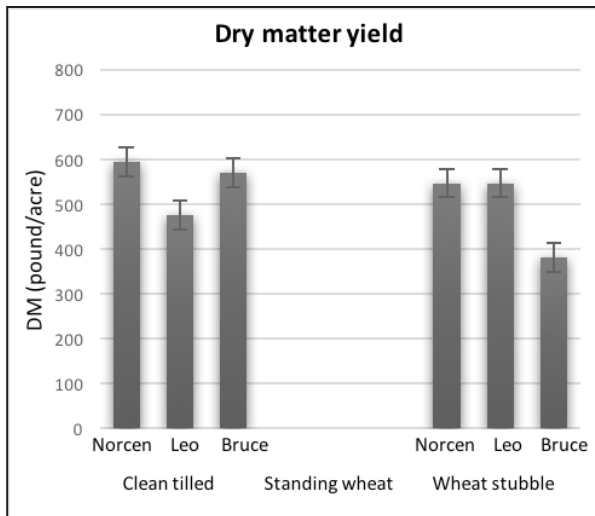
Agriculture Producer Research Grant Program and Wyoming Agricultural Experiment Station Hatch funds.

**Contact Information**

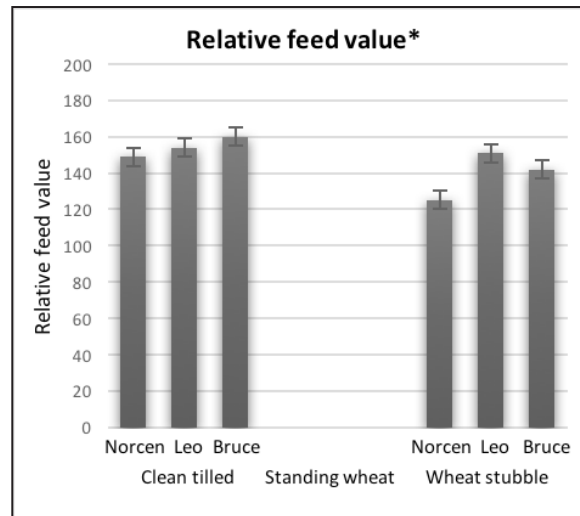
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**Keywords:** bird's-foot trefoil, planting method, harvest frequency

**PARP:** I:2,7, II:8, III:2



**Figure 1.** Effects of planting methods and cultivars on dry matter (DM) yield of bird's-foot trefoil.



**Figure 2.** Effects of planting methods and cultivars on relative feed value of bird's-foot trefoil.

\*Relative feed value (RFV) ranks forages relative to the digestible dry matter intake at full-bloom alfalfa.

# Bacterial Blight of Pinto Bean Control with GWN-10073

*M. Wallhead<sup>1</sup> and W. Stump<sup>1</sup>*

## Introduction

Wyoming is a major contributor to dry bean production in the U.S. In 2014, it ranked fourth in the country in pinto bean production and ninth in the category of “all dry beans,” according to the Wyoming office of the National Agricultural Statistics Service. Growers in Wyoming and across the country, however, face a variety of issues. Among them, dry beans may be affected by a number of distinct diseases, including three bacterial diseases. Bacterial blight and Halo blight are two of these pathogens that are commonly found in Wyoming. Bacterial blight is favored by warmer temperatures whereas halo blight is favored by cooler temperatures. Copper-based bactericides have been shown to be effective at controlling both diseases with new formulations being introduced regularly.

## Objectives

The objectives of this study are to determine the effect of copper-based bactericides on bacterial and halo blight development and yield of pinto bean.

## Materials and Methods

Field plots were placed in 2015 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle. The experiment was a randomized complete block design with four replications; plots were four rows (30-in row centers) by 20-ft long, with a 5-ft in-row buffer. Immediately prior to inoculation, leaves were wounded using a floral pin frog. Inoculum used was a 50/50 mix of *Pseudomonas syringae* pv. *phaseolicola* and *Xanthomonas campestris* pv. *phaseoli*. Inoculum was applied with the aid of a CO<sub>2</sub> backpack sprayer in a total volume 27.05 oz per 200 ft of row at 40 psi.

Bactericides were applied on July 14 and 30, and August 10 with the aid of a CO<sub>2</sub> backpack sprayer in a total volume 0.42 gal per 400 ft of row at 41 psi. Phytotoxicity was rated on a 0–10 scale on August 3. Disease severity was expressed as the average number of bacterial lesions per leaflet out of 10 total leaflets on August 3. Two rows by 20 ft were cut and placed in windrows September 14. Plots were harvested September 17. Mean separation was tested using Fisher’s protected least significant difference (LSD) ( $p \leq 0.05$ ).

## Results and Discussion

No phytotoxicity due to treatment was observed on the pinto bean crop. Data is summarized in Table 1. No significant effect was observed for disease severity or bean yield ( $p \leq 0.05$ ). Although there was lack of significant disease development affecting the study results, there were data trends of reduced disease severity and increased yield with bactericide treatments.

## Acknowledgments

We thank Wendy Cecil and SAREC field crews for assistance in plot establishment and harvesting. Also, we thank Gowan for its support (the company is a marketer of crop protection products).

## Contact Information

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**Keywords:** dry bean, bactericides, blight

**PARP:** I:1, X:3

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**Table 1.** Bacterial blight of pinto bean control with GWN-10073, 2015.

Treatment and Rate/ac <sup>1</sup>	Disease Severity <sup>2</sup>		Yield <sup>3</sup>	
Untreated Check	18.1	a <sup>4</sup>	30.5	a
Kocide® 3000 (1.5 lb)	26.6	a	30.2	a
GWN-10073 (8 fl oz)	11.0	a	36.3	a
GWN-10073 (16 fl oz)	9.7	a	37.0	a
GWN-10073 (32 fl oz)	14.6	a	37.5	a
Badge® SC (8 fl oz)	12.2	a	35.2	a
Badge SC (16 fl oz)	11.9	a	35.1	a
Badge SC (32 fl oz)	9.0	a	33.5	a
	<i>LSD (p≤0.05)</i>	<i>ns</i>		<i>ns</i>

<sup>1</sup>Treatments were applied on July 14 and 30, and August 10 using a four-nozzle sprayer with 0.125% NIS (non-ionic surfactant).

<sup>2</sup>Average number of lesions per leaflet out of 10 total leaflets per plot on August 3.

<sup>3</sup>Seed yield bu/ac.

<sup>4</sup>Treatment means followed by different letters differ significantly ( $p \leq 0.05$ ).

# Management of Rhizoctonia Root and Crown Rot with Single Fungicide Applications at Planting Under a Sugarbeet Replant Scenario

*M. Wallhead<sup>1</sup> and W. Stump<sup>1</sup>*

## Introduction

*Rhizoctonia solani* is the soil-borne fungus that causes a seedling damping off and Rhizoctonia root and crown rot disease (RRCR). It is a major problem facing sugarbeet growers in Wyoming and across the country. One of the management strategies is to plant early when soil temperatures are not optimal for *R. solani* activity, thereby giving the crop a head start. When growers are faced with a replant scenario, soils are typically warmer and, hence, have an increased *R. solani* infection risk. A study was designed to determine which single fungicide application method would provide the best season-long management of beet diseases caused by *R. solani*. This was the second year of the study, which started in 2014.

## Objectives

The objectives are to determine which single fungicide application method would provide the best season-long management of sugarbeet diseases caused by *R. solani* in a shortened season.

## Materials and Methods

Field plots were placed at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle. The experimental design was a randomized complete block with four replications; plots were four rows (30-in row centers) by 25-ft long, with a 5-ft in-row buffer. Inoculum was a mixture of two *Rhizoctonia solani* isolates cultured on barley grain and was broadcast with a cyclone spreader at a rate of 25 lb/ac and then incorporated into the soil. In-furrow fungicide treatments were applied June 1, 8, and 19, 2015. Foliar fungicides were applied at the 4–8 leaf stage on July 2 for planting date one, July 10 for planting date two, and July 22 for planting date three. In-furrow

and foliar fungicides were applied with the aid of a CO<sub>2</sub> backpack sprayer in a total volume of 0.42 gal per 400 ft of row at 40 psi. For each planting date stand counts were conducted by counting all plants in a sub-plot (2 rows by 25 ft). Disease incidence is presented as the average number of plants showing RRCR symptoms in the two rows by 25 ft. On September 25 the plots were evaluated for percent canopy decline. Two rows by 25 ft were harvested September 29 and 30 using a mechanical beet harvester. At harvest, 10 random beets per plot were evaluated for RRCR severity.

## Results and Discussion

Fungicide treatment had significant effects on stand count, percent canopy decline, RRCR, and yield. Data is summarized in Table 1. All in-furrow fungicides and the Kabina® seed treatment improved stands compared to the non-treated inoculated check ( $p \leq 0.05$ ). Although RRCR development was low to moderate, fungicide treatments reduced late-season canopy decline compared to the non-treated inoculated check ( $p \leq 0.05$ ). For root yield all in-furrow and foliar-band treatments resulted in yields greater than the inoculated check and equivalent to or greater than the non-inoculated check ( $p \leq 0.05$ ). The Proline® treatment also had greater yield than the non-treated, non-inoculated check ( $p \leq 0.05$ ). Results indicate that in a shortened season due to a plant back scenario, a Kabina seed treatment alone does not provide season-long disease protection. The in-furrow treatments of Quadris®, Priaxor™, and Vertisan® provided season-long protection against RRCR. Waiting until the 4–8 leaf stage to apply the foliar band provided some protection, but there are more losses due to disease in the period prior to the foliar application.

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<sup>1</sup>Department of Plant Sciences.

## Acknowledgments

We thank Wendy Cecil and SAREC field crews for assistance in plot establishment and harvesting. Also, we thank Western Sugar Cooperative and Betaseed for support.

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**Keywords:** sugarbeet, *Rhizoctonia solani*, fungicides

**PARP:** I:1, X:3

**Table 1.** Management of *Rhizoctonia* root and crown rot with single fungicide applications at planting under a sugarbeet replant scenario, 2015.

Treatment and Rate <sup>1</sup>	Timing <sup>2</sup>	Stand Count <sup>3</sup>	% Canopy Decline <sup>4</sup>	RRCR <sup>5</sup>	Yield <sup>6</sup>
Non-treated inoculated check	A	124 e <sup>7</sup>	35 a	10 a	20,370 c
Non-treated non-inoculated check	A	140 a	1 c	1 b	26,779 b
Quadris (0.6 fl oz/1,000 ft)	B	131 dc	2 c	0 b	30,710 ab
Priaxor (0.46 fl oz/1,000 ft)	B	136 abc	1 c	0 b	28,904 ab
Proline (0.33 fl oz/1,000 ft)	B	132 c	2 c	1 b	33,227 a
Vertisan (1.2 fl oz/1,000 ft)	B	139 ab	1 c	1 b	29,526 ab
Quadris (0.6 fl oz/1,000 ft)	C	125 de	3 c	0 b	25,972 b
Kabina (0.75 fl oz/seed unit)	D	133 bc	27 b	12 a	20,623 c
LSD ( $p < 0.05$ )		6.42	6.66	5.00	5,226.7

<sup>1</sup>Treatments were applied using a single-nozzle sprayer.

<sup>2</sup>Application timings: A=untreated, B=In-Furrow, C=Foliar band at the 4-8 leaf stage, D=seed treated by manufacturer.

<sup>3</sup>Total number of plants in each plot was determined on July 10, July 21, and August 3 for June 1, 8, and 19 planting dates, respectively.

<sup>4</sup>Percent canopy decline was determined September 25.

<sup>5</sup>Ten beets per plot were rated for percent surface area showing discoloration at harvest.

<sup>6</sup>Beet root yield in lb/ac on September 29 and 30.

<sup>7</sup>Treatment means followed by different letters differ significantly ( $p \leq 0.05$ ).

# Management of Rhizoctonia Root and Crown Rot with In-Furrow and Banded Fungicide Applications

M. Wallhead<sup>1</sup> and W. Stump<sup>1</sup>

## Introduction

Sugarbeet (*Beta vulgaris*) represents an important crop for Wyoming (the value of the 2015 crop, for example, is estimated at \$46.3 million). Rhizoctonia root and crown rot (RRCR), which is caused by the pathogen *Rhizoctonia solani*, is the number one disease affecting sugarbeet across the growing region. To manage soil-borne diseases, treatment with in-furrow fungicide at planting is one management option. Serenade Soil® (*Bacillus subtilis* strain QST 713) (Bayer CropScience, Research Triangle Park, North Carolina) is a broad spectrum biofungicide potentially suitable for the management of RRCR in Wyoming. Under high disease pressure, in-furrow fungicide treatment can be supplemented with additional foliar-banded applications of fungicides.

## Objectives

The objectives of this study are to determine the effect of in-furrow and foliar-banded fungicides on RRCR and yield for sugarbeet.

## Materials and Methods

Field plots were established in 2015 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle. The experiment was a randomized complete block design with four replications; plots were 4 rows (30-in row centers) by 20-ft long, with a 5-ft in-row buffer. Inoculum used was a mixture of two *Rhizoctonia solani* isolates cultured on barley grain and was spread at the rate of 50 lbs/ac and incorporated into the soil. In-furrow fungicide treatments were applied at planting May 5. Foliar-banded fungicides were administered at the 8–12 leaf stage June

19. All fungicides were applied with the aid of a CO<sub>2</sub> backpack sprayer in a total volume 0.42 gal per 400 ft of row at 40 psi. Stand counts were determined June 30 by counting the number of plants in the two middle rows of each plot. On August 3 the plots were evaluated for percent canopy decline. Two rows by 20 ft were harvested September 28. At harvest, 10 random beets per plot were evaluated for RRCR severity.

## Results and Discussion

Rhizoctonia disease development was light in the plots in 2015. Data is summarized in Table 1. Seedling decay was not a factor early in the season as evidenced by no significant effect on stand counts between the non-treated inoculated check and the non-treated non-inoculated check. All fungicide treatments had significantly reduced percent canopy decline as compared to the inoculated check ( $p \leq 0.05$ ). Treatments had no significant effect on disease on harvested beets or root yield.

## Acknowledgments

We thank Wendy Cecil and SAREC field crews for assistance in plot establishment and harvesting. Also, we thank Western Sugar Cooperative and Bayer for their support.

## Contact Information

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**Keywords:** sugarbeet, *Rhizoctonia solani*, fungicides

**PARP:** I:1, X:3

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**Table 1.** Management of Rhizoctonia root and crown rot with in-furrow and banded-fungicide applications, 2015.

Treatment and Rate <sup>1</sup>	Timing <sup>2</sup>	Stand Count <sup>3</sup>	% Canopy Decline <sup>4</sup>	RRCR <sup>5</sup>	Yield <sup>6</sup>
1. Non-treated non-inoculated check	A	131.3 a <sup>7</sup>	1.5 a	2.1 a	33,867.8 a
2. Non-treated inoculated check	A	124.5 a	17.6 b	12.5 a	19,822.6 a
3. Serenade Soil (1qt/ac)	B	118.8 a	2.0 a	8.4 a	34,699.8 a
Proline® (0.33 fl oz/1,000 ft)	C				
4. Serenade Soil (2qt/ac)	B	116.5 a	5.0 a	3.0 a	33,974.9 a
Proline (0.24 fl oz/1,000 ft)	C				
5. Quadris® (0.6 fl oz/1,000 ft)	B	119.8 a	2.0 a	2.0 a	32,100.0 a
Proline (0.33 fl oz/1,000 ft)	C				
6. Serenade Soil (1qt/ac)	B	128.5 a	1.5 a	2.1 a	28,649.8 a
Quadris (0.6 fl oz/1,000 ft)	B				
Proline (0.33 fl oz/1,000 ft)	C				
<i>LSD (p≤0.05)</i>		<i>ns</i>	<i>9.81</i>	<i>ns</i>	<i>ns</i>

<sup>1</sup>Treatments were applied using a single-nozzle sprayer.

<sup>2</sup>Timings: A=untreated, B=In-furrow on May 5, C=Banded 8-12 leaf stage on June 19.

<sup>3</sup>Average number of plants for each plot was determined June 30.

<sup>4</sup>Percent canopy decline was determined August 3.

<sup>5</sup>Ten beets per plot were rated for percent surface area showing discoloration at harvest.

<sup>6</sup>lbs/ac on September 28.

<sup>7</sup>Treatment means followed by different letters differ significantly ( $p \leq 0.05$ ).



# Pinto Bean *Rhizoctonia* Root Rot Management with In-Furrow Fungicides

M. Wallhead<sup>1</sup> and W. Stump<sup>1</sup>

## Introduction

Dry beans are an important crop in Wyoming—in 2015, 31,000 acres were harvested. Wyoming dry bean growers have a strong economic incentive to plant dry beans as early as possible: the earlier the planting date, the greater the potential yield. This practice, however, carries considerable risk because emerging seedlings may be killed or infected by soil-borne pathogens. Early season infections and damping-off can lead to significant yield losses at harvest. By utilizing direct placement of fungicide at planting, crop losses due to soil-borne pathogens may be minimized, enhancing crop health and increasing yields and profitability.

## Objectives

The objectives of this study are to determine the effect of in-furrow fungicides on *Rhizoctonia* root rot and yield of pinto bean. (This disease is caused by the soil-borne pathogen *Rhizoctonia solani*.)

## Materials and Methods

Field plots were placed in 2015 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle. The experiment was a randomized complete block design with four replications; plots were four rows (30-in row centers) by 20-ft long, with a 5-ft in-row buffer. Inoculum used was a mixture of two *Rhizoctonia solani* isolates cultured on barley grain and was broadcast at the rate of 35 lb/ac and incorporated into the soil. In-furrow fungicide treatments were applied at planting on June 9. All fungicides were applied with the aid of a CO<sub>2</sub> backpack sprayer in a total volume 0.42 gal per 400 ft of row at 40 psi. Stand counts were determined on June 24. On August 3, five plants per plot were pulled randomly and rated

for *Rhizoctonia* root rot symptoms. Two rows by 20 ft were cut and placed in windrows to dry on September 14. Beans were threshed September 17. Mean separation was tested using Fisher's protected least significant difference (LSD) ( $p \leq 0.05$ ).

## Results and Discussion

No phytotoxicity due to treatment was observed on the pinto bean crop. Data is summarized in Table 1. Disease development was light despite plot inoculations. In-furrow fungicide treatment had no effects on stand count. Differences were observed between treatments with Propulse® 400SC applied at 13.6 fl oz/ac and Proline® 480SC applied at 5.7 fl oz/ac having significantly lower levels of *Rhizoctonia* root rot as compared to the untreated control ( $p \leq 0.05$ ). In-furrow fungicide programs had no significant effect on yield. Since disease pressure was low, it's difficult to surmise treatments were effective due to the lack of yield effect. However, results are promising since there was a significant reduction of disease at the June 24 plant ratings.

## Acknowledgments

We thank Wendy Cecil and SAREC field crews for assistance in plot establishment and harvesting. Also, we thank Bayer CropScience for its support.

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**Keywords:** dry bean, *Rhizoctonia solani*, fungicides

**PARP:** I:1, X:3

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<sup>1</sup>Department of Plant Sciences.

**Table 1.** Pinto bean Rhizoctonia root rot management with in-furrow fungicides, 2015.

Treatment and rate/ac <sup>1</sup>	Stand count <sup>2</sup>	RRR (0-4) <sup>3</sup>	Yield <sup>4</sup>
Untreated check	47a <sup>5</sup>	2.8a	27.8a
Proline 480SC 5.7 fl oz	63a	1.9bc	28.6a
Propulse 400SC 10.2 fl oz	48a	2.3ab	27.5a
Propulse 400SC 13.06 fl oz	35a	1.3c	22.6a
Serenade Soil® SC 1 pt	58a	2.8ab	29.6a
Serenade Soil SC 2 pt	55a	2.7ab	29.5a
<i>LSD (p≤0.05)</i>	<i>ns</i>	<i>0.855</i>	<i>ns</i>

<sup>1</sup>All treatments were applied in-furrow on June 9 using a single-nozzle sprayer.

<sup>2</sup>Stand counts represent the total number of plants in the two center rows of each plot on June 24.

<sup>3</sup>Five stems per plot were rated (0-4 scale) for Rhizoctonia root rot (RRR) on August 3. A higher number represents greater disease.

<sup>4</sup>Bean seed yield bu/ac on September 17.

<sup>5</sup>Means followed by different letters differ significantly ( $p \leq 0.05$ ).

# Rhizoctonia Management in Sugarbeet with Xanthion

M. Wallhead<sup>1</sup> and W. Stump<sup>1</sup>

## Introduction

Sugarbeet (*Beta vulgaris*) represents an important crop for Wyoming. In 2015, farmers harvested 942,000 tons having an estimated value of \$46.3 million, according to the Wyoming office of National Agricultural Statistics Service. Rhizoctonia root and crown rot (RRCR), which is caused by the pathogen *Rhizoctonia solani*, is the number one disease affecting sugarbeet across the growing region. To manage soil-borne diseases, in-furrow fungicide at planting is one management option. Xanthion™ is a new generation biofungicide from BASF Corp., Research Triangle Park, North Carolina. It combines *Bacillus subtilis* (strain MBI 600) with the chemical fungicide pyraclostrobin. Foliar fungicides are an option later in the growing season if in-furrow applications are not made, fail, or are found to provide inadequate control.

## Objectives

The objectives of this study are to determine the effect of in-furrow fungicide and foliar fungicides on Rhizoctonia root and crown rot development and final sugarbeet yield.

## Materials and Methods

Field plots were placed at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle in 2015. The experiment was a randomized complete block design with four replications; plots were 4 rows (30-in row centers) by 20-ft long, with a 5-ft in-row buffer. Inoculum was a 50:50 mixture of *Rhizoctonia solani* AG2-2 R1 and R9 isolates cultured on barley grain and was broadcast with a cyclone spreader at a rate of 25 lb/ac and then incorporated into the soil. In-furrow fungicide treatments were applied at planting May 5. Foliar-banded fungicides were applied at the 8–12 beet leaf stage on June

19. Stand counts were determined on June 30 on the two middle rows by 20 ft. On July 2 the plots were evaluated for percent canopy decline. RRCR incidence in each plot was determined August 17 (2 rows x 2 ft). Two rows by 20 ft were harvested September 28. During harvest, 10 random beets per plot were evaluated for percent RRCR severity.

## Results and Discussion

Seedling decay was not a factor early in the season as evidenced by no significant effect on stand counts between the non-treated inoculated check and the non-treated non-inoculated check. Data is summarized in Table 1. For percent canopy decline only Headline® applied at 9 fl oz/ac and Xanthion™ IF Comp A Integral (1.2 fl oz/ac) + Xanthion IF Comp B Headline (9 fl oz/ac) had significantly less canopy decline compared to the non-treated inoculated control ( $p \leq 0.05$ ). All fungicide treatments reduced disease incidence compared to the non-treated inoculated check. The treatments of Headline alone and Xanthion IF Comp A Integral (1.2 fl oz/ac) + Xanthion IF Comp B Headline (9 fl oz/ac) + Priaxor™ (foliar band) also had incidence numbers similar to the non-treated non-inoculated check ( $p \leq 0.05$ ). All fungicide treatments had significantly higher yields compared to the non-treated inoculated control ( $p \leq 0.05$ ). As a result of completing this research we have identified several fungicides and non-traditional fungicides suitable for managing RRCR. The biofungicide efficacy results are promising, but will require further testing.

## Acknowledgments

We thank Wendy Cecil and SAREC field crews for assistance in plot establishment and harvesting. Also, we thank Western Sugar Cooperative and BASF for support.

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**Keywords:** sugarbeet, *Rhizoctonia solani*,  
biofungicide

**PARP:** I:1, X:3

**Table 1.** Rhizoctonia management in sugarbeet with Xanthion, 2015.

Treatment and Rate <sup>1</sup>	Timing <sup>2</sup>	Stand Count <sup>3</sup>	% Canopy Decline <sup>4</sup>	RRCR <sup>5</sup>	Yield <sup>6</sup>
1. Non-treated non-inoculated check	A	0.0 b <sup>7</sup>	0.3 d	2.0 a	30,202.1 a
2. Non-treated inoculated check	A	23.5 a	58.8 a	11.0 a	11,297.9 b
3. Headline 9 fl oz	B	0.5 b	7.8 bcd	8.0 a	29,222.2 a
4. Xanthion IF Comp A					
Integral 1.2 fl oz	B	15.9 ab	10.5 bc	5.5 a	26,842.3 a
Xanthion IF Comp B					
Headline 9 fl oz	B				
5. Xanthion IF Comp A					
Integral 1.2 fl oz	B	2.0 b	3.0 cd	3.0 a	30,726.8 a
Xanthion IF Comp B					
Headline 9 fl oz	B				
Priaxor 6.7 fl oz	C				
6. Priaxor 6.7 fl oz	C	23.5 a	14.8 b	5.5 a	22,579.4 a
<i>LSD (p≤0.05)</i>		<i>17.79</i>	<i>9.81</i>	<i>ns</i>	<i>9,590.0</i>

<sup>1</sup>Treatments were applied using a single-nozzle sprayer.

<sup>2</sup>Timings: A=untreated, B=In-furrow on May 5, C=Banded 8–12 leaf stage on June 19.

<sup>3</sup>Percent canopy decline was determined July 2.

<sup>4</sup>Incidence is reported as average number of plants displaying RRCR symptoms August 17.

<sup>5</sup>Ten beets per plot were rated for percent surface area showing discoloration at harvest.

<sup>6</sup>lb/ac of roots on September 28.

<sup>7</sup>Treatment means followed by different letters differ significantly ( $p \leq 0.05$ ).

# Foliar Fungicide Effect on Early Blight Severity and Yield of Potato in Wyoming

M. Wallhead<sup>1</sup> and W. Stump<sup>1</sup>

## Introduction

Early blight of potato (*Solanum tuberosum*) caused by the pathogen *Alternaria solani* is a disease of concern for growers in all potato growing regions of the country, including seed production areas of eastern Wyoming and western Nebraska. If left uncontrolled the disease may cause severe defoliation, resulting in reduced tuber size and number. Foliar fungicides are the primary means of early blight management on potato in the U.S.

## 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 in 2015 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle. The experimental design was a randomized complete block with four replications. Plots were four rows (36-in row centers) by 20-ft long, with a 5-ft in-row buffer. Plots were planted June 2 with cultivar Atlantic. Emergence was observed June 15, and plots were hilled July 1. After irrigation on both June 23 and 30, *A. solani* conidia ( $1.65 \times 10^4$  conidia/ml) were applied along the length of two center rows of each plot. Inoculations were made in a total volume of 1.06 gal/1,000 ft of row via a single-nozzle CO<sub>2</sub>-assisted sprayer. Foliar fungicide treatments were applied July 22 and 30, and August 7 and 13. Fungicides were applied with a CO<sub>2</sub>-assisted sprayer in a total volume of 43 gal/ac at 30 psi boom pressure. Early blight disease severity was measured by calculating the average number of lesions per leaflet. 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 August 4, 12, and 19. Two rows by 10 ft were harvested with a two-row mechanical digger on September 24.

## Results and Discussion

Disease initiated and progressed slowly throughout the season resulting in low disease, overall. Data is summarized in Table 1. No phytotoxicity due to foliar treatment was observed in the potato crop. Early blight was first confirmed in the plots on June 30, following inoculations on June 23 and 30. Fungicide treatments reduced overall disease by, on average, 41% as measured by a season-long measurement of disease, the area under the disease progress curve (AUDPC), compared to the non-treated check ( $p \leq 0.05$ ). The exception was the Echo® + Dithane™ Rainshield treatment, which had similar levels of disease as the untreated check. Fungicide programs had no significant effect on yield, most likely due to low disease pressure.

## Acknowledgments

We thank Wendy Cecil and SAREC field crews for assistance in plot establishment and harvesting. Also, we thank Bayer CropScience and Western Potatoes Inc. for their support.

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**Keywords:** potato, early blight, fungicides

**PARP:** I:1, X:3

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<sup>1</sup>Department of Plant Sciences.

**Table 1.** Foliar fungicide effect on early blight severity and yield of potato in Wyoming, 2015.

Treatment and rate (fl oz)/ac <sup>1</sup>	Fungicide application dates <sup>2</sup>	Aug. 4 <sup>3</sup>	Aug. 19 <sup>3</sup>	AUDPC <sup>4</sup>	Yield <sup>5</sup>
Untreated Check		6.3 a <sup>6</sup>	36.6 ab	257.1 a	262.0 a
Luna® Tranquility (11.2)	AB	1.9 b	8.8 c	112.2 b	311.1 a
Scala® 60 SC (7)	C				
Echo ZN (24)	C				
Echo ZN (32)	D				
Luna Tranquility (11.2)	AC	2.2 b	11.0 bc	113.3 b	353.2 a
Scala 60 SC (7)	BD				
Echo ZN (24)	BD				
Luna Tranquility (11.2)	AB	2.1 b	8.8 c	102.9 b	326.2 a
Echo ZN (32)	C				
Reason® (5.5)	C				
Quash® (5.5)	D				
Echo ZN (32)	A	2.4 b	6.2 c	88.4 b	353.0 a
Endura® (2.5)	BD				
Headline® (9)	C				
Echo ZN (32)	AC	7.0 a	42.3 a	255.5 a	281.4 a
Dithane Rainshield (32)	BD				
<i>LSD</i>		<i>3.7</i>	<i>18.2</i>	<i>115.5</i>	<i>ns</i>

<sup>1</sup>All fungicide treatments included 0.125% v/v (volume/volume) NIS (non-ionic surfactant).

<sup>2</sup>Fungicide application dates as follows: A=July 22, B=July 30, C=August 7, D=August 13.

<sup>3</sup>Average number of early blight lesions per leaflet.

<sup>4</sup>Area Under the Disease Progress Curve.

<sup>5</sup>Total tuber yield (cwt/ac)

<sup>6</sup>Treatment means followed by different letters differ significantly ( $p \leq 0.05$ ).

# Foliar Fungicide Programs to Manage Potato Early Blight

*M. Wallhead<sup>1</sup> and W. Stump<sup>1</sup>*

## Introduction

Early blight is a disease of potato (*Solanum tuberosum*) caused by the pathogen *Alternaria solani*. Despite incorporating cultural practices to discourage the development of disease, early blight often requires additional control measures. Foliar fungicides are the primary means for achieving effective early blight control on potato in the U.S., including eastern Wyoming, western Nebraska, and other important seed potato production areas.

## 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 in 2015 at the James C. Hageman Sustainable Agriculture Research and Extension Center near Lingle. The experimental design was a randomized complete block design with four replications. Plots were four rows (36-in row centers) by 20-ft long, with a 5-ft in-row buffer. Plots were planted June 2 with cultivar Atlantic. Emergence was observed June 15, and plots were hilled July 1. After irrigation on both June 23 and 30, *Alternaria solani* conidia ( $1.65 \times 10^4$  conidia/ml) were applied along the length of two center rows of each plot. Inoculations were made in a total volume of 1.06 gal/1,000 ft of row via a single-nozzle CO<sub>2</sub>-assisted sprayer. Foliar fungicide treatments were applied July 22 and 30, and August 7 and 13. Fungicides were applied with a CO<sub>2</sub>-assisted sprayer in a total volume of 43 gal/ac at 30 psi boom pressure. Early blight disease severity was measured by calculating the average number of lesions

per leaflet. Six leaves were randomly selected from each treatment plot—two leaves each from the top, middle, and bottom third of the canopy. Leaves were collected August 4, 12, and 19. Two rows by 10 ft were harvested with a two-row mechanical digger on September 24.

## Results and Discussion

No phytotoxicity due to foliar treatments was observed in the potato crop. Data is summarized in Table 1. Following inoculations on June 23 and 30, disease initially progressed slowly then advanced slowly throughout the season resulting in low disease levels. Early blight was first confirmed in the plots June 30. All treatments reduced overall disease by roughly 50% as measured by the area under the disease progress curve (AUDPC), compared to the non-treated check ( $p \leq 0.05$ ). For AUDPC (a measure of season-long disease) there were no significant differences between fungicide treatments. Fungicide programs had no significant effect on yield and quality most likely due to low disease pressure.

## Acknowledgments

We thank Wendy Cecil and SAREC field crews for assistance in plot establishment and harvesting. Also, we thank Gowan Co. for its support.

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**Keywords:** potato, early blight, fungicides

**PARP:** I:1, X:3

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<sup>1</sup>Department of Plant Sciences.

**Table. 1** Foliar fungicide programs to manage potato early blight, 2015.

Treatment and rate/ac <sup>1</sup>	Fungicide application dates <sup>2</sup>	Aug. 4 <sup>3</sup>	Aug. 19 <sup>3</sup>	AUDPC <sup>4</sup>	Yield <sup>5</sup>
Untreated Check		1.5 a <sup>6</sup>	11.0 a	137.1 a	292.2 a
Luna® Tranquility (11 fl oz)	A	0.3 ab	3.3 c	52.3 b	332.9 a
Zing!® (32 fl oz)	B				
Gavel® (2 lb)	C				
Endura® (5.5 fl oz)	A	0.1 b	3.6 bc	66.4 b	313.8 a
Zing! (32 fl oz)	B				
Gavel 75DF (2 lb)	C				
Omega® 500F (8 fl oz)	A	0.4 ab	5.4 bc	76.5 b	288.4 a
Zing! (32 fl oz)	B				
Gavel (2 lb)	C				
Zing! (32 fl oz)	ABC	0.1 b	7.0 b	79.2 b	326.4 a
Gavel 75DF (2 lb)	ABC	0.4 ab	5.6 bc	71.7 b	295.9 a
Luna Tranquility (11 fl oz)	A	0.1 b	3.1 c	64.3 b	344.3 a
Badge® SC (1.5 pt)	A				
Dithane™ F45 (1.5 qt)	B				
Zing! (32 fl oz)	C				
<i>LSD</i>		<i>0.9</i>	<i>3.7</i>	<i>28.9</i>	<i>ns</i>

<sup>1</sup>All fungicide treatments included 0.125% v/v (volume/volume) NIS (non-ionic surfactant).

<sup>2</sup>Fungicide application dates as follows: A=July 22, B=July 30, C=August 7, D=August 13.

<sup>3</sup>Average number of early blight lesions per leaflet.

<sup>4</sup>Area Under the Disease Progress Curve.

<sup>5</sup> Total tuber yield (cwt/ac) on September 24.

<sup>6</sup>Treatment means followed by different letters differ significantly ( $p \leq 0.05$ ).



# Seed Treatment and In-Furrow Fungicide Effects on Rhizoctonia Stem Canker and Yield of Potato in Wyoming

M. Wallhead<sup>1</sup> and W. Stump<sup>1</sup>

## Introduction

Rhizoctonia stem canker is a disease of potato (*Solanum tuberosum*) caused by the soil-borne pathogen *Rhizoctonia solani*. Seed treatment and in-furrow fungicides are management options for Rhizoctonia stem canker of potato in the U.S., which includes the potato growing areas of eastern Wyoming and western Nebraska.

## Objectives

The objectives of this study are to determine the effect of seed treatment and in-furrow fungicides on Rhizoctonia stem canker management and yield for potato.

## Materials and Methods

Field plots were placed in 2015 at the James C. Hageman Sustainable Agriculture Research and Extension Center near Lingle. The experimental design was a randomized complete block with four replications. Plots were 4 rows (36-in row centers) by 20-ft long, with a 5-ft in-row buffer. Fresh cut seed (cultivar Atlantic) was treated on May 27 and planted June 4. While planting, 1.8 ounces of ground barley infested with *Rhizoctonia solani* was applied in-furrow along each of the two center rows of each plot. In-furrow fungicides were applied at planting with the aid of a CO<sub>2</sub> backpack sprayer at a volume of 1.06 gal/1,000 ft of row. Final emergence was determined June 30. Five stems were randomly selected from each treatment plot on August 27 and rated for Rhizoctonia stem canker severity. Two rows by 10 ft were harvested with a two-row mechanical digger on September 24.

## Results and Discussion

No phytotoxicity due to seed treatments or in-furrow fungicide treatment was observed in the potato crop. Data is summarized in Table 1. Rhizoctonia stem canker progressed slowly throughout the season resulting in low disease levels. Fungicide treatment had a significant effect for the June 30 stand count improving final stands on average 23% compared to the untreated check ( $p \leq 0.05$ ). Fungicide treatments had no significant effect on Rhizoctonia stem canker incidence or severity. Fungicide program had a significant effect on yield with the Emesto<sup>®</sup> Silver + Nubark Mancozeb + Serenade Soil<sup>®</sup> + Quadris<sup>®</sup> treatment having significantly higher yields ( $p \leq 0.05$ ) than both the untreated control and the Nubark<sup>®</sup> Mancozeb treatment.

## Acknowledgments

We thank Wendy Cecil and SAREC field crews for assistance in plot establishment and harvesting. Also, we thank Gowan Co. for its support.

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**Keywords:** potato, *Rhizoctonia solani*, fungicides

**PARP:** I:1, X:3

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<sup>1</sup>Department of Plant Sciences.

**Table 1.** Seed treatment and in-furrow fungicide effects on Rhizoctonia stem canker and yield of potato in Wyoming, 2015.

Treatment and rate	Fungicide application dates <sup>1</sup>	June 30 <sup>2</sup>	Rhizoctonia Severity <sup>3</sup>	Yield <sup>4</sup>
Untreated Check		26.8 b <sup>5</sup>	0.9 a	287.1 b
Emesto Silver FS (0.31 fl oz/cwt)	A	33.0 ab	0.8 a	353.5 ab
Nubark Mancozeb DS (60 gr A.I./cwt)	A			
Quadris (8.7 fl oz/ac)	B			
Emesto Silver FS (0.31 fl oz/cwt)	A	32.3 ab	0.8 a	383.0 ab
Nubark Mancozeb DS (60 gr A.I./cwt)	A			
Serenade Soil FL (2 qt/ac)	B			
Emesto Silver FS (0.31 fl oz/cwt)	A	35.3 a	0.4 a	428.9 a
Nubark Mancozeb DS (60 gr A.I./cwt)	A			
Serenade Soil FL (1 qt/ac)	B			
Quadris (8.7 fl oz/ac)	B			
Emesto Silver FS (0.31 fl oz/cwt)	A	30.0 ab	0.8 a	351.2 ab
Serenade Opti (16 fl oz/ac)	A			
Emesto Silver FS (0.31 fl oz/cwt)	A	35.3 a	0.7 a	371.9 ab
Nubark Mancozeb DS (60 gr A.I./cwt)	A			
Nubark Mancozeb DS (60 gr A.I./cwt)	A	31.3 ab	0.7 a	317.0 b
	<i>LSD</i>	<i>4.15</i>	<i>ns</i>	<i>65.1</i>

<sup>1</sup>Fungicide application dates as follows: A=Seed Treatment, May 27, B=In-furrow, June 4.

<sup>2</sup>Stand count determined by counting the total number of plants in the center two rows (20 ft) of each plot.

<sup>3</sup>Five stems representing five hills were randomly selected from each treatment plot on August 27. Rhizoctonia stem canker severity was measured by calculating the average stem surface area showing discoloration on a scale of 0–3 where 0=no lesions, 1=<10% lesion of root surface area, 2=lesion surface area is 10–50%, 3=>50% surface area affected with lesions.

<sup>4</sup>Total tuber yield cwt/ac on September 24.

<sup>5</sup>Treatment means followed by different letters differ significantly ( $p \leq 0.05$ ).

# Willingness to Pay and Information Demand for Locally Produced Honey

*L. Thunstrom<sup>1</sup>, C. Jones Ritten<sup>2</sup>, M. Ehmke<sup>2</sup>, J. Beiermann<sup>2</sup>, and C. Ehmke<sup>2</sup>*

## Introduction

The market for honey is changing rapidly. One important factor affecting this is the recent die-off of domestic honey bees at dramatic rates, leading to drastic decreases in domestic honey production. The honey market, therefore, increasingly relies on foreign honey to satisfy demand. Foreign honey, however, may pose risks to consumer health because of reports of high levels of pesticides and heavy metals.

## Objectives

This project aims at analyzing how consumers evaluate health risks of consuming international honey and how these risks influence consumer willingness to pay for honey produced in Wyoming. Our focus is on Wyoming consumers. More specifically, our objectives are to answer the following: (1) are consumers willing to pay a premium for Wyoming honey? (2) how is consumer willingness to pay for Wyoming honey impacted by health information about Wyoming honey?; and (3) do consumers value information regarding the origin of honey?

## Materials and Methods

The study was conducted using economic experiments at (1) the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle during spring 2015; (2) Eastern Wyoming College in Torrington during spring 2015; and (3) the University of Wyoming during fall 2015. The experiments were designed to extract consumers' true willingness to pay for Wyoming honey versus honey of unknown origin. The study included 449 participants who were divided into different treatment groups, which enabled measures of how consumer demand for local honey is affected by different types of information. Locally produced honey

and honey of unknown origin were put in identical looking "honey bear" bottles (Figure 1). Each subject was randomly given a bottle, which they could switch to a bottle of different origin, depending on their decisions in the experiment. Each subject got to keep the bottle they chose as part of the experiment. We also included treatments where consumers could choose to take or avoid information. In real markets, consumers are often able to choose if they want to learn or disregard product information, including origin information. The latter enabled us to test if demand for origin information matters for demand for local honey.

## Results and Discussion

We found that consumers were highly concerned about their honey being locally produced. A majority of consumers (53%) were willing to pay a premium of \$2.48 for an eight-ounce jar of honey produced in Wyoming



**Figure 1.** Locally produced honey and honey of unknown origin were put in identical looking bottles that were given randomly to subjects.

<sup>1</sup>Department of Economics and Finance; <sup>2</sup>Department of Agricultural and Applied Economics.

compared to honey of unknown origin. We also found that providing information on the health benefits of locally produced honey increased the percentage of consumers willing to pay the premium for Wyoming honey. Further, consumers generally assign a positive value to information on the origin of the honey they are offered to buy. More specifically, around 80% of study participants preferred information about the origin of the honey (over not knowing the origin), and they used that knowledge to ensure that they bought locally produced honey, even if the local honey came at an additional cost of \$2.48.

### **Acknowledgments**

This study is supported by the Wyoming Agricultural Experiment Station's Competitive Grants Program.

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**Keywords:** honey, demand, locally produced

**PARP:** VII:5 (although the project concerns honey, not meat)

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# Sheridan Research and Extension Center: 125 Years of Agricultural Research in Northeast Wyoming

B.A. Meador<sup>1,2</sup>

The University of Wyoming, in cooperation with the citizens of Sheridan County, initiated the Sheridan Agricultural Experiment Station in 1891. The primary location of the station has moved several times, but agricultural research has been continuous at the Wyarro experiment farm east of Sheridan since 1916. Thanks to cooperation from Sheridan College (SC), Whitney Benefits, and other partners, UW expanded research and outreach efforts over 2012–13 to include irrigated and non-irrigated lands immediately south of the SC campus as well as the SC Watt Regional Agriculture Center and a research greenhouse complex. Our goals today are very similar to the goals of the experiment station described in the original Bulletin No. 1 in 1891: “to acquire useful and practical information” related to agriculture and grazing, “to diffuse the same among the farmers and grazers of Wyoming,” and to hold “Farmer’s Institutes,” where “station workers can talk personally with our citizens about the experiments.”

From its inception, what is now called the Sheridan Research and Extension Center (ShREC) has focused on the development and evaluation of plant materials under local environmental conditions and on assessing how various management practices influence the performance of those plants. Very early efforts included experiments in growing wheat, oats, corn, sorghum, sugarbeets, rhubarb, fruit trees, willows, and other plant species and varieties. Over the years, ShREC has provided valuable, locally relevant, scientific information on dryland farming, vegetable and fruit production, sheep and poultry production, range improvements, ornamental horticulture, weed management, seed production and certification, and other subjects. ShREC’s current efforts

reflect advanced scientific methods applied to practical challenges faced by agriculture and natural resources in three primary emphasis areas:

## Horticulture

Broadly, horticultural science focuses on producing, improving, marketing, and using plants for food, ornamentation, and aesthetics. Horticultural projects at ShREC encompass this diverse array of subject areas. Developing grape cultivars suited to Wyoming’s relatively harsh climates is a difficult task, but by incorporating conventional breeding techniques with molecular biotechnology, ShREC researchers are using precision breeding in their attempt to accelerate the selection process. Research comparing vegetable production in high and low tunnels to production in unprotected areas seeks to extend the duration of time Wyoming growers can produce vegetables to meet growing demand for locally produced food. Exploration of potential new high-value crops, such as goji berry, may provide new enterprise options for diversified producers.



**Figure 1.** Sheridan Research and Extension Center faculty and staff, from left, Mike Albrecht, assistant farm manager; Rochelle Koltiska, office associate; Brian Meador, director; Dan Smith, farm manager; and Sadanand Dhekney, assistant professor.

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<sup>1</sup>Sheridan Research and Extension Center; <sup>2</sup>Department of Plant Sciences.

## **Forage Agronomy**

Crops grown for livestock consumption make up the majority of farming acreage in Wyoming. Optimizing those forage species' performance under various management scenarios and understanding how to best manage their persistence and productivity through time are key components to any forage production systems. Current forage research projects at ShREC focus on evaluating single-species and mixed-species forage crops for productivity and persistence in irrigated or dryland settings. In addition to comparing relative performance among species and varieties under uniform growth conditions, applied research at ShREC seeks to better understand how field management practices, such as mechanical soil disturbance or including alternative crops into rotations, affect hay production.

## **Rangeland Restoration**

This diverse area of research, which includes multiple specializations, focuses on repairing ecological structure and function to rangeland ecosystems that have been degraded by various stressors: invasive plant species, mismanaged grazing, direct disturbance caused by human activities, wildfires, prolonged drought, and others. Successful rangeland restoration requires applying knowledge of biology and ecology toward impaired natural systems. In some cases, reduction or removal of invasive weeds is sufficient to initiate natural recovery of rangeland ecosystems. In other instances, more intensive restoration efforts, such as reintroducing desirable plant species, is needed. ShREC is increasing its efforts in this field with a number of projects, including ones that investigate (1) control of problematic weeds—such

as cheatgrass and Canada thistle—with herbicides and non-chemical methods; (2) the contribution of genetic diversity to seeding success; and (3) the use of non-conventional methods to increase native plant materials for restoration.

## **Outreach and Education**

While we emphasize the research mission of UW's College of Agriculture and Natural Resources, we actively engage in teaching and extension missions as well. ShREC-based faculty members teach formal coursework in the UW Outreach School and contribute regularly to programs at SC. Students (from junior high to Ph.D. candidates) and local producers gain firsthand experience by participating in internships, field days, and special sessions at ShREC.

## **Acknowledgments**

Members of the ShREC team strive to provide a setting where researchers, students, and other partners have access to high-quality research and learning opportunities (Figure 1). Our partnerships with Whitney Benefits, SC, UW Extension, the ShREC Advisory Board, and others expand our ability to serve the needs of stakeholders in Sheridan County and north-central/northeast Wyoming.

## **Contact Information**

Brian Mealor at [bamealor@uwyo.edu](mailto:bamealor@uwyo.edu) or 307-673-2647.

**Keywords:** horticulture, forage agronomy, rangeland restoration

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



# Short Reports

## 1. Studying cellular and physiological responses of grapevine to abiotic stress factors

**Investigators:** Sadanand Dhekney and Ami Erickson

**Issue:** Global shifts in climate change resulting from rising temperatures and drought can severely affect grape yield and quality attributes and limit cultivation in regions otherwise suitable for grapevine cultivation. Semiarid grapevine production regions frequently suffer from drought and are prone to salinization.

**Goal:** The overall goal of the project is to examine tissue development and compare physiological responses to water stress to better utilize precision breeding tools for deriving drought-tolerant *Vitis* varieties for Wyoming.

**Objectives:** (1) Examine tissue development and plant physiology during water stress to better understand the effects of drought on plant growth and development; and (2) genetically engineer grapevines for drought and salinity tolerance.

**Expected Impact:** Understanding how grapes respond to water stress in the form of drought or salinity is important for identifying cultivars and plant traits that will facilitate variety development for Wyoming.

**Contact:** Sadanand Dhekney at [sdhekney@uwyo.edu](mailto:sdhekney@uwyo.edu) or 307-673-2754.

**Keywords:** grape, drought, salinity

**PARP:** I:1, X:1

## 2. Deep-pot cottonwoods for riparian restoration

**Investigators:** Brian A. Mealor, Daniel Smith, Jennifer Hinkhouse, and Debbie Hepp

**Issue:** Cottonwood trees play an important role in many of Wyoming's riparian systems, but multiple stressors may be leading to reduction in establishment of new cottonwoods from seed. Various efforts have been undertaken to restore cottonwoods to areas where they have been depleted, and U.S. Department of Agriculture research in Montana indicates that transplanting cottonwoods grown in deep pots (>24-inch depth) improves transplant survival and subsequent growth.

**Goal:** Produce sufficient numbers of deep-potted cottonwood trees from locally sourced cuttings and purchased plant materials to support a future evaluation of transplant survival in a Campbell County riparian area.

**Objectives:** Propagate multiple cottonwood trees in deep pots in the Sheridan Research and Extension Center greenhouse and high tunnels so they are ready for transplanting into a field setting in spring 2017.

**Expected Impact:** The cottonwoods grown from this initial project will support a planned restoration project and evaluation of plant materials in Campbell County. Information gained should assist landowners and conservation partners with riparian restoration projects in the future.

**Contact:** Brian Mealor at [bamealor@uwyo.edu](mailto:bamealor@uwyo.edu) or 307-673-2647.

**Keywords:** riparian restoration, cottonwood regeneration, wildlife habitat

**PARP:** IX:4, X:3, XII:1

### 3. Evaluating chronic herbicide exposure for long-term reduction of Canada thistle

**Investigators:** Brian A. Mealor

**Issue:** Although newer herbicides are effective in controlling creeping perennial weeds, which negatively affect agroecosystems by altering species composition and productivity, it is difficult to achieve long-term control with a single herbicide application. Split applications (multiple applications of a recommended rate distributed throughout a growing season) have not been fully investigated for their ability to affect such noxious weeds.

**Goal:** This pilot study seeks to evaluate the effect split applications of a single herbicide rate have on the perennial noxious weed Canada thistle (*Cirsium arvense*).

**Objectives:** We will apply a systemic herbicide known to be effective on Canada thistle in six different timing/rate treatments and evaluate treatment impacts over multiple years.

**Expected Impact:** If we are able to achieve long-term Canada thistle control by multiple applications within a single growing season, weed managers may have the flexibility to focus efforts in a target geographic area without the need to return to a site for several years into the future.

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

**Keywords:** Canada thistle (*Cirsium arvense*), weed control, invasive species

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

### 4. Evaluating foxtail barley management options

**Investigators:** Brian A. Mealor and Gustavo Sbatella

**Issue:** Foxtail barley (*Hordeum jubatum*)—a short-lived perennial grassy weed found in pastures and hayfields—has long awns on the seed heads that may injure livestock if consumed as standing forage or in hay. Foxtail barley management has been a challenge for producers in Wyoming for many years, and control options are limited.

**Goal:** Control foxtail barley while increasing desirable forage grass species.

**Objectives:** Evaluate various herbicides to control foxtail barley in an irrigated hayfield, and determine whether seeding of competitive desirable grasses improves foxtail barley reduction over time.

**Expected Impact:** If suitable management options are identified, this research could help increase pasture and hayfield productivity and quality.

**Contact:** Brian Mealor at bamealor@uwyo.edu or 307-673-2647, or Gustavo Sbatella at gustavo@uwyo.edu or 307-754-2223.

**Keywords:** foxtail barley, control, desirable grass

**PARP:** III:3,5,7, VI:3

## 5. Evaluating herbicide mixtures and seeding of cheatgrass-dominated sites

**Investigators:** Brian A. Mealor

**Issue:** Cheatgrass is one of the most significant weeds in western North America because it causes many negative ecological and economic impacts. Direct-seeding of desirable native species may be required to restore ecosystem function where cheatgrass dominates; however, because cheatgrass is a strong competitor for early season moisture, it is difficult to establish seeded species in the absence of cheatgrass control.

**Goal:** Evaluate various herbicides within a restoration setting for their ability to reduce cheatgrass competition and facilitate desirable native species establishment.

**Objectives:** (1) Apply 10 different herbicide treatments in spring 2016; (2) seed six different desirable species or species mixes in fall 2016; and (3) evaluate cheatgrass control and native species establishment and growth for two years.

**Expected Impact:** Identifying methods for re-establishing desirable species in cheatgrass-dominated sites should help land managers increase grazing carrying capacity for livestock, improve habitat for important wildlife such as greater sage-grouse and mule deer, and reduce wildfire risk.

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

**Keywords:** cheatgrass (*Bromus tectorum*), weed control, invasive species

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

## 6. Evaluating new herbicide mixtures for rangeland cheatgrass management

**Investigators:** Brian A. Mealor

**Issue:** Although current methods to control cheatgrass are relatively consistent and effective, they require relatively frequent re-treatment to maintain low levels of this noxious weed. Some herbicides not previously used in rangeland settings may provide longer-term control with a single application.

**Goal:** Evaluate various herbicides for their ability to reduce cheatgrass with limited impact on existing desirable plants.

**Objectives:** We applied eight different herbicide treatments at two timings (late winter and spring 2016) and will evaluate their impacts on cheatgrass and desirable species in a field setting.

**Expected Impact:** Any methods that provide longer-term cheatgrass control while limiting harm to desirable species will have broad-reaching impacts in the West, including Wyoming, where cheatgrass is found across much of the region and state.

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

**Keywords:** cheatgrass (*Bromus tectorum*), weed control, invasive species

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

## 7. Evaluating soil amendment MB906 with and without imazapic for cheatgrass control

**Investigators:** Brian A. Mealor

**Issue:** A significant amount of public interest has been generated in the last few years regarding a soil quality amendment containing the bacteria *Pseudomonas fluorescens* for its potential to reduce cheatgrass on rangelands. Land managers have been applying it alone or mixed with the herbicide imazapic under various circumstances, but little replicated research is available on its efficacy.

**Goal:** Determine the efficacy of MB906 soil amendment for reducing cheatgrass alone and with two different rates of imazapic.

**Objectives:** We applied MB906 at three different rates alone or crossed with two different rates of imazapic in a field setting in late fall 2015 to assess their relative effects on cheatgrass populations and desirable species.

**Expected Impact:** We will be able to provide first-hand knowledge to interested land managers about this potential method for managing cheatgrass in rangelands.

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

**Keywords:** cheatgrass (*Bromus tectorum*), weed control, invasive species

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

## 8. Biological versus mechanical tillage for hayfield improvement

**Investigators:** Daniel Smith, Mike Albrecht, and Brian A. Mealor

**Issue:** Repeated use of machinery in perennial crops grown for hay production may result in soil compaction, reduced water infiltration, and potential declines in plant productivity. While various mechanical methods are most common, there is increasing interest in the use of cover crops as an alternative for improving soil structure and adding biological diversity to a cropping system.

**Goal:** Compare a cover crop, which includes tillage radish, to subsurface mechanical tillage methods for renovating an alfalfa field in heavy clay soils.

**Objectives:** Compare the effects of tillage radish, chisel plowing, subsoiling, and disc-ripping on hay production over multiple years.

**Expected Impact:** This project originated from a discussion in a Sheridan Research and Extension Center Advisory Board meeting related to extending the life and productivity of alfalfa hay. Findings may provide producers with alternative approaches in managing aging alfalfa stands.

**Contact:** Dan Smith at dmsmith@uwyo.edu or 307-673-2856.

**Keywords:** hay production, alfalfa

**PARP:** I:7, II:6

## 9. Evaluating alfalfa and sainfoin under dryland conditions

**Investigators:** Daniel Smith, Mike Albrecht, and Brian A. Mealor

**Issue:** Perennial hay being the most prominent crop in Wyoming has resulted in many varieties of alfalfa and several varieties of sainfoin being available for various situations. Dryland hay production in northeast Wyoming is important to many agricultural producers, but comparative information on production in dryland conditions is limited.

**Goal:** Evaluate forage production among alfalfa and sainfoin varieties three years after seeding under dryland conditions (seeding took place June 12, 2012, at the Sheridan Research and Extension Center's Wyarno station).

**Objectives:** Document forage production of 17 alfalfa and three sainfoin varieties in dryland, and provide local producers an opportunity to see the different varieties firsthand.

**Expected Impact:** This variety trial should provide locally relevant information on various forage varieties in dryland, which may assist producers in decision-making regarding forage choices.

**Contact:** Dan Smith at [dmsmith@uwyo.edu](mailto:dmsmith@uwyo.edu) or 307-673-2856.

**Keywords:** hay production, alfalfa

**PARP:** I, II:9

## 10. Mechanical renovation of deteriorating alfalfa stands

**Investigators:** Daniel Smith, Mike Albrecht, Brian A. Mealor, and Brian Lee

**Issue:** Hay fields are typically renovated by costly tillage or by herbicide application followed by no-till seeding. Some local producers have historically preformed various types of management practices during the lifespan of their fields to rejuvenate existing stands.

**Goal:** Evaluate whether low-cost mechanical methods used each season can be used to improve productivity of an aging alfalfa hay stand over multiple years.

**Objectives:** (1) Compare the effectiveness of various mechanical treatments (harrow, aerate, cultivate) with conventional hayfield renovation techniques (herbicide, plow, reseed with cover crop); and (2) evaluate the costs of each practice.

**Expected Impact:** This project originated from a discussion in a Sheridan Research and Extension Center Advisory Board meeting related to extending the life and productivity of alfalfa hay. Findings may provide producers with alternative approaches to managing aging alfalfa stands.

**Contact:** Dan Smith at [dmsmith@uwyo.edu](mailto:dmsmith@uwyo.edu) or 307-673-2856.

**Keywords:** hay production, alfalfa

**PARP:** I:7, II:6

## 11. Studying propagation techniques for goji berry

**Investigators:** Jeremiah Vardiman, Sadanand Dhekney, and Michael Baldwin

**Issue:** Goji berry, which offers a host of health benefits including amino acids, vitamin C, and antioxidants, is currently imported from China to meet demands of the U.S. health and supplement food industries. Preliminary studies at Sheridan Research and Extension Center indicate that goji berry has the potential to be a viable crop for Wyoming growers seeking to diversify their operations.

**Goal:** Explore greenhouse propagation of goji berry through hardwood and softwood cuttings to optimize vegetative propagation for rapid production and availability of planting material.

**Objectives:** (1) Study the effect of various rooting hormones and substrate media on rooting of softwood and hardwood cuttings for the production of healthy true-to-type plants; and (2) compare the growth and reproductive parameters of plants obtained through vegetative propagation and seed-derived plants to identify potential differences in time required for flowering, fruiting, and yield.

**Impact:** The direct potential economic impact would include development of a new cold-hardy crop suitable for Wyoming growing conditions. The project could benefit current and prospective growers of fruits and vegetables under field and protected conditions (high tunnels, for example), and it could help commercial growers wishing to diversify their agricultural operations.

**Contact:** Sadanand Dhekney at [sdhekney@uwyo.edu](mailto:sdhekney@uwyo.edu) or 307-673-2754.

**Keywords:** goji berry, fruit, cold-hardy

**PARP:** I:1, X:1

# Evaluation of Forage Productivity and Environmental Benefits of Meadow Bromegrass in Various Mixtures with Popular Legumes under Irrigation

*D.S. Ashilenje<sup>1</sup> and M.A. Islam<sup>1</sup>*

## Introduction

Forage grass-legume mixtures have been associated with relatively higher forage production and quality, as well as reduced use of nitrogen (N) fertilizers. The latter is beneficial because N can give rise to pollution of the environment. High quality hay and pastures in such mixtures further contribute to desirable livestock performance and product quality; as a result, more profits can be realized. Common mixtures comprising popular N-fixing leguminous species include alfalfa, sainfoin, and bird's-foot trefoil (BFT) in varied ratios with carbohydrate-rich, cool-season grasses such as meadow bromegrass. The success of such production systems, however, lies in consistent yields, quality, and lengthened crop lifespan. Furthermore, forage mixtures that exploit natural sources of nutrients can significantly reduce reliance on the application of inorganic N fertilizers.

## Objectives

The objectives of this study are to determine N fixation by irrigated alfalfa, sainfoin, and bird's-foot trefoil in varied mixtures with meadow bromegrass and how this influences forage yield profitability and trace gas emissions.

## Materials and Methods

The field experiment was established at the Sheridan Research and Extension Center (ShREC) in September 2013. There are 15 treatments consisting of unfertilized alfalfa (cultivar 'WL363HQ'), sainfoin (cultivar 'Shoshone'), and BFT (cultivar 'Norcen') monocrops as well as meadow bromegrass (cultivar 'Fleet'). The treatments were supplied with 0, 50, and 100 pounds of N per acre as urea. In addition, meadow bromegrass is in a

50:50 and 70:30 percent-ratio combination with each of the above-stated legume species. The other set of treatments constitutes 50% grass combined with 25% each of two alternative legumes (alfalfa with BFT, alfalfa with sainfoin, and sainfoin with BFT). Lastly, meadow bromegrass (50%) is entirely mixed with the three legumes, each accounting for a 16.7% ratio. The amount of N fixed by respective legumes in monoculture and mixtures will be monitored along with yield and quality parameters at four different growth stages, beginning mid-April, mid-June before first cut, mid-July during growth initiation, and early September. Economic benefits will be determined using partial budgets based on costs of inputs and prevailing market value for hay. Trace gas samples will be collected with soil samples for moisture and microbial biomass quantification during different crop-management phases in early season before N application, mid-season after N application, and, ultimately, end-season following final harvest.

## Results and Discussion

Preliminary results indicate that dry matter yield increased from 1,619 to 2,033 pounds per acre (lbs/ac) for 50:50 and 70:30 grass-alfalfa mixtures, respectively. Yields obtained from mixing these two crops were similar to grass monocrop (1,583 to 1,997 lbs/ac) regardless of the amount of N supplied. Similarly, sainfoin-grass mixtures had dry matter yields ranging from 1,439 to 1,529 lbs/ac, which were similar to those from grass monocrops. Alfalfa monocrop contributed to greater crude protein in forage mixtures, which were 322.7 to 354.8 lbs/ac for 50:50 and 30:70 ratios with grass, respectively, compared to similar crop mixtures incorporated with sainfoin (177 to 193.5 lbs/ac).

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<sup>1</sup>Department of Plant Sciences.

The above-mentioned alfalfa-grass mixtures gave forage biomass that was superior in protein content compared to grass monocrops that received N fertilizer (199.4 to 305.8 lbs/ac). Overall, BFT produced the least yields and protein contents in mixtures as well as monocrops. Grass-legume mixtures and N fertilizer application had significant ( $p=0.0022$ ) effects on shoot biomass total N measured in lbs/ac. As shown in Table. 1, alfalfa monocrop had highest shoot N content of 7.33 lbs/ac, which was similar to that for meadow brome-grass monocrop (5.23 lbs/ac) when supplied with 100 lbs/ac of N fertilizer. N content for alfalfa in 50:50 and 30:70 mixtures were 2.80 and 2.85 lbs/ac, respectively, which were comparable to 3.03 lbs/ac for grass fertilized with 50 lbs/ac of N.

These results confirm that inclusion of legumes in grass swards promotes yields and forage nutritive value compared to monocrops. In addition, meadow brome-grass biomass supplied with moderate amounts of N fertilizer accumulates similar amounts of N as when grown in mixtures with alfalfa. This indicates that grass-legume mixtures may give rise to more profitable

forage production and, at the same time, minimize the consequences of using highly soluble N fertilizers to the environment. These beneficial aspects will be evaluated further through 2018 while considering key plant microbe interactions and trace gas emissions alongside irrigation.

### Acknowledgments

We acknowledge—with much appreciation—ShREC staff for logistical support. The study is supported by a grant from Western SARE (Sustainable Agriculture Research and Education) and funds from the Wyoming Agricultural Experiment Station and Department of Plant Sciences.

### Contact Information

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**Keywords:** grass-legume mixtures, nitrogen fixation, trace gas analysis

**PARP:** I:2, II:2, VII

**Table 1.** Nitrogen (N) yield for meadow brome-grass and alfalfa in different ratios.

Treatment	Shoot Nitrogen Content (lbs/ac)
Alfalfa monocrop	7.33a
Alfalfa constituting 50% in grass mixture	2.80c
Meadow brome-grass constituting 50% in alfalfa mixture	2.43c
Alfalfa constituting 30% in grass mixture	2.85c
Meadow brome-grass constituting 70% in alfalfa mixture	2.68c
Meadow brome-grass monocrop without N	2.63c
Meadow brome-grass monocrop with 50 lbs N/ac	3.03bc
Meadow brome-grass monocrop with 100 lbs N/ac	5.23ab

Values followed by the same letter in the same column are not significantly different at  $p \leq 0.05$ .



# Screening Grapevine Cultivars and Optimizing Management Practices for Improving Grapevine Production in Wyoming

*S.A. Dhekney<sup>1,2</sup>, M.R. Baldwin<sup>1</sup>, and D.R. Bergey<sup>2</sup>*

## Introduction

Interest in grapevine production in Wyoming has been steadily rising for the past 15 years since the first vineyard and winery were established in 2001. Harsh climatic conditions such as sub-zero winter temperatures and late spring frosts are complicated by a short growing season. These factors, in summation, essentially prevent the cultivation of traditional European grape cultivars (*Vitis vinifera*) in Wyoming. However, intensive breeding efforts in recent history have resulted in the development of cold-hardy, excellent-quality, interspecific grapevine hybrids, which can be successfully grown in colder regions including Wyoming. The selection of suitable cultivars and optimized management practices play a significant role in obtaining high fruit yields that are of good quality.

## Objectives

The goals of the project are to identify promising grapevine cultivars and optimize management practices for grape production in Wyoming, which may lead to early vineyard establishment, higher yields, and improved fruit quality.

## Materials and Methods

Grape cultivar trials were established near Sheridan and Powell in 2013. Cold-hardy wine, table, and juice grape cultivars were screened for cold hardiness, bud break, and vine survival in 2014 and 2015. Grapevines were trained on a high wire cordon system, and data were recorded in early spring. Fruiting in vines was discouraged by removing any inflorescences to ensure vine establishment and enhance cold hardiness in the subsequent winter season. Experiments were initiated to study grapevine water requirements and possible approaches for efficient water utilization, which could

result in improved grapevine growth and development, yield, and berry quality in Wyoming vineyards.

A test site was also established at a grower's vineyard near Wheatland in southeast Wyoming. The vines were approximately 10 years old when the project was initiated. There were two treatments: (A) cover with landscape fabric; and (B) bare ground (no cover). Two varieties—'Frontenac' and 'La Crescent'—were included in the study. Four rows for each cultivar were selected for the investigation with each of the eight rows containing 40 vines (total of 320 vines). Drip-irrigation systems were fabricated to separate the irrigation supply to vines receiving the fabric treatment and vines with no cover. Time required for veraison (change in color of berries) and fruit quality (sugar level, which is generally measured as total soluble solids [TSS], pH, and titratable acidity) were recorded in both treatments.

## Results and Discussion

Preliminary data on winter vine survival indicated better hardiness and survival rates in Sheridan compared to Powell (Figure 1). Among the various cultivars tested, 'Frontenac', 'Marechal Foch', and 'Osceola Muscat' exhibited higher survival rates in Sheridan, whereas 'Elvira' and 'Frontenac Gris' performed well in Powell.

Experiments conducted in Wheatland to study the influence of landscape fabric on fruit yield and quality indicated differences may exist in time required for veraison, juice TSS, pH, and titratable acidity between the covered and bare treatments for 'Frontenac'. Earlier veraison, higher juice pH, and lower titratable acidity were observed in the landscape fabric treatment compared to the bare treatment for Frontenac (Figures 2 and 3). Similar results were observed in 'La Crescent'.

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<sup>1</sup>Department of Plant Sciences; <sup>2</sup>Sheridan Research and Extension Center.

This is significant considering the fact that major problems in Wyoming grape and wine production include a low juice pH and higher titratable acidity, which ultimately influence wine production practices and wine quality. Although we did not realize pH and titratable acidity values that typify traditional *V. vinifera* cultivars, we hope to see continued improvement through the manipulation of irrigation treatments.

We will continue to screen grapevine cultivars and optimize management practices for several years to study the effects of seasonal variation on vine survival and fruit yield and quality.

### Acknowledgments

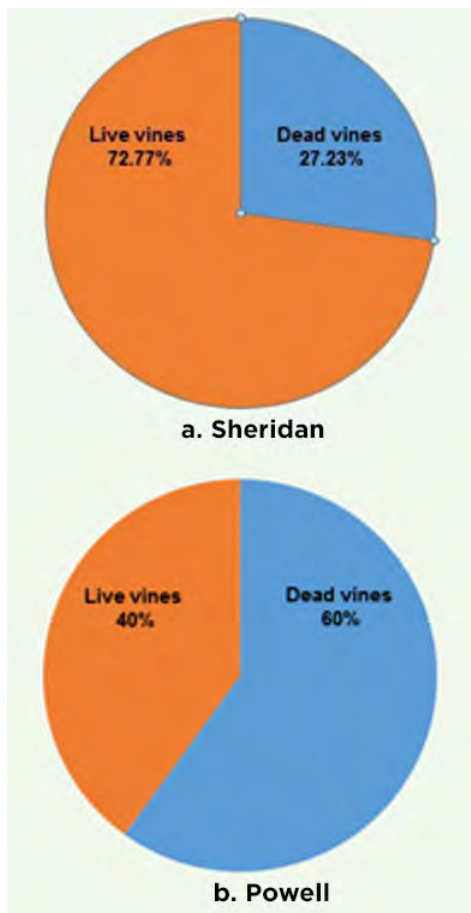
The project is supported by the Wyoming Department of Agriculture and U.S. Department of Agriculture's Specialty Crop Block Grant program.

### Contact Information

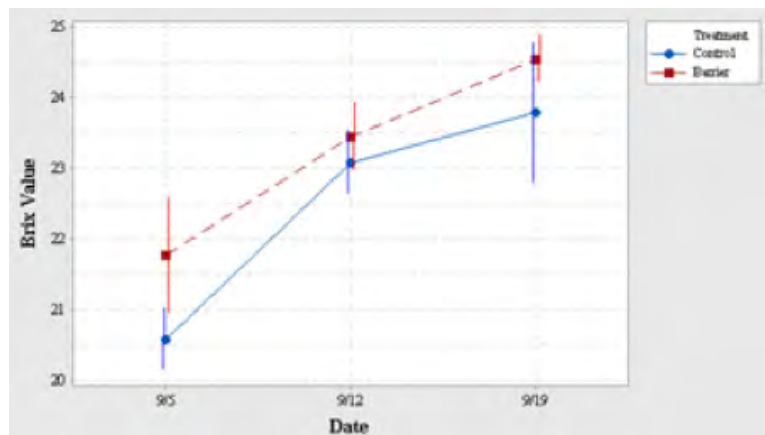
Sadanand Dhekney at sdhekney@uwyo.edu or 307-673-2754.

**Keywords:** grapes, wine, cold-hardy

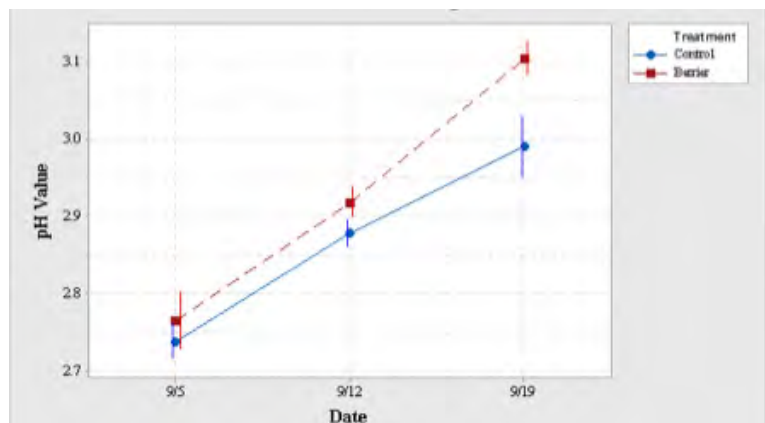
**PARP:** I:1, X:1



**Figure 1.** Frost susceptibility based on grapevine survival rates (observed bud swell) at Sheridan and Powell locations.



**Figure 2.** Effect of landscape fabric treatment on Frontenac TSS.



**Figure 3.** Effect of landscape fabric treatment on Frontenac juice pH.

# Season Extension for Production of Vegetables under Protection Cultivation Systems

*A. Erickson<sup>1</sup>, S.A. Dhekney<sup>2,3</sup>, and K. Panter<sup>2</sup>*

## Introduction

High tunnels can offer uninterrupted growing periods for specialty crops in addition to protection from late spring frosts, unseasonal hail, and foraging pests. Vegetable and herb production in Wyoming is a relatively small industry; most of the fresh vegetables consumed are produced outside the state or imported from other countries. Some Wyoming growers and homeowners are interested in small-scale, extended-season production.

## Objectives

The goals of the project are to establish sustainable vegetable production in Sheridan and surrounding areas and study the possibility for season extension under protected conditions. Specific objectives include (1) comparing low-tunnel (LT), high-tunnel (HT), and open-field production systems for tomatoes, hot peppers, broccoli, beans, and cucumber; and (2) optimizing the transplant time of selected vegetable species for early spring and fall production seasons.

## Materials and Methods

Seedlings for tomatoes, hot peppers, broccoli, beans, and cucumber were started March 15, 2015, in a Sheridan Research and Extension Center (ShREC) greenhouse. The land was tilled, and raised beds were prepared and covered with black plastic mulch. Seedlings were planted in replicated blocks and randomized throughout the raised beds in the high tunnel. Similar plantings were carried out in low tunnels and under open-field conditions. Seedlings were planted at the test site on May 29. The cumulative yield for each crop was recorded by combining crop weights recorded at weekly intervals during the duration of the crop. The length of

the duration for crop harvest was also recorded to study potential differences in cropping season extension under each cultivation system.

## Results and Discussion

Greenhouse-grown seedlings established well in the high tunnel, in low tunnels, and under outdoor field conditions (Figures 1–4). The broccoli and tomato plants exhibited extremely vigorous growth and were not suitable for low-tunnel cultivation/production. Summer temperatures exceeded 90°F under low and high tunnel, and bolting (production of flower stalks) was observed in broccoli. Harvesting was initiated July 6 and continued till October 30 in the high- and low-tunnel treatments. The plants growing under field conditions without any covers showed diminished production in early September due to decreasing night temperatures, and harvesting in this treatment was terminated at the end of September.

The majority of vegetables grown under the high tunnel exhibited higher yields and could be grown for a longer duration compared to the crop grown under open-field conditions. We will continue to record data for production under high tunnel, low tunnels, and open conditions for another year to study the seasonal variation and long-term effects of providing protective covers for vegetable production.

Vegetables harvested from the project were served at the Sheridan Research and Extension Center Field Day meal. Information was provided to field day attendees, and arrangements were made to interested parties who wanted to visit the field site.

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<sup>1</sup>Sheridan College; <sup>2</sup>Department of Plant Sciences; <sup>3</sup>Sheridan Research and Extension Center.

## Acknowledgments

The project is supported by the Wyoming Department of Agriculture and U.S. Department of Agriculture's Specialty Crop Block Grant program.

## Contact Information

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**Keywords:** protected cultivation, vegetables

**PARP:** I:1, X:1



**Figure 1.** A view of the experimental plot.



**Figure 2.** Vegetable production in the high tunnel.



**Figure 3.** Low-tunnel production of vegetables.



**Figure 4.** Vegetable production under field conditions.

# Perennial Cool-Season Grasses for Hay Production and Fall Grazing Under Full and Limited Irrigation

*B.E. Horn<sup>1</sup>, M.A. Islam<sup>2</sup>, D. Smith<sup>3</sup>, V. Jeliaskov<sup>3,4</sup>, and A. Garcia y Garcia<sup>5,6</sup>*

## Introduction

Perennial cool-season grasses comprise nearly 25% of hay field acreage in northeast Wyoming (Campbell, Crook, Johnson, Sheridan, and Weston counties). The most popular grasses used for hay production under irrigation in this region have been smooth or meadow brome. Although these two grasses are productive with good stand persistence, the aggressive nature of smooth brome makes it a poor choice for mixtures with legumes (e.g., alfalfa), and it can become sod bound resulting in reduced yields. In addition, it does not regrow following a hay harvest until late summer. Meadow brome is not as aggressive as smooth brome and works well in mixtures with legumes. It also produces some level of early summer regrowth. However, the variety ‘Regar’ has been found to contain less crude protein compared to the variety ‘Paddock’ and the smooth brome variety ‘Manchar’, often containing less than the amount needed by a lactating beef cow. Furthermore, smooth and meadow brome-grasses can require 24 or more inches of growing-season (April through September) precipitation to show their full growth potential. In eastern Wyoming this could mean application of up to 18 inches of irrigated water most years. Due to this moisture requirement these two grasses may not be the best choice for dryland or limited-irrigated hay production.

There are other cool-season perennial grasses—orchardgrass, intermediate/pubescent wheatgrass, tall fescue, and timothy—that might produce high forage yields of good quality with similar or less amounts of irrigation water compared to the smooth and meadow bromes.

## Objectives

The objectives of this study are to assess (1) late spring/early summer hay yields of perennial cool-season hay/pasture grasses under full and reduced (50%) irrigation regimes; (2) regrowth yields of these grasses for fall grazing; and (3) forage quality of the hay and regrowth.

## Materials and Methods

Fourteen cool-season perennial grasses were each seeded into separate plots within eight blocks (four for full irrigation regime and four for limited-irrigation regime) with a Truax FlexII grass drill on September 8, 2014, at the Sheridan Research and Extension Center’s (ShREC) Adams Ranch.

The grasses were ‘Manchar’ and ‘Carlton’ smooth brome-grass; ‘MacBeth’ and ‘Paddock’ meadow brome-grass; ‘Latar’ and ‘Profile’ orchardgrass; ‘Fawn’ and ‘Texoma MaxQ II™’ tall fescue; ‘Oahe’ and ‘Rush’ intermediate wheatgrass; ‘Luna’ and ‘Manska’ pubescent wheatgrass; and ‘Climax’ and ‘Tuukka’ timothy. (Note: all blocks received the same level of irrigated water in summer 2015 with the hope of improving grass stands for this study, which is to last through at least 2017.)

## Results and Discussion

There was poor establishment of the orchardgrass, tall fescue, and timothy varieties and, as a result, did not undergo an early summer harvest in 2015. Although the two smooth bromes and ‘MacBeth’ meadow brome had mediocre stands, they were subjected to June 18 harvest to assess their dry matter yields (Table 1) as was ‘Paddock’ meadow brome. The intermediate and pubescent wheat-grasses underwent a harvest on July 1. The bromes mature earlier than the wheatgrasses, thus, the reason for the different harvest dates. Desired stage of maturity

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for harvest is post-flowering to visible seed development; however, this delay in harvest of the wheatgrasses may be why their forage quality, on average, was lower compared to the bromes (Table 1). Seedlings of grasses with poor to mediocre stands may have succumbed to the minus 17° temperature on November 13, 2014, following above-normal fall temperatures. Regrowth of the bromes and wheatgrasses plus that of ‘Latar’ orchardgrass and ‘Texoma MaxQ II’ tall fescue was harvested October 7 (Table 1). All harvested grasses were analyzed for crude protein, energy (Table 1), and macro- and micro-mineral contents.

### Acknowledgments

We thank ShREC field crews for assistance in plot establishment and harvesting. The ongoing study is supported by the Wyoming Department of Agriculture’s Agriculture Producer Research Grant Program.

### Contact Information

Blaine Horn at bhorn@uwyo.edu or 307-684-7522.

**Keywords:** cool-season grasses, hay production, regrowth yields

**PARP:** I:2, IV:4

**Table 1.** Dry matter yields, and crude protein and net energy for maintenance (NEm) contents of the cool-season perennial grasses harvested in 2015. (For mineral contents contact Blaine Horn.)

Grass	Variety	June 18 (bromes) and July 1 (wheatgrasses) harvest			October 7 (all) harvest			Total Yield ton/ac
		Yield ton/ac	% Crude protein	NEm <sup>1</sup> (Mcal/lb)	Yield ton/ac	% Crude protein	NEm <sup>1</sup> (Mcal/lb)	
Smooth brome	Carlton	0.44 d	13.9 a	0.61 a	0.88 bc	15.8 a	0.63	1.32 c
	Manchar	0.36 d	13.4 ab	0.60 a	0.46 d	14.1 ab	0.62	0.84 c
Meadow brome	MacBeth	0.57 d	11.7 bc	0.54 b	0.80 bcd	13.9 ab	0.59	1.37 c
	Paddock	1.42 c	9.8 cd	0.53 b	1.35 a	12.9 ab	0.60	2.78 b
Intermediate wheatgrass	Oahe	3.34 a	9.1 d	0.45 c	1.10 ab	14.0 ab	0.61	4.43 a
	Rush	2.17 bc	10.5 cd	0.48 c	1.11 ab	15.0 ab	0.63	3.29 b
Pubescent wheatgrass	Luna	2.63 ab	8.9 d	0.45 c	0.69 cd	12.8 b	0.61	3.31 b
	Manska	1.82 bc	13.1 ab	0.55 b	1.16 ab	14.2 ab	0.65	2.98 b
Orchardgrass	Latar	-----	----	----	0.45 d	14.3 ab	0.60	-----
Tall fescue	Texoma	-----	----	----	0.76 bcd	15.0 ab	0.60	-----

\*means followed by same letters do not differ at  $p < 0.05$

<sup>1</sup>NEm is an estimate of the energy value of a feed used to keep an animal at a stable weight.

# Off-Station Reports

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# Short Reports

## 1. Targeted goat grazing for weed control

**Investigators:** Mae Smith and Brian A. Mealor

**Issue:** Noxious weeds such as Russian knapweed and whitetop negatively impact agricultural lands and wildlife habitat throughout the West. They are primarily managed using herbicides, but intentional use of small ruminants for weed control is growing in popularity. Land managers, however, need a fair comparison of targeted grazing and herbicides for their ability to (1) reduce weeds; and (2) maintain or enhance desirable vegetation.

**Goal:** Evaluate goat grazing, herbicides, and the combination of goat grazing and herbicides for their ability to control Russian knapweed and whitetop while maintaining or enhancing desirable vegetation.

**Objectives:** Compare goat grazing at different timings to commonly used herbicides for their effects on target weed species and non-target desirable plants.

**Expected Impact:** Results could help land managers select potential weed-management approaches that best meet their goals for agricultural production and wildlife habitat.

**Contact:** Mae Smith at [maep@uwyo.edu](mailto:maep@uwyo.edu) or 307-765-2868.

**Keywords:** weed management, riparian restoration, wildlife habitat

**PARP:** III:3,5, VI:3,4,5, XII:1

## 2. Impact of histophilosis on bovine respiratory disease

**Investigators:** Kerry Sondgeroth, Donal O'Toole, and Brant Schumaker

**Issue:** The bacterium *Histophilus somni* is a common cause of respiratory disease in cattle, most often when large groups of weaned calves are stressed. Current studies have not been performed in the U.S. to determine its importance in respiratory disease and death of feedlot cattle (the last study we are aware of was conducted in California dairy cattle about 30 years ago).

**Goal:** Determine the association of *H. somni* with bovine respiratory disease and death in feedlot cattle in the West.

**Objectives:** (1) Determine when calves acquire antibodies to *H. somni* by collecting blood samples at different times while they are in the feedlot; and (2) use different testing methods to identify *H. somni* in lung and heart samples from those animals that die from respiratory disease.

**Expected Impact:** Understanding when animals become infected and the potential role *H. somni* plays in respiratory disease will have a positive impact on cattle health. This could help producers and clinical veterinarians better control bovine respiratory disease by vaccination and/or treatment.

**Contact:** Kerry Sondgeroth at [ksondger@uwyo.edu](mailto:ksondger@uwyo.edu) or 307-766-9932.

**Keywords:** *Histophilus somni*, histophilosis, bovine respiratory disease

**PARP:** Goal 2

### 3. Evaluating the use of thresholds' concepts for improving habitat through cheatgrass management

**Investigators:** Clay Wood and Brian A. Mealor

**Issue:** Cheatgrass (*Bromus tectorum*) is an invasive winter annual grass species widely distributed throughout western North America and has the ability to alter fire frequency, leading to degradation of critical wildlife habitat. Identifying ecological and economic thresholds in cheatgrass-invaded systems is a primary challenge for land managers as these thresholds are ill-defined for invasive species in rangelands.

**Goal:** Identify thresholds of cheatgrass infestation levels where treatment responses are positive or negative and develop management approaches informed by those thresholds.

**Objectives:** (1) Determine if there is a direct, predictable relationship between pre-treatment vegetation condition and post-treatment increases in perennial grass biomass; and (2) compare the efficacy of a granular formulation of imazapic herbicide (Open Range™ G) to the widely used liquid formulation (Plateau®) for cheatgrass control beneath an existing shrub canopy.

**Expected Impact:** Identifying thresholds within a cheatgrass-invaded system should aid land managers in making well-informed, cheatgrass management decisions on a landscape scale. Proactive management strategies could be identified through use of newer herbicides that may provide better control beneath shrub canopies, providing proactive opportunities for maintaining critical wildlife habitat.

**Contact:** Clay Wood at cwood13@uwyo.edu or 307-290-0678, or Brian Mealor at bamealor@uwyo.edu or 307-673-2647.

**Keywords:** cheatgrass (*Bromus tectorum*), thresholds, imazapic

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

# Valuing the Non-Agricultural Benefits of Flood Irrigation in the Upper Green River Basin

*S. Blevins<sup>1</sup>, K. Hansen<sup>1</sup>, G. Paige<sup>2</sup>, and A. MacKinnon<sup>3</sup>*

## Introduction

Flood-irrigation practices in the Upper Green River Basin (UGRB) of west-central Wyoming generate return flows, which support late-season stream flows and groundwater recharge. In some locations, water quality issues such as sediment, nutrient loading, and salinity may be associated with agricultural return flow. In this area of the UGRB, however, these are not an issue due to the porous soils, shallow alluvium, and low use of fertilizer. These late-season stream flows can generate environmental benefits for downstream fisheries and riparian habitat, which, in turn, create recreational benefits for Wyoming residents and visitors alike. The most common UGRB agricultural crop is native grass hay, a relatively low-value crop used by ranchers in the basin to feed livestock over the winter.

Although flood irrigation is by far the most common irrigation technology used by UGRB ranchers, they currently face economic pressure to change their use of land and water. There have been economic incentives to subdivide their land for residential development. They may face additional economic pressure in the future to adopt more-efficient irrigation technology such as center pivot, or to forego diversions to make water more available for other water users further downstream in the Colorado River Basin. What would be the downstream environmental and recreational effects of altered return-flow patterns?

## Objectives

The objective of this study is to quantify some of the economic value of the recreational benefits associated with flood irrigation in one particular irrigation district that could be lost due to hypothetical land-use changes and the resulting altered return-flow patterns.

## Materials and Methods

Our study area is the New Fork Irrigation District (NFID) in Sublette County north of Pinedale. The NFID is located in an alluvial aquifer system of the type often found in the Rocky Mountain West. Of the water diverted for agriculture in June and July, approximately 70% returns to the New Fork River, primarily later during the agricultural season when flows would otherwise be lower.

We first use a hydrology model to show how return-flow patterns change under three scenarios: increased residential development, increased use of center pivots, and increased fallowing. We next use brown trout as an indicator species to track how changes in return-flow patterns alter recreational opportunities. We then use studies conducted elsewhere in the Intermountain West of how much anglers spend (or would spend) when they go on fishing trips to approximate the economic impact of having more or fewer brown trout in the New Fork. This particular river at the foot of the Wind River Range is promoted as “A fly fisherman’s and floater’s dream” by the Pinedale Travel and Tourism Commission (<http://www.visitpinedale.org/explore/rivers/new-fork-river>).

## Results and Discussion

Agricultural value is highest for the flood-irrigation scenario (Table 1). The net value of hay produced by one acre is approximately \$45; this is, in theory, the cost of buying replacement winter feed. Ranchers are unlikely to shift away from flood-irrigation practices under current economic conditions if they keep the land in agriculture because switching to center pivot would only bring about \$13/ac in net revenues. If yields were to increase from 1 ton/ac to approximately 1.5 ton

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<sup>1</sup>Department of Agricultural and Applied Economics; <sup>2</sup>Department of Ecosystem Science and Management;

<sup>3</sup>University of Wyoming Haub School of Environment and Natural Resources.

(assuming 50% installation cost-share), ranchers might switch to center pivot. If downstream water users pay ranchers at least \$45/ac to fallow, ranchers might fallow (and buy replacement winter feed). On some properties, the economic benefits of residential development already outweigh the benefits of keeping land in agriculture.

Recreational value for brown trout is also, like agricultural value, highest under the flood-irrigation scenario. If key parameters change ranchers' private incentives for land use, sources interested in maintaining brown trout may decide to supply additional revenues to ranchers to encourage them to maintain current flood-irrigation practices.

We are able to quantify the recreational benefits associated with late-season flows for brown trout; however, we are unable to quantify the recreational benefits of other wildlife and fish species due to insufficient data. More scientific research is required in those areas. The recreational benefits presented here are consequently only the lower limit of the non-agricultural benefits potentially associated with flood irrigation in the NFID. Higher values may arise from including hunting, angling, floating, and benefits associated with other species, such as

bird watching. This is a case study of hydrologic and economic conditions in one irrigation district; results do not necessarily generalize to other locations. Extensions to this research are in development.

### Acknowledgments

We thank Tom Annear, Kathy Raper, Pamela Adams, and several NFID members for helpful information. The study is supported by the Walton Family Foundation and the UW Haub School of Environment and Natural Resources.

### Contact Information

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**Keywords:** water, economics, flood irrigation

**PARP:** VII:4,6, IX:1

### Literature Cited

Mellinger, A. J., 2012, Economic and ecological tradeoffs of targeting conservation easements for habitat protection: A case study of Sublette County, Wyoming [Master's thesis]: Laramie, Wyoming, University of Wyoming, *vi* + 78 p.

**Table 1.** Agricultural and recreational value of return flows (per acre).

Scenario	Agricultural Value	Recreational (Brown Trout) Value
Flood Irrigation	\$45	\$31
Center Pivot*	\$13	\$27
Pasture**	\$15	\$29
Residential Development***	Varies (\$172 to \$1,800)	\$27

\*Center-pivot scenario assumes per-acre yields of 1.5 tons and 50% cost-share on center-pivot installation with installation costs spread over 10 years at a 6% interest rate.

\*\*Pasture rental rate.

\*\*\*Annualized average sale prices (from Mellinger, 2012).

# Understanding Epigenetic Mechanisms of Lactation Failure

*B. Cherrington<sup>1</sup>*

## Introduction

Breastfeeding protects infants against the onset of childhood obesity and reduces the risk for type 2 diabetes later in life. In mothers, exclusive lactation for the first six months is associated with lower weight retention, weight issues 15 years later, and incidence of type 2 diabetes. Despite the importance of breastfeeding to the mother and infant, the mechanisms that control the initiation of lactation are not well understood. For example, obese mothers have inadequate breast milk production. This problem is directly related to the hormone prolactin, which normally stimulates milk production by breast cells. But we do not currently understand exactly how prolactin initiates milk production in breast cells.

Human peptidylarginine deiminase (PAD) enzymes are highly expressed in the lactating breast cells. PADs regulate the structure and function of other proteins through a reaction termed citrullination. For example, PAD enzymes can turn the expression of genes on by modifying histones, which organize DNA. Understanding how PADs regulate the expression of genes in the breast cells may allow us to target these enzymes to increase breast milk production in obese women.

## Objectives

The goal of this study is to determine how prolactin regulates PAD expression and if mammary proteins are citrullinated during lactation.

## Materials and Methods

Experiments are being conducted in the University of Wyoming's Biological Sciences Building. These studies utilize a mouse mammary epithelial cell line termed CID-9 cells. Studies also use mouse mammary glands collected on lactation days two and nine. All animals

are housed and cared for following approved guidelines by the UW Institutional Animal Care and Use Committee.

## Results and Discussion

Prolactin is critical to initiate lactation. It binds the prolactin receptor on breast cells, which stimulates the expression of lactation-related genes to produce breast milk. If prolactin initiates epigenetic mechanisms (i.e., changes in gene expression that do not involve changes in the underlying gene DNA sequence) to control milk production is unclear. To investigate this question, we used CID-9 cells and lactating mice. First, CID-9 cells treated with prolactin for 48 hours show an increase in PAD3 expression; however, this response is blocked in the presence of an inhibitor (SD-1029) (Figure 1). Next, we examined if citrullinated proteins are present in lactating mouse mammary glands. On lactation days two (L2) and nine (L9), we collected mammary glands and examined the levels of citrullinated proteins. Our results show that multiple proteins are citrullinated including histones suggesting that PADs regulate the expression of genes (Figure 2).

Our upcoming studies will use DNA sequencing to determine which genes are regulated by PAD enzymes in the lactating mammary gland. Our overall goal is to determine how prolactin acts through PADs to regulate lactation. We believe that our results will increase understanding of the molecular mechanisms controlling lactation and provide novel treatments for obese women with milk production problems.

## Acknowledgments

Thanks to Amy Navratil and Guangyuan Li for technical support. This study is supported by U.S. Department of Agriculture Hatch funds.

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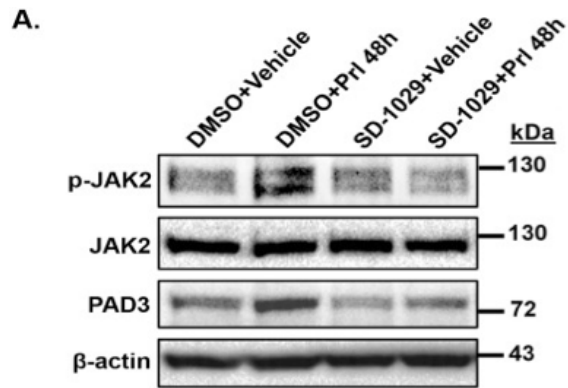
<sup>1</sup>Department of Zoology and Physiology.

## Contact Information

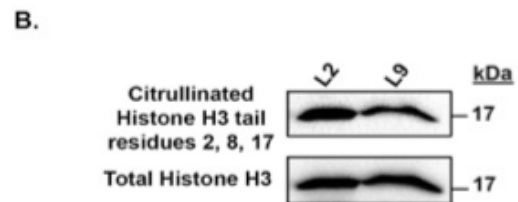
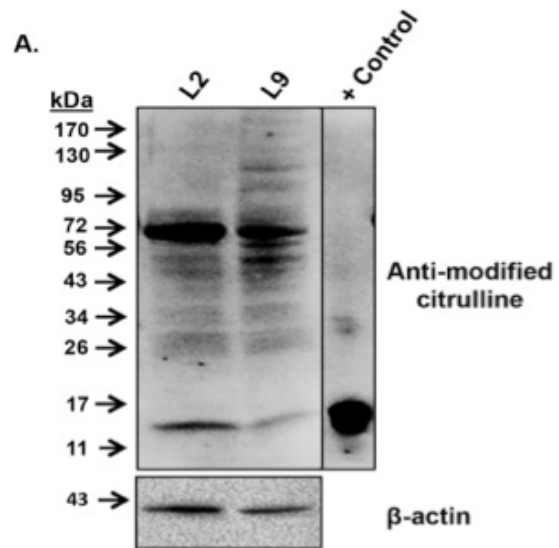
Brian Cherrington at [bcherrin@uwyo.edu](mailto:bcherrin@uwyo.edu) or 307-766-4200.

**Keywords:** lactation, epigenetics

**PARP:** VII:1,2



**Figure 1.** Prolactin induces PAD3 protein expression. (DMSO is short for dimethyl sulfoxide.)



**Figure 2.** Multiple proteins are citrullinated in the lactating mammary gland including histones. (A) Citrullinated proteins are present in L2 and L9 mammary glands. (B) L2 and 9 lysates contain citrullinated histones.

# A 20-year Retrospective Evaluation of Seeding Competitive Perennial Grasses for Dalmatian Toadflax Suppression

B. Fowers<sup>1</sup> and B.A. Meador<sup>1,2</sup>

## Introduction

Weed-management studies commonly focus on relatively short-term results, often due to practical and logistical constraints; however, the effects of integrated weed-management strategies may persist over time in semiarid rangeland ecosystems. As rangeland weed management has moved from primarily a ‘weed killing’ endeavor toward a systematic approach for reducing weeds and restoring desirable vegetation, a better understanding of the long-term agricultural and ecological impacts of management is needed. In this project, we focus on Dalmatian toadflax (*Linaria dalmatica*)—a perennial forb that was introduced to North America in the late 1800s as an ornamental plant. It is a noxious weed in most Western states; in Wyoming, it’s one of 26 weeds on the state’s “designated noxious weeds” list. Dalmatian toadflax is a strong competitor with desirable species on rangelands, but research in the 1990s indicated that seeding of competitive perennial grasses can provide short-term toadflax suppression.

## Objectives

Our objective was to evaluate plant community composition, particularly the ratio of Dalmatian toadflax to perennial grasses within a Dalmatian toadflax infestation that had been seeded to various perennial cool-season grasses 20 years ago.

## Materials and Methods

The study was established in 1994 at the U.S. Department of Agriculture’s High Plains Grasslands Research Station near Cheyenne. The entire study site was prepared by applying picloram at 0.55 lb active ingredient/ac on September 10, 1994, followed by rototilling to 3 inches on April 6, 1995. Five perennial grass species were drill seeded April 6 and August 15, 1995. Grasses included: ‘Bozoisky’ Russian wildrye (*Psathyrostachys juncea*) at 6.24 lb pure live seed (PLS)/ac, ‘Hycrest’ crested wheatgrass (*Agropyron cristatum*) at 9.84 lb PLS/ac, ‘Luna’ pubescent wheatgrass (*Thinopyrum intermedium*) at 9.84 lb PLS/ac, ‘Sodar’ streambank wheatgrass (also known as thickspike wheatgrass) (*Elymus lanceolatus* ssp.

*lanceolatus*) at 9.84 lb PLS/ac, and ‘Critana’ thickspike wheatgrass (*Elymus lanceolatus* ssp. *lanceolatus*) at 9.84 lb PLS/ac. Plots were 10 x 26 feet with three replicates while seeding season (spring versus fall) was organized by block. Biomass was collected in three 2.7 ft<sup>2</sup> (0.25 m<sup>2</sup>) frames from each treatment plot and separated into Dalmatian toadflax, seeded species, and other associated species in June 1997 and 1998. In 2015 (20 years after seeding), we collected biomass in four 2.7 ft<sup>2</sup> frames per plot. We then separated biomass by toadflax, seeded species, and plant functional groups (grasses and forbs by annual or perennial growth habit).

## Results and Discussion

All perennial cool-season grasses seeded in August 1995 reduced Dalmatian toadflax biomass production by more than 70% three years after seeding (1998). Thickspike and crested wheatgrasses provided the greatest short-term Dalmatian toadflax reduction (91 and 90%, respectively) (Table 1). Increase in grass production varied by seeding date and grass species (Table 1). In the short-term, picloram treatment followed by reseeding of cool-season grasses shifted the site toward significantly more grass and less toadflax. By 2015, the spring-seeded grasses showed slight to moderate Dalmatian toadflax reductions, whereas toadflax production was markedly higher in the fall-seeded treatments than where no seeding occurred (Table 2). Pubescent wheatgrass seeded in April 1995 most closely met the long-term goals of decreasing Dalmatian toadflax and increasing perennial grass. This study illustrates the importance of a *long-term management program*, instead of a short-term, one-step approach for managing a perennial weed like toadflax.

## Acknowledgments

The initial experiment was started in 1994 by Tom Whitson (University of Wyoming professor and UW Extension weed specialist emeritus) and Kristi Rose (a UW graduate student at the time). Dr. Whitson provided helpful information for resampling the study. Thanks to the 2015 UW range weed

<sup>1</sup>Department of Plant Sciences; <sup>2</sup>Sheridan Research and Extension Center.

science team for assistance in collecting and processing data and samples.

**Keywords:** weed management, Dalmatian toadflax, restoration

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**PARP:** III:3,5

**Table 1.** Perennial grass, Dalmatian toadflax biomass, and change relative to non-treated (%) in 1998.

Seeded Species	April 6, 1995, seeding				August 15, 1995, seeding			
	Perennial Grass		Toadflax		Perennial Grass		Toadflax	
'Hycrest' crested wheatgrass	1,571 <sup>a</sup>	83 <sup>b</sup>	259 <sup>a</sup>	-73 <sup>b</sup>	2,129 <sup>a</sup>	148 <sup>b</sup>	93 <sup>a</sup>	-90 <sup>b</sup>
'Luna' pubescent wheatgrass	1,921	124	209	-78	2,135	149	230	-76
'Critana' thickspike wheatgrass	1,550	81	206	-79	1,485	73	86	-91
'Bozoisky' Russian wildrye	2,561	198	244	-75	1,796	109	273	-72
'Sodar' streambank wheatgrass	1,334	55	370	-61	1,491	74	173	-82
not seeded	858	0	961	0	858	0	961	0

**Table 2.** Perennial grass, Dalmatian toadflax, and annual grass biomass and change relative to non-treated (%) in 2015.

Seeded Species*	April 6, 1995, seeding						August 15, 1995, seeding					
	Perennial Grass		Toadflax		Annual Grass		Perennial Grass		Toadflax		Annual Grass	
'Hycrest' crested wheatgrass	2,826 <sup>a</sup>	175 <sup>b</sup>	210 <sup>a</sup>	-21 <sup>b</sup>	4 <sup>a</sup>	-98 <sup>b</sup>	1,590 <sup>a</sup>	55 <sup>b</sup>	395 <sup>a</sup>	48 <sup>b</sup>	12 <sup>a</sup>	-94 <sup>b</sup>
'Luna' pubescent wheatgrass	2,696	163	71	-73	162	-19	2,324	127	327	23	18	-91
'Critana' thickspike wheatgrass	1,266	23	176	-34	722	261	860	-16	334	26	299	50
'Bozoisky' Russian wildrye	1,093	7	431	62	438	119	803	-22	428	61	126	-37
'Sodar' streambank wheatgrass	490	-52	177	-33	1,182	491	1,003	-2	469	76	403	102
not seeded	1,026	0	266	0	200	0	1,026	0	266	0	200	0

\*the same cultivars as in Table 1 were used

<sup>a</sup>air-dried biomass (lb/ac)

<sup>b</sup>% relative to non-treated



# Writing Emerging Science to Engage Resource Navigators: Results from State and National Surveys

*K. Gunther<sup>1</sup>, A.L. Hild<sup>1</sup>, S.L. Bieber<sup>2</sup>, and J.J. Shinker<sup>3</sup>*

## Introduction

Researchers and managers must communicate effectively to achieve sustainable resource management. Frequently, “communication gaps” hinder application of new ideas and technologies. Though scientists are often taught to present information free from value judgments, we know that values, beliefs, and emotions play important roles in communication about ecosystems. “Priming” is a psychological effect in which an earlier experience influences a subject’s perception of a later experience. We wanted to learn how introducing neutral scientific texts with value-based language (“positive” or “negative” contexts familiar to a management-oriented audience) affects how readers respond. In 2014 we conducted a statewide survey and found that participants without “hands-on” experience in agricultural production have greater response to value-loaded introductory language. Surveying was expanded to a national group of range scientists in 2015.

## Objectives

Our objective is to learn how to deliver science so that it is more likely to be retained by information-seeking manager audiences. We wanted to test the effect of priming with value-loaded language (“positive” or “negative”) on audience reception. We sought to identify differences in reception among subpopulations of ecosystem managers. Ultimately our plan is to develop training materials for researchers and educators who want their science to be applied in the field.

## Materials and Methods

Following a state-level survey, we surveyed national attendees of Society for Range Management meetings

in early 2015. Participants were asked to rate “how true” they found 15 statements related to the topic of ecosystem uncertainty. Next, they were presented with neutral text that provided information related directly to those 15 statements. Introductions to the neutral text were divided into three treatment groups; the technical information was introduced with a paragraph using either “positive” language (words like “opportunity” and “profit”) or “negative” language (words like “threat” and “loss”). The control group received no introductory paragraph. One month later, we asked participants to re-evaluate the same statements.

## Results and Discussion

Our results indicate that the language used to present technical information does influence how an audience receives it. Different value-loaded content (priming) can change audience perception of technical information. Often, readers receiving “positive” contexts shifted their assessments less and remained more neutral than “negative”-context readers. In both our state and national surveys, we found that readers with less direct experience of landscape (e.g., time spent working indoors) shifted their assessments more readily than readers who have more direct field experience (Figure 1).

We are using our findings to develop a curriculum for delivery of science to land managers. We plan to (1) introduce key concepts for interfacing with user-groups for enhancing the effectiveness of science delivery; and (2) hold a workshop to share communication techniques among teachers such as Extension personnel and graduate students tasked with delivery of scientific knowledge.

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<sup>1</sup>Department of Ecosystem Science and Management; <sup>2</sup>Department of Statistics; <sup>3</sup>Department of Geography.

### Acknowledgments

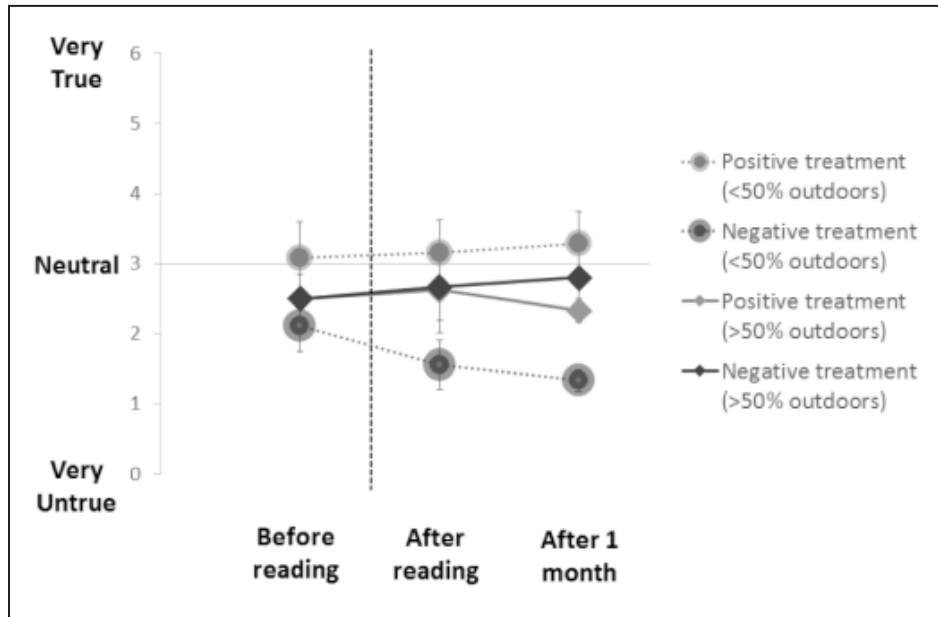
This research is supported by a grant from the U.S. Department of Agriculture’s National Institute of Food and Agriculture under award #1005942.

**Keywords:** science communication, adaptive management

**PARP:** IX:2,4,5

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**Figure 1.** “Managers do not often have opportunities to make good observations of ecosystem complexities.” Among national respondents, agency personnel who spent less than 50% of their work time outdoors were more likely to rate this statement as “untrue” after receiving the negative treatment.

# Studies of Parasitoid Wasps Associated with Mountain Pine Bark Beetle

*L. Haimowitz<sup>1</sup> and S.R. Shaw<sup>1</sup>*

## Introduction

Unprecedented bark beetle epidemics in Wyoming and across North America during the past decade have been driven by climate change and amplified by past forest-management practices, notably fire suppression. Parasitoid wasps are among the most important natural enemies of bark beetles. Parasitoids deposit an egg into or on a host insect, which then gets eaten by the wasp larva. This makes knowledge of their roles in regulating bark beetle populations important to forest managers. Even so, there is currently little study of the interactions between bark beetles and the natural enemies that feed upon them. Much basic information is not available for most forests in Wyoming—for example, which species of beneficial wasps are present. We focus on mountain pine bark beetle (MPBB) in limber pine because there have been few studies of the beetle in this tree. Our work is being carried out at two study sites of comparable elevation, one in the Medicine Bow National Forest in southeast Wyoming near Laramie and the other in the Shoshone National Forest in western Wyoming near South Pass City.

We are using a combination of old and new methods for a fresh look at natural enemies of the mountain pine beetle. **Among older methods**, our study employs flight-intercept traps to investigate the presence, numbers, and seasonality of natural enemies. These traps capture flying insects and are a proven method to sample a large proportion of the parasitoid diversity in an area. Another conventional approach is to rear insects from infested wood or bark. **Our new approaches include** (1) a novel method to trap insects emerging from standing trees; and (2) predator exclusion. To carry out the latter, a portion of an infested tree trunk is covered to prevent predators and parasitoids

from reaching the bark beetles. Beetle survival is then compared between the excluded portion and the rest of the trunk.

Application of these new methods can help answer some long-standing questions about MPBB biology. For example, past research has not made it clear that natural enemies play a major role in MPBB survival because there has been no simple, direct way to measure that effect. Predator exclusion, which provides a means of directly measuring the effect of predators on beetle survival, has been used successfully to assess the role of predation in related beetles, such as the southern pine beetle and European spruce bark beetle.

## Objectives

Our objectives are to characterize the parasitoids associated with mountain pine beetle in limber pine and to adopt new approaches to answer questions about MPBB biology.

## Materials and Methods

Flight-intercept traps were used to sample parasitoid wasps in the vicinity of bark beetle-infested trees. Three emergence traps (Figure 1), designed to capture parasitoids, were set up on beetle-infested trees in 2014 on the Medicine Bow National Forest (Figure 1). The first predator-exclusion experiments were set up in three trees in 2015 in the Shoshone National Forest (Figure 2). These activities will continue for the next two field seasons at both locations.

## Results and Discussion

Seven species of parasitoids have been commonly found to attack MPBB in the western United States, and we have found all seven species in our surveys in Wyoming.

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<sup>1</sup>Department of Ecosystem Science and Management.

Our data for relative numbers of the known parasitoids differ somewhat from that reported in the past. This may reflect differences in the insect populations associated with limber pine as compared to other pines or other regions, but a literature review suggests that sampling differences may also contribute to this finding. We also gathered data suggesting that one of the parasitoids, *Rhopalicus pulchripennis*, may have two generations per year, which has not been previously recorded; however, more study is needed to determine if this is true or not. Additionally, a number of less common species of parasitoids were found, and further work will be needed to determine which of these, if any, attack the pine beetle.

A design flaw in the 2014 emergence traps allowed some insects to escape. Although the design was modified for 2015, we did not deploy traps that summer because we could not find suitable trees for this experiment. The results of the first predator-exclusion experiment are not expected until summer 2016 since the beetle has a one-year generation time.

### Acknowledgments

This work is supported by a grant from the National Institute of Food and Agriculture's McIntyre-Stennis program awarded through the Wyoming Agricultural Experimental Station Competitive Grants Program. We thank our undergraduate research technicians for help with sampling, preparing, and preserving insect specimens for study, and we thank Shoshone and Medicine Bow National Forest personnel for assistance with locating suitable study sites and for their prompt review of our research permits.

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**Keywords:** mountain pine bark beetle, limber pine, parasitoid wasps

**PARP:** not applicable



**Figure 1.** Completed emergence trap designed to sample natural enemies of bark beetles.



**Figure 2.** Research assistant Rachel Lentsch with predator exclusion cage for mountain pine beetle.

# Assessment of Alfalfa Pest Management Challenges in Wyoming

*R. Jabbour<sup>1</sup> and S. Noy<sup>2</sup>*

## Introduction

Alfalfa hay is a major crop throughout the Intermountain West, including Wyoming. In 2014, farmers in Wyoming produced 1.27 million tons. But they, along with producers around the country, face a variety of issues, including crop susceptibility to a suite of insect pests, notably the alfalfa weevil, Figure 1. Considerable economic and environmental costs of chemical pest management highlight a critical need to develop more effective and efficient control strategies. This need aligns with the goal of many Wyoming producers to improve agricultural productivity considering economic viability and stewardship of natural resources. An essential first step to accomplishing this goal is to assess the current state of alfalfa pest management challenges and strategies in Wyoming so that new or modified approaches align with farmer priorities.

## Objectives

Our specific objective is to define farmer priorities and decision-making strategies regarding pest management through surveys distributed statewide.

## Materials and Methods

In 2015, we worked with the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS) to mail surveys to all 3,141 alfalfa producers throughout Wyoming. We asked farmers how they marketed their alfalfa (hay, seed, or on-farm feed), which alfalfa pests they had encountered, which pests they considered most problematic, and how they solved these pest problems. We also asked farmers whom they turn to for advice on alfalfa production.

## Results and Discussion

Surveys were returned from 634 Wyoming producers (20.2% of those surveyed). Though we are still analyzing and summarizing the wealth of information gained from this project, we present an initial summary here. Producers most often named alfalfa weevil as the most problematic insect pest in alfalfa production (66% of respondents), followed by grasshoppers (18%), aphids (7%), and lygus bugs (2%).

We wanted to know which management practices producers considered most effective. For those who named alfalfa weevil as most problematic, 74% considered insecticides as most effective, with only 5% naming early harvest as most effective. With regard to grasshoppers, 57% of farmers considered insecticides as most effective, and 22% early harvest most effective.

Producers were asked to name major challenges in alfalfa production aside from insect pests.

The most frequently mentioned challenges related to water management—including drought and water shortage—as well as irrigation challenges, such as getting enough water to the crop. Producers also named many kinds of weeds, small and large mammal pests, and challenges with soil quality and fertility.

Farmers reported seeking advice from neighbors and fellow farmers, and most indicated that these people are also their friends. Thus, advice networks among alfalfa producers are characterized by friendship. Given that friends are typically accorded higher trust than advisers, it is likely easier to disseminate information and have this information be trusted.

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<sup>1</sup>Department of Plant Sciences; <sup>2</sup>Department of Sociology.

To best address producer problems in the future, our research suggests that we need to find effective solutions for not only the most problematic insect pests, but ideally solutions that can be well-integrated with other management challenges, like weed management and mammal pests.

### **Acknowledgments**

We are exceedingly grateful to the 634 Wyoming producers who took time to complete and return the survey. Thank you to Caleb Carter, Ricardo Ramirez, and a trial group of six farmers for providing feedback on the survey tool to improve the wording and relevance of our questions. We acknowledge Bill Meyer and others at NASS for coordinating our survey efforts.

We appreciate the support received from the University of Wyoming Office of Research and Economic Development and UW Office of General Counsel to facilitate UW Institutional Review Board approval as well as the contract process.

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**Keywords:** alfalfa pests, decision-making, focus groups

**PARP:** X:2



**Figure 1.** Adult alfalfa weevil. (Photo courtesy Joseph Berger, Bugwood.org.)

# Economics of Vaccinating Sheep against Bluetongue Disease

*D. Peck<sup>1</sup>, T. Munsick<sup>1</sup>, M. Miller<sup>2</sup>, and R. Jones<sup>3</sup>*

## Introduction

Bluetongue (BT) disease is a serious and recurring threat to sheep producers in Wyoming and surrounding states. Bluetongue virus (BTV) is transmitted by biting midges (*Culicoides sonorensis*) in late summer and early autumn, just before lambs are typically sent to market. Symptoms of BT include inflammation and congestion, a bluish discoloration of the skin, hemorrhages and ulcerations (most visible in the mouth and nose), and lameness. These symptoms can be fatal, or cause sheep to go off feed, lose weight, and fail to breed.

Currently, no vaccine for BTV—specifically, serotype 17—is readily available for sale in Wyoming. Modified-live virus vaccines for BT are available for purchase through the California Wool Growers Association, but cannot be legally imported to Wyoming. It is possible, however, for vaccine companies to manufacture custom-made killed-virus vaccines for susceptible premises within an affected region of Wyoming, upon special approval by the Wyoming state veterinarian.

For this study, we (1) estimate the cost to a representative sheep producer of a BTV-17 outbreak that causes relatively severe clinical symptoms; (2) estimate the cost of administering a custom-ordered BTV-17 vaccine to our hypothetical sheep flock; and (3) explore the potential cost-effectiveness of using a BTV-17 vaccine to prevent catastrophic outbreaks.

## Objectives

Our primary objective is to provide economic information that sheep producers can use to evaluate whether vaccinating their flock against BTV might be economically worthwhile.

## Materials and Methods

To estimate the farm-level economic consequences of a BT outbreak on a Wyoming sheep operation, we built enterprise budgets for three representative range flocks with 256, 640, and 1,440 breeding ewes. We then used partial budget analysis to estimate changes in an operation's resource use, output, costs, and revenues due to a BT outbreak or adoption of a BTV-17 vaccine.

## Results and Discussion

Preliminary results are available for the 640-ewe flock. Under a worst-case scenario, when the flock is naïve to the virus (has not been exposed in recent years), we assume 36% of the flock becomes infected and 20% of the flock dies (this is based on an actual outbreak in the Bighorn Basin in 2007). When all costs associated with supportive care, pharmaceuticals, death loss, weight loss, and labor are considered, the producer incurs a loss of \$72,120 (Table 1).

Regarding BT vaccines, two types can be custom-made—modified-live virus (MLV) or killed virus (KV)—in coordination with the Wyoming state veterinarian, the Wyoming State Veterinary Laboratory, and a manufacturing company. **The MLV vaccine** currently costs \$0.32 per dose to manufacture, and one dose is required per animal. We assume that the flock is vaccinated every other year, in late spring or early summer, when ewes are not pregnant (otherwise, there is a risk of vaccine-induced abortions). With labor costs included, the MLV vaccine costs \$498 to obtain and administer to a 640-ewe flock (Table 2). **The KV vaccine** costs \$1.20 per dose to manufacture, and it requires two doses per animal. We assume that the flock is vaccinated every other year and is safe to use any time of the year, regardless of pregnancy status. With labor costs included, the KV vaccine costs \$3,500 to obtain and administer to

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<sup>1</sup>Department of Agricultural and Applied Economics; <sup>2</sup>Department of Veterinary Sciences; <sup>3</sup>Producer Cooperator.

a 640-ewe flock (Table 2). We assume **both vaccines** protect 84% of vaccinated sheep.

Bluetongue disease tends to occur cyclically, roughly every 5–10 years. For a five-year return period, given the MLV’s cost and efficacy, an outbreak in a 640-ewe flock would only need to cost \$1,479 to justify vaccinating the flock every other year (i.e., to just break-even). Given the KV’s cost, an outbreak would need to cost \$10,404 or more to justify vaccinating the flock. Our outbreak cost estimate of \$72,120 is much higher than these “break-even outbreak costs,” indicating that the vaccine is very likely to be economically worthwhile. In fact, with an outbreak cost of \$72,120, vaccinating would still be worthwhile, even if BT occurred only once every 48 years (for the MLV) or every 18 years (for the KV).

## Acknowledgments

This study is supported by the Wyoming Department of Agriculture’s Wyoming Agriculture Producer Research Grant Program, Wyoming Agricultural Experiment Station, and two private donors to the University of Wyoming College of Agriculture and Natural Resources.

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**Keywords:** sheep, disease, vaccine

**PARP:** VII:3,7

**Table 1.** Economic costs incurred during a bluetongue outbreak, 640-ewe flock.

Category	Description	Flock-Level Costs (Year 2014)
Supportive Care	Tube with water and creep-feed mixture	\$5,143
Pharmaceuticals	Permethrin 10%	\$38
	Nuflo <sup>®</sup>	\$4,855
	Dexamethasone	\$48
BT Death Loss	Rams, Ewes, Lambs lost	\$56,678
Sickness	Lamb weight loss	\$1,919
Labor	Treatment and Flock Checks	\$3,439
Total		\$72,120

**Table 2.** Annual costs of purchasing and administering a bluetongue vaccine. Two types of vaccines are considered: modified-live virus (MLV) or killed virus (KV).

Cost of vaccinating with MLV (one dose per year)	
Labor	\$ 42.06
Vaccine	\$ 455.44
Total	\$ 497.51
Cost of vaccinating with KV (two doses per year)	
Labor	\$ 84.13
Vaccine	\$ 3,415.80
Total	\$ 3,499.93



# Response of Bird's-foot Trefoil Cultivars to Producer's Field

*S. Sarkar<sup>1</sup> and M.A. Islam<sup>1</sup>*

## Introduction

Bird's-foot trefoil has been used as an alternative to alfalfa in the U.S. as a forage legume to increase the quality and productivity of livestock. Bird's-foot trefoil is non-bloating in nature and highly persistent. It has shown to increase meat and milk quality as well as protein use efficiency in ruminants. The degrees of effect of bird's-foot trefoil on ruminants' performance hinge greatly on cultivars and the presence and amount of condensed tannins (naturally occurring non-bloating agent). Cultivar performance depends on climate variations, environmental conditions, and agronomic practices. To validate the results from small-plot trials at experiment stations, it is important to conduct the study at a producer's farm under that farm's management system.

## Objectives

The objective of this study was to evaluate the performance of three bird's-foot trefoil cultivars in a producer's field.

## Materials and Methods

This study was conducted at the Forrest farm in southeast Wyoming near Torrington. Scott Forrest is a forage crop grower and has experience in cultivation of bird's-foot trefoil. He is an organic grower and does not use any sort of agrochemicals in his fields. Ten acres of his crop field was used for this study. Three cultivars were selected: 'Norcen', 'Leo', and 'Bruce'. Norcen is a North American cultivar known for its high-yielding ability and good quality. Leo is an old European cultivar and is promising due to its better physiological characteristics including both vigor and semi-prostrate nature (branches close to the ground and not upright). Bruce, a new cultivar developed in Canada, is an erect-type

variety, making it suitable to cut for hay; it is winter hardy and can be slightly higher yielding than Leo.

The plot was divided into three strips of about three-plus acres each, one for each cultivar. Each strip was divided into three equal plots for replication. The tillage, seed-bed preparation, seeding (this took place in June 2015), irrigation, and mowing were done by the producer.

Data collection included plant height, crop canopy coverage, and weed coverage. All plots were mowed twice (once in August and again in October) to help control weeds and enhance establishment of bird's-foot trefoil. Dry matter (DM) yield was estimated at the end of the growing season by clipping each plot. Forage quality was also determined using the clipped samples. After being dried and ground, samples were analyzed for forage quality using near-infrared spectroscopy (NIRS) in the University of Wyoming forage agronomy laboratory.

## Results and Discussion

All three cultivars established well. Plant height and crop coverage were highest in Norcen throughout the growing period, followed by Bruce and Leo. Norcen had the highest DM yield and relative feed value followed by Bruce and then Leo (Figures 1 and 2). The DM yields were comparatively low, which was not unexpected in the establishment year. Growth and quality data is again being measured in 2016. Information obtained should be very useful for producers in the region in deciding whether to use bird's-foot trefoil as a potential forage crop.

## Acknowledgments

We thank Scott Forrest, owner of the farm, for providing land and assistance and UW forage agronomy

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<sup>1</sup>Department of Plant Sciences.

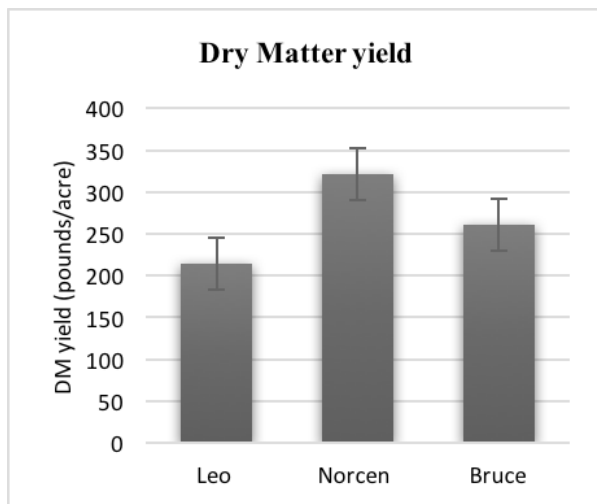
laboratory members for assistance in data collection. The study is supported by the Wyoming Department of Agriculture's Agriculture Producer Research Grant Program and Wyoming Agricultural Experiment Station Hatch funds.

### Contact Information

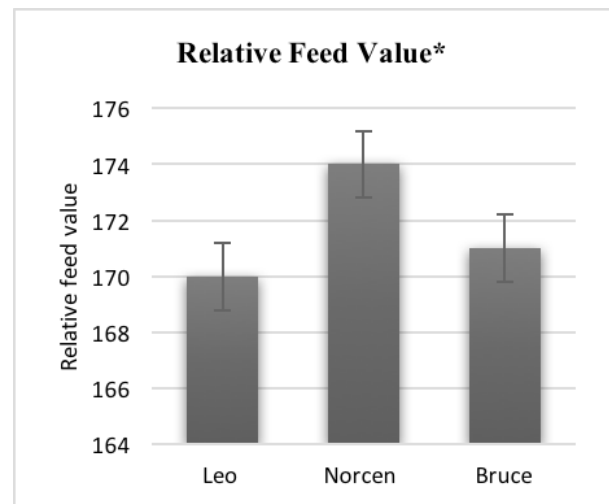
Sayantan Sarkar at [ssarkar@uwyo.edu](mailto:ssarkar@uwyo.edu), or Anowar Islam at [mislam@uwyo.edu](mailto:mislam@uwyo.edu) or 307-766-4151.

**Keywords:** bird's-foot trefoil, cultivars, relative feed value

**PARP:** I:2, II:9, IX:2



**Figure 1.** Dry matter (DM) yield of different bird's-foot trefoil cultivars in a producer's field near Torrington.



**Figure 2.** Relative feed value of different bird's-foot trefoil cultivars in producer's field near Torrington.

\*Relative feed value (RFV) ranks forages relative to the digestible dry matter intake at full-bloom alfalfa.

# Prevalence of *Brucella ovis* in Wyoming domestic sheep

K. Sondgeroth<sup>1</sup> and M. Elderbrook<sup>1</sup>

## Introduction

*Brucella ovis* has direct negative effects on lamb production and is of major concern for Wyoming producers as sheep and lamb production accounts for 35% of their gross agricultural sales (Gardiner et. al, 2012). Infection is introduced into a flock through an infected ram. Historically, infection is associated with ram epididymitis; however, less than half of infected rams show clinical signs. The implications of a *B. ovis* infection for the flock include: ram infertility, decreased ewe conception rates, more abortions, and higher numbers of premature lambs.

## Objectives

(1) Collect and test blood samples from apparently healthy rams and ewes across Wyoming and determine how many have been exposed to *B. ovis*; and (2) compare two different assays for *B. ovis* testing.

## Materials and Methods

Initial contact with producers occurred by introducing the 2015–2016 Sheep Brucellosis Study at the 2015 Wyoming Wool Growers Association winter meeting, mailing a study pamphlet to all members of the WWGA, and developing a website with the study information ([www.uwyo.edu/wyovet/wysheepbrucellosis](http://www.uwyo.edu/wyovet/wysheepbrucellosis)).

Serology testing (antibody in blood samples) can be used to detect exposure to *B. ovis*, and for Wyoming producers with larger flocks (>50 ewes) it is used as part of the breeding soundness exam. While ewes are not typically tested, there is evidence that they can be infected for multiple estrus cycles and be a source of ram infection. The enzyme-linked immunosorbent assay (ELISA) is utilized by most veterinary diagnostic labs that test for *B. ovis*. Among the drawbacks of this assay are variability between different laboratories and the classification

of samples as “Indeterminate” (not quite positive and not quite negative). To address this issue, a direct comparison will be made between the ELISA that is currently utilized in Europe to the one that is used in the U.S. with a subset of samples.

## Results and Discussion

In fall 2015, samples were collected from 1,661 sheep owned by 13 producers across Wyoming (Figure 1). While the majority of initial samples were from rams (1,252), 409 were from ewes (Table 1). The testing will continue on ewes from operations that had previously only tested rams, as well as sampling rams and ewes from flocks owned by producers new to the study. University of Wyoming graduate students, producers, and veterinarians are taking the blood samples. The goal is to sample between 1 to 1.5% of sheep in Wyoming (3,819–5,730) based on the 2013 sheep census (Table 1). The results should give a better understanding of how many Wyoming domestic sheep have been exposed to *B. ovis* and provide data regarding risk factors associated with *B. ovis* infection. The outcome, in turn, should help producers identify infected animals, decrease infection rates through blood testing, and, ultimately, increase lamb production rates.

## Acknowledgments

Funding for this study is provided by the Wyoming Department of Agriculture’s Agriculture Producer Research Grant Program, with matching funds from the Wyoming Agricultural Experiment Station.

## Contact Information

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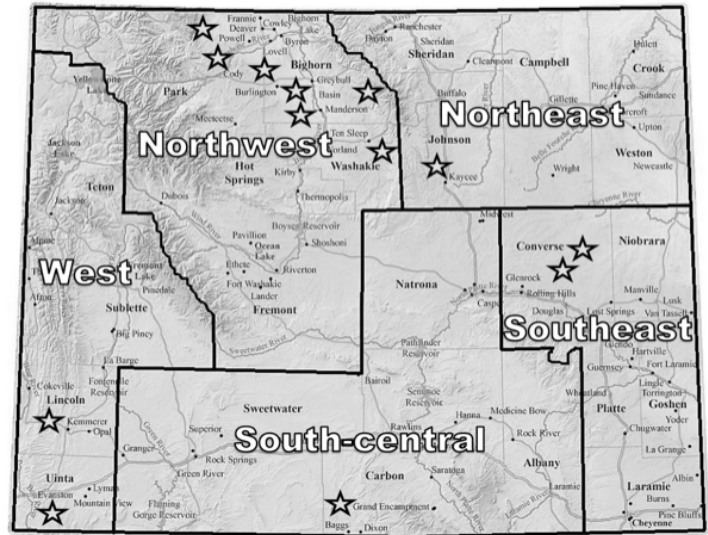
<sup>1</sup>Department of Veterinary Sciences.

**Keywords:** sheep brucellosis, reproduction, *Brucella ovis*

**PARP:** not applicable

**Literature Cited**

Gardiner, L., Rashford, B., Hewlett, J., and Alexander, B., 2012, The state of Wyoming sheep industry: University of Wyoming Extension Bulletin 1229, ii + 19 p.



**Figure 1.** Map of the five sampling districts in Wyoming. Stars indicate producers who have already participated in the study (13 total). For producer privacy, stars do not indicate exact producer location.

**Table 1.** Summary of sampling efforts through December 2015.

District	Counties within District	Total Sheep per County	Total Sheep per District	1.5% Sampling Rate	Total Sheep Sampled (as of 12/2015)	Rams	Ewes
1 Northwest	Park	6,800	69,100	1,037	224	224	-
	Bighorn	10,700					
	Hot Springs	5,100					
	Fremont	20,500					
	Washakie	26,000					
2 Northeast	Sheridan	3,900	76,600	1,149	225	29	196
	Johnson	28,500					
	Campbell	29,000					
	Crook	12,400					
	Weston	2,800					
3 West	Uinta	37,500	92,300	1,385	644	580	64
	Lincoln	39,500					
	Sublette	15,000*					
	Teton	300					
4 South-Central	Sweetwater	12,400	59,500	893	202	202	-
	Carbon	8,200					
	Natrona	36,000					
	Albany	2,900					
5 Southeast	Converse	62,000	84,400	1,266	366	217	149
	Niobrara	4,700					
	Platte	300					
	Goshen	2,000					
	Laramie	15,400					
Total	23	381,900	381,900	5,730	1,661	1,252	409

All numbers were compiled by the Wyoming Field Office of the U.S. Department of Agriculture's National Agricultural Statistics Service and released January 1, 2013.

\*Latest estimates were taken in 2008

# Spring and Fall Herbicide Application for Dalmatian Toadflax Control

*J.M. Workman<sup>1</sup> and B.A. Mealor<sup>1,2</sup>*

## Introduction

Weed invasion is recognized as a threat to ecosystem function in North American rangelands. Controlling weedy species is generally assumed to positively impact these systems; however, primary considerations for land managers should include overall community response both to weed suppression and to the treatment itself.

One species that has contributed to community composition alteration in rangelands throughout the western United States and Canada is Dalmatian toadflax (*Linaria dalmatica*). This noxious, competitive perennial forb reduces available forage and spreads readily once established. Listed as a noxious weed in many states, it's one of 26 weeds on Wyoming's "designated noxious weeds" list. Dalmatian toadflax is typically controlled via herbicide application, often applied in the spring.

## Objectives

Objectives of this study were to evaluate response of Dalmatian toadflax (hereafter called toadflax) and associated vegetation to fall and spring applications of eight herbicide treatments.

## Materials and Methods

We established two experiment sites, with four replicates in each, in fall 2013 on northern mixed-grass prairie at the U.S. Department of Agriculture's (USDA) High Plains Grasslands Research Station near Cheyenne. We applied eight herbicide treatments made up of four active ingredients individually and in pair combinations (Table 1), in fall (November 2, 2013) and spring (June 19, 2014) to 10 × 30-ft plots.

We estimated toadflax density by counting live stems in a belt transect in each plot in midsummer 2014 and

2015. We also measured biomass by functional group at midsummer 2015 and estimated foliar cover by species in fall 2013, spring and summer 2014, and spring 2015.

## Results and Discussion

In 2014, fall herbicide treatments reduced toadflax cover and stem density more than spring treatments at site 1. Herbicide and application timing interacted to influence spring 2015 toadflax cover (Figure 1). We saw less toadflax cover in fall than in spring treatments for most herbicides, but application timing differences were indistinguishable for Chaparral™ or treatments containing aminocyclopyrachlor (AMCP). In summer 2015, toadflax biomass was lowest for Chaparral and AMCP-containing treatments, and stem densities were lower in fall than in spring treatments. We made similar observations at site 2, but cheatgrass (*Bromus tectorum*) abundance and a small toadflax population at this site prevented meaningful responses to our treatments.

We saw no treatment effects on perennial grass in 2014; however, in summer 2015, plots with fall herbicide application had greater perennial grass biomass than spring treatments at both sites. At site 1, Perspective® and Rejuvra™ treatments resulted in lower perennial grass biomass than any other herbicides except Method™. Milestone® had the greatest perennial grass biomass, followed by Chaparral and Telar® + Milestone, which were intermediate between Milestone and Telar (Figure 2).

## Acknowledgments

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<sup>1</sup>Department of Plant Sciences; <sup>2</sup>Sheridan Research and Extension Center.

Agricultural Research Service High Plains Grasslands Research Station near Cheyenne. Special thanks go to the UW range weed science crew for project assistance.

**Contact Information**

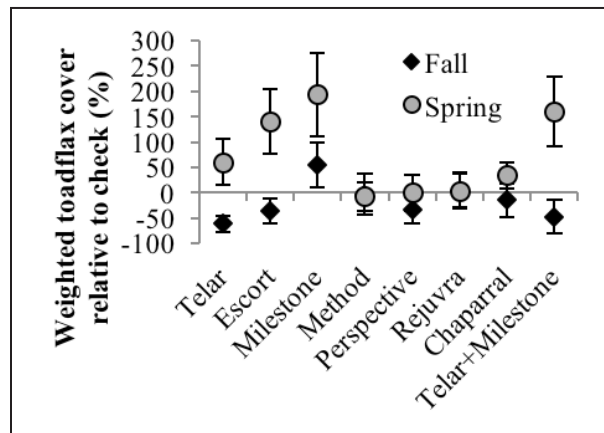
Brian Mealor at bamealor@uwyo.edu or 307-673-2647.

**Keywords:** weed management, rangelands

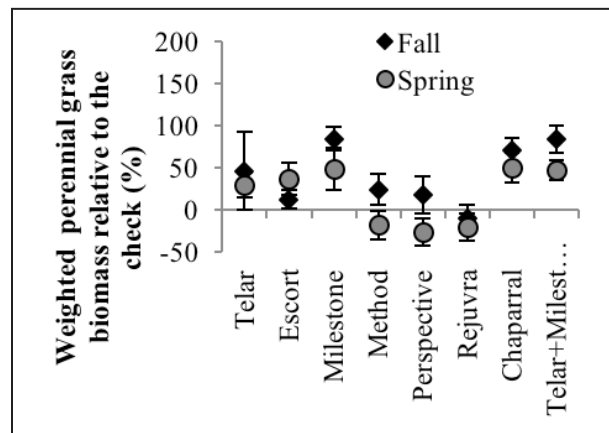
**PARP:** III:2,3,5,7

**Table 1.** Four active ingredients were combined in eight herbicide treatments, with active ingredient rates consistent throughout. All herbicide treatments were applied in fall 2013 and spring 2014.

Herbicide	Active Ingredients (AI)	Product Rate	AI Rate
Telar	chlorsulfuron (CHLR)	1.0 oz/ac	0.7 oz/ac
Escort	metsulfuron (MET)	0.5 oz/ac	0.3 oz/ac
Milestone	aminopyralid (AMP)	6 fl oz/ac	1.5 fl oz/ac
Method	aminocyclopyrachlor (AMCP)	3.6 oz/ac	0.025 oz/ac
Perspective	CHLR+AMCP	4.5 oz/ac	0.7 oz/ac + 0.025 oz/ac
Rejuvra	MET+AMCP	4.0 oz/ac	0.3 oz/ac + 0.025 oz/ac
Chaparral	MET+AMP	2.8 oz/ac	0.3 oz/ac + 1.5 fl oz/ac
Telar + Milestone	CHLR+AMP	1.0 oz/ac + 6.0 fl oz/ac	0.7 oz/ac + 1.5 fl oz/ac



**Figure 1.** An interaction between herbicide and application timing influenced toadflax cover at site 1, expressed as a weighted percent relative to the check, in spring 2015 (11 months after spring and 19 months after fall herbicide application).



**Figure 2.** Herbicide and application timing independently influenced perennial grass biomass at site 1, expressed as a weighted percent relative to the check, in summer 2015 (13 months after spring and 21 months after fall herbicide application).

# Evaluation of the Phosphorous Bioavailability in Semiarid Soils

M. Zhu<sup>1</sup> and C. Gu<sup>1</sup>

## Introduction

Phosphorous (P) is an important limiting nutrient for plant growth. Chemical forms of P ultimately determine P bioavailability that can be evaluated with the Hedley sequential. This method uses increasingly aggressive chemical reagent to extract P so that the sizes of P pools of various bioavailability are obtained. Unfortunately, the pool size information from the Hedley extraction is operational and may not truly reflect P chemical forms. This limits our understanding of P bioavailability in both agricultural and natural soils. X-ray absorption spectroscopy (XAS) is an in situ and direct method for elemental speciation measurement and has been increasingly used for determining P chemical forms in soils. Combining the Hedley extraction with XAS allows for more thorough understanding of P chemical forms and its bioavailability in soils.

## Objectives

The objectives of this study are to evaluate the Hedley P sequential extraction with P XAS and to use the combination of the two approaches to understand P speciation and bioavailability evolution during soil formation in semiarid ecosystems.

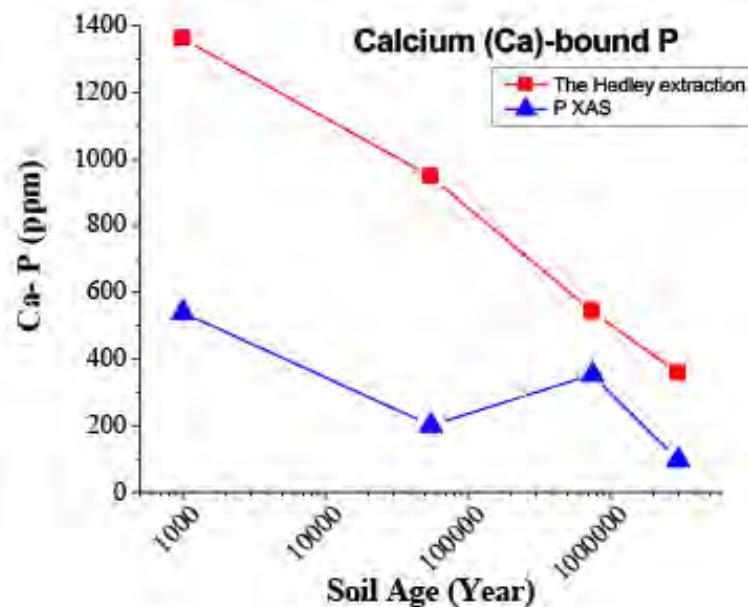
## Materials and Methods

The soils—with ages ranging from approximately 1,000 years to 3 million years—were collected from the San Francisco volcanic

field sites in northern Arizona. The soils were then sieved and milled for Hedley extraction and P XAS analysis. In each extraction step, the residual was measured for P XAS at the Canadian Light Source in Saskatoon, Canada (<http://www.lightsource.ca>).

## Results and Discussion

As shown in Figure 1, the Hedley extraction overestimates the calcium-bound P pool size, i.e., hydraulic chloride acid (HCl) extracted P fractions, by a couple of times at all soil ages. Our further quantification analysis shows that the HCl extraction step removed a significant amount of iron- and aluminum-bound P, which accounts for the overestimation. This result has important implications for evaluating P bioavailability in soils in semiarid environments, including Wyoming.



**Figure 1.** Calcium-bound P fractions determined from the Hedley extraction and P XAS analysis. The soils are approximately 1,000, 55,000, 750,000, and 3 million years old.

<sup>1</sup>Department of Ecosystem Science and Management.

The results that soil testing labs usually provide regarding P bioavailability may need to be interpreted with caution.

### **Acknowledgments**

The study is supported by U.S. Department of Agriculture Hatch funds.

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**Keywords:** phosphorus, Hedley extraction, X-ray absorption spectroscopy

**PARP:** not applicable



# Wyoming Production Agriculture Research Priorities

**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.

## Producer Recommendations

### I. Production Systems Objectives

1. Develop and maintain base line agriculture production systems to evaluate effects of innovations on the natural resource base, sustainability, and profitability.
2. Develop best-agronomic management practices for alternative crops such as sunflower seed production and various forages (perennial and annual legumes, grasses, and legume-grass mixtures) and other oilseed crops.
3. Identify synergistic effects among crops to improve crop rotation systems.
4. Develop methods to deal with residue when establishing new stands in crop rotation systems.
5. Evaluate effects of legumes in dryland wheat production systems.
6. Evaluate incorporating crops and crop aftermath into livestock production systems.

7. Evaluate and compare no-till versus tillage techniques.
8. Identify improved harvesting techniques.
9. Evaluate the use of legumes in rotational cropping systems.

### II. Soil Fertility Management Objectives

1. Develop methods to ameliorate poor soil pH for crop production.
2. Investigate effects of fertilizer type, placement, and timing on crop production (sugarbeets, cereal grains, pinto beans, and forages).
3. Evaluate the efficacy of managing soil nitrogen applied by pivot irrigation.
4. Determine and categorize nitrogen release times for varied forms of nitrogen.
5. Discover methods to reduce dependence on commercial fertilizers.
6. Develop tillage systems that minimize soil disturbance.
7. Develop cheaper alternatives to commercial fertilizer (e.g., cover crops, legumes).
8. Test the ability of compost and manure to enhance soil fertility.
9. Identify plants such as legumes that enhance soil fertility.

### III. Weed Control Objectives

1. Develop control methods for weeds resistant to roundup or other herbicides.
2. Develop methods to control weed emergence that can be applied in the fall.
3. Improve procedures to control noxious weeds, especially milkweed and thistle.
4. Evaluate the efficacy of weed-control chemicals applied before planting in dry bean fields.
5. Develop chemical and non-chemical methods to control cheatgrass and other noxious weeds.
6. Coordinate application of roundup with precision agriculture.
7. Optimize use of herbicides economically and environmentally.

### IV. Irrigation Objectives

1. Test and develop surge and drip irrigation techniques for specific crops, especially alfalfa seed, dry beans, and sugarbeets.
2. Test the ability and reliability of moisture monitors to indicate timing of irrigation.
3. Conduct irrigation management studies to optimize water use for specific crops (alfalfa seed, dry beans, sugarbeets).
4. Develop methods to maximize (optimize) production with less water.

5. Improve irrigated pasture production at high elevations.

### V. Livestock Objectives

1. Develop strategies to enhance the efficiency of feed utilization.
2. Evaluate effects of additives or chemicals to feeds to influence forage and/or weed consumption.
3. Train livestock to consume alternative feeds such as brush and weeds.
4. Determine heifer development strategies that optimize reproduction, foraging ability, and cow longevity to maximize profitability.
5. Identify strategic supplementation protocols that optimize animal production traits with costs of production.
6. Develop improved methods to control flies.
7. Determine how to minimize feed costs and maximize profit per unit of production.
8. Develop genetic markers for feed efficiency.
9. Develop practical estrous synchronization methods for commercial producers.
10. Determine cumulative effects of minerals, ionophores, worming, and implants on animal productivity.
11. Provide cost/benefit information on grazing of irrigated pastures.

## **VI. Grazing Management Objectives**

1. Develop improved forage based livestock production systems.
2. Demonstrate and evaluate benefits of strip grazing corn stalks.
3. Increase the carrying capacity of range and pastureland.
4. Evaluate effects of multi-species grazing on forage utilization and range health and productivity.
5. Develop alternative grazing strategies to enhance rangeland health.
6. Evaluate Management-intensive Grazing and rotational grazing strategies in dry environments.
7. Identify optimum grazing height for alfalfa aftermath and effects of grazing on stand longevity.
8. Develop forage species that are drought resistant.
9. Investigate ways to optimize wildlife-livestock interactions.
10. Provide new information on meadow management and irrigated pasture grazing in higher elevations.

## **VII. Production Economics Objectives**

1. Determine the cost-effectiveness of fertilizer alternatives.

2. Determine the economics of alternative grazing systems.
3. Determine the cost-effectiveness of vaccines, mineral supplements, and pour-ons in livestock production systems.
4. Develop practical methods to assign economic values to ecological management procedures.
5. Identify obstacles and evaluate options and opportunities for marketing Wyoming-produced meat to consumers.
6. Determine impacts of alternative management strategies on whole-ranch/farm economics.
7. Provide information on costs per unit of production.

## **VIII. Crop and Animal Genetics and Biotechnology Objectives**

1. Improve marker-assisted selection procedures to identify plants and animals with desired production traits.
2. Develop and evaluate genetically modified organisms that enhance desired production traits.
3. Identify optimum cow size for Wyoming environments.
4. Increase longevity and production persistence of forage legumes.

**IX. Rural Prosperity, Consumer and Industry Outreach, Policy, Markets, and Trade Objectives**

1. Analyze economic impacts of farming/ranching management decisions. Consider input costs, budgets, and market risks by region and crop.
2. Conduct applied research studies with producers and develop demonstration trials with cooperators to facilitate adoption of new or changing technologies.
3. Increase dissemination of research results (*Wyoming Livestock Roundup*, radio programs, etc.).
4. Work with commodity groups to enhance adoption of new technologies.
5. Conduct hands-on classes at Wyoming Agricultural Experiment Station research and extension centers or with cooperators for young/new producers.

**X. Responding to Climate Variability Objectives**

1. Consider regionally unique environmental conditions when designing research studies.

2. Conduct integrated agricultural systems research that links environment and conservation to production and profitability.
3. Develop drought-resistant plants that fit the extreme environmental conditions of Wyoming.

**XI. Sustainable Energy**

1. Conduct research on bioenergy/biofuels and bio-based products that are suitable to Wyoming's environment.

**XII. Landscape-Scale Conservation and Management**

1. Develop improved methods to reclaim disturbed lands.
2. Evaluate water, soil, and environmental quality using appropriate organisms as indicator species.

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