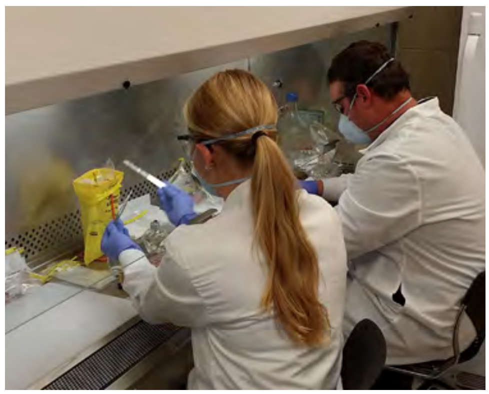
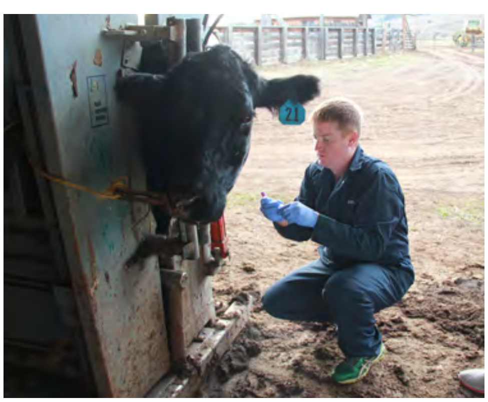
2017 WYOMING AGRICULTURAL EXPERIMENT STATION

FIELD DAYS BULLETIN





UW Agricultural Experiment Station

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Field Days Bulletin 2017

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Introduction to the Wyoming Agricultural Experiment Station Field Days Bulletin

Bret Hess[1]

Introduction

Last year marked a historic milestone for the Wyoming Agricultural Experiment Station (WAES). Members of our team had the privilege to join friends and supporters of WAES in what became nearly a year-long celebration of 125 years of research service to the state of Wyoming. It is not possible to declare the last 125 years to be officially in the books and set our sights on the next 125 years without recapping some of the most encouraging occurrences that will propel WAES into the immediate future.

Pistol and Pete Become Icons

Who would have guessed that having a two-horse team of Haflingers—now famously known as Pistol and Pete—pull the University of Wyoming's College of Agriculture and Natural Resources' sheep wagon at various events around the state throughout the year would create such a stir? Doug Zalesky and Travis Smith with the Laramie Research and Extension Center expended tremendous effort to make appearances with Pistol and Pete at as many events as possible. The expression of disappointment by many people in Laramie when Pistol had to rest his hoof for the Laramie Jubilee Days parade was offset by jubilation when the team returned to Laramie for the UW Homecoming parade. Pistol and Pete were greeted with the same level of enthusiasm everywhere they appeared. What's more, Doug and Travis lost track of how many times they were thanked for bringing the team to various community events around Wyoming.

The overwhelming response to the team of Haflingers gave Chavawn Kelley with the UW Extension Communications and Technology (C&T) team the idea of creating a Pistol and Pete calendar. Attendees of this year's field days will receive the calendar as a gift from WAES. Thanks to Tanya Engel, also with UW Extension C&T, the back cover of this year's edition of the WAES Field Days Bulletin will feature the calendar photos. Tanya is also working to make the photos available for download as computer wallpaper (instructions for downloading are at www.uwyo.edu/uwexpstn).

Celebrating WAES Success

Pistol and Pete were introduced to many WAES supporters at an event held before the 2016 UW football season opener (Figure 1). The college's major gift officer, Pepper Jo Six, called the event "Friends of AES." This name became the inspiration for one WAES supporter to provide gifts of belt buckles to two of the best friends of WAES. Leesa Zalesky was recognized for launching Pistol and Pete's career as WAES mascots and ambassadors. David Kruger, UW Libraries' liaison to the College of Agriculture and Natural Resources, was recognized for the remarkable job of presenting the history of WAES and its affiliated research and extension (R&E) centers.

The Friends of AES event also sparked an idea for another one of our supporters to provide a lead gift to create an award honoring former WAES employee Kathleen Bertoncelj. It seems fitting that Kathleen's successor in the main AES office, Joanne Newcomb, would receive the staff award, which embodies the spirit and dedication of all our WAES staff. Our other 2017 honoree, Rochelle Koltiska, is recognized in Brian Mealor's "Introduction to the Sheridan Research and Extension Center."

Field Days

Last year's four field days included special events at each R&E center to complement the WAES 125-year celebration. Although we will not be celebrating in the same manner this year, we are looking forward to having audiences join us for field days at R&E center locations in

Sheridan (July 7), Powell (July 13), Lingle (August 24), and Laramie (August 26). Research at RRS, the four R&E centers, and other locations in Wyoming are summarized throughout this bulletin.

WAES Field Days Bulletin and the Searchable Database

The printed version of the WAES Field Days Bulletin is available to attendees at field days, and it is also available online at www.uwyo.edu/uwexpstn/publications/. In addition, new as of last year, we launched a searchable database online that includes all of the sources of research that WAES tracks for the college, including the annual Field Days Bulletin. I invite readers to visit www.wyagresearch.org/research/index.php to conduct searches by keyword, R&E center, or the source of research, to learn about work that is planned, is underway, or has been completed, and that addresses one or more of the Wyoming Production Agriculture Research Priorities. It is a useful tool to quickly find specific topics you may be interested in.

Acknowledgments

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

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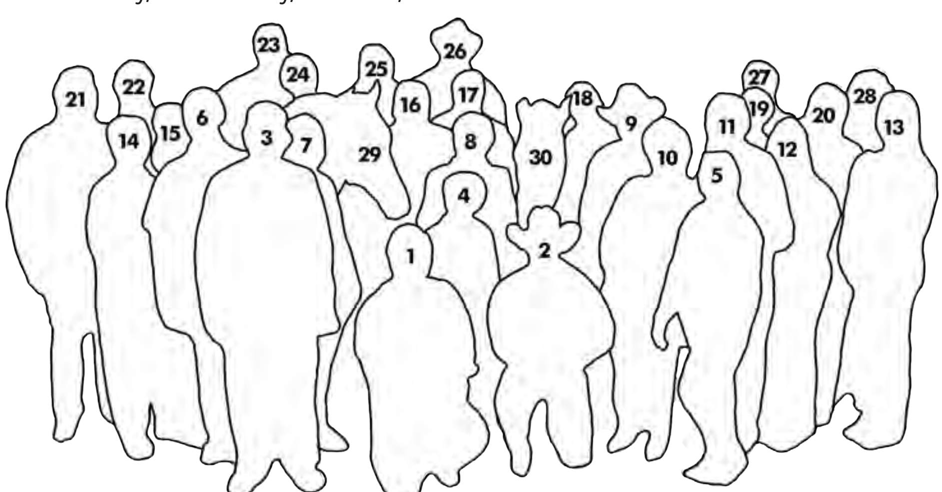
Figure 1. WAES employees and supporters with Pistol and Pete at the "Friends of AES" event in September 2016 in Laramie. Pictured are: 1. John Tanaka, 2. Bret Hess, 3. Jerry Schuman, 4. Kahlia Hill, 5. Pepper Jo Six, 6. George Vance, 7. Maureen Vance, 8. Joann Schuman, 9. Conrad "Connie" Kercher, 10. Ruth Kaltenbach, 11. Kurt "Cub" Feltner, 12. Ann Tanaka, 13. Toni Day, 14. Kathleen Bertoncelj, 15. Jeanne Kennedy, 16. David Kruger, 17. Chad Hutchens, 18. Jane Kercher, 19. Donna Brown, 20. Lynne Pulley, 21. Colin Kaltenbach, 22. Keith Kennedy, 23. Justin Derner, 24. Tansie Derner, 25. Stephen Miller, 26. Doug Zalesky, 27. Frank Galey, 28. Mike Day, 29. Pistol, and 30. Pete.



[1]Director, Wyoming Agricultural Experiment Station.

Introduction to the Laramie Research and Extension Center

Doug Zalesky[1]

Introduction

The Laramie Research and Extension Center (LREC) consists of the greenhouse complex at 30th and Harney streets in Laramie, the Livestock Farm west of Laramie on Highway 230, animal facilities at the Wyoming State Veterinary Laboratory, and lab animal facilities and forage resources at the McGuire Ranch property northeast of Laramie.

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

LREC Highlights and Accomplishments

LREC enjoyed another successful year in 2016. Despite the budget reductions that were realized, LREC continues to provide quality resources for research, teaching, and outreach. This past year was the 125th anniversary celebration of the Wyoming Agricultural Experiment Station (WAES). Throughout the year WAES celebrated this milestone in various ways and at various events throughout Wyoming. One of the highlights was the introduction of a Haflinger team of horses named Pistol and Pete, who pulled the College of Agriculture and Natural Resources sheep wagon through numerous parades and other events throughout the state (Figure 1). The sheep wagon was adorned with banners advertising the 125th anniversary of WAES. We concluded the year of celebration by providing hay rides at a holiday open house hosted by University of Wyoming President Laurie Nichols. Pistol and Pete reside at LREC, and Travis Smith, with the help of others, was instrumental in ensuring that the team made it to so many events throughout the year.

Unfortunately, 2016 did include the departure of two valued staff members. In August, Dale Hill retired from his position at LREC after serving UW and LREC for 18 years. Additionally, Casey Seals, operations manager at the LREC greenhouse complex, resigned his position to pursue a career opportunity in the research and development division of a Laramie-based food production company that continues to see positive growth. We wish both of these gentlemen the very best.

The LREC Swine Unit provides resources for teaching and outreach activities throughout the year. This unit along with the LREC Sheep Unit completed another successful pig and lamb sale, which is conducted annually for local 4-H and FFA students.

Figure1. Pistol and Pete with the College of Agriculture and Natural Resources sheep wagon.

The LREC Sheep Unit (Figure 2) was busy again in 2016 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 2016 and collaborated with the U.S. Sheep Experiment Station (Dubois, Idaho) on a project evaluating feed efficiency in rams.

The LREC greenhouse complex is a hub of activity year-round. Faculty, graduate students, and staff 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. The garden is devoted to testing and highlighting the best of the best in flowering annuals and perennials. In addition to the display garden at the greenhouse complex, there is another garden in front of Old Main on the UW campus.

The LREC Beef Unit (Figure 3) has been busy this past year conducting research projects related to feed efficiency and brisket disease in cattle. Feed efficiency is an important trait due to the high cost of feed. Brisket disease (also known as high-altitude disease) can lead to heart failure, and it poses most risk to cattle above 5,000 feet elevation. 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 animal science classes and other activities.

The LREC Lab Animal Facility is utilized by faculty 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.

One of the busiest and most heavily utilized facilities at LREC is the Cliff and Martha Hansen Livestock Teaching Arena and Mary Mead Room. 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, and host numerous outreach events and meetings. This past year saw a renovation of the arena floor in addition to the replacement of all of the old rodeo equipment and panels with new equipment and panels.

Figure 2. Lambs and ewes at the LREC Sheep Unit.

Acknowledgments

The success of accomplishing the LREC mission is totally dependent upon the quality staff at LREC, along with the support they receive from faculty members, students, the management teams for each unit, and others. Their efforts are what make it possible to provide these resources for the faculty and students of UW as well as the people of Wyoming and beyond.

Contact Information

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Figure 3. Cow/calf pairs at the LREC Beef Unit.

[1]*Director, Laramie Research and Extension Center.*

Genetic and maternal influences on calf rumen microbiome and post-weaning performance

Investigators: Kristi Cammack, Hannah Cunningham, Kathleen Austin, Scott Lake, and Kelly Carpenter

Issue: The rumen microbiome consists of microbes responsible for the breakdown of feedstuffs into energy for use by the host animal. It is possible that influences, such as genetic background and maternal environment, may impact the early calf rumen microbiome and lead to long-term changes in calf performance.

Goal: Determine if the calf rumen microbiome is subject to genetic and maternal influences in early life.

Objectives: Determine the extent of (1) the genetic background; and (2) the maternal environment on calf rumen microbiome development and subsequent post-weaning feed efficiency performance.

Expected Impact: Our goal is to use the results of this study to determine future efforts for improving beef cattle feed efficiency via the rumen microbiome, including using the dam's influence or genetic selection to promote favorable rumen microbes in the young calf.

Contact: Hannah Cunningham at hcunnin6@uwyo.edu or 307-766-4984.

Keywords: beef cattle, feed efficiency, microbiome

PARP: V:1

Testing three native species for establishment potential in weedy sites

Investigator: Kristina Hufford

Issue: Establishment of native plant species in weedy areas can be challenging, and one of the key decisions made by restoration practitioners is what species to include in the seed mix. In an ongoing study of the effects of species and seed provenance (or origin) for restoration success, I am testing the ability of three native species to establish and grow in weedy sites.

Goal: Evaluate the extent to which three native species commonly planted in restoration sites in Wyoming and beyond can establish at weedy sites.

Objectives: Evaluate survival and growth of scarlet globemallow (*Sphaeralcea coccinea*), Sandberg bluegrass (*Poa secunda*), and fringed sage, aka prairie sagewort (*Artemisia frigida*) in field plots infested with weeds.

Expected Impact: Results should assist restoration practitioners with seed mix selection for revegetation of rangeland sites. Weedy native species may be best suited for planting at sites infested with exotic, introduced plant species.

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Keywords: weeds, restoration, native species

PARP: I:2, IX:2–5, X:1,3

All-America Selections annual and perennial flowers

Investigator: 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 flowering annuals and perennials (all-americaselections.org). There are more than 70 AAS Trial Grounds plus almost 200 Display Gardens in the U.S. and Canada; the gardens at UW are Display (Figure 1) and are the only AAS gardens in Wyoming.

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

Objectives: Purposes of this program are to (1) test new, unsold cultivars; (2) inform gardeners and landscapers about AAS winners; (3) earn gardeners' and landscapers' trust in AAS winners; and (4) determine which of the AAS selections can be successfully grown in Wyoming's climate.

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

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

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

Keywords: flowers, annuals, perennials

PARP: not applicable

Fresh cut flower production

Investigator: Karen Panter

Issue: Locally grown, edible horticultural crops are in demand, and there are reasons to produce ornamental crops locally as well; however, many cut flowers are shipped to the U.S. from other countries. We have already successfully grown and flowered several cultivars of fresh cut sunflowers, and we are launching a series of studies to determine production strategies for local fresh cut flowers.

Goal: Develop production strategies for several species of annual cut flowers for commercial production in the high-altitude Wyoming climate.

Objectives: (1) Determine greenhouse and high tunnel production strategies; (2) grow zinnias (Figure 1), verbena, gomphrena (globe amaranth), centaurea (cornflower), celosia (cock's comb), calendula (marigold), and amaranth for cut flower use; (3) determine which of these flowers can be successfully grown for Wyoming's markets; and (4) inform gardeners and landscapers about production strategies.

Expected Impact: Greenhouse- and high tunnel-grown fresh cut flowers can be added as niche specialty crops for Wyoming growers. These cut flowers can be grown for sales at local venues such as retail florist shops and farmers' markets and may encourage expansion of specialty crop production in Wyoming.

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

Keywords: annuals, specialty crops, floriculture

PARP: not applicable

Figure 1. Zinnias and other flowers are being grown to help determine their cut flower niche market possibilities in Wyoming.

Yield and Associated Traits of Three Sweet Corn Hybrids Grown in Laramie

Jim Heitholt[1], Ali Alhasan[1], and Thomas Suhr[1]

Introduction

It is challenging to grow sweet corn in areas of Wyoming (such as Laramie) where the seasonal heat unit accumulation (growing degree days) is low and the frost-free period is less than 90 days. Therefore, testing hybrids is needed to identify options for local farmers.

Objectives

The main objective is to identify early maturing sweet corn varieties and management practices that allow development of full, marketable ears in cooler regions of Wyoming. The specific objective is to quantify yield and its components of three *supersweet* corn hybrids that reportedly reach maturity in 70 days. (Supersweet corn carries the *shrunken-2* (*sh2*) gene, which causes very slow conversion of sugar into starch, which, in turn, allows the corn to maintain its sweetness longer than sweet varieties; however, kernels can become tough.)

Materials and Methods

Three supersweet hybrids from Jung Seed (Randolph, Wisconsin) with ≤70-day maturity were planted in early June 2016 at the Laramie Research and Extension Center (LREC). Four seeds per foot were planted in three-row plots that were six feet long with 24-inch row spacing. There were 22 plots for each hybrid, and plots were randomly distributed across the field (completely randomized design). The field was treated with a pre-emergent application of Outlook® (14 fl oz/ac) and Prowl® (2 pts/ac) herbicides. The field was top-dressed with nitrogen (N), phosphorus (P), and potassium (K) (20-10-20) on June 22 and again in mid-July. Both applications resulted in a total of 100 lb N, 22 lb P, and 83 lb K per acre, respectively. Final stand (total plants per plot) and plant height (from ground to base of the tassel on three plants per plot) were recorded at maturity. Ears that appeared mature were hand harvested, counted, and weighed beginning September 7 and ending September 21.

Results and Discussion

Final stands were ~22,000 to ~25,000 plants/ac and, surprisingly, varied significantly among hybrids (Table 1). Hybrids differed significantly in height (36 to 40 in), yield per acre (9,340 to 14,500 lb), and average ear weight (233–269 g [8.2–9.5 oz]). The number of ears/ac also differed significantly (18,300–24,500). The higher yield of Northern Xtra was associated with more ears per acre, a heavier per-ear weight, a higher ratio of ears per plant, and a shorter stature than Xtra Sweet 4427. Concerning the latter, it is common for short hybrids to outyield tall hybrids. In this case, it is also possible that the response was associated with Northern Xtra being shorter and earlier in maturity, and it also partitioned more of its photosynthate into ears and less into stalk and leaves.

Because the two lower-yielding hybrids had a greater stand density than Northern Xtra and a lower percentage of harvestable ears per plant (i.e., more plants without ears), one might argue that these hybrids were not thinned aggressively enough. However, the difference in stand between Xtra Sweet 4427 and Northern Xtra was only 0.12 plants/ft (1.13 vs. 1.01 plants/ft), and these are relatively low plant densities. Many of the plants tillered and/or produced secondary ears that were less than one-third normal size and, therefore, were not harvested.

Most harvested ears had fully developed kernels, appeared to be market quality, and were “attractive”; however, all ears tasted bland. Perhaps the tough pericarp (the wall of the kernel) associated with *sh2* ears contributed to the poor taste. We spoke with a Wyoming sweet corn grower who has also experienced bland-tasting ears with the early maturing hybrids.

Potential for sweet corn production on a commercial scale in climates like Laramie (elevation 7,200 ft; cool nights; short growing season) remains risky. Freezing temperatures in mid-September are commonplace in this region and is a factor in preventing normal development of late-emerging ears. Using an average of 21,000 harvested ears per acre and a selling price of 33 cents per ear, gross revenue of ~$700/ac is possible; however, with seed, water, and fertilizer costs, net profit would likely be small or maybe even negative. In 2017, we expect to test *su* (sugary) and *se+* (sugar-enhanced) hybrids or *sh2* hybrids with varying maturity to determine if yields can be increased and the bland taste avoided.

Acknowledgments

We thank Ethan Walter for field preparation/irrigation scheduling, David Claypool for guidance on herbicide application, and LREC staff for helping with other tasks critical to this study.

Contact Information

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Keywords: corn, yield, short growing season

PARP: Goal 2

Table 1. Yield and other traits of three supersweet corn hybrids grown at LREC from late spring through late summer 2016.

Hybrid	Yield	Ear Number	Ear Weight**	Height	Final Plant Stand
	Lb per ac	No. per ac	g per ear	inches	No. per ac
Xtra Sweet 4427 Hybrid*	9,340	18,300	233	40	24,700
Early Xtra Sweet Hybrid*	10,800	19,600	248	36	24,200
Northern Xtra Sweet Hybrid*	14,500	24,500	269	36	21,900
Least significant difference (0.05)	1,560	2,700	13	3	1,890

**Maturity ratings (from the Jung Seed website) for Xtra Sweet 4427, Early Xtra, and Northern Xtra are 70, 68, and 67 days, respectively.*
***One pound equals 454 g.*

[1]*Department of Plant Sciences.*

Yield and Stomatal Conductance Response of Experimental Dry Bean Genotypes to Drought under Greenhouse Conditions

Jim Heitholt[1] and Annalisa Piccorelli[2]

Introduction

Dry bean breeders and physiologists continue to seek varieties with better drought tolerance. To assess drought tolerance, researchers grow plants under drought conditions and perform a calculation that allows a ranking of genotypes. Our goal is to identify parental lines for our breeding program.

Objectives

The objectives are to quantify the yield and yield component (i.e., pod number and seed size) response of differing genotypes to drought and to calculate their drought susceptibility indices.

Materials and Methods

Seed of six dry bean genotypes were sown in 3-gallon pots (with a sand:soil:bark mix) in a Laramie Research and Extension Center (LREC) greenhouse on May 10, 2016. We used four cultivars and two experimental lines (courtesy of Associate Professor Carlos Urrea, University of Nebraska–Lincoln's Panhandle Research and Extension Center near Scottsbluff, Nebraska) with six pots per genotype. At bloom, half the pots were assigned to a full irrigation and the other half received half that amount. Stomatal conductance (SC) was measured during pod fill (July 2, 2016) with a Decagon SC-1 leaf porometer. Other agronomic traits were measured at maturity. Pod harvest index (PHI) was determined as: ([seed weight]/[seed weight + pod wall weight]). Aborted seed per normal seed (ASPNS) was calculated as: aborted seed number/normal seed number. Drought susceptibility index (DSI) was calculated as per Fischer and Maurer (1978).

Results and Discussion

Drought reduced seed yield (p=0.009), but genotypes did not differ (p=0.077) (Table 1). The 52% greater yield due to full irrigation was paralleled by increases in seed number per pot (47%), pod number per pot (29%), seed per pod (13%), nodule number per pot (28 vs. 8), whereas seed size only increased 5%. Drought did not affect PHI or ASPNS, but genotypes differed (Table 2). Drought reduced SC and maturity (68 vs. 71 days). Additional studies with the genotype NE28-15-51 are planned for 2017 to see if its drought tolerance is consistent.

Acknowledgments

The authors thank LREC employees for monitoring environmental conditions in the greenhouse throughout the study and Ali Alhasan for technical assistance.

Contact Information

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Keywords: dry bean, yield, drought

PARP: Goals 1 and 2

Literature Cited

Fischer, R. A., and Maurer, R., 1978, Drought resistance in spring wheat cultivars. I. Grain yield responses: Australian Journal of Agricultural Research, v. 29, p. 897–912.

Table 1. Effect of drought on yield and drought susceptibility index (DSI) of six dry bean genotypes grown in the greenhouse under two watering regimes (DT, drought; FI, full irrigation) during spring–summer 2016.

Genotype	Yield – DT	Yield – FI	Seed Size – DT	Seed Size – FI	DSI
	g*	g	mg**	mg	
Long's Peak	23.8	35.5	316	363	0.95
Marquis	24.9	38.7	288	260	1.03
NE28-15-9	25.1	38.4	305	345	1.00
NE28-15-51	23.0	31.5	319	360	0.78
Othello	24.1	37.4	305	360	1.15
Powderhorn	22.7	37.6	330	317	1.00
Mean	23.9	36.5	311	327	na
Least significant difference (0.05)	4.4	4.4	28	28	na

Notes: 1 gram*=0.04 oz; for example, 23.8 g=0.84 oz; 1 mg**=0.000035 oz; for example, 316 mg=0.01 oz

Table 2. Effect of drought on aborted seed per normal seed (ASPNS), pod harvest index (PHI), root weight per pot (RW), nodule number per pot (Nod), and stomatal conductance (SC) of six dry bean genotypes grown in the greenhouse under two watering regimes (drought, DT; full irrigation, FI) during spring–summer 2016.

Genotype	ASPNS	PHI	RW – DT	RW – FI	Nod	SC – DI*	SC – FI
	%	%	g	g	no.	mmol m-2 s-1	mmol m-2 s-1
Long's Peak	5.5	76	3.1	3.8	3	399	1040
Marquis	9.3	75	2.6	5.6	13	424	701
NE28-15-9	17.0	78	3.1	4.9	29	433	873
NE28-15-51	4.7	75	4.1	5.4	32	456	791
Othello	10.8	78	2.7	3.2	20	671	736
Powderhorn	2.2	78	2.7	3.0	12	477	991
Mean	8.6	77	3.0	4.3	18	477	855
Least significant difference (0.05)	5.7	2	1.1	1.1	21	276	276

Note: mmol m-2 s-1* is the standard units for quantifying leaf stomatal aperture.

[1]*Department of Plant Sciences;* [2]*Department of Statistics.*

Effect of Planting Time on Dry Matter and Seed Yield of Fenugreek

Saugat Baskota[1] and Anowar Islam[1]

Introduction

Fenugreek is a leguminous plant used for food, spices, tea, and medicinal purposes, as well as animal feed. Fenugreek stimulates milk production of dairy animals, has excellent forage quality (comparable to alfalfa), and is non-bloating to grazing animals. But limited information is available on fenugreek cultivation and management, especially in respect to time of planting and its effect on growth.

Objectives

The objectives were to determine the effect of planting time on dry matter yield and seed production of fenugreek.

Materials and Methods

The experiment was conducted at the Laramie Research and Extension Center (LREC) under irrigated conditions from May to October 2015 and 2016. The study was laid out in a strip-split randomized complete block design with three replicates. Fenugreek seeds were planted on three different dates each (treatments): in 2015, May 18, June 1, and June 18; in 2016, May 5, May 19, and June 3. Seeds were inoculated with *Rhizobium* bacteria prior to seeding, and the seeding rate was 30 pounds/acre. Fenugreek cultivars used for this study were Tristar, F96, F75, LRC3375, and LRC3708.

In 2015, plots were harvested August 19 for dry matter (DM) and October 10 for seed yield. In 2016, the harvest was September 6 for DM and November 15 for seed yield.

Results and Discussion

In 2015, the greatest DM (1,232 lb/ac) and seed production (181 lb/ac) were in the plots planted on May 18 (Figure 1). Likewise, in 2016, the plots planted on May 19 produced the greatest DM (3,250 lb/ac) and seed yield (682 lb/ac) (Figure 2). Across three planting times, average DM and seed yields were greater in 2016 (2,401 versus 1,056 lb/ac) than in 2015 (372 versus 121).

The difference in DM and seed yield was likely due to high natural precipitation in June and October 2015 (2.81 and 2.67 in, respectively), which significantly reduced the plant count per plot and caused shattering of seeds (when seeds are dispersed). This indicates that planting time has a great effect on plant growth and, ultimately, seed production.

Factors like temperature and precipitation are important for crops to perform at highest potential. Results in 2015 and 2016 showed that temperatures around 45–50°F and precipitation less than 1 inch during seeding was suitable for fenugreek cultivation. Results suggest that the second to third week of May might be a good time to plant fenugreek for optimum plant growth and yield in the Laramie area and similar environments.

Acknowledgments

The experiment was funded by the Wyoming Department of Agriculture's Agriculture Producer Research Grant Program and Specialty Crop Block Grant Program, as well as the U.S. Department of Agriculture's Hatch program. We appreciate the assistance of LREC staff and forage agronomy lab members.

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Keywords: fenugreek, planting time, dry matter

PARP: I:1,2,12, II:2, VI:1

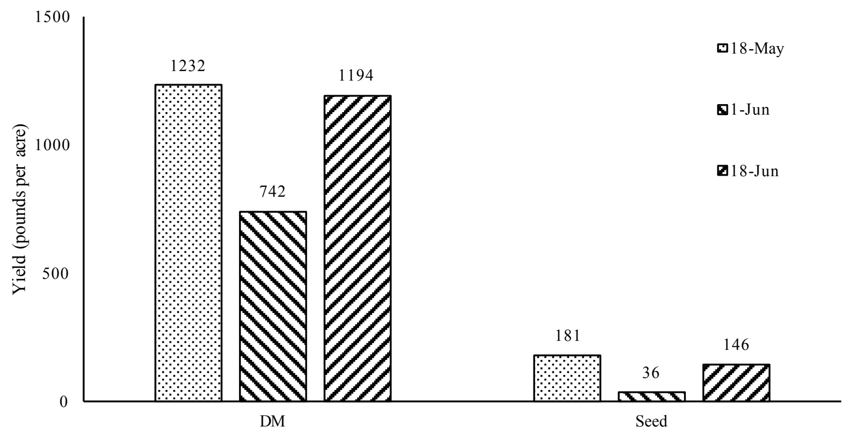

Figure 1. Dry matter (DM) and seed yield production of fenugreek at different planting times in 2015.

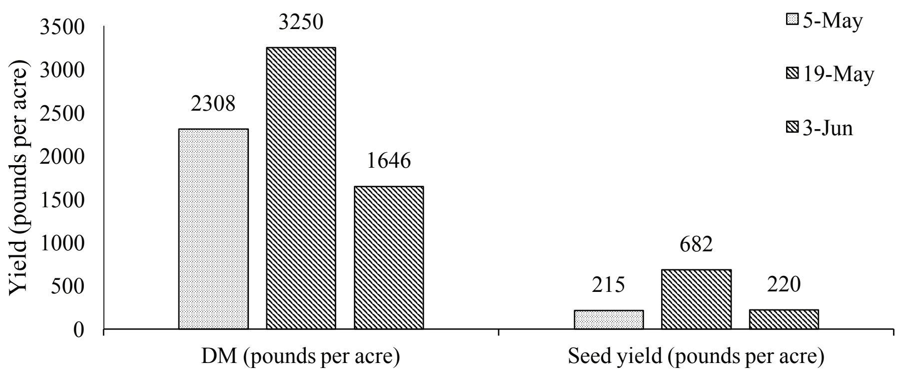

Figure 2. Dry matter (DM) and seed yield production of fenugreek at different planting times in 2016.

[1]*Department of Plant Sciences.*

Evaluation of Forage Nutritive Value of Quinoa Cultivars

Saugat Baskota[1] and Anowar Islam[1]

Introduction

Quinoa is a specialty crop that originated from the Andean region. Its seeds provide health benefits for humans, and in recent years quinoa has been used as an animal feed because of its high nutritional value.

There are various parameters to judge the quality of a forage crop, including crude protein (CP), relative feed value (RFV), total digestible nutrients (TDN), and in vitro dry matter digestibility (IVDMD).

In contrast, anti-quality factors like acid detergent fiber (ADF) and neutral detergent fiber (NDF) should be at a minimum level. ADF refers to the cell wall portions of forage that are made up of cellulose and lignin. NDF refers to the cell wall portion including ADF plus hemicellulose. As ADF and NDF content increases, digestibility of the forage decreases. Further, forage quality of a crop also depends on various factors like plant species, growth stage, and management practices.

Quinoa has been evaluated worldwide for its potential as a forage crop, but in Wyoming limited information is available on its cultivation and nutritive values.

Objectives

The objective of this study was to determine the forage nutritive value of different quinoa cultivars.

Materials and Methods

The study was carried out at the Laramie Research and Extension Center (LREC) in 2015 and 2016 under irrigated conditions. Six cultivars of quinoa (Cherry Vanilla, Mint Vanilla, Red Head, Oro de Valle, Brightest Brilliant Rainbow, and French Vanilla) were planted in a randomized complete block design with three replicates. In 2015, planting was on May 18, while harvesting took place August 21. In 2016, planting and harvesting were May 5 and August 31, respectively. Forage quality parameters (CP, NDF, ADF, IVDMD, TDN, and RFV) were determined. Samples were ground in a Wiley® mill, nutritive values were analyzed using near infrared reflectance spectroscopy, and data were analyzed using the statistical software SAS 9.4.

Results and Discussion

In 2015 and 2016, there were no significant differences in any of the forage quality parameters among quinoa cultivars (Table 1). However, forage quality differed over the two years. Quality parameters like CP, IVDMD, TDN, and RFV were higher, while anti-quality parameters like ADF and NDF were lower in 2015 as compared to 2016. Thus, quinoa grown in 2015 had higher nutritive values than in 2016. The difference in forage quality between these two years was likely due to the age of crop. Nutritive value of a crop usually declines with the advancement of plant age. In 2015, quinoa was harvested at 96 days after planting while in 2016, it was 119 days.

Furthermore, the nutritive values of quinoa were in the range of a crop used for forage. Quinoa seems to be comparable to corn silage (7–10% CP, 41–54% NDF, 24–33% ADF, and 67–71% TDN). Also, forage quality of quinoa can be compared to that of alfalfa if harvested at the earlier stage.

So, regardless of the cultivars tested, quinoa has the potential for use as an alternate forage crop for all farm animals in Wyoming.

Acknowledgments

The study was funded by the Wyoming Department of Agriculture's Agriculture Producer Research Grant Program and Specialty Crop Block Grant Program, as well as the U.S. Department of Agriculture's Hatch program. We also appreciate the kind assistance of forage agronomy lab and LREC staff members.

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Keywords: quinoa, forage yield and quality, nutritive value

PARP: I:1,2,12, II:2, VI:1

Table 1. Forage nutritive values of different quinoa cultivars at LREC in 2015 and 2016.

	CP (%)		NDF (%)		ADF (%)		IVDMD (%)		TDN (%)		RFV	
Cultivars	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Cherry Vanilla	26	13	29	34	21	30	85	70	79	68	234	181
Mint Vanilla	23	14	31	35	22	30	81	71	79	70	219	178
Red Head	25	14	30	37	21	31	83	67	78	68	226	163
Oro de Valle	23	14	30	34	21	30	82	70	78	70	223	179
Brightest Brilliant Rainbow	22	13	33	39	24	35	78	62	76	64	202	147
French Vanilla	22	13	32	38	23	32	80	66	77	67	210	160
Average	24	13	31	36	22	31	81	68	79	68	219	168

[1]*Department of Plant Sciences.*

Meadow Bromegrass in Mixture with Alfalfa Affects Light and Nitrogen Acquisition, Forage Yield, and Nutritive Value

Dennis Ashilenje[1] and Anowar Islam[1]

Introduction

For decades, forage legumes have remained attractive for inclusion in mixtures with grass crops because of their role in fixing atmospheric nitrogen (N). Compared to monocrops, grasses modify their growth to get more sunlight when growing in mixture with legumes. They do this by developing longer and thinner leaves with less amounts of tissue; thus, they store less carbon, but accumulate more N, the latter of which is used for photosynthesis. In such cases, grass absorbs more N from the soil. On the other hand, legumes fix more N when there are low amounts of this nutrient in the soil. In addition, alfalfa develops fewer branches when in mixtures compared to a monocrop. These changes in growth and tissue composition may translate to better forage quality, particularly greater protein and digestibility for mixed crops; however, a gradual reduction in alfalfa growth due to competition from grass eventually lessens the benefits from N fixation and crude protein in their shoots.

Objectives

The aim of this experiment is to determine changes in light interception, growth, and N acquisition and their effects on forage yield and quality in a meadow bromegrass-alfalfa mixture compared to monocrops.

Materials and Methods

A greenhouse experiment was conducted at the Laramie Research and Extension Center (LREC) greenhouse complex from February to June 2016. The study involved four treatments: meadow bromegrass monocrops receiving 0 and 50 pounds of N per acre, alfalfa monocrop (inoculated), and a 50:50 ratio mixture of alfalfa and meadow bromegrass. At 8, 10, and 12 weeks after seedlings emerged, plant height, the number of branches, and the number of leaves were determined. During these stages of plant growth, the proportion of incoming sunlight that was absorbed by leaf surfaces for different crops was also measured. At harvest, forage dry weight from each pot (0.2 ft^2) was converted to equivalent yield in tons/ac. Forage nutritive value was measured as crude protein (CP) and in vitro dry matter digestibility (IVDMD), which determines how much fiber in feeds is being digested in the rumen to provide energy for livestock growth and milk production. Fiber content was determined based on neutral detergent fiber (NDF) and acid detergent fiber (ADF), which, in low amounts, contributes to high relative feed value (RFV), a standard measure of forage quality. The treatments in the greenhouse study are replicated in a field study at the Sheridan Research and Extension Center (ShREC).

Results and Discussion

Treatments did not affect (p=0.092) forage dry matter yield, which ranged between 7.7 and 10.4 tons/ac (Table 1). However, the meadow bromegrass-alfalfa mixture (50:50) had 21% CP, which was significantly greater (p<0.05) than the 11% recorded in the meadow bromegrass monocrop. The mixture also gave higher forage IVDMD (80%) and RFV (170) compared to grass monocrop (68% and ~100, respectively). Both ADF (39 to 27%) and NDF (55 to 37%) reduced significantly in the mixed crop compared to the grass monocrop. The meadow bromegrass-alfalfa mix captured 25% of incoming light, which is significantly more than 16% in each of the meadow bromegrass and alfalfa monocrops. Meadow bromegrass shoots in mixture with alfalfa accumulated 2% of N, which was more (p<0.05) than 1% recorded in the grass monocrop. Alfalfa fixed similar amounts (p=0.364) of N in monocrop (80%) as in mixture (93%). It is evident that meadow bromegrass and alfalfa in a mixed crop acquire more light and N, resulting in a forage rich in crude protein and digestibility. Our experiment at ShREC is ongoing to ascertain how consistent these benefits are in a field situation.

Acknowledgments

We appreciate the assistance of LREC and ShREC staff. The study received financial support from Western Sustainable Agriculture Research and Education, the Wyoming Agricultural Experiment Station, and the University of Wyoming's Department of Plant Sciences.

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Keywords: grass-legume mixtures, nitrogen, forage

PARP: I:2, II:2, VII

Table 1. Dry matter (DM) yield, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), in vitro dry matter digestibility (IVDMD), relative feed value (RFV), and light interception (LI) for meadow bromegrass and alfalfa monocrops compared to a 50:50 mixture (LREC in 2016).

Treatment	DM ton/acre	CP %	NDF %	ADF %	IVDMD %	RFV	LI %
Meadow bromegrass monocrop without N	7.7	11	55	39	68	100	16
Meadow bromegrass monocrop + 50lb N/ac-1	7.7	11	54	38	68	102	24
Alfalfa monocrop	10.4	23	37	25	78	175	16
Meadow bromegrass-alfalfa mixture (50:50)	9	21	37	27	80	170	26
Least significant difference (0.05)	2.4	9	15	13	15	7	8

[1]*Department of Plant Sciences.*

Vegetables and Herbs Under High and Low Tunnels: Completion Report

Karen Panter[1], Sadanand Dhekney[2], and Ami Erickson[3]

Introduction

Growing vegetables and herbs in unheated high tunnels, either alone or in combination with low tunnel row covers, may help producers overcome some of Wyoming's climate obstacles. The goal of this project was to successfully grow fresh tomatoes, peppers, green beans, and basil in two high tunnels (one north–south [NS] oriented, one east–west [EW]) with and without low tunnel row covers. The project was completed in 2016.

Objectives

Our main objective was 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. Fresh 'Ace 55' tomato, 'Anaheim Chili' pepper, and 'Thai Asian' basil seeds were sown in the greenhouse April 4, 2016, and were transplanted to the high tunnels May 26, 2016. Fresh seeds of 'Earli Serve' green beans were directly sown into the high tunnels May 26.

Three tomatoes, four peppers, 10 bean seeds, and five basils were planted in northeast, southeast, northwest, and southwest locations within each high tunnel. All plants in the NE and NW sections of the N–S tunnel, and the NE and SE sections of the E–W 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 19, 2016. The study ended the same day.

Results and Discussion

Basil: The locations with the highest average basil fresh weights were both SE corners. Highest average fresh weight was in the uncovered SE spot of the N–S high tunnel (3.5 oz), but the next highest, 3.1 oz, was in the covered SE section of the E–W tunnel (Figure 2). Overall average of basil plant weights were 2.5 oz in the covered low-tunnel plots and 2.0 oz in the uncovered plots. Overall, basil plant weights were 2.3 oz in the N–S tunnel and 2.3 oz in the E–W tunnel.

Beans: For unknown reasons, green bean seed germination was very poor with zero germination in the E–W tunnel in the NE and SE corners, both of which were covered with low tunnels. Of those that germinated, 44% of the plants produced no fruit. Of those that did produce fruit, the highest average was 1.3 oz (N–S SW section).

Figure 1. Some plants in the test were covered with white fabric low tunnel row covers suspended over metal hoops.

Chili peppers: 39% of the plants produced no fruit. The highest average fruit weights were in the N–S NE (1.3 oz) and E–W SE (1.3 oz) sections, both low tunnel-covered.

Tomatoes: 67% of the tomato plants produced no fruit by the end of the study. Of those that did flower and fruit, the highest average fruit weights were in the E–W NE low tunnel-covered plot (3.9 oz) and N–S NW low tunnel-covered section (3.0 oz).

Results indicated no particular yield advantage to either tunnel. Low tunnel row covers did seem to help increase yields with basil, chili peppers, and tomatoes, but made little difference with green beans. Less evapotranspiration, less exposure to wind, and potentially more consistent temperatures under the low tunnels may have contributed to slightly higher yields.

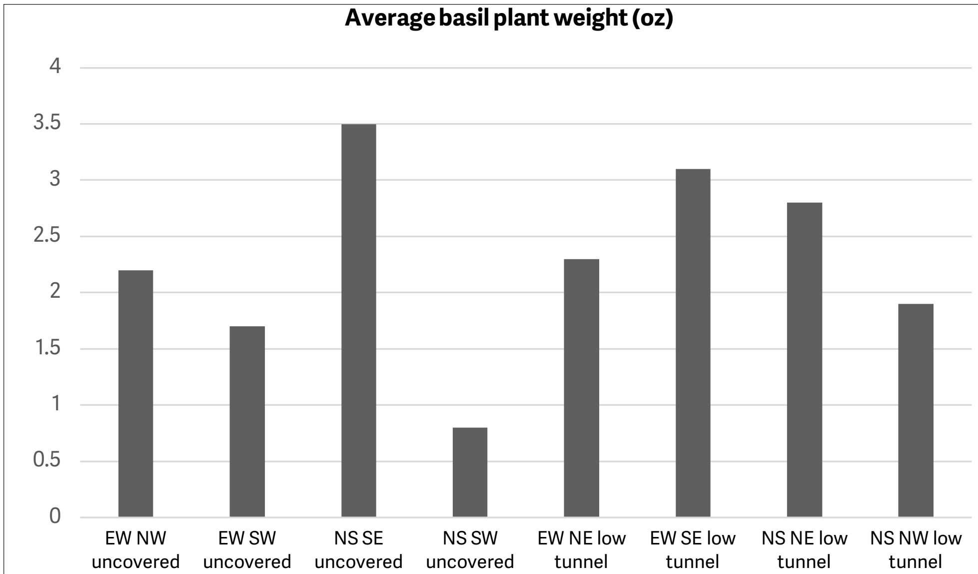

Figure 2. Average fresh weights (ounces) of whole basil plants grown in east–west (EW) and north–south (NS)-oriented high tunnels, uncovered or covered with low tunnel row covers.

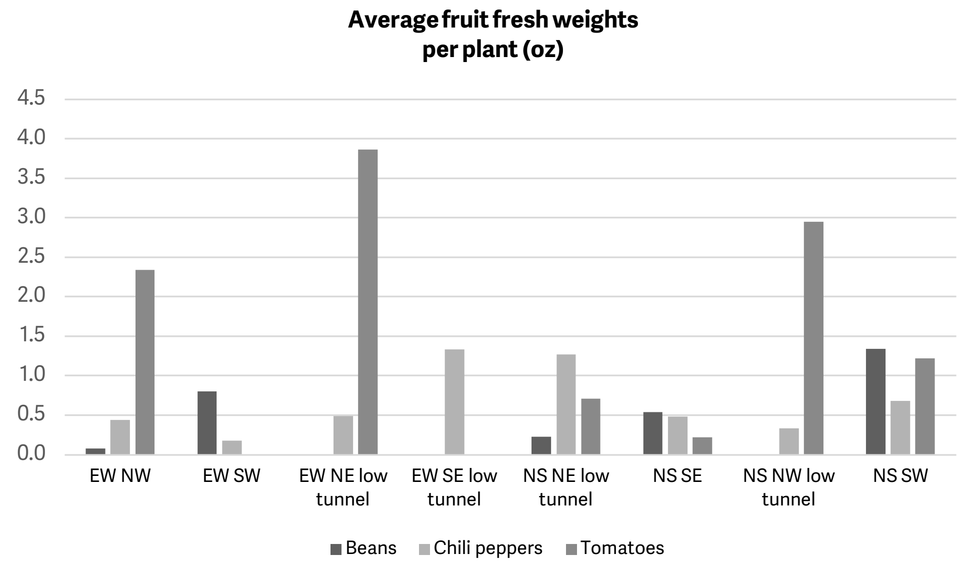

Figure 3. Average fresh weights (ounces) of green bean, chili pepper, and tomato fruits from plants grown in east–west (EW) and north–south (NS)-oriented high tunnels, uncovered or covered with low tunnel row covers.

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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Fresh Cut Sunflower Production

Karen Panter[1]

Introduction

Interest in local production of horticultural commodities is increasing in Wyoming. Ornamental crops should be part of the discussion along with edible crops. We grew fresh cut sunflowers in a Laramie Research and Extension Center (LREC) greenhouse and in two high tunnels in two different growing seasons, 2012 and 2016.

Objectives

Our overall goal was to add a niche specialty cut flower crop for Wyoming growers who use high tunnels or greenhouses for production. Other aims were to grow fresh cut sunflowers in the brown and gold, University of Wyoming colors (Figure 1) for the local market and to make available to Wyoming growers the methods used. We wanted to add a specialty crop that can be grown in Wyoming for sale at local venues such as retail florists and farmers' markets. We want to expand and encourage specialty crop production Wyoming.

Materials and Methods

2012: Seeds of three cultivars of *Helianthus annuus* were sown on May 2 and transplanted either into 19 oz containers in the greenhouse or in the ground in two high tunnels. Cultivars used were 'Dafna', 'ProCut Bicolor', and

Figure 1. *Helianthus annuus* sunflowers ready for market.

'Sunbright Supreme'. All plants were spaced on six-inch centers, irrigated daily or as needed, and fertilized with one teaspoon (0.2 oz) of slow release 15-9-12 fertilizer per plant.

2016: Two cultivars, Dafna and ProCut Bicolor, were sown on May 26 and transplanted into #1 (95 oz) containers and into the ground in the high tunnels on June 8. Spacing, watering, and fertilization were the same as 2012.

Harvest and data collection for both years: Stems were cut when the outer ring of petals on each sunflower was fully open. Stem lengths and days from sowing to harvest were recorded.

Results and Discussion

In 2012, days to harvest varied by cultivar. It took longer for Dafna to reach maturity in the high tunnels (94 days) than in the greenhouse (89 days); the same held true for Sunbright Supreme, which took 95 days in the high tunnels and 90 in the greenhouse. ProCut Bicolor took about the same number of days to reach cutting stage: 77 days in the high tunnels and 80 in the greenhouse. In 2016, Dafna took 78 days in the tunnels while ProCut Bicolor took ~70 days. The overall average of days to harvest of the two cultivars in the greenhouse was 63 (Figure 2).

Longer time to harvest in the high tunnels as opposed to the greenhouse is probably due to lower night temperatures outdoors. This has a tendency to increase cropping time. Warmer, more consistent temperatures in the greenhouse contributed to shorter times to harvest.

In 2012, stem lengths varied by cultivar, but not by where they were grown. Sunbright Supreme showed an average stem length of 54.7 inches, Dafna 45.7, and ProCut Bicolor 41.7. In 2016, the opposite occurred—differences in stem lengths depending on where they were grown, but no differences between the two cultivars. Stem lengths in 2016 averaged 50.5 inches when grown in the greenhouse, but anywhere from 35.2 (east side of the north–south-oriented tunnel) to 29.3 (west side of the north–south tunnel) (Figure 3).

We did not see differences in stem lengths between cultivars in 2016. Differences in stem lengths because of locations were likely due to higher light levels during early morning hours on the east side. Westerly winds hitting the west side plants tended to shorten them.

Acknowledgments
I thank LREC greenhouse staff members for assistance with watering and data collection.

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Keywords: annuals, specialty crops, floriculture

PARP: not applicable

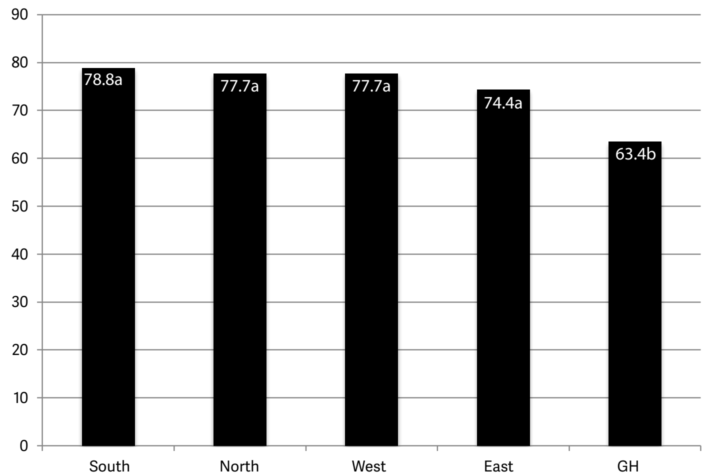

Figure 2. 2016 days to harvest of fresh cut sunflowers in the greenhouse (far right) versus high tunnels.

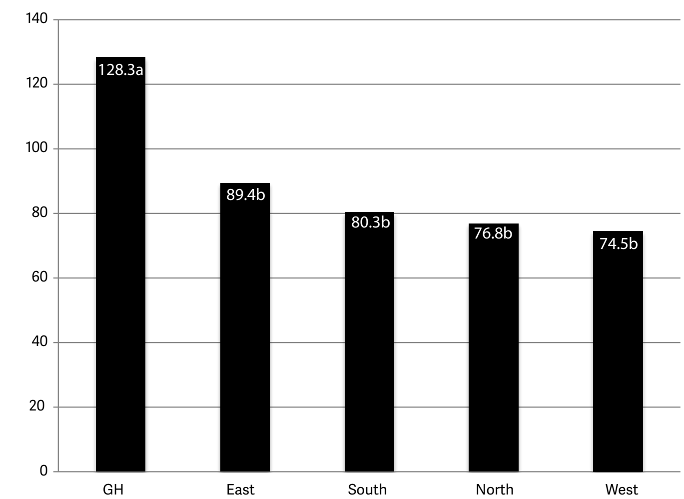

Figure 3. 2016 average stem lengths (in centimeters) of two cultivars of fresh cut sunflowers when grown in a greenhouse and high tunnels. Note: 1 cm=0.39 inches (the longest stem length, grown in the greenhouse, is 128.3 cm, or 50.5 in.)

[1]*Department of Plant Sciences.*

Fresh Cut Sunflowers in Two Wyoming Greenhouses

Karen Panter[1], Sadanand Dhekney[2], and Eric Oleson[3]

Introduction

In addition to growing fresh cut sunflowers in high tunnels, we also grew them in two Wyoming greenhouses in 2016. Cut sunflowers are another niche, specialty crop that can be easy to grow by gardeners and producers in Wyoming for farmers' markets and other local sales.

Objectives

Our main goal was to add a niche specialty cut flower crop for Wyoming growers who use greenhouses for production. Other aims were to grow fresh brown and gold cut sunflowers for the local market and to make available to Wyoming growers the methods used (Figure 1). We wanted to add a specialty crop that can be grown in Wyoming for sales at local venues such as retail florists and farmers' markets. We want to expand and encourage specialty crop production in Wyoming.

Figure 1. *'ProCut Bicolor' sunflowers in the ShREC greenhouse.*

Figure 2. Sunflowers on the bench at the LREC greenhouse, June 20, 2016.

Materials and Methods

This project was carried out simultaneously in the greenhouses at the Laramie Research and Extension Center (LREC) (Figure 2) and the Sheridan R&E Center (ShREC) (Figure 3). Seeds of two cultivars of cut sunflowers—'Dafna' and 'ProCut Bicolor'—were sown May 25, 2016, in 128-cell plug trays in a peat-based seed germination growing medium. All seedlings were transplanted to #1 pots on June 9 and were placed on one bench in each of the two greenhouses. Pots were spaced 6 inches apart, watered by hand daily, and fertilized using a slow-release 15-9-12 fertilizer at 1 teaspoon per container. Data taken were days to harvest from sowing and stem lengths. Stem lengths are important in the florist trade—longer stems are preferred over short because they are more versatile.

Figure 3. Sunflowers on the bench at the ShREC greenhouse, June 21, 2016.

Results and Discussion

We found that stem lengths were statistically different between the two locations. Stems were longer at the ShREC greenhouse (average 57 inches, both cultivars combined) than those grown at the LREC greenhouse (average 51 inches, both cultivars combined). Although temperatures were similar in both greenhouses, the shade cloth had been drawn at ShREC to cut down on cooling for the first few weeks. As a result, light levels were lower at ShREC leading to stems 'stretching' to try to find more light. Shade cloth was not drawn in the LREC greenhouse.

Days to harvest were also different between the two greenhouses. It took less time at LREC for sunflowers to reach saleable maturity (average 63 days, both cultivars combined) than it did at the ShREC greenhouse (68 days, both cultivars combined). Reasons for this difference can also be attributed to the shade cloth drawn early in the production cycle at ShREC. This decreased the amount of available light for the sunflowers, slowing their growth and development.

Acknowledgments
Thank you to the staffs at LREC and ShREC for assistance.

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Keywords: annuals, specialty crops, floriculture

PARP: not applicable

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Wyoming Native vs. Commercial Wildflower Seed Mixes for Potential Agriculture, Landscaping, and Reclamation Applications

Brian Sebade[1] and Jennifer Thompson[1]

Introduction

Wildflower plantings can benefit agricultural producers by attracting and feeding insects that pollinate crops. We set up our project to simulate how producers might prepare fields or pastures for planting wildflowers. This project can then be directly tied to management practices and decisions for producers in southeast Wyoming.

Additionally, the owners of new homes, those wishing to re-landscape existing properties, and the owners of small, rural acreages may want to include wildflowers in their landscapes and disturbed areas. Results of this project will assist property owners when making recommendations.

Objectives

The objectives are to: (1) compare the establishment of a seed mix we selected and developed to a commercial mix; (2) determine if wildflowers establish better when they are planted in spring or fall; and (3) determine if wildflowers native to Wyoming attract more or less pollinators compared to non-Wyoming native wildflower species.

Figure 1. Wildflower seeding project at the Laramie Research and Extension Center.

Materials and Methods

The commercial mix is distributed from Sharp Brothers Seed Co., Greeley, Colorado, and is labeled "Buffalo Brand Western Wildflower Mix" (Table 1). Commercial mixes like these tend to vary greatly and don't necessarily contain seeds that are native to Wyoming. Many of the seeds in this particular mix are native to Wyoming, but not all of them. The native mix we selected (from Granite Seed Co., Denver) contains species native to Wyoming; thus, we named it the "Wyoming Wildflower Mix" (Table 2).

The different mixes were broadcast seeded in both fall 2015 and spring 2016 at the Laramie Research and Extension Center (LREC) (Figure 1). Prior to planting the soil was disced, but no weed control was performed to emulate the most basic approach for reseeding and to provide a baseline for future studies. Seeds were planted prior to forecasted precipitation events. Mixes were planted at similar rates for each plot, and each specific mix was planted at the same rate. Twelve 7- by 7-meter (23 × 23-ft) plots were used in a randomized complete block design (three fall-planted native plots, three spring, three fall commercial plots, and three spring). Plants were monitored for establishment, desired species, and density via a line transect at three points using a 0.25-square-meter (.25m^2=2.7 square ft) hoop. Weeds were also monitored. No supplemental water or irrigation was applied at any time.

Results and Discussion

Fall seeding led to better early establishment for both the western and Wyoming mix. The total number of weeds for each plot—regardless if commercial or native—is almost the same with high densities. Native plots contain an average of 15.3 weeds per .25m^2, while commercial plots contain an average of 15.0. The total number of wildflowers from the commercial mix averages 6.38 per .25m^2, greatly outnumbering the Wyoming mix, which averages only 1.1 flowers per .25m^2. This is most likely due to the abundance of annual species in the western mix.

We will monitor plots in 2017 to collect better pollinator information, and to record changes in establishment, density, number of weeds, and specific wildflower species of each mix. Seeds that dropped to the ground from mature plants in 2016 may aid in the establishment and density of wildflower species this growing season. There is also a chance that seeds planted in fall 2015 and spring 2016 have not yet germinated and might provide an increase in plant numbers. Based on our early results, weeds should be recognized as a potential issue. Landowners and managers of both large and small acreages can greatly reduce weed problems by planting flowers (and other desirable species such as grass) into weed-free beds. For tips on weed control please visit the Barnyards and Backyards weed management page at www.uwyo.edu/barnbackyard/resources/weeds.html.

Acknowledgments
We thank LREC crews for help with preparation and space allowed for this study.

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Keywords: wildflowers, pollinators, seeding

Table 1. Buffalo Brand Western Wildflower Mix.

COMMON NAME	SCIENTIFIC NAME
Dwarf (garden) cornflower	*Centaurea cyanus*
Deerhorn Clarkia (pinkfairies)	*Clarkia pulchella*
Clarkia (cornflower)	*Clarkia ungiuculata*
Plains coreopsis (golden tickseed)	*Coreopsis tinctoria*
California poppy	*Eschscholzia californica*
Perennial gaillardia (blanketflower)	*Gaillardia aristata*
Annual gaillardia (blanketflower)	*Gaillardia pulchella*
Globe gilia	*Gilia capitata*
Candy tuft	*Iberis umbellata*
Blue flax	*Linum perenne*
Perennial lupine	*Lupinus perennis*
Polka dot cornflower (tansyaster)	*Machaeranthera tanacetifolia*
Evening primrose (dwarf)	*Oenothera missouriensis*
Evening primrose	*Oenothera pallida*
Corn poppy	*Papaver rhoeas*
Palmer's penstemon	*Penstemon palmeri*
Rocky Mountain penstemon	*Penstemon strictus*
Upright prairie coneflower	*Ratibida columnifera*
Stiff greenthread	*Thelesperma filifolium*
Showy goldeneye	*Viguiera multiflora*

Table 2. Wyoming Wildflower Mix.

COMMON NAME	SCIENTIFIC NAME
Upright prairie coneflower	*Ratibida columnifera*
Missouri evening primrose	*Oenothera macrocarpa*
Rocky Mountain penstemon	*Penstemon strictus*
Blackeyed Susan	*Rudbeckia hirta*
Firecracker penstemon	*Penstemon eatonii*
Plains coreopsis (golden tickseed)	*Coreopsis tinctoria*

[1]*University of Wyoming Extension.*

Introduction to the Powell Research and Extension Center

Camby Reynolds[1], Andi Pierson[1], and Bret Hess[1,2]

Introduction

The Powell Research and Extension Center (PREC) is located one mile north of Powell at 747 Road 9 with an elevation of 4,378 feet. PREC has ~200 irrigated acres, including 2.5 ac under on-surface drip, 1.2 under sub-surface drip, 112 under variable-rate sprinkler, and 84 acres under surface irrigation using gated pipes and syphon tubes. Research 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.

The full-time staff at PREC includes two researchers (assistant professors Gustavo Sbatella and Vivek Sharma), a farm manager (Camby Reynolds), a research associate (Andi Pierson), two assistant farm managers (Brad May and Keith Schaefer), and an office associate (Samantha Fulton). Administrative support is provided by Wyoming Agricultural Experiment Station Director Bret Hess. The center works closely with UW staff located at the main office complex in Wyoming Seed Certification (Mike Moore, Jolene Sweet, and Debbie Hufford) and the Wyoming Seed Analysis Laboratory (Crystal May, Jill Rice, Tonya Espinosa, and Denny Hall). Jeremiah Vardiman with University of Wyoming (UW) Extension in Park County also coordinates with PREC on multiple activities.

Figure 1. Lance and Jolene Streets of Pryor, Montana, operate the 1910 Avery steam tractor during the 2016 Powell Research and Extension Center Field Day. The tractor is owned by Keith Murray of Murraymere Farms south of Powell.

2016 Field Day Highlights

As part of the Wyoming Agricultural Experiment Station's (WAES) 125th anniversary celebration last year, the PREC Field Day featured items that had not been part of past field days. There were presentations and demonstrations from individuals who had not necessarily conducted research at PREC, but had information and displays that were of interest to a broad audience. For example, there was a 1910 Avery steam tractor on-site (Figure 1). As far as we know, this Avery happens to be one of only six left in the world and one of just three in running condition. It was amazing to see how the 140 horsepower steam tractor compared in size to the Haflinger horse team that was attached to the UW College of Agriculture and Natural Resources' newly renovated sheep wagon. David Kruger, author of the book *125 Years of the Wyoming Agricultural Experiment Station, 1891–2016*, attended the field day to discuss and sign copies of his book highlighting the history of the 125 years of WAES. Kruger is UW's agricultural liaison librarian for research and instruction.

New This Year

The PREC Advisory Board was revamped in an effort to develop PREC into a research and extension center that we can all benefit from and be proud to support. The current financial environment facing UW and state government forced us to recognize that PREC must operate in a different manner to be sustainable into the future. Consequently, we enlisted the assistance of our UW Extension educators throughout the Bighorn and Wind River basins to recruit producers and industry representatives in their area who would be willing to commit to focusing on relationships and partnerships. We had an excellent winter advisory board meeting in Worland on January 26 and look forward to continuing efforts to build relationships and partnerships in northwest Wyoming.

This year we are very excited about a couple of new equipment purchases. We were able to acquire a new Kincaid plot planter. This will allow us to plant varying plant populations with precision. The planter is also equipped with a six-canister side-dress unit. This enables us to do in-furrow applications of six different pop-up fertilizers or pre-emergent liquid products. The second equipment purchase is a half pivot equipped with variable-rate irrigation (VRI). We have experienced an increase in demand for research space under sprinkler irrigation, and the new sprinkler will help us meet those requests. The VRI allows us to simulate drought conditions as well as precision application of varying amounts and timing of irrigation.

2016 Growing Season

The 2016 growing season was fairly characteristic of the Powell area. We experienced 145 frost-free days beginning on May 13 and ending October 4 (Figure 2). We also experienced an unusually wet fall with 45% of our annual rainfall occurring in September and October.

Acknowledgments

We thank the PREC staff for their hard work and dedication as they strive to make PREC and the research that happens here successful. We are very grateful to Keith Murray and his crew for making the 1910 Avery tractor part of the field day last year. Finally, we thank our PREC Advisory Board and others who support our efforts.

Contact Information

Bret Hess at aes@uwyo.edu or 307-766-3667.

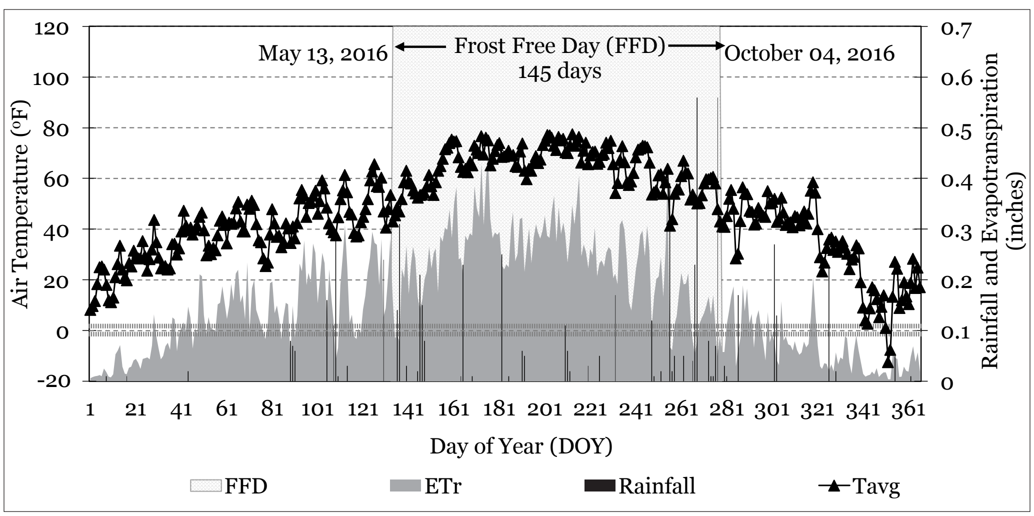

Figure 2. Weather conditions during 2016 at Powell Research and Extension Center. (FFD=frost-free days; ETr=reference evapotranspiration.)

Table 1. Month average measure climatic variables for 2016 at Powell Research and Extension Center. [Tair, Tmax, and Tmin: Average, maximum, and minimum air temperature; RH: Relative Humidity; u: wind speed; RF = Rainfall and ETr = Reference Evapotranspiration]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
T_{avg} (˚F)	24.1	35.8	39.9	47.9	54.1	69.4	70.3	68.0	57.5	47.4	39.0	14.7
T_{max} (˚F)	36.2	50.3	53.2	60.5	66.6	85.5	87.2	84.5	71.7	60.7	52.0	25.9
T_{min} (˚F)	13.6	21.8	25.9	36.2	41.9	53.0	53.4	52.2	45.0	35.8	27.5	4.3
RH (%)	70.7	44.3	45.8	55.3	55.1	41.2	44.5	41.7	60.2	65.6	63.4	70.4
u (mi/hr)	2.7	5.1	6.2	6.1	4.6	3.8	3.6	3.7	4.1	4.1	3.7	3.8
RF (inch)	0.02	0.02	0.21	0.59	1.18	0.5	0.31	0.25	1.58	1.25	0.25	0.06
ETr (inch)	1.11	3.28	4.48	5.28	6.34	9.14	8.89	7.86	5.06	3.24	1.96	0.90

[1]Powell Research and Extension Center; [2]Director, Wyoming Agricultural Experiment Station.

Sustainable production practices for edible dry beans

Investigators: Jay Norton, Jeremiah Vardiman, Jim Heitholt, Carrie Eberle, and Urszula Norton

Issue: Reduction in sugarbeet acres due to increased yields in the Bighorn Basin is facilitating longer rotations that often include edible dry beans, along with transition from furrow irrigation to overhead sprinklers. These changes create opportunities for conservation tillage systems that can reduce erosion and improve soil health; however, current dry bean production systems do not support goals of conservation tillage systems because they include undercutting and windrowing for harvest, removing much of the bean root system from the soil.

Goal: Study interactions between conservation tillage, direct bean harvest, soil health, and nitrogen fixation.

Objectives: (1) Evaluate effects of a conservation tillage system in a sugarbeet–dry bean–barley rotation on soil and plant health and productivity (particularly on nitrogen fixation by beans); and (2) develop extension materials and programs that focus on opportunities for including edible dry beans in alternative, conservation-oriented crop rotations.

Expected Impact: Results should assist growers in designing soil-building cropping systems that include dry beans in rotations by providing information about how reduced tillage, direct harvest, and variety selection affect bean yields, soil health, and bean nitrogen fixation.

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

Keywords: dry bean, conservation tillage, soil health

PARP: I:8,9,13, II:6,7

Dry bean water management and yield response under surface and sprinkler irrigation

Investigators: Vivek Sharma, Jim Heitholt, and Jeremiah Vardiman

Issue: As many Wyoming growers face significant management decisions to conserve irrigation water, many questions need to be addressed, including how to maximize use of available water. Despite the relatively high irrigated dry bean acreage in Wyoming (the state ranks about eighth in the country with ~30,000 harvested acres [2016]), information is lacking when it comes to helping producers plan and operate their irrigation systems, notably short- and long-term crop evapotranspiration (ETc), crop coefficients (Kc), and crop yield response.

Goal: (1) Quantify and compare dry bean ETc, Kc, and crop water-use efficiency under surface and sprinkler irrigation management systems; and (2) demonstrate effective irrigation management strategies that could result in higher yields.

Expected Impact: Results could help Wyoming dry bean producers better optimize irrigation water under surface and sprinkler systems, which could boost yields.

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

Keywords: evapotranspiration, crop coefficient, dry bean

PARP: IV:1,2,3

Testing for suitable corn hybrids for the Bighorn Basin

Investigators: Gustavo Sbatella and Camby Reynolds

Issue: Growing conditions in the Bighorn Basin are very different than the locations where corn hybrids are typically tested for performance. For this reason it is important to evaluate corn hybrid production under local environmental conditions.

Goal: Evaluate different corn hybrids in the Bighorn Basin.

Objectives: Determine which corn hybrids are best adapted for local growing conditions.

Expected Impact: Results from this study should provide local growers with information regarding the performance of different corn hybrids in the Bighorn Basin. The study is performed annually, with results released each fall.

Contact: Gustavo Sbatella at gustavo@uwyo.edu or 307-754-2223.

Keywords: corn, hybrids

PARP: I:12

Interplanting forage legumes with grain corn for late-season forage production

Investigators: Gustavo Sbatella and Camby Reynolds

Issue: Growers who plant grain corn in the Bighorn Basin often graze cattle in the planted area after harvest because of a lack of other forages this time of year; however, the corn stalks can lack nutritional value. Because of the latter issue, there is a need to evaluate ways to increase the nutritional value of this late-season forage.

Goal: Determine if it is possible to interplant grain corn and forage legumes to maximize grain and forage production.

Objectives: Evaluate different corn/soybean planting ratios in an effort to provide maximum corn grain production and late-season forage.

Expected Impact: Results from this study should provide local growers information regarding the possibility to interplant grain corn and forage legumes in the Bighorn Basin for grain and late-season forage production. The study got underway in 2016, and we expect to release preliminary findings in 2018.

Contact: Gustavo Sbatella at gustavo@uwyo.edu or 307-754-2223.

Keywords: corn, forage legumes, interplanting

PARP: I:3,6,9

Testing for suitable soybean maturity groups for the Bighorn Basin

Investigators: Gustavo Sbatella and Camby Reynolds

Issue: Some growers in the Bighorn Basin are considering planting soybean as an alternative for their crop rotation. Currently, however, there is limited information about which is the best maturity group that is adapted to the area's growing conditions

Goal: Evaluate different soybean maturity groups in the Bighorn Basin.

Objectives: Determine which soybean maturity groups are best adapted for local growing conditions.

Expected Impact: Results from this study should provide local growers with important information about the performance of different soybean maturity groups in the Bighorn Basin (2017 marks the third year of the study).

Contact: Gustavo Sbatella at gustavo@uwyo.edu or 307-754-2223.

Keywords: soybean, maturity group, alternative crop

PARP: I:9, II: 9

Effect of micronutrients on sugarbeet production in Wyoming

Investigators: Vivek Sharma and Camby Reynolds

Issue: Profitable sugarbeet production is based on a number of factors, including root yield, sucrose content, and sucrose recovery efficiency. The availability of adequate amounts of both primary and secondary macronutrients (notably nitrogen, phosphorous, potassium, and sulfur) and micronutrients (notably iron, zinc, and manganese) can affect these factors; however, even when adequate amounts of primary and secondary nutrients are present, a lack of micronutrients in soil can limit sugarbeet growth. In Wyoming, the effect of micronutrients on sugarbeet production has not been adequately addressed.

Goal: Evaluate the effect of micronutrients on sugarbeet production at the Powell Research and Extension Center and the James C. Hageman Sustainable Agriculture Research and Extension Center.

Objectives: Determine how different combinations of micronutrient applications affect sugarbeet root yield, sugar yield, and eco-physiological variables.

Expected Impact: Results could (1) assist Wyoming sugarbeet growers better understand the optimum quantity of various micronutrients and the timing of their applications in sugarbeet production; and (2) provide a better understanding of the economic impact of micronutrient applications as related to overall sugarbeet root and sucrose yield.

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Keywords: micronutrient, sugarbeet, yield

PARP: II:2

Preplant weed control in sugarbeet

Investigators: Gustavo Sbatella and Andrew Kniss

Issue: Herbicide-resistant weeds can be particularly difficult to control in sugarbeet because this crop is sensitive to a variety of active ingredients, limiting the options. Therefore, it is important to evaluate if there are alternatives for weed control before planting in sugarbeet.

Goal: Evaluate alternatives for preplant weed control for sugarbeet in Wyoming's sugarbeet growing areas.

Objectives: Assess herbicide efficacy and crop safety of herbicides applied preplant to sugarbeet for weed control.

Expected Impact: Results from this study should provide information regarding performance of different herbicides for preplant weed control in sugarbeet in Wyoming. The study got underway in 2017 at the Powell Research and Extension Center, and we expect to release preliminary findings in 2018.

Contact: Gustavo Sbatella at gustavo@uwyo.edu or 307-754-2223.

Keywords: sugarbeet, preplant herbicides, weed management

PARP: III:1,7

2016 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 of spring malting barley varieties grown in northern Wyoming for MillerCoors.

Expected Impact: Malting barley trials, including the one conducted in 2016, should assist with selection of high performing varieties for MillerCoors production in the Bighorn Basin.

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

Keywords: malt barley, variety trial, MillerCoors

PARP: I:12

Broadleaf weed control in barley

Investigator: Gustavo Sbatella

Issue: Management of herbicide-resistant weeds requires an integrated approach; therefore, the ability to control weeds in all crops included in a rotation is essential.

Goal: Evaluate alternatives for the Bighorn and Wind River basins to control broadleaf weeds such as kochia, common lambsquarters, and pigweeds in barley.

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

Expected Impact: Results should provide important information regarding performance of potentially new commercially available herbicides when compared to current options for broadleaf weed control in Bighorn and Wind River Basin barley fields. The study got underway in 2017, and we expect to release preliminary findings next year.

Contact: Gustavo Sbatella at gustavo@uwyo.edu or 307-754-2223.

Keywords: barley, broadleaf weeds, weed management

PARP: III:1,7

Weed control in established alfalfa stands

Investigator: Gustavo Sbatella

Issue: Weed control in established alfalfa stands is critical to ensure the long-term productivity (both quality and quantity) of alfalfa hay. Herbicide applications to fields with dormant alfalfa allow the use of active ingredients that otherwise would injure the crop if applied during vegetative growth.

Goal: Evaluate the performance of different weed control options in established alfalfa stands for the Bighorn and Wind River basins.

Objectives: Assess herbicide efficacy and crop safety of herbicides applied to established alfalfa stands for weed control.

Expected Impact: Results from this study should provide important information regarding local performance of different herbicides for weed control in established alfalfa stands. The study got underway in 2017, and we expect to release preliminary findings in 2018.

Contact: Gustavo Sbatella at gustavo@uwyo.edu or 307-754-2223.

Keywords: established alfalfa, weed management, crop productivity

PARP: III:7

Exploring options for post-emergent control of annual grassy weeds in new seedling grass grown for seed

Investigator: Gustavo Sbatella

Issue: Farmers face the challenge to control annual grassy weeds in grasses grown for seed with post-emergent herbicides, but alternatives are limited. A great number of active ingredients are currently labeled for use in small grains, but the crop tolerance of the different species planted for grass seed production to these active ingredients is mostly unknown.

Goal: Explore potential options for controlling annual grassy weeds in grasses grown for seed.

Objectives: Evaluate crop safety of different active ingredients for annual grassy weed control on perennial grasses grown for seed.

Expected Impact: Results should provide important information regarding the potential options for annual grassy weed control in perennial grasses grown for seed.

Contact: Gustavo Sbatella at gustavo@uwyo.edu or 307-754-2223.

Keywords: annual grassy weeds, grass grown for seed, weed management

PARP: III:8

Evaluate goji berry as a potential high-value fruit crop in Wyoming

Investigators: Jeremiah Vardiman, Sadanand Dhekney, and Michael Baldwin

Issue: Some Wyoming farmers, including local food producers, are looking for alternative crops and markets to keep their operations economically viable, especially during years of poor crop prices. High-value alternative crops, such as fruit crops, provide potential new markets and, subsequently, economic stability. Unfortunately, Wyoming's short growing season, late spring and early fall freezes, wind, high altitudes, and harsh winters can make fruit production extremely difficult and inconsistent as a reliable cash crop.

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

Objectives: Evaluate the performance of the cold-hardy (U.S. Department of Agriculture Plant Hardiness Zone 3a) goji berry plant to determine the days required for flowering, fruiting, and yield potential at two locations, Powell and Sheridan.

Expected Impact: In early June 2016, 50 plants were planted at the Powell Research and Extension Center and 47 at the Sheridan center with a 100% establishment rate. These plants grew late into the fall (early November) even amidst freezes, with some of the plants flowering and producing some fruit. The fruit production was late in the fall, and the yield was not significant enough to measure; however, preliminary results indicate that the plants are well established at both locations. This is very encouraging because other fruit crops such as grapes, raspberries, and strawberries do not typically grow this late in the season and do not produce fruit without season extension protection, such as high tunnels or greenhouses. This research will continue thru 2018.

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

Keywords: goji berry, fruit, cold-hardy

PARP: I:1, X:1

2016 Elite Malt Barley Variety Performance Evaluation

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

Introduction

The Wyoming Agricultural Experiment Station (WAES) at Powell conducts barley variety performance trials as part of an ongoing research program. In cooperation with the U.S. Department of Agriculture's Agricultural Research Service 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 various climatic conditions in the Pacific Northwest and Northern Great Plains regions, 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 2016. Fertilizer was applied March 9 at the rate of 100 lb/ac of nitrogen (N) and 25 lb/ac of P_2O_5 in the form of urea (46-0-0) and monoammonium phosphate (11-52-0). The experimental design of all trials was randomized complete block with three replications. On March 28, 31 barley varieties were planted 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 in, and the seeding rate was 100 pounds of seed/ac. Weeds were controlled by an application of a post-emergence tank mix of 15 fl oz Huskie® and 1 fl oz Affinity® on June 27. Furrow irrigations were April 15, June 27, July 7, and July 15. Measurements included grain yield, test weight (TWT), height, lodging, kernel plumpness, and heading date (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 ft, were harvested August 9 using a Wintersteiger plot combine.

Results and Discussion

Results from 2016 are presented in Table 1. The highest yielding malting entry was 10ARS156-1 at 151 bu/ac. Entries in bold in Table 1 are regional checks. Results are posted annually at www.uwyo.edu/uwexpstn/variety-trials/index.html.

Acknowledgments

Appreciation is extended to the Powell Research and Extension Center staff and summer crew for assistance during 2016.

Contact Information

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Keywords: malt barley, variety trial

PARP: I:12

Table 1. 2016 elite malt barley variety performance evaluation.

Cultivar Name	Yield bu/ac	Test Weight lb/bu	Height in	Lodging 0/9	Plump[2] (6/64)
10ARS156-1	151	54	34	0.7	97%
2Ab08-X05M010-65	148	53	33	0.7	98%
2Ab04-X01084-27	142	52	32	0.3	98%
08ARS043-28	139	53	31	0.0	98%
2Ab08-X05M010-82	139	53	33	0.3	96%
05ARS023-16	138	53	32	0.3	97%
10ARS041-1	138	53	31	0.0	97%
08ARS028-20	138	53	32	0.3	98%
10ARS191-3	137	54	35	0.3	98%
M69[1]	136	53	30	0.0	99%
08ARS001-75	135	53	33	1.0	98%
Merit 57[1]	134	52	33	0.3	96%
10ARS156-3	130	50	30	0.0	97%
2Ab07-X031098-31	129	52	32	0.3	97%
11ARS108-4	128	53	32	1.0	97%
Conrad[1]	128	54	33	0.0	99%
10ARS043-1	127	53	32	0.3	98%
08ARS012-79	127	53	33	0.0	98%
10ARS101-1	127	53	33	0.3	98%
CDC Copeland[1]	126	54	36	0.3	99%
11ARS156-4	125	51	33	0.3	98%
08ARS035-47	122	52	26	0.7	98%
08ARS116-91	118	53	32	0.0	97%
08ARS112-75	118	53	32	0.3	98%
Harrington[1]	117	54	33	0.3	99%
Voyager[1]	115	53	33	0.7	99%
10ARS150-2	114	52	30	0.0	99%
08ARS031-16	106	54	34	0.7	98%
AC Metcalfe[1]	104	53	33	0.3	99%
08ARS018-8	99	52	30	0.3	98%
Location Mean	127.86	52.86	32.17	0.34	0.98
Checks Mean	122.86	53.22	33.12	0.29	0.98
CV%[3]	11.22	2.37	5.72	136.86	0.78
Least significant difference (0.05)[4]	23.44	2.05	3.00	0.77	0.01

[1]*Entries in bold are regional checks*
[2]*Plump is % above screen*
[3]*CV=coefficient of variation, a measure of variability in the trial*
[4]*Least significant difference: The mean yields of any two varieties being compared must differ by at least the amount shown to be considered different at the 5% level of probability of significance.*

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

2016 Western Regional Spring Barley Nursery Performance Evaluation

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

Introduction

The Wyoming Agricultural Experiment Station (WAES) at Powell conducts 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 and feed barley grown under various climatic conditions in the Pacific Northwest and Northern Great Plains regions, 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 during 2016. Fertilizer was applied March 9 at the rate of 100 lb/ac of nitrogen (N) and 25 lb/ac of P2O5 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 28, 31 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 in, and the seeding rate was 100 pounds of seed/ac. Weeds were controlled by a post application of WideMatch® applied at 1.5 qt/ac on May 27. Furrow irrigations were April 6, April 29, June 14, June 25, and July 16. Measurements included height, heading date, lodging, grain yield, test weight, and kernel plumpness (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 ft, were harvested August 9 using a Wintersteiger plot combine.

Results and Discussion

Results from 2016 are presented in Table 1. The highest yielding malting entry was MT090182 at 120 bu/ac, the highest yielding feed entry was BZ509-601 at 113 bu/ac, and the highest yielding hulled entry was 2Ab09-X06F084-51 at 112 bu/ac. The four entries in bold in Table 1 are regional checks. Results are posted annually at www.uwyo.edu/uwexpstn/variety-trials/index.html.

Acknowledgments

Appreciation is extended to the Powell Research and Extension staff and summer crew for assistance during 2016.

Contact Information

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Keywords: malt barley, feed barley, variety trial

PARP: I:12

Table 1. 2016 western regional spring barley results.

Cultivar Name	Row Type	Grade	Yield bu/ac	TWT lb/bu	Height in	Lodging 0/9	Plump[2] (6/64)
MT090182	2	malting	120	53	32	1.0	98%
BZ509-601	2	feed	113	54	29	0.3	96%
08ARS112-75	2	malting	113	53	31	0.7	98%
2Ab09-X06F084-51	2	hulled, high BG[3], food	112	53	31	0.3	96%
UTSB10902-91	6	feed	110	51	32	0.7	99%
MT100126	2	malting	110	54	33	0.3	98%
MT090190	2	malting	110	54	32	0.3	98%
2B11-4949	2	malting	110	52	27	0.0	98%
2B11-5166	2	malting	108	51	31	0.0	96%
11WA-107.20	2	feed	107	54	31	0.3	97%
MT124555	2	malting	107	54	31	0.0	98%
12WA-120.14	2	feed	106	53	32	0.7	99%
2B10-4162	2	malting	106	53	27	0.3	94%
MT100120	2	malting	105	54	32	0.3	98%
10WA-106.18	2	feed	105	54	31	0.3	95%
10WA-117.17	2	feed	104	53	29	0.3	98%
2ND28065	2	malting	103	53	28	0.0	98%
08ARS028-20	2	malting	103	52	26	0.0	97%
2B10-4378	2	malting	103	53	27	0.0	97%
2B12-5582	2	malting	101	51	28	0.0	98%
Baronesse[1]	**2**	**feed**	**101**	**54**	**29**	**0.0**	**98%**
Steptoe	6	feed	101	51	30	0.3	99%
UTSB10905-72	6	feed	100	50	31	0.3	99%
Harrington[1]	**2**	**malting**	**100**	**53**	**28**	**0.0**	**98%**
11WA-107.43	2	feed	98	54	27	0.3	98%
2Ab09-X06F058HL-31	2	hulled, high BG[3], food	95	61	31	0.3	84%
08ARS116-91	2	malting	94	53	28	0.0	97%
AC Metcalfe[1]	**2**	**malting**	**94**	**53**	**28**	**0.3**	**98%**
11WA-107.58	2	feed	92	55	28	0.3	98%
2ND30837	2	malting	89	53	32	0.3	98%
10WA-117.24	2	feed	85	51	32	0.0	98%
Location Mean			103.43	53.03	29.77	0.27	0.97
Checks Mean			99.01	52.61	28.71	0.17	0.98
CV%[4]			10.78	1.03	4.11	168.14	0.90
Least significant difference (0.05)[5]			18.19	0.89	2.00	0.74	0.01

[1]*Entries in bold are regional checks*
[2]*Plump is % above screen*
[3]*BG is short for beta-glucan, a soluble food fiber called a polysaccharide, which has been found to have positive health effects.*
[4]*CV=coefficient of variation, a measure of variability in the trial*
[5]*Least significant difference: The mean yields of any two varieties being compared must differ by at least the amount shown to be considered different at the 5% level of probability of significance.*

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

2016 Briess Barley Variety Performance Evaluation

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

Introduction

The Wyoming Agricultural Experiment Station (WAES) at Powell conducts barley variety performance trials as part of an ongoing research effort. In cooperation with private seed companies and regional small grain breeding programs, WAES evaluates a wide range of germplasm each year. With the growing number of small or custom breweries across the United States, demand is increasing for new and unique malting ingredients including malt barley. The Bighorn Basin'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.

Objectives

The purpose of the trial is to evaluate the performance of new malting barley varieties against locally grown check varieties for Briess Malt and Ingredients Co. based in Chilton, Wisconsin.

Materials and Methods

The experiment was located at the Powell Research and Extension Center (PREC) during 2016. Fertilizer was applied preplant on March 9 at the rate of 100 lb/ac of nitrogen (N) and 25 lb/ac of P_2O_5 in the form of urea (46-0-0) and monoammonium phosphate (11-52-0). The experimental design of all trials was randomized complete block with three replications. Twelve barley varieties were planted on March 28 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/ac. Weeds were controlled by a post-emergence application of WideMatch® at 1.5 qt/ac. Furrow irrigations were May 6, May 29, June 14, June 25, and July 16. Measurements included height, heading date, lodging, grain yield, test weight, and kernel plumpness (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 9 using a Wintersteiger plot combine.

Results and Discussion

Results from 2016 are presented in Table 1. The highest yielding entry was Aberdeen S3 with 113 bu/ac. Complete results are posted online at www.uwyo.edu/uwexpstn/variety-trials/index.html.

Acknowledgments

Appreciation is extended to the PREC staff and summer crew for their continuing support throughout the 2016 season.

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Keywords: malt barley, variety trial, performance evaluation

PARP: I:12

Table 1. 2016 Briess malting barley variety performance trial results.

Variety	Yield (bu/ac)	Test Weight (lb/bu)	Height (in)	Lodging (1–9)	Plump[2] (6/64)	Plump[2] (5.5/64)	Thin[3]
Aberdeen S3	113	52	29	0.7	96%	99%	1%
Sangria	111	53	26	0.7	98%	99%	1%
Newdale	107	52	25	0.7	97%	99%	1%
S2	107	52	28	0.3	97%	99%	1%
S1	104	53	27	0.7	97%	99%	1%
Lenora	102	53	22	0.0	98%	99%	1%
Bojo	102	53	29	0.7	98%	99%	1%
Synergy	101	52	30	0.7	98%	99%	1%
Baronesse[1]	**101**	**54**	**29**	**0.0**	**98%**	**99%**	**1%**
Harrington[1]	**100**	**53**	**28**	**0.0**	**98%**	**99%**	**1%**
AC Metcalfe[1]	**94**	**53**	**28**	**0.0**	**98%**	**99%**	**1%**
Steffi	94	52	25	0.3	99%	100%	0%
Mean	102	53	27	0.1	98%	99%	1%
Least significant difference (0.05) [4]	20.2	1.0	2.7	0.56	1.3%	0.9%	0.3%

[1]*Entries in bold are regional checks*
[2]*Plump is % above screen*
[3]*Thin is % below screen*
[4]*Least significant difference: The mean yields of any two varieties being compared must differ by at least the amount shown to be considered different at the 5% level of probability of significance.*

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

Broadleaf Weed Control in Barley—2016

Gustavo Sbatella[1,2]

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

Our objectives were to assess herbicide efficacy and crop safety of post-emergence herbicides for broadleaf weed control in barley.

Materials and Methods

Barley variety Moravian 69 was drill planted at a rate of 60 lb/ac on March 28, 2016, 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 lb nitrogen and 50 lb 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_2-pressurized knapsack sprayer delivering 10 gallons of total volume/ac at 40 psi with a TeeJet® 8001-DG. Crop stage was two tillers with three leaves, and weed height was between 2 and 3 inches at time of herbicide application. 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^2 quadrant 20 days after treatment (DAT). Barley yields were estimated by mechanically harvesting a 150-ft^2 section from each plot.

Results and Discussion

Low levels of crop injury (stunning) were observed five DAT after applying Brox®-M, Affinity® TankMix, and WideMatch®, but barley quickly recovered from this initial injury and no negative effects were perceivable at 10 DAT. Kochia, common lambsquarters, and redroot pigweed were the main weeds present. Kochia control was poor with WideMatch and Affinity TankMix (Table 1). Meanwhile, redroot pigweed control was deficient with Brox-M and Starane® Ultra. Meanwhile, Talinor™ and Huskie® provided excellent wide-spectrum weed control, which was reflected in higher barley yields (Table 1). Results indicate that several herbicides can be effective to target specific weed species, but special attention should be paid to herbicide selection when in presence of weed communities rich in species.

Acknowledgments

The author thanks 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 weeds, weed management

PARP: III:1,7

Table 1. Weed control 20 days after treatment for herbicide treatments applied to dormant barley at PREC in 2016. Under each weed is the number of weeds counted in a 5.4ft^2 quadrant 20 days after treatment.

	Treatment	Rate	Unit	Kochia	Common lambsquarters	Redroot pigweed	Total[1] weeds	YIELD (lb/ac)
1	Non-treated check		3	2.8	0.8	6.8	3,354	
2	Talinor	13.7	fl oz/ac	1	0.8	0	1.8	4,679
	COC[2]	1	% v/v[3]					
3	Talinor	16	fl oz/ac	0.5	0	0.8	1.8	4,538
	COC	1	% v/v					
4	Talinor	18.2	fl oz/ac	0	0	0	0	4,592
	COC	1	% v/v					
5	Huskie	11	fl oz/ac	0	0	0.5	1	4,447
	NIS[4]	0.25	% v/v					
6	WideMatch	1	pt/ac	2	3	0.8	5.8	4,371
	NIS	0.25	% v/v					
7	Affinity Tank Mix	0.6	oz wt/ac	2.5	0.5	1	4.5	3,960
	MCPA[5] ester	0.75	pt/ac					
8	Brox-M	2	pt/ac	1	0	3.3	4.5	4,069
	NIS	0.25	% v/v					
9	Brox-M	2	pt/ac	0	0	2	2.3	3,913
	Starane Ultra	0.4	pt/ac					
	NIS	0.25	% v/v					
10	Starane Ultra	0.4	pt/ac	0	1.5	4.3	6.5	4,305
	NIS	0.25	% v/v					
	Least significant difference (0.5)			1.6	2.1	2.1	3.7	814

[1]*The total number of weeds includes the three listed as well as other weeds found in each quadrant*
[2]*COC=crop oil concentrate*
[3]*v/v=volume/volume*
[4]*NIS=non-ionic surfactant*
[5]*MCPA=2-methyl-4-chlorophenoxyacetic acid*

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

Yield in 36 Dry Bean Genotypes and its Correlations with Agronomic Traits

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

Introduction

To provide our region's dry bean producers with varieties that are economically and environmentally sustainable, our team has engaged in (1) the screening of released cultivars and experimental genotypes for drought tolerance; and (2) the development of new genotypes.

Objectives

The objectives of this study were to characterize the yield, height, and maturity of 36 dry bean cultivars. The long-term goals are to identify easy-to-measure traits—recorded within mid-generation progeny—that correlate with yield. If successful, we can eliminate a higher percentage of progeny during mid-generation and focus more time on fewer late-generation lines.

Materials and Methods

The study was sown on May 25, 2016, at the Powell Research and Extension Center (PREC) using a split-plot arrangement with two irrigation rates and 36 genotypes replicated three times. Irrigation rate (full vs. less-than-full) was the main plot and genotype the subplot. Plots (three rows) were 15 feet long with 22-inch row spacing at ~90,000 seeds/ac. Height and maturity ratings were collected toward the end of the growing season. Yield was collected at maturity, and plots were hand-harvested and threshed using an Almaco stationary plot thresher. Seed size was determined from collecting all seed from a two-plant sample.

Results and Discussion

No irrigation effects or irrigation-by-genotype interactions were observed; thus, only genotype differences are presented. The pinto cultivar PT9 5-6 exhibited the highest yield; in general, however, the yields of several other pinto cultivars and red-seeded Common Red Mexican were not significantly lower than PT9-5-6. Plant height was positively correlated with yield (n=36), but unlike previous years, yield was not correlated with maturity.

Acknowledgments

The authors thank the crew at PREC for managing the crop from planting to harvest. For funding, we thank the Wyoming Bean Commission and the U.S. Department of Agriculture Hatch program.

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Keywords: breeding, genetic diversity, dry bean

PARP: Goals 1 and 2

Table 1. Yield and agronomic traits of 36 dry bean genotypes grown at Powell in 2016 averaged across two irrigation levels.

Genotype	**Market Class**	**Grain Yield**	**Seed Size**	**Plant Height**	**Maturity**	**Seeds/ Pound**
		lb/ac	mg*	inches	days after planting	number
Avalanche	navy	3,480	188	29	99	2,460
CELRK	light red kidney	2,540	485	15	78	937
Centennial	pinto	4,100	378	27	91	1,220
Com Red Mex	small red	4,690	316	14	92	1,440
COSD-7	pinto slow darkening	3,670	389	27	91	1,170
COSD-35	pinto slow darkening	3,990	342	30	89	1,330
CO-46348	pinto	3,690	378	26	88	1,200
Coyne	Great Northern	4,070	418	26	96	1,100
Croissant	pinto	4,130	356	23	94	1,280
Desert Song	Flor de Mayo	3,920	380	25	88	1,200
Dynasty	dark red kidney	3,610	493	18	86	930
Eclipse	black	3,290	192	25	93	2,460
ISB96-3156	navy	3,570	252	27	91	1,810
ISB1259-60	pinto	3,730	393	27	91	1,160
La Paz	pinto	4,440	371	29	98	1,225
Lariat	pinto	4,240	413	30	99	1,110
Long's Peak	pinto	4,350	385	27	93	1,190
Monterrey	pinto	4,240	370	30	98	1,230
ND-307	pinto	3,860	446	29	97	1,020
Othello	pinto	4,390	376	24	88	1,210
Poncho	pinto	4,640	433	29	91	1,050
Powderhorn	Great Northern	3,510	373	24	93	1,220
PT9-5-6	pinto	4,750	386	30	91	1,180
Rio Rojo	small red	3,650	297	23	96	1,530
Rosie	light red kidney	3,010	432	17	92	1,070
Stampede	pinto	4,610	370	26	102	1,330
Talon	dark red kidney	2,400	422	19	93	1,080
T-39	black	3,810	199	28	92	2,290
T-9905	navy	3,860	196	25	98	2,350
UCD-0908	Jacob's Cattle	3,240	509	19	109	893
UI-259	small red	3,870	344	25	91	1,330
UI-537	pink	3,960	362	23	98	1,260
UIP-35	pinto	3,840	357	30	96	1,270
Yeti	white kidney	3,140	470	19	92	968
Zenith	black	3,910	227	22	101	2,000
0863Per	yellow	3,770	346	22	106	1,315
Least significant difference (0.05)		790	36	4	3	159

*mg=milligrams. To convert mg to oz, multiply by 0.035; one CELRK seed weighs 0.017 oz.

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2016 Dry Bean Performance Evaluation

Mike Moore[1], Camby Reynolds[2], Jolene Sweet[1], Jeremiah Vardiman[3], and Andi Pierson[2]

Introduction

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

Objectives

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

Materials and Methods

Weed control for the 2016 trial consisted of a preplant-incorporated treatment of 2 pints Sonalan® and 1 pint Outlook™. The plots received 100 units of nitrogen (N), 20 units of phosphorous (P), and five units of zinc (Zn) 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 May 24. 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 ft were pulled by hand and threshed with an ALMACO stationary plot thresher.

Results and Discussion

Stand establishment was very good. Summer temperatures and precipitation were moderate, and all entries matured prior to frost.

Acknowledgments

This study was conducted with the assistance of the staff of the Powell Research and Extension Center.

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Keywords: dry bean, performance evaluation, yield trial

PARP: II

Table 1. Agronomic data, 2016 cooperative dry bean nursery, Powell.					
Name	**Market class**	**Yield** lb/ac	**Seeds per pound**	**Bloom days after planting**	**Buckskin days after planting**
PT9-5-6	Pinto	2,833	1,423	54	92
PT-11-13	Pinto	2,903	1,314	49	85
XRAV-40-4	Black	2,783	2,309	55	87
BK 11-8	Black	2,149	2,397	56	88
COSD-7	Pinto	2,901	1,441	48	84
COSD-35	Pinto	3,028	1,418	51	88
CO 14790-3	Pinto	3,204	1,323	51	87
CENTENNIAL	Pinto	2,368	1,354	48	84
NE12-15-161	Pinto	3,206	1,007	45	89
LIGHTHOUSE	Navy	2,363	2,446	52	89
ACUG 13-SR1	Small Red	2,162	2,353	57	89
DYNASTY	Dark Red Kidney	2,908	981	43	86
YETI	White Kidney	1,910	1,108	43	87
ZENITH	Black	2,899	2,242	56	93
ALPENA	Navy	2,466	2,758	56	92
SAMURAI	Otebo	3,153	1,880	54	88
ECLIPSE	Black	3,106	2,344	56	88
LA PAZ	Pinto	3,378	1,342	55	87
OTHELLO	Pinto	2,975	1,278	42	83
CELRK	Light Red Kidney	2,068	978	41	81
PALOMINO	Pinto	2,490	1,267	42	85
	Mean	2,726	1,665	50	87
	Least significant difference (0.05)[1]	784	123	2	2
	CV[2]	20	5	3	2

[1]*Least significant difference: The mean yields of any two varieties being compared must differ by at least the amount shown to be considered different at the 5% level of probability of significance.*
[2]*CV=coefficient of variation, a measure of variability in the trial*

[1]*Wyoming Seed Certification Service;* [2]*Powell Research and Extension Center;* [3]*University of Wyoming Extension.*

Dynamics of Leaf Stomatal Resistance to Photosynthetic Photon Flux Density for Different Dry Bean Genotypes

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

Introduction

Crop evapotranspiration (ETc) is defined as the combined transfer of water from land surfaces to atmosphere in the form of water vapor by evaporation and transpiration. During the process of transpiration, water vapor from vegetative surfaces has to overcome a diffusive resistance (i.e., stomatal resistance; Rs) and a boundary layer resistance before entering the atmosphere. Rs is defined as the opposition to transport of water vapor and carbon dioxide to or from the stomata (small pores on the leaf surface). Quantification of Rs is vital to estimate the transpiration rate from plant communities.

Many researchers have observed that leaf Rs depends on photochemical processes (i.e., chemical effects of light) and is a function of the radiation flux density (Sinclair et al., 1976; Norman, 1980). Radiative flux density is the amount of power radiated through a given area, in the form of photons. It is often measured as photosynthetic photon flux density (PPFD is a measurement of light), and it explains the majority of variation in Rs. Good estimates of integrated Rs can be obtained by dividing the plant canopy into two layers of leaves: those that are sunlit and those that are shaded. Currently, little information exists on the relationship between Rs and PPFD at different crop development stages for dry bean genotypes.

Objectives

The objective of this study is to investigate the relationship between stomatal resistance (Rs) and photosynthetic photon flux density (PPFD) at different growth development stages for different dry bean genotypes.

Materials and Methods

Field experiments were conducted during the 2016 growing season at the Powell Research and Extension Center (PREC). Four dry bean genotypes (La Paz, Othello, Poncho, and CO46348) were selected for the analysis. Rs and PPFD were measured using an AP4 steady-state leaf porometer (Delta-T Devices Ltd., Cambridge, United Kingdom). On each measurement day, three to four plants were sampled for each genotype. On each plant, measurements were taken for three healthy leaves at three levels of canopy, i.e., bottom leaves (shaded), middle leaves, and top leaves (sunlit).

Results and Discussion

The measured Rs response to PPFD at leaf level for four days (July 14, July 21, August 2, and August 17) and four genotypes is presented in Figure 1. The curves were developed by simultaneously measuring incident PPFD and Rs on leaves for sunlit, middle, and shaded leaves. In general, no significant difference in Rs vs. PPFD relationship was observed among different dry bean genotypes on all dates; however, relationships changed with the measurement day because of variation in climatic and plant characteristics. Figure 1 indicates that sunlit leaves in the upper canopy layer (higher PPFD values in Figure 1, along the x-axis) with low Rs (along the y-axis) contribute to the majority of transpiration compared to leaves in the lower canopy layer. The research is part of an ongoing study. The relationship developed in this study along with meteorological and plant variables can further be used to quantify dry bean crop transpiration and evapotranspiration rates, which have important applications in agricultural water management.

Acknowledgments

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Keywords: evapotranspiration, dry bean, stomatal resistance

PARP: IV:3,4

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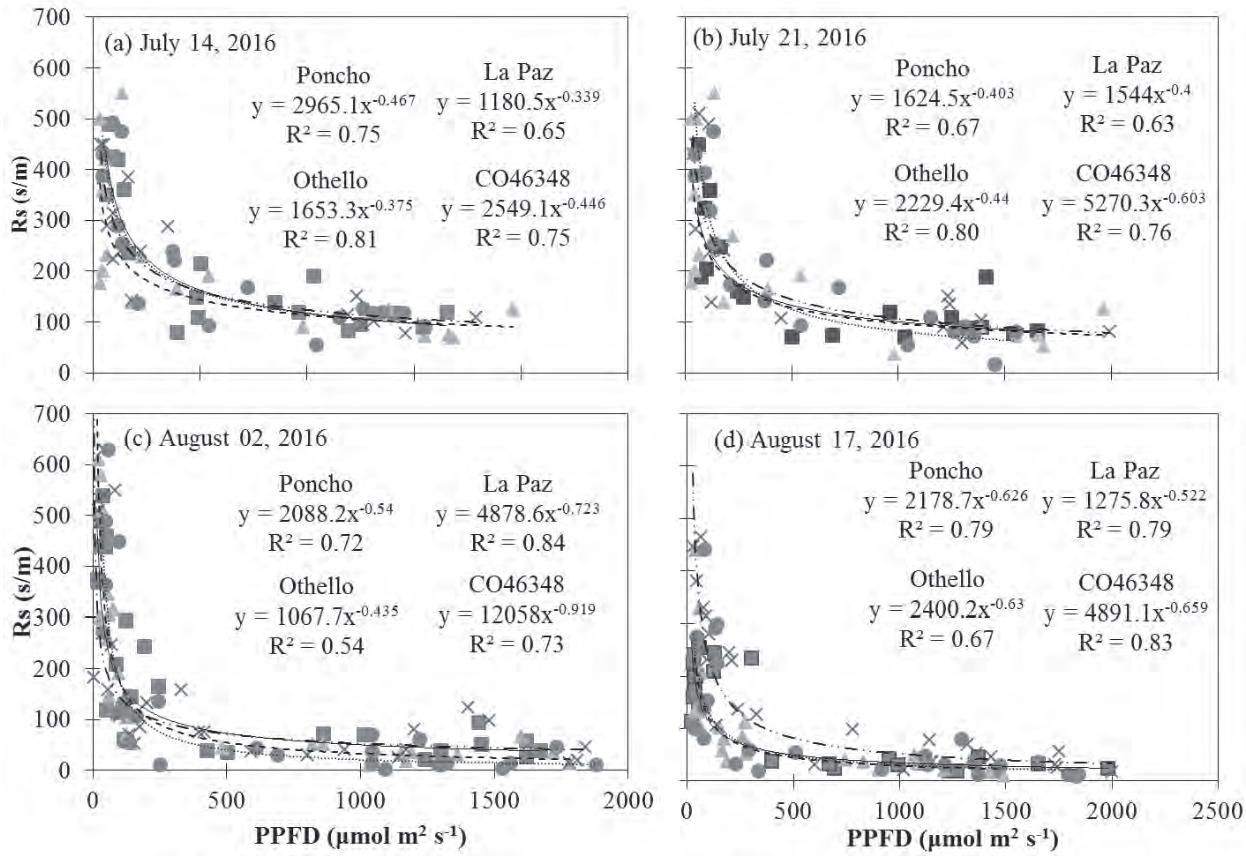

Figure 1. Relationship between measured leaf stomatal resistance (Rs) and photosynthetic photon flux density (PPFD) for four dry bean genotypes: Poncho, La Paz, Othello, and CO46348 on (a) July 14, 2016, (b) July 21, 2016, (c) August 2, 2016, and (d) August 17, 2016.

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Dynamics of Soil Moisture and Crop Canopy Architecture Traits for Dry Beans in Wyoming

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

Introduction

Efficient use of irrigation in dry beans requires knowledge of growing season crop water use, i.e., evapotranspiration (ETc), which, in turn, requires information on soil moisture dynamics and dry bean canopy agronomic traits. Increased knowledge of soil moisture dynamics in irrigated bean fields would allow producers to better plan irrigation applications, which could help cut down on disease pressure and also boost dry bean quality and yield. Various processes occur at different growth stages that affect dry bean yield. Among these processes, the leaf area index (LAI) and plant height (PH) are important agronomic traits that reflect dry bean growth. LAI (the amount of leaf area per unit soil area) plays a decisive role in the photosynthetic efficiency and light energy distribution of crops, which further impacts crop transpiration, ETc rate, and dry bean yield. Detailed information on crop transpiration and ETc is provided in the University of Wyoming Extension bulletin *Evapotranspiration: Basics, Terminology and its Importance*, B-1293. It's available at www.wyoextension.org/agpubs/pubs/B-1293.pdf.

Objectives

Objectives are to better understand the dynamics of dry bean soil moisture and other physiological parameters for different dry bean genotypes.

Materials and Methods

Field experiments were conducted in 2016 at the Powell Research and Extension Center (PREC). The soil at the study site is Garland loam with a field capacity (FC) of 0.29 ft^3/ft^3 and a permanent wilting point (PWP) of 0.16 ft^3/ft^3. Detailed descriptions of FC and PWP are provided in an article by this paper's lead author titled "Soil Moisture Monitoring Tools," at www.drcaitlin.us/hot-topics/soil-moisture-monitoring-tools. The soil moisture was measured at three soil depths (1, 2, and 3 ft) for the La Paz genotype using a model 503 neutron attenuation soil moisture meter. For LAI measurement and plant height, four genotypes (La Paz, Othello, Poncho, and CO46348) were used. These genotypes were selected based on yield differences from previous research.

Results and Discussion

The seasonal distribution of measured soil water content for each depth (1, 2, and 3 ft) is presented in Figure 1a. Throughout the growing season, maximum water depletion was observed for the top 1-ft layer. Some level of depletion occurred in the 2- and 3-ft layers, indicating soil water uptake by dry beans up to the 3-ft layer. The greater depletion from the upper surface is due to the greater rate of plant water uptake from shallow roots in combination with soil water evaporation from the topsoil. Figure 1b represents the total available water in the dry bean crop root zone (0–3 ft soil profile).

As expected, PH gradually increased as the growing season progressed and peaked between August 1 and August 8 (Figure 2a). Thereafter, PH remained relatively constant. A small decrease in PH at the end is due to leaf aging, folding, and senescence as the plants progressed toward physiological maturity. Similar findings were observed for LAI, which increased as the crop canopy development peaked in the middle of the growing season and then decreased as dry beans progressed toward maturity (Figure 2b). The peak values were observed near blossom stage when dry bean plant structure has a clumped and intertwined canopy, which reduces light penetration and distribution within the dry bean canopy. This research is part of an ongoing study. Soil moisture, PH, and LAI data generated in this study will further be used to quantify dry bean transpiration and ETc.

Acknowledgments
The authors thank the Wyoming Bean Commission for funding and PREC personnel for assistance throughout the growing season.

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Keywords: irrigation, crop canopy, evapotranspiration

PARP: IV:2,3

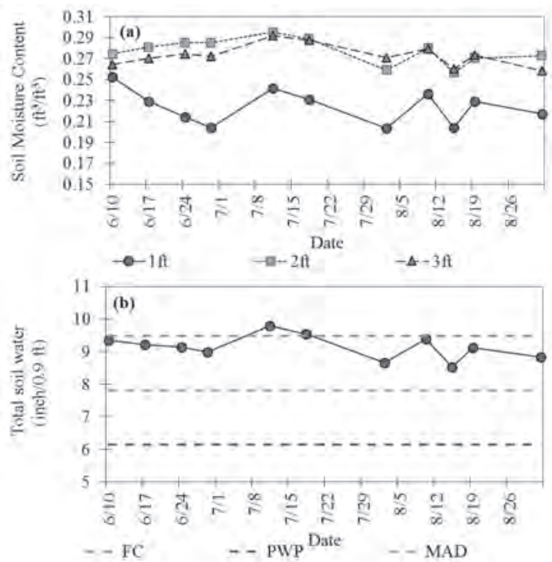

Figure 1. Seasonal distribution of (1a) soil moisture content at each measurement depth (1, 2, and 3 ft) and (1b) total soil water in the crop root zone (0–3 ft soil profile) for dry bean. (FC=field capacity; PWP=permanent wilting point; MAD=manageable allowable depletion.)

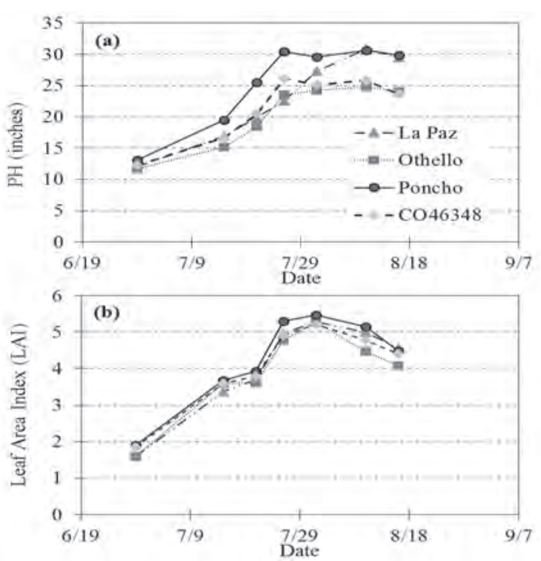

Figure 2. Plant height (PH) (2a) and leaf area index (LAI) (2b) for selected dry bean genotypes at PREC.

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Response of Silage Corn to Irrigation Water and Nitrogen under On-Surface and Sub-Surface Drip Irrigation

Abdelaziz Nilahyane[1] and Anowar Islam[1]

Introduction

In semiarid regions, water and nitrogen (N) are typically the major limiting factors of crop yield. Corn, the most important silage plant in the world, can provide high yields and high energy forage, but it requires adequate amounts of water, nutrients, and good management practices for profitable production. Understanding the response of silage corn to irrigation water and N is important for maximizing yield and improving crop water use. For instance, reduction in corn yield has been reported when high amounts of N were applied under deficit irrigation. Meanwhile, high rates of N fertilizer are required when corn is grown under conditions of no water stress.

Objectives

The objective of the study was to determine the response of silage corn yield to irrigation water and N under on-surface drip irrigation (ODI) and sub-surface drip irrigation (SDI).

Materials and Methods

Two separate field experiments were conducted during the 2014 and 2015 growing seasons at the Powell Research and Extension Center (PREC). The study area is known for its cold and dry winters, and warm and dry summers (the average annual temperature is 44°F, and the average precipitation is 6.9 inches). The hybrid Pioneer 'P8107HR' was planted on May 20 and 22 in the same field in 2014 and 2015 under ODI, and May 22 in 2014 and 2015 under SDI with 22-inch row spacing. Both experiments were laid out as randomized complete block design in a split-plot arrangement with three replications in the ODI and four replications in the SDI. Each experiment consisted of irrigation as the main treatment, and included 100% crop evapotranspiration (100ETc equivalent to 12 in of water per season), 80ETc (10 in), and 60ETc (8 in). Five N rates were the sub-treatment, including 0, 80, 160, 240, and 320 lb N/ac as a urea-ammonium-nitrate aqueous solution. Harvested plants were oven-dried at 140°F for 72 hours for dry matter (DM) yield. Data were analyzed using the statistical software SAS.

Results and Discussion

The greatest DM yield was obtained at 100ETc and 240 lb N/ac under both ODI and SDI (Table 1). Under ODI, a significant difference was obtained between irrigation treatments, while little difference was observed between 160, 240, and 320 lb N/ac, suggesting that 160 lb N/ac could be used in combination with full irrigation for maximum DM yield (Table 1). Under SDI, the greatest DM yield was obtained at 100ETc, and the least DM yield was observed under 60ETc with little difference between 80ETc and 100ETc (Table 1). For N, little difference was obtained between high rates of N starting at 160 lb N/ac, suggesting that the 160 rate could be used in combination with 80ETc for profitable corn-for-silage production under SDI (Table 1). Results show that good silage corn production can be achieved under SDI as compared to ODI. This might be due to low evaporation, runoff, and nutrient leaching under SDI.

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Keywords: corn silage, irrigation, nitrogen

PARP: I:2, II:2, IV:3,4

Table 1. Dry matter yield of silage corn as influenced by irrigation water and N under ODI and SDI at PREC in 2014–2015. Values are averaged over two years.

		DM yield (lb/ac)	
Factor	**levels**	**ODI§**	**SDI§**
Irrigation	60ETc	9,073c	11,357b
	80ETc	13,097b	15,479a
	100ETc	15,863a	15,738a
p-value		<0.0001	<0.0001
Nitrogen (lb/ac)	0	9,546c	11,331b
	80	11,991b	12,473b
	160	14,132a	15,390a
	240	14,418a	15,908a
	320	13,293a	15,854a
p-value		<0.0001	<0.0001

§ *Within column, means followed by same letters do not differ at $p<0.05$.*

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Effect of Water Stress on Yield and Water Use of Corn for Silage Grown in a Semiarid Environment of Wyoming

Abdelaziz Nilahyane[1] and Anowar Islam[1]

Introduction

Corn is the primary source of both silage and biofuel in the U.S. and many parts of the world. Corn-for-silage production faces many challenges in arid and semiarid environments. In these regions, adequate water along with proper irrigation techniques are required to achieve outstanding yields of corn for silage. Corn is very susceptible to limited water during early and late vegetative stages and during early reproductive stages of development. Further, water stress occurring during periods of high temperatures may cause significant reductions in shoot growth, leaf area, and yield depending on the intensity and duration.

Objectives

The objective of the study was to determine the effect of water stress on yield of corn for silage grown under on-surface drip irrigation.

Materials and Methods

A field experiment was conducted at the Powell Research and Extension Center (PREC) during the 2014 and 2015 growing seasons. The study area is characterized by a semiarid climate with an average temperature of 66°F and cumulative precipitation of 3.2 inches during the growing season. The experiment was set in a randomized complete block design with three replications under an on-surface drip-irrigated field. The treatments consisted of four irrigation strategies: 100% crop evapotranspiration (100ETc [full irrigation], which was equivalent to 12 inches of water applied during the growing season), 80ETc, 60ETc, and limited water (full water from planting to the V9 stage of development, no water from V9 to R3, and then full water through the rest of the growing season. V9 is the stage at which the leaf collar of the ninth leaf appears, while R3 corresponds to the milk stage.) Harvested plants were oven-dried at 140°F for 72 hours, and then the dry matter yield was measured. Data were analyzed using the statistical software SAS.

Results and Discussion

Dry matter yield decreased with increased water stress, with no significant difference between 60ETc and limited water treatments (Table 1). The significant yield decrease in the stressed silage corn as compared to the full irrigation treatment could have been due to an insufficient supply of carbohydrates, which limits a plant's ability to grow and develop 'normally'. The water stress for a period of 35 days (limited water) was sufficient to cause a 40% reduction in yield (Table 1). The substantial loss in dry matter yield occurred at the late vegetative and early reproductive stages. Farmers may want to avoid water stress during these critical periods for profitable production of corn for silage.

Acknowledgments

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

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Keywords: corn silage, irrigation, limited water

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

Table 1. Dry matter yield, water use of corn for silage, and water reduction (%) relative to 100ETc (full irrigation) at PREC in 2014 and 2015. The values are averaged over the two years.

Irrigation	Dry matter yield (lb/ac)§	% yield reduction	Water use (inches)§	% water reduction
100ETc	17,397a	0	11.9a	0
80ETc	14,159b	19	10.0b	16
60ETc	10,831c	38	8.1c	32
Limited water	10,447c	40	7.9d	34

§*Within column, means followed by different letters are significantly different based on the least significant difference (0.05).*

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Evaluation of Irrigation Water and Nitrogen Management for Silage Corn Production in Wyoming

Abdelaziz Nilahyane[1] and Anowar Islam[1]

Introduction

Crop production is influenced by several factors including climatic conditions, soil type, and cropping practices including irrigation and nitrogen (N) management. To better understand the interaction between all of these factors, the use of crop models may enable farmers to make better decisions, which, in turn, could help them boost crop yields, quality, and, ultimately, profits. CERES-Maize (Crop Environment Resource Synthesis) is part of the Decision Support System for Agrotechnology Transfer (DSSAT) suite of crop models that can help predict the growth of leaves, stems, and roots, water use, and yield of crops growing under specific conditions (for example weather, soil water, soil N and carbon), and management of the cropping system over time.

Objectives

The objectives were to determine the best irrigation water and N fertilization management practices for silage corn production in three locations in Wyoming using the CERES-Maize model.

Materials and Methods

The field experiment was conducted at the Powell Research and Extension Center and was laid out as a randomized complete block design with four replications under a sub-surface drip irrigation system. Irrigation included three strategies based on crop evapotranspiration (ETc): 100% or full irrigation (100ETc, which is equivalent to 12 inches of water at this site), 80ETc, and 60ETc. Nitrogen application included 0, 80, 160, 240, and 320 lb/ac as a urea-ammonium-nitrate aqueous solution. The combination of irrigation water and N treatments resulted in 15 treatments. The CERES-Maize model was used to simulate the response of a hybrid Pioneer corn cultivar to water and N for growing conditions in three Wyoming locations (Powell, Sheridan, and Lingle). For each location, the long-term simulation was performed using 31 years of weather data (1985–2015) to simulate the yield of corn for silage during the growing season. Data were analyzed using the statistical software SAS.

Results and Discussion

At the three locations, outstanding yields were obtained at the 100ETc/160 N, 100ETc/240 N, and 100ETc/320 N treatments with no significant differences among them (Figure 1). Lower yield values were obtained under lower irrigation water and N levels (Figure 1). The long-term simulated results indicate that high yield of corn for silage can be obtained under the combination treatment 100ETc and 160 pounds N/ac. This could help producers save water and N fertilizer if both factors are well optimized.

Acknowledgments

This project was supported by the University of Wyoming Department of Plant Sciences and Wyoming Agricultural Experiment Station.

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Keywords: corn silage, irrigation, nitrogen

PARP: I:2, II:2, IV:3,4, X:2

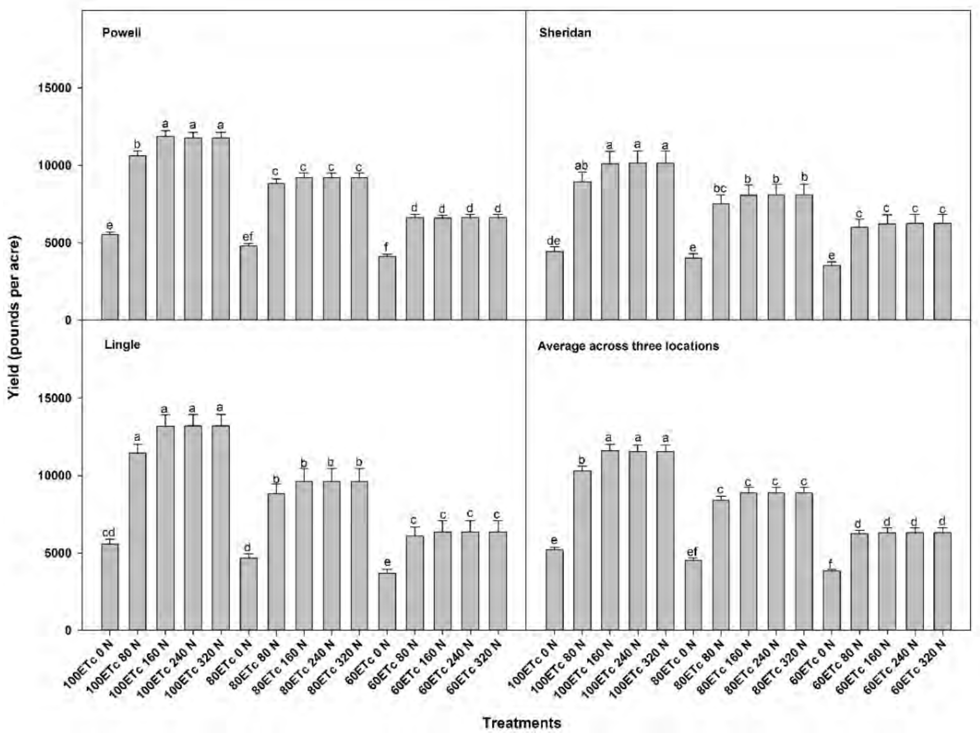

Figure 1. Yield of corn for silage at three locations: Powell, Sheridan, and Lingle. The simulated means were obtained using 31 years of weather data. Within location, means followed by same letters do not differ at p<0.05.

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Intercropping Forage Legumes with Grain Corn for Late-Season Forage Production—2016

Gustavo Sbatella[1,2] and Camby Reynolds[2]

Introduction

Corn stubble remaining after grain harvest is often a source of forage late in the fall. Annual legumes such as forage soybeans can be interplanted with grain corn with the objective to increase quality of late-season forage. Supplementing the amount of nutrients available for the crops through fertilization can be an option to reduce the effects of inter-specific competition.

Objectives

Objectives were to evaluate the impacts of interplanting corn for grain with forage soybeans on yield and quality when produced under different fertilization levels.

Materials and Methods

A field trial was conducted in 2016 at the Powell Research and Extension Center (PREC). Forage soybean Eagle Large Lad RR™, group VII, was drill planted at 52, 39, 26, and 14 lb/ac, and Pioneer® 8107HR hybrid corn was planted at a rate of 35,000 seeds/ac at 22-inch row spacing. The site was furrow irrigated. Plot size was 11 by 50 ft, arranged in a split plot randomized complete block design with four replications. Fertilizer levels were assigned to the main plots and corn/soybean ratios to the subplots. Fertilizer levels were low (150 nitrogen [N] units), medium (180 N units), and high (240 N units). Grain yields were estimated by harvesting 10-ft-length sections from the two middle rows on November 14. Corn stubble production was calculated by harvesting the aboveground biomass from a 10.76 ft^2 area. The harvested biomass was ground and a subsample weighing approximately one pound was sent for quality analysis.

Results and Discussion

Corn grain yield and stubble biomass increased with increasing levels of N fertilization, independently of the corn/soybean plant ratio (Table 1). In regard to forage quality, no differences were observed between the different corn/forage soybean ratio protein levels, but quality varied between N fertilization levels. Although protein levels were similar, differences were recorded for other components. For instance, acid digestible fiber (ADF) increased while total digestible nutrients (TDN) decreased with increasing N fertilization. Similarly, the calculated net energy for lactation (CNL), for maintenance (CNM), and for gestation (CNG) all decreased when N was applied at higher rates.

Nitrogen fertilization rates impacted grain and stubble biomass, but had no effect on the percent crude protein of the forage. Other quality factors such as ADF and TDN were negatively affected by increasing N applications. These results suggest that there may be a tradeoff between increasing grain yield and stubble biomass by adjusting the N supply and stubble quality.

Acknowledgments

The authors thank personnel from PREC and University of Wyoming 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 grain yield, stubble biomass after harvest, protein content, acid digestible fiber (ADF), and total digestible nutrients (TND) at PREC in 2016.

Fertility	Grain yield	Stubble biomass	Protein	ADF	TDN
	bu/ac	lb/ac	%	%	%
Low	62.7	18,312	4.7	38	60
Medium	73.3	19,107	4.0	42	55
High	92.3	26,426	4.8	43	54
Least significant difference	15.5		0.6	2	3

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

Nitrogen and Phosphorus Rates for Sugarbeet under Sprinkler Irrigation and Conservation Tillage

Jay Norton[1] and Onesmus Ng'etich[1]

Introduction

As irrigated agriculture continues to shift from flood to sprinklers, and from conventional to conservation tillage, new approaches to fertility management are needed. Improved control over water application reduces nutrient loss, and more soil organic matter (SOM) from less tillage increases water and nutrient supplying potential of soils. Both present opportunities for improved crop nutrient management. Improved understanding of interactions among conservation tillage, sprinkler irrigation, and nutrient management are needed. In this investigation we sought to establish nitrogen (N) and phosphorus (P) fertilizer rates in a sugarbeet–dry bean–barley rotation in transition to a conservation tillage system. This paper reports on sugarbeet yield and quality in response to five levels of N and P and two tillage systems. Responses of dry beans and barley, soil health parameters, and limited irrigation were also evaluated, and results are being analyzed.

Objectives

Our objectives were to establish optimum N and P rates and investigate whether reduced tillage affects those rates immediately after transition to conservation tillage.

Materials and Methods

Our crop-rotation experiment was established in 2014 under the lateral-move sprinkler at the Powell Research and Extension Center (PREC). Sugarbeet, dry bean, and barley were each planted in eight plots measuring 44 × 105 feet. Four plots under each crop were tilled by conventional methods and four by reduced-tillage practices, including strip-till to 10 inches using a Schlagel strip tiller for sugarbeet. Each of the plots was divided into 12 subplots measuring 11 × 35 ft. Five N and five P rates were randomly and permanently assigned to each plot, including zero, low, medium, high, and very high. The sugarbeet rates for N were 0, 65, 130, 195, and 260 lb N/ac, half incorporated preplant as urea and half side-dressed as urea-ammonium nitrate (UAN). The sugarbeet rates for P were 0, 35, 70, 105, and 140 lb P/ac. Fertilizer was added to residual soil N and P to attain target rates, so there are no 0-level plots in the results.

Results and Discussion

Results demonstrate some challenges in transition to conservation tillage and growing sugarbeets in the Bighorn Basin: yields were good in 2014, but very low in 2015 because of late frost and replanting, and even lower in 2016 because of poor emergence. Only the first two years were analyzed (Figure 1). This early in transition, conservation tillage did not affect yield. Soil P built up from past fertilization precluded response to P.

Nitrogen rate significantly affected sugarbeet yield under full irrigation, and may provide some guidance for optimum economic N rates in high- and low-yielding seasons. Using 2015 prices for N fertilizer ($0.65/lb) and sugarbeet roots ($37/ton), the N rate yielding the maximum economic return would be 208 lb N/ac (residual + added) for 32 tons of roots/ac in 2014 and 121 lb N/ac for 7 tons of roots/ac in 2015. This suggests that if all goes well in the early season, producers should use a high-yield goal and side-dress to meet the full N rate. If late frost or other spring problems suggest that yields will be lower, producers can save money by adjusting down or eliminating early summer side-dressing. The economic optimum N rate varies with prices of sugar and N. In 2011, for example, root prices were about $60/ton and N prices were slightly lower than in 2015. Under these conditions, the economic optimum N rate for 2014 would be 217 lb N/ac.

We expect that more time under conservation tillage will change fertilizer needs as soils accumulate organic matter, which, in turn, improves soil water and nutrient supplying potential. The plots at PREC are intended to be long-term plots that will allow us to track those changes over three to four 3-year rotations, and possibly to repeat the fertilizer rate study after notable soil changes have been observed.

Acknowledgments

We thank PREC field crews for assistance in plot establishment and harvesting. The study is supported by U.S. Department of Agriculture Hatch funds and the Wyoming Department of Agriculture's Agriculture Producer Research Grant Program.

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Keywords: sugarbeet, phosphorus, nitrogen

PARP: I:1,7, II:6

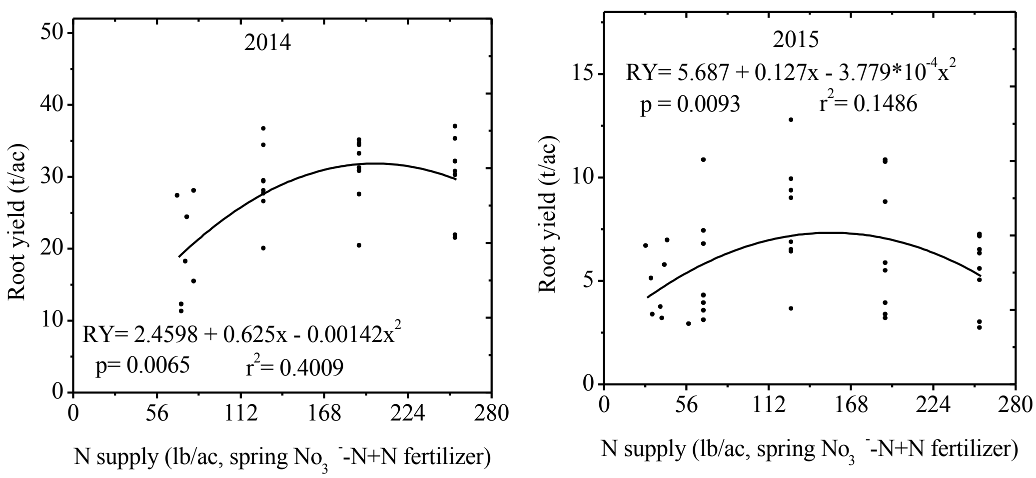

Figure 1. Sugarbeet yield response to N rates in two study years. *P*-values less than 0.05 indicate that the fitted curves adequately explain the response according to the equation, where RY is root yield and x is N supply, including residual soil N plus added fertilizer.

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Pre-plant Burndown Options for Kochia Control in Sugarbeet

Andrew Kniss[1] and Gustavo Sbatella[1,2]

Introduction

The spread of glyphosate-resistant kochia (*Kochia scoparia*) represents a major challenge for sugarbeet growers in the West because other effective herbicide options for control are limited. Kochia seeds germinate early in the growing season; therefore, controlling kochia previous to crop planting could be an option.

Objectives

A trial was conducted at the Powell Research and Extension Center (PREC) in 2016 to evaluate control efficacy of kochia with Vida® and other preplant burndown options as potential alternatives for weed control in sugarbeet.

Materials and Methods

Sugarbeet variety Hilleshög 9418RR was planted with a John Deere MaxEmerge™ planter at 22-inch row spacing at a rate of ~41,000 seeds/ac on May 24. Sugarbeet planting was delayed to ensure an adequate level of kochia infestation. The soil at the site is a Garland loam (organic matter: 1.3%; pH: 7.8). Prior to planting, the plots were broadcast fertilized with 80 lb nitrogen, 30 lb phosphorous, and 40 lb potassium per acre. The trial was under furrow irrigation. Herbicide treatments were applied with a CO_2-pressurized knapsack sprayer delivering 16 gallons of total volume/ac at 40 psi with TeeJet® 8002DG nozzles. Plots were 11 feet wide by 30 ft long and arranged in a randomized complete block design with four replications. Weed control was estimated five and 25 days after treatment (DAT). Sugarbeet yields were estimated by harvesting the two center rows on September 19. Herbicide treatments, adjuvants, and rates are detailed in Table 1.

Results and Discussion

Kochia control with Vida® applied with no other herbicide was between 82 and 91%, and it varied with the adjuvant added in the tank mix (Table 1). Kochia control improved when Vida® was tank mixed with Gramoxone® SL or Roundup PowerMAX®. Liberty® 280 alone provided 90% control, while kochia control improved to 99% when combined with Vida. No visual crop injury was observed in any of the treatments. Sugarbeet yields for all treatments were higher when compared to the non-treated checks, but no yield differences were observed among the treatments (Table 1).

Acknowledgments

The authors would like to thank personnel from PREC, University of Wyoming graduate students, and Western Sugar Cooperative for their contributions to this project.

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Keywords: sugarbeet, preplant burndown, kochia

PARP: III:1,7

Table 1. Kochia control (%) five and 25 days after treatment (DAT), and sugarbeet yield (ton/ac) at PREC. Note: herbicides are listed on the table in UPPERCASE/BOLDFACE to distinguish them from adjuvants, surfactants, and crop oil concentrates.

	Treatment	Rate		% Control 5 DAT	% Control 25 DAT	Yield (ton per ac)
1	Non-treated			0	0	5.5
2	**VIDA**	2	fl oz/ac	83	39	17.4
	Hel-Fire[1]	2	qt/100 gal			
3	**VIDA** w/	2	fl oz/ac	82	69	18.6
	NIS[2]	1	qt/100 gal			
4	**VIDA** w/	2	fl oz/ac	91	55	19.3
	COC[3]	2	qt/ac			
5	**VIDA** w/	2	fl oz/ac	99	82	20.6
	GRAMOXONE SL	32	fl oz/ac			
	Hel-Fire	2	qt/100 gal			
	NIS	1	qt/100 gal			
6	**VIDA** w/	2	fl oz/ac	99	61	18.5
	GRAMOXONE SL	32	fl oz/ac			
	Hel-Fire	2	qt/100 gal			
	COC	2	qt/ac			
7	**ROUNDUP POWERMAX** w/	32	fl oz/ac	90	77	18.0
	Hel-Fire	2	qt/100 gal			
	ammonium sulfate	17	lb/100 gal			
8	**VIDA** w/	2	fl oz/ac	98	92	14.4
	ROUNDUP POWERMAX	32	fl oz/ac			
	Hel-Fire	2	qt/100 gal			
	ammonium sulfate	17	lb/100 gal			
9	**LIBERTY 280** w/	36	fl oz/ac	91	78	20.6
	ammonium sulfate	17	lb/100 gal			
10	**VIDA** w/	2	fl oz/ac	99	88	15.1
	LIBERTY 280	36	fl oz/ac			
	Hel-Fire	2	qt/100 gal			
	ammonium sulfate	17	lb/100 gal			
	Least significant difference: p=0.05			5	4	6

[1]Hel-Fire is an adjuvant; [2]NIS=non-ionic surfactant; [3]COC=crop oil concentrate

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

Effect of Variable Irrigation and Nitrogen Application on Sugarbeet Root and Sugar Yield

Vivek Sharma[1,2], Andi Pierson[2], and Camby Reynolds[2]

Introduction

The sugarbeet (*Beta vulgaris*) is one of the most important row crops in Wyoming. In 2014, growers harvested 8.34 million tons on 30,200 acres. The value of the 2014 crop was $41 million (Brandt and Hussey, 2016). Sustainability of sugarbeet production in semiarid to arid regions of the western U.S., including Wyoming, is dependent on such factors as water availability, irrigation management, and nutrient management, including nitrogen (N). As Wyoming growers face significant management (sprinkler vs. surface irrigation, for example) and environmental changes (e.g., spatio temporal climate variability), a better understanding of the interaction of irrigation and N management could allow them to better utilize water while maintaining crop yields and quality.

Previous research under furrow irrigation suggests that as much as half of N applied as fertilizer can be lost from soils through runoff and leaching without being taken up by crops (Draycott and Christenson, 2003). Such losses are detrimental to both profitability and the environment. For example, runoff water carries heavy nitrate loads from fertilizer and eventually these nitrates make their way into streams, rivers, and lakes. Nitrates in water bodies can cause excessive algae growth; this depletes oxygen, which can kill fish and other aquatic life. Sprinkler irrigation systems provide the advantage of more even and controlled distribution of water above the canopy, which helps to minimize N leaching and reduce runoff losses.

Objectives

Objectives of this study are to evaluate the impact of variable irrigation and N application rates on sugarbeet root and sugar yield in the Bighorn Basin.

Materials and Methods

Field experiments were conducted in 2016 at the Powell Research and Extension Center (PREC). The dominant soil is a Garland clay loam, which is a fine, mixed mesic (Typic Haplarid). The area is characterized by a semiarid climate with long-term average annual and seasonal (April 1 to September 30) precipitation of 5.6 and 4.5 inches, respectively. The experiment was a split-plot design with variable irrigation and N levels. The investigated irrigation regimes were full irrigation treatment (FIT), 75% FIT, and 60% FIT. The N levels were 220 lb/ac (100 lb/ac at preplant and 120 lb/ac side-dress) and 150 lb/ac (100 preplant and 50 side-dress). The N fertilizer blend (SSN-46N and SSP 11-52-0) was broadcasted on March 9, and urea-ammonium nitrate (UAN 32%) was side-dressed on June 16. Sugarbeet hybrid 9418RR was planted on April 13 at a depth of 1 inch, emerged April 24–26, and was harvested on September 28. The number of plants per acre was approximately 48,000. Irrigation was applied using a Global Positioning System (GPS) guided variable-rate linear-move irrigation system (Valmont Industries Inc., Omaha, Nebraska). Irrigation scheduling was based off FIT and the 220 lb/ac N treatment. A total of 23 irrigation events occurred during the growing season. Sugarbeet yields were estimated by harvesting two rows at three locations within the same plot.

Results and Discussion

As expected, sugarbeet root yield increased with increasing levels of irrigation (Figure 1). A maximum sugarbeet root yield of 31 ton/ac was observed for FIT at 220 lb N/ac. The lowest yield (19 ton/ac) was obtained under 60% FIT for both N application rates. There was no significant difference in sugarbeet root yield between 75% FIT and FIT at a significance level of 0.05. This indicates that in the Bighorn Basin, irrigating at 75%

of the crop water requirements provides nearly equal sugarbeet root yield relative to a full irrigation strategy. This could reduce irrigation water usage by 25% and could also cut down on costs associated with irrigation, including labor and energy costs associated with pumping. The highest sugar content (15.3%) was achieved with the 150 lb/ac N application at 75% FIT. The lowest percent sugar content (14.0) was obtained for FIT at the 220 lb N level. Our results indicate that there is an optimal N level for each irrigation regime, and in general, lower N application rates are required to produce acceptable tonnage and maximum sucrose content at limited irrigation compared to FIT. This is an ongoing study, and this year we are adding more N levels (as low as 75 lb/ac to as high as 240 lb/ac) to better understand the irrigation and N interaction.

Acknowledgments
The authors thank PREC personnel for their assistance throughout the 2016 growing season.

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Keywords: irrigation, nitrogen, sugarbeet

PARP: II:2, IV:1

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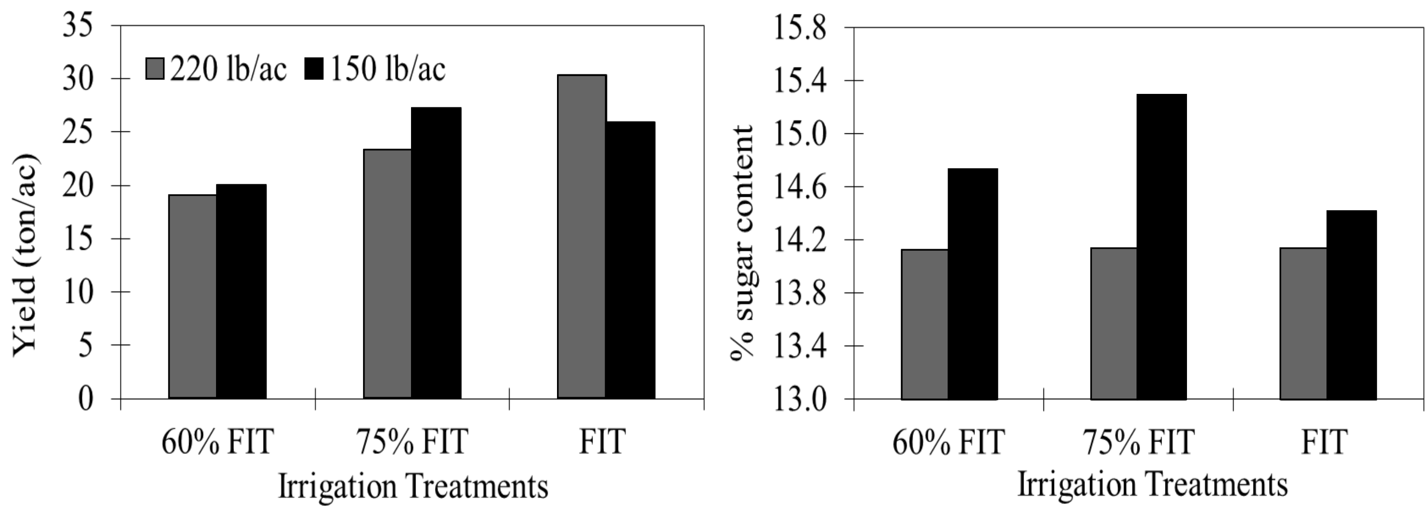

Figure 1. Sugarbeet root yield and sugar content response to nitrogen application rates (lb/ac) under full irrigation (FIT) and limited irrigation (75% FIT and 60% FIT) conditions at PREC in 2016.

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Management of Rhizoctonia Root and Crown Rot Disease in Sugarbeet with a Fungicide-Glyphosate Tank-Mix to Improve Farm Efficiency, 2016

William Stump[1], Stephan Geu[1], and Matthew Wallhead[2]

Introduction

Treating sugarbeet seed with a fungicide prior to planting is recommended for various soil-borne diseases including those caused by Rhizoctonia. Infection by Rhizoctonia, however, can occur all season, and seed treatment is only effective for up to six weeks after planting at which point foliar applications of fungicide may be necessary. This fungicide application typically occurs around the time the second to third application of Roundup PowerMax® herbicide (glyphosate) would be applied to the crop for weed control. The proposed research investigated the potential of tank-mixing Quadris®, Priaxor®, and Proline® fungicides along with the glyphosate herbicide. By combining fungicide with the herbicide application, efficacy can be improved due to reduced trips across the field.

Objectives

The objective is to determine if co-applying fungicide and the herbicide glyphosate is a viable, safe, and effective management practice for Rhizoctonia management in sugarbeets.

Materials and Methods

The study was established in 2016 at both the Powell Research and Extension Center (PREC) and James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) with four replicates. Prior to planting the plot, areas were inoculated with *Rhizoctonia solani* grown on barley at two inoculum levels. Sugarbeet was planted on April 14 (PREC) and May 13 (SAREC). All seed used was treated with Kabina ST at standard rates. Foliar fungicides and Roundup PowerMax were applied at the 8–10 leaf stage. Treatment structure was such that all fungicide + Roundup tank-mixes were compared to a sequential application of the same fungicide-Roundup combination. All fungicides and Roundup were applied at normal field rates and compared to non-inoculated and inoculated checks. Parameters measured included crop injury, weed control, Rhizoctonia disease incidence, and sugar yield.

Results and Discussion

The effect of inoculum level was not significant so data presented is combined over the two levels for each site. Rhizoctonia disease pressure was light at PREC, resulting in no differences in disease incidence between treatments including the non-inoculated check. For SAREC, fungicide treatment significantly reduced disease incidence compared to the inoculated check ($p \leq 0.05$). Disease control was uniform across the fungicide treatments so tank mixing the glyphosate had no effect on fungicide efficacy. All of the treatments with fungicide similarly improved final sugar yields compared to the inoculated check ($p \leq 0.05$). Weed control, as measured by weed counts, was similar across all treatments for both sites. Treatments also had no effect on crop injury or on final yield; therefore, there was no evidence that tank mixing the various fungicides and Roundup PowerMax had any effect on weed and disease control efficacy or on crop injury.

Acknowledgments

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

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

PARP: I:11

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

Treatments and rates* (fl oz/ac)	Total weed counts (1.1 yd2)		Rhizoctonia disease incidence (40 row ft)		lb sugar/ac	
	PREC	SAREC	PREC	SAREC	PREC	SAREC
Non-inoculated Check Roundup** (24)	2.8 a***	4.1 a	0.5 a	0.1 b	4,712 a	3,337 a
Inoculated Check Roundup (24)	3.1 a	5.8 a	1.1 a	21.0 a	5,185 a	2,176 b
Priaxor (0.46) + Roundup (24) Tank-mix	3.7 a	3.0 a	1.1 a	0.9 b	5,099 a	3,398 a
Priaxor (.46) • Roundup (24)	1.9 a	5.6 a	0.9 a	1.3 b	4,974 a	3,404 a
Proline + Roundup (0.33 + 24) Tank-mix	4.0 a	4.5 a	0.8 a	1.1 b	5,285 a	3,205 a
Proline (0.33) • Roundup (24)	2.7 a	5.3 a	1.4 a	2.5 b	4,724 a	3,488 a
Quadris + Roundup (0.6 fl + 24) Tank-mix	4.8 a	4.1 a	1.0 a	0.1 b	4,704 a	3,272 a
Quadris (0.6) • Roundup (24)	1.7 a	4.5 a	0.8 a	0.5 b	5,364 a	3,299 a

**Unless indicated as a tank-mix, treatments were applied sequentially (after first application was dry)*
***Roundup PowerMAX was the herbicide used, but 'PowerMAX' was deleted from this list because of space limitations*
****treatment means followed by a different letter differ significantly (Fisher's protected least significant difference, $p \leq 0.05$).*

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Weed Control in Dormant Alfalfa

Gustavo Sbatella[1,2]

Introduction

Proper herbicide selection and subsequent treatments to dormant alfalfa allow the use of active ingredients that otherwise would injure the crop if applied during vegetative growth. 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, but to my knowledge weed control efficacy and crop safety of indaziflam on alfalfa has not been established in the U.S.

Objectives

Objectives were to evaluate weed control efficacy and crop response of indaziflam (Alion®) when applied to dormant established alfalfa.

Materials and Methods

Alfalfa variety 'Vernal' was drill planted at the Powell Research and Extension Center (PREC) at the rate of 8 lb/ac in spring 2014. The trial was furrow irrigated, and water was supplied according to crop needs. Herbicide treatments were applied to established dormant alfalfa in March 2015 with a CO_2-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 ft long and arranged in a randomized complete block design with four replications. Herbicide treatments and rates are detailed in Table 1. Flumioxazin (Chateau®) was added for comparison. No further herbicides were applied in 2016. Visual evaluations for weed control and crop injury in 2016 were assessed 365 days after treatment (DAT). Alfalfa hay was cut on June 15 and August 14, and fresh and dry biomass production was estimated by harvesting a 135 ft^2 area with a forage plot harvester.

Results and Discussion

Indaziflam provided excellent weed control during the 2016 season, with no visual injury observed for any of the treatments or rates. In addition, alfalfa dry hay yields were similar between treatments suggesting no negative effects from the application of indaziflam. Results from this study suggest that indaziflam could be an option for weed control in alfalfa grown for hay in northwest Wyoming.

Acknowledgments

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

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Keywords: dormant alfalfa, weed management

PARP: III:2,7

Table 1. Dry alfalfa hay yield (ton/ac) at PREC one year after application.

	Treatment	Rate	Control*[1] (%)	Yield-dry (ton/ac)	
			365 DAT	First cut	Second cut
1	Non-treated Check		0	1.8	1.6
2	Alion	1 fl oz/ac	95	1.9	1.9
3	Alion	2 fl oz/ac	97	2.0	1.9
4	Alion	3 fl oz/ac	97	2.1	1.9
5	Alion	4 fl oz/ac	99	2.2	1.8
6	Alion	5 fl oz/ac	97	1.8	1.7
7	Chateau	2 oz wt/ac	0	1.7	1.5
Least significant difference *p*=.05			5	.8	.4

*means followed by same letter do not differ at $p<0.05$
[1]mainly kochia

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

Sainfoin Stand Removal

Gustavo Sbatella[1,2] and Andrew Kniss[1]

Introduction

Sainfoin is a non-bloat causing perennial legume that can be used for hay, or grazed in pastures alone or in a grass-legume mix. Properly managed stands can persist three to six years under irrigation. Insects, diseases, age, weed competition, etc., can lead to the need to remove old stands, the latter of which can be accomplished by tillage, herbicides, or a combination of herbicides and tillage. To our knowledge, however, there is no information regarding which are the best herbicide options for sainfoin stand removal.

Objectives

A trial was conducted at the Powell Research and Extension Center (PREC) in 2016. Our objective was to determine the efficacy of different herbicides that could possibly be used for sainfoin stand removal.

Materials and Methods

Two field trials were conducted at PREC on a 5-year-old stand of 'Delaney' sainfoin. Soil at the site is a Garland loam (organic matter: 1.6%; pH: 8.1). The trials were under furrow irrigation. The following herbicides were tested for sainfoin stand removal: RoundUp PowerMAX®, 2,4-D amine, Clarity®, and Stinger®. Herbicide treatments were applied with a CO_2-pressurized knapsack sprayer delivering 16 gallons of total volume per acre at 30 psi with TeeJet® DG8002 nozzles; application dates and weather conditions are detailed in Table 1. Experimental plots were 11 feet wide by 25 ft long and arranged in a randomized complete block design with four replications. Herbicide efficacy on sainfoin stand removal was estimated by visual evaluations, measuring the normalized difference vegetation index (NDVI is used to measure live green vegetation), measuring canopy coverage with the use of a Canopeo® app, and by mechanically harvesting the biomass from a 100 ft^2 area from each plot.

Results and Discussion

Sainfoin stand removal was more effective when RoundUp PowerMAX was used (Table 1). Sainfoin visual injury was near 90%, the plant canopy was reduced to 13%, and plant biomass decreased by 87%. It is worth noting that the tested rate is the maximum labeled rate allowed for use in perennials. The next best options were 2,4-D amine and Clarity at the highest tested rates. In these treatments, sainfoin stand visual injury was near 67%, canopy coverage was 45%, and biomass reduction was close to 75%. Stand removal with Stinger was not satisfactory regardless of the rate used.

Acknowledgments

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

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Keywords: sainfoin, stand removal

PARP: III:7

Table 1. Sainfoin stand removal measured by different parameters in 2016 at the Powell Research and Extension Center.

	Name	Rate	Unit	Visual %	NDVI[1]	CANOPEO %	Biomass lb/ac
1	Untreated Check			0	0.84	91	15.8
2	RoundUp PM	108[2]	fl oz/ac	89	0.34	13	2.1
	ammonium sulfate	17.5	lb/100 gal				
3	2,4-D amine	16	fl oz/ac	56	0.66	59	4.7
	NIS[3]	0.25	% v/v[4]				
	ammonium sulfate	17.5	lb/100 gal				
4	2,4-D amine	32	fl oz/ac	68	0.60	48	4.1
	NIS	0.25	% v/v				
	ammonium sulfate	17.5	lb/100 gal				
5	Clarity	8	fl oz/ac	48	0.70	53	5.4
	NIS	0.25	% v/v				
	ammonium sulfate	17.5	lb/100 gal				
6	Clarity	16	fl oz/ac	66	0.60	47	3.8
	NIS	0.25	% v/v				
	ammonium sulfate	17.5	lb/100 gal				
7	Stinger	4	fl oz/ac	45	0.71	65	4.3
	NIS	0.25	% v/v				
	ammonium sulfate	17.5	lb/100 gal				
8	Stinger	8	fl oz/ac	54	0.69	62	4.5
	NIS	0.25	% v/v				
	ammonium sulfate	17.5	lb/100 gal				

[1] *NDVI is used to measure live green vegetation cover. Higher values mean more green vegetation.*
[2] *Maximum labeled rate for perennial species*
[3] *NIS=non-ionic surfactant*
[4] *v/v=volume/volume*

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Testing for Suitable Soybean Maturity Group for the Bighorn Basin—2016 Trial

Gustavo Sbatella[1,2] and Camby Reynolds[2]

Introduction

Hairy nightshade (*Solanum sarrachoides*) control is becoming increasingly difficult in fields with a long history of dry bean production in the Bighorn Basin. Weed control programs in dry beans rely on pre-plant incorporated herbicides, which do not control late-emerging weeds such as nightshades. Glyphosate-resistant soybeans are an alternative that could allow better hairy nightshade control while maintaining 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 2016 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). It was broadcast fertilized with 50 lb nitrogen (N) and 20 lb phosphorous per acre prior to planting. On May 31, Asgrow® soybean varieties AG0333, AG0430, AG0735, AG0835, AG0934, and AG1135 were planted with a John Deere MaxEmerge™ planter at 22-inch row spacing. All varieties were inoculated with N-Dure™ at 2.5 oz/50 lb of seed (this treatment promotes rhizobia root nodulation, which helps N fixation). The trial was furrow irrigated, and water was supplied according to crop needs. Roundup WeatherMAX®, at 32 oz/ac, was applied twice for weed control. Outlook® herbicide, at 14 oz/ac, was tank-mixed with the second application. Herbicide and fungicide treatments were applied with a CO_2-pressurized knapsack sprayer delivering 16 gallons of total volume per acre at 40 psi with TeeJet® 8002-DG nozzles. Plots were 22 feet wide by 50 ft 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 27.

Results and Discussion

Soybean varieties based on growth and development are classified in maturity groups. The larger 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 at PREC. The number of plants per acre and weight of 100 seeds are important yield components, and for that reason these were recorded. Plant populations after emergence ranged from ~143,000 to 163,000 plants/ac (Table 1). Differences in the weights of 100 seeds were recorded between varieties. Soybean variety AG0735 had the heaviest weight of 100 seeds (11.8 g), followed by AG0934 (11 g). No major differences were recorded in the weight of 100 seeds among the rest of the tested varieties. The highest yields were recorded for varieties AG0735 at 19.9 bu/ac and AG1135 at 17.3 (Table 1). Results suggest that the maturity group to which the variety belonged was not the main factor determining soybean yields at PREC. Soybean yields were considerably lower in 2016 when compared to the 2015 trial, which offered promising results. To help determine why there was such a big difference in yields, we are repeating the study in 2017.

Acknowledgments

The authors thank personnel from PREC, UW graduate students, Monsanto weed management technology development representative Ryan Rapp, and Monsanto technical agronomist David Heimkes for their contributions during this project.

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Keywords: soybean maturity group, alternative crop, hairy nightshade

PARP: I:9, II:9

Table 1. Soybean plant population, weight of 100 seeds, and yields at PREC in 2016.

	Variety	Population/ac*	Weight 100 seeds(g**)	Yield (lb/ac)	Yield (bu/ac)
	AG0333	143,100	10.2	917	15.3
	AG0430	155,400	9.6	561	9.3
	AG0735	159,600	11.8	1,187	19.8
	AG0835	163,100	9.8	872	14.6
	AG0934	158,500	11.0	887	14.8
	AG1135	161,400	9.6	1,039	17.3
Least significant difference *p*=.05		14,800	0.7	1.2	2.6

**Means followed by different letters are significantly different at p=0.05*
***1 gram=0.035oz.*

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

Dissipation of Soil-applied Herbicides under Limited Irrigation

Daniel Adamson[1], Gustavo Sbatella[1,2], Andrew Kniss[1], and Franck Dayan[3]

Introduction

A major challenge for sustainable agriculture is to increase crop production with limited resources, particularly water. Decreased soil moisture, however, can result in extended herbicide persistence, which, in turn, can potentially damage rotational crops through carryover (herbicides remaining in the soil from the previous growing season).

Objectives

Our objective was to determine the impact of limited irrigation on efficacy, soil persistence, and carryover of soil-applied herbicides commonly used in corn and dry bean production.

Materials and Methods

The study was established in spring 2015 at the Powell Research and Extension Center (PREC), when 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 randomly assigned to 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 required water needs. Soils were sampled before and after herbicide application and tested for herbicide level. In 2016, rotational crops (sugarbeet, sunflower, and corn or dry bean) were planted over the original plots and assessed for injury and yield damage from any remaining residual herbicides. The entire study is being repeated in 2017.

Results and Discussion

As expected, reduced irrigation significantly affected yield; however, laboratory extractions showed reduced irrigation did not significantly affect the rate of herbicide loss from the soil. Instead, herbicide carryover appeared to be determined by the inherent persistence of individual herbicides. Plant weights taken at the beginning of July 2016 showed Pursuit® damaged sugarbeet, corn, and sunflower. Prequel® damaged dry beans and sunflower. Other herbicides did not significantly reduce crop growth. Yields depicted a similar pattern, with Prequel® significantly reducing yield of dry bean and Pursuit® significantly reducing yield of sugarbeet and sunflower (Table 2).

Acknowledgments

The authors thank personnel from PREC, University of Wyoming students, and the Colorado State University weed lab for their contributions to the project. This project was funded by the Wyoming Agricultural Experiment Station's Competitive Grants Program.

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Keywords: herbicides, irrigation, carryover

PARP: III:4,7, X:1

Table 1. Cropping restrictions in months for soil-applied herbicides in corn and dry bean plantings.

Corn treatments	Rate	Sugarbeet	Barley	Dry bean
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				
Dry bean treatments				
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

*2CS, two cropping seasons
**NCS, next cropping season

Table 2. Crop yields the following growing season after corn and dry bean plantings were treated with soil-applied herbicides.

Herbicide	Sugarbeet (ton/ac)	Sunflower (lb/ac)	Corn (bu/ac)	Dry Bean (lb/ac)
Non-treated	19.4 a	2,423 a	100 a	1,993 a
Pursuit®	2.5 b	838 b	79 a	NA
Prowl® H2O	17.6 a	2,443 a	93 a	NA
Sonalan®	16.0 a	2,604 a	105 a	NA
TreflanTM	16.3 a	2,377 a	109 a	NA
Atrazine	20.8 a	2,548 a	NA	2,368 a
Verdict®	22.2 a	2,442 a	NA	2,165 a
Zidua®	16.2 a	2,607 a	NA	2,079 a
Prequel®	17.0 a	1,907 a	NA	207 b

*means followed by same letter do not differ at $\alpha=0.05$

[1]*Department of Plant Sciences;* [2]*Powell Research and Extension Center;* [3]*Department of Bioagricultural Sciences and Pest Management, Colorado State University.*

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

John Tanaka[1]

Introduction

The James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) was established in 2002, and research activities began fully in 2006. SAREC has 349 acres of irrigated cropland using a combination of three center pivots, a lateral-move sprinkler, and furrow irrigation. There are 1,523 acres of dryland crops, primarily in wheat and corn, 1,880 acres of rangeland, and a 400-head feedlot. SAREC also oversees management of the approximately 320-acre Rogers Research Site in the Laramie Mountains near Laramie Peak, land that was gifted to the University of Wyoming by Colonel William C. Rogers.

SAREC Personnel

We work as a team (Figure 1) to provide the best possible research and extension activities serving a six-county region in eastern Wyoming (Albany, Converse, Goshen, Laramie, Niobrara, and Platte counties), 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, grazing on pasture and rangelands, and feeding primarily cattle in the feedlot. We are also heavily involved in extension activities throughout the year by both providing a place for hands-on demonstrations to giving talks and writing articles of interest to a wide variety of constituents. We are highly committed to conducting research and extension activities that help solve issues for farmers, ranchers, agricultural organizations, the owners of small acreages, the managers of both public and private lands, and others.

Figure 1. SAREC staff and faculty include, from left, Troy Cecil, Kelly Greenwald, Brian Lee, Kevin Madden, Carrie Eberle, Larry Miller, Lori Schafer, Al Unverzagt, John Tanaka, Jeff Edwards, Larry Howe, and Steve Paisley.

Devastating Hailstorm

During the 2016 crop year, we were hit with a devastating hailstorm for about 10 minutes on July 27 with dime- to quarter-size hail. While most of our winter wheat and first two cuttings of alfalfa were harvested, pretty much everything else was either destroyed or damaged. As you will read in other papers in the SAREC section of this bulletin, many of the research studies were impacted by the hail, but early results could still be reported. Other projects were either severely impacted or impacted to such a level that no results were obtained including a flower study by Assistant Professor Randa Jabbour, a dry bean nursery by Professor Jim Heitholt (Figure 2), fungicide and disease management in sugarbeets and seed treatments in winter wheat by Assistant Professor Bill Stump, and sun hemp and other corn research by Assistant Professor Carrie Eberle. SAREC has some production acres where we grow crops for sale or use by livestock herds at SAREC and the Laramie Research and Extension Center. We lost all corn production (Figure 3), production in our third cutting of alfalfa was much lower than normal, sugarbeets were damaged, and a small field of winter wheat had lower production than previously harvested acres. We also lost a lot of our rangeland forage for late-summer grazing. We don't know the full extent of damage on lands near SAREC, but many of our neighbors to the west were also impacted by the hailstorm.

The Aftermath

Recovering from the storm was not all doom and gloom. We took the opportunity to initiate a short-term study to learn what farmers might be able to do following a hailstorm if they want to recuperate some production. The hail study is described elsewhere in this bulletin. We expect several pieces of information to come out of this study including some management options, production levels of planted cover and forage crops, and impact on the next year's corn production.

The only part of SAREC not significantly damaged by the storm was the Wyoming Restoration Challenge, a cheatgrass management competition described in a paper in this bulletin. While we don't recommend planting cheatgrass to ward off hail, we were glad that this community-involved challenge was able to continue this year. We are all looking forward to the results.

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. A new fence was built around our new seeding on the highly erodible cropland making it a useful pasture. We are installing some small paddocks for grazing systems and soil health research. There was some minor hail damage to buildings that we are slowly addressing. We were able to replace our research plot combine and planter with new research-capable machines. We have developed a plan to upgrade and modernize our equipment over the next several years.

Acknowledgments

SAREC was formed to be a place where applied research will be conducted to help agricultural production in the region become more sustainable. Our mission is to serve the citizens of Wyoming, the region, and nation by facilitating innovative discovery, dissemination, and engagement of integrated agricultural systems that are ecologically sound, economically viable, and socially acceptable. The success of SAREC depends upon the staff and faculty. 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.

Figure 2. Dry bean nursery after the July 27 hailstorm. All production was lost.

Figure 3. Corn and sugarbeets following the July 27 storm. Corn production was lost, and though sugarbeets recovered their production and quality dropped.

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Incorporating forage crops into traditional irrigated corn systems

Investigators: Randa Jabbour, Sara Carabajal, and Andrew Kniss

Issue: Corn stalks are grazed in much of the West. Interseeded annual forage crops could potentially provide needed supplemental protein and energy when grazing corn stalks and could have other ecological implications.

Goal: Evaluate the advantages and risks of growing annual forages in standing corn.

Objectives: Test whether annual forage crop species and soil disturbance alter forage quantity and quality. Determine whether forage crop diversity drives associated abundance and diversity of pests as well as beneficial insects.

Expected Impact: Annual forage crops have the potential to increase productivity, efficiency, and sustainability of corn-based systems in Wyoming, but are deemed risky in this water-limited region and perhaps not worth the extra effort or cost. It's our goal to provide information that helps producers decide whether to implement this practice on their land.

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Keywords: forage, beneficial insects, interseeding

PARP: I:6

Shade tolerance of pepper varieties grown in a high-tunnel environment

Investigators: Brian Lee and Jeff Edwards

Issue: Wyoming high-tunnel producers may be able to increase yield and plant health by utilizing shade cloth for pepper production. High-tunnel environments can reach temperatures in excess of 100°F, and studies have shown that peppers prefer slightly shadier environments than other vegetables.

Goal: Record yield and environment temperature data for 12 different pepper varieties produced in shaded and non-shaded high-tunnel beds.

Objectives: Determine yield increase (if any) of pepper varieties grown in a shaded environment for optimal high-tunnel growth.

Expected Impact: Results should help growers produce greater yields in the limited area of a high tunnel by increasing plant health.

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Keywords: high tunnel, pepper, shade tolerance

PARP: I:2, VII:4

Evaluating bioherbicide efficacy on invasive winter annual grasses

Investigator: Daniel Tekiela

Issue: Bioherbicides have been suggested as an alternative tool to managing the current invasion of winter annual grasses; however, no data exists on their efficacy in Wyoming.

Goal: Determine if bioherbicides are a viable invasive winter annual grass management tool in Wyoming.

Objectives: Study the efficacy of various bioherbicide formulations on a troublesome winter annual, cheatgrass, aka downy brome (*Bromus tectorum*).

Expected Impact: Land managers seek alternative long-term methods of controlling invasive winter annuals in rangelands and are already utilizing bioherbicides, but with no data on their efficacy. These results should help land managers decide if this tool is a viable management option.

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Keywords: weeds, bioherbicides, invasive species

PARP: III:5,9,11

Chlorophyll and Vegetative Traits of 18 Dry Bean Genotypes Grown with Zero Fertilizer N and 60 Pounds N/Acre

Ali Alhasan[1] and Jim Heitholt[1]

Introduction

Dry bean (*Phaseolus vulgaris* L.) is a widely consumed legume crop worldwide. This crop originates in Central and South America, and it is grown in tropical and temperate climates for its dry seed and fresh pod consumption. But nitrogen (N) fixation by rhizobia bacteria within dry bean nodules is deemed poor compared with other legume crops such as soybean and alfalfa, and many dry bean producers fertilize with copious amounts of N. Our lab is among many across the world seeking to identify genotypes and management practices that will reduce fertilizer N use on beans without reducing profits.

Objectives

The main objective is to identify the best dry bean genotypes and the N management that will increase dry bean production in Wyoming. The specific objective is to determine the yield of 18 dry bean genotypes under two rates of inorganic N fertilizer.

Materials and Methods

The 18 cultivars were planted at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle on May 27, 2016, with three replicates in a split-plot design. N level (0 vs. 60) was the main plot and cultivar the subplot. Plots were four rows wide and 16 ft long, and there were 108 total plots. For the fertilized main plots only, N was surface-applied at 60 lb/ac as urea on 26 days after planting (dap) prior to an irrigation event. Chlorophyll was measured at 33, 39, 43, and 50 dap using a Spectrum Technologies SPAD meter. The normalized difference vegetation index (NDVI) was recorded at 50 dap using a RapidScan CS-45 handheld crop sensor. (NDVI is an index of plant *greenness*, or photosynthetic activity.) The center leaflet was sampled from the third uppermost trifoliolate on five plants per plot using a Li-Cor Environmental LI-3100C area meter on 50 dap.

Results and Discussion

Averaged across all cultivars, N fertilizer did not increase leaf chlorophyll significantly at 43 dap (8% difference), but the difference at 50 dap was significant (42.8 vs. 40.3). Cultivars differed significantly in leaf chlorophyll at 50 dap (Table 1). No N level-by-genotype interaction was detected on chlorophyll for any of the four measurement dates. For NDVI, no N effects were observed, and there was no cultivar-by-N interaction. NDVI was positively correlated with leaf chlorophyll (Figure 1). Leaf size (area per leaflet) was greater with high N compared to no N (28.3 vs. 23.3 cm^2), but it was also significantly affected by a significant cultivar-by-N interaction. This interaction was caused by a large response to N by Eclipse, Othello, Talon, and UI-259 and a negligible response by La Paz.

Acknowledgments

The authors thank the staff at SAREC for help with planting and weed control and Carrie Eberle for help with the NDVI.

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Keywords: dry bean, nitrogen management, yield

PARP: II:5

Table 1. Leaf chlorophyll (50 dap), NDVI (50 dap), and area per leaflet (cm^2) at two N levels of 18 dry bean genotypes grown at SAREC in 2016. Values for chlorophyll and NDVI are averaged across N levels.

Cultivar	**Chlorophyll**	**NDVI**	**Area – No N**	**Area – High N**
Avalanche	38.3	0.62	21.3	24.3
Bill-Z	44.9	0.80	20.8	25.1
CO-46348	46.8	0.82	26.7	29.2
COSD-35	43.4	0.73	24.6	26.3
Centennial	42.2	0.73	23.6	27.9
Eclipse	37.5	0.54	22.8	29.1
La Paz	43.2	0.68	24.7	23.4
Lariat	43.0	0.75	22.7	27.5
Long's Peak	40.5	0.75	24.0	27.8
Monterrey	41.8	0.74	23.6	28.2
ND-307	41.8	0.78	23.1	29.3
Othello	43.0	0.80	22.2	31.0
Poncho	45.5	0.80	23.6	29.0
Rio Rojo	37.7	0.70	22.0	28.0
Stampede	39.6	0.72	22.9	29.4
Talon	37.3	0.79	27.5	40.2
UI-259	39.8	0.79	21.5	32.2
UI-537	42.2	0.76	21.2	25.3
Least significant difference (0.05)	2.7	0.03	4.8	4.8

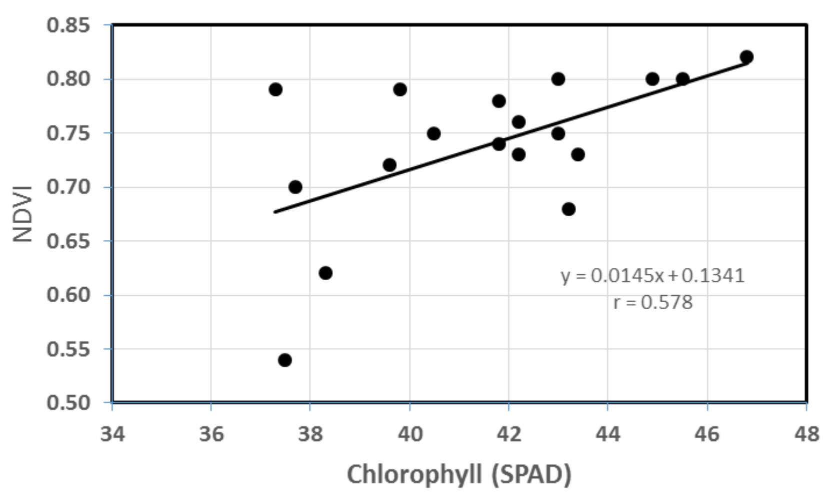

Figure 1. Relationship between NDVI and leaf chlorophyll among 18 cultivars at 50 dap. Each point represents six data points (cultivar means were averaged across the two N rates).

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Variation in Canopy Temperature and Normalized Difference Vegetation Index for 23 Dry Bean Genotypes Grown under Well-Watered and Water Stress Conditions

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

Introduction

In recent years, breeders and crop physiologists have tried to quantify dry bean canopy traits to see if those traits relate to yield or would help in the identification of parental material for use in breeding programs. Two very simple traits are midday canopy temperature (CT) and normalized difference vegetation index (NDVI), where cooler canopy temperatures and canopies that reflect more far-red light are presumed healthier.

Objectives

The objectives of this study were to characterize CT, NDVI, leaf chlorophyll, and stomatal conductance of 23 dry bean cultivars.

Materials and Methods

The study was sown on May 27, 2016, at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) using a split-plot arrangement with two irrigation rates and 23 genotypes replicated three times. Irrigation rate (full vs. less-than-full) was the main plot and genotype the subplot. Plots (four rows) were 16 feet long with 30-inch row spacing at ~90,000 seeds per acre. Leaf chlorophyll was measured with a soil plant analysis development (SPAD) meter on June 28 prior to any visible water stress. NDVI was collected mid- to late-morning on July 8 with a handheld crop sensor after the first differential watering where the stress plots received less irrigation (0.75 inches vs. 0.50 inches). Canopy temperature was collected mid-morning and mid-afternoon on July 23 with an infrared thermometer several days after another differential watering. Also on July 23, stomatal conductance was measured midday on three genotypes with a leaf porometer. A hail storm on July 27 terminated the crop.

Results and Discussion

Leaf chlorophyll differed among genotypes as expected (Table 1). NDVI also differed among genotypes, but values were in the expected range and are not discussed in detail here. Stomatal conductance was not significantly affected by any of the treatments although leaves from well-watered plots had numerically higher conductance than leaves from drought-plots, meaning that the well-watered leaves transpired at a greater rate and possibly had a higher photosynthetic rate. As expected, canopy temperatures on July 23 were lower in the morning (88.0°F) than in the afternoon (90.7°F). Differences in canopy temperature were not significantly different between watering regimes although a noticeable trend was apparent. In the morning, drought plots exhibited CT of 90.7° vs. 85.1° for the well-watered plots. In the afternoon, the difference was 92.8° vs. 88.5° with drought plots being warmer. Genotypes that are considered more adapted to southeast Wyoming tended to have lower CT than genotypes not adapted to Wyoming. In our other studies where yield was collected, genotypes with cooler canopies yielded higher than genotypes with warmer canopies, but because yield could not be measured in this study due to the hail storm, we cannot provide management or genotype recommendations.

Acknowledgments

The authors thank the crew at SAREC for managing the crop from planting to harvest and Ali Alhasan for help with planting. For funding, the authors thank the Wyoming Bean Commission and the USDA Hatch program.

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Keywords: dry bean, canopy temperature, normalized difference vegetation index (NDVI)

PARP: Goals 1, 2

Table 1. Canopy traits of 23 dry bean genotypes grown at SAREC in 2016 averaged across two irrigation levels. Measurement dates are provided in the text.

Genotype	Chlorophyll (SPAD[1] Units)	NDVI	Canopy Temp (a.m.) °F	Canopy Temp (p.m.) °F
Avalanche	44.1	0.54	88.7	92.1
Bill-Z	48.3	0.72	88.2	90.9
Centennial	43.5	0.61	86.7	89.6
Com. Red Mexican	43.9	0.69	87.6	90.0
CO-46348	49.1	0.72	86.5	89.4
COSD-25	42.7	0.62	86.9	90.3
COSD-35	47.9	0.65	91.2	90.7
Croissant	45.1	0.70	88.5	89.2
Desert Song	53.4	0.62	86.0	89.8
Eclipse	41.4	0.49	90.0	93.4
El Dorado	46.8	0.62	86.7	89.2
ISB1231-1	48.8	0.69	88.2	89.1
La Paz	45.3	0.59	86.5	91.2
Long's Peak	43.1	0.66	85.8	89.6
Monterrey	48.3	0.65	87.1	91.4
Othello	49.9	0.71	85.8	90.1
Poncho	48.2	0.71	88.2	90.3
Rosie	44.2	0.72	91.9	95.2
T-9905	45.3	0.44	89.2	92.3
UI-259	42.7	0.69	88.9	91.2
UIP-40	42.0	0.59	86.4	90.5
UIP-46	43.9	0.65	87.3	90.1
Zorro	43.3	0.45	89.1	92.1
Least significant difference (0.05)	3.7	0.06		3.1

[1]SPAD=soil plant analysis development. The higher the number, the greener the plant.

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

Management of Stem and Root Rot Diseases of Pinto Bean with In-Furrow Fungicides

William Stump[1], Wendy Cecil[1], and Matthew Wallhead[2]

Introduction

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

Objectives

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

Materials and Methods

Research plots were located at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Three in-furrow and sequential foliar fungicide treatment programs were compared to a non-treated inoculated check. A randomized complete block design with four replicates was established. Each treatment plot was 20-feet long and four rows wide with a five-foot in-row buffer between plots. Plots were inoculated with an isolate mix of *Rhizoctonia solani* and *Fusarium* spp. The planting date was June 2, 2016, with variety Centennial, and in-furrow applications were made prior to row closure. The field plot area received fertility, weed control, and irrigation appropriate for dry bean production. The foliar maintenance treatments were not applied because of a hail storm on July 27. Parameters measured were stand counts, plot vigor, and incidence of stem and root rot.

Results and Discussion

No phytotoxicity due to treatments was observed on the pinto bean crop. Bean stands were somewhat variable in the plots most likely due to the open-furrow planting procedure. Effects of in-furrow fungicide applications on the bean crop and stem rot are shown in Table 1. Stem and root rot development was light to moderate and not uniform in the plot area. In-furrow fungicide treatment had no effect on vigor, final stand count, and incidence of stem and root disease ($p \leq 0.05$). A severe hail storm defoliated the trial on July 27; therefore, the trial was terminated (disced under) after the stem/root ratings were conducted.

Acknowledgments

We thank SAREC field crews for assistance in plot establishment, maintenance, and termination. The study was supported by Bayer Crop Science and the Wyoming Bean Commission.

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

PARP: I:11

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

Treatment and rate/ac[1]	Application timing[2]	Plant vigor (1–10)[3]	Final stand (# plants/40 ft)	% Incidence of stem and root rot[4]
		June 23	July 11	Aug. 6
Non-treated inoculated check	NA	9.3 a[5]	173.3 a	30.0 a
Proline® (5.7 fl oz) Endura® (8 oz)	In-furrow foliar	10.0 a	167.8 a	30.0 a
Velum® Prime (3 fl oz) Endura (8 oz)	In-furrow foliar	9.3 a	159.0 a	15.0 a
Propulse® (6 fl oz) Endura (8 oz)	In-furrow foliar	9.3 a	175.3 a	40.0 a

[1] Treatment rates (per acre) were concentrated in-furrow.
[2] Foliar applications were not applied due to hail event.
[3] Plant vigor rating scale (1–10) where 1=no stand and 10=best stand in the replicate.
[4] % disease incidence due to presumptive Fusarium and or Rhizoctonia infection was based on visual ratings of five plants pulled from each plot.
[5] Means followed by the same letter were not significantly different ($p \leq 0.05$).

[1]*Department of Plant Sciences;* [2]*U.S. Department of Agriculture, Agricultural Research Service.*

Composted Manure and Cover Crops in Wyoming Wheat-Fallow Rotations: Weed Biomass and Soil Moisture

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

Introduction

Weed control and soil productivity are important considerations for Wyoming winter wheat (*Triticum aestivum* L.) producers. Because low yield potential in the semiarid climate limits cost-effectiveness of inputs like herbicides, many wheat producers rely on repetitive tillage to control weeds, which ultimately damages soil structure and reduces soil organic matter (SOM). Planting cover crops during fallow is a proven conservation practice in many parts of the world, but in semiarid regions where precipitation is below 12 inches, cover crops may utilize much needed soil moisture and, hence, negatively affect winter wheat yield. One possible solution is to plant cover crops after applying composted manure to the field; the cover crops compete with weeds while the compost increases soil-water-holding capacity, possibly providing water for both the cover crop and the subsequent wheat crop. Evaluation of immediate plant and soil responses to this combination of practices in the northern High Plains wheat-producing region, including southeast Wyoming, may assist farmers with access to large amounts of composted manure to improve soil health and manage soil fertility.

Objectives

Our objectives are to determine the influence of cover crops planted after the application of four rates of composted manure and inorganic fertilizer on cover crops, weeds, and soil moisture.

Materials and Methods

Four rates of composted feedlot manure (0, 7, 14, and 20 ton/ac) supplying 0, 125, 250, and 366 lb/ac nitrogen (N) were applied to the fallow phase of the winter wheat/fallow rotation in April 2016. The experiment at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) was laid out in a randomized complete block design. Shortly after the compost application, half of the fallow plots were planted to a cover crop mixture of 25 lb/ac *Pisum sativum* L. (Australian winter pea) and 50 lb/ac *Avena sativa* (oat) seeds. Cover crops remained on the field for six weeks, and were then terminated before flowering stage and incorporated into the soil with discing and tilling. Soil moisture (to a soil depth of 4 in.) was monitored weekly. Weed biomass in both cover crop and bare fallows was collected once (just before termination of the cover crops).

Results and Discussion

Cover crops reduced weed biomass by 46% compared with no cover crops (Figure 1). Presence of the cover crops had a notable effect on weed biomass decline across all amendments, yet the greatest and statistically significant difference occurred at a compost application rate of 14 ton/ac only (Figure 2) where the highest cover crop biomass was also observed (Figure 3). Cover crops depleted soil moisture by 2–4% across all compost rates (Figure 4). Reduced weed pressure with cover crops may mean that less tillage is needed. Data collection will continue through the 2017 and 2018 growing seasons.

Acknowledgments

We thank Erin Rooney, Ada Harris, Brandon Fulcher, and the entire SAREC crew for assistance. This project was funded through grants from the U.S. Department of Agriculture's Organic Transitions Program, Wyoming Department of Agriculture, and USDA Hatch program.

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Keywords: winter wheat, compost, cover crops

PARP: I:3, III:3

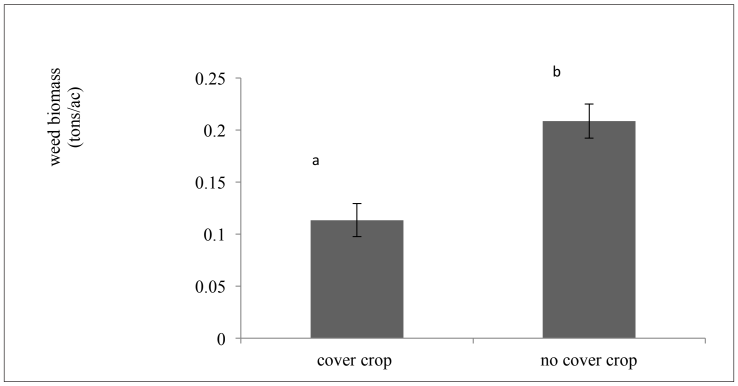

Figure 1. Weed biomass in cover crop and no cover crop plots.

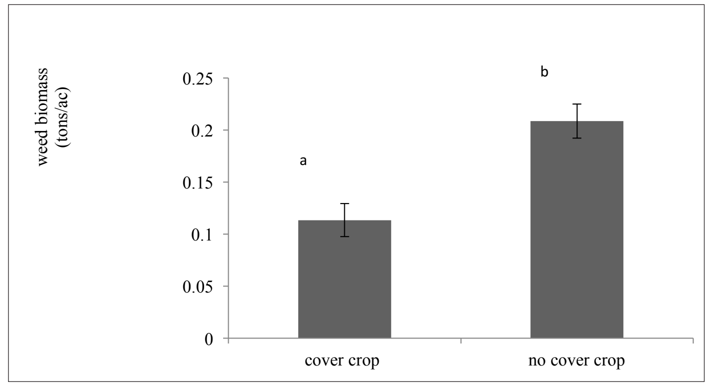

Figure 2. Amendment-Cover crop interaction effect on weed biomass.

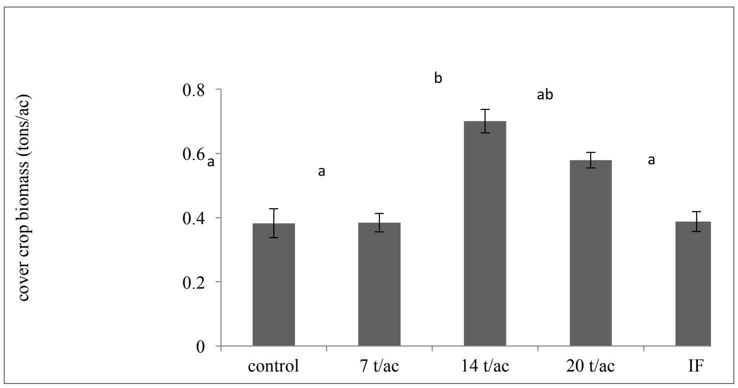

Figure 3. Cover crop biomass in response to compost rate.

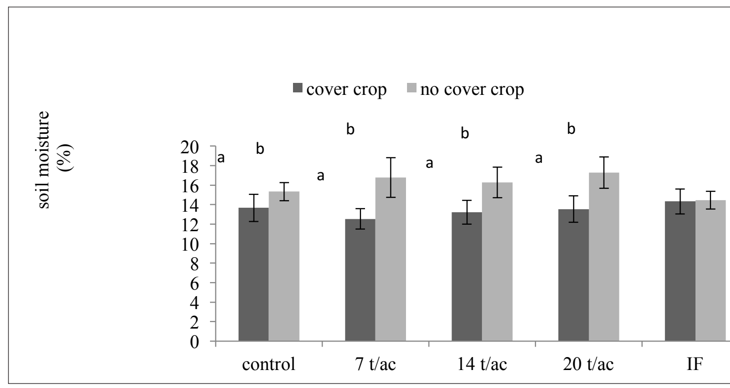

Figure 4. Amendment-Cover crop interaction effect on soil moisture.

Means followed by the same letters do not differ at $p \leq 0.05$; IF=inorganic fertilizer

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

Effect of Variable Rates of Composted Manure on Growth and Yield of Winter Wheat

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

Introduction

Limited success of soil fertility restoration threatens the economic viability of winter wheat (*Triticum aestivum* L.) production in semiarid environments, such as eastern Wyoming. To maintain long-term sustainability of agricultural productivity in this region, there is a need for continuous improvement of wheat-based cropping systems. Amending soil with high rates of composted manure is known to improve soil fertility and provide an economically beneficial alternative to inorganic fertilizers. The positive carry-over (residual) effect of a one-time high application rate of compost on soil organic matter (SOM) and inorganic nutrient supply have been documented in the past, but limited information exists on regions that experience low (12 inches) precipitation.

Objectives

Our objectives were to evaluate the effect of high rates of composted manure on winter wheat growth and yield in the first year following the amendment.

Materials and Methods

Our study started in 2015 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). The site has alkaline soils with silty clay texture and low (1%) organic matter. It receives about 12 inches of precipitation per year. Four rates of compost (0, 7, 14, and 20 ton/ac) supplying 0, 125, 250, and 366 lb/ac nitrogen (N), respectively, and an inorganic fertilizer treatment—79 lb/ac $(NH_4)_3PO_4$ and 107 lb/ac $NH_4(SO_4)_2$ suppling 44 lb/ac N—were applied to wheat–fallow rotations in a randomized complete block design in September 2015. Winter wheat variety (Goodstreak JD 9300) was seeded at 70 lb/ac. Plant height and biomass data were collected weekly from May 13 to June 3, 2016. Yield data were collected at harvest.

Results and Discussion

Our early results suggest that adding composted manure has a positive effect on wheat growth and yield during the first growing season. All amendments, including inorganic fertilizer (IF), resulted in significantly greater plant height compared with the control starting on May 21 (Figure 1). Wheat biomass was comparable amongst all treatments except for June 3 at the 14 ton/ac compost application (Figure 2). The compost rate of 20 ton/ac resulted in the highest wheat yield (Figure 3), which could assist farmers having access to large amounts of composted manure with decision-making. The study will continue in 2017 and 2018.

Acknowledgments

We thank Erin Rooney, Ada Harris, Brandon Fulcher, and the entire SAREC crew for assistance. This project was funded through grants from the U.S. Department of Agriculture's Organic Transitions Program, Wyoming Department of Agriculture, and USDA Hatch program.

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Keywords: plant height, wheat biomass, compost

PARP: I:1,5, II:8

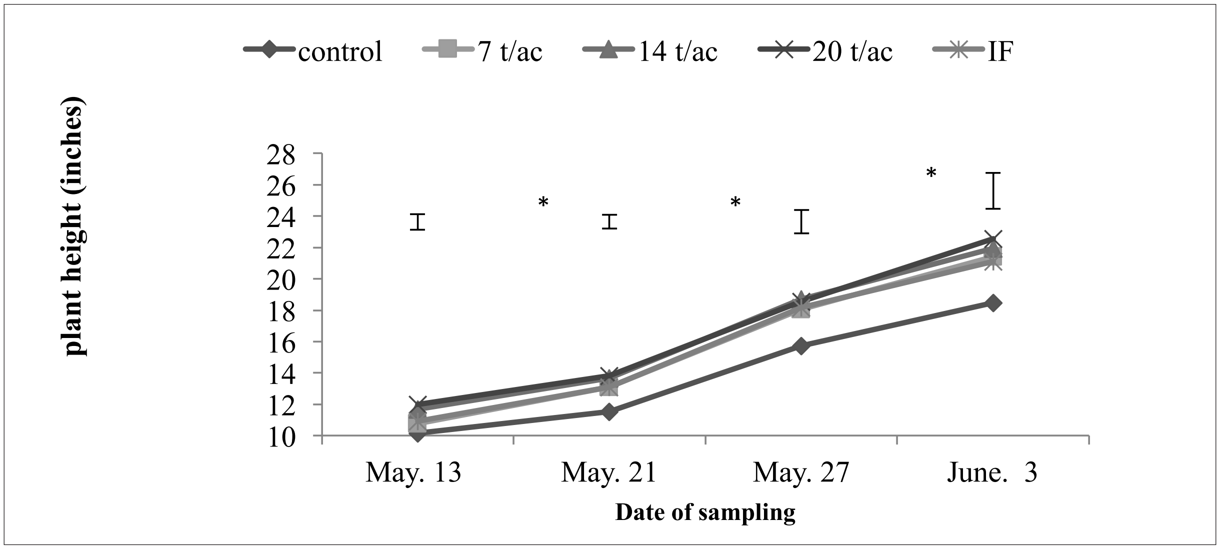

Figure 1. Plant height response to amendment. "*" next to LSD error bars indicates statistical difference between the control and the other amendments at $p \leq 0.05$. IF=inorganic fertilizer.

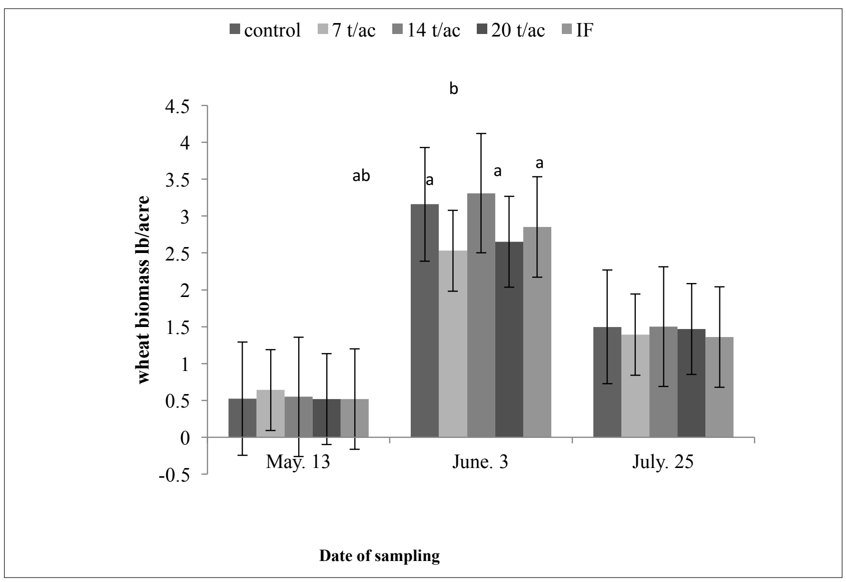

Figure 2. Plant biomass response to amendment.

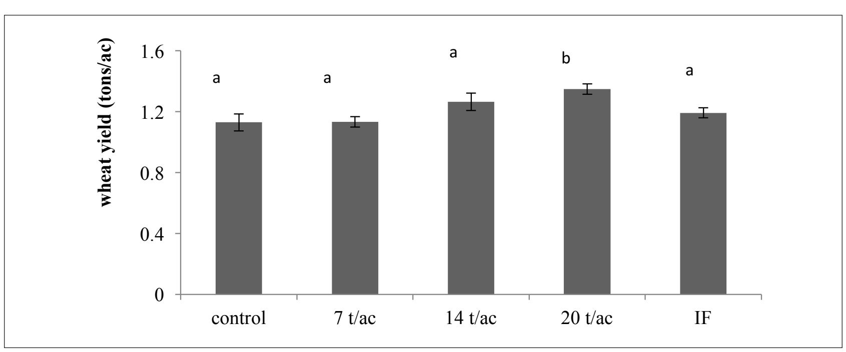

Figure 3. Wheat yield response to amendment.

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

Management of Soil-Borne Diseases of Potato with Seed Piece and In-Furrow Fungicide Treatments

William Stump[1] and Matthew Wallhead[2]

Introduction

Soil-borne diseases like those caused by *Rhizoctonia solani* are common limiting factors in potato production areas. Seed treatments and in-furrow fungicides are some management options for Rhizoctonia stem canker.

Objectives

The objectives of this study are to determine the effects of seed piece treatment alone and seed piece treatment combined with in-furrow fungicide application on management of soil-borne diseases of potato.

Materials and Methods

The research plot was established in 2016 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Four seed piece treatments combined with an additional in-furrow fungicide treatment were compared to a seed piece treatment only and a non-treated control for the management of stem infections caused by Rhizoctonia. A randomized complete block design with four replicates was established. Each treatment plot was 20-ft long and four rows wide with a 5-ft non-treated, in-row buffer between plots. Whole seed potatoes, cultivar 'Atlantic', were cut, treated, and stored at 45°F until planting. On May 26, potato seed pieces were planted at 12-inch spacing with 36-in row centers in an open furrow. After seed placement, fungicides were applied in-furrow in a 5- to 7-in band over the seed. At this time, *Rhizoctonia solani*-infested barley grain was applied in-furrow at a rate of 50 lb/ac. In-furrow rates listed in Table 1 were concentrated in the furrows. After application, the furrows were closed with the planter closing discs. The plot received fertility, weed control, and irrigation appropriate for potato production. Parameters measured were final stand counts, crop vigor, stem infection incidence, and final yield.

Results and Discussion

Treatments had no observable effects on final stands or on plant vigor. Rhizoctonia stem canker development was light, and there were no significant treatment effects on disease development. Treatments also had no significant effect on overall tuber yields. However, there was a trend in the data showing that treatments receiving in-furrow fungicide applications had reduced yields compared to the non-treated check and seed piece treatment only. Overall, yields were low by a factor of three to four because the experiment was completely defoliated by hail on July 27.

Acknowledgments

We thank SAREC field crews for assistance in plot establishment, maintenance, and harvesting and Western Potatoes Inc., Alliance, Neb., for the seed. The study was supported by Bayer Crop Science and the Colorado Potato Administrative Committee, Area 3.

Contact

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Keywords: potato, Rhizoctonia stem canker management, in-furrow fungicide application

PARP: I:11

Table 1. Management of soil-borne diseases of potato with seed piece and in-furrow fungicide treatments.

Treatment, rate, and timing[1]	**Crop stand (40 row ft)**	**Vigor (1–10)**[2]	**Disease incidence (%)**[3]	**Tuber yield (cwt[4]/ac)**
	June 17	June 23	Sept. 1	Sept. 29
Non-treated check	25.8 a[5]	8.5 a	15.0 a	67.9 a
Standard seed piece treatment A	24.0 a	9.3 a	10.0 a	74.0 a
Standard seed piece treatment A Serenade® ASO (2 qt/ac) B	28.3 a	9.5 a	5.0 a	53.8 a
Standard seed piece treatment A Serenade ASO (2 qt/ac) + Velum® Prime (6.7 fl oz/ac) B	25.0 a	8.5 a	5.0 a	58.3 a
Standard seed piece treatment A Quadris® (8.7 fl oz/ac) + Velum Prime (6.7 fl oz/ac) B	32.0 a	8.5 a	5.0 a	51.4 a
Standard seed piece treatment A Quadris (8.7 fl oz/ac) + Serenade ASO (2 qt/ac) + Velum Prime (6.7 fl oz/ac) B	28.3 a	8.8 a	15.0 a	55.7 a

[1]Standard seed piece treatment=Emesto Silver (0.31 fl oz/cwt) + NuBark Mancozeb (1 lb/cwt). A=seed piece treatment; B=in-furrow application.
[2]Vigor takes into consideration size and color of plants where 1=no stand, 10=best looking plants in replicate block.
[3]The % of plant stems (five total) that had Rhizoctonia infection.
[4]cwt=hundredweight.
[5]Treatment means followed by different letters differ significantly (Fisher's protected least significant difference, $p \leq 0.05$).

[1]*Department of Plant Sciences;* [2]*U.S. Department of Agriculture, Agricultural Research Service.*

Management of Soil-Borne Diseases of Potato with Seed Piece and In-Furrow Biological Fungicide Treatments

William Stump[1] and Matthew Wallhead[2]

Introduction

Soil-borne disease like those caused by *Rhizoctonia solani* and *Fusarium* spp. are common limiting factors in potato production areas. Serenade® ASO is a biofungicide used to manage certain soil-borne fungal pathogens. A specific strain of the bacteria *Bacillus subtilis* forms an exclusion zone around the developing root systems of potatoes, thereby protecting against fungal invasion. The numbered compound QRD001.109 is a more concentrated bacterial formulation.

Objectives

The objectives were to determine the effects of seed treatment and seed treatment combined with in-furrow biofungicide application on soil-borne disease of potato.

Materials and Methods

The research plot was established in 2016 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Four seed piece treatments with an additional in-furrow biofungicide treatment were compared to a seed piece treatment plus a conventional in-furrow fungicide and a non-treated control for the management of Rhizoctonia and Fusarium stem infections. A randomized complete block design with four replicates was established. Each treatment plot was 20-ft long and four rows wide with a 5-ft non-treated, in-row buffer between plots. Whole seed potatoes (cultivar 'Atlantic') were cut, treated, and stored at 45°F until planting. On May 26, potato seed pieces were planted in a 12-inch spacing with 36-in row centers in an open furrow. After seed placement, fungicides were applied in-furrow in a 5- to 7-in band over the seed. At this time, barley grain infested with *Rhizoctonia solani* and *Fusarium* spp. was applied in-furrow at a rate of 100 lb/ac. In-furrow rates listed in Table 1 were concentrated in the furrows. After application, the furrows were closed with the planter closing discs. The plot received fertility, weed control, and irrigation appropriate for potato production. Parameters measured were final stand counts, crop vigor, stem infection incidence, and final yield.

Results and Discussion

Treatments had no significant effects on final stands or on plant vigor; however, there were data trends of increased stands and vigor with fungicide treatment. Although there was a fair amount of disease incidence, it was variable. Additionally, the severity of Rhizoctonia stem canker and Fusarium wilt disease was light, resulting in no significant treatment effects on disease development. Treatments also had no significant effect on overall tuber yields. Overall yields were low because the experiment was completely defoliated by hail on July 27.

Acknowledgments

We thank the SAREC field crews for assistance in plot establishment, maintenance, and harvesting and Western Potatoes Inc., Alliance, Neb., for the seed. The study was supported by Bayer Crop Science and the Colorado Potato Administrative Committee, Area 3.

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Keywords: potato, Rhizoctonia stem canker management, Fusarium wilt

PARP: I:11

Table 1. Management of soil-borne diseases of potato with seed piece and in-furrow biofungicide treatments.

Treatment, rate, and timing[1]	Crop stand (40 row ft)	Vigor (1–10)[2]	Disease incidence (%)[3]	Tuber yield (cwt[4]/ac)
	June 17	June 23	Sept. 1	Sept. 29
Non-treated check	22.8 a[5]	7.3 a	45.0 a	74.5 a
Standard seed piece treatment A Quadris® (8.7 fl oz/ac) B	29.3 a	7.5 a	15.0 a	72.2 a
Standard seed piece treatment A QRD001.109 (12.8 fl oz/ac) B	24.5 a	8.5 a	30.0 a	88.8 a
Standard seed piece treatment A QRD001.109 (25.6 fl oz/ac) B	26.3 a	6.3 a	45.0 a	45.3 a
Standard seed piece treatment A Serenade® ASO (1 qt/ac) B	26.5 a	8.0 a	35.0 a	53.8 a
Standard seed piece treatment A Serenade ASO (2 qt/ac) B	29.5 a	8.5 a	20.0 a	65.1 a

[1]Standard seed piece treatment =Emesto Silver (0.31 fl oz./cwt) + NuBark Mancozeb (1 lb/cwt). A=seed piece treatment; B=in-furrow application.
[2]Vigor takes into consideration size and color of plants where 1=no stand, 10=best looking plants in replicate block.
[3]The % of plant stems (five total) that had Rhizoctonia and/or Fusarium infection.
[4]cwt=hundredweight.
[5]Treatment means followed by different letters differ significantly (Fisher's protected least significant difference, $p \leq 0.05$).

[1]*Department of Plant Sciences;* [2]*U.S. Department of Agriculture, Agricultural Research Service.*

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

William Stump[1] and Matthew Wallhead[2]

Introduction

Biofungicides (biologically derived fungicides) are becoming a disease management option for sugarbeet growers. Serenade® SOIL is a new liquid product of beneficial bacteria used to protect sugarbeet roots from soil-borne diseases like those caused by Rhizoctonia. This product was tested as an in-furrow treatment in various combinations with traditional fungicides and with all treatments followed by a foliar-banded conventional fungicide (Proline®) application.

Objectives

The objectives are to determine if a biofungicide applied in-furrow, in combination with conventional fungicides can provide season-long Rhizoctonia root and crown rot (RRCR) management.

Materials and Methods

The study was established in 2016 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Five in-furrow fungicide treatments followed by foliar-band fungicide treatments were compared to a non-treated inoculated check. A randomized complete block design with four replicates was established. Each plot was 20-ft long and four rows wide with a 5-ft, non-treated, in-row buffer between plots. Prior to planting, the plot area was inoculated with *Rhizoctonia solani* grown on barley. Sugarbeet was planted on May 19 and the in-furrow treatments made at this time. Foliar-banded Proline was applied at the eight-leaf stage. The field plot area received fertility, weed control, and irrigation appropriate for sugarbeet production. Parameters measured included final crop stand, Rhizoctonia disease incidence, and sugar yield.

Results and Discussion

RRCR development was light and variable in the plot area, and treatments had no significant effect on final crop stands or RRCR incidence. Treatments had no effects on sugar yields, presumably due to the low disease pressure. Overall, results were disappointing due to low disease pressure and potentially data-confounding hail injury from the late July storm that hit SAREC. We have plans to do a similar study in 2017.

Acknowledgments

We thank PREC and SAREC field crews for assistance in plot establishment, maintenance, and harvesting, and Western Sugar Cooperative for quality analysis. The study was supported by Bayer Crop Science.

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Keywords: sugarbeet, Rhizoctonia management, biofungicide

PARP: I:11

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

Treatment, rate, and timing[1]	**Beet stand (40 row ft)**	**RRCR incidence (40 row ft)**	**lb sugar/ac**
	June 17	July 11	Sept. 22
Non-treated inoculated check	87.3 a[2]	2.8 a	2,952 a
Serenade® SOIL (1qt/ac) A Proline® 480 SC (0.33 fl oz/1,000 row ft) B	90.5 a	1.5 a	3,042 a
Serenade SOIL (2qt/ac) A Proline 480 SC (0.24 fl oz/1,000 row ft) B	101.5 a	3.0 a	3,116 a
Quadris® (0.6 fl oz/1,000 row ft) A Proline 480 SC (0.33 fl oz/1,000 row ft) B	91.8 a	1.3 a	3,201 a
Serenade SOIL (1qt/ac) A Quadris (0.6 fl oz/1,000 row ft) A Proline 480 SC (0.33 fl oz/1,000 row ft) B	92.8 a	1.3 a	3,183 a
Serenade SOIL (1qt/ac) A Quadris (0.6 fl oz/1,000 row ft) A Velum® Prime (6.5 fl oz/ac) A Proline 480 SC (0.33 fl oz/1,000 row ft) B	93.0 a	0.3 a	3,215 a

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

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Response to Late-Season Hail Damage in Irrigated Corn

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

Introduction

After a hail event, determining how to manage a field to mitigate crop loss, reduce economic loss, and prepare for the next year's crop can be difficult for producers. Unfortunately, hail damage in crop fields is not a novel occurrence for growers in Wyoming. Following a late July 2016 hail storm at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC), we designed a study using hail-damaged corn to help provide answers for growers on how they could better respond to such weather events in the future.

Objectives

Objectives are to (1) determine the best management to remove late-season, hail-damaged corn from the field; (2) evaluate forage cover crops following late-season, hail-damaged corn; (3) measure the impact that management (a) and cover crops (b) have on the next year's corn crop; and (4) calculate the economic costs and gains for each treatment.

Materials and Methods

On July 27, 2016, SAREC was hit with a hail storm that resulted in a complete loss of the corn crop. On August 12 and 17, corn management of stalk shredding, discing, and a combination of stalk shredding, discing, and Landstar tillage were applied to the plots. Three winter-hardy grass cover crops (winter wheat, rye, and triticale) and one warm-season grass cover crop (sorghum) were seeded on August 18 and 20 (Table 1). Aboveground biomass was sampled on October 10 and 29. Costs associated with all crops and operations are operational costs and do not include any cost of ownership or leasing (real estate taxes, leasing costs, etc.). Biomass cost is calculated in dollars per pound ($/lb), which can be described as what it costs to produce one pound of dried biomass. Animal unit days (AUD) per acre were calculated with AUD defined as 26 lb of forage to feed one animal for one day.

Results and Discussion

Table 2 outlines observed biomass yields (measured on October 10) and associated costs per acre for the crops and operations. Triticale, winter wheat, and rye all yielded very well, averaging more than 1,800 dry pounds of forage/ac. Sorghum had the lowest biomass, as the late planting and early frost affected growth of this non-winter-hardy crop. Forage production cost was the lowest for winter wheat at an average of $0.83/AUD (Table 2). While triticale forage was produced on average at $1.38/AUD, it yielded the highest AUDs per acre (83). Depending on a producer's situation, he or she may value higher biomass production over lower costs. Comparatively, alfalfa hay priced from $90 to $145 per ton would cost $1.17 to $1.89 per AUD, respectively. The warm fall in 2016 resulted in an additional 313 growing degree days (base 40°F) from October 10 to October 29, producing a 70% increase in wheat biomass and 60% increase in rye and triticale biomass. (The weather data is from the weather report generated from our awdn.unl.edu linked weather station at SAREC.) This increased biomass production also increased the number of AUDs per acre of each crop and decreased the cost per AUD to between $0.47 and 0.85 for the different crops (excluding sorghum).

Our early analysis indicates that winter-hardy forage grasses offer low cost/high yield options for producers if they find themselves in this unfortunate position. This project will continue through fall 2017. We plan to measure the nutritional value of the different crops as well as the impact of management/cover crop combinations on the subsequent corn crop. These data are preliminary, and a complete assessment of the cropping system will take place at the conclusion of the growing season.

Acknowledgments

We thank the SAREC crew for their support in this study. The project was supported by the Wyoming Agricultural

Experiment Station's Rapid Response Agricultural Research Fund and through funds received from the U.S. Department of Agriculture's National Institute of Food and Agriculture, Hatch project 1009586.

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Keywords: hail damage, forage, grazing

PARP: I:3,6,15

Table 1. Cover crops and seeding rates.

	Winter Wheat	Rye	Triticale	Triticale (1/2)	Sorghum
Cultivar	SY Wolf	Guardian Fall	Fridge Beardless	Fridge Beardless	Grazex III
Seeding Rate	120 lb/ac	120 lb/ac	120 lb/ac	60 lb/ac	30 lb/ac
Planting Date	8/18/2016	8/20/2016	8/20/2016	8/20/2016	8/18/2016

Table 2. Summary of fall production cost and value through October 10, 2016. Average values are given for each cover crop by management treatment.

Cover Crop	Corn Management	Biomass Yield[1] (lb/ac)	Fall Cost[2] ($/ac)	Biomass Cost ($/lb)	AUD[3]/ac	$/AUD[4]
Wheat	Drill	1,727	$51.91	$0.03	66	$0.79
	Shred	1,770	$62.71	$0.04	68	$0.96
	Disc	1,711	$46.90	$0.03	66	$0.75
	S/D/LS4	2,087	$62.57	$0.03	80	$0.80
Rye	Drill	1,389	$68.71	$0.05	53	$1.29
	Shred	2,034	$79.51	$0.04	78	$1.03
	Disc	1,781	$63.70	$0.04	68	$0.94
	S/D/LS	2,080	$79.37	$0.04	80	$1.00
Triticale (1/2)	Shred	1,816	$73.51	$0.04	70	$1.08
	Disc	1,216	$57.70	$0.05	47	$1.36
	S/D/LS	1,443	$73.37	$0.06	55	$1.46
Triticale	Drill	1,753	$92.71	$0.06	67	$1.50
	Shred	2,150	$103.51	$0.05	83	$1.30
	Disc	1,753	$87.70	$0.05	67	$1.34
	S/D/LS	1,942	$103.37	$0.05	75	$1.39
Sorghum	Drill	154	$54.31	$0.35	6	$9.10
	Shred	218	$65.11	$0.30	8	$7.80
	Disc	87	$49.30	$0.56	3	$14.56
	S/D/LS	138	$64.97	$0.47	5	$12.22

[1]Biomass is given for dry weight

[2]Fall cost includes seed cost and cost of farm operations (fuel, equipment, herbicide, labor)

[3]Animal unit day (food required to feed one animal unit for one day=26 lb of biomass

[4]S/D/LS=stalk shredding/discing/Landstar tillage

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

Makenzie Pellissier[1] and Randa Jabbour[1]

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 that kill pests. We are 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). Twenty-five-foot × 25-ft plots of alfalfa were adjacent to either a perennial flower strip, an annual flower strip, or a control strip of fescue grass. 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 (Figure 1) seven times throughout the 2015 growing season, 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 in the early season, herbivores showed no preference between annual flowers, perennial flowers, or control-fescue habitats (Figure 2A), and predators were more abundant in the control-fescue habitats (Figure 2B). In the late season, both herbivores and predators responded to the annual habitats. An important distinction between herbivores and predator densities in the late season is that while predators responded positively to both annual and perennials (although increases in perennials were not significantly greater than in the fescue habitats), herbivores responded only to the annual habitats. This may be important because it is possible that herbivores can spill over into nearby crop fields, an undesirable outcome of habitat management. More research is needed to determine if herbivores are spilling over into adjacent alfalfa crops and to determine the level of pest control provided by predators. Therefore, we cannot make any recommendations for planting these flower strips for control of pests such as alfalfa weevil. Flower strips may be beneficial for producers for other reasons such as providing pollinator habitat or food resources for honeybees.

Acknowledgments

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

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Keywords: alfalfa, biological pest control, flowering strips

PARP: I:1,2, X:2

Figure 1. Makenzie Pellissier collects insect samples in alfalfa plots. A mesh bag is secured to the end of a reversed leaf blower to capture insects.

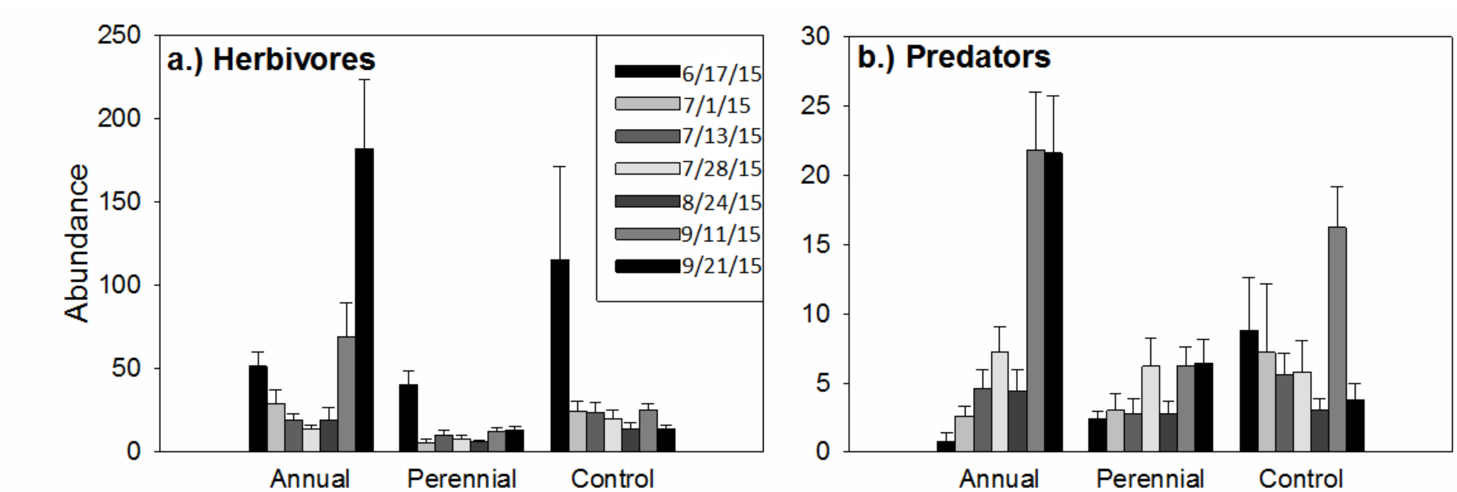

Figure 2. Abundances of A, herbivores, and B, predators in annual, perennial, and control-fescue habitats for seven sampling dates in 2015. Error bars indicate standard error of the mean.

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Evaluation of Forage Nutritive Value of Different Fenugreek Entries in Wyoming

Saugat Baskota[1] and Anowar Islam[1]

Introduction

Quality forage crops have high palatability, digestibility, and, of most importance, availability of essential nutrients. For successful livestock production, producers must have good knowledge of animal nutritional needs and characteristics of the forage crop they grow.

Fenugreek, a leguminous crop, is rich in nutrients. A Kansas State University study (Obour et al., 2015) reported that the nutritive value of fenugreek is comparable or even greater than alfalfa. Research conducted in Canada also supported the results in Kansas (Acharya et al., 2008). Fenugreek also has similar dry matter intake as alfalfa.

The quality of a forage crop also depends on species or cultivars, maturity stage, storage methods, and management practices. Though there is potential to grow fenugreek as a forage crop in Wyoming, little information is available on its nutritive value under our state's growing conditions along with management practices.

Objectives

The objective of this study was to determine the nutritive value of different fenugreek entries.

Materials and Methods

The study was carried out at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) during the 2015 and 2016 growing seasons. The experiment was laid out in a strip-split randomized complete block design with three replicates. Four fenugreek entries that are still being studied for possible release (F96, LRC3708, LRC3375, and F75) as well as one previously released cultivar ('Tristar') were planted under irrigated conditions.

Fenugreek was planted in May and June both years. Harvesting took place on August 21, 2015, and August 31, 2016. Forage nutritive values (crude protein, CP; neutral detergent fiber, NDF; acid detergent fiber, ADP; in-vitro dry matter digestibility, IVDMD; total digestible nutrients, TDN; and relative feed value, RFV) were determined using near infrared reflectance spectroscopy (NIRS) after grinding the samples in a Thomas® Wiley Mill. Data were analyzed using SAS 9.4.

Results and Discussion

Taking all of the measured forage quality parameters into consideration, fenugreek entry "LRC3375" had the highest forage quality both years. Across two years for the five entries, average CP (22.5%), NDF (36%), ADF (24.5%), IVDMD (77.5%), TDN (75.5%), and RFV (181.5) are fairly consistent for both growing seasons. The normal ranges for nutrients in quality alfalfa are: 18–24% CP, 33–44% NDF, 26–34% ADF, 70–80% IVDMD, 57–63% TDN, and 120–190 RFV. Initial results from our study indicate that the forage quality of fenugreek under growing conditions similar to those at SAREC is comparable to the forage quality of alfalfa. This particular study is complete, but other research is focused on identifying best management practices to enhance the yield and quality of fenugreek.

Acknowledgments

We thank forage agronomy lab and SAREC staff members for assistance in experiment set-up and data collection. The experiment was funded by grant funds from the Wyoming Department of Agriculture's Agriculture Producer Research Grant Program and Specialty Crop Grant Program and Hatch funds from the U.S. Department of Agriculture.

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Keywords: fenugreek, forage quality, animal nutrition

PARP: I:1,2,12, II:2, VI:1

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Obour A. K., Obeng, E., and Holman, J., 2015, Influence of different seeding dates on fenugreek (*Trigonella foenum-graecum* L.) forage yield and nutritive value: Manhattan, Kansas, Kansas Agricultural Experiment Station Research Reports, v. 1, issue 2, article 12, 5 p.

Table 1. Forage nutritive values of different fenugreek entries at SAREC in 2015 and 2016.

Entries	CP (%)		NDF (%)		ADF (%)		IVDMD (%)		TDN (%)		RFV	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Tristar	21 b	22 a	36 a	37 ab	25 a	25 a	77 a	76 a	75 b	74 a	178 a	175 ab
F96	24 a	23 a	36 a	36 b	23 b	24 a	78 a	77 a	76 a	76 a	183 a	182 ab
LRC3375	23 a	23 a	35 a	35 b	24 b	24 a	78 a	78 a	76 a	76 a	187 a	186 a
LRC3708	24 a	22 a	36 a	36 ab	23 b	25 a	79 a	77 a	77 a	75 a	184 a	178 ab
F75	24 a	22 a	35 a	38 a	23 b	25 a	79 a	77 a	77 a	74 a	187 a	173 b
Average	23	22	36	36	24	25	78	77	76	75	184	179

CP=crude protein, NDF=neutral detergent fiber, ADF=acid detergent fiber, IVDMD=in-vitro dry matter digestibility, TDN=total digestible nutrients, RFV=relative feed value.
Values with same letters within a column do not differ at $p>0.05$.

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Effect of Planting Method, Harvesting Frequency, and Cultivars on Yield of Bird's-foot Trefoil

Sayantan Sarkar[1] and Anowar Islam[1]

Introduction

Bird's-foot trefoil (BFT) is a promising forage legume that has the potential to increase quality and production of livestock forage in the U.S., including Wyoming. It can be used as an alternative to alfalfa due to its non-bloating properties, high persistence, and improved forge quality. Literature suggests that it can be grown and grazed as a monocrop as well as in mixture with grasses, and it has shown to increase feed-use efficiency and both milk and meat quality of cattle. BFT planted with a companion crop, such as oats, has lesser weed competition compared to monocropping. BFT can also be seeded into stubble of a previous crop to help prevent weeds and save resources on farm activities like tillage for seed-bed preparation. Some studies suggest that fewer harvests can be economical for BFT as the total yield remains the same by the end of growing season. Being a slow establishing crop, BFT is less competitive against weeds; however, production information in Wyoming is limited due to lack of information on its agronomic- and weed-management practices.

Objectives

The objectives were to determine the effects of planting method, harvesting frequency, and cultivars on yield of bird's-foot trefoil.

Materials and Methods

The study was conducted at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Planting took place in June 2015; the 81 plots were arranged in a randomized complete block design. All the plots received uniform irrigation every two weeks. Each plot had a combination of three distinct treatments. The first treatment was three different BFT cultivars: 'Leo', 'Norcen', and 'Bruce'. The second treatment involved different planting methods: planting in actively growing winter wheat planted previous year, planting in wheat stubble, and clean-tilled planting. The third treatment was harvesting frequency, which included either harvesting once (H1), twice (H2), or three times (H3) during the growing season. Harvesting in 2016 included: August 23 (H1); August 23 and October 7 (H2); June 3, August 23, and October 7 (H3). Plant samples were clipped from each plot, and weeds were manually removed. The BFT remaining after weed removal were used to calculate dry matter (DM) yield by adding the yields from the whole season of each plot.

Results and Discussion

Variations in DM yield were observed among treatments (Figure 1). In general, total DM production increased as the number of harvests increased. Except planting with actively growing wheat, plots with three harvests had the greatest DM yield across the planting methods and cultivars (Figure 1). On average, however, the difference between two and three harvests was minimal, indicating that harvesting twice in a season might be an economically viable option. The planting with standing wheat had the lowest yield because the standing wheat out-competed BFT seedlings for sunlight and water, and most of the seedlings died during the establishment year. Planting trefoil into a clean-tilled field generally produced a higher yield than planting into stubble; however, planting into wheat stubble could be the preferred method as this will reduce field preparation costs. Among the cultivars, Bruce performed the best in the clean-tilled planting; whereas, in wheat stubble, Norcen performed similarly to or marginally better (e.g., in three harvests) than Bruce. This can be attributed to the fact that Bruce is of semi-erect nature and, therefore, had an advantage over weeds. Norcen, a native North American, high-yielding cultivar, consistently performed in all planting methods. Early results are promising in terms of planting method (clean tilled) and harvesting frequency (three harvests in a season). The study is ongoing, and data is being collected and analyzed.

Acknowledgments

We thank SAREC crew members and UW forage agronomy laboratory members for assistance. The study was supported by Wyoming Department of Agriculture's Agriculture Producer Research Grant Program and USDA Hatch funds administered through the Wyoming Agricultural Experiment Station.

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

PARP: I:2, II:9, IX:2

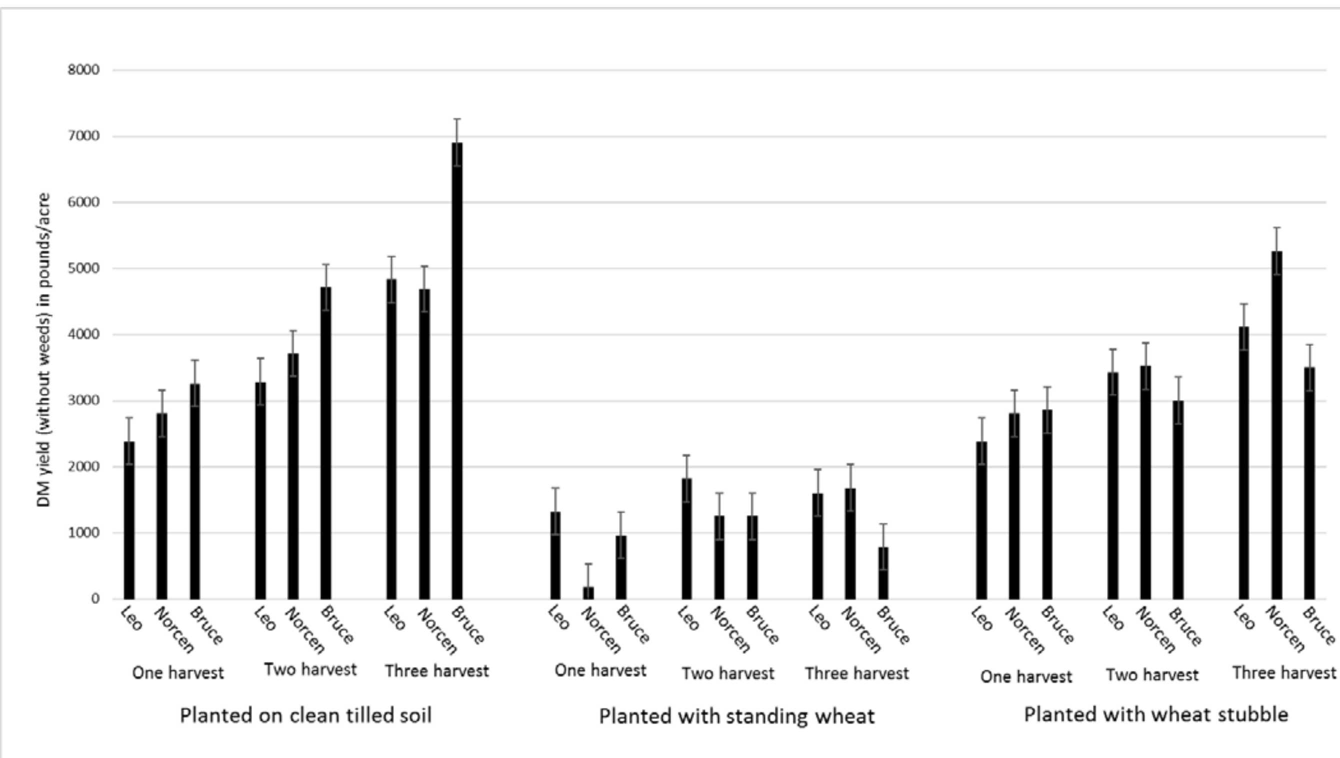

Figure 1. Dry matter (DM) yield of bird's-foot trefoil cultivars under different planting methods and harvests at SAREC in 2016.

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Wyoming Restoration Challenge: Cheatgrass, a Scientific and Social Demonstration Project

Beth Fowers[1,2], Brian Mealor[1,2], Clay Wood[1,2], and Rachel Mealor[3]

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 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 pastures infested with cheatgrass and other annual weeds; (4) share information with various audiences on those methods and their relative performance; and (5) encourage participatory learning and 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 1/4-acre plot by drawing plot numbers. 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 2017. Any legal methods for removing cheatgrass and reestablishing a diverse, desirable plant community are allowed. Teams are evaluated on multiple categories (Table 1). The most efficient way to follow the competition is at www.facebook.com/WYrestorationchallenge/.

Results and Discussion

Twelve Wyoming-based teams and one Nebraska team 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. During the first and second years of the competition, 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, weed-suppressive bacterial applications, and seedings of desirable species. Cheatgrass cover was reduced in all plots, with reductions ranging from 20% to 96% relative to pre-treatment measurements (Figure 1). Perennial grass (desirable) change varied from a slight loss to substantial gains (as much as 4,000% [Figure 1]). Bare ground greatly varied by plot as some teams reduced bare ground by 100% while others greatly increased bare ground compared to pre-treatment cover. A preliminary ranking was compiled based on 2016 vegetation data and educational activities for the top five teams (Table 1). Final evaluations will be performed summer of 2017 and a final ranking of teams will then occur. Our plan is to present awards at this year's SAREC Field Day, scheduled August 24. The challenge will remain as a demonstration project, illustrating various cheatgrass management methods. Communication and education between teams and to other individuals and groups continue to be a dynamic part of the project. We are developing a website based on current content that will also house videos. Our ultimate goal is to release a short educational video (~30 minutes) that mimics a reality TV format.

Acknowledgments

Many thanks go to the Wyoming Agricultural Experiment Station and SAREC crew for support of the challenge; our partners that 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.

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Keywords: cheatgrass (*Bromus tectorum*), rangeland restoration, participatory learning

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

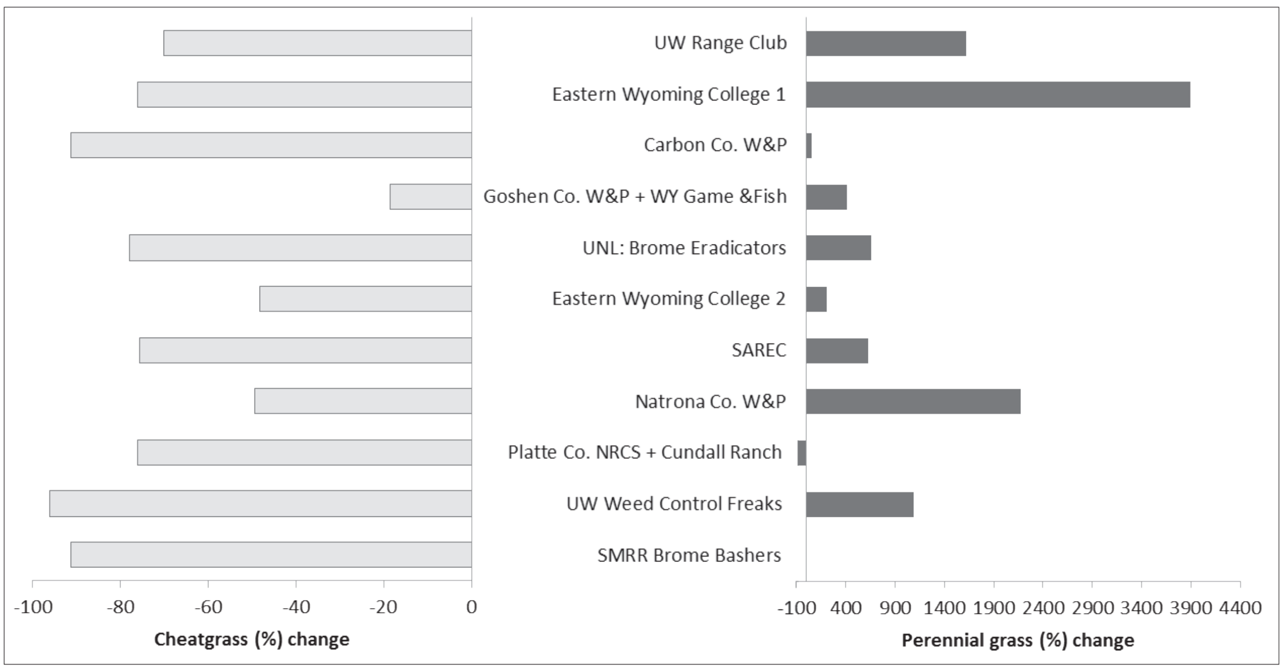

Figure 1. Change in cheatgrass (left) and perennial grass (right) canopy cover from pretreatment (April 6, 2015) to July 12, 2016 (note: UNL is short for University of Nebraska–Lincoln).

Table 1. Rankings following the 2016 growing season by judging criteria. Teams are only in order of plot number (not shown). The number within each category is the relative rank for that team.

	Education	Cheatgrass	Productivity	Diversity	Scalability
UW Range Club	3	8	2	5	3
UNL Brome Eradicators	7	4	2	5	5
Cundall Ranch/Platte County NRCS	4	6	10	1	4
UW Weed Control Freaks	2	1	9	2	10
SMRR Brome Bashers	1	2	11	8	10

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Willingness to Pay and Information Demand for Locally Produced Honey

Linda Thunström[1], Chian Jones Ritten[2], Mariah Ehmke[2], Jenny Beiermann[2], and Cole Ehmke[2]

Introduction

The market for honey is changing rapidly. One important factor affecting the market 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 (Ward and Boynton, 2010). Foreign honey, however, runs the risk of containing traces of pesticides and heavy metals; therefore, they may pose risks to consumer health (Ezenwa, 2009; Wei Guo-xue et al., 2012).

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. 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 food safety information about Wyoming honey?; (3) do consumers feel guilty about consuming non-local honey?; (4) will consumers avoid information about the origin of honey to avoid feelings of guilt?

Materials and Methods

The studies were 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 in Laramie during fall 2015 and spring 2016. The experiments were designed to extract consumers' true willingness-to-pay for Wyoming honey, versus honey of unknown origin, as well as determinants of honey demand. In the first round of experiments (in 2015), 449 people from the general public participated, while another 516 subjects participated in the second round of experiments (spring 2016). Subjects were divided into different treatment groups, which enabled measures of how consumer demand for local honey is affected by different types of information, as well as by their willingness to inform themselves about the food safety attributes of local honey. Further, different methods were used to extract the willingness-to-pay (or demand) for Wyoming honey, compared to honey of unknown origin. In the first round of experiments, participants were faced with a fixed-price premium for Wyoming honey (and stated if they wanted to buy Wyoming honey at that premium, under different information regimes), while in the second round of experiments, participants got to state their own individual, willingness-to-pay for Wyoming honey. The latter enabled us to examine the variation in willingness-to-pay for Wyoming honey over different consumer types.

Results and Discussion

In general, we found that consumers are highly concerned about their honey being locally produced. In one study, we found that the average premium Wyoming consumers are willing to pay for Wyoming honey—over honey of unknown origin—is $2.08 per eight ounces of honey. In another study, we presented participants with a fixed premium of $2.48 for an eight-ounce jar of honey produced in Wyoming, compared to honey of unknown origin. We found that a majority of consumers (53%) were willing to pay the premium. In a third study, we found that providing consumers with information on the food safety benefits of locally produced honey significantly increased the percentage of consumers willing to pay the $2.48 premium for Wyoming honey.

Further, we found that consumers generally assign a positive value to information on the origin of the honey they are offered to buy. More specifically, around 80% of experiment participants preferred (costless) information about the origin of the honey (over ignorance of the origin), and they used that knowledge to ensure that they bought locally produced honey, even if the local product came at an additional cost of $2.48.

Finally, we found that the willingness to pay for Wyoming-produced honey is higher for consumers who assign a higher value to local production in general, and who are less concerned about price.

Our results suggest that a successful strategy to expand the market share of Wyoming honey may entail communication of food safety benefits to locally produced honey. It may also entail information that strengthens consumer preferences for local production in general.

Acknowledgments
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Keywords: honey, demand, locally produced

PARP: VII:5 (although the project concerns honey, not meat)

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Wei Guo-xue, Huang Ji-kun, and Yang Jun, 2012, Honey safety standards and its impacts on China's honey export: Journal of Integrative Agriculture, v. 11, p. 684–693.

Figure 1. Locally produced honey and honey of unknown origin were put in identical looking bottles that were given randomly to subjects.

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Introduction to the University of Wyoming's Rogers Research Site, North Laramie Mountains, Wyoming, and its Potential for Research, Teaching, and Extension

Stephen Williams[1,2] and Robert Waggener[3]

Introduction

Colonel William Catesby Rogers (Figure 1) bequeathed his Triple R Ranch in the north Laramie Mountains, southeast Wyoming, to the University of Wyoming in 2002. The approximately 320-acre property passed to the UW College of Agriculture and Natural Resources by 2005, and it has since been under management of the Wyoming Agricultural Experiment Station (WAES).

The property officially became known as the Rogers Research Site (RRS).

In his will, Colonel Rogers stated that the land should be used by UW and others, in part, to conduct research relating to the improvement of forestry and wildlife resources. RRS is near the prominent Laramie Peak, and at the time UW received the gift the site was predominately covered by ponderosa pine. The area is home to a rich array of resident and migratory wildlife species.

In summer 2012, during a significant drought, the lightning-caused Arapaho Fire burned nearly 100,000 acres in the Laramie Mountains, including RRS lands. The blaze killed nearly 95% of the ponderosa pine on the site.

Objectives

The overall objective is to conduct research at RRS that honors the wishes of Colonel Rogers. Among the specific objectives are to conduct research relating to the improvement of forestry and wildlife resources at the site and on surrounding lands in the Laramie Mountains, which are predominately composed of U.S. Forest Service, private, and State of Wyoming lands.

Materials and Methods

A variety of materials and methods have been used to conduct several completed and ongoing projects at the site, including vegetation mapping, ponderosa pine restoration and erosion control following a high-severity fire, and pre- and post-fire soils research. A summary of some of that research is contained in the three papers that follow this Introduction, and details will be presented in several RRS bulletins that are on-track to be completed this year.

Bulletin 1, which was nearing completion by July 1, gives an overview of RRS. It will include a chapter about the most interesting Colonel Rogers and his life. The bulletin will also cover early planning and the potential for research, teaching, and extension, including collaboration between UW students, faculty, staff, and others.

Results and Discussion

Fortunately for current and future researchers, much baseline data were compiled prior to the 2012 Arapaho Fire, including vegetation and soils mapping.

A great deal of planning has also taken place both before and after the fire. This has included a formal survey of 50 people who attended a field day at RRS in 2005, informal comments submitted by participants of another field day in 2009, work of the RRS Management Committee in 2010 and 2011, a forest audit conducted at RRS in 2011, and work of an ad hoc committee that formed in 2012 following the wildfire.

Starting in 2016, WAES devoted funding to publish bulletins relating to planning, research, extension, and teaching at RRS. Once complete, bulletins in the series will be posted at www.uwyo.edu/uwexpstn/centers/sarec/ (click on the “Rogers Research Site” link).

Acknowledgments

Funding and support for these projects were provided by WAES and the U.S. Department of Agriculture McIntire-Stennis program. Numerous other acknowledgments will be listed in the RRS bulletins.

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Keywords: Colonel William C. Rogers, Rogers Research Site, forestry research

PARP: not applicable

Figure 1. This is an official U.S. Army photo (circa 1951) of William Catesby Rogers when he was a lieutenant colonel in the Army. By 1955 he had been promoted to colonel. After retiring, he spent much time on his beloved property in Wyoming’s Laramie Mountains as well as in Mexico and on a farm in Nebraska. (U.S. Army photo courtesy Mary Laura Kludy, Preston Library, Virginia Military Institute)

Figure 2. A variety of research has and is taking place at RRS, including a post-fire ponderosa pine restoration study. Here, summer intern James Harkin prepares to plant a seedling in July 2015. (Photo by Mollie Herget)

[1]*Department of Ecosystem Science and Management;* [2]*now retired;* [3]*Wyoming Agricultural Experiment Station.*

Vegetation Mapping of Rogers Research Site, North Laramie Mountains, Using High Spatial Resolution Photography and Heads-Up Digitizing

Mathew Seymour[1,2], Kenneth Driese[3], and Robert Waggener[4]

Introduction

The Rogers Research Site (RRS) is an approximately 320-acre area in the Laramie Mountains of southeast Wyoming that was bequeathed to the University of Wyoming in 2002 by Colonel William C. Rogers. The site was donated to UW, in part, for forestry- and wildlife-related research.

Objectives

Our main objective was to create a vegetation map using high spatial resolution AEROCam photography and heads-up digitizing. The goal was to provide an accurate inventory of existing vegetation within RRS and lands immediately surrounding the site.

Materials and Methods

In 2006, a project was launched to produce an accurate land-cover map of RRS using high spatial resolution (3.3–6.6 ft) multispectral (blue, green, red, and near-infrared bands) AEROCam photography and a procedure called "heads-up digitizing." The latter involves manually interpreting the photography to infer vegetation classes. The mapping effort was led by the lead author of this paper, Mathew Seymour, a UW undergraduate student during the project.

Results and Discussion

In 2006, RRS and surrounding lands in the Laramie Mountains were covered predominately by sparse and thick stands of ponderosa pine (*Pinus ponderosa*) forest in various age classifications. Specifically, our vegetation map (Figure 1) showed that 80% of RRS lands were covered by ponderosa pine, with mixed grass and shrublands occupying about 10% of the site and quaking aspen (*Populus tremuloides*) 4%.

In 2012, during a severe drought, a significant natural event occurred, the lightning-caused Arapaho Fire, which burned approximately 98,000 acres in the Laramie Mountains, including RRS. Our vegetation map is, therefore, of great importance for future work associated with RRS and nearby lands. Specifically, for researchers and land managers planning to assess temporal changes in habitat structure and land cover, the map will be invaluable.

Starting in 2016, the Wyoming Agricultural Experiment Station (WAES) devoted funding to publish results from this and other completed and ongoing research projects at RRS. Once complete, the bulletins will be available at www.uwyo.edu/uwexpstn/centers/sarec/ (click on the "Rogers Research Site" link).

Acknowledgments

Funding and support for the vegetation mapping project was provided by WAES through the U.S. Department of Agriculture McIntire-Stennis program. Additional funding came from WyomingView, AmericaView, and the U.S. Geological Survey. Numerous other acknowledgments are listed in the RRS bulletins.

Contact Information

Mathew Seymour at m.seymour@bangor.ac.uk, or Ken Driese at kdriese@uwyo.edu or 307-766-3975.

Keywords: Rogers Research Site, vegetation mapping, high spatial resolution photography

PARP: not applicable

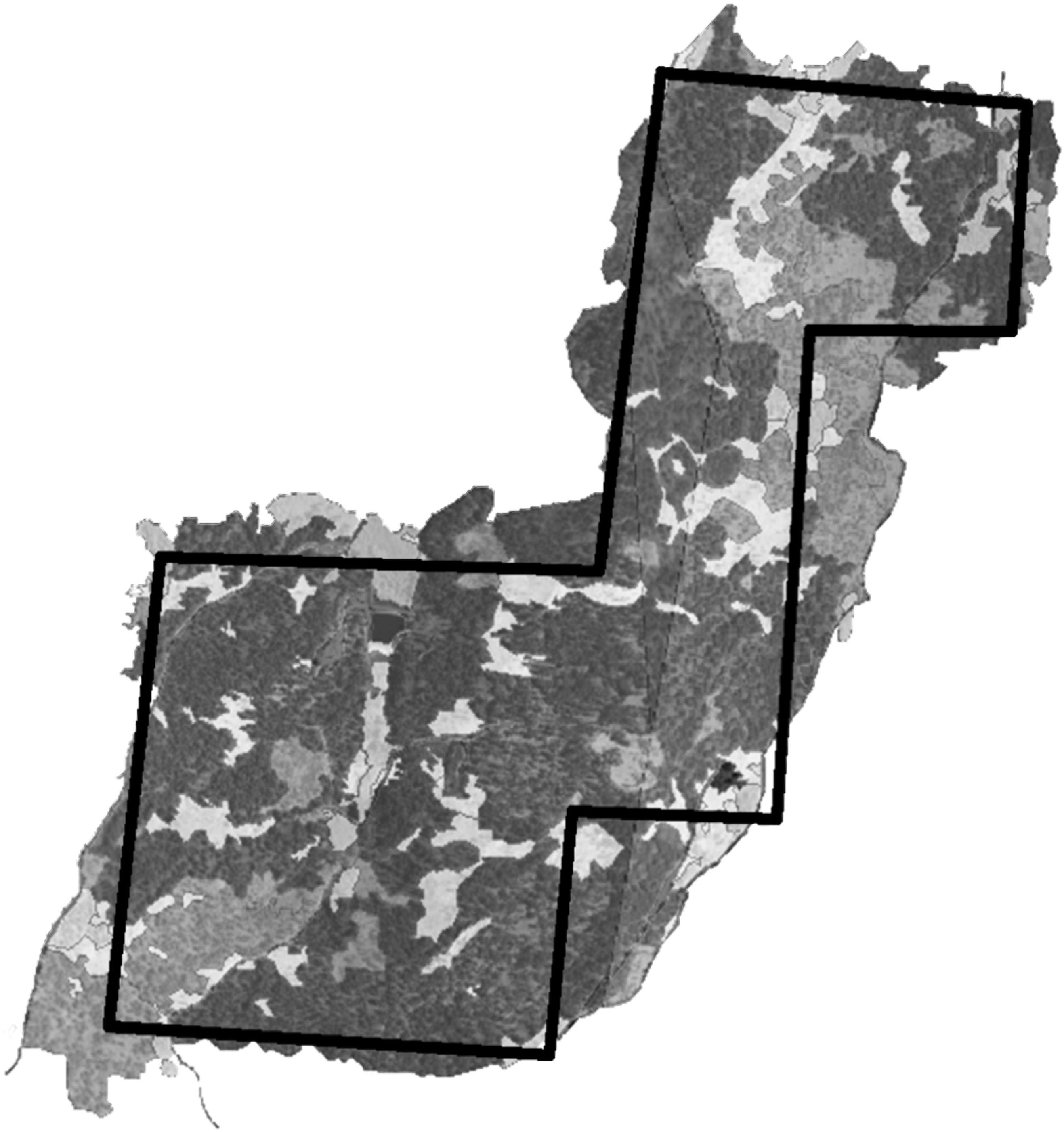

Figure 1. Land-cover map of the Rogers Research Site in 2006. It shows that 80% of RRS lands were covered by ponderosa pine. A more detailed map, many other figures, and much more information is presented in an upcoming RRS bulletin. The map in the bulletin is in color, which allows readers and future researchers to easily distinguish between vegetation types and other features on the property. (Map by Mathew Seymour)

[1]*University of Wyoming student;* [2]*now with Bangor University, Bangor, Gwynedd, United Kingdom;* [3]*Department of Botany;* [4]*Wyoming Agricultural Experiment Station.*

Restoration of Ponderosa Pine and Erosion-Control Treatment at the Rogers Research Site Following High-Intensity Wildfire

Mollie Herget[1,2], Stephen Williams[1,3], and Robert Waggener[4]

Introduction

Wildfires have been an important part of the evolutionary history of most forest ecosystems in the West. Within this region, ponderosa pine (*Pinus ponderosa*) dominates many forests of the semiarid areas. The post-fire restoration of these forests pose a major task for national, regional, and local governing agencies, land managers, and landowners, but there is still a significant lack of knowledge on the best management practices. In 2012, the lightning-caused Arapaho Fire burned nearly 100,000 acres in the Laramie Mountains of southeast Wyoming, including the University of Wyoming-owned Rogers Research Site (RRS), which was heavily forested by *P. ponderosa* at the time.

Objectives

To test the best management practices for a post-fire ponderosa pine restoration site, this study set out to determine: (1) if seeding a native grass mixture on the burned site will aid in controlling soil erosion; (2) which method of introducing *P. ponderosa* to the burned site is most effective for forest regeneration; and (3) which cutting treatment of standing dead *P. ponderosa* is most effective for forest regeneration.

Materials and Methods

To test the experimental objectives, Mollie Herget, a UW master's student and lead field researcher at the time, directed other employees during this project in establishing four blocks of treatments within the ~320-acre RRS (Figure 1). Each experimental block replicated 18 plots, each measuring 50 meters × 50 meters (164 feet × 164 feet). Every plot received a combination of three treatments to test the three study questions. The treatments included (1) seeding a native grass mixture on the burned site as compared to not seeding; (2) planting ponderosa pine seedlings, planting ponderosa pine seed, and no planting (natural regeneration); and (3) cutting all standing dead trees and removing timber from the plot, cutting all standing dead trees and leaving slash behind, and no cutting. All treatments were completed during the 2015 growing season (May into August).

Results and Discussion

A preliminary survey of survival was performed on the planted tree seedlings from August 18 through August 26, 2015. Results indicated that 83% of the seedlings were still alive at the end of the 2015 summer season. This project, along with preliminary results, will be presented in an upcoming RRS bulletin. That bulletin and others in the RRS series will be posted at www.uwyo.edu/uwexpstn/centers/sarec/ (click on the "Rogers Research Site" link).

During the 2017 growing season, Linda T. A. van Diepen and John Derek Scasta, assistant professors in the UW Department of Ecosystem Science and Management, and others will gather additional data about the survival rates of planted ponderosa pine seedlings, the success rates of plots that were planted with ponderosa pine seed, the success of natural ponderosa regeneration, native grass restoration, and soil microbial dynamics. Additionally, UW master's student Stephanie Winters, working under the supervision of van Diepen, will study the abundance of invasive weeds to help determine if the erosion control treatment with the grass seed mix, for example, reduces the occurrence of weeds.

Acknowledgments

Initial funding and support for this project was provided by the Wyoming Agricultural Experiment Station through the U.S. Department of Agriculture McIntire-Stennis program. Other acknowledgments will be listed in the RRS bulletins.

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Keywords: Rogers Research Site, ponderosa pine (*Pinus ponderosa*), post-fire research

PARP: not applicable

Figure 1. Mollie Herget, lead field researcher at the time of this project, pauses for a picture at one of her study sites at the Rogers Research Site. (Photo by Michael Curran)

[1]*Department of Ecosystem Science and Management;* [2]*now with the Natural Resources Conservation Service, Elsberry Plant Materials Center, Elsberry, Missouri;* [3]*now retired;* [4]*Wyoming Agricultural Experiment Station.*

Soil Investigations at Rogers Research Site, Laramie Mountains, Wyoming, Before and After High-Severity Forest Fire

Stephen Williams[1,2], Claire Wilkin[1,3], Larry Munn[1,2], Michael Urynowicz[4], and Robert Waggener[5]

Introduction

The Laramie Mountains present a heterogeneous landscape of rocky slopes, mostly shallow soils, and variable vegetation in southeastern and central Wyoming. The University of Wyoming-owned Rogers Research Site (RRS) is representative of these mountains and is located approximately five miles southeast of Laramie Peak. This research site, about 320 acres in size, is surrounded on three sides by lands managed by the U.S. Forest Service. Nearly the entire RRS (along with some 100,000 acres in the area) burned in a lightning-caused forest fire in the early summer of 2012 (this occurred during an extreme drought). Prior to the fire, RRS vegetation was dominated by ponderosa pine (*Pinus ponderosa*) of various age classifications, with patches of aspen (*Populus tremuloides*) along the water courses. The RRS botanic understory included a variety of forbs, grasses, shrubs, as well as noxious weeds. Much of this understory, particularly weedy species including Canada thistle (*Cirsium arvense*) and cheatgrass (*Bromus tectorum*), has re-established in several dense patches since the Arapaho Fire. Aspen, too, is re-establishing, but natural ponderosa pine re-establishment is not yet evident.

The fire also dramatically changed the research agenda at RRS, which is now largely devoted to understanding the regeneration of vegetation, particularly ponderosa pine. Prior to establishing a landscape-level reforestation project at RRS, several studies were undertaken to determine the nature and biological activity of shallow soils at the site, both before and after the fire. An upcoming RRS bulletin will describe in detail these soil-related investigations. This paper provides a brief synopsis of these investigations and highlights regarding their importance.

Objectives

The three principle objectives of this portion of the study at RRS include: (1) determining basic soil characteristics before and after the 2012 Arapaho Fire; (2) constructing a soils map of the principle soils at RRS; and (3) providing experimental information on the immediate impact of added nutrients and stimulants (in the form of compost tea and nitrogen fertilizer) on the near-surface microbial community characteristics of the soils.

Materials and Methods

Pre-fire characterizations were performed, fortuitously, just prior to the 2012 wildfire; post-fire soil studies took place immediately thereafter. Eight control plots were established during the field season of 2011. These plots were located to capture the general variability in soils and vegetation across RRS. Prior to the fire, five of these plots were vegetated with ponderosa pine. The others were primarily vegetated with aspen and an occasional ponderosa. Soil pits were excavated at the center of each of these plots before the fire, and samples were collected from the surface soil (A-horizon) and subsoils (B-horizons where present and/or C-horizons).

After the fire, new soil pits were constructed within a few feet of the pre-fire sampling locations, and samples were collected from similar depths. These samples were analyzed for the following chemical parameters: pH, electrical conductivity (EC), soil adsorption ratio (SAR), phosphate phosphorous (PO_4-P), nitrogen as nitrate (NO_3-N), nitrogen as ammonium (NH_4-N), calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), weight percent N (wt %N), and wt% carbon (C). Additionally, the presence and relative size of microbial communities were characterized by extracting the phospholipid-fatty acids (PLFAs) from soil samples.

Soil mapping of RRS was initiated at a very cursory level in 2010, but not intensified until well after the 2012 fire. Standard mapping methods are being employed, and the maps should be completed within the year.

As a master's degree project at UW, Claire Wilkin designed and implemented an experiment to examine the effect of applied nutrients—especially N and compost tea—on the post-fire recovery of microbial communities within near-surface soils. The experimental design included randomized, replicated treatment blocks located on a 1.5-ac west-facing slope at RRS. The site was chosen for its homogeneous distribution of vegetation and burn severity. Composite surface soil samples were collected within each treatment block prior to treatment application, one week following treatment, and again at six months and nine months. Samples were analyzed for PLFAs, which form a majority component of microbial cellular walls. Results of this analysis served as quantifiers of active microbial life within the soil at the time of sampling. Much of the pre- and post-fire soil work was performed by the lead author of this paper and Wilkin.

Results and Discussion

Results of the pre- and post-fire soil analyses showed that most chemical parameters measured increased post-fire. Fire tends to release nutrients from biomass, and these accumulate in the soil. Among those parameters for which the largest change was observed, base-forming cations (Ca, K, Mg), mineral-N, and phosphorus all increased significantly in shallow soils. The pH increased in all surface horizons as well. The indicators of biological activity in the soil reported decreases in most soil biota post-fire. These organisms include fungi, in general, as well as symbiotic fungi, particularly the arbuscular mycorrhizal fungi. Filamentous bacteria (actinomycetes) as well as protozoa also decreased significantly post-fire. It was to be expected that, in general, microbial populations would be depressed immediately following the fire; however, the presence of increased macro- and micro-nutrient concentrations in the soil should provide an enhanced environment for growth for many of these populations.

The study examining the addition of nutrients (N as ammonium nitrate) and compost tea showed that some belowground microbial populations responded favorably to the nutrients and compost tea additions. Populations examined were total microbial abundance, bacteria, actinomycetes, arbuscular mycorrhizal fungi, total fungi, and protozoa. Some populations (e.g., protozoa and total fungi) were significantly increased by some treatments, but largely the heterogeneous nature of the soils in this area masked the treatment effects, making other comparisons non-significant. An upcoming bulletin will detail results. Once complete, it will be available at www.uwyo.edu/uwexpstn/centers/sarec/ (click on the "Rogers Research Site" link).

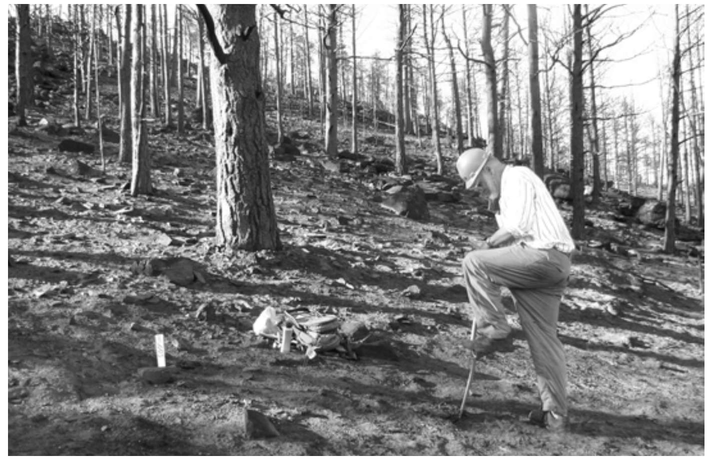

Figure 1. Professor Steve Williams (now retired) samples soils at RRS in late July 2012, less than one month after the Arapaho Fire burned through the area.

Acknowledgments

Funding and support for this project was provided by WAES through the U.S. Department of Agriculture's McIntire-Stennis program. Other acknowledgments will be listed in the RRS bulletins.

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Keywords: Rogers Research Site, soil investigation, forest fire

PARP: not applicable

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Introduction to the Sheridan Research and Extension Center

Brian Mealor[1,2]

Introduction

The Sheridan Research and Extension Center's (ShREC) mission is to serve Wyoming's applied research, education, and extension needs in horticulture, rangeland restoration, and forage science. We seek to continually improve our performance in all aspects of this mission. Our extension and outreach efforts have significantly increased over the past few years and have included target-specific field days, intensive multi-day workshops, and one-on-one consultations with local producers, land managers, and homeowners.

With two field locations (Wyarno, east of Sheridan, and the Adams Ranch, just south of Sheridan and Sheridan College), a research greenhouse, and state-of-the-art laboratory space, we are able to facilitate research ranging from highly technical to very applied. While a lot of research occurs on these sites, ShREC also serves as home base for additional research and educational endeavors around the state and region.

Highlights

We have a high-quality team at ShREC, which allows us to meet our mission, and apparently we are not the only ones who think so. Assistant Professor Sadanand Dhekney was awarded the Early Career Research Achievement Award from the Wyoming Agricultural Experiment Station in 2016. A brief video describing his research can be viewed here: www.uwyo.edu/uwexpstn/ (click on the "AES Awards Videos" on the bottom of the page). Office associate Rochelle Koltiska was one of two inaugural recipients of the Kathleen Bertoncelj AES Staff Award for staff excellence in early 2017. Other members of the ShREC team include Dan Smith, farm manager; Mike Albrecht, assistant farm manager; Beth Fowers, assistant research scientist; and many students and volunteers.

A ShREC-based team was directly involved with documenting self-sustaining populations of two invasive grass species new to Wyoming in 2016: Medusahead wildrye and ventenata grass. Both species negatively impact rangeland ecosystems in various ways, and a cooperative working group has now been established to clarify the extent of the problem and develop strategies for landscape-scale management.

In addition to the research that is presented in this bulletin, several additional lines of investigation are in the startup phase. A project to evaluate suitability of cover crop mixes for improving dryland soil health while providing in-season grazing resources is underway at Wyarno. We are working with multiple partners on improving our understanding of production and use of various native plant species for restoration efforts. Finally, we are investigating the development of a weevil-resistant alfalfa; if successful, this long-term project has the potential to alleviate one of the leading pests in alfalfa production.

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 University of Wyoming coursework and contribute regularly to programs at Sheridan College. Students (from junior high school to Ph.D. candidates) and local producers gain firsthand experience by participating in internships, field days, and special sessions at ShREC. In 2017, we supported 11 undergraduate student interns at ShREC working on a wide variety of topics. Results of their work will be presented in the 2018 *Field Days Bulletin*. We have emerging and ongoing cooperative programs with Science Kids, Rooted in Wyoming, Yale School of Forestry and Environmental Studies/Ucross High Plains Stewardship Initiative, Sheridan County schools (Figure 1), Northeast Wyoming Invasive Grass Working Group, U.S. Bureau of Land Management, Campbell County Conservation

District, Wyoming Game and Fish Department, Wyoming Weed and Pest Council, and others.

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. Our partnerships with Whitney Benefits, Sheridan College, University of Wyoming Extension, the ShREC Advisory Board, and others expand our ability to serve the needs of stakeholders in Sheridan County and northeast Wyoming. We also thank other entities that have provided direct support in multiple forms over the past year: Monsanto Co., Wilbur-Ellis, Plank Stewardship Initiative, Sheridan County CattleWomen, Alforex™ Seeds, and others.

Contact Information

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

Figure 1. University of Wyoming Professor Steve Miller discusses the Wyoming Apple Project with Sheridan Research and Extension Center (ShREC) interns as they prepare to transplant apple trees into the newly established germplasm conservation orchard at the Adams Ranch south of Sheridan. Interns participating in the project include, from left, Tyler Jones, Dylan Collins, Jaycie Arndt, Jordan Skovgard, and Hannah Ostheimer. The Wyoming Apple Project is featured on pages 148–149

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

ShREC Short Reports

Testing the relative effects of solarization and herbicide for weed control and native species establishment

Investigators: Kristina Hufford and Brian Mealor

Issue: Introduced species such as cheatgrass (*Bromus tectorum*) often outcompete native plants, and they represent an ongoing challenge for restoration of the natural environment. Prior to planting of native species, weed management with herbicide(s) is a common practice, but use of solarization (clear plastic to superheat the soil and kill weeds) may be a cost-effective alternative.

Goal: Compare and contrast the extent to which weed control with solarization vs. herbicide application improves the establishment of native grass species.

Objectives: (1) Test the extent to which solarization of weeds can improve the subsequent establishment of native grass species from seed; and (2) compare the rates of native seedling establishment between field plots treated with either solarization or glyphosate herbicide.

Expected Impact: Restoring native plant communities in areas infested by invasive, exotic weeds is often challenging and requires extensive site management and costly applications of herbicide(s). In cases where restoration sites are small, or islands of native species are desired, solarization may be a cost-effective solution to improve establishment of native plants and minimize use of herbicides.

Contact: Kristina Hufford at khufford@uwyo.edu or 307-766-5587.

Keywords: restoration, solarization, weeds

PARP: I:2, IX:2–5, X:1,3

Evaluating herbicide mixtures and seeding of cheatgrass-dominated sites

Investigators: Brian Mealor and Beth Fowers

Issue: Invasive annual grasses, such as downy brome, aka cheatgrass (*Bromus tectorum*), have broad-reaching impacts for agriculture and conservation across Wyoming and the West. Sites that have been affected by both annual grass invasion and repeated surface disturbance may have severely depleted perennial plant communities.

Goal: Evaluate various herbicides within a restoration setting for their ability to reduce cheatgrass competition and facilitate desirable native species establishment.

Objectives: On April 21, 2016, we applied 10 different herbicide treatments plus a non-treated check to 10- × 60-foot plots replicated three times in a randomized complete block design. We seeded five perennial grasses in late November 2016 and seeded the same species in spring 2017 to evaluate different lag times between herbicide application and seeding. The grasses include western wheatgrass (*Pascopyrum smithii*), Indian ricegrass (*Achnatherum hymenoides*), green needlegrass (*Nassella viridula*), blue grama (*Bouteloua gracilis*), and crested wheatgrass (*Agropyron cristatum*).

Expected Impact: Identifying methods for re-establishing desirable species in cheatgrass-dominated sites could help land managers increase grazing carrying capacity for livestock, improve habitat for important wildlife species 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, weed management, invasive species

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

Evaluating chronic herbicide exposure for long-term reduction of Canada thistle

Investigators: Brian Mealor, Beth Fowers, and Clay Wood

Issue: Invasive plants negatively affect agroecosystems by altering species composition, productivity, and other attributes. Although newer herbicides are effective, it is still relatively difficult to achieve long-term control of creeping perennial weeds 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 perennial weeds.

Goal: This pilot study seeks to evaluate the effect of a single annual herbicide rate—split into different sequential treatments through time—on the perennial noxious weed, Canada thistle (*Cirsium arvense*).

Objectives: We initiated this study in fall 2016 by applying 6 fluid oz/ac of Milestone® and 3 oz/ac of Method™ herbicides, both systemic herbicides known to be effective on Canada thistle. In 2017, we will distribute these total rates throughout summer at different timings to determine if chronic exposure to herbicides affects Canada thistle differently than an acute dose.

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 their 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, weed management, invasive species

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

Engineering alfalfa cultivars for alfalfa weevil resistance

Investigators: Sadanand Dhekney, Randa Jabbour, and Anowar Islam

Issue: Alfalfa weevil is a major pest affecting production and hay quality of alfalfa in Wyoming and other states. Up to 40% crop losses can occur in cases of severe infestations.

Goal: Improve existing commercial alfalfa cultivars for alfalfa weevil resistance.

Objectives: Insert genes for insect resistance in commercial alfalfa cultivars, and test transgenic plants for weevil resistance and hay quality.

Expected Impact: Development of alfalfa weevil-resistant cultivars would be a valuable addition to existing biological, cultural, and chemical pest-management strategies. The project addresses a serious problem facing Wyoming alfalfa growers and could pave the way for the development of improved cultivars.

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Keywords: alfalfa, forage insect resistance, alfalfa weevil

PARP: I:2, IX:2–5, VIII

Optimizing protocols for vegetative propagation of goji berry

Investigators: Michael Baldwin, Jeremiah Vardiman, and Sadanand Dhekney

Issue: *Lycium barbarum* (goji berry; aka matrimony vine) is a cold-hardy specialty crop with potential for commercial production in Wyoming. Currently, there is no known information on asexual propagation techniques of goji berry.

Goal: Optimize protocols for vegetative propagation of goji berry.

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

Expected Impact: Information generated on propagation techniques can be utilized by both small retail nurseries and commercial nurseries throughout the nation, including Wyoming, to produce plants efficiently. These plants, in turn, could be sold to local growers and homeowners. The availability of quality planting material could enable Wyoming growers to produce this niche crop in an economically sustainable fashion.

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Keywords: goji berry, vegetative propagation, plant cuttings

PARP: I:2, IX:2–5, VIII

Perennial Cool-Season Grasses for Hay Production and Fall Grazing Under Full and Limited Irrigation

Blaine Horn[1], Anowar Islam[2], Dan Smith[3], Valtcho Jeliazkov[3,4], and Axel Garcia y Garcia[5,6]

Introduction

Perennial cool-season grasses comprise nearly 25% of hay field acreage in northeast Wyoming. The most popular grasses used for hay production under irrigation in this region are smooth and meadow bromegrass. Although these two grasses are productive with good stand persistence, they 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 irrigation water most years. Due to this moisture requirement these two grasses may not be the best choice for dryland or limited irrigated hay production. Other cool-season perennial forage grasses might produce high forage yields of good quality with similar or less amounts of irrigation water compared to smooth and meadow bromes.

Objectives

Objectives of this study are to assess (1) late spring/early summer hay yields of perennial cool-season grasses under full and reduced (50%) irrigation; (2) regrowth yields of these grasses for fall grazing under full and 50% irrigation; and (3) forage quality of the hay and regrowth.

Materials and Methods

Fourteen perennial cool-season forage grasses were seeded into separate plots within eight blocks (four for full irrigation and four for limited [50%] irrigation) in September 2014 at the Sheridan Research and Extension Center (ShREC). In late fall 2015, nitrogen at 150 lb/ac and phosphate at 30 lb/ac were applied to the plot area. The irrigation regimes were implemented in early June 2016 and continued through mid-September 2016. On June 16, 2016, eight of the grasses underwent a mechanical harvest to assess dry matter yields, and on June 30 five of the remaining six grasses were harvested. The desired stage of maturity for harvest is post-flowering to visible seed development. Following the June 30 harvest, the entire plot area was hayed the next day to remove all standing plant material. Regrowth of the grasses underwent a mechanical harvest on October 10, 2016. Grass material from the June and October harvests were analyzed for crude protein, energy, and macro- and micro-minerals (contact the lead author for forage quality results from both harvests).

Results and Discussion

Natural precipitation at the plot site was 4.1 inches in April, 1.1 inches in May, and 0.3 inches from June 1 to 13. The amount of water applied between June 2 and 13 was 1.65 and 0.85 inches, respectively, for full and limited irrigation regimes. An additional 2.0 and 1.0 inches of water were applied between June 17 and 27 for the full and limited regimes, respectively. There was no difference in June dry matter yields among the grasses between irrigation levels (Table 1). The intermediate and pubescent wheatgrasses produced the highest dry matter yields, although 'Carlton' smooth brome and 'Paddock' meadow brome had similar yields. 'Fawn', 'Profile', 'Carlton', 'Manchar', and 'Latar' contained the highest levels of crude protein averaging 12.7%, and 'Paddock' the least amount at 9.5%. 'Fawn', Tuukka', and 'Profile' contained the highest levels of Net Energy maintenance (NEm) averaging 0.68 Mcal/lb, and 'Paddock' and the wheatgrasses the least amount averaging 0.61 Mcal/lb. (NEm measures ability of feed to meet maintenance energy requirements of an animal.) Irrigation regime did not influence grass protein or NEm contents. July through September natural precipitation totaled 8.0 in with 75% of it occurring in September. Irrigation amounts during this period totaled 10.5 and 7.5 inches for the full and limited regimes, respectively, with the limited amount 2.0 inches greater than planned. There was no difference in September dry matter yields among the grasses between irrigation regimes. 'Texoma', 'Latar', and 'Tuukka' produced the highest amount of regrowth dry matter and the wheatgrasses and 'Carlton' smooth brome the least (Table 1).

Acknowledgments

We thank ShREC field crews for assistance in plot establishment and harvesting. The ongoing study is supported by Wyoming Department of Agriculture's Agriculture Producer Research Grant Program.

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Keywords: cool-season grass, hay production, regrowth yields

PARP: I:2, IV:4

Table 1. Dry matter yields in tons per acre of the cool-season perennial grasses in June 2016. The bromes, orchard, and tall fescues on the 16th; wheatgrasses and timothy on the 30th.

Grass	Variety	June 16 and 30		October 10		Total	
		Full	Limited	Full	Limited	Full	Limited
Smooth brome	Carlton	5.1 ab	4.9 abc	1.0 cde	0.5 d	6.0 abcd	5.4 abc
	Manchar	4.1 bc	3.8 cd	1.4 bc	1.2 abc	5.5 bcd	5.0 bcd
Meadow brome	MacBeth	3.4 cd	4.3 bcd	1.4 bc	1.2 abc	4.8 de	5.5 abc
	Paddock	5.0 ab	5.0 ab	1.1 bcde	1.0 bcd	6.1 abc	5.9 abc
Orchard	Latar	3.1 cd	3.5 d	1.9 a	1.2 abc	5.0 cde	4.7 cde
	Profile	1.5 e	2.0 e	1.4 b	1.4 ab	2.9 f	3.5 ef
Tall fescue	Fawn	2.3 de	1.3 e	1.4 b	1.5 ab	3.7 ef	2.7 f
	Texoma MaxQII™	3.0 cd	3.3 d	2.0 a	1.7 a	5.1 cde	5.0 bcd
Intermediate wheatgrass	Oahe	5.8 a	5.1 ab	1.3 bcd	1.3 ab	7.1 a	6.4 a
	Rush	5.6 a	5.4 a	0.8 e	1.0 bcd	6.4 ab	6.4 a
Pubescent wheatgrass	Luna	5.9 a	5.6 a	0.9 de	0.7 cd	6.8 ab	6.3 ab
	Manska	5.5 a	5.4 ab	1.1 bcde	1.0 bcd	6.6 ab	6.4 a
Timothy	Tuukka	2.8 d	1.9 e	1.2 bcde	1.6 ab	3.5 ef	3.0 def
	Climax	Did not establish					
All	Average	4.08	3.96	1.31	1.16	5.36	5.11

*column means followed by same letters do not differ at $p<0.05$

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Changes in Plant Community Structure Influence Forage Yield and Quality of Irrigated Meadow Bromegrass-Legume Mixtures in Wyoming

Dennis Ashilenje[1] and Anowar Islam[1]

Introduction

Forage species in mixtures are known to make complementary use of mineral nutrients, water, and light, thus enhancing productivity. Alfalfa, bird's-foot trefoil (BFT), and sainfoin are popular forage legumes in Wyoming that can be grown in mixture with meadow bromegrass, a cool-season grass. Legumes in such cropping systems, however, can succumb to exploitation and shading by grass, which can lead to less vigorous growth and a shortened lifespan. As a consequence, their contribution to overall forage nutritive quality and yield is lowered. These adverse effects can be evaluated based on change in dry matter contributed by each species in mixture.

Objectives

The objective of this study was to determine the effects of species diversity mechanisms against forage yield and quality for irrigated meadow bromegrass-legume mixtures in Wyoming.

Materials and Methods

The field experiment has been ongoing since September 2013 at the Sheridan Research and Extension Center (ShREC). There were 15 treatments with alfalfa (cultivar 'WL363HQ'), sainfoin ('Shoshone'), and BFT ('Norcen') monocrops as well as meadow bromegrass ('Fleet') supplied with 0, 50, and 100 lb of nitrogen (N) per acre as urea. Crops have mixtures of two, three, and all four species. The two-species mixtures are composed of meadow brome-alfalfa, brome-sainfoin, and brome-BFT in 50:50 and 70:30 seeding ratios. The three-species mixtures consist of 50% meadow brome combined with 25% each of two legumes (alfalfa-BFT, alfalfa-sainfoin, and sainfoin-BFT). The four-species formulation has 50% meadow brome with all three legumes each accounting for ~16.7%. Forage dry matter (DM) was measured in June, August, and October 2016 to determine cumulative yields and over-yielding effects (in this case, over-yielding is when a mixed crop yields more than a monocrop). The samples were further analyzed for forage nutritive value including acid detergent fiber (ADF), in-vitro dry matter digestibility (IVDMD), neutral detergent fiber (NDF), crude protein (CP), and relative feed value (RFV).

Results and Discussion

Varying grass-legume crop mixtures significantly affected ($p<0.0001$) forage DM yield and nutritive values (Table 1), the highest being 6.6 ton/ac from the meadow brome-alfalfa-BFT 50:25:25 mixture followed by meadow brome-alfalfa 50:50 (6.5 ton/ac). The lowest-producing mixtures were the meadow bromegrass-sainfoin 50:50 (3.4 ton/ac) and 70:30 (3.1 ton/ac). Each of the forage crop mixtures had some over-yielding, ranging from 4 to 30%.

There was up to 1.7 ton/ac dry matter increase for mixtures compared to the grass monocrop supplied with 100 lb N/ac. Overall, the meadow bromegrass-alfalfa mixture (70:30) had the best levels of CP (16%), IVDMD (71%), and RFV (127). Forage quality improved significantly for meadow bromegrass-alfalfa, 70:30 mixture (ADF=34.3%; NDF=47.2%) and also meadow bromegrass-BFT, 70:30 mixture (ADF=34.4%; NDF=48%) compared to grass monocrop (ADF=35.3–38.1%; NDF=53.4–57.9%). The CP values obtained from grass-legume mixtures (13.2 to 15.7%) were within the range for premium quality hay (>13%). In conclusion, a mixture of meadow bromegrass with alfalfa and also meadow bromegrass with BFT enhances yield and forage quality to a level that can help to maximize livestock dry matter intake, growth, and milk production.

Acknowledgments

We acknowledge with much appreciation ShREC staff for logistical support. The study is supported by a Western Sustainable Agriculture Research and Education grant, and funds from the Wyoming Agricultural Experiment Station and the University of Wyoming's Department of Plant Sciences.

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Keywords: biodiversity mechanisms, grass-legume mixtures, forage yield and quality

PARP: I:2, II:2, VII

Table 1. Forage dry matter (DM) yield and nutritive value for meadow bromegrass receiving different rates of nitrogen (N) and in different mixtures with legumes.

		Forage Nutritive Value				
Forage Mixture and N Treatments	**DM[1] (tons/ac)**	**ADF[2] (%)**	**IVDMD[3] (%)**	**NDF[4] (%)**	**CP[5] (%)**	**RFV[6]**
Alfalfa monocrop (100)	4.6	34	71	46	18	132
Meadow brome:alfalfa (50:50)	6.5	37	66	51	14	112
Brome:alfalfa (70:30)	4.9	34	71	47	16	126
Brome:alfalfa:sainfoin (50:25:25)	4.1	38	66	56	13	101
Sainfoin monocrop	1.3	31	69	41	17	151
Brome:sainfoin (50:50)	3.4	36	67	52	13	117
Brome:sainfoin (70:30)	3.1	37	64	55	12	113
Brome:alfalfa:BFT[7] (50:25:25)	6.6	36	69	52	15	116
BFT monocrop (100)	3.7	33	71	40	18	150
Brome:BFT (50:50)	4.7	35	70	50	15	121
Brome:BFT (70:30)	5.2	34	69	48	15	125
Brome:alfalfa:sainfoin:BFT (50:16.7:16.7:16.7)	5.2	36	67	52	13	113
Brome without N	3.3	37	66	55	12	108
Brome + 50 lb N/ac	4.2	38	66	58	12	99
Brome + 100 lb N/ac	4.8	35	69	53	14	123
Least significant difference (0.05)	1.44	3.317	3.96	6.21	2.96	23.7

[1]dry matter, [2]acid detergent fiber, [3]in-vitro dry matter digestibility, [4]neutral detergent fiber, [5]crude protein, [6]relative feed value, [7]bird's-foot trefoil

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Mechanical Renovation of Deteriorating Alfalfa Stands

Dan Smith[1], Mike Albrecht[1], Brian Mealor[1,2], and Brian Lee[3]

Introduction

Hay fields in northeast Wyoming are typically renovated by costly tillage or by herbicide application followed by no-till seeding. Some producers have historically performed various types of management practices during the lifespan of their fields to rejuvenate existing stands. This project originated from a discussion of the Sheridan Research and Extension Center (ShREC) Advisory Board related to extending the life and productivity of alfalfa hay fields. The goal is to evaluate whether low-cost mechanical methods used each season can improve productivity of an aging alfalfa hay stand over multiple years.

Objectives

Our objectives are to (1) compare the effectiveness of various mechanical treatments (harrow, aerate, disc, cultivate) with conventional hayfield renovation techniques (herbicide, plow, reseed with cover crop) and no-till renovation (herbicide, reseed without cover crop); and (2) evaluate the costs and values of each practice.

Materials and Methods

This project was established in 2016 in an aging irrigated hayfield on ShREC's Adams Ranch south of Sheridan. The trial is semi-circular and covers 21.3 acres across three wheel tracks of the center pivot. Each wheel track was split equally using a Global Positioning System-guided tractor to make six equal-width strips. Six treatments were randomized, balanced, and replicated four times resulting in an average of 3.5 acres total for each rejuvenation method. Mechanical treatments included chain harrowing alone or in combination with tandem disc, pasture aerator, or field cultivator. Each treatment will be compared to conventional tillage and no tillage renovation treatments in 2017. The conventional treatments include herbicide, moldboard plow, disc, roller harrow, and seed alfalfa with hay barley cover crop, while the no tillage treatments include herbicide, no-till seed alfalfa without a cover crop. Crop yield comparisons were measured by hand clipping 2.7-ft^2 plots in four random locations within each plot resulting in roughly 11 ft^2 of biomass collected from each plot. This allows the large trial to be bulk harvested for hay production along with the remainder of the field. We analyzed 2016 biomass data with a one-way analysis of variance and separated means with Fisher's protected LSD.

Results and Discussion

Unusually warm temps and no snow cover in early March 2016 allowed the alfalfa to break dormancy and grow rather rapidly. It was determined that significant crop damage could result if the four mechanical treatments were performed on a crop that advanced. The decision was made to only do the conventional and no-till renovation treatments when conditions permitted. The remaining mechanical treatments took place in spring 2017 (we plan to present results of this phase of the study in next year's Wyoming Agricultural Experiment Station *Field Days Bulletin*). Biomass harvest of three treatments (conventional, no-till, and remainder of field a non-treated check) was performed 10 days past the heading of the seeded barley. Air dried forage biomass was greatest for conventional rejuvenation, although the no-till approach still produced higher biomass than the non-treated check ($p<0.001$; Figure 1). Long-term impacts of these various approaches on alfalfa production remain to be seen.

Acknowledgments

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Keywords: hay production, alfalfa

PARP: I:7, II:6

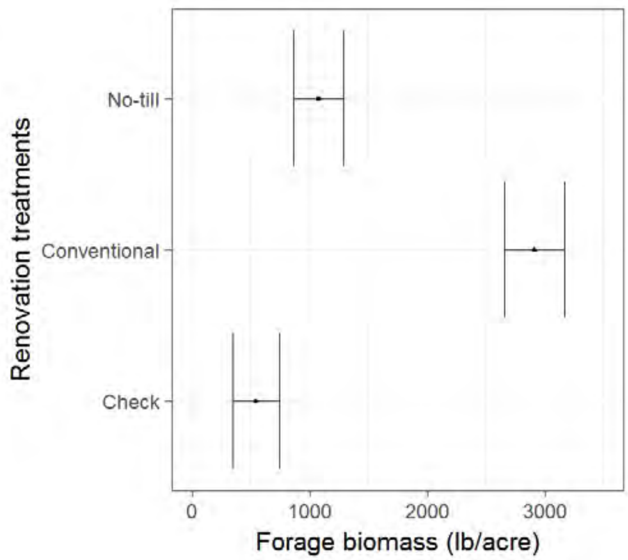

Figure 1. Air-dried forage biomass (lb/acre) for two alfalfa rejuvenation treatments (conventional and no-till) and a non-treated check. Points represent means and error bars are 95% confidence intervals about each mean.

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Evaluating New Herbicide Mixtures for Rangeland Cheatgrass Management

Brian Mealor[1,2]

Introduction

Cheatgrass is present throughout a large portion of Wyoming at varying intensities. Although current methods for cheatgrass control are fairly effective, they require relatively frequent re-treatment to maintain cheatgrass suppression on infested sites. Some herbicides not previously used in rangeland settings may provide longer-term control with a single application. Additional tools for suppressing or controlling cheatgrass may improve the ability of land managers to restore cheatgrass-impacted rangelands while diminishing potential for developing herbicide-resistant cheatgrass populations by repeated applications of herbicides with the same mechanism of action.

Objectives

The objectives are to evaluate seven herbicide mixtures at two different timings for their effectiveness in reducing cheatgrass and their impacts on associated vegetation.

Materials and Methods

Seven herbicide mixtures at two different timings (March and April) were applied in spring 2016 with a total volume of 20 gallons per acre with a CO_2-pressurized sprayer and a 10-foot boom with six 8002 nozzles. The study at the Sheridan Research and Extension Center (ShREC) was applied to 10 × 30 foot plots set in a randomized complete block design with three replicates and a replicated, non-treated check. Treatments included Plateau® (7 oz/ac) and Olympus™ (1.2 oz/ac) applied alone and in combination; Esplanade® (5 and 7 oz/ac) combined with Roundup WeatherMAX® (16 oz/ac) or combined with Olympus™ (1.2 oz/ac).

Applications on March 3 occurred with a 54°F air temperature, 38% relative humidity, 41°F soil temperature at 2 inches deep, and 5–8 mph wind. Cheatgrass on-site varied from the 1–3 leaf growth stage, and roughly half the plants were purple due to semi-dormancy from cold weather.

Applications on April 21 occurred with a 60°F air temperature, 54% relative humidity, 48°F soil temperature at 2 inches deep, and 3 mph wind. Cheatgrass was 2–3 inches tall and actively growing.

Cheatgrass control (% visual relative to non-treated) was evaluated in early summer and in late fall 2016.

Results and Discussion

In early summer 2016, only treatments containing Roundup showed reductions in cheatgrass. By fall 2016, treatments containing Esplanade provided high levels of cheatgrass control, irrespective of application timing (Figure 1). We will continue to evaluate cheatgrass control and respective treatments in 2017. These preliminary results confirm concurrent research at other institutions that Esplanade provides good to excellent cheatgrass control in the short term.

Acknowledgments

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Keywords: weed management, cheatgrass, grass seeding

PARP: III:3,5

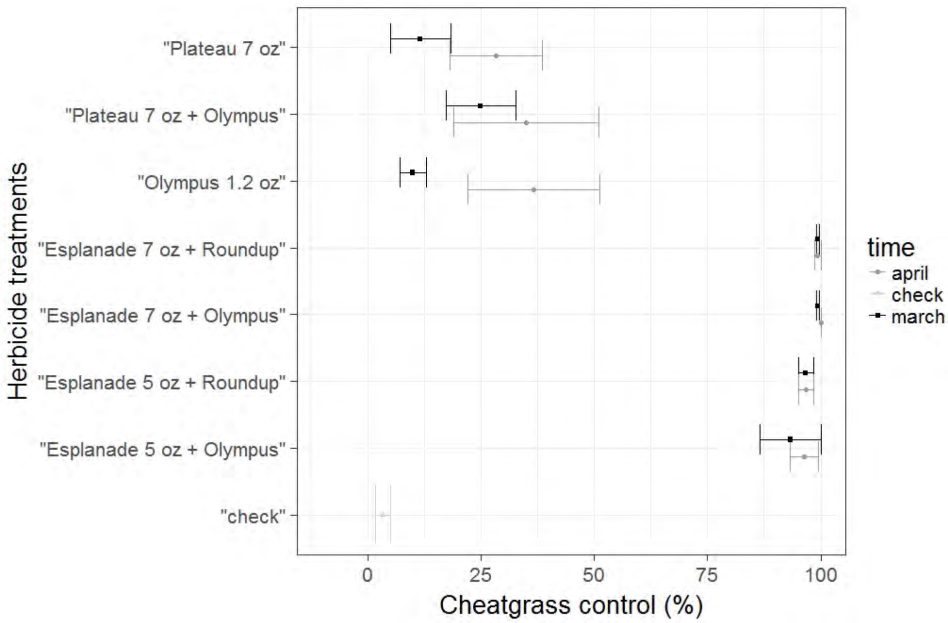

Figure 1. Cheatgrass control (% visual) provided by seven herbicide treatments (plus a non-treated check) at two different timings six months after treatment at ShREC.

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Impact of histophilosis on bovine respiratory disease

Investigators: Kerry Sondgeroth, Donal O'Toole, and Brant Schumaker

Issue: The bacterium *Histophilus somni* is a cause of respiratory disease in cattle, most often when large groups of weaned calves are stressed. Recent studies have not been performed in the U.S. to determine its importance in respiratory disease and death of feedlot cattle

Goal: Determine the association of *H. somni* with bovine respiratory disease and death in western U.S. feedlot cattle.

Objectives: Determine when calves acquire antibodies to *H. somni* by collecting blood samples at different times while they are in the feedlot. Blood samples from a total of 486 cattle in two feedlots were collected upon entry, then at 30 and 60 days after placement. Testing of these 1,458 samples was underway in early 2017. This is being done with an ELISA (enzyme-linked immunosorbent assay) to determine if and when antibodies to *H. somni* develop. Lung and heart samples from approximately 20 animals that died from respiratory disease have also been collected, and are being tested using bacterial cultures, histopathology, polymerase chain reaction, and immunohistochemistry. This first year of sampling will aid in understanding the importance of *H. somni* in bovine 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. It will increase awareness for producers and clinical veterinarians, which should lead to better control of bovine respiratory disease by vaccination and treatment.

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Keywords: *Histophilus somni*, histophilosis, bovine respiratory disease

PARP: not applicable

Understanding motivations and impediments to rancher participation in NRCS conservation programs

Investigators: Anna Collins, John Tanaka, Kristie Maczko, John Ritten, and Derek Scasta

Issue: The U.S. Department of Agriculture's Natural Resources Conservation Service (USDA NRCS) funds various conservation programs through the USDA Farm Bill. Designing programs that increase participation will assist NRCS in fulfilling its objectives.

Goal: Better understand producers' socioeconomic characteristics and motivations for participating in NRCS conservation programs.

Objectives: Conduct a statistically valid survey of ranchers throughout the U.S. to gain knowledge about why ranchers participate in NRCS conservation programs.

Expected Impact: NRCS will be provided insight into motivations for participation, as well as socioeconomic characteristics of producers who participate in NRCS conservation programs. Information derived may be used to improve delivery of conservation programs and technical assistance.

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Keywords: conservation programs, Natural Resources Conservation Service, survey

PARP: VI:3,5, IX:4,6

Research needs for dry beans in Wyoming

Investigators: John Tanaka and Anna Collins

Issue: The Wyoming Bean Commission, which formed in 2015, recently began funding research projects using checkoff dollars collected on dry bean sales; however, it is currently unknown what the bean producers in the state think are the research needs.

Goal: Gather information from producers on dry bean research needs and provide it to the Wyoming Bean Commission.

Objectives: Conduct a statistically valid survey of dry bean producers in Wyoming to ascertain their perceptions of research needs.

Expected Impact: Results will provide guidance to the Wyoming Bean Commission as it selects research proposals.

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Keywords: dry bean, survey, Wyoming Bean Commission

PARP: IX:6

Ranch economic models for evaluating management changes in greater sage-grouse habitat

Investigators: John Tanaka, John Ritten, and Kristie Maczko

Issue: The U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) has significant conservation funds available to enhance greater sage-grouse (*Centrocercus urophasianus*) habitat across the West; however, little is known how those funds and subsequent projects could impact ranch economics. (The sage grouse was being considered for protection under the federal Endangered Species Act [ESA]; however, in 2015 the U.S. Fish and Wildlife Service announced that because of an unprecedented, landscape-scale conservation effort across the West, it was withdrawing the species for ESA consideration.)

Goal: Develop multi-period ranch models to estimate economic impacts over the life of a treatment designed to improve sage grouse habitat.

Objectives: Develop ranch enterprise budgets and ranch models for public/private and private ranches where the owners work on the ranch full- or part-time in nine NRCS Major Land Resource Areas covering the majority of greater sage-grouse habitat in the West.

Expected Impact: NRCS will be provided quantified economic and ecological information on the effects of prescribed grazing on forage production, season of use, and livestock distribution for the representative ranches. Information can be used to help ranchers make informed decisions on whether to adopt practices designed to improve sage grouse habitat based on how those practices may affect their livestock operations.

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Keywords: sage grouse, ranch models, Natural Resources Conservation Service

PARP: VI:3,5, VII:2,4,7, IX:1,6

Economic Impact of Beef Genomic Research

Chris Bastian[1], Nicole Ballenger[1], Justin Schaffer[1], Matt Andersen[1], Bridger Feuz[2], Steve Paisley[3], and Timur Ibragimov[1]

Introduction

The beef industry adds value to its product, in part, through health and nutrition programs, through genetic choices, and by addressing temperament of the cattle. Genetic testing of cattle is becoming increasingly important to maximize the economic performance of cattle traits coupled with value-adding production practices. Despite the recognition that genetic traits have economic value, and the priority on funding for functional genomics, there is little information on the economic benefits and distribution of benefits among beef industry participants from these scientific investments.

Objectives

Our objectives are to develop and test an empirical model for exploring both the benefits and the distribution of economic benefits of genetic technologies within the vertically segmented beef cattle industry, including an estimate of the potential distribution of benefits to Wyoming's cow-calf producers.

Materials and Methods

To analyze the distribution of benefits among industry sub-sectors, we developed an equilibrium displacement model (EDM) of the U.S. beef industry and its reaction to the adoption of a specific genetic predictive technology. (An EDM model takes into account changes in quantities and prices from supply and demand changes caused by a change across all market segments analyzed and then estimates the economic changes in benefits or costs to those segments.)

We intend to conduct two analyses. The first uses myostatin mutation—which produces double muscling in cattle—as a representative genetic innovation. The genetic predictions and potential changes in costs and revenues for cattle producers in different segments of the industry have been published, making the development of an economic model feasible. The second analysis, now underway, will use data from research being conducted at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) on feed efficiency characteristics in beef cattle.

Results and Discussion

Because of the extensive documentation of the myostatin mutation, its genomic predictability, and its related impacts on physical production, this characteristic was more easily analyzed in an EDM. From this model we estimated the changes in economic benefits for producers and consumers for each industry segment nationally and for Wyoming cow-calf producers due to the adoption of the innovation (Table 1).

A conservative, most likely outcome in terms of costs and benefits nationally under this scenario indicates on a per-head basis that (1) cow-calf operations see a loss of $0.17 when they breed myostatin into their herds; (2) feedlots realize a gain in profit of $0.05; (3) slaughterhouses see a profit gain of $0.19; and (4) retailers see a gain of $0.12 when the industry moves to double-muscled beef.

Putting this into total dollars, cow-calf producers nationally could lose up to $40 million by 100% adoption of this technology, while Wyoming cow-calf producers could lose $323,725 over a 10-year period. However, the feedlot, packing, and retail- to-consumer segments could all show positive gains, creating a net positive of $41 million overall for the total U.S. beef industry (Table 1). Myostatin mutation is a useful case study because it demonstrates clearly how unevenly returns can be distributed across the beef value chain.

Our next analysis on feed efficiency is underway; this research is taking place at SAREC. It is a much more complex genetic trait to analyze economically, but we believe it offers greater opportunities for economic gains to cow-calf producers than was expected for the myostatin mutation analysis. We hope to have this part of our study completed by spring 2018.

Acknowledgments

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Keywords: genomics, economic benefits, beef cattle

PARP: V, VII, VIII

Table 1. A conservative scenario for total change in economic benefits nationally and in Wyoming for myostatin mutation research and adoption.

		Total Benefits
National Market Segment	Cow-calf producers	($40,011,769)
	Feedlots	11,633,543
	Packers	42,801,126
	Retail	26,605,064
	Total U.S. Beef Industry	$41,027,964
Wyoming	Cow-calf producers	($323,725)

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Diet Quality and Selection Differences in Two Contrasting Grazing-Management Strategies

Tamarah Plechaty[1], Derek Scasta[1], Justin Derner[2], and David Augustine[2]

Introduction

The capability of cattle to convert cellulose into energy and protein available to the human population for consumption allows rangelands (land typically unsuitable for cropping) to contribute to global food production. Understanding how grazing-management strategies influence cattle nutrition is lacking, and additional research using novel technological advances is needed to improve our understanding about the efficacy of different grazing strategies.

Objectives

Our objective was to quantify differences in diet quality (crude protein and digestible organic matter) and diet plant protein composition between two contrasting grazing-management strategies in two rangeland ecosystems (northern mixed-grass prairie [Figure 1] and shortgrass steppe) using new technological advances.

Materials and Methods

Our study took place at two USDA-ARS research stations: (1) the High Plains Grasslands Research Station (HPGRS), a northern mixed-grass prairie ecosystem near Cheyenne; and (2) the Central Plains Experimental Range (CPER), a shortgrass steppe ecosystem at the western edge of the Pawnee National Grassland in northeast Colorado near Nunn. Two different grazing-management strategies were used at both locations: continuous season-long and adaptive rotational.

At HPGRS, we compared continuous season-long to the adaptive rotation system. For season-long, we used three different stocking rates: light (0.14 animal unit months/acre), moderate (0.36 AUM/ac), and heavy (0.47). For adaptive rotational, we used a heavy stocking rate in 2015 (0.54) and a stocking rate 15% heavier for 2016 (0.62). Yearling heifers grazed from early June through mid-September in both 2015 and 2016. (One AUM is the approximate amount of forage a 1,000-pound cow and her calf consume in one month.)

At CPER, we compared continuous season-long to adaptive rotational. Both grazing-management strategies had a moderate stocking rate (0.24 AUM/ac), but differed in stocking density across the grazing season. The adaptive strategy had a stocking density of 0.625 steers/ac, whereas the traditional strategy had a density of 0.0625 steers/ac. Yearling steers grazed from mid-May to early October in both 2015 and 2016.

At both locations, we used near-infrared reflectance spectroscopy (NIRS) to analyze diet quality weekly across the grazing season. NIRS exposes dried, ground-up fecal samples to specific wavelengths of light to detect and record reflected wavelengths. This technique is an accepted, non-invasive methodology for assessing diet quality. Herd composite fecal samples were collected weekly during the grazing season, frozen, and sent to the Texas A&M University Grazing Animal Nutrition Lab for analysis. The lab generated reports with crude protein (CP), digestible organic matter (DOM), ratio of digestible organic matter to crude protein, fecal nitrogen, and fecal phosphorus. CP and DOM were used as the indicator for diet quality because they are often the parameters limiting cattle rumination, cellulose conversion, and growth on rangelands. At CPER only, diet composition was evaluated using DNA metabarcoding, an analysis that uses DNA in the plant chloroplast to identify plant species' *diet protein contribution* from fecal samples, bimonthly across the grazing season. Every two weeks, herd composite fecal samples from each treatment were sent to the Jonah Ventures laboratory (Boulder, Colorado) where analyses compared the gene sequences in the fecal samples to a gene reference library. We calculated the percentage of plant species' contribution to the protein diet composition across the grazing season.

Results and Discussion

We determined that CP and DOM levels were consistently higher across the grazing season in the continuous season-long grazing strategy at both locations. These findings were consistent in both a below- and above-average precipitation year, with yearling cattle gaining 10–15% more weight (lb/animal) than animals in the adaptive rotational strategy for both years at both locations. Distinct differences in plant protein diet composition at CPER were observed between continuous season-long and adaptive rotational grazing later in the season. Early in the season, the continuous grazing herd consumed a large amount of the annual grass sixweeks fescue (*Vulpia octoflora*) and forbs, whereas yearlings in the adaptive strategy had a diet with greater protein contributions from a sixweeks fescue/western wheatgrass (*Pascopyrum smithii*) combination. Later in the season, the continuous grazing herd consumed more forbs and blue grama (*Bouteloua gracilis*), but the adaptive rotational herd continued to consume a diet dominated by western wheatgrass. Cattle in both strategies consumed little needleleaf sedge (*Carex duriuscula*) early in the grazing season, but increased consumption toward the end of the grazing season. Preliminary results indicate that these two contrasting grazing-management strategies influence cattle dietary selection, which can lead to observed differences in diet quality.

We hypothesize that this difference may be due to greater inter-animal competition in the adaptive rotational strategy. The high stocking density may not allow cattle to select the highest quality feed; instead, they focus on consuming larger quantities because they are competing with more animals for food and do not have the ability to spend time choosing high quality forage. This has been reflected in observed grazing pattern differences of the two treatments with the adaptive rotational strategy animals foraging in straight lines and the traditional grazing strategy animals foraging in a more serpentine pattern. We are continuing our research this year to solidify results and to better understand the impact of grazing-management decisions on cattle diet quality and dietary protein selection.

Figure 1. Derek Scasta and Tami Plechaty discuss an ongoing cattle research project in southeast Wyoming. (Photo by Robert Waggener)

Acknowledgments

We thank Crow Valley Livestock Cooperative for providing cattle for CPER, the Eisele family for providing cattle for HPGRS, and USDA-ARS research technicians and Crow Valley employees for helping with fecal collections. Funding is from Western Sustainable Agriculture Research and Education, and USDA-ARS.

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Keywords: grazing management, diet quality, cattle

PARP: VI:1,6, VII:2

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Development of a New Assay for Diagnosis of *Brucella abortus* Infections in Wyoming Livestock

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Introduction

Bovine brucellosis is one of the world's most widespread human diseases and still causes problems to domestic livestock producers in Wyoming and the other two states surrounding the Greater Yellowstone Area (GYA), Idaho and Montana. In the U.S., the Cooperative State-Federal Brucellosis Eradication Plan, initiated in 1934, was successful in eradicating brucellosis from cattle populations. However, the disease still has a reservoir in elk and bison in GYA with multiple instances of spillover into cattle herds on private and public lands within GYA in the last decade. Positive cases in livestock lead to quarantines that can cost the producer upward of $254,000 based on an analysis of a "typical" Wyoming beef cattle operation.

Additionally, producers may elect, and in some cases be required, to cull their herd and submit them to imperfect and time-consuming diagnostic testing. Producers who are located in the Designated Surveillance Area (DSA), which spans Wyoming, Idaho, and Montana, are also required to undertake increased testing requirements prior to shipping cattle to some specific states. This applies to producers not under quarantine, but who conduct their livestock operations within the DSA.

Figure 1. Sierra Amundson and Noah Hull trim tissues that were collected from suspect animals in preparation for *Brucella* DNA extraction and polymerase chain reaction testing at the Wyoming State Veterinary Laboratory.

Objectives

The objective of this study was to develop a new, more accurate assay to detect brucellosis in the tissues of affected animals.

Materials and Methods

For this project, we conducted the most in-depth computer analysis of *Brucella* spp. ever performed using genetic sequences acquired from the U.S. Department of Agriculture's (USDA's) National Veterinary Services Laboratories. This analysis revealed potential targets for diagnostic testing. These targets went through an extensive screening process, ultimately leaving eight candidates for full optimization and validation.

In parallel to this process, we wanted to make sure that the methods used to extract *Brucella* DNA from tissue samples produced the highest yield as the bacterium is presumed to exist in small numbers in these samples. We screened six different commercial extraction kits against blood and its fractions and all standard tissue types. The kits that we are using on field samples were taken directly from this analysis.

Results and Discussion

Through this project, we have been able to acquire samples from 87 suspect/reactor animals (18 cattle and 69 bison). Of these animals, only 42 (48.3%) were culture positive despite all of the animals being suspect or positive on the standard blood test for *Brucella* exposure. On these animals, our top polymerase chain reaction (PCR) candidate set is currently detecting *Brucella* DNA on 77 (88.5%) of the animals tested. This indicates that our PCR assay has the ability to detect almost twice as many animals as the current gold-standard assay, bacterial culture. Thus far, on seronegative cattle, elk, and bison located outside of the endemic area, our assay has 100% specificity (n=51). With our development of vaccine-specific primers-probe sets, we are able to differentiate vaccine-related infections from field infections.

The potential to replace the current gold-standard diagnostic test of culture with a more sensitive test could decrease the cost of an outbreak in livestock. Additionally, PCR testing of a suspect animal is about one-quarter of the cost of culture and can be completed in a few hours, in comparison to 10–14 days with culture. This means producers and veterinarians can have results the same day samples arrive at the lab. This assay is still in the research phase, and validation is expected in the next year.

Acknowledgments
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Keywords: brucellosis, livestock disease, diagnostic testing

PARP: V:13

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Prevalence of *Brucella ovis* in Wyoming Domestic Sheep

Kerry Sondgeroth[1] and Molly Elderbrook[1]

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 in pregnant ewes, and higher numbers of premature lambs.

Objectives

Our objectives were to (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

The initial contact with producers in 2015 and 2016 resulted in 18 producers volunteering to participate in the Wyoming "2015–2016 Sheep Brucellosis Study" (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 was made between the ELISA that is currently utilized in the U.S. (ELISA 1) to the one that is used in Europe (ELISA 2).

Results and Discussion

From fall 2015 through spring 2016, samples were collected by graduate students, producers, and veterinarians from 2,278 sheep owned by 18 producers across Wyoming (Table 1). A total of 1,332 samples were from rams, while 946 were from ewes. Two different ELISAs were used to determine exposure to *B. ovis*. Both determined an overall prevalence of close to 1% (Table 2); however, the number of positive animals increased with ELISA 2, as well as the number of positive flocks (Table 2). Both assays were in agreement with 90.4% of the samples (2,059/2,278), which leaves 219 discordant samples. The majority of these samples were "negative" by ELISA 1, and "indeterminate" by ELISA 2. Additional testing of these samples by more specific assays could help resolve the conflicting results and aid in our determination as to which ELISA performs better as a screening assay. Although the sample size is small (less than 1% of the sheep in the state) this project has given us a glimpse of how many Wyoming domestic sheep have been exposed to *B. ovis*. The outcome, in turn, should help producers identify infected animals, decrease infection rates through blood testing, and, ultimately, increase lamb production rates.

Acknowledgments

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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.

Table 1. Summary of sampling efforts through spring 2016.

Sampling District	Counties within District	# Sheep Sampled	# Flocks Sampled	# Flocks with positive animal
Northwest	Park, Bighorn, Hot Springs, Fremont, Washakie	298	9	2
Northeast	Sheridan, Johnson, Campbell, Crook, Weston	211	2	1
West	Uinta, Lincoln, Sublette, Teton	832	2	1
South-central	Sweetwater, Carbon, Natrona, Albany	471	3	3
Southeast	Converse, Niobrara, Platte, Goshen, Laramie	466	2	1

Table 2. Comparison of seroprevalence with two different ELISAs.

	Animal level	Flock level
ELISA 1	0.88% (20/2,278)	44.4% (8/18)
ELISA 2	1.14% (26/2,278)	55.6% (10/18)

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Winter Wheat Planting Date Trial: Dryland

Carrie Eberle[1]

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, 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 dryland fields in Goshen, Platte, and Laramie counties in southeastern Wyoming. The experimental design consisted of three replications in a complete block. Measurements taken included: grain yield, test weight, and moisture. Other information was gathered, as well, including disease and weather data (Figure 1; information not presented). Goodstreak winter wheat was seeded on September 16, October 9, and October 21, 2015. Seeding took place in plots 5 by 25 feet using a hoe drill with a row spacing of 14 inches in Platte and Goshen counties. Laramie County plots were seeded using a disc drill with row spacing of 10 in. The seeding depth was 1.5 in, and the seeding rate was 50 lb/ac. Plots were harvested July 17 (Goshen), July 21 (Platte), and July 23, 2016 (Laramie dryland), using an ALMACO plot combine.

Figure 1. Wendy Cecil and Matt Bebo collect disease data at one of the dryland wheat test sites in southeast Wyoming. A weather station is in the background.

Results and Discussion

Yield results are presented in Table 1. In Laramie and Platte counties, the earliest planting date had the highest yield, with the yields of the two later dates being significantly lower. This yield decline is most likely due to smaller plant size going into the winter season. In Goshen County the yields of the first and second planting were not significantly different, while the third planting date yield was significantly lower. Another trial was planted in 2016 and will be harvested this growing season. Results from the 2014–15, 2015–16, and 2016–17 studies will be used to help determine final planting dates established by the U.S. Department of Agriculture's Risk Management Agency. Complete results for these trials and many others are available at: www.uwyo.edu/uwexpstn/variety-trials.

Acknowledgments

Appreciation is extended to the cooperators: Marti and Lou Hubbs (Goshen), Derek Jackson (Platte), and Tim Anderson (Laramie County) who allowed us to place trials on their land and to the Panhandle Coop Association, Scottsbluff, Nebraska.

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Keywords: winter wheat, variety trial, USDA Risk Management Agency

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Table 1: Yield of Goodstreak winter wheat variety planted on three dates in Goshen, Platte, and Laramie counties. Letters next to means indicate significant difference between planting date within a location.

	Grain Yield (bu/ac)					
Planting Date	**Goshen County**		**Platte County**		**Laramie County**	
9/16/2015	43.8	a	44.1	a	47.8	a
10/9/2015	26.8	b	25.7	b	41.4	a
10/21/2015	8.1	c	9.8	c	23.8	b
Average of all entries	26.2		26.5		33.4	
Least significant difference	4.0		6.0		7.5	
p-value	0.0001		0.0001		0.0006	

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Winter Wheat Variety Trial Nurseries: Eastern Wyoming Dryland and Irrigated

Carrie Eberle[1] and Wendy Cecil[1]

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, Colorado State University, Montana State University, and private seed companies.

Objectives

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

Materials and Methods

The experiments were located in Goshen (dryland), Platte (dryland), and Laramie (dryland and irrigated) counties in eastern Wyoming. The experimental design consisted of three unfertilized replications in the dryland plots and four fertilized replications in the irrigated plots in a randomized complete block. Measurements taken included: grain yield, test weight, moisture, lodging at harvest, stripe rust infection, and septoria/tan spot infection. In the irrigated study, fertilizer was applied at a rate of 135-20-5-1 lb/ac nitrogen-phosphorus-sulfur-zinc. Wheat varieties were seeded September 16, 2015. Seeding took place in plots 5 by 25 feet using a hoe drill with a row spacing of 14 inches in Platte and Goshen counties. Laramie County was seeded using a disc drill with row spacing of 10 in. The seeding depth was 1.5 in, and the seeding rate was 50 lb/ac in the dryland and 100 lb/ac in the irrigated. Plots were harvested July 17 (Goshen), July 21 (Platte), July 23 (Laramie dryland), and July 24, 2016 (Laramie irrigated), using an ALMACO plot combine.

Results and Discussion

Results for yield, lodging, and stripe rust score are presented in Table 1. The yield differences between varieties was not significant in either the Platte or Laramie dryland trials. The highest yielding varieties in the Goshen trial were the experimental lines CO011D1397 and CO011D1767, both at 58 bu/ac. In the irrigated trial the experimental line CO0121D955 was the highest yielding variety at 111 bu/ac. Lodging at time of harvest is also reported for each variety, and was used as a proxy measure for sawfly (Table 1). (Lodging is the bending over of stems near the ground in wheat and other grain crops, reducing yield and making harvest more difficult.) There was no significant relationship between yield and lodging among varieties, as some high-yielding varieties had high lodging. This could be an effect of heavy heads increasing lodging; however, for individual varieties Robidoux, Panhandle, Cowboy, Brawl, and Antero yield was negatively correlated with increased lodging. Stripe rust infection was also measured at heading in the Goshen and Platte trials, which were not treated with fungicide (Table 1). Antero was the only variety where decreased yield was correlated with increased rust infection, and among varieties there was no significant correlation of yield and rust infection. Complete results for these trials and many others are available at: www.uwyo.edu/uwexpstn/variety-trials/wheat.html.

Acknowledgments

Appreciation is extended to the cooperators who allowed us to place trials on their land, Derek Jackson (Platte), Marti and Lou Hubbs (Goshen), Tim Anderson and Theron Anderson (Laramie); to University of Wyoming assistant professor of plant pathology Bill Stump and the UW plant clinic for help with disease assessment; and to the staff at the James C. Hageman Sustainable Agriculture Research and Extension Center for their help. This work was funded by the Wyoming Crop Research Foundation.

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PARP: I:12

Table 1: 2016 eastern Wyoming dryland (D) and irrigated (I) winter wheat variety test. Yield (bu/ac) with standard error, percent of stand that was lodged at harvest (%L), and stripe rust score (SRS*) at heading.

	Goshen (D)			Platte (D)			Laramie (D)		Laramie (I)	
Entry	bu/ac	%L	SRS	bu/ac	%L	SRS	bu/ac	%L	bu/ac	%L
Antero (W)	45 ± 12	28	3	47 ± 12	15	3	56 ± 12	8	98 ± 14	1
Bearpaw (SS)	45 ± 4	1	6	41 ± 9	10	5	45 ± 11	3	62 ± 7	3
Brawl CL Plus	42 ± 1	17	4	51 ± 3	37	2	**68 ± 1**	**4**	87 ± 9	0
Buckskin	38 ± 2	3	9	33 ± 5	47	5	38 ± 11	20	n/a	n/a
Byrd	52 ± 3	33	4	52 ± 5	23	4	61 ± 10	4	99 ± 10	1
CO011D1236	54 ± 9	43	5	39 ± 2	47	3	57 ± 19	5	92 ± 10	0
CO011D1306W	48 ± 8	47	4	40 ± 1	47	3	48 ± 20	15	73 ± 19	3
CO011D1312	51 ± 7	22	7	54 ± 10	27	3	57 ± 20	12	91 ± 8	1
CO011D1397	**58 ± 9**	**27**	**4**	51 ± 7	13	4	60 ± 15	2	94 ± 6	0
CO011D1539	51 ± 6	43	3	42 ± 1	22	2	65 ± 6	7	96 ± 9	10
CO011D174	47 ± 3	43	4	54 ± 7	8	4	59 ± 12	4	96 ± 5	0
CO011D1767	**58 ± 5**	**15**	**2**	52 ± 2	5	1	64 ± 7	2	97 ± 6	0
CO011D421	53 ± 9	12	3	46 ± 6	17	3	54 ± 22	10	94 ± 7	0
CO011D446	52 ± 16	30	3	50 ± 6	27	3	48 ± 21	10	102 ± 4	0
CO0121D922	50 ± 2	32	3	52 ± 8	8	2	59 ± 7	7	**111 ± 5**	**4**
CO012D1028	48 ± 1	10	8	**56 ± 6**	**40**	**4**	53 ± 13	5	95 ± 4	1
CO012D2010	48 ± 9	40	3	44 ± 9	22	1	59 ± 12	8	82 ± 9	4
CO012D2011	48 ± 8	40	2	40 ± 7	50	2	59 ± 5	17	87 ± 10	8
CO012D906	55 ± 9	10	5	48 ± 5	0	2	57 ± 16	6	86 ± 9	0
Cowboy	41 ± 4	53	5	53 ± 10	7	4	61 ± 16	0	88 ± 10	1
Denali	52 ± 4	38	5	49 ± 5	15	3	63 ± 3	7	83 ± 9	1
Goodstreak	38 ± 7	33	7	39 ± 16	32	4	42 ± 11	18	n/a	n/a
Hatcher	50 ± 2	25	3	49 ± 9	27	4	52 ± 7	5	90 ± 5	0
Judee (SS)	49 ± 6	4	2	40 ± 0	4	1	47 ± 18	5	79 ± 3	2
MT1138	51 ± 5	15	3	52 ± 8	23	2	54 ± 14	8	85 ± 8	1
MTS1024 (SS)	45 ± 7	5	1	49 ± n/a	22	2	63 ± 3	2	65 ± 7	0
NE10589	37 ± 7	18	3	53 ± 9	18	2	49 ± 13	12	86 ± 3	5
Panhandle	39 ± 6	30	5	47 ± 7	40	2	54 ± 16	2	76 ± 5	3
Robidoux	47 ± 5	43	4	54 ± 5	27	3	60 ± 7	5	91 ± 3	1
Settler CL	47 ± 1	40	6	49 ± 10	15	1	62 ± 8	3	80 ± 9	3
Sunshine (W)	49 ± 9	8	5	49 ± 5	4	2	50 ± 21	7	91 ± 6	0
SY Monument	46 ± 1	7	2	43 ± 3	15	2	62 ± 20	2	83 ± 7	3
SY Sunrise	41 ± 10	7	3	49 ± 11	18	2	60 ± 22	2	96 ± 7	0
SY Wolf	39 ± 5	8	3	51 ± 10	10	2	58 ± 4	0	91 ± 6	3
Warhorse(SS)	43 ± 6	0	2	47 ± 2	27	3	53 ± 14		68 ± 8	0
Average	47			47			56		88	
p-value	0.01			0.08			0.86		<0.0001	

(W) = Hard White Winter Wheat; (SS) = Solid Stem

*1=0%, 2=1–3%, 3=4–12%, 4=13–25%, 5=26–50%, 6=51–75%, 7=76–88%, 8=89–97%, 9=98–100%

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On-Farm Performance of Bird's-foot Trefoil Cultivars

Sayantan Sarkar[1] and Anowar Islam[1]

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 grazing lands for livestock. Bird's-foot trefoil is non-bloating, and planting a stand of this legume can provide 5–6 years of quality forage. It has shown to increase meat and milk quality as well as protein-use efficiency in ruminants. The degree of effect of bird's-foot trefoil on ruminants' performance depends greatly on cultivars and the amount of condensed tannins present (tannins are naturally occurring non-bloating agents). Cultivar performance of bird's-foot trefoil depends on soils, climatic conditions, and agronomic practices. Studies suggest that fewer harvests can be economical as the quality of bird's-foot trefoil, like many forages, deteriorates by the end of the growing season. Also, bird's-foot trefoil, being a slow establishing crop, is less competitive against weeds. Production information on bird's-foot trefoil, however, is limited due to a lack of information on agronomic management and its performance on a ranch- or farm-scale.

Objectives

The objective of this on-farm study was to evaluate the performance of three bird's-foot trefoil cultivars under three harvesting frequencies.

Materials and Methods

This study was conducted at the Scott Forrest farm in southeast Wyoming near Torrington. Mr. Forrest is a forage crop grower, follows organic practices, and has experience in the cultivation of bird's-foot trefoil. Ten acres of his crop field were used for this study. Three cultivars were planted in June 2015: 'Norcen', 'Leo', and 'Bruce'. The plot was divided into three strips of about three acres each, one for each cultivar. Each strip was then divided into three equal plots for replication. Each of these plots, in turn, was subdivided into three smaller plots for three harvesting frequencies: harvesting once (H1), twice (H2), and three times (H3) during the growing season. Each harvesting frequency was randomly assigned. Tillage, seed-bed preparation, seeding, irrigation, and mowing were performed by the producer. Harvesting in 2016 included: July 23 (H1); July 23 and October 7 (H2); and June 4, July 23, and October 7 (H3). Two samples were clipped from each plot and used to calculate dry matter (DM) yield by adding the yields from the entire season of each plot.

Results and Discussion

Variations in DM yield were observed among harvesting frequencies and cultivars (Figure 1). In general, total DM production increased as the number of harvests increased. On average, however, the difference between two and three harvests was minimal, indicating that harvesting twice in a season might be a viable and profitable option. Among cultivars, Bruce yielded better than Leo and Norcen. This can be attributed to the fact that Bruce is more upright growing by nature and, therefore, better equipped to outcompete weeds. Also, erect types generally have a better DM yield than prostrate types when used for hay production. The study is ongoing, and data is being collected and analyzed. Early results, however, are promising, especially in terms of harvest frequency (twice) and cultivar performance (Bruce).

Acknowledgments

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Keywords: bird's-foot trefoil, cultivars, harvest frequency

PARP: I:2, II:9, IX:2

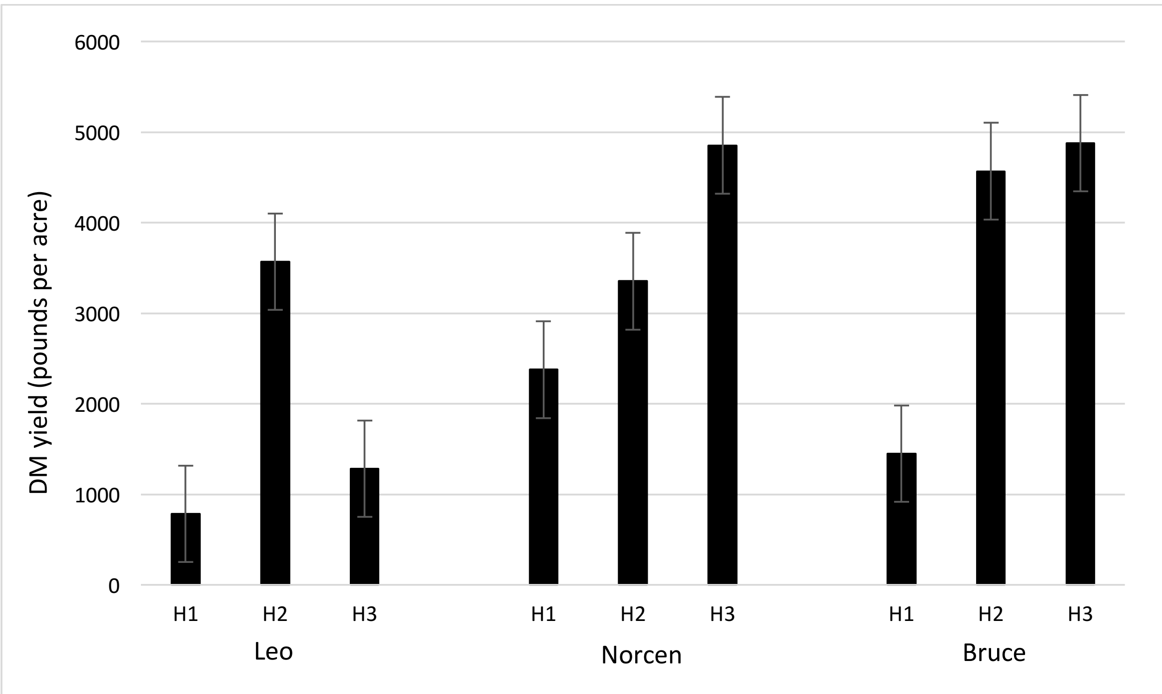

Figure 1. Dry matter (DM) yield of bird's-foot trefoil at the Scott Forrest farm near Torrington in 2016. H1=one harvest; H2=two harvests; H3=three harvests.

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Using Next-Gen Sequencing to Identify Heirloom, Historic, and Novel Apple Cultivars in 100-year-old Orchards in Wyoming

Steve Miller[1]

Introduction

The sweet apple was a critical resource during settlement of Wyoming. Fresh fruit was not readily available at the store, and fresh apples of many varieties were widely grown and highly prized. For the pioneer farmers and ranchers, however, the utility of the different apple varieties was much greater than just for fresh fruit: some provided a source of cider (both sweet and hard), some provided a source of pectin to thicken jam and jelly, and some were good for animal feed. Vinegar made from other varieties was used as a preservative, tonic, medicine, and household cleaner. The diversity of apple varieties in Wyoming during these "Golden Years of Apple Growing" was quite high. Several varieties were developed specifically for the cold, drought-prone, high-elevation climate of Wyoming at the Wyoming State Experimental Fruit Farm in Lander and by early orchardists.

Unfortunately, Wyoming has reached a milestone regarding these apple varieties. The last remnants of 19th- and early 20th-century plantings struggle to survive in isolated, nearly forgotten, or abandoned orchards. Many have been poorly maintained and have experienced drought and abnormally cold winters. Further, the identity of many of these varieties has been lost, and some trees still alive in these orchard remnants are, in fact, novel varieties that were developed specifically for conditions in Wyoming; others arose from chance crossings between and among heirloom and wild crabapple varieties. These apples have survived for half a century or longer unattended under harsh conditions and are still producing an abundance of highly desirable fruit. That makes identification of each of these cultivars extremely important.

Objectives

The objective is to develop and use molecular techniques to identify heirloom, historic, and novel apple varieties in Wyoming orchards that are some 100 years old.

Materials and Methods

The study is using a comparative approach to identify heirloom, historic, and novel apple cultivars in Wyoming. DNA is extracted from trees of unknown variety that are located in historic orchards or from individual trees remaining in old farmsteads around Wyoming (Figure 1). Microsatellite or simple sequence repeats' (SSR) markers are compared with those from the Germplasm Resources Information Network (GRIN) database operated by the U.S. Department of Agriculture's (USDA) Agricultural Research Service.

Results and Discussion

During the first round of sampling and analyses for the "Wyoming Apple Project," 540 samples were submitted for analysis. Of those, 12 varieties were confirmed by matches to the known cultivars supplied by the GRIN database. In addition to the 122 samples identified to cultivar, 111 samples matched another "potential cultivar name" (i.e., a likely name provided by the sampler or landowner). Sixty-four samples (12%) didn't match any sample or control. This is quite low in comparison to other studies conducted along the East Coast.

There are several potential causes for this low percentage. The apple cultivars found in Wyoming may not be in the GRIN database. If the cultivars were not previously sampled by the USDA, they cannot provide a match to our samples from Wyoming. A second cause would be that many Wyoming apples sampled are novel cultivars. We know in talking with the orchard/tree owners that in almost every orchard there is a novel cultivar, but the percentage of unidentifiable ones is likely too large to account for so many novel varieties.

Immediate plans will be to conduct additional testing of samples from Wyoming. Several sub-studies are underway, such as sampling along the path of pioneer trails through Wyoming and following the time-course of homesteading in Wyoming. We have also created a master list of cultivar names likely to be found in Wyoming from early reports published by the Wyoming Horticultural Society, documents associated with winning apple entries at the Wyoming State Fair, etc. We will obtain documented reference leaf samples from orchards, heirloom apple collections, and individuals and include them in our next round of SSR analyses.

Acknowledgments

We thank all of the orchardists and individuals who allowed access to their apple trees. The study is supported by USDA Hatch funds.

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Keywords: apples, cultivars, molecular techniques

PARP: VIII:1

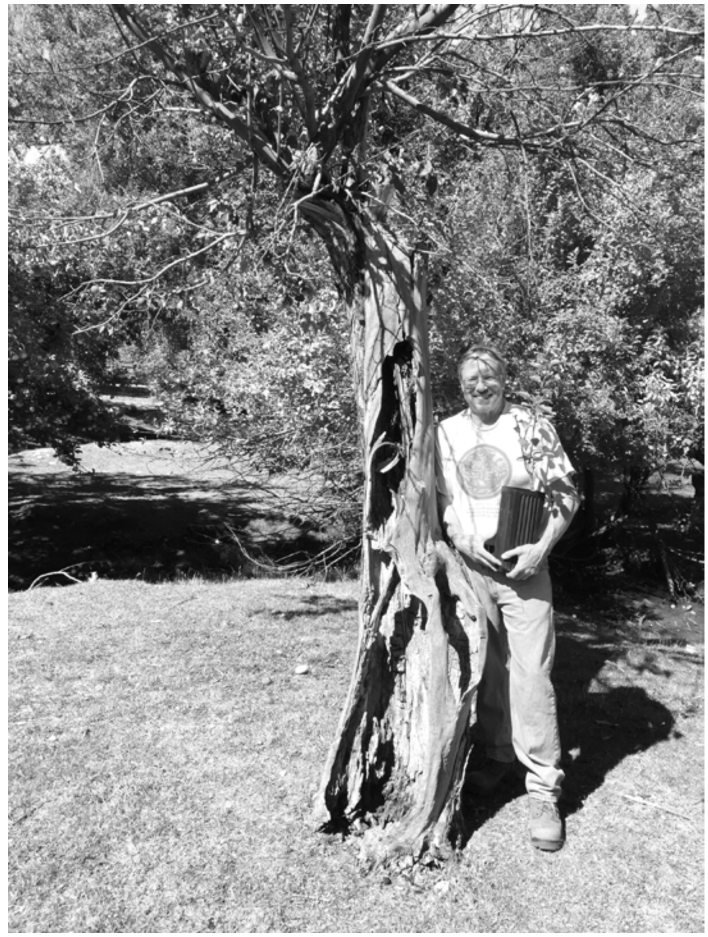

Figure 1. Professor Steve Miller took a small sample of wood from this historic Wyoming apple tree and grafted it onto young rootstock to grow bench-grafted trees. He then returned to the orchard to present the young trees to the owner of the orchard, Nannette Slingerland. “This particular tree is in the old Ed Young orchard in Red Canyon near Lander, now owned by Nannette,” Professor Miller says. “Nannette doesn’t know any of the true names for the cultivars, but her name for this tree is ‘Near Dead.’ With our molecular work, we hope to provide names for all her remaining trees.”

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

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

Introduction

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

Objectives

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

Materials and Methods

This study is being conducted on multiple field sites throughout Wyoming, but for this paper we only present data from a site near Pinedale in western Wyoming. To determine landscape variability we mapped cover of cheatgrass and perennial grasses through ocular estimation at an approximated 50-foot grid pattern. A balanced subset of mapped points was selected for intensive sampling across each treatment area and across a range of cheatgrass and perennial grass cover. At each intensive sample location vegetation cover is measured using both transects and quadrats; additionally, all herbaceous biomass is collected from the cover quadrats. Pre-treatment data were collected in June 2015, and pre-emergence herbicide treatments were conducted in September 2015 using two formulations of imazapic. Plateau®, a liquid formulation, and Open Range™ G, a granular formulation, were applied at a rate of 7 oz/ac and 13 lb/ac, respectively. Post-treatment data were collected in June 2016.

Results and Discussion

Pre-treatment cheatgrass cover was highly variable across the landscape, but post-treatment cheatgrass cover mapping revealed reductions in cheatgrass (Figure 1). Cheatgrass cover was reduced across herbicide treatments, yet we observed a slight increase in cheatgrass cover in areas with low pre-treatment cheatgrass cover in the untreated check (Figure 2). Perennial grasses also increased in both herbicide treatments relative to the untreated check (Figure 2).

With further data collection and analysis we intend to see if these data continue to show similar trends and begin to determine where thresholds occur. A better understanding of thresholds' concepts relating to cheatgrass management could aid in implementing landscape-scale management to reduce fire frequency, increase perennial grasses and shrubs, and improve wildlife habitat and forage for livestock.

Acknowledgments

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

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Keywords: cheatgrass (*Bromus tectorum*), thresholds, imazapic

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

Literature Cited

Groffman, P. M., Baron, J. S., Blett, T., and 13 others, 2006, Ecological thresholds: The key to successful environmental management or an important concept with no practical application: Ecosystems, v. 9, p. 1–13.

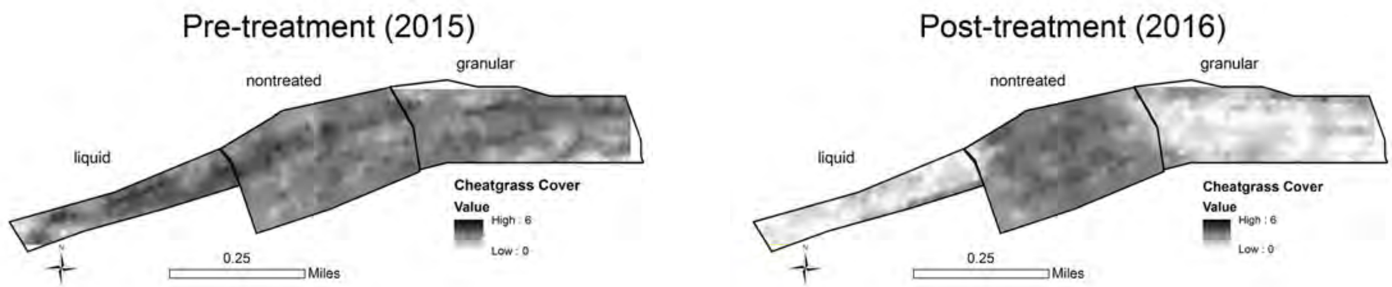

Figure 1. Pre-treatment and one-year post-treatment cheatgrass cover across three treatments near Pinedale. Darker colors indicate higher cheatgrass cover (black=high, white=low or none).

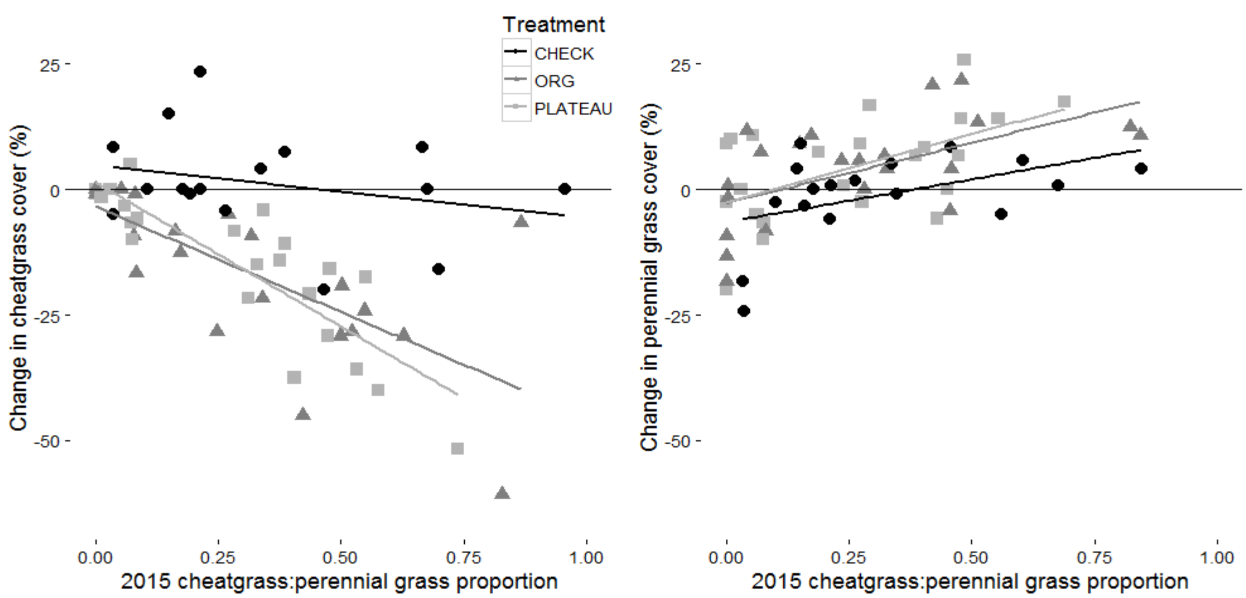

Figure 2. One year post-treatment changes in cheatgrass (a) and perennial grass (b) cover at Pinedale. Change in cover is absolute change in cover (%), not percent change across years. Multiple equations per panel indicate differences among herbicide treatments for slope or intercept ($p<0.05$). ORG=Open Range G herbicide.

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Quantifying Shrub Canopy Interception of Two Imazapic Formulations and Impacts on Cheatgrass Biomass

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

Introduction

Cheatgrass (*Bromus tectorum*) is an invasive winter annual grass that is widely distributed throughout much of the West, including Wyoming. Many efforts have been made to restore cheatgrass-dominated rangelands to native perennial grass and shrub-dominated communities. Among these efforts is the use of herbicides. Imazapic is a commonly used herbicide to manage annual grasses in rangelands while providing limited negative impacts to established native grasses, forbs, and shrubs. One confounding factor of herbicide applications in shrubland ecosystems is the potential for physical interception of liquid herbicides by shrub canopies, leading to less herbicide reaching the target species.

Objectives

Our objectives are to compare the efficacy of two formulations of imazapic (Plateau®, a liquid formulation, and Open Range™ G, a granular formulation) at reducing cheatgrass biomass beneath shrub canopies and quantify herbicide coverage beneath shrub canopies and within interspaces between shrubs.

Materials and Methods

We conducted post-treatment biomass collection at two field sites (near Saratoga in south-central Wyoming and Pinedale in western Wyoming) one year post-treatment. Cheatgrass biomass was collected from within four-inch diameter quadrats both beneath shrub canopies and within interspaces between shrubs. Ten shrubs were randomly selected across each herbicide treatment and the untreated check for biomass collection. Quadrats sampled beneath shrub canopies were positioned so they were located entirely underneath the shrub canopy (Figure 1). Biomass samples were dried in a forced air oven at 140°F for 72 hours and weighed to the nearest gram.

To quantify shrub canopy interception of the two imazapic formulations we conducted additional field experiments coinciding with aerial herbicide applications on two field sites in 2016 (near Hyattville and Sheridan in north-central Wyoming). Plateau was applied at 7 oz/ac and Open Range G at 13 lb/ac.

Results and Discussion

Differences in cheatgrass biomass were not observed one year post-treatment in interspaces between shrubs versus beneath shrub canopies at both Saratoga (p=0.683) and Pinedale (p=0.781). Both herbicide treatments reduced total cheatgrass biomass relative to the check at Saratoga (p=<0.001) and Pinedale (p=0.0483). At Saratoga both Plateau and Open Range G reduced cheatgrass under shrubs, but at Pinedale, Plateau provided the greatest reduction in cheatgrass biomass. Herbicide coverage at Sheridan and Hyattville did not differ under shrubs versus within interspaces between shrubs for Open Range G (p=0.72 and 0.77, respectively), but Plateau coverage was consistently less beneath shrub canopies (p=0.05 and <0.001, respectively).

Our initial results indicate that Open Range G and Plateau provided similar cheatgrass control, despite more consistent herbicide coverage with Open Range G. Due to the differences in locations biomass sampling sites and herbicide coverage sites and differences in herbicide application equipment across the two treatment years, additional biomass sampling is being conducted at all field sites in 2017 to determine if similar cheatgrass biomass results are observed.

Acknowledgments

We thank the University of Wyoming Department of Plant Sciences, Wilbur-Ellis, Sublette County Weed and Pest District, and Wyoming Local Sage-Grouse Working

Groups for support and funding, and UW field crews for assistance.

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

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

Figure 1. Four-inch diameter quadrat used to collect cheatgrass biomass shown beneath sagebrush canopy.

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Terrestrial Carbon and Nitrogen Eight Years after Bark Beetle-Caused Forest Mortality

Urszula Norton[1], Ada Harris[1], Susan Schmidt[2,3], and Jay Norton[4]

Introduction

Recent epidemics of mountain pine beetle (*Dendroctonus ponderosae*) and spruce beetle (*Dendroctonus rufipennis*) have decimated at least 30 million acres of coniferous forests in western North America. Such massive-scale forest mortality has caused shifts in carbon (C) and nitrogen (N) pools and fluxes in soils, plants, and duff on the forest floor. Corresponding changes in understory vegetation, tree seedling recruitment, and future forest structure are likely to be affected, but the information on the early successional forest response is still limited and long-term response is unknown.

Objectives

Our objectives are to assess the impact of beetle-induced tree mortality on vegetation succession and terrestrial ecosystem C and N in three types of forests eight years after the insect infestation.

Materials and Methods

The study was established in the No Name Watershed of the Medicine Bow-Routt National Forests. Our study site, elevation 9,500 feet, is in south-central Wyoming's Snowy Range near the popular recreation area of Libby Creek. Soils are predominantly Entisols with minimal soil development, formed from mixed colluvium and metamorphic schist. Climate is cold and snowpack-dominated. Forests are dominated by subalpine fir, Engelmann spruce, and lodgepole pine. Five clusters of dead and five clusters of live trees were selected at the toe-slope (subalpine fir forest), foot-slope (Engelmann spruce forest), and shoulder (lodgepole pine forest). Samples were collected for total C and N determination of the understory vegetation (shoots and roots), soil (0–4 in), and surface soil litter. Vegetation inventory, density of dead and live trees, and species composition as seedlings, mid-canopy, and overstory trees were carried out in the middle of the growing season (July).

Results and Discussion

All three forest types experienced 30–32% stand mortality (Table 1). They are transitioning to denser forests with subalpine fir becoming more prevalent and lodgepole pine disappearing from subalpine fir and Engelmann spruce-dominated forest types. Eight years after the infestation, only lodgepole pine forest continues to show 32% more C and 35% more N, which is mainly attributed to high accumulation of surface soil litter (Figure 1). Surviving trees and the large abundance of tree seedlings, grasses, and forbs will likely trigger high demand for soil N. Accelerated competition may result in earlier onset of plant N deficiency, premature tree death, and pests and disease outbreaks.

Acknowledgments

We thank Alex Foulk, Betsy Trana, Mavis Badu, and David Lere for assistance with field and lab work. The study was supported by grant funding from the National Science Foundation and Wyoming Experimental Program to Stimulate Competitive Research (EPSCoR).

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Keywords: lodgepole pine, Engelmann spruce, subalpine fir

PARP: X:1, XII:1,2

Table 1. Forest tree species inventory, stand mortality, and recovering vegetation at toe-slope, foot-slope, and shoulder positions of the No Name Watershed in the Snowy Range. Seedling density and seedling composition reflect values in clusters of dead trees in comparison with clusters of live trees. (The common name for *Vaccinium scoparium** is grouse whortleberry.)

Tree species	Toe-slope	Foot-slope	Shoulder
Engelmann Spruce (ES)	80%	15%	14%
Subalpine Fir (SF)	18%	48%	0%
Lodgepole Pine (LP)	2%	36%	86%
Forest Mortality	31%	30%	32%
Seedling Density	10 times greater	10 times greater	2 times greater
Seedling Composition	More SF Loss of LP	More SF Loss of LP	More SF
Dominant Understory Vegetation	Grass	Mixed	*V. scoparium**

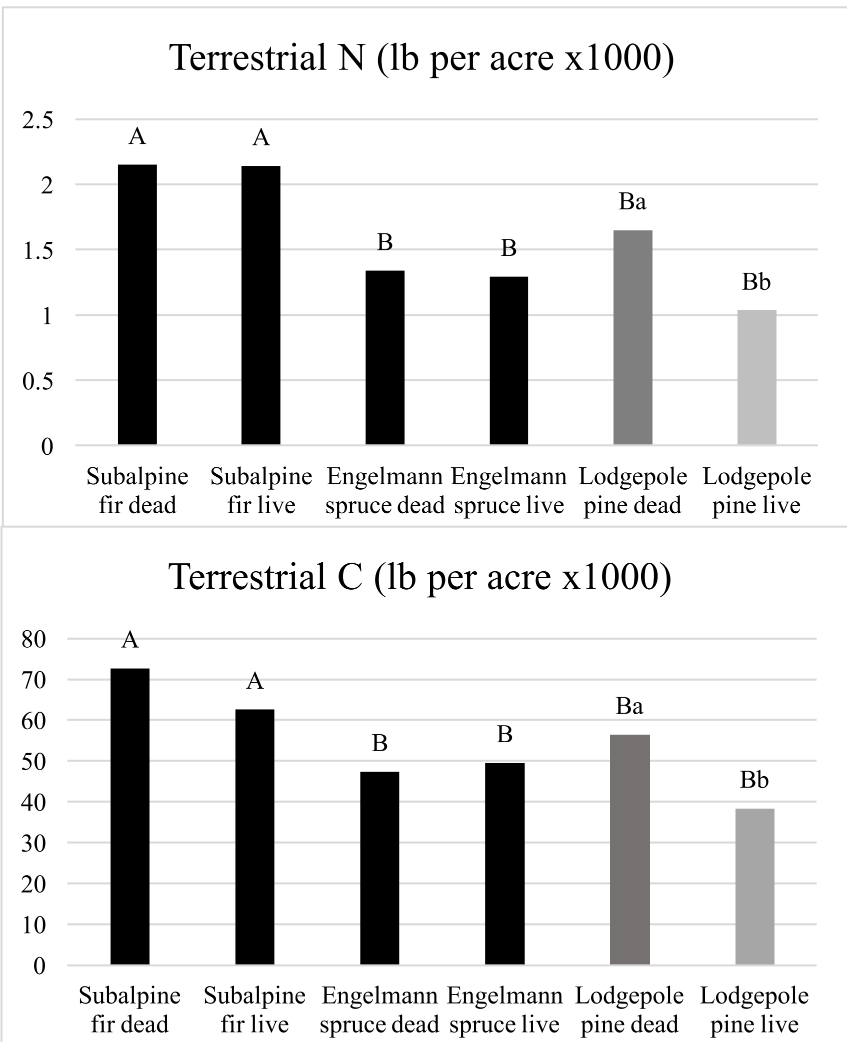

Figure 1. Terrestrial ecosystem N and C (sums of N and C in roots, shoots, soil, and litter) beneath dead and live subalpine fir, Engelmann spruce, and lodgepole pine stands. Capital letters (A and B) indicate significant differences between tree stands while lowercase letters (a and b) indicate significant differences between live and dead tree clusters within tree stands (at $p \leq 0.05$).

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Studies of Natural Enemies and Other Insects Associated with Mountain Pine Bark Beetle

Lawrence Haimowitz[1] *and Scott Shaw*[1]

Introduction

The mountain pine bark beetle (MPBB [*Dendroctonus ponderosae*]) is a tiny, native insect with a disproportionate influence on the western pine forests of North America. It is one of only a handful of bark beetles with the capacity to kill healthy trees. Of those beetles, it affects by far the widest geographical area—nearly a third of the continent. Recent pine beetle activity in southern Wyoming and northern Colorado affected more than 1.5 million acres (U.S. Forest Service, 2017). Although the epidemic is largely over in this area, large expanses of dead trees leave the impression of enormous destruction, which belies the fact that these native insects are as important as fire to the diversity and health of forest ecosystems.

Bark beetles can only kill healthy trees when their numbers are very high. Most years, there are too few beetles to successfully attack healthy trees, and their populations are kept in check by weather-related mortality, predation, and competition from other wood-infesting insects. Under favorable conditions, however, beetle populations can increase enough to kill healthy trees. Because they can reproduce much faster in healthy than in declining trees, epidemics can occur sporadically. Natural enemies (such as beneficial parasitic wasps) play an important role in this process, a role that is not well understood, despite a rich literature on the subject. Even less is known about other MPBB-associated insects.

Most of what bark beetles and their insect associates do in nature takes place under the bark of standing trees, and what happens in a standing tree is difficult to study in the field and not easy to duplicate in the lab. We are adapting new methods for the field study of the MPBB in standing trees.

Objectives

Our objectives are to develop some better tools for the field-study of MPBB and associated insects.

Materials and Methods

We have been conducting our study in the Medicine Bow-Routt National Forests in southeast Wyoming (between Laramie and Cheyenne) and in the Shoshone National Forest in southwest Wyoming (near South Pass) since summer 2014. We are evaluating designs and materials for two methods that can make it easier to conduct field studies of insect-associates of MPBB. One is predator exclusion, a simple, direct method to measure the effect of predation, which has not yet been tried in MPBB research, so far as we are aware. Briefly described, a portion of a beetle-infested tree trunk is protected from predators, and then beetle survival in the protected portion is compared with survival in the rest of the trunk (Figures 1–2). The other method is a trap to capture insects as they emerge from MPBB-infested trees. Both methods require cages to capture and/or exclude insects. Such cages have been commonly used in the study of other bark beetles, and are employed to a small extent with MPBB, so our experiments were based on designs and materials previously described.

Results and Discussion

The only material that we tested that worked reliably for MPBB cages was 60-mesh brass screen. In past bark beetle research, the materials most widely used for insect cages were various forms of shade cloth or weed cloth. We found these to be ineffective for containing or excluding MPBB. Our 2014 and 2015 prototype emergence traps had one or more serious failings, but our most recent iteration (summer 2016, employing brass mesh) was completely successful. Our first predator exclusion experiment, set up in 2015 using cloth mesh, failed to completely exclude or contain insects of interest, so could not be relied upon for a quantitative result. We set up additional prototype exclusion cages in 2016 using the same brass mesh used for emergence traps. Because the MPBB has a one-year life cycle, we should see those results in summer 2017.

Our methods are refinements of methods already in use and are widely applicable to studies of subcortical insects worldwide (insects that live under the bark of trees are called sub-cortical insects).

Acknowledgments

This work is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, as McIntyre-Stennis project WYO-553-15 through the Wyoming Agricultural Experimental Station Competitive Grants Program. We thank our undergraduate research technicians for help with sampling and preparing insect specimens for study and voucher, and we thank personnel with the Shoshone National Forest and Medicine Bow-Routt National Forests 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, predator exclusion, natural enemies

PARP: not applicable

Literature Cited

U.S. Forest Service, 2017, Mountain pine beetle epidemic: Medicine Bow-Routt National Forests, at www.fs.usda.gov/detail/mbr/home/?cid=stelprdb5139168 (accessed April 2017).

Figure 1. Field assistants Karann Putrevu, left, and Ada Harris add breeding pairs of mountain pine bark beetles to a fine mesh cage on a pine tree on Pole Mountain between Laramie and Cheyenne during summer 2016. The beetles inside the cage will breed predator-free, while beetles in the rest of the tree are exposed to natural levels of predation.

Figure 2. Experimental trees are cut into sections, which are moved into the lab to study insect emergence. To determine the effects of predation, beetle survival in the exclusion zone is compared to survival in the rest of the tree.

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

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 baseline 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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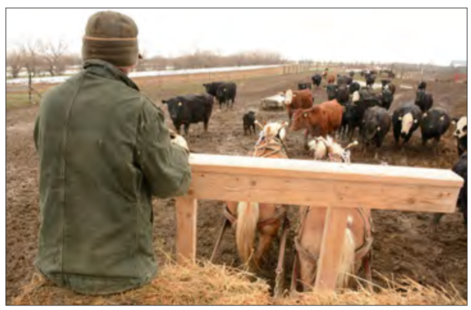
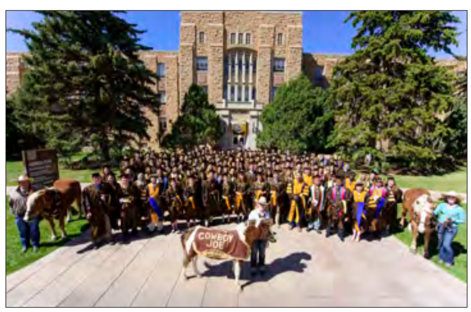
I ♥ Pistol & Pete 2017–2018 Academic Year Calendar









The I ♥ Pistol & Pete calendar is available through the Wyoming Agricultural Experiment Station.
Contact WAES at aes@uwyo.edu or (307) 766-3667.

Download these images as desktop wallpapers at www.uwyo.edu/uwexpstn/calendar

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