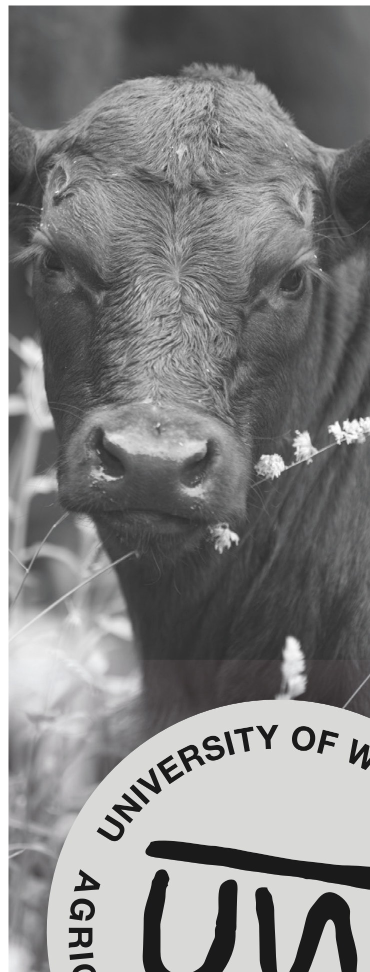
FIELD DAYS BULLETIN



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AGRICULTURAL EXPERIMENT STATION

2013 WAES Field Days Bulletin

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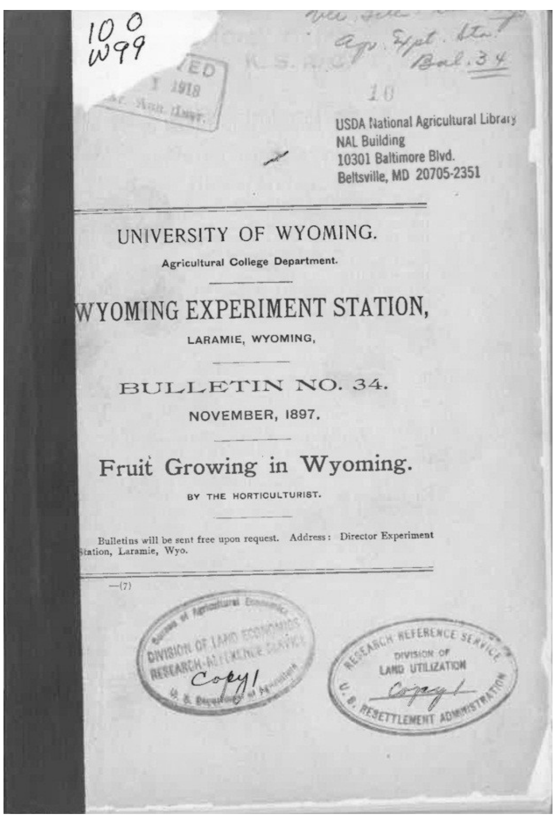
Introduction to the Third Edition of the Wyoming Agricultural Experiment Station Field Days Bulletin

B.W. Hess[1]

[1]Director, Wyoming Agricultural Experiment Station.

Introduction

Passage of the Hatch Act by Congress on March 2, 1887, paved the way for the creation of the Wyoming Agricultural Experiment Station (WAES), and WAES was born by an act of the Wyoming Legislature on January 10, 1891. In the first publication of WAES—printed in May 1891—Director John "Dice" McLaren explained that WAES would distribute bulletins containing reports of various experiments. He further expressed his desire to have WAES researchers talk personally about their experiments with Wyoming citizens.



UNIVERSITY OF WYOMING.
Agricultural College Department.
WYOMING EXPERIMENT STATION,
LARAMIE, WYOMING,
BULLETIN NO. 34.
NOVEMBER, 1897.
Fruit Growing in Wyoming.
BY THE HORTICULTURIST.
Bulletins will be sent free upon request. Address: Director Experiment Station, Laramie, Wyo.

In the beginning, WAES researchers summarized their studies in a series of experiment station bulletins, with the third bulletin calling on Wyoming farmers to participate in cooperator trials. Results of experiments conducted at various stations and cooperating farms were published in subsequent bulletins. Those early reports also invited farmers to contact WAES if they were interested in additional information about the state's emerging agricultural industries.

Those early days of WAES were not very different from the WAES of today. The modern day WAES and its affiliated research and extension (R&E) centers host field days where citizens can learn about WAES experiments through a combination of oral and written presentations. Field day attendees receive an update on the centers' activities and research projects at various stages of completion. Albeit a modification of the early WAES bulletins, today's WAES Field Days bulletins are published annually in an effort to inform citizens about research and other activities being conducted by WAES and the R&E centers.

Early Day WAES Bulletins

The early WAES bulletins, including those in the 1890s, addressed topics with the potential to advance Wyoming's emerging agricultural industry, and that were of interest to the public. The in-depth reports addressed specific topics in a comprehensive manner.

As the state's agriculture evolved, the series provided stakeholders science-based information to help them make sound decisions. Ag scientists often published their work as WAES bulletins because the series was recognized as an important mechanism to disseminate scientific advances to colleagues and stakeholders alike.

Today's WAES Field Days Bulletin

The current WAES Field Days Bulletin series began three years ago. The modern bulletin is published annually and contains a collection of reports summarizing experiments and other WAES activities in a standardized, reader-friendly format. Unlike the extensive and highly focused publications authored more than a century ago by relatively few scientists, each modern-day WAES Field Days Bulletin consists of two-page summaries of projects being conducted across the state by numerous scientists. Authors of this peer-reviewed bulletin are requested to address the high points of their specific project and provide contact information in case readers wish to receive more in-depth information about a particular topic. The WAES Field Days Bulletin is not intended to be a comprehensive report of each experiment; rather, it demonstrates the vast array of activities that may be of interest to a wide variety of citizens in Wyoming. Scientists are encouraged to publish extensive details of their projects in the scientific literature.

Accessing the WAES Bulletin Reports

Bulletin reports from both series can be accessed online. The first 31 reports in the early WAES Bulletin series are available in the Wyoming Scholars Repository at: repository.uwyo.edu/ag_exp_sta_bulletins

The first three of the recent series of WAES Field Days Bulletin reports are at: www.uwyo.edu/uwexpstn/publications

This is an ongoing project, and additional bulletins are being uploaded to the website, so keep checking back.

Acknowledgments

The WAES Field Days Bulletin is funded by the Wyoming Agricultural Experiment Station. Thank you to all the past and present contributors to WAES bulletins, especially current bulletin editors Robert Waggener and Joanne Newcomb for their superb efforts. WAES is very grateful to the UW Libraries' Janis Leath, Chad Hutchens, and Cynthia Kellogg for their efforts in getting the early bulletins digitized and made available online to the public.

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Laramie Research and Extension Center

D. Zalesky[1]

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Introduction

The Laramie Research and Extension Center (LREC) is composed of various units providing a wide range of facilities and animals for use by a large number of disciplines. These units include the greenhouse complex at Harney and N. 30th streets, lab animal facility at the Wyoming State Veterinary Laboratory, and the Livestock Farm two miles west of Laramie. Included in the Livestock Farm are the Swine, Sheep, and Beef units and Cliff and Martha Hansen Livestock Teaching Arena. The mission of LREC is to provide opportunities in research, extension, and teaching for faculty and staff, students, and the people of Wyoming. Facilities and animals at LREC are utilized by numerous individuals to meet the mission of the University of Wyoming's College of Agriculture and Natural Resources. The multiple disciplines that utilize the facilities and animals include the UW departments of Animal Science, Molecular Biology, Plant Sciences, Ecosystem Science and Management, Veterinary Sciences, Agricultural and Applied Economics, and Family and Consumer Sciences, the Microbiology Program, and UW Extension.

LREC Accomplishments

During 2012, several highlights and accomplishments occurred at LREC:

The greenhouse complex (Figure 1) continues to see unprecedented utilization both inside and outside for research, teaching, and outreach. Improvements include installation of additional growth chambers for use by research faculty.

Following the retirement of Kelli Belden in September 2012, we were fortunate to move a long-time employee, Casey Seals, into the position of operations manager for the greenhouse complex. Casey has assumed several of Kelli's roles and brings many years of experience to the position. Additionally, we were able to fill the third full-time position at the greenhouse with a former student employee, Ethan Walter. Ethan earned a bachelor's degree in agroecology in 2012 and will fill the position of laboratory assistant.

Figure 1. Research plants being grown in the greenhouse.

The remodel work on the LREC lab animal facility continues and should be finished this summer. Once the renovation is complete, the facility will immediately be utilized to capacity by several research faculty members in the College of Agriculture and Natural Resources.

During 2012, the LREC Sheep Unit (Figure 2) had a change in managers. Long-time manager Brent Larson resigned to pursue other opportunities in his home state of South Dakota. We thank him for all of his service and dedication to the Sheep Unit and UW. We were fortunate to hire a former student and graduate of the Department of Animal Science, Kalli Koepke, as the new manager. Kalli worked at the Sheep Unit as a student employee for four years. We welcome Kalli and are glad to have her as part of the LREC team.

Figure 2. Lambs born at the Sheep Unit in 2012.

We continue to work with the management teams developed for each of the LREC units. The teams continue to provide valuable input for development of both short- and long-term goals. Input from the teams is also being utilized to develop a long-range strategic plan for LREC, which will be part of the overall plan for the College of Agriculture and Natural Resources and UW.

The Swine and Beef (Figure 3) units continue to be busy with research projects and providing resources for teaching. The units are always working to improve facilities.

Figure 3. Calves born at the Beef Unit in 2012.

The Hansen arena continues to be a hub of activity with numerous events throughout the year. This facility is home to the UW rodeo team and provides a place for other UW teams and clubs to practice throughout the year. During 2012, improvements including a new trophy case and paint in the arena were completed.

Acknowledgments

The success of LREC in providing quality resources for research, teaching, and outreach results from the tireless efforts of the LREC team. The staff that comprises LREC makes all things possible in serving faculty members and students of UW and the people of Wyoming.

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Multi-Dose RB51 Immunity in Cattle

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Introduction

The current vaccine to help prevent brucellosis in cattle in the United States is RB51. It was introduced in the mid-1990s as an improvement over the previous vaccine, S19. While S19 remains approved for use in the country, it is not commonly administered to cattle outside of research protocols. RB51 is an improvement over S19 in that it does not interfere with diagnostic tests and allows for more accurate diagnosis of potentially exposed cattle. RB51, however, does not provide complete protection against infection with brucellosis nor does it prevent production of anti-brucellosis antibodies. It is only designed to reduce the incidence of abortion and thus help prevent the spread of brucellosis from cow to cow.

Wyoming currently requires one dose of RB51 during "calfhood" with the option of an adult booster for all cattle that reside in the designated surveillance area; however, the adult booster is not required, and written permission must be obtained from the state veterinarian to give the booster. All cattle that reside within the designated surveillance area in Wyoming must either be vaccinated with RB51 or spayed prior to becoming sexually mature. Currently, there is no data available on whether booster vaccines provide better protection against abortion due to brucellosis.

Objectives

The objectives are to determine: 1) if one, two, or three doses of RB51 provide better protection against infection and abortion; and 2) if a vaccine given prior to pregnancy will protect against abortion due to a vaccine given during pregnancy.

Materials and Methods

All pre-infection experiments are being conducted at the Wyoming State Veterinary Laboratory (WSVL) in Laramie (Figure 1). Twenty-five Black Angus cattle were divided into four groups. There are three groups of

Figure 1. Cow immunized with RB51 vaccine at the WSVL.

seven and a control group of four. One group of seven will receive just an RB51 calfhood vaccine while another group will receive the calfhood vaccine plus an adult vaccine given during pregnancy. The last group will receive a calfhood vaccine, a vaccine booster before pregnancy, and a vaccine during pregnancy. The control group will not receive an RB51 vaccine. After each vaccine, cattle will be bled (Figure 2) for four weeks and immune tests run on their cells. The tests to be conducted are the: 1) measurement of cell killing; 2) measurement of secreted immune cell products; and 3) analysis of memory cells to RB51 to help determine if there is an increase in immune response to more doses of RB51. All cows at the end of the study in Laramie will be shipped to the U.S. Department of Agriculture's National Veterinary Services Laboratory in Ames, Iowa, to be experimentally infected with brucellosis, so that we can compare clinical data with our results throughout the study.

Discussion

Currently, designated cattle have received their first dose of RB51 vaccine, and blood samples have been collected. The cells have been frozen and stored in a WSVL freezer as we finalize testing procedures. We will then begin to test the cattle for their baseline immunity to the calfhood vaccine. These heifers are scheduled to be vaccinated again in September 2013 and will be artificially inseminated this December. The last vaccine is scheduled for May 2014, and then cattle will be shipped to Iowa in June

Figure 2. Graduate student Alex Kesterson collects blood from a study calf.

2014 to be challenged with a field strain of *B. abortus*. The outcome of this study should provide valuable information on the usefulness of multiple doses of RB51 for cattle in the designated surveillance area. We also hope to better understand the ability of multiple doses of RB51 to reduce abortions in vaccinated cattle.

Acknowledgments

The project was funded by the Wyoming Agricultural Experimental Station, Wyoming Livestock Board, and COANIR Brucellosis Funds. Thanks to Doug Zalesky, Dr. Walt Cook, and Dr. Jim Logan for their hard work obtaining funding. Thanks also to the WSVL staff for continued help with the study.

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Key words: cattle, brucellosis, immunity

The Scent of an Estrous Ewe: Neural Activity in Sexually Active and Inactive Rams Following Sexually Evocative Olfactory Stimuli

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Introduction

The presence of sexually inactive rams decreases the overall productivity of a flock and increases the need for additional rams, prolongs the breeding season, and may decrease pregnancy rates. Approximately 25% of all rams are sexually inactive. Rams rely on olfactory cues to identify ewes in estrus and, unlike bulls and bucks, do not seem to utilize visual cues as observing mating does not increase sexual activity in rams. Sexual inactivity may result from the inability to discriminate sexually evocative odors; or, alternatively, neural pathways required to translate sexual signals into mounting behavior may be impaired in those rams.

The amygdala is a neural structure on the path between the olfactory bulb and the hypothalamus. At the amygdala, olfactory stimuli are placed in context (i.e., estrus vs. non-estrus odors). Neural pathways from the amygdala to the hypothalamus signal the appropriate motoric response (i.e., breed the ewe or head to the feed bunk). In rodents, surgical lesions to the amygdala cause deficits in mating behaviors including the inability to recognize female odors.

The amygdala has several distinct nuclei. The central nucleus of the amygdala has been implicated in states of emotional arousal while the medial nucleus is known to be important in the expression of copulatory behaviors.

Objectives

The objective of this research was to determine if changes in neural activity in response to sexually evocative stimuli may indicate impaired processing of odors in sexually inactive rams.

Materials and Methods

Twelve white-faced rams with established mating behavior were exposed to sexually evocative (urine from estrous ewes) or neutral (urine from ewes that had their ovaries surgically removed) stimuli at the Laramie Research and Extension Center.

Rams were exposed to olfactory stimuli for one hour by wearing a fitted mask with a urine-soaked pad inside. Following the stimulus period, rams were killed so that their brains could be analyzed. Brain tissue was dissected and areas important for the processing of olfactory stimuli were stained for fos proteins, which are indicators of neural activity.

Results and Discussion

Rams with a sexual preference for females (female-oriented) exhibited increased neural activity (*P*<0.001) in the central amygdala when compared to sexually inactive (asexual) rams.

The neural activity in the central nuclei of the amygdala was specific to sexually evocative odors since exposure to urine from ewes with their ovaries removed attenuated (*P*<0.001) neural activity. Increased neural activity in the central amygdala may indicate a state of sensory arousal so that the ram would be “cued” to further stimuli (i.e., the presence of an estrous ewe).

Rams preferring to mount other males (male-oriented) had similar (*P*=0.3) levels of neural activity in the central nuclei of the amygdala in response to urine from estrous ewes as did sexually active, female-oriented rams. In this study, there were limited numbers of male-oriented rams (n=2), and with low numbers of animals, there is always reduced confidence in the results.

Differences in neural activity in the medial amygdala, considered to be important in the expression of sexual behavior, were not detected among rams. Interestingly, sexually active female-oriented rams did not exhibit an increased release of testosterone when exposed to urine from estrous ewes. A lack of an endocrine response to sexually evocative odors may indicate sexually experienced rams require additional sensory stimuli to elicit a sexual

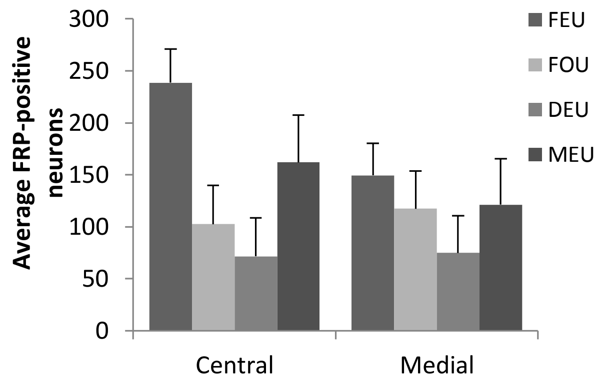

Figure 1. Average fos-positive neurons (FRP) (per 1 mm^2 area) in the central and medial amygdala. (FEU) Female-oriented rams exposed to estrous ewe urine (n=4); (FOU) female-oriented rams exposed to ovariectomized (ovaries removed) ewe urine (n=3); (DEU) asexual rams exposed to estrous ewe urine (n=3); (MEU) male-oriented rams exposed to estrous ewe urine (n=2).

response. Similar levels of neural activity in the medial amygdala among rams exposed to sexually evocative or neutral stimuli support this notion.

Acknowledgments

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Key words: rams, breeding, behavior

The Effect of Diet and Feed-Efficiency Status on Rumen Microbial Profiles in Sheep

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Introduction

Microbes in the rumen of livestock regulate the fermentation of feedstuffs and the energy produced that is used by the animal. They have a significant effect on livestock maintenance, growth, and performance. In turn, the animal provides an ideal environment and substrate for microbes to thrive, creating a benefit for both the animal and microbial populations. Several factors can effect microbial composition in the rumen, including type of feed and changes in diet, age and health of the animal, environmental temperature and seasonality, and geographic location. It has been determined that diet is the main effect on rumen microbial composition; however, there is currently limited understanding of ruminal bacterial communities in livestock, especially as related to feed efficiency.

Because feed costs for livestock are a substantial portion of production costs, improving feed efficiency becomes more important as feed costs continue to rise. Improved feed efficiency can increase performance of animals while decreasing necessary inputs. Residual feed intake (RFI) is a measurement of feed efficiency that is the difference between the actual and predicted feed intake. Relationships between RFI and microbial profiles could lead to the ability to select on feed efficiency using a simple rumen sample.

Objectives

The objectives of this study were to determine whether diet and feed efficiency had effects on rumen microbial populations in growing lambs. We hypothesized that microbial profiles would differ between diets as well as feed-efficiency status.

Materials and Methods

Animals and Diet. Growing wethers of Rambouillet, Hampshire, and Suffolk breed types were randomly allocated by body weight (BW) to receive either a concentrate- or forage-based pelleted diet. Individual feed intake was measured using the GrowSafe system for a 49-day trial. Two-day average initial and final BW were obtained to calculate average daily gain (ADG). From this data, RFI was calculated as the deviation of true feed intake from expected feed intake. Expected feed intake was determined by regressing ADG and metabolic mid-weight on actual feed intake. Residual feed intake calculations were used to rank wether efficiency. Rumen fluid samples were collected at the end of the feeding trial by inserting a tube down the esophagus of each animal into the rumen and suctioning contents up through it using a 50-milliliter syringe.

Microbial Sequencing. DNA was extracted from the rumen fluid of the most- (low RFI) and least-efficient (high RFI) wethers from each diet and was sent to the University of Missouri's DNA Core Facility for sequencing. Sequences were compared with a known database to identify individual microbial species, and individual microbial species included all sequences that were ≥97% similar.

Statistical Analysis. The MIXED procedure of SAS (SAS Institute Inc., Cary, North Carolina) was used to determine the effect of diet on feed intake, ADG, and gain-to-feed ratio using data from all wethers. Breed and pen were considered random effects but had no effect on performance data. A generalized linear model was fitted using the GENMOD procedure of SAS to determine the effects of diet and feed efficiency status, and their interaction on microbial abundance using a Poisson distribution.

Results and Discussion

There were 349 microbial species present in at least one animal. The most abundant species across diets was *Prevotella ruminicola*, which had greater abundance in forage-fed lambs compared with concentrate-fed lambs. In total, there were 56 species that differed by diet, and 39 of those were of greater abundance in forage-fed wethers. Out of 13 *Prevotella* species, nine were greater in forage-fed lambs than in concentrate-fed lambs. Additionally, 11 microbial species differed by feed efficiency (i.e., low versus high), with eight of those species having greater abundance in low-efficiency lambs. Finally, there were 15 species affected by the interaction between diet and feed efficiency; 13 of those were in greater abundance in low-efficiency, concentrate-fed lambs.

Results indicate that diet influences rumen microbes. Furthermore, key rumen microbial species may play an important role in the regulation of feed efficiency, and those species may differ according to diet composition.

Acknowledgments

This research was funded by the U.S. Department of Agriculture–National Institute of Food and Agriculture. The authors thank the Laramie Research and Extension Center Sheep Unit farm crew, the University of Wyoming Meat Lab, and the undergraduate research assistants for assistance with data collection.

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Key words: feed efficiency, microbes, sheep

Microbial Ecology Associated with Improved Feed Efficiency in Sheep

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Introduction

Feed costs represent a substantial portion of the total production costs for livestock producers. For sheep producers, cost of feed can account for 50–70% of total production costs, and for cattle producers it can account for 60–65% of costs. In the future, it is unlikely that feed costs will decrease due in part to an increased demand for limited feed resources. Improvements in feed efficiency would allow producers to maintain a high level of production while utilizing less feed, thus reducing production costs.

Previous research also indicates that improved feed efficiency is associated with lower methane production in livestock species. This suggests that genetic selection for improved feed efficiency would provide potential for increased profitability while reducing the environmental impact of livestock production.

Residual feed intake (RFI) is a novel measure of efficiency that is gaining popularity in livestock industries. RFI is defined as the difference between expected feed intake and actual intake, where lower RFI values indicate greater efficiency. Feed efficiency has been associated with differences in microbial profiles in grain-fed cattle; however, the link between increased feed efficiency and ruminal microflora profiles has yet to be determined.

Objectives

The objectives of this study are to 1) determine ruminal microflora characteristics associated with divergence in feed efficiency in roughage-fed sheep, and 2) determine if ruminal microflora characteristics can be used to rank sheep for feed efficiency.

Materials and Methods

Growing ewes (initial body weight [BW] = 111.3 ± 23.8 pounds) of Targhee breed type received a forage-based (85% roughage) pellet diet. Individual feed intake was measured using the GrowSafe system for a 70-day trial period.

Two-day average initial (start and day two), mid (days 33 and 34), and final (days 69 and 70) body weights were obtained. Rumen samples were collected on days 33 or 34 by inserting a flexible plastic tube into the rumen and siphoning fluid into sterile containers. Rumen fluid samples were immediately frozen and stored at -112^{o} F for future DNA analysis.

Results and Discussion

Data were collected and are currently being analyzed. Initial and final BW will be used to calculate average daily again (ADG). Expected intake will be calculated by regressing ADG and metabolic mid-weight on actual feed intake. From this data, RFI will be calculated as the difference between true feed intake and expected feed intake. RFI will be used to rank ewes from least- (high RFI) to most-efficient (low RFI).

DNA will be extracted from rumen samples of the 5% most-efficient and 5% least-efficient roughage-fed ewes. These samples will be used for metagenomic sequencing (i.e., determining microbial species using genetic technology) at the University of Missouri to identify rumen microflora characteristics associated with greater feed efficiency on a high forage diet. "Profiles" of rumen microbial species important to feed efficiency will be developed, and in a subsequent trial they will be assessed for the ability to predict feed efficiency.

Development of a rumen microbial profile consistent with greater feed efficiency would, in the long-term, allow researchers and producers to rank animals for feed efficiency without the need to undertake an expensive and lengthy feed-intake trial.

Acknowledgments

This project was supported by Agriculture and Food Research Initiative Competitive Grant No. 2011-68006-30185 from the U.S. Department of Agriculture's National Institute of Food and Agriculture.

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Key words: residual feed intake, ruminal microflora, sheep

Effects of Phosphorus Fertilization on the Growth of a Caterpillar Pest

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Introduction

Application strategies for fertilizer can have profound effects on crop–pest interactions in agricultural systems. Higher fertilizer levels can improve a crop's ability to tolerate damage from insect pests. On the other hand, higher fertilizer levels can make plants more attractive to pests, increase pest survival, and increase the chance of pest outbreaks.

These phenomena are best documented for nitrogen (N) fertilization. The effects of phosphorus (P) fertilizer on pest insects are poorly known. Yet application strategies for P vary widely among growers; instead of annual applications, some growers use "mega-applications" of P because leaching is not an issue (as it can be with N). These "mega-applications" reduce application costs. Might different P application strategies affect pest population outbreaks?

Recent studies with aquatic invertebrates and fruit flies suggest that P is a crucial component of genetic material (DNA and RNA), which, like nitrogen (protein), is required for both development and reproduction. A recent review of the effect of P on aquatic invertebrates proposed that the response of animal development to dietary P should be "dome-shaped." That is, animals should initially do better on higher P foods and then do worse as P levels increase, presumably because of energy costs of excreting excess P. Applied to pest insects, this "intermediate P" hypothesis suggests that pest growth should initially increase as levels of P fertilization increase; however, very high levels of P should negatively affect insect pests.

Objectives

The objective of this research was to test the "intermediate P" hypothesis using the cabbage looper (*Trichoplusia ni*) feeding on broccoli (*Brassica oleracea*) as an experimental system. Cabbage loopers are one of four key caterpillar pests of cole crops (broccoli and cabbage, mustard greens, and canola) in the U.S.

Materials and Methods

Broccoli plants were grown in 800-milliliter pots from seed in the Laramie Research and Extension Center (LREC) greenhouse complex. An initial batch of 10-week-old plants was used to raise caterpillars to a transferable size (9 days in age). These plants were grown under conditions of low P (0.8 mg PO_4/pot) and high potassium nitrate, magnesium sulfate, iron chelate, and micronutrients (weekly at three times the standard rate). Nine-day-old caterpillars were weighed and then transferred from

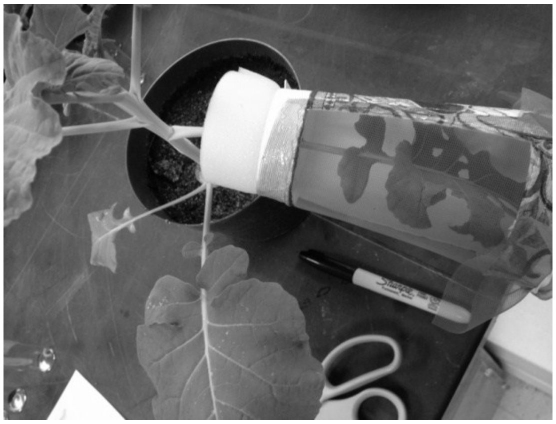

Figure 1. Experimental broccoli plant with cage.

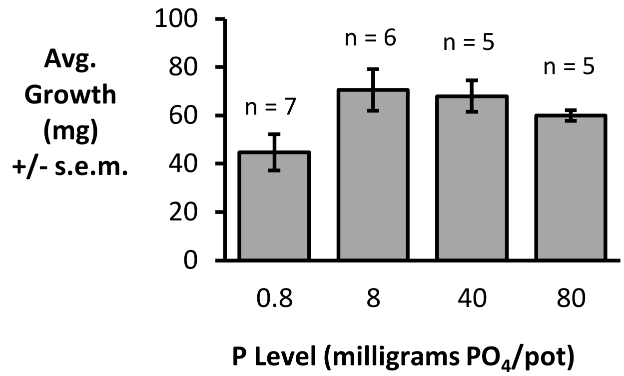

Figure 2. Effects of phosphorus fertilization on cabbage looper growth. The number of caterpillars (n) for each treatment is given above the bars.

these "feeder" plants to 10-week-old experimental plants that had received one of four different P treatments: 0.8, 8, 40, or 80 milligrams PO_4/pot. Experimental plants also received a weekly dose of high levels of potassium nitrate, magnesium sulfate, iron chelate, and micronutrients. Each caterpillar was housed inside a cage constructed of a Styrofoam cup on a single leaf of an experimental plant (Figure 1). After one week on the experimental plants, the caterpillars were weighed.

Results and Discussion

Caterpillars grew the most on plants receiving the two intermediate levels of P, as predicted by the "intermediate P" hypothesis (Figure 2). Growth was reduced most for caterpillars feeding on plants receiving the lowest level of P; growth was less reduced at the highest level of P. These results suggest that fertilizer-application strategies for P have the potential to affect pest insects. "Mega-applications" of P, which can save growers in application costs, are not expected to promote insect outbreaks, as high levels of N fertilizer can. High P may in fact negatively impact pest insects.

Key questions remain. How are other insect pest species affected by P, especially under field conditions? How do levels of P affect plant attractiveness to pest insects? Finally, how is plant tolerance to pest damage affected by levels of P fertilizer? The effect of P application strategies on crop–pest interactions is multi-faceted and much remains to be investigated.

Acknowledgments

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Key words: crop production, pest management, *Brassica*

Forage Kochia May Have Potential for Both Forage and Reclamation

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Introduction

Areas of land disturbed by human activities—such as mineral extraction, travel corridors, and agricultural operations—often require specialized treatment to rehabilitate. This task is complicated in the semiarid West by lack of precipitation, low nutrient content, and high salinity. Challenging weed species such as cheatgrass (*Bromus tectorum*) create barriers to the success of reclamation. Disturbed sites may remain without plant cover for a quarter century or longer despite revegetation efforts. These problematic areas are often unsuitable for grazing, subject to erosion, lacking in organic material, and invaded by weeds.

Forage kochia (*Bassia prostrata*) is a semi-shrub evergreen species that was introduced to the U.S. It is native to central Asia and has the ability to provide feed during late fall and winter when most native rangeland grasses are dormant and unproductive. It can tolerate harsh environments with limited vegetation and has the ability to compete successfully with annual weed species. There is a misconception that this species is related to the weed kochia (*Kochia scoparia*; also known as burningbush), a toxic annual found throughout the Intermountain West. Forage kochia, however, is not related to this annual weed and should not be confused with it. There are two released cultivars of forage kochia ('Snowstorm' and 'Immigrant') in the U.S. that have been used on private land throughout the West. Considering its characteristics, forage kochia may have potential to serve as an additional tool for reclamation and land management.

Objectives

The major objectives of this project are to: 1) determine the potential of forage kochia to reclaim and revegetate disturbed areas of low reclamation potential; 2) determine the level at which forage kochia is competitive with multiple common species; and 3) develop an establishment and management plan to reclaim and revegetate areas that are of low reclamation potential. An additional objective is to research the differences between Snowstorm and Immigrant.

Materials and Methods

This is an ongoing study that includes a field experiment, located at the Laramie Research and Extension Center, and multiple greenhouse competition trials. The field study consists of 19 treatments of different mixtures of commonly used perennial grasses for reclamation placed on a disturbed site. A fall dormant planting took place in November 2012, and a late winter dormant planting was completed March 8, 2013. The relatively short viability of forage kochia seed (up to 85% reduction in germination after one year) presents many questions about planting time and seedstock use. The two planting times should provide insight for management.

Results and Discussion

Growth monitoring and data collection will start in summer 2013 for this ongoing field study. The greenhouse study has shown differences in competitive ability between Immigrant and Snowstorm. Immigrant responded with significantly less ($p<0.0001$) biomass loss as a result of increased plant density within the pots (Figure 1); however, the opposite occurred for interspecific competition (data not shown).

Our previous studies showed that forage kochia increased forage quality and yields throughout August–October compared to adjacent perennial grass communities (details can be found in the 2012 Field Days Bulletin, pages 35–36, at www.uwyo.edu/uwexpstn/publications).

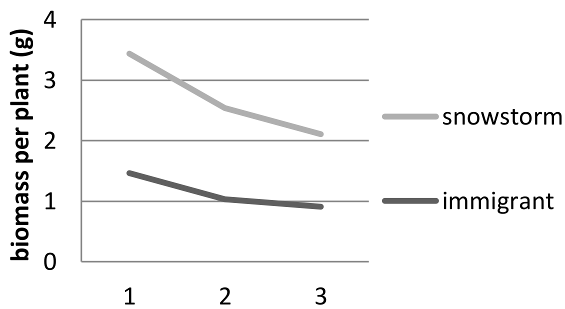

Figure 1. Intraspecific competition level of forage kochia grown at 1=low, 2=medium, and 3=high levels of self-competition.

This indicates that forage kochia, with its high forage value and competitive ability, may have potential for reclamation of disturbed areas. Insights from this study will help determine the competitive abilities of the two cultivars being studied and to develop best-establishment and management strategies of forage kochia.

Acknowledgments

The study was funded by the Wyoming Reclamation and Restoration Center.

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Key words: reclamation, forage kochia, cheatgrass

Benefits from Grass–Legume Mixtures in Forage-Production Systems

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Introduction

In forage-production systems, one of the most limiting factors is nitrogen (N). Nitrogen fertilizer often accounts for almost one-third of total forage-production costs. Application of chemical fertilizers is a general practice to increase crop production; however, it has many adverse effects. For example, producing and transporting these fertilizers are energy intensive and costly. These processes also increase fossil fuel consumption and create environmental problems by emitting greenhouse gases and polluting ground water. Blue baby disease in humans and nitrate toxicity in cattle are associated with the use of synthetic N fertilizer. Additionally, it can deplete soil organic matter, acidify soils, and reduce soil microbial activity and diversity. To minimize these problems, it is necessary to find an environmentally friendly option to provide N for forage production.

Mixing legumes with grass may be a good option as legumes can "fix" atmospheric N (through rhizobium bacteria in root nodules), improve forage yield and quality, reduce N fertilization costs, help produce uniform crop yields, improve soil properties, save energy, and help protect the environment. Previous studies on grass–legume mixtures show that legume persistency is a problem when grown in a mixture with grass and tends to disappear after a few years of continuous cultivation. Limited information is available on the appropriate proportion of grass–legume mixture for the best production and persistence. The major goal of this study is to improve yield and quality of forage, help lower production costs, and improve the long-term profitability and sustainability of forage-production systems.

Objectives

Objectives are to compare the performance of different combinations of grass–legume mixes, study the effect of grass–legume mixtures on soil carbon (C) and N status, and estimate and compare the economics and fertilizer N replacement value of legumes when mixed with grass.

Materials and Methods

This is an ongoing study at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Sixteen treatment combinations with two grasses ('Fleet' cultivar of meadow brome and 'Paiute' cultivar of orchardgrass) and one legume ('WL 319 HQ' cultivar of alfalfa) were planted September 20, 2011. The grass:legume seeding ratios (percentages) were 100:0, 75:25, 50:50, 25:75, and 0:100 for both grasses with legume. Both grasses were also planted as 100% grass monocultures with and without N fertilizer application. Nitrogen was applied at the rate of 134 pounds per acre as urea. A mixture of three crops as a percentage was also used: 12.5:12.5:75, 25:25:50, and 37.5:37.5:25 for meadow brome, orchardgrass, and alfalfa. Sixteen treatments were replicated three times in a randomized complete block design.

Results and Discussion

There were variations among treatments for dry matter (DM) yield of forage (Figure 1). For example, 50%:50% mixture of alfalfa and meadow brome produced the highest DM yield (12,048 pounds per acre per year) while the orchardgrass monoculture without N fertilizer application produced the lowest DM yield (7,420 pounds per acre per year). Likewise, variations were also observed among treatments for crude protein (CP) production with the higher CP production from 50%:50% mixture of grass and legume (data not shown). It appears that the 50%:50% ratio of grass–legume mixture could increase yield, improve quality, and reduce production costs (no use of nitrogen) in forage-production systems. However, please keep in mind that this study is ongoing.

Acknowledgments

We thank SAREC crews and lab members for their assistance.

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Key words: grass–legume mixture, forage quality, soil N

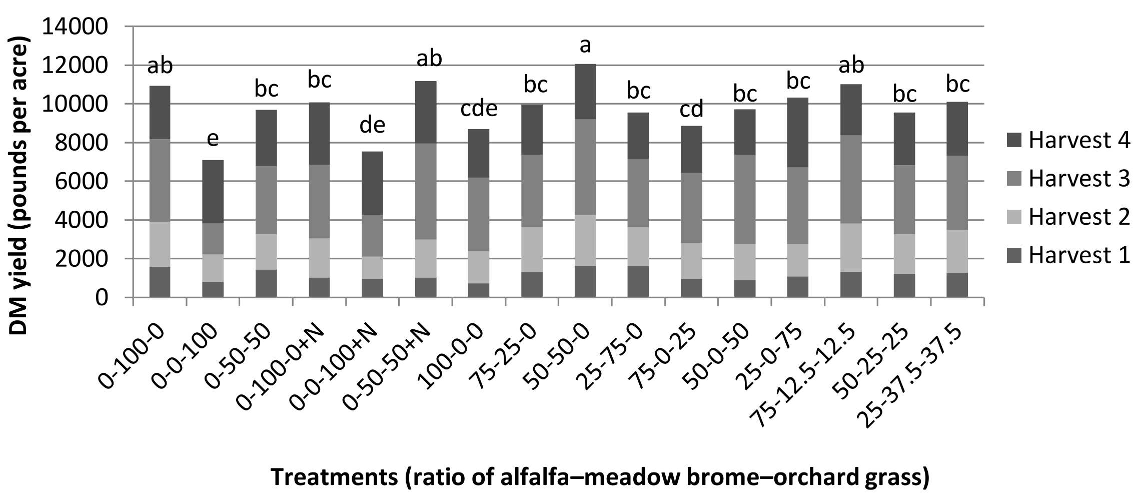

Figure 1. Dry matter (DM) yield of forage from different ratios of grass–legume mixtures at SAREC in 2012. N=recommended dose of N as urea. Harvesting dates were: June 12, July 10, August 14, and October 12. Means followed by the same letters in the bars do not differ significantly (P>0.05).

Forage and Biomass Potential and Their Genetics of Tall Fescue Genotypes

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Introduction

Tall fescue [*Schedonorus arundinaceus* (Schreb.) Dumort] is one of the most productive cool-season grass species in the U.S. It can grow on a wide range of soils, has high drought and winter hardiness, and can be used for pasture, hay, silage, soil conservation, and turf grass.

Forage crops have low requirements of fertilizers, herbicides, and land preparation compared to other crops. High net biomass can be expected in marginal lands when forages are utilized. As a consequence, forages may allow producers to harvest important commodities (e.g., fiber, animal feed) from lands that would otherwise be incapable of high productivity.

Demand for new and suitable plant materials is a long-term issue and is increasing continuously to improve productivity. Major limitations are lack of appropriate cultivars or selections, limited growth response to added resources (e.g., fertilizers, irrigation, rain-fed conditions), and poor adaptation.

Objectives

Objectives of this study are to measure the production potential of tall fescue genotypes and identify agronomic traits relating to growth and biomass production.

Materials and Methods

This experiment was established at the Laramie Research and Extension Center (LREC) in 2008. The 252 genotypes of tall fescue were planted in three replicated plots under both irrigated and dryland conditions. Field measurements of multiple growth parameters (e.g., plant vigor, plant height, leaf width, tiller number, plant girth, seed head, and canopy temperature) were collected three times each year starting in 2009. Fresh weights, dry weights, and relative water content were also recorded. Plant samples from selected genotypes were ground, and near-infrared reflectance spectroscopy (NIRS) is being used to determine forage quality (e.g., crude protein, fiber contents), relative feed value, sugar/starch content, and total digestible nutrients.

Approximately 9,000 polymerase chain reactions have been run and analyzed to generate the genotypic dataset for future improved variety selection and development. Advanced computer programs are being used to carry out the plant genotyping and mapping of traits.

Results and Discussion

Data show substantial variation between treatments (irrigated vs. dryland) and among genotypes for several desirable traits during four years of data collection (details can be found in the 2012 Field Days Bulletin, pages 33–34, at www.uwyo.edu/uwexpstn/publications). For example, in 2012, some of the dryland genotypes had similar relative water content (RWC) compared to irrigated conditions indicating their relatively high drought tolerance (Table 1). Range and mean for RWC and other growth parameters are summarized in Table 2.

Our genetic mapping is identifying the most productive genotypes, which will aid in development of future cultivars specifically suitable for Wyoming's conditions. This analysis is ongoing. Measuring genetic effects on complex traits like drought tolerance, biomass production, and forage quality should result in the development of new cultivars with improved and desired traits, such as drought tolerance, high forage quality, and high biomass.

Acknowledgments

We thank The Samuel Roberts Noble Foundation for providing genotypes and assistance in genetic analysis.

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Key words: tall fescue, genetic analysis, forage

Table 1. Average dry weight and RWC of selected genotypes of tall fescue under two treatments (dryland vs. irrigated) in 2012 at LREC.

Genotype	Dry Weight (g/plant)		RWC (%)	
	Dryland	Irrigated	Dryland	Irrigated
249	12	85	68	68
163	8	62	66	66
169	7	38	64	64
126	10	69	64	64

Table 2. Range and mean of different growth parameters across all replicates and harvests in 2012.

Trait	Dryland			Irrigated		
	Min.	Max.	Mean	Min.	Max.	Mean
Plant height (cm)	7	17	12	10	23	19
Tiller/plant	10	108	63	48	392	244
Leaf width (cm)	0.5	0.7	0.6	0.6	0.8	0.7
Fresh weight (g/plant)	5	140	71	48	500	305
Dry weight (g/plant)	2	40	21	10	133	80
RWC (%)	63	78	67	64	74	69

The Effects of Winter Protein Supplementation on Subsequent Calf Feedlot Performance and Carcass Characteristics

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Introduction

At present, little is known about the underlying mechanisms whereby alterations in conceptus nutrient deprivation result in permanent changes in structure, physiology, and metabolism of the neonate, a condition referred to as "fetal programming." Our laboratories have demonstrated that protein supplementation during the last trimester of pregnancy can impact the growth and reproductive success of the heifer calf progeny, and more steer calves grade choice than progeny from non-supplemented cows.

Although good evidence exists that protein supplementation can enhance offspring development, detailed studies are needed to determine if there are changes in potential nutrient transport during pregnancy and if the steer progeny have differing rates of gain. This is particularly important for the northern Great Plains, where a large proportion of feeder calves are generated. Even when genetics and nutritional management of calves are constant, growth characteristics and subsequent carcass composition vary considerably. Additionally, the relatively large variations in tenderness in postmortem beef muscle from animals of similar genetics, sex, age, and nutritional management cannot presently be explained.

Objectives

The objectives of the experiment are to evaluate 1) the impacts of maternal protein supplementation during the last trimester on growth rates and feed efficiency of steer calves from weaning to finish, and 2) the impact of maternal nutrition on heifer calf performance.

Materials and Methods

A large number of cattle in the Great Plains are produced in regions that are either too high in altitude or receive inadequate moisture to support corn production or corn stalk grazing as a winter feed source. Because of this, 150 mature crossbred cows from the Laramie Research and Extension Center (LREC) were randomly assigned to receive grass hay (48% total digestible nutrients and 5.8% crude protein [CP]) and either 0 or 2 pounds of protein supplement (distillers grains with solubles based; 30% CP) at LREC. Supplementation began

December 1, 2010, through February 28, 2011. The non-supplemented group grazed winter pasture until either weather or forage quantity dictated that forage was supplemented.

Results and Discussion

Cows that were supplemented protein over the winter gained more weight and had greater condition scores compared to cows that were just fed winter hay alone. Although the cows that were not supplemented protein over the winter had a lower condition score at calving, there was no difference in the first-service or overall conception rates of the cows. There is much data to suggest that cows in a lower body condition score (BCS) will have worse conception rates. There was a 0.5 BCS difference at calving between the two groups; however, there was no difference between the two groups by the breeding season, indicating the non-protein-supplemented group was on an increasing plane of nutrition by the breeding season, likely resulting in similar conception rates.

Calf birth weight between the two treatment groups also did not differ; however, weaning weight was 25 pounds greater for calves born from cows supplemented protein over the winter. This weight advantage remained throughout the feedlot period and resulted in a strong tendency at hot carcass weight with a 50-pound advantage for the protein-supplemented group. However, there was no other feedlot-performance or carcass-characteristic differences between calves from the two groups. Heifers born from the cows on this study had similar body weights at breeding, and there was a tendency for greater conception rates (15% greater) in the heifers born of protein-supplemented dams.

This data is in agreement with previous research that suggests there is a development programming response to the fetus that is in utero. In this study, supplementing protein over the winter to beef cows resulted in statistically heavier weaning weights for all calves and tendencies for greater hot carcass weights from steers and increased first-service conception rates in heifers, which could have an economic impact to ranchers.

Acknowledgments

We recognize the hard work of Travis Smith, Beef Unit manager at LREC, and Jim Freeburn and the entire staff at the James C. Hageman Sustainable Agriculture Research and Extension Center near Lingle. This project was funded by the U.S. Department of Agriculture’s Five-State Ruminant Consortium.

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Key words: protein supplementation, carcass characteristics, fetal development

Regulation of Nuclear Size in Cancer Cells

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Introduction

The nucleus is a compartment within each cell that contains the genetic information directing the growth and identity of that cell. The size of the nucleus is often inappropriately enlarged in cancer cells, a change that pathologists use to diagnose and stage disease. Little is known about the causes or effects of nuclear morphology changes in cancer.

Objectives

The goals of this study are to determine how nuclear size impacts cell function and contributes to cancer development and progression. Novel approaches and targets for cancer diagnosis and treatment will be suggested, and new cancer susceptibility factors could be identified to aid in prevention. The proposed basic biomedical research on nuclear-size regulation will help provide the foundation for cancer diagnosis, treatment, and prevention.

Materials and Methods

Using a *Xenopus* (African clawed frog) model system, we previously identified protein factors that regulate nuclear size: importin α, Ntf2, and lamin B. To test if these same proteins regulate nuclear size in human cells, we utilized three different human tissue culture cell lines. These are cells that we are able to grow and propagate in dishes in the lab. HeLa cells were derived from a cervical cancer, U2OS cells were derived from a malignant bone tumor, and MRC5 cells are normal lung fibroblasts (cells that contribute to the formation of connective tissue fibers). Using a technique called transfection, we introduce DNA encoding importin α, Ntf2, and lamin B into these cells to alter levels of the proteins. Twenty-four hours after transfection, we visualize nuclei in the cells by fluorescence microscopy using a DNA dye. We then quantify nuclear and cell size using imaging software. We are also able to reduce the levels of specific proteins using a technique called RNAi.

Results and Discussion

We find that in all three cell lines tested, increasing the levels of importin α or lamin B resulted in increased nuclear size. Conversely, increasing the levels of Ntf2 led to smaller nuclei (Figure 1). These results are consistent with how these proteins are known to control nuclear size in *Xenopus*. The most extreme effects on nuclear size were observed in MRC5 cells. We think this makes sense because these are relatively normal cells while the other two cell lines are derived from cancers. Reducing the levels of importin α and lamin B in HeLa cells reduced nuclear size (Figure 1).

Interestingly, we observed that cell size changed concomitantly with nuclear size. When we increased nuclear size in HeLa cells, cells also became larger. Conversely, reducing nuclear size also reduced cell size (Figure 2). These data suggest that cells are able to sense the size of their nuclei and respond accordingly. Now that we have established that we can alter nuclear size in mammalian tissue culture cells, our plan is to assess the functional consequences. Cancer cells generally display high rates of growth and proliferation and the ability to migrate. We will test how altering nuclear size affects these activities. In particular, we want to know if reducing nuclear size in cancer cells leads to reduced growth and spreading. Conversely, we will determine if increasing nuclear size in normal cells is sufficient to confer rapid growth and migration characteristic of cancer cells.

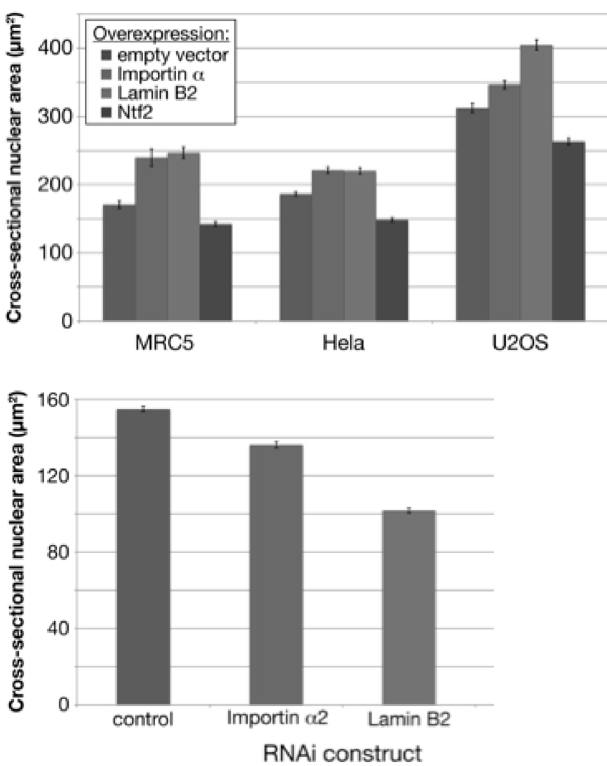

Figure 1. For overexpression (top), we transiently transfected three cell lines with the indicated plasmids and analyzed nuclear size 24 hours post-transfection. RNAi knockdown (bottom) was performed in HeLa cells for 72 hours. N>100 nuclei for each condition. All differences from control are significant by student's t-test (P<0.005).

Acknowledgments

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Key words: nuclear size, cancer cell biology, health

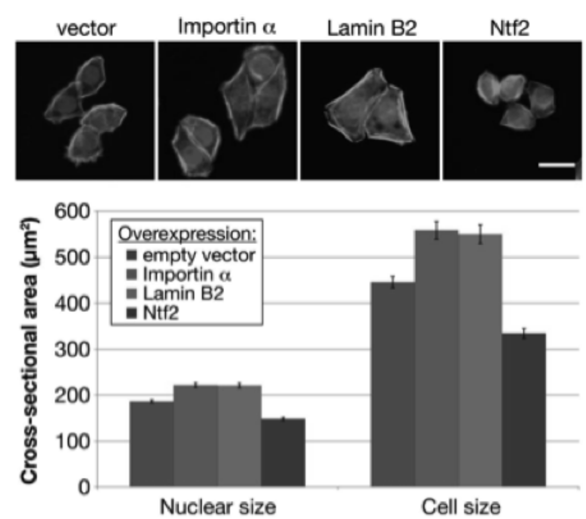

Figure 2. We transiently transfected HeLa cells with the indicated expression constructs for 24 hours. Nuclei were stained with Hoechst and cells were stained with Alexa Fluor 488 phalloidin to visualize the actin cytoskeleton. The scale bar is 25µm. Quantification was performed as in Figure 1.

Effects of Supplementation with a Pressed Dried Distillers Grain Block on Beef Cow Performance and Subsequent Calf Body Weights

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Introduction

Feed costs represent the majority of operating costs for beef cow–calf producers. Grazing of low-quality forages often requires protein and/or energy supplementation for optimal production of cattle. Supplementation can be expensive and labor intensive; therefore, investigation of alternative supplementation methods that minimize labor while still offering adequate nutrients is necessary.

Use of co-product feeds such as dried distillers grains with solubles (DDGS) has increased recently due high corn prices. DDGS contains more protein (and increased ruminally undegradable protein), fat, and fiber content than many traditional supplements such as corn. Reports indicate that feeding diets containing greater overall protein content to dams during mid and late gestation results in improved fetal and pre-weaning calf growth, resulting in heavier weaning weights.

Objectives

Our initial objective was to evaluate the effects of supplementing medium-quality grass hay with a SweetPro® 16 DDGS block to beef cows during late gestation. Because cows supplemented with SweetPro 16 showed greater performance during late gestation and consumed less feed, our current objective was to determine the effects of maternal nutrition on subsequent calf birth weight and weaning weights.

Material and Methods

Seventy-two late-gestation crossbred beef cows at the Laramie Research and Extension Center Beef Unit ranging from 5 to 9 years of age (average=6.9 years) were blocked by expected calving date and randomly allocated by body weight to one of three treatments. Eighteen pens were used, allowing for six replicates of each treatment (four cows/pen). All treatments had access to *ad libitum* chopped grass hay for the 70-day trial. The control (CON) treatment received only *ad libitum* grass hay (8.1% crude protein [CP]; 57.7% neutral detergent fiber) without any supplementation. The second treatment (BLOCK) had *ad libitum* access to SweetPro 16, a pressed DDGS-based block (22.4% CP and 6.9% Fat). The positive control treatment (POS) received 1.26 $lb \bullet cow^{-1} \bullet d^{-1}$ (as fed) of supplement to resemble suggested intake and nutrient composition of the BLOCK (57% corn and 43%DDGS; 19.2% CP and 6.4% Fat).

Table 1: Effects of supplementation on hay intake and cow performance

	Treatment			
	CON	BLOCK	POS	*P*-value
Hay intake, lb DM	28.0[a]	27.3[b]	27.8[ab]	0.05
BW change, lb	128.0[a]	168.7[b]	168.2[b]	0.007
BCS change	0.34[a]	0.53[b]	0.68[c]	0.006

[abc] Means with different superscripts differ ($P < 0.10$). (Previously presented by Marshall et al. in the 2012 WAES Field Days Bulletin.)

Hay fed to pens was measured once daily and refusals measured once weekly to monitor hay intake per pen. Individual body weights and body condition scores (BCS) were monitored throughout the study. Treatments were ended 10 days before calving began, and cows were managed together. Birth and weaning body weights of calf progeny were recorded.

All animal procedures were approved by the University of Wyoming Institutional Animal Care and Use Committee.

Results and Discussion

As previously reported, dry matter intake was decreased in cows fed BLOCK compared to cows receiving CON (Table 1). Body weight increase was greater for cows in the BLOCK and POS treatments compared with CON over the entire study. Cows receiving the POS treatment had the greatest increase in BCS during the study, while the BLOCK treatment was intermediate, and CON was least.

Table 2: Effects of dam supplementation on subsequent calf body weights.

	Treatment			
	CON	BLOCK	POS	*P*-value
Calf Birth Weight, lb	89.4	87.2	85.2	0.50
Calf Weaning Weight, lb	502	487	487	0.74

Despite these differences in cow performance, there was no effect of dam treatment on calf birth weight or weaning weight (Table 2). These data suggest that the increased dietary intake of protein from supplementation was not enough to alter fetal growth or pre-weaning growth. Because CON cow body weight and BCS increased during this study, nutrients provided by hay only may have met cow nutrient requirements during late gestation. Cows in this study had previously been grazing winter range; thus, the hay was likely an increase in nutritional plane resulting in compensatory growth.

Acknowledgments

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Key words: beef cows, gestation, supplementation.

The Relationship of Feed Efficiency and Visceral Organ Size in Growing Lambs Fed a Concentrate or Forage-Based Diet

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Introduction

Rising costs of limited-feed resources within the sheep and beef cattle industries have increased feed costs, decreasing producer profitability. One way to reduce feed costs is to select for animals within the flock or herd with reduced intake and improved feed efficiency. Residual feed intake (RFI) is a measure of feed efficiency that is moderately heritable and genetically independent of mature size.

Although interest in RFI and feed efficiency is increasing in both research and industry settings, physiological mechanisms underlying differences in individual feed efficiency remain largely unknown. The gastrointestinal tract (GIT) is not only essential for nutrient digestion and absorption, but it is also a major energy and nutrient user in the animal. Despite recent research in our lab and others, the role of the GIT in feed efficiency is still unclear.

Objectives

We hypothesized that a portion of individual differences observed for feed efficiency can be attributed to GIT size and function, which would vary based on diet. The objective of this study was to determine GIT and visceral organ size in high- and low-efficiency growing lambs fed either a concentrate- or forage-based diet.

Materials and Methods

Eighty-two growing wethers of Rambouillet, Hampshire, and Suffolk breed types were randomly allocated by body weight to receive either a pelleted concentrate-based diet (CONC; 50.2% corn and 31% wheat middlings) or pelleted forage-based diet (FOR; 67.7% alfalfa pellets and 27.5% wheat middlings). Individual feed intake was measured by the GrowSafe feed intake system for a 49-day trial period, and RFI was calculated for each lamb.

Based on their RFI, the 20% most efficient (low RFI; n=8) and 20% least efficient (high RFI; n=8) wethers from each diet type were slaughtered at the University of Wyoming Meat Lab. At this time, the GIT and visceral organs were dissected and measured. All animal procedures were approved by the UW Institutional Animal Care and Use Committee.

Results and Discussion

Body weight at slaughter was not affected by diet type or RFI class (average=146.7 lb). High-efficiency (low RFI) lambs tended to have greater (*P*=0.09) pancreas (0.21 vs. 0.18 lb) and spleen (0.24 vs. 0.21 lb) mass than low-efficiency lambs, although RFI class did not affect empty GIT, stomach complex, small intestinal, large intestinal, omental (belly) fat, mesenteric fat (the protective fat layer that covers the intestines), liver, lung, heart, or kidney mass. Organ mass per unit of body weight of all visceral organs was unaffected by RFI class. Additionally, small intestinal length was not influenced by RFI class in this study. As expected, diet type impacted ($P<0.05$) mass and mass per unit of body weight for several visceral and GIT organs.

To the authors' knowledge, this is the first study investigating a relationship between visceral organ size and RFI in growing lambs. Results indicate that pancreas and spleen size may be greater in more-efficient lambs. Given the many digestive and metabolic functions of the pancreas, increased pancreas function could improve feed efficiency. A companion study, however, found no differences in two digestive enzymes produced by the pancreas (α-amylase or trypsin) between high- and low-efficiency lambs. Increased spleen mass may suggest greater blood volume or altered red blood cell dynamics or immune response in more-efficient lambs.

Recent data from our lab in feedlot cattle demonstrate a possible relationship of small intestinal mass and growth with RFI in feedlot cattle. Differences between the current study in lambs and work in cattle may be due to species, or multiple breeds in the current study may have diminished differences due to RFI class.

In summary, visceral organ size in growing lambs was more affected by diet type than individual feed efficiency status, as measured by RFI, in the current study. Despite this, pancreas and spleen size and function differences may exist between high- and low-efficiency lambs.

Further research is necessary to determine the role of the visceral organs, and especially the GIT, in ruminant animal metabolic efficiency. Better understanding of this relationship will allow for creation of management strategies to improve efficiency at the gut level.

Acknowledgments

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Key words: feed efficiency, residual feed intake, sheep

Wyoming Brown and Gold Fresh Cut Sunflowers Completion Report

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[1]Department of Plant Sciences.

Introduction

Interest in local production of agricultural commodities is increasing in Wyoming. Much of the discussion centers on edible crops, but interest in growing ornamentals is increasing as well.

One purpose of this project was to successfully grow fresh brown and gold cut sunflowers for local market. Another purpose was to make available to Wyoming growers the methods used. And, using University of Wyoming brown and gold colors may increase the attractiveness of the flowers for consumers.

Objectives

This project had the main goal of adding a niche specialty cut flower for Wyoming growers who use high tunnels or greenhouses for production. The aim was to add a quick turn-around specialty crop that could be grown in Wyoming for sale at local venues such as retail florists and farmers' markets. This would hopefully encourage expansion of specialty crop production in Wyoming.

Materials and Methods

Three cultivars of sunflowers, *Helianthus annuus*, were grown in a greenhouse and two high tunnels at the University of Wyoming's Laramie Research and Extension Center greenhouse complex in Laramie. The current project began in November 2011, and data collection continued through April 5, 2013, when the last flower was harvested.

Cultivars grown were 'Dafna', 'Procut Bicolor', and 'Sunbright Supreme' (Figure 1). For greenhouse production, seeds were sown every two weeks, enough for at least 16 plants per cultivar for continuous production (one seed equaled one harvestable stem) from November 2011 through April 2013.

The first crop of seedlings was transplanted into the high tunnels May 17, 2012, with a subsequent planting August 23, 2012.

Figure 1. Fresh cut sunflowers grown in a greenhouse and two high tunnels. 'Dafna' is on the left, 'Sunbright Supreme' is upper center, and 'Pro Cut Bicolor' is to the right.

Data were collected on days to emergence from sowing, days to harvest, and stem lengths. Experimental design was a randomized complete block with four replications. All data were analyzed using analysis of variance and mean separations. Stems were harvested when all outer (ray) petals had opened.

Results and Discussion

We found statistical differences between the two tunnels in stem lengths (50–60 cm minimum for most purposes) but not in days to harvest (Figure 2). There were numerous differences between the greenhouse-grown sunflowers and those grown in the high tunnels. These differences were cultivar-dependent (Figure 2).

Acknowledgments

Funds for this project were provided through the Wyoming Department of Agriculture and the U.S. Department of Agriculture's Specialty Crop Block Grant Program.

Contact Information

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Key words: flowers, greenhouse, high tunnel

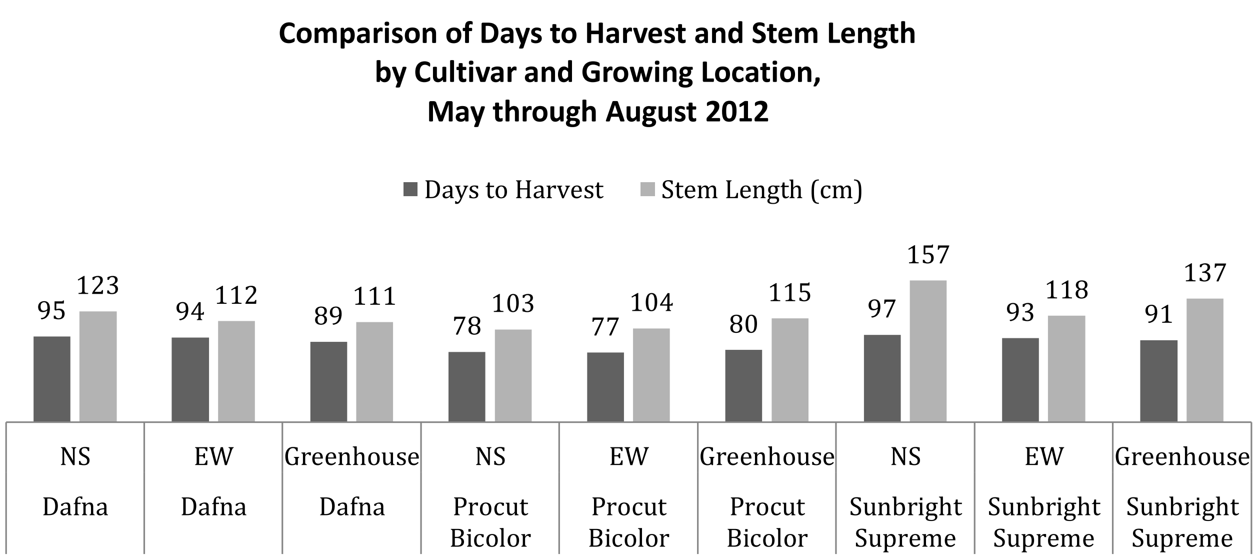

Figure 2. Average stem lengths and days to harvest of fresh cut sunflowers grown in the greenhouse and in two high tunnels from May through August 2012. NS=north–south high tunnel orientation, and EW=east–west.

Wyoming Fresh Herb Production

C. Seals[1] *and K. Panter*[1]

[1]Department of Plant Sciences.

Introduction

Interest in local production of agricultural commodities is increasing in Wyoming. Discussion mainly centers around edible crops, and fresh herbs are part of the mix.

One purpose of this project is to successfully grow fresh oregano, chives, marjoram, and basil for local market. Another goal is to make the methods used available to Wyoming growers.

The first of our herb crops were transplanted into a University of Wyoming greenhouse and two high tunnels in mid-May 2013 as part of a new research project.

Objectives

This project has the main objective of adding niche crops for Wyoming growers who use high tunnels or greenhouses. The aim is to study specialty crops that can be grown in Wyoming for sale at local venues such as farmers' markets. This could encourage expansion of specialty crop production in Wyoming.

Materials and Methods

Four species of herbs are being grown in the greenhouse and two high tunnels at the UW Laramie Research and Extension Center (LREC) greenhouse complex in Laramie. The current project began in April 2013 and will continue through fall 2014. The four herbs are oregano (*Origanum vulgare*), garlic chives (*Allium tuberosum*), sweet marjoram (*Origanum majorana*), and sweet basil (*Ocimum basilicum*). Two additional species—lavender (*Lavandula* spp.) and rosemary (*Rosmarinus officinalis*)—are being grown as edge rows surrounding test plant species.

Figure 1. Seed trays of lavender, sown March 25, 2013.

Seeds of lavender (Figure 1) and rosemary (Figure 2) were sown March 25, 2013, while seeds of the other four species were sown in April 2013. Seedlings were transplanted into the high tunnels and greenhouse in mid-May 2013.

Data being collected include days to germination, days to transplant, and fresh weight of harvested herbs on a per-plant basis. Fresh herbs are harvested twice a week, just prior to blooming, and are weighed immediately. The experimental design is a randomized complete block with four replications. All data will be analyzed using analysis of variance and mean separations.

Figure 2. Seed trays of rosemary, sown March 25, 2013.

Results and Discussion

Initial results should be available for the August 29, 2013, field day at the LREC greenhouse complex.

Acknowledgments

Funding for this project is being pursued from the Wyoming Department of Agriculture's Specialty Crop Block Grant Program.

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Key words: herbs, greenhouse, high tunnel

High Mountain Disease in Cattle

R.J. McCormick[1], M. Stayton[2], and T. Holt[3]

[1]Department of Animal Science; [2]Department of Molecular Biology; [3]College of Veterinary Medicine and Biomedical Sciences, Colorado State University.

Introduction

High-mountain disease (also known as brisket disease) is a debilitating, often fatal condition, affecting some cattle raised at elevations over 6,000 feet. Mortality may run as high as 5% among cattle native to high country; however, in lowland cattle brought to higher altitudes or in offspring from untested sires, losses can be as high as 30–40%.

The physiological reaction of susceptible cattle to reduced oxygen at high-altitude is expansion of the arterial walls in the lung resulting in decreased internal diameter, decreased blood flow, and high blood pressure (pulmonary hypertension). Ultimately, these changes cause impairment of heart function. As a result, cattle susceptible to brisket disease exhibit progressive limitation in movement, labored breathing, fatigue, slow growth and weight gain, diarrhea, and edema of the brisket.

To date, direct measurement of pulmonary arterial pressure (known as a PAP test [Figure 1]) of cattle at altitude is the only method available to determine if an animal is susceptible to brisket disease. Efforts to understand and recognize inheritance patterns or develop blood-based markers that would identify susceptible animals have proven inconclusive. PAP testing has been successful in identifying resistant animals, and their use as seedstock has reduced the overall incidence of brisket disease in high-country herds; despite these efforts, the incidence of brisket disease is on the rise, probably because cattle are increasingly bred for size.

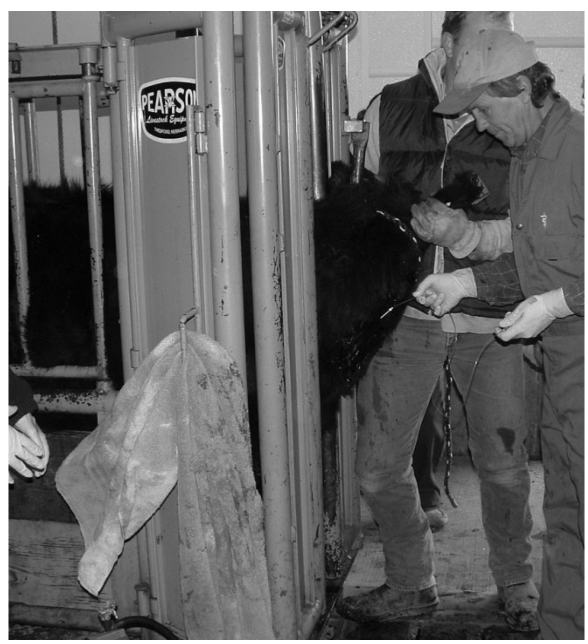

Figure 1. Veterinarian Tim Holt performs PAP testing at the Laramie Research and Extension Center.

Objectives

In the first phase of this project, we explored a candidate gene approach to bovine brisket disease based on studies in humans. The follow-on phase is to correlate economically important beef cattle production traits with PAP scores in a population of animals that show no clinical signs of brisket disease.

Materials and Methods

We recently purchased the necessary instrumentation to perform PAP tests at the Laramie Research and Extension Center (LREC) and the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle. We have a long-standing collaboration with Colorado State University veterinarian Tim Holt, who is instructing personnel in PAP testing procedures and data interpretation.

Results and Discussion

Interestingly, human patients with an inherited form of pulmonary hypertension similar to brisket disease carry mutations in the gene BMPR2. BMPR2 suppresses arterial wall expansion in the lungs, which is consistent with our hypothesis that the BMPR2 signaling pathway is defective in cattle suffering from brisket disease.

We sequenced BMPR cDNAs from 40 half-sibling steers and did not find any mutations in the bovine BMPR2 DNA sequence that correlate with elevated PAP score. However, we have found evidence that BMPR2 gene expression in cattle is reduced in lungs of animals with elevated PAP scores. In addition, lungs from affected animals showed changes in expression of secondary genes, which are regulated by BMPR2. However, these observations do not prove that BMPR2 is causally involved in brisket disease. In the next step, we propose to create a population of steers, a subset of which will be predisposed to the development of the disease. These animals will not develop brisket disease, however, because they will be raised at about 4,100 feet at SAREC and finished under feedlot conditions. Growth rate and feed efficiency will be recorded.

At the completion of the finishing period, animals will be PAP tested and slaughtered at the University of Wyoming Meat Lab, and measures of carcass quality, carcass composition, and meat quality will be taken. Parameters of growth, carcass composition, and quality will be correlated with PAP score to determine if potential for development of brisket disease in the absence of clinical signs influences beef production traits.

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Key words: high-mountain disease, brisket disease, cattle

Molecular and Cellular Basis for Water-Responsive Corn Leaves

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[1]Department of Molecular Biology.[2]

Introduction

Corn is a water-intensive crop that has been domesticated for high yield under optimum water availability. Current breeding efforts leverage the sequenced corn genome to develop new lines that are adaptive to lower water use without compromising yield. In Wyoming, corn for grain has the third highest crop value estimated at $54.6 million as of 2011[1]; therefore, the state will benefit from crop-improvement strategies.

The Sylvester lab has been developing mutants and lines that will be useful for marker-assisted breeding. As part of this effort, a new trait was discovered that controls the cell structure and function associated with leaf rolling, an adaptive response of corn to water stress (Figure 1). When water is reduced, the leaf rolls inward, protecting the plant from excess water loss by sheltering pores in the leaf surface. A corn line was identified that expresses a single gene mutation that alters this response. Molecular and cellular analysis of this gene is necessary to test for the basis of leaf rolling and to explore its breeding potential for future crop studies.

Objectives

The goals of this study are to identify the gene (called *WTY2*) underlying the new leaf trait and begin to study its function in controlling leaf rolling.

Materials and Methods

The *WTY2* gene was "positionally" mapped to the third chromosome of corn and a candidate gene identified. The candidate gene, encoding a kinase protein, was cloned and sequenced. Other alleles of the gene were identified using corn genomic resources that were recently developed and displayed in the genome browser for corn[2]. To study the function of the protein, a visual marker was introduced into the identified gene, and an antibody to the protein is being generated to facilitate study of protein function.

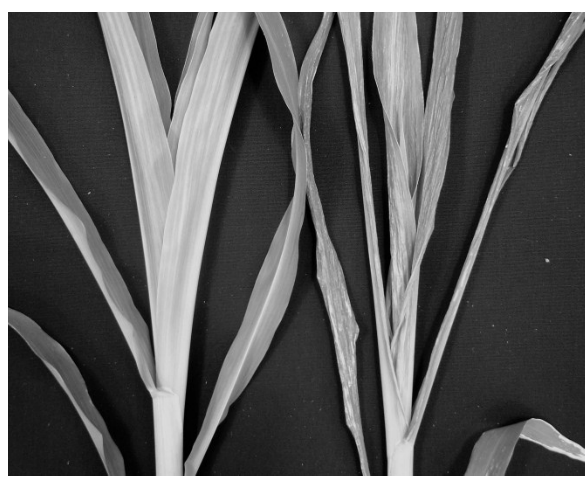

Figure 1. Mutants (right) cause the leaves to roll abnormally compared with normal (left).

Results and Discussion

The mutant leaf has extra cells that are overly enlarged and are similar in appearance to "bulliform cells" (Figure 2), which are the large cells that occur in longitudinal rows in the leaf epidermis of some grasses, including corn. Normally, bulliform cells are on the inner leaf surface and contract to roll the leaf inward. In the mutant, the cells look similar based on the specific purple color from staining the leaves in cross-sections: these cells are also specifically enlarged (Figure 2). Through use of genomic tools, the gene was mapped, cloned, and confirmed to molecular standards.

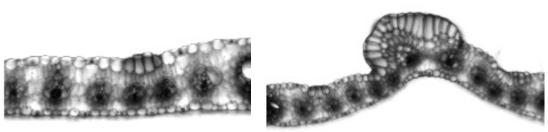

Figure 2. Cells in the mutant are enlarged (right) compared to non-mutant (left). The gene was mapped progressively, and the candidate gene was found that encodes a kinase protein**.**

The gene encodes a protein that is important in signaling a change in cellular development. Study of when and where the protein is produced confirms that the protein likely signals the proper development of bulliform cells. Therefore, the gene can be studied for its normal function and could potentially be used to breed corn expressing this protein in new ways. The impact of extra leaf rolling must first be investigated to determine how the rolling impacts plant growth and development.

This work is being conducted at the Laramie Research and Extension Center (LREC) greenhouse complex, which provides facilities necessary for controlled breeding. The project also works in collaboration with Assistant Professor Axel Garcia y Garcia to test for mutant responses to leaf rolling under differing irrigation regimes at the Powell Research and Extension Center. The studies could allow breeders to modify corn through traditional or recombinant methods so that plants have enhanced leaf-rolling capabilities and potentially better water-use efficiency.

Acknowledgments

The research was funded by the National Science Foundation. Special thanks to Casey Seals and Ryan Pendleton at LREC, William Folsom at Colorado State University's Horticulture Research Center, and Kan Wang and Bronwyn Frame at the Plant Transformation Facility at Iowa State University.

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Key words: crop production, genetics, corn

References

[1]Ballard, T., et al. 2012. *Wyoming Agricultural Statistics 2012*. U.S. Department of Agriculture, National Agricultural Statistics Service, Wyoming Field Office, p. 98, http://www.nass.usda.gov/wy

[2]Maize Genetics and Genomics Database, http://www.maizegdb.org/

Mapping Function-Value Traits in *Brassica rapa* (Field Mustard, Turnip)

R. Baker[1], M.T. Brock [1], M.J. Rubin[1,2], J.N. Maloof [3], S.M. Welch[4], and C. Weinig[1,2,5]

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Introduction

A major challenge in agriculture and ecology is predicting phenotype (traits) from genotype (genetic makeup) in variable natural environments. Such predictions would be aided greatly by describing gene function in diverse field environments and by models that combine recent advances in integrating meteorological data (e.g., temperature, light, humidity) with an understanding of gene networks. Studies manipulating a single gene in a uniform genetic background under controlled growth conditions give an important preliminary view of gene function; however, clear evidence exists that the phenotypic effect(s) of many genes vary depending on genetic background, environment, and stage of growth of the plant.

To fully understand gene function and the role of specific genes in determining yield, it is critical to use natural variants and agroecologically relevant growth settings. Furthermore, many important traits are process endpoints, whose phenotypic expression is determined by varying genetic and environmental factors over weeks. Single-point measurements cannot capture the age dependency of these traits, and therefore provide a poor link to the underlying biological mechanisms. An alternative is to make time-course measurements of plant growth over the entire growing season, and then develop mathematical functions (akin to exponential or logistic functions) to capture relevant features of growth (possibly a rapid phase of leaf and height expansion during certain weeks of the growing season, followed by leveling off of growth near the end of the season).

Objectives

The overarching objectives of this research are to understand the genetic underpinnings of plant morphology and the effects on plant yield. Specific goals were to: 1) characterize the mathematical functions that describe the expansion of organs such as leaves and stems,
2) ascertain how micrometeorological variation (like temperature, light intensity, or humidity) affects trait expression, and
3) evaluate the relationship between function-value traits and the circadian clock (an internal mechanism of time-keeping that alerts humans, for instance, when to

be tired and prepares plants, for instance, to begin photosynthesis in the morning).

Materials and Methods

We studied morphological traits in diverse cultivars of *Brassica rapa* (common mustard), which has been domesticated as turnip, diverse leaf crops such as pak choi, the flower crop brocoletto, and the original canola seed oil crop. Plants were measured daily for the expression of morphological traits such as leaf length and width and stem height as well as for phenological traits like flowering time. We also recorded high-frequency micrometeorological data at the site (e.g., temperature changes that occur over the course of minutes during the day). Our collaborators evaluated the same lines for the expression of circadian rhythms.

Results

We identified mathematical functions and estimated features of plant growth for 130 unique genetic lines. We have mapped features for leaf and height growth curves to unique genomic regions. Notably, the genomic regions that affect dynamic expansion patterns are not always the same as those that affect final size, indicating that our approach identifies previously unknown genes affecting the expression of agroeconomically important traits. Further, the growth models can be improved by use of daily temperature estimates and other environmental variables as predictors, rather than simply elapsed time. Several aspects of growth are affected by the circadian clock; that is, we identify correlations between our parameters of the growth functions and estimates of circadian time.

In prior research in experimental genetic lines at the Laramie Research and Extension Center (LREC), we observed that variation in the clock was correlated with gas-exchange traits, such that shorter circadian cycles were associated with higher photosynthesis (i.e., plants that predict dawn more accurately have a better ability to take carbon in the form of carbon dioxide from the atmosphere and transform it to usable sugars). The regulation of photosynthesis and sugar production by the circadian clock may partly account for the correlation between the morphological traits (like leaf expansion) and the circadian clock.

Acknowledgments

We are grateful for field assistance from the LREC staff, Casey Seals, and Ryan Pendleton in maintaining and establishing greenhouse and field conditions. The research was supported by a National Science Foundation grant.

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Key words: canola, morphology, function-value traits

Powell Research and Extension Center

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Introduction

The Powell Research and Extension Center (PREC) is one mile north of Powell on Highway 25 at an elevation of 4,374 feet.

Employees at PREC include one faculty researcher, a research associate II, a farm manager, two assistant farm managers, and an office associate. PREC personnel conduct research and provide services to benefit the northwestern Wyoming counties of Fremont, Hot Springs, Washakie, Big Horn, and Park—and beyond.

Two hundred of the 220 acres at PREC are irrigated cropland. Research focuses on agronomic weed control, irrigation, cropping systems, high tunnel production, variety performance testing, transgenic variety response to herbicide treatments, and alternative crops. The center participates in numerous regional research and education projects.

Background Information

The 30-year average annual precipitation at PREC is 6.67 inches. Based on Wyoming Agricultural Weather Network (www.wawn.net) data, the 2012 growing season was characterized as dry, with total rainfall of 2.6 inches. This compares to 7.4 inches in 2011 and 4.6 inches in 2010 (Figure 1). The growing season, considered as the period of frost-free days (from May 7 through October 3), had 150 days, which was longer than the previous two years (Figure 2). The wettest month—with less than one inch—was May.

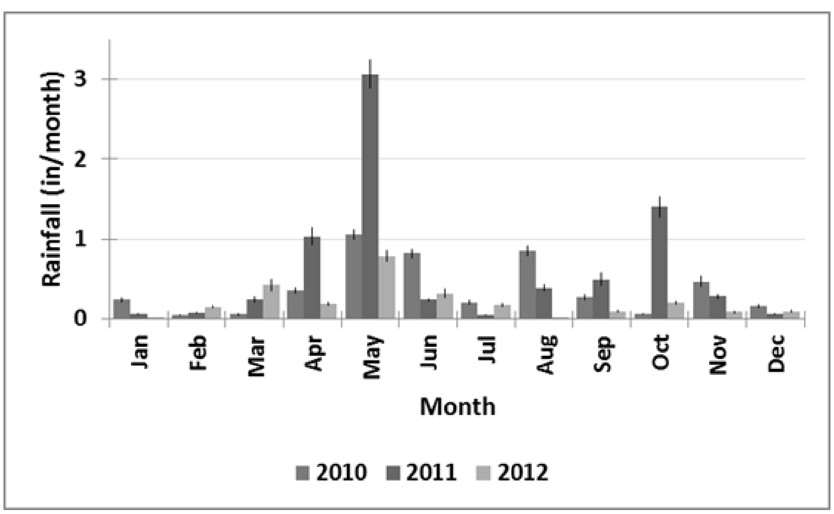

Figure 1. Monthly precipitation recorded at PREC (Wyoming Agricultural Weather Network at www.wawn.net) during 2012.

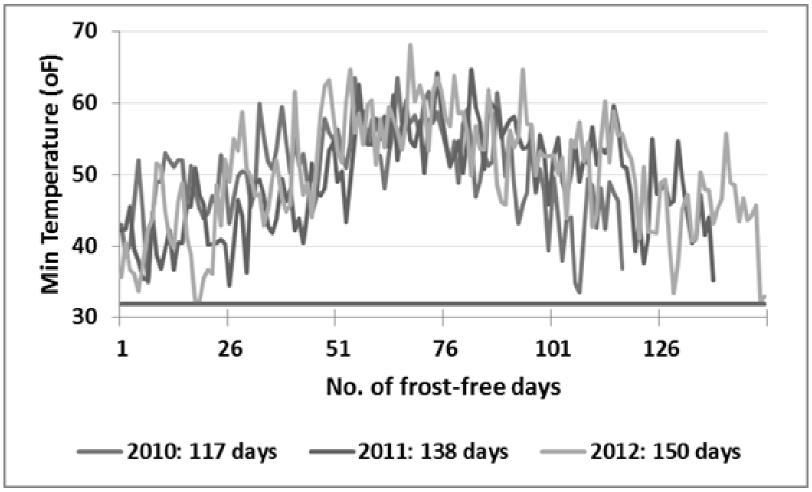

Figure 2. Weather conditions at PREC during the 2012 growing season.

Overall, however, the growing season was extraordinarily productive, with record yields in most crops. We believe this was because of the higher-than-normal minimum temperature throughout the season.

Facility Improvements and Acquisitions

Improvements at PREC during 2012 included the addition of two high tunnels: a Gothic type and a two-sided design (Figures 3 and 4). They are 72 ft long, 26 ft wide, and 14 and 16 ft tall, respectively. The large size of these high tunnels will provide more room for experimental replicates as well as irrigation research. The project was made possible by research funds awarded to Abdel Mesbah.

Acknowledgments

The dedication and effort of University of Wyoming Extension Educator Jeff Edwards, PREC employees, and community residents made the high tunnel project possible.

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Figure 3. High tunnel construction (the Gothic type).


Figure 4. High tunnel construction (the two-sided type).

Effects of Limiting Water on the Yield, Water Productivity, and Forage Quality of Alfalfa

C. Carter[1], A. Islam[1], K. Hansen[2], and A. Garcia y Garcia[1,3]

[1]Department of Plant Sciences; [2]Department of Agricultural and Applied Economics; [3]Powell Research and Extension Center.

Introduction

Alfalfa production in Wyoming accounted for 41% of crop production by area and 41% of the total value of crop production in 2011 (Ballard et al., 2012). Although some alfalfa is produced under dryland conditions in Wyoming, the majority is produced under irrigation. During times of water shortage, such as an extended drought, concerns may arise regarding negative effects—especially when combined with the fact that alfalfa is a high-water-demand crop. In Wyoming, little has been done to evaluate the effects of deficit irrigation on the growth, yield, and quality of alfalfa. This study was established to look at these effects.

Objectives

The objectives were to evaluate the effects on the dry-matter (DM) yield, water-use efficiency (WUE), and forage quality of alfalfa grown under limited irrigation.

Materials and Methods

The study was conducted at the Powell Research and Extension Center (PREC). Three alfalfa varieties (‘Lander’, ‘Mountaineer’, and ‘Shaw’) were planted under a subsurface drip irrigation (SDI) system in June 2011, with four replications. Four irrigation treatments consisting of fully irrigated (100%) and 75, 50, and 25% of fully irrigated were established (Table 1) with no significant precipitation. Irrigation amounts were determined using a daily water balance that tracked the crop’s water needs based on weather factors and crop-specific coefficients. Samples for DM measurements were obtained in 11-foot-square sections for each variety in each irrigation treatment. Soil moisture was monitored following the first harvest and up until the third cutting. This information was then used to create a water balance for each irrigation plot that was used to calculate the actual crop water use, known as crop evapotranspiration (ET_c). WUE was calculated as a ratio of DM yield (pounds/acre) to ET_c (inches). Following each cut, samples were dried for dry matter during 48 hours at 140°F. The forage quality analysis, including relative feed value (RFV) and protein content, was performed using near-infrared reflectance spectroscopy.

Table 1. Total irrigation amounts (inches) per treatment and for each of two cuts.

	Irrigation Treatment			
Cut #	**100%**	**75%**	**50%**	**25%**
Cut 2 (6/7–7/12)	5	4	3	1
Cut 3 (7/13–8/22)	8	6	4	2

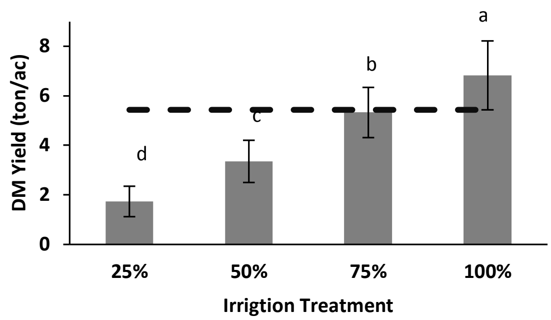

Figure 1. Average DM yield from cuts 2 and 3 compared to flood-irrigated variety trial average. Different letters indicate a significant difference (α=0.05) between irrigation treatments.

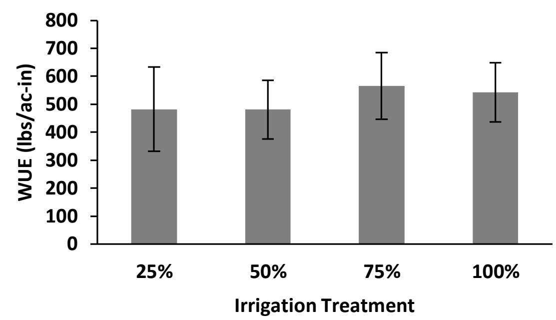

Figure 2. WUE of alfalfa grown under conditions of limiting water.

Results and Discussion

Our results showed no significant difference between varieties in all analyses. Despite the strong effect on DM yield (Figure 1), irrigation amount had no significant effect on WUE (Figure 2) or forage quality (Table 2). Comparing the results to a variety trial performed at PREC in 1998, we can see that average yields can be obtained with less water (Figure 1). Table 1 shows the irrigation amounts for each cut.

The WUE and forage quality showed very small decreases across the irrigation treatments. This shows that even in times of water stress, good quality alfalfa can be produced when proper irrigation scheduling practices are followed that match water needs of the crop.

Table 2. Average RFV and protein content per irrigation treatment.

Irrigation Treatment	RFV	STDEV‡	Protein	STDEV‡
25%	173.16	10.07	22.50	1.13
50%	174.62	11.42	23.20	1.01
75%	167.64	9.13	23.18	1.06
100%	164.44	18.98	23.50	2.13

‡ Standard deviation

Acknowledgments

This project was funded by the Wyoming Agricultural Experiment Station's Competitive Grants Program. Thanks to Mike Killen and his crew as well as Justine Christman, Joan Tromble, and Andrea Pierson for their support with this study.

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Key words: alfalfa, irrigation, water shortage

Reference

Ballard, T., et al. 2012. *Wyoming Agricultural Statistics 2012*. U.S. Department of Agriculture, National Agricultural Statistics Service, Wyoming Field Office, 98 p. http://www.nass.usda.gov/wy

Automated Monitoring of Soil Moisture on Irrigated Alfalfa

A. Garcia y Garcia[1,2], C. Carter[2], and A. Islam[2]

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

Introduction

Most of Wyoming's alfalfa is produced on irrigated lands. Irrigation methods vary from flood, the most common in the state, to sprinkler, and even subsurface drip. On-farm irrigation water management strategies vary among locations and among farmers; as a result, the efficient use of irrigation water also varies. Irrigation scheduling is perhaps the simplest option to improve on-farm irrigation water management.

Objectives

The objective of this study was to determine the potential for use of Watermark sensors (www.irrometer.com) for irrigation scheduling in alfalfa production.

Materials and Methods

Three alfalfa varieties ('Shaw', 'Mountaineer', and 'Lander') were planted under a sub-surface drip irrigation (SDI) system June 7, 2011, at the Powell Research and Extension Center (PREC). The SDI drip lines were placed at a depth of 12 inches. Irrigation treatments for each variety were fully irrigated, and 75, 50, and 25% of fully irrigated. Irrigation amounts were estimated as proposed by Allen et al. (1998).

Figure 1. Watermark sensor.

After establishment, soil moisture was monitored in each irrigation treatment at four depths (6, 12, 24, and 36 inches) using Watermark sensors (Figure 1) during a period of 10 weeks. The data was transmitted to a data logger via radio. A Watermark is a solid-state electrical resistance sensing device that measures soil water tension (how hard the plant has to work to uptake water from the soil). As the tension changes with water content, the resistance changes as well. The sensor consists of a pair of highly corrosion-resistant electrodes that are imbedded within a granular matrix. A current is applied to the Watermark to obtain a resistance value. The Watermark meter correlates the resistance to centibars (kilopascals) of soil water tension. The higher the value of soil water tension, the drier the soil.

Results and Discussion

The crop depleted soil moisture in a period of three weeks (8/25 to 9/15).

A heavy irrigation, followed by one-half inch rainfall, brought the soil moisture to field capacity (amount of water remaining in the soil having been wetted and after free drainage has ceased). Then, the irrigation treatments were established again (Figure 2).

Alfalfa quickly extracted water in the plots irrigated with 25% and 50% of the fully-irrigated treatment (Figure 2a and Figure 2b). In the 75%-irrigated plot, soil moisture variation was higher at the 24-inch depth (Figure 2c). The soil profile was sufficiently wet in the fully-irrigated plot (Figure 2d). By October 10, soil moisture started to be depleted (higher tension) at different rates within the irrigation treatment (Figure 2).

Further studies include the assessment of different irrigation scheduling strategies using Watermark sensors.

Acknowledgments

Thanks to our summer helpers for their support with this study. The project is funded by the Wyoming Agricultural Experiment Station's Competitive Grants Program (WYO-462-11).

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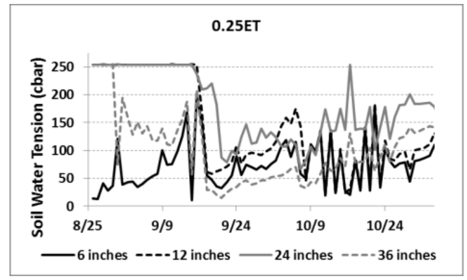
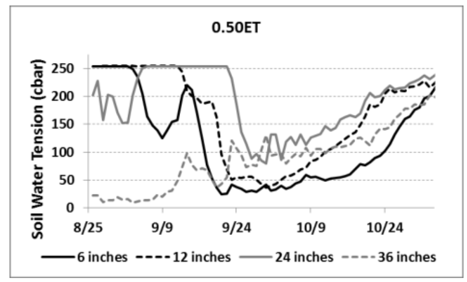
Key words: irrigation scheduling, Watermark, soil moisture probes



(a)



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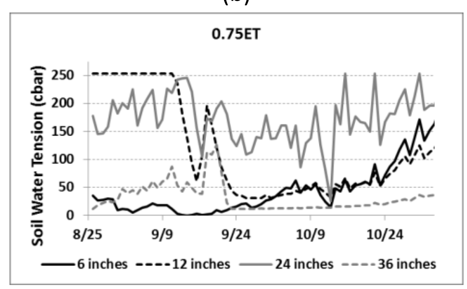

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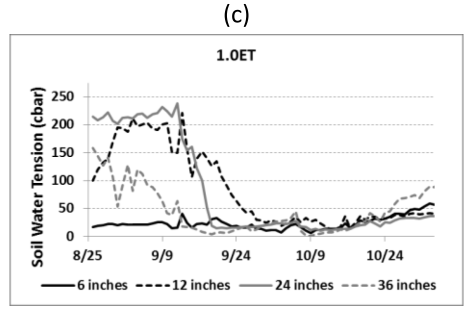

(d)

Figure 2. Variation of soil water tension at different depths on a drip-irrigated alfalfa field at PREC.

Reference

Allen, R.G., L.S. Pereira, D. Raes, M. Smith. 1998. Crop evapotranspiration: Guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper No. 56, Food and Agriculture Organization of the United Nations, Rome, Italy.

Effect of Planting Date and Early Termination of Irrigation on Grain Yield and Quality of Confection Sunflower

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

Introduction

Confection sunflower is a crop of increasing importance in Wyoming. While some sunflower is produced in the eastern part of the state, most production occurs in the western Bighorn Basin. Although more growers are producing confection sunflower in the state, little to no research is being done to address important issues related to the performance of the crop for conditions in Wyoming.

In the Bighorn Basin, sunflower is typically irrigated every 10–14 days; the last irrigation usually occurs around September 1. Farmers are asking whether the effect of an early termination of irrigation (ETI) may be translated into better grain yield and quality of confection sunflower.

Objectives

The objectives of this study were to determine the best planting dates and the best combination of planting date and early irrigation termination that will result in higher grain yield and better quality of confectionary sunflower.

Materials and Methods

The confection sunflower hybrid 'Dahlgren D-9569' was planted in 2012 on a clay–loam soil at the Powell Research and Extension Center (PREC). PREC is located in the northwestern region of the state. (The elevation averages 4,380 feet. The average rainfall is 6.67 inches/year, and about half is received during the growing season period of May to August.)

The experiment consisted of a randomized complete block design in a split-plot array with three replicates. Different planting dates (PD) were the main treatment and early termination of irrigation (ETI) the sub-treatments. Seven PDs—May 1, May 10, May 20, May 30, June 10, June 20, and June 29—were evaluated. Each PD plot consisted of 24 rows that were 200 feet long and 22 inches apart. Within a PD plot, three ETI of eight rows each, including ending irrigation at growth stages R5.5 (50% flowering), R6 (complete flowering), and R7 (change color on the back head), were evaluated in the three central rows. The three central rows of each PD/ETI were split in three replicates where all measurements and observations were obtained.

Table 1. Yield of confection sunflower at different planting dates.

	Yield (lb/A) ‡	
PD	Total	20/64 Sieve §
May 30	5071 A	3998 A
May 20	4502 B	3450 B
June 10	3845 C	2781 C
May 10	3758 C	2919 BC
June 20	3696 C	2714 C
May 1	2848 D	2046 D
June 29	2745 D	1922 D
LSD	340	547

‡Means with the same letter are not significantly different at α=0.05.

§Confection sunflower prices are typically quoted on a dual scale: one price for large seeds (sizing over 20/64-inch round-hole sieve) and a lower price for small seeds (sizing through a 20/64 and over a 14/64-inch round-hole sieve). The higher the percentage of large seeds in the lot, the greater the profit potential. (www.oznet.ksu.edu).

Results and Discussion

Our results showed significant differences (P<0.05) on total yield and 20/64 sieve yield (seeds remaining over a 20/64-inch round-hole screen) between planting dates. Also, significant differences on total yield were observed for the interaction of PD–ETI. The higher yield was obtained when planting occurred around May 30, while the lower yields were obtained for early and late planting dates (Table 1). The interaction of PD–ETI had no effect on 20/64 sieve yield (Figure 1).

Our results from one year of research showed that yield and quality of confection sunflower are better for planting around

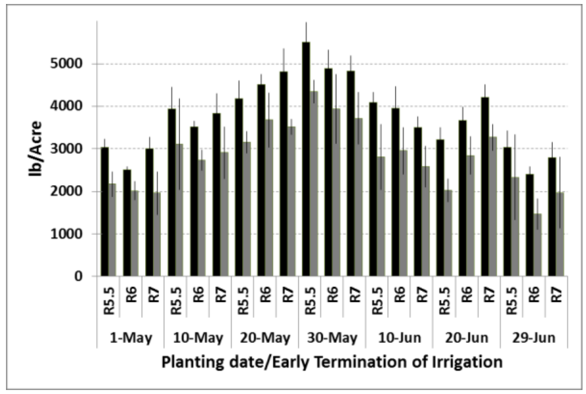

Figure 1. Effect of planting date and early termination of irrigation on yield and quality of confection sunflower grown at PREC.

May 30. The total yield of sunflower was significantly affected by the interaction of PD x ETI. However, no significant differences were observed for quality. Our results show that the optimization of on-farm irrigation water management may enhance yield of confection sunflower.

Acknowledgments

Thanks to Brad May and Keith Schaefer for their field support. Project funding is from the Department of Plant Sciences and the Wyoming Agricultural Experiment Station.

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Key words: irrigation termination, confection sunflower

Effect of Phosphorus Fertilization on Sainfoin

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Introduction

Sainfoin is an introduced perennial forage legume that can be a good alternative to alfalfa (Figure 1). It is highly palatable and nutritious and is preferred over alfalfa by cattle, sheep, and some wildlife, including deer. Sainfoin does not cause bloat problems in cattle, has limited insect pests (resistance to alfalfa stem nematode), is non-invasive, has excellent drought tolerance and cold hardiness, and is an excellent candidate for honey production.

Figure 1. 'Shoshone' sainfoin plant with flower.

There are a few varieties available to purchase including 'Shoshone', 'Delaney', 'Eski', 'Remont', and 'Rocky Mountain'. In a trial at the Powell Research and Extension Center (PREC), these sainfoin varieties produced about 1 ton of dry matter (DM) per acre from one harvest in the establishment year (2007), which was about 0.5 ton lower than 'Ranger' alfalfa. However, in the following years, all varieties produced similar or even higher DM yields than alfalfa from two cuts ranging from 5–7 tons per acre. Shoshone yielded the most, with up to 7 tons per acre. Forage quality of sainfoin was also similar to alfalfa (e.g., crude protein 17–19%, total digestible nutrients 61–65%, and relative feed value 130–144). Sainfoin likes calcareous soils (i.e., high calcium and pH) with low phosphorus; however, anecdotal evidence suggests that sainfoin may respond to phosphorus fertilization.

Objectives

The objectives of this study are to determine the effect of phosphorus fertilization on sainfoin growth and yield.

Materials and Methods

The study was established in 2011 at the Powell Research and Extension Center (PREC). 'Shoshone' was used. Five phosphorus levels (0, 20, 40, 60, and 80 pounds P_2O_5/acre) were incorporated in May 2011 with four replicates. Growth parameters collected include plant growth, forage yield, and forage quality.

Results and Discussion

Previous studies at PREC (reported in the 2012 Wyoming Agricultural Experiment Station Field Days Bulletin; available at www.uwyo.edu/uwexpstn/publications; pages 171–172) showed no differences among treatments for forage yield in 2007-planted sainfoin from phosphorus fertilization. Numerically higher yields were associated with higher phosphorus treatments up to 60 pounds P_20_5 in 2009-planted sainfoin. Additionally, no differences were observed in forage quality. It was thought that old sainfoin stands and surface application of phosphorus might have contributed to this result. In 2012, when phosphorus was incorporated into soils, data revealed that yield was increased with the addition of 20 pounds P_2O_5, while further addition of P_2O_5 up to 60 pounds had minimal effect on yield increase (Table 1). Interestingly, the highest rate—80 pounds P_2O_5—increased yield only by 12% over the control. The study will be repeated in 2013 to see the effects of phosphorus in the second year after establishment.

Acknowledgments

We thank PREC field crews for their assistance in plot establishment and harvesting. The study is supported by various sponsored programs.

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Key words: sainfoin, phosphorus, fertilization.

Table 1. Sainfoin dry matter yields as influenced by different phosphorus treatments when incorporated into the soils of established plots at PREC in 2012.

Treatment (pounds/acre)	Dry matter yield (tons/acre)* 1st cut 6/13/12	2nd cut 7/27/12	Total	Total yield increase over control (%)
0 P_20_5	1.5b	1.0a	2.5b	0
20 P_20_5	2.7a	1.4a	4.1a	64
40 P_20_5	2.3a	1.2a	3.5a	40
60 P_20_5	2.6a	1.3a	3.9a	56
80 P_20_5	1.6b	1.2a	2.8b	12

*means followed by same letters do not differ at P>0.05.

Phosphorus Rates and Formulations in Sugarbeets

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Introduction

It has often been reported that banding phosphorus (P) fertilizer results in more efficient uptake of this essential nutrient. As a result, it is sometimes recommended that P application rate be decreased by 30–50% compared to broadcast rates when the fertilizer is banded. Banding, also called side dressing, involves the placement of fertilizer to one or both sides of a plant row. With the rising cost of fertilizer, sugarbeet growers are interested in banding P and any other practices that may reduce input costs. Little field research data is available under modern production practices, however, that show whether these practices provide enough of an increase in P-use efficiency to allow growers to reduce application rates.

Objectives

Our goals are to evaluate the effect of P fertilizer placement, formulation, and rate on sugarbeet yield and sugar content, and to determine the optimum P rate for banded and broadcast applications.

Materials and Methods

This study was established under furrow irrigation at the Powell Research and Extension Center (PREC). Treatments were applied to a furrow-irrigated field that was prepared for planting with conventional tillage practices. The field had medium to low P levels based on soil tests (0–10 inches=9 ppm). Dry monoammonium phosphate fertilizer (analysis: 11–52–0) was broadcast in the spring on tilled plots at 0, 30, 60, 120, 180, 240, and 300 pounds P_2O_5/acre. Broadcast fertilizer was applied to individual plots using a Valmar Airflo Inc. air spreader designed for small plots and incorporated by tillage prior to bedding. Liquid ammonium polyphosphate fertilizer (analysis: 11–37–0; density: 12 lb/gallon) was banded in the spring at a depth of 3 inches down and 2 inches to the dry side of seed row at 0, 30, 60, 120, 180, 240, and 300 lb P_2O_5/acre. Dry and liquid were applied alone or in combination with Avail (a polymer coating that absorbs cations in the soil to help keep phosphorus more available to the crops). Band application was accomplished using fertilizer injection knives mounted on the front of the tractor followed by a bedder mounted on the rear to firm the beds for planting. The area was pre-bedded to ensure accurate fertilizer placement. To one complete set of banded P treatments, Helena Chemical Co.'s Nucleus 0-Phos (8–24–0), a low-salt liquid-popup, was applied at 5 gallons/acre (12.78 lb P_2O_5/acre) in the seed row at planting. Popup is a starter fertilizer applied in a small amount near the seed to meet the demands of the seedling for readily available nutrients until the plant's root system develops. Plots of 11 by 50 feet were arranged in a split-plot arrangement of a randomized complete block design. Phosphorus formulation is the main plot and P rate the split plot.

Results and Discussion

Placement and Avail Effects: Initial soil test P values of 10 and 4 ppm for the 0–12 and 12–24 inch depths, respectively, suggest that there was a reasonably good probability (~50–60%) that a yield response to added P would be observed; however, results show no yield or quality response with any of the treatments applied. Adjusted sucrose yield was between 12,615 and 13,201 lb/acre^{-1} and was not affected by P placement or Avail (Table 1).

Yield Response to P Rate: Root yield did not increase significantly when P fertilizer was added regardless of the application rate, method, or Avail treatment (Table 2).

Popup Effect: Application of a low-salt fertilizer in-furrow did not affect the sugarbeet crop. Plant stand was around 15 plants per 10 feet of row regardless of whether popup was applied (Table 3).

Table 1. Effect of P source/placement and Avail on sugarbeet yield and sucrose.

P Source	Placement	Avail	Yield (tons/A)	Sucrose (%)
Liquid	Banded	No	39.0 a	17.81 a
Liquid	Banded	Yes	38.5 a	17.73 a
Dry	Broadcast	No	37.4 a	17.75 a
Dry	Broadcast	Yes	38.6 a	17.58 a

Numbers followed by the same letter within a column are not significantly different (p<0.05).

Table 2. Effect of P rates on sugarbeet root yield and sucrose.

P Rate (lb/A)	Root Yield (tons/A)	Sucrose (%)	Sugar Yield (lb/A)
0	37.4 a	17.67 a	12543 a
30	38.6 a	17.61 a	12898 a
60	38.4 a	17.80 a	13025 a
120	38.3 a	17.78 a	12936 a
180	38.3 a	17.70 a	12887 a
240	38.3 a	17.66 a	12854 a
300	39.4 a	17.76 a	13247 a

Numbers followed by the same letter within a column are not significantly different (p<0.05).

Table 3. Effect of popup fertilizer on beet stand, root yield, and sucrose content.

Treatment	Plant stand (Plts/10 ft)	Yield (tons/A)	Sucrose (%)
No popup	15.1 a	38.5 a	17.73 a
Popup	14.8 a	38.5 a	17.64 a

Numbers followed by the same letter within a column are not significantly different (p<0.05).

Acknowledgments

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Key words: sugarbeet, fertility, phosphorus

2012 Dry Bean Performance Evaluation

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Introduction

The University of Wyoming's Wyoming Seed Certification Service funds and coordinates the dry bean variety performance evaluation at the Powell Research and Extension Center (PREC). With assistance from PREC staff, a wide range of germplasm is evaluated, assisting producers in selecting varieties.

Objectives

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

Materials and Methods

The experiment was conducted at PREC. Weed control consisted of a preplant-incorporated treatment of 2 pints Sonalan® and 14 ounces of Establish™. The plots received 65 units of nitrogen (N), 50 units of phosphorous (P), and five units of zinc (Zn).

The plot design was a complete randomized block with four replicates. The seeding rate was four seeds per foot of row on 22-inch rows. The three-row by 20-foot plots were planted May 18, 2012. Visual estimates were made for the number of days to reach 50% bloom (50% of plants with a bloom) and days to maturity (50% of the plants with one buckskin pod). Subplots of one row by 10 feet were pulled by hand and threshed with a stationary plot thresher.

Results and Discussion

Stand establishment was excellent, with timely planting and warm soil temperatures. High summer temperatures and limited summer precipitation followed by an exceptional fall allowed all of the entries to reach maturity. Yields across entries averaged 2,904 pounds per acre (Table 1). Use caution in assessing this data as it is only from one growing season.

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Key words: dry beans, variety trial

Table 1. 2012 dry bean performance evaluation.

Name	Market class	Yield lbs./A	Seeds per pound	50% bloom days after planting	Pod maturity days after planting
Zorro	black	2593	2096	58	92
Eclipse	black	2438	2378	57	97
T-39	black	1923	2372	58	102
UCD 0801	cranberry	2288	940	52	103
Majesty	dk. red kidney	2483	768	54	92
SVS-0815	great northern	3097	1015	47	87
GN9-1	great northern	3027	1234	53	88
Coyne	great northern	2715	1219	52	87
CELRK	lt. red kidney	2011	860	44	82
T-9905	navy	2692	2111	57	96
T-9903	navy	2559	2058	54	91
Avalanche	navy	2486	2278	56	92
Rexeter	navy	2419	2379	51	98
UCD-9634	pink	3186	1357	48	89
PK9-4	pink	3077	1234	54	89
Rosetta	pink	2966	1328	56	95
Lapaz	pinto	3828	1338	59	95
6185	pinto	3583	1337	59	96
PT9-6	pinto	3477	1209	56	94
Windbreaker	pinto	3419	1126	53	95
Sinaloa	pinto	3308	1337	56	93
Lariat	pinto	3162	1142	57	100
Medicine Hat	pinto	3160	1166	52	88
Maverick	pinto	3136	1255	52	95
ISB-18	pinto	3089	1180	49	86
6189	pinto	3077	1292	58	94
ND-307	pinto	3071	1191	53	91
Othello	pinto	3042	1170	45	79
ND020351-R	pinto	2981	1283	55	93
ISB-16	pinto	2944	1172	48	90
Long's Peak	pinto	2863	1265	55	89
ISB-11	pinto	2842	1343	54	93
ISB-24	pinto	2780	1203	48	89
Rio Rojo	red	3225	1520	56	90
SR10-20	red	2547	1340	55	89
SVS-0863	yellow	3057	1269	57	104
Mean		2904	1410	53	92
CV		11.1	4.3	3.1	2.7
LSD		452	86	2.3	3.4

Water-Responsive Corn Leaves

A.W. Sylvester[1] and A. Garcia y Garcia[2,3]

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Introduction

Corn is a crop plant that requires significant amounts of water for efficient growth and yield. Breeders are interested in identifying new lines of corn that could use less water without reducing yield. We are examining how corn adapts to water use, and we are screening for drought-adaptive traits that could serve as future breeding stock.

One trait of interest is leaf rolling. Commonly, corn plants experience a mid-day depression in growth and photosynthetic rate when water stress is extreme. An adaptive response of corn (and other grain crops) to mid-day environmental stress is to roll leaves inward, thereby conserving water loss through the gas and water exchange pores called stomata. Specific cells on the upper leaf surface called “bulliform cells” are thought to facilitate this leaf-rolling response. These large cells expand to unroll the leaf or deflate to roll the leaf inward, depending on leaf-water status.

Objectives

The goal of this preliminary study is to determine if a corn line with altered leaf-rolling traits affects the water-use efficiency of corn.

Materials and Methods

The preliminary experiments were conducted at the Powell Research and Extension Center (PREC). Corn of three mutant genotypes that express a defect in bulliform cell structure were planted in July 2012 under three controlled irrigation regimes that represent varying water supply from drought to optimal conditions (Figure 1). Plants with mutant bulliform cells were compared with their non-mutant normal siblings for differences in growth, physiology, and anatomy. Leaves from four plants were sampled for microscopic analysis. Physiological responses to water use and growth rate were compared under the three irrigation regimes for selected mutant and non-mutant normal plants.

Figure 1. Leaf-rolling corn plants growing under three irrigation regimes at PREC.

Physiological measurements were taken to monitor the plant response to limited water in the field. Measurements were conducted throughout the season (six dates) between 2 to 4 p.m., the period of maximum heat and water stress to the crop. Two to three plants of each type (mutant and non-mutant), and a minimum of six readings per plant on leaves well exposed to sunlight, were conducted. Plant samples were collected at harvest and then processed to measure how big the leaves had grown and the amount of biomass produced.

Results and Discussion

Preliminary results showed potential responsiveness of the leaf-rolling mutant to water stress conditions. In general, the mutant showed greater resistance to drought at the earlier stages of growth than the non-mutant, especially under chronic drought stress. A preliminary explanation is that greater leaf rolling in the mutant caused it to be less water-stressed than the non-mutant, especially under the lowest evapotranspiration regime. Sample sizes were small in this experiment, but preliminary statistical analysis of the data support a difference between mutant and non-mutant, suggesting a full field trial is warranted.

Combined with molecular and cellular analysis conducted at the Laramie Research and Extension Center, the results suggest that the mutant line could be developed for breeding stock to test drought responsiveness of this corn trait. The preliminary design of this experiment will be repeated for a complete growing season during the summer of 2013 or 2014. The leaf-rolling capability will be quantified and its impact on water-use efficiency in corn will be conducted to determine effects on growth and yield.

Acknowledgments

Thanks to the staff at PREC and to the University of Wyoming students of Axel Garcia y Garcia. Special thanks to Sylvester lab high school student Christopher Hoyt and post-doc Carolyn Rasmussen, who described the leaf-rolling trait in the mutant line of corn.

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Key words: corn, irrigation, genetics

James C. Hageman Sustainable Agriculture Research and Extension Center

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Introduction

The James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle began with the purchase of the first property in 2002. The University of Wyoming employees who worked at the former UW research and extension (R&E) centers at Torrington and Archer moved to SAREC in 2006 and began research in earnest. SAREC is a unique facility among R&E centers because of the foresight of the review team that developed the strategic plan in 1999 and 2000. The team specified that SAREC would be a facility where integrated, systems-oriented research would take place. SAREC has nearly 400 acres of irrigated cropland, more than 1,000 acres of rain-fed cropland, and more than 2,000 acres of native range and improved pasture along with a feedlot capable of handling both cattle and sheep.

Employees at SAREC are dedicated to completing relevant research to benefit the agricultural community in southeast Wyoming and beyond. There are one tenure track faculty member, two research scientists, a research associate, a project manager, and an operations staff of up to nine supporting the approximate 75 research projects completed each year at SAREC. These range from long-term projects funded from National Institute of Food and Agriculture grants to small projects completed at the suggestion of SAREC focus group leaders.

Background Information

The weather at SAREC has been highly varied the past few years. Precipitation in 2009, 2010, and 2011 was above normal each year. Spring 2011 was significantly above normal for rain and snow and serious flooding occurred, but the remainder of the year was quite dry. Meanwhile, 2012 was the driest year in recorded history in southeast Wyoming. Range production was only 10% of 2011, and dryland crop yields were abysmal. Irrigated yields were average to above average, but the irrigation water sources and system at SAREC are well equipped to handle dry conditions.

SAREC PRECIPITATION 2007–2013 (inches)

	2009	2010	2011	2012	2013	30-Year Avg
Jan	0.46	trace	0.18	0.10	0.20	0.31
Feb	0.15	0.92	0.18	0.21	0.60	0.40
Mar	0.66	1.04	0.99	0.00	trace	0.70
Apr	2.57	3.38	2.37	0.30	1.92	1.68
May	0.91	2.62	4.57	1.19	0.61	2.54
June	3.27	4.31	1.97	1.24	1.65	2.09
July	0.86	1.01	1.08	0.82	0.59	1.78
Aug	3.45	0.85	1.11	0.00		1.19
Sept	0.65	0.00	0.13	0.37		1.27
Oct	1.64	0.95	1.84	0.93		0.95
Nov	0.12	0.55	0.43	0.11		0.57
Dec	0.37	0.59	0.25	0.14		0.36
Total	**15.11**	**16.22**	**15.1**	**5.41**	**5.57**	**13.84**

Facility Improvements and Activities

SAREC has matured as a research center (Figure 1), and fewer improvements have been made in recent years. The past couple of years have been short from a funding perspective so there have not been many new additions. We are hoping for a new center pivot on the west 80 acres.

Educational programs such as the ongoing High Plains Ranch Practicum are held at SAREC. Diverse groups such as the Wyoming Bankers Association, the Crop Research Foundation of Wyoming, the Wyoming Wheat Growers Association, the Goshen County Stock Growers Association, Goshen County CattleWomen, school groups, international exchanges, local conservation districts, and others used SAREC as a meeting and education site in the past year.

The Rogers Research Site at Fletcher Park, near Laramie Peak, is also part of the SAREC mission. A wildfire in early July 2012 burned the entire property and destroyed all of the buildings except the outhouse. More than 98% of the trees perished, and the reservoir became heavily silted. But the incident provides a unique research opportunity, and the Wyoming Agricultural Experiment Station (WAES) is laying out research for 2013 and beyond to examine the effects of the fire and evaluate potential post-fire rehabilitation.

Acknowledgments

The dedication and effort of the SAREC team cannot be overstated. The employees at SAREC make research possible, and we are indebted to them for the work they do to serve the agricultural community. Our work is funded in part by the WAES.

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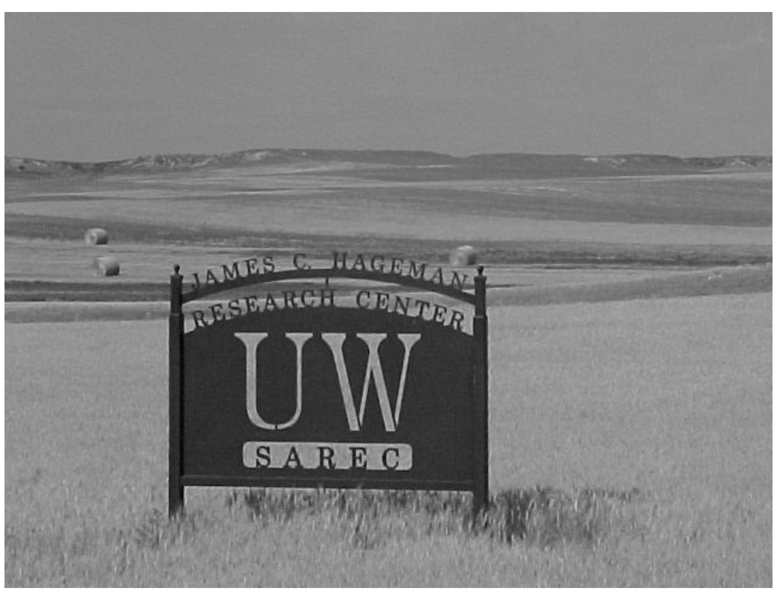

Figure 1. SAREC dryland rotation fields.

Effects of Cropping System on Water Use and Water Productivity of Dryland Winter Wheat

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Introduction

Conventionally tilled dryland winter wheat–fallow is the predominant cropping system in the semiarid high plains of Wyoming. It consists of 14 months of a long fallow period in between two wheat crops. This system seems to be inefficient as the soil water-storage efficiency during fallow is frequently less than 25% with conventional tillage. Also, increasing costs of inputs and climate change threaten the economic viability of agriculture in the semiarid northern High Plains, including southeast Wyoming. As a result, alternative cropping systems that decrease costs and increase yields, while conserving soil water, can help in mitigating these problems.

Cropping systems such as no-tillage and organic production may help achieve these goals. No-till is often recommended as a conservation tillage measure for controlling erosion and increasing water storage and water-use efficiency. No-till systems can increase precipitation storage efficiency during the fallow period by reducing soil water evaporation. In the long run, soils of organic systems may be better suited to store water for use by crops. Organic production practices are alternatives to energy-intensive production inputs such as synthetic fertilizers.

Objectives

The objectives of our study were to determine water use and water productivity of winter wheat under conventional, organic, and no-till cropping systems.

Materials and Methods

This study was conducted at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Soil water content was monitored using a neutron probe from 8 to 55 inches below soil surface. Yields were obtained (at 12% moisture) by manually harvesting a 40-inch length of one row, randomly selected in each plot. The organic system had one extra tillage operation compared to the conventional system, whereas no tillage operations were performed in the no-till system. Conventional and no-till systems rely on herbicides for weed control. Organic systems use tillage for controlling weeds.

Results and Discussion

Although water stored at the time of planting was nearly the same in all the systems, wheat water use per season was higher (4.3 inches) in the conventional system than in the no-till (2 inches) (Table 1). Wheat water use (3.4 inches) in the organic system was not significantly different to either the conventional or the no-till systems. The conventional cropping system had the highest yield (1,884 pounds/acre), while no-till had the lowest yield (1,001 lb/acre).

Table 1: Average yield, water use and water productivity of dryland winter wheat under different cropping systems.

Cropping System	Yield (lb/acre)	Total Water Use (Inches)	Water Productivity (lb/acre-inch)
Conventional	1884a	4.3a	441a
Organic	1262b	3.4ab	430a
No-till	1001a	2.0b	511a

Within column, means followed by same letter are not significantly different at P<0.05

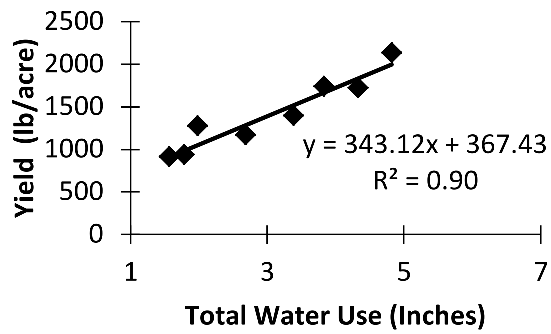

Figure 1. Relationship between winter wheat yield and water use.

Variation in yield may be because of differences in water use under the three cropping systems. Winter wheat yield increased linearly with increasing water use by the crop. For every inch increase in water use, there was a 343.12-lb increase in winter wheat yield (Figure 1). Water productivity was calculated as the ratio of yield to total water use by the crop. There were no significant differences in water productivity of winter wheat under all three cropping systems. The no-till system resulted in the highest water productivity (511 lb/acre-inch) among all three systems. Conventional and organic winter wheat had a water productivity of 441 and 430 lb/acre-inch, respectively.

Our results showed that organic production practices were as efficient as the conventional system to store water in the soil. The no-till system seems more efficient in water conservation compared to the other two systems.

Acknowledgments

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Key words: water use, water productivity, cropping systems, winter wheat

Breeding Winter-Hardy Feed Pea for Wyoming

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Introduction

Winter pea, as a nitrogen-fixing, cool-season annual legume, might serve as a partial or complete replacement for fallow in the winter wheat–summer fallow system in the central Great Plains (CGP). This could help make farming and ranching in the region more economically and environmentally sustainable, considering all the benefits of a legume in the rotation and the potential to integrate cereal and livestock production. Benefits resulting from rotation with legumes include soil nitrogen, increased soil organic matter, reduced soil erosion, pest control, increased soil water-storage efficiency, economic diversity, and perhaps sequestration of carbon via more intensive cropping in an age of climate change. Growers in Europe, Australia, and the Pacific Northwest's Palouse region have successfully integrated cereal and livestock production with winter feed pea in crop rotation.

Objectives

The goal of this long-term project is to breed winter feed pea for adaptation to the CGP and for potential adoption by Wyoming producers into farming/ranching operations. The specific objective of the present study is to evaluate our best breeding lines in comparison with existing winter pea cultivars.

Materials and Methods

In 2000, diverse winter pea genetic lines/cultivars were hybridized in the greenhouse at the Laramie Research and Extension Center (LREC). Hybrid plants were grown there to produce the next generation. Selection then began in the field and continued over several generations at University of Wyoming research and extension centers. Throughout this process, selection began among single plants, and then among single plants within superior segregating families, and finally among bulked progenies of the best lines. As breeding populations were advanced, the number of lines retained was reduced, as quantity of seed of the best lines was increased. All selection was in the Wyoming winter wheat–summer fallow environment. Finally, in the 2010–2011 and the 2011–2012 winter wheat growing seasons, and at two locations (SAREC and LREC), seven Wyoming breeding lines were tested together with the three most available U.S. winter pea cultivars ('Common', 'Specter', and 'Windham', all from the Pacific Northwest). In large randomized, replicated experiments, we evaluated yield of lines/cultivars for yield of both forage and seed, and under both dryland and irrigated conditions.

Results and Discussion

Our winter field pea breeding project demonstrates that breeding for the Wyoming environment can produce superior locally adapted lines (Table 1).

Table 1. Mean yield of winter pea in pounds per acre for 10 lines/cultivars grown for early-season forage (**F**) or to maturity for seed (**S**), on dryland (**D**) or under irrigation (**I**)*.

Line	FD†	FI	SD	SI
Wyo#11	619 a	2444 c	851 a	2006 b
Wyo Mix	525 c	2551 b	758 ab	2247 a
Wyo#13	501 c	2666 a	876 a	1653 d
Wyo#8	428 e	2232 d	731 ab	2246 a
Wyo#6	571 b	1769 h	682 abc	1828 c
Common	473 d	1915 f	632 bc	1663 d
Wyo#12	391 f	1976 e	480 d	1665 d
Specter	340 g	2014 e	557 c	1536 e
Windham	336 g	1570 i	696 abc	1446 f
Wyo#10	335 g	1870 g	555 c	1233 g
Mean	455	2094	682	1751

* **FD**=Forage Dryland; **FI**=Forage Irrigated; **SD**=Seed Dryland; **SI**=Seed Irrigated
†Within column, means followed by the same letter are not significantly different at α=0.05.

An "index of merit" combining relative yield for forage dryland (**FD**), forage irrigated (**FI**), seed dryland (**SD**), and seed irrigated (**SI**) is illustrated in Figure 1. The index averages yield performance over years and locations, as well as for plant product (forage or seed) and growing conditions (dryland or irrigated). Five Wyoming-bred lines are the top five lines tested in this evaluation. The three check cultivars were in the bottom five lines tested. The two Wyoming lines in the bottom five were retained because they exhibited unique leaf and seed traits, but not high yield potential, in early-generation testing.

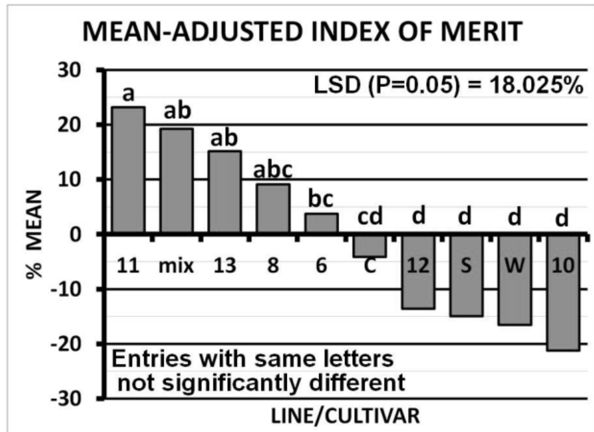

Figure 1. Index of merit for Wyoming-bred winter pea lines (numbered and "mix" in comparison with check cultivars 'Common' [C], 'Specter' [S], and 'Windham' (W).

We conclude that our best lines, especially Wyo#11 and Wyo#13—and the mix of the two—are well-adapted to Wyoming and yield well under different conditions. Wyo#11 (proposed as 'Archer') is currently under seed increase for varietal release as per the recommendation of the Wyoming Crop Improvement Association. Wyo #13 (proposed as 'Arrow') is also under purification and seed increase.

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Key words: pea, dryland farming, legume

Improving the Frost Resistance of Sugarbeet Seedlings

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Introduction

High Plains sugarbeet growers have a strong incentive to plant sugarbeet as early as possible: The earlier the planting date, typically the greater the yield. However, this is risky because emerging seedlings may be killed by frost. Replanting is expensive, and the yield of replanted sugarbeets is less. Manipulating seedlings to survive frost would rebalance the risk–benefit calculation in favor of earlier planting. Freezing kills plants by causing water stress. Ice appears and grows outside the cells, in extracellular spaces, and sucks water out from the cells' contents, dehydrating them. The colder the temperature, the drier and more damaged the cells become. We propose to manipulate sugarbeet seedlings to tolerate hard frosts by using a two-pronged approach. Firstly, seedlings will be sprayed with ice-triggering particles to intentionally trigger freezing at 32°F; this should prevent them from supercooling, which is problematic because it leads to rapid and destructive freezing once the seedlings do finally freeze. Secondly, plants will be primed to tolerate freezing to colder temperatures by boosting their levels of a naturally occurring chemical (glycine betaine [GB]) that protects plants from water stress. Resistance to frost will help maintain productivity if climate change leads to drier springs prone to frosts.

Objectives

The goal is to prove that frost tolerance of sugarbeet seedlings can be increased by preventing supercooling and making tissues more resistant to freezing damage by using GB.

Materials and Methods

Experiments were conducted at the Laramie Research and Extension Center (LREC) greenhouse complex. Tests were performed on cotyledon- (a simple embryonic leaf) and leaf-stage sugarbeet seedlings germinated under cool spring conditions in growth chambers. For freezing tests, pots were placed in insulated coolers and sprayed with water, and then the coolers were placed in a freezer. Rate of temperature decrease was kept low to match natural rates. When the temperature reached 33°F, plants were sprinkled with snow to trigger freezing. After slow thawing, plants were returned to growth chambers and assessed after one week. First, we defined the upper limits of GB that could be used without phytotoxicity. Second, a range of GB concentrations were applied with three surfactants (LI 700, Induce, and MSO) that promote absorption. Plants were tested three days after spraying.

Results and Discussion

Leaf-bearing seedlings were more tolerant of GB than cotyledon-stage seedlings. The upper limit of GB that could be used with cotyledons was 250 mM. Spray application of GB significantly (p<0.05) reduced frost damage in two- to six-leaf seedlings frozen to 24°F. Leaf kill was reduced from 19% in controls to 2% in plants treated with 300 mM GB. Cotyledon-stage seedlings were intrinsically frost hardy, able to tolerate freezing to 21°F before damage occurred (Figure 1). GB-treated seedlings tolerated at least a further 2°F of cooling (the lower limit was not defined). This project tested a combination of "therapies" to protect sugarbeet seedlings from frost. Seedlings were intentionally frozen at 32°F to circumvent the natural and damaging sequence of supercooling followed by freezing. In practice, an efficient ice-triggering particle (e.g., the inert mica fluorophlogopite) would be used to prompt freezing above the lethal supercooling point. Additionally, the intrinsic freezing tolerance of spring-germinated sugarbeet seedlings was enhanced with a spray of GB supplemented with a surfactant. This, including the ice-triggering particle, would be applied 1–3 days before a predicted frost.

Acknowledgments

The project was funded by the Western Sugar Cooperative Grower Joint Research Committee. We are grateful to Robert Baumgartner at the James C. Hageman Sustainable Agriculture Research and Extension Center for advice and arranging planting and to Casey Seals at the LREC greenhouse complex for access to facilities.

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Key words: sugarbeets, frost, seedlings

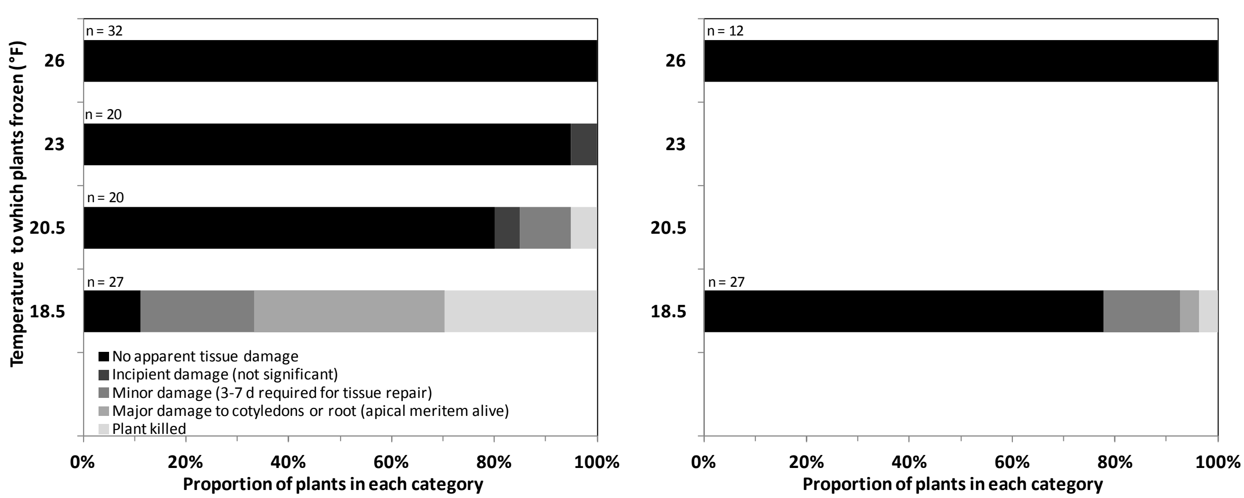

Figure 1. Innate and enhanced tolerance of freezing of cotyledon-stage sugarbeet seedlings. Left panel gives results for untreated plants, and right panel gives results for plants sprayed with 200 mM glycine betaine.

Effects of Early to Mid-Gestation Nutrient Restriction and Protein Supplementation on Intestinal Vascularity and Gene Expression of Market Weight Calves

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Introduction

Beef cows are often undernourished during gestation due to limited forage quality and quantity. Due to current drought conditions, nutrient restriction is especially relevant. Maternal nutrition during gestation affects fetal growth and development, and nutrient restriction during gestation can have adverse effects on the fetus. These include impacts on the development of the small intestine and its blood supply. The small intestine is the main site of nutrient absorption, and thus blood flow is important to transport nutrients to the rest of the body for growth. Targeted supplementation during gestation may impact fetal development and subsequent calf performance. Specifically, supplementation of ruminally undegradable protein (RUP), which supplies essential amino acids, may improve development and growth of the fetus during times of cow nutrient restriction.

Objectives

The objective of this study was to investigate the effects of nutrient restriction and RUP supplementation during early to mid-gestation on small intestinal vascularity (indicator of blood flow) and expression of genes that encode related proteins in market weight calves. Because of the potential impact of the small intestine on feed intake and efficiency, we also wanted to determine the relationship of these measures with feed efficiency and intake in finishing cattle.

Materials and Methods

Thirty-six Angus x Gelbvieh cows (3 and 4 years of age) were allocated to one of three diets from day 45 to 185 of gestation:
1) control (CON) diet of grass hay and supplement to meet or exceed National Research Council recommendations;
2) nutrient-restricted (NR) diet providing 70% of CON net energy; 3) or NR diet with a RUP supplement (NRP) providing similar essential amino acids as CON. At the end of the feeding trial, cows were managed together through calving and weaning. Calves, meanwhile, were managed together after weaning and fed a finishing diet for 84 days at the James C. Hageman Sustainable Agriculture Research and Extension Center near Lingle. Intake was recorded using the

GrowSafe feed intake system to determine residual feed intake (RFI) and gain:feed (G:F) for the finishing period. RFI is the difference between actual and expected feed intake of each animal. After finishing, calves were slaughtered and their small intestines were sampled at the University of Wyoming Meat Lab.

All animal procedures were approved by the University of Wyoming Institutional Animal Care and Use Committee.

Results and Discussion

In this study, cow gestational nutrition did not affect RFI, although RFI was positively correlated with small intestinal weight. This means that more efficient animals (low RFI) had a decrease in intestinal mass. Maternal nutrition also did not affect small intestinal weight or measures of vascularity.

Calves born to cows fed NRP had increased small intestinal gene (mRNA) expression of soluble guanylate cyclase (*GUCY1B3*). There was 1.7X increased fold change in *GUCY1B3* of NRP calves compared with the other treatments. *GUCY1B3* is a nitric oxide receptor that stimulates vasodilation and angiogenesis, both of which can increase blood flow to tissue.

Small intestinal vascularity measures were not correlated with RFI or G:F. Despite this, feed intake was positively correlated with total small intestinal vascularity (r=0.51). This positive correlation indicates that as intake increases so does small intestinal vascularity, which most likely results in more blood getting to the small intestine.

Feed intake was also positively correlated with small intestinal gene (mRNA) expression of two genes—vascular endothelial growth factor receptor 2 and endothelial nitric oxide synthase 3—that also stimulate angiogenesis and vasodilation. This indicates that as feed intake increases so does the expression of these factors associated with blood flow.

We know that gestational nutrition can impact fetal small intestinal growth and development. In this study, gestational nutrition did not affect small intestinal vascularity of market weight calves, but gene expression was altered. This suggests that some, but not all, changes in small intestinal development of calves due to maternal nutrition do not persist later in life. We are currently studying the role of the small intestine in feed efficiency of feedlot cattle to better understand how these changes impact production.

Acknowledgments

The project was funded by the U.S. Department of Agriculture's National Research Initiative and North Dakota State Board of Agricultural Research and Education.

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Key words: developmental programming, feed efficiency, small intestine

2012 Irrigated Corn Variety Trial: Goshen County

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Introduction

Variety performance evaluations conducted by the Wyoming Agricultural Experiment Station (WAES) are a continuous and ongoing program. In cooperation with the University of Nebraska and private seed companies, WAES evaluates numerous varieties/lines of corn each year.

Objectives

Testing of corn varieties is conducted to help growers select varieties adapted to the region.

Materials and Methods

The experimental design of this trial was four replications in a randomized complete block. Measurements taken included: plant height, population, grain yield, test weight, and moisture content. The experiment was at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle.

Fertilizer was applied at a rate of 185 pounds of nitrogen (N) per acre, 50 pounds phosphorus (P), and 20 pounds sulfur (S) before planting. On May 8, 2012, 16 corn varieties were seeded in plots 2 rows by 30 feet using a HEGE precision plot planter set at a row spacing of 30 inches. The seeding depth was 1.5 inches, and the seeding rate was 30,000 seeds per acre. Weeds were controlled with Option® + Status®. Plots were harvested November 16 using an ALMACO plot combine.

Results and Discussion

Results are presented in Table 1. The highest yielding entry was LG Seeds' LG 2468VT3 at 273 bushels/acre.

Results for this trial and many others are available on the web at: www.uwyo.edu/plantsciences/uwplant/trials.html

Acknowledgments

Appreciation is extended to the SAREC staff for great plot care.

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Key words: corn, variety trial

Table 1. Goshen County (SAREC), Wyo., Irrigated Corn Variety Test – 2012.

Brand	Hybrid	Yield (bu/a, 15.5%)	Harvest Moisture (%)	Bushel Weight (lb/bu)	Stand (plts/a)	EPV ($)
LG Seeds	LG 2468VT3	273	16	55	32160	1710
G2 Genetics	5H-806™	267	16	53	30030	1659
G2 Genetics	5H-399™	259	16	50	29270	1618
LG Seeds	LG 5499VT3PRO	259	17	53	28930	1608
G2 Genetics	5H-0504™	257	17	51	27660	1585
NuTech	5B-604™	253	16	48	31440	1576
LG Seeds	LG 2478VT3PRO	242	15	54	30880	1530
G2 Genetics	5H-202™	248	18	56	28940	1515
G2 Genetics	5Z-198™	240	15	50	28730	1507
G2 Genetics	5H-905™	242	16	48	21600	1499
LG Seeds	LG 2414VT3PRO	233	15	54	30200	1461
G2 Genetics	5H-502™	232	15	52	28850	1451
G2 Genetics	5Z-802™	234	17	51	25510	1451
G2 Genetics	5X-0004™	224	18	48	27270	1375
G2 Genetics	5X-903™	221	19	47	26310	1352
NuTech	5N-001™	198	17	50	27230	1230
Average		243	17	51	28440	1508
LSD (0.05)		32	2	2	2920	209

2012 Winter Wheat Variety Trial Nursery: Crook County Dryland

J.J. Nachtman[1]

[1]James C. Hageman Sustainable Agriculture Research and Extension Center.

Introduction

Variety performance evaluations conducted by the Wyoming Agricultural Experiment Station (WAES) are a continuous and ongoing program. 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 (CSU), and private seed companies.

Objectives

Testing of winter wheat varieties is conducted to help growers select varieties adapted to the region.

Materials and Methods

The experimental design consists of five replications in a randomized complete block. Measurements taken included: heading date, plant height, grain yield, test weight, grain moisture, and protein. The experiment was located on the Whalen farm in extreme northeast Wyoming near Aladdin. Fertilizer was not applied. On September 23, 2011, 26 winter wheat varieties were seeded in plots 5 by 25 feet using a hoe drill with a row spacing of 14 inches. The seeding depth was 1.5 inches, and the seeding rate was 50 pounds per acre. No herbicides were used. Plots were harvested July 19, 2012, using an ALMACO plot combine.

Results and Discussion

Results are presented in Table 1. The highest yielding entry was “Byrd” hard red winter wheat at 72.1 bushels/acre. Another variety that tested well, CO050322, will soon be released as “Cowboy”. It will be a joint release from the Crop Research Foundation of Wyoming, CSU, and WAES. Results for this trial and many others are available on the web at: www.uwyo.edu/plantsciences/uwplant/trials.html

Acknowledgments

Appreciation is extended to the cooperators who allowed us to place trials on their land.

Contact Information

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Key words: winter wheat, variety trial

Table 1. Crook County Dryland Winter Wheat Nursery – 2012.

Entry	Grain Yield (bu/a)	Bushel Weight (lb/bu)	Grain Protein (%)	Heading date (days from Jan. 1)	Plant Height (in)	Grain Moisture (%)
Byrd	72.1	60.0	11.0	147	20	12.8
Bill Brown	70.6	60.1	11.5	148	20	12.9
Ankor	68.7	60.5	11.6	151	19	12.8
CO050337-2	68.3	60.3	11.0	154	23	13.1
CO050322(Cowboy)	68.0	59.6	10.8	154	23	12.8
Ripper	67.5	60.3	12.0	149	20	12.6
CO07W245 (W)	67.3	61.0	11.4	149	20	12.8
Settler CL	67.3	61.1	12.2	151	19	13.0
CO050173	67.1	61.7	11.7	148	20	13.1
Denali	67.0	60.3	11.7	153	23	12.7
Thunder CL (W)	66.0	59.4	12.5	150	19	12.3
Robidoux	65.3	60.5	12.1	151	19	12.8
Wahoo	63.6	60.0	13.0	154	24	12.9
Hatcher	63.5	60.3	11.6	149	19	12.6
CO05W111 (W)	60.2	60.6	12.0	154	22	13.0
Unknown*	59.8	59.3	12.9	155	23	12.8
Snowmass (W)	59.2	60.3	11.7	153	23	13.2
Pronghorn	59.0	60.6	13.5	151	23	13.0
Brawl CL Plus	58.4	61.3	13.1	147	20	12.9
NE05496	58.2	59.7	11.9	151	20	12.5
Unknown*	58.0	61.6	13.0	156	23	13.1
Buckskin	54.7	60.8	12.9	153	28	12.8
Judee (SS)	52.6	60.4	13.4	157	21	12.5
Goodstreak	52.0	60.0	12.5	153	27	12.9
Camelot	50.8	59.4	12.0	149	21	12.5
Centurk 78	48.7	61.1	12.4	153	25	13.2
Average	62.1	60.4	12.1	152	22	12.8
LSD 0.05%	7.2	1.2	---	1	1	0.6

(W) Hard white winter wheat.
(SS) Solid stem for sawfly resistance.
*Seed lot misidentified in Montana.

2012 Winter Wheat Variety Trial Nursery: Goshen County Dryland

J.J. Nachtman[1]

[1]James C. Hageman Sustainable Agriculture Research and Extension Center.

Introduction

Variety performance evaluations conducted by the Wyoming Agricultural Experiment Station (WAES) are a continuous and ongoing program. 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 (CSU), and private seed companies.

Objectives

Testing of winter wheat varieties is conducted to help growers select varieties adapted to the region.

Materials and Methods

The experimental design consists of five replications in a randomized complete block. Measurements taken included: heading date, plant height, grain yield, test weight, and moisture. The experiment was located on the Hubbs farm in southeast Wyoming near Hawk Springs. Fertilizer was not applied. On September 20, 2011, 53 winter wheat varieties were seeded in plots 5 by 25 feet using a hoe drill with a row spacing of 14 inches. The seeding depth was 1.5 inches, and the seeding rate was 50 pounds per acre. Herbicides were applied by the cooperator. Plots were harvested June 28, 2012, using an ALMACO plot combine.

Results and Discussion

Results are presented in Table 1. The highest yielding entry was CO050322 ("Cowboy") hard red winter wheat at 40.5 bushels/acre. Cowboy will be released soon by the Crop Research Foundation of Wyoming, CSU, and WAES.

Results for this trial and many others are available on the web at: http://www.uwyo.edu/plantsciences/uwplant/trials.html

Acknowledgments

Appreciation is extended to the cooperators who allowed us to place trials on their land.

Contact Information

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Key words: winter wheat, variety trial

Table 1. Goshen County, Wyo., Dryland Winter Wheat Variety Test – 2012.

Variety	Grain Yield (bu/a)	Moisture (%)	Bushel Wt (lb/bu)	Plant Height (in)	Heading date (May)
CO050322 (Cowboy)	40.5	13.3	63.8	21	16
Hatcher	39.8	12.4	62.5	18	9
CO050337-2	38.9	15.1	62.9	20	17
CO05W111 (W)	38.6	13.0	63.4	21	13
Denali	38.1	13.5	63.6	22	15
CO07W245 (W)	37.3	12.5	62.7	20	11
Bill Brown	36.2	14.0	63.1	20	9
Byrd	36.0	12.7	62.6	21	10
Armour	35.7	11.9	60.5	18	10
Settler CL	35.7	12.8	62.5	20	14
Brawl Cl Plus	35.4	12.3	61.5	21	9
Snowmass (W)	35.1	12.8	61.8	21	16
CO050173	34.3	13.2	63.6	22	11
NE05548	33.8	12.5	61.9	21	15
SY Wolf	33.4	12.5	62.1	20	14
Wesley	33.4	12.6	62.0	21	13
Infinity CL	33.3	12.9	62.0	21	16
Judee (SS)	33.3	13.6	63.7	19	20
WB-Stout	32.9	12.1	60.4	21	8
NE05496	32.8	12.6	62.7	20	13
NE08659	32.7	14.3	61.0	21	20
Thunder CL (W)	32.7	12.6	62.9	19	13
Unknown*	32.6	13.2	62.7	20	20
Unknown*	32.5	14.1	61.4	20	19
Overland	32.5	12.4	62.5	21	13
Camelot	32.5	13.0	61.1	21	12
Winterhawk	32.4	13.4	62.4	21	10
Arrowsmith (W)	32.3	13.5	60.6	22	19
Buckskin	32.2	12.6	62.0	23	17
CO050175-1	32.1	13.1	63.1	20	13
Alliance	32.0	12.5	61.6	20	14
NW03666 (W)	31.5	14.3	62.2	20	12
NX04Y2107 (Mattern)	31.4	11.7	58.9	19	11
T158	31.2	12.8	61.4	19	8
NE06430	31.0	12.5	61.6	21	10
Scout 66	30.9	14.2	61.1	23	14
NI08708	30.8	12.5	60.7	21	12
NW07505 (W)	30.6	13.1	61.9	21	15
Goodstreak	30.3	12.5	62.8	22	15
Robidoux	30.0	12.7	62.2	20	13
Mace	29.2	12.6	61.2	19	13
NE07531	29.1	13.1	61.0	20	17
Millennium	28.8	12.7	61.8	20	17
NE06545	28.6	11.9	60.1	19	10
McGill	28.2	12.8	60.0	19	13
T163	28.0	12.2	60.5	21	10
NE08457	27.8	12.5	61.6	21	12
NE06607	27.7	11.9	61.1	21	12
NE08509	27.1	12.7	62.2	19	15
Turkey	26.3	13.2	60.2	22	17
NE08476	25.1	12.6	60.7	19	17
Pronghorn	25.0	12.8	61.8	22	13
WB-Cedar	24.4	11.7	57.9	19	8
Average	32.1	12.9	61.7	20	13
LSD 0.05%	5.7	1.5	1.9	2	3

(W) Hard white winter wheat; (SS) Solid stem for sawfly resistance; *Seed lot misidentified in Montana.

2012 Winter Wheat Variety Trial Nursery: Laramie County Dryland

J.J. Nachtman[1]

[1]James C. Hageman Sustainable Agriculture Research and Extension Center.

Introduction

Variety performance evaluations conducted by the Wyoming Agricultural Experiment Station (WAES) are a continuous and ongoing program. 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 (CSU), and private seed companies.

Objectives

Testing of winter wheat varieties is conducted to help growers select varieties adapted to the region.

Materials and Methods

The experimental design consisted of five replications in a randomized complete block. Measurements taken included: heading date, plant height, grain moisture, grain yield, test weight, and protein. The experiment was located on the Mattson farm in southeast Wyoming near Pine Bluffs. Thirty-three pounds of nitrogen fertilizer was applied per acre. On September 22, 2011, 26 winter wheat varieties were seeded in plots 5 by 25 feet using a hoe drill with a row spacing of 14 inches. The seeding depth was 1.5 inches, and the seeding rate was 50 pounds per acre. Weeds were controlled by the cooperator. Plots were harvested July 20, 2012, using an ALMACO plot combine.

Results and Discussion

Results are presented in Table 1. The highest-yielding entry was Ripper hard red winter wheat at 29.2 bushels/acre. Another good performing entry, CO050322, will soon be released as “Cowboy”. It will be a joint release from the Crop Research Foundation of Wyoming, CSU, and WAES. Results for this trial and many others are available on the web at: www.uwyo.edu/plantsciences/uwplant/trials.html

Acknowledgments

Appreciation is extended to the cooperators who allowed us to place trials on their land.

Contact Information

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Key words: winter wheat, variety trial

Table 1. Laramie County Dryland Winter Wheat Nursery – 2012.

Entry	Grain Yield (bu/a)	Bushel Wt (lb/bu)	Grain Protein (%)	Heading date (days from Jan. 1)	Plant Height (in)	Grain Moisture (%)
Ripper	29.2	52.5	14.6	150	16	10.0
Bill Brown	28.7	55.4	13.2	149	16	10.7
Hatcher	27.6	54.7	13.4	153	16	10.3
CO050173	27.5	56.0	14.1	152	17	10.5
Brawl CL Plus	27.3	55.4	14.0	147	17	10.4
Byrd	27.2	53.5	13.5	149	17	10.1
CO07W245 (W)	26.7	56.7	13.0	153	17	10.5
CO050337-2	26.6	56.3	13.7	155	17	10.4
Thunder CL (W)	26.2	56.2	13.6	149	16	10.5
SY Wolf	26.1	56.4	13.9	153	18	10.3
Ankor	25.7	54.1	13.7	152	17	10.0
CO050322(Cowboy)	24.4	53.9	14.1	156	17	10.0
CO05W111 (W)	24.1	53.8	14.0	155	18	10.3
Goodstreak	24.1	55.5	13.1	154	19	10.4
Settler CL	24.0	53.1	14.6	152	17	9.6
NE05496	22.9	53.5	13.5	152	16	9.8
Camelot	22.5	53.4	14.3	148	17	10.0
Pronghorn	22.3	56.2	14.7	151	19	10.5
Robidoux	22.3	52.9	14.0	151	16	10.3
Snowmass (W)	22.3	54.1	13.7	154	17	9.9
Judee (SS)	21.4	55.8	16.6	157	17	9.9
Denali	21.0	55.9	14.8	155	18	10.7
Buckskin	20.7	54.5	14.9	153	20	10.3
Unknown*	20.4	54.5	13.3	156	17	10.1
Unknown*	19.8	54.1	15.0	159	17	10.1
Wahoo	19.7	55.2	14.5	155	17	9.9
Average	24.3	54.8	14.1	153	17	10.2
LSD 0.05%	6.0	2.3	---	3	1	0.5

(W) Hard white winter wheat
(SS) Solid stem for sawfly resistance
*Seed lot misidentified in Montana.

2012 Winter Wheat Variety Trial Nursery: Laramie County Irrigated

J.J. Nachtman[1]

[1]James C. Hageman Sustainable Agriculture Research and Extension Center.

Introduction

Variety performance evaluations conducted by the Wyoming Agricultural Experiment Station (WAES) are a continuous and ongoing program. 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 (CSU), and private seed companies.

Objectives

Testing of winter wheat varieties is conducted to help growers select varieties adapted to the region.

Materials and Methods

The experimental design consisted of five replications in a randomized complete block. Measurements taken included: heading date, plant height, grain yield, test weight, and moisture. The experiment was located on the Theron Anderson farm in extreme southeast Wyoming near Albin. Fertilizer was applied at 190 pounds nitrogen, 45 pounds phosphorus, and 24 pounds sulfur per acre. On September 22, 2011, 50 winter wheat varieties were seeded in plots 5 by 25 feet using a hoe drill with a row spacing of 14 inches. The seeding depth was 1.5 inches, and the seeding rate was 90 pounds per acre. Herbicides were applied by the cooperator. Plots were harvested July 23, 2012, using an ALMACO plot combine.

Results and Discussion

Results are presented in Table 1. The highest yielding entry was CO050322 (soon to be released as "Cowboy") hard red winter wheat at 145 bushels/acre. It will be a joint release from the Crop Research Foundation of Wyoming, CSU, and WAES. Results for this trial and many others are available on the web at: www.uwyo.edu/plantsciences/uwplant/trials.html

Acknowledgments

Appreciation is extended to the cooperators who allowed us to place trials on their land.

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Key words: winter wheat, variety trial

Table 1. Laramie County, Wyo., Irrigated Winter Wheat Variety Test – 2012.

Variety	Grain Yield (bu/a)	Moisture (%)	Bushel Wt (lb/bu)	Plant Height (in)	Heading date (days from Jan. 1)
Cowboy(CO050322)	145	12	61	27	152
Denali	140	12	62	29	151
CO07W245 (W)	139	12	62	26	147
Art	135	12	62	26	148
CO050337-2	135	12	61	27	151
Robidoux	135	12	63	27	149
Byrd	135	12	62	26	148
SY Wolf	132	12	62	26	151
SY Gold	132	12	62	26	148
Thunder CL (W)	132	12	63	25	147
Hitch	132	12	62	25	152
NE06545	129	12	61	26	146
CO05W111 (W)	129	12	61	29	152
CO050173	129	12	62	27	149
NE08509	129	12	61	26	150
NI06737	127	12	61	26	148
Brawl Cl Plus	127	12	62	27	145
Settler CL	126	12	61	27	150
Bond CL	126	11	59	28	145
NI06736	125	12	61	26	148
Overland Crus	125	12	62	28	151
T158	125	12	61	25	146
NE07531	125	12	62	27	150
Overland	125	12	62	28	151
NE06430	124	12	61	26	147
Antelope (W)	124	12	61	25	150
Overland Untreated	124	12	62	28	150
Unknown*	124	12	61	28	152
PostRock	123	12	62	25	149
Judee (SS)	122	12	62	27	154
Mace	122	12	61	26	151
NX04Y2107 (Mattern)	122	11	61	24	147
NE08476	122	12	61	28	150
NI07703	122	12	62	27	146
Wesley	121	12	62	25	148
NE06607	121	12	61	28	147
Aspen (W)	121	12	62	24	145
NI08708	121	11	60	27	149
NE05496	121	12	62	27	150
WB-Cedar	119	12	62	24	144
Anton (W)	118	12	61	26	153
Camelot	117	12	62	29	146
NW03666 (W)	117	12	62	27	148
Armour	116	12	61	24	145
NW07505 (W)	116	12	61	27	151
NE08457	116	12	62	29	149
NE05548	115	12	61	29	151
Unknown*	112	12	62	32	155
NE08659	108	12	61	29	152
T163	105	12	63	27	146
Average	125	12	62	27	149
LSD 0.05%	8	0	1	1	1

(W) Hard White Winter Wheat; (SS) Solid stem for Sawfly resistance; *Seed lot misidentified in Montana.

2012 Winter Wheat Variety Trial Nursery: Platte County Dryland

J.J. Nachtman[1]

[1]James C. Hageman Sustainable Agriculture Research and Extension Center.

Introduction

Variety performance evaluations conducted by the Wyoming Agricultural Experiment Station (WAES) are a continuous and ongoing program. 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 (CSU), and private seed companies.

Objectives

Testing of winter wheat varieties is conducted to help growers select varieties adapted to the region.

Materials and Methods

The experimental design consisted of five replications in a randomized complete block. Measurements taken included: heading date, plant height, grain yield, test weight, and protein. The experiment was located on the Baker farm in southeast Wyoming near Chugwater. Fertilizer was not applied. On September 21, 2011, 26 winter wheat varieties were seeded in plots 5 by 25 feet using a hoe drill set at a row spacing of 14 inches. The seeding depth was 1.5 inches, and the seeding rate was 50 pounds per acre. No herbicides were used. Plots were harvested July 9, 2012, using an ALMACO plot combine.

Results and Discussion

Results are presented in Table 1. The highest yielding entry was CO050322 (soon to be released as “Cowboy”) hard red winter wheat at 31.8 bushels/acre. It will be a joint release from the Crop Research Foundation of Wyoming, CSU, and WAES. Results for this trial and many others are available on the web at: http://www.uwyo.edu/plantsciences/uwplant/trials.html

Acknowledgments

Appreciation is extended to the cooperators who allowed us to place trials on their land.

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Key words: winter wheat, variety trial

Table 1. Platte County Dryland Winter Wheat Nursery – 2012.

Entry	Grain Yield (bu/a)	Bushel Weight (lb/bu)	Grain Protein (%)	Heading date (days from Jan. 1)	Plant Height (in)
CO050322(Cowboy)	31.8	62.6	11.5	142	18
Ripper	29.9	60.8	13.1	140	17
CO050337-2	29.7	60.7	12.5	142	18
Hatcher	28.6	60.3	12.3	140	17
Bill Brown	28.4	60.9	12.5	140	17
Byrd	27.4	61.6	12.9	140	17
CO05W111 (W)	27.2	59.9	13.3	143	18
CO07W245 (W)	27.0	59.7	12.5	140	17
CO050173	26.7	60.1	12.8	140	18
Buckskin	25.9	61.5	13.6	141	20
Denali	25.2	61.5	12.0	141	18
Thunder CL (W)	24.4	62.8	12.9	142	17
Robidoux	24.3	59.6	13.1	141	18
Settler CL	24.3	57.7	13.5	141	18
Brawl CL Plus	24.1	60.1	13.3	139	18
Snowmass (W)	23.3	59.4	12.6	141	18
NE05496	22.9	58.3	12.8	141	17
Wahoo	22.7	58.1	12.9	141	17
Ankor	22.4	58.4	13.1	140	17
Pronghorn	22.2	59.2	13.7	140	20
Unknown*	22.0	58.2	14.4	146	16
Unknown*	21.4	57.3	14.6	145	17
Camelot	20.8	59.7	14.7	140	19
SY Wolf	20.8	61.9	13.6	141	18
Goodstreak	20.6	59.1	13.6	141	18
Judee (SS)	18.1	58.3	15.1	145	17
Average	24.7	60.5	13.2	141	18
LSD 0.05%	4.3	2.2	---	2	1

(W) Hard white winter wheat.
(SS) Solid stem for sawfly resistance
*Seed lot misidentified in Montana.

2011 Irrigated National Winter Canola Variety Trial

J.J. Nachtman[1]

[1]James C. Hageman Sustainable Agriculture Research and Extension Center.

Introduction

The Wyoming Agricultural Experiment Station is among the many collaborators participating in the National Winter Canola Variety Trial. The NWCVT is coordinated by Kansas State University, and testing is occurring in 22 states, including Wyoming.

Objectives

Testing of winter canola varieties is conducted to help growers select varieties adapted to the region.

Materials and Methods

One of the two Wyoming trials is at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) near Lingle. The other is near Torrington.

The 2011 experimental design at SAREC consisted of three replicates in a randomized complete block. Measurements taken included: 50% bloom date, plant height, fall stand, winter survival, grain yield, test weight, and oil content. Fertilizer was applied in both the fall (20 pounds of nitrogen [N] per acre) and spring (70 lbs N/a). On August 30, 2010, 44 winter canola varieties were seeded in plots 5 by 20 feet using a hoe drill with a row spacing of 14 inches. The seeding depth was one-half inch, and the seeding rate was five pounds per acre. Weeds were controlled by incorporating Treflan® at 1 quart/acre before planting. Plots were harvested August 1, 2011.

Results and Discussion

Results for 2011 are presented in Table 1. The highest-yielding entry was Hornet at 3,960 pounds/acre. The trial at SAREC was the second-highest-yielding trial across 26 trials in 22 states. However, 95% of the 2012 winter canola trial at SAREC was lost to winter kill. At the time of this report, it appears that much of the 2013 winter canola trial has also been winter-killed. This has been a recurring problem over the past 20 years that we've conducted these trials. We will try an earlier seeding date to see if this will increase winter survival. The results for the 2012 NWCVT are posted at http://www.ksre.ksu.edu/bookstore/pubs/SRP1080.pdf

Acknowledgments

Appreciation is extended to the SAREC staff for great plot care.

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Key words: winter canola, variety trial

Table 1. 2011 irrigated national winter canola variety trial at SAREC.

Source and line	Yield (lb/a)	Yield (% of test avg.)	Winter survival (%)	Plant Height (in.)	Test Weight (lb/bu)	Oil (%)
ALABAMA A&M UNIVERSITY						
AAMU-33-07	2770	88	85	52	47.5	38.3
AAMU-6-07	2802	89	83	57	49.3	40.2
AAMU-62-07	2062	66	82	51	46.2	37.8
AAMU-64-07	2611	83	77	51	47.9	38.7
CROPLAN GENETICS®						
HyClass110W	2711	86	90	53	46.7	38.4
HyClass115W	2893	92	95	52	46.7	39.6
HyClass125W	2909	93	95	56	48.2	39.5
HyClass154W	2947	94	95	**60**	47.8	37.3
DL SEEDS INC.						
Baldur	3210	102	93	56	49.2	39.6
Dimension	2897	92	85	58	49.3	41.3
Dynastie	3201	102	90	57	47.9	37.7
Flash	3294	105	88	57	48.9	39.3
Hornet	**3960**	**126**	98	59	48.5	39.9
Safran	3754	120	92	56	46.5	39.0
Sitro	2531	81	90	55	44.9	38.9
Visby	3251	104	92	58	47.3	40.0
HIGH PLAINS CROP DEVELOPMENT						
Claremore CL	3188	102	95	56	48.3	39.1
HPX-7228	3181	101	88	55	47.5	38.3
HPX-7341	3519	112	98	57	48.0	39.1
KANSAS STATE UNIVERSITY						
Kiowa	3122	100	98	59	49.4	37.9
KS4083	3350	107	97	59	47.7	38.8
KS4426	3730	119	95	57	48.6	39.7
KS4428	3464	110	**100**	59	48.9	39.5
Riley	3600	115	98	57	48.8	41.2
Sumner	3429	109	99	53	49.5	39.3
Wichita	3274	104	97	59	49.1	39.9
MOMONT						
Chrome	3529	113	92	58	48.8	40.2
Hybrilux	3728	119	77	**60**	48.5	39.7
Hybristar	2967	95	90	53	47.4	39.8
Hybrisurf	3125	100	85	55	49.0	40.4
Kadore	2998	96	98	55	45.8	38.9
MH06E10	3484	111	82	56	48.3	39.7
MH06E11	3307	105	75	59	48.2	40.5
MH06E4	3278	105	85	57	48.4	40.5
MONSANTO/DEKALB®						
DKW41-10	2333	74	98	46	47.7	36.9
DKW44-10	2529	81	99	50	47.7	36.7
DKW46-15	2858	91	97	55	49.8	40.7
DKW47-15	3141	100	96	57	48.4	39.2
TECHNOLOGY CROPS INTERNATIONAL						
Rossini	3048	97	87	53	46.3	41.8
UNIVERSITY OF IDAHO						
Amanda	2974	95	94	54	45.4	39.4
Athena	3245	103	88	54	**49.9**	39.1
Durola	3236	103	87	55	49.4	**43.1**
VIRGINIA STATE UNIVERSITY						
Virginia	3188	102	92	53	48.3	38.4
VSX-3	3360	107	93	55	48.5	37.6
AVERAGE	3136	---	91	56	48.0	39.3
CV	14	---	6	7	3.7	2.5
LSD (0.05)	696	---	8	6	NS	2.0

Greenhouse Gas Emissions from Alternative Management Approaches of Irrigated Crop and Forage Production System

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Introduction

Escalating input costs and increasing prices of value-added products have motivated many farmers toward organic and reduced-input production. In addition, reduced input and organic management slows down organic matter decomposition thereby reducing emissions of greenhouse gasses (GHGs). Conventional management, on the other hand, exposes soil to air, sunlight, and microbial activity, which results in rapid oxidation of organic matter and higher emissions of GHGs. Benefits of organic and reduced-input management approaches have been documented previously (e.g., Clark et al., 1998) but not in enough detail to understand the environmental impacts due to emissions of GHGs.

Objectives

This experiment aims to evaluate GHG emissions, specifically carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) from alternative-management approaches in cash-crop (crops for cash income) and forage production systems.

Materials and Methods

The experiment was established at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Six 6.5-feet x 6.5-feet plots were established randomly (Figure 1). Treatments compared include conventional, reduced-input, and organic management approaches of cash-crop and beef calf forage production (forage production hereafter). Crop rotations differed among management approaches.

Greenhouse gas samples were collected from chambers consisting of permanent polyvinyl chloride (PVC) pipe bases and a PVC cap with a vent tube and sampling port. Gas samples were collected with a syringe, injected into 15-mL evacuated glass vials and brought to the lab. Composition of gas trapped in chambers was measured on an automated gas chromatograph (Shimadzu GC-2014).

Results and Discussion

There was more loss of soil organic matter, “the farmers’ gold”, as CO_2 from forage-production systems than from cash-crop

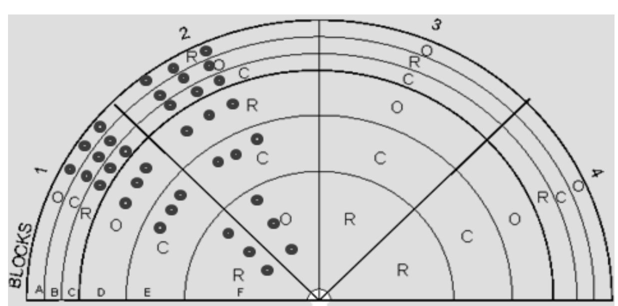

Figure 1. Plot layout: Tiers A, B, C = cash-crop plots; tiers D, E, and F = forage-production plots; gas emissions were measured in replicates 1 and 2.

production systems. Averaged across all management approaches, forage-production emitted 57% more CO_2 than the cash-crop. The presence of alfalfa+grass in forage production or alfalfa in organic cash-crop systems results in the highest CO_2 emission. The lowest CO_2 emission was observed from the reduced-input cash-crop production systems (Figure 2).

CH_4 is absorbed in soils. CH_4 uptake in soils (3.8±0.3 µg C m^{-2} hr^{-1}) was not significantly different among management approaches and production systems.

N_2O emissions were 19% higher from cash-crop production systems than from forage-production systems (Figure 2). Among management approaches, reduced-input approach plots emitted 29% less N_2O than conventional plots in the forage-production system and 39% less than conventional plots in the cash-crop system.

Decline in CO_2 and N_2O emissions in reduced-input plots suggests effective soil organic matter restoration through reducing soil disturbance.

Acknowledgments

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Key words: soil organic matter, greenhouse gas, organic management

Reference

Clark, M.S., W.R. Horwath, C. Shennan, and K.M. Scow. 1998. Changes in soil chemical properties resulting from organic and low-input farming practices. Agronomy Journal, v. 90, p. 662–671.

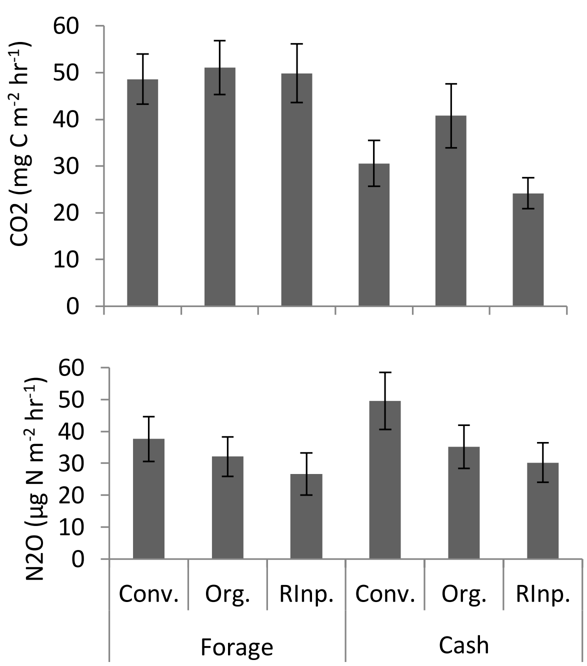

Figure 2. Greenhouse gas emissions as influenced by cropping systems and management approaches. Conv.=conventional management; Org.=organic management; RInp.=reduced-input management.

Effect of Summer Tillage on Greenhouse Gas Emissions from Organic, Conventional, and No-Till Fallows in Dryland Winter Wheat Production

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Introduction

There is growing interest among dryland winter wheat farmers in Wyoming to convert to high premium, organically certified production. However, organic production is fully dependent on tillage to control weeds and lacks active soil-fertility practices. A combination of both depletes soil organic matter (SOM) and degrades soil tilth. Alternatively, a no-till system has also been widely adopted by many dryland farmers. This system relies on chemical weed control, and the lack of tillage results in a gradual accumulation of SOM and buildup of soil tilth.

Establishing organic production after a period of no-till may prove more beneficial to farmers because of soil resources' improvement and a possibility of using less tillage for weed control. Research shows, however, that plowing of land that was previously under the Conservation Reserve Program (CRP) in the Midwest resulted in rapid and significant SOM losses to greenhouse gas (GHG) emissions. Carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) produced during this process are of particular importance due to their role in atmospheric climate warming. We hypothesize that high GHG losses are not anticipated after a first-time plowing of dryland no-till fields because low annual precipitation (11 inches) reduces microbial activity and, hence, staggers GHG emissions. We hypothesize that the magnitude of GHG losses after the first no-till plowing will be lower compared to emissions from long-term organic or conventional systems.

Objectives

Our objectives are to assess the magnitude of CO_2 and N_2O production as well as CH_4 assimilation from a single summer tillage event performed on winter wheat fallow in long-term no-till, organic, and conventional systems.

Materials and Methods

The study was conducted in a fallow phase of a winter wheat–fallow cropping system at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) during summer 2011 (Figure 1). Different management systems were: long-term conventional till (CT), organic (OR), no-tillage (NT), and no-till transition to organic (NTTO). The number of tillage operations required to manage CT is four times and OR

Figure 1. Tillage in CT plots, summer 2011.

is six times. Weeds were controlled by herbicides in NT; no chemicals are used in OR; and a combination of tillage and herbicides is used in CT. All fields besides NT were plowed on the same day. Air samples were collected once before tillage and at one-, five-, 25-, and 50-hour intervals after tillage in each of the five 9- by 9-meter plots for each treatment and analyzed for CO_2, CH^4, and N_2O using gas chromatography.

Results and Discussion

The NTTO plots did not generate high CO_2 emissions compared to frequently tilled soils (CT and OR), which produced 70–80% more CO_2 over a period of 50 hours (Table 1). Moreover, NTTO showed high levels of CH_4 assimilation compared to OR and no differences in the magnitude of N_2O emissions compared to other treatments. Overall, the first tillage of long-term no-till plots did not generate any significant C and N losses to GHG. Introducing no-till for a period of time before transitioning to organic may help establish high SOM content and result in longer soil productivity and, hence, higher yields. Since

Table 1. GWP for conventional till (CT), no-till (NT), no-till transition to organic (NTTO), and organic (OR). Lower-case letters within each row indicate significant differences between treatments at $p<0.05$.

GWP (ton $ha^{-1}yr^{-1}$)	CT	NT	NTTO	OR
GWP CO_2	4.41a	2.84b	2.54b	4.36a
GWP CH_4	-0.024c	-0.016a	-0.021bc	-0.016ab
GWP N_2O	2.13	2.44	2.67	2.04
GWP total	6.51	5.26	5.18	6.39

the majority of GHG contributions to global warming potential (GWP) come from CO_2 in dryland agricultural systems, practices aimed at reducing tillage in organic farming should be considered. Reducing tillage should also provide economic benefits to farmers by reducing the cost associated with tillage application and fertilizer inputs.

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Key words: soil organic matter, global warming potential (GWP)

Summer Rainfall Effects on Greenhouse Gas Emissions from Dryland and Irrigated Alfalfa/Grass Hay Production

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Introduction

Wyoming has approximately 620,000 acres of alfalfa grass production under dryland and irrigated management. Increasing variability of summer weather (periods of severe drought and intense rainfall events) has been recently affecting yields of hay. Corresponding cycles of wetting and drying of soil have negative impacts on soil organic matter (SOM) and, therefore, can affect long-term productivity and sustainability. Greenhouse gas (GHG) emissions are an important measure used to assess carbon (C) and nitrogen (N) losses. Specifically, information on the magnitude of carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) emissions is critical because these gases are large contributors to atmospheric warming. In general, dryland soils are important sinks for CH_4 assimilation and small sources of CO_2 and N_2O emissions, but frequent summer soil wetting and drying can negatively impact the GHG production and, hence, SOM storage. To better understand the concept of the effect of GHG gases on atmospheric heat retention, all gas emissions are converted to units of global warming potential (GWP).

We hypothesize that summer GHG emissions will be affected by the amount of precipitation and that irrigated hay production will lose more C and N to GHG emissions compared to dryland production. Moreover, dryland production will play a more important role in CH_4 assimilation compared to irrigated hay production.

Objectives

The goals of this study were to (1) quantify N_2O emissions and (2) calculate cumulative GWP over a 48-hour period following high-intensity rainfall events from soils beneath dryland and irrigated alfalfa/grass hay production in a summer experiencing an average amount of precipitation (2011) and a summer experiencing 50% of normal cumulative precipitation (2012).

Materials and Methods

The experiment was conducted at the James C. Hageman Sustainable Agriculture Research and Education Center (SAREC). Permanent plots were established in irrigated and dryland alfalfa/grass hay fields. Sub-plots representing areas containing soil beneath different plant species (alfalfa and perennial grass) were established within each of the replicated plots. Irrigated plots were dominated by legumes (66% area cover) while dryland plots were dominated by grass (70% area cover). Two water additions simulating rainfall events were applied at 0.41 inches and 0.28 inches in July 2011 and 2012, respectively. Air samples were collected before watering and at 3, 6, 24, and 48 hours after, and then the samples were analyzed using gas chromatography.

Results and Discussion

The GHG emissions responded immediately to soil watering by increasing five times compared to pre-wet emissions as early as three hours after wet-up, which suggests high N and C losses (Figure 1). The magnitude of the N_2O emissions was 17% to 24% greater from irrigated plots compared to dryland (Table 1). Moisture had a significant impact on the GWP with the drier year exhibiting smaller emissions. The greatest reduction occurred in CH_4 assimilation, which was five times lower compared to the normal year, suggesting limited ability to offset atmospheric GWP in low precipitation years.

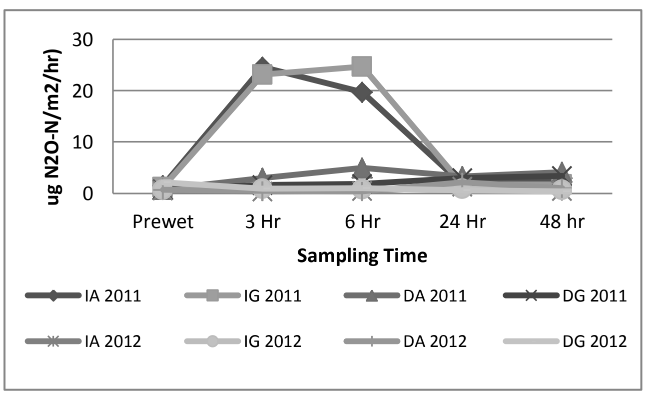

Figure 1. Emissions of N_2O from irrigated alfalfa (IA) and irrigated grass (IG) and dryland alfalfa (DA) and dryland grass (DG) in 2011 and 2012.

Table 1. Cumulative GWP estimates for dryland and irrigated alfalfa/grass hay production in 2011 and 2012 (CO_2-C eq ton ha^{-1} yr^{-1}).

		2011	
	GWP (CO_2)	**GWP (CH_4)**	**GWP (N_2O)**
Irrigated	159.79 A*	-0.35 B*	1.50 *
Dryland	133.43 B*	-0.48 A*	1.49 *
		2012	
	GWP (CO_2)	**GWP (CH_4)**	**GWP (N_2O)**
Irrigated	105.19 A	-0.10 A	0.59 A
Dryland	81.06 B	-0.07 B	0.30 B

Upper-case letters represent cases where differences in GWP have >95% chance of being significant due to differences between treatments, and asterisks represent cases where differences in GWP have >95% chance of being significant due to differences between years.

In conclusion, climate variability—specifically summer precipitation—will significantly impact C and N losses to GWP and limit the ability to efficiently assimilate CH_4. Predictions of C sequestration of hay production systems to assess future C credits will have to include GHG responsiveness to climate variability.

Acknowledgments

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Key words: legumes, global warming potential (GWP)

Micronutrient Fertilization of Edible Dry Beans and Sugarbeet in Calcareous Soils of Wyoming

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Introduction

Dry edible beans and sugarbeets are major crops grown in Wyoming. Sound soil fertility and nutrient management are valuable components of producing profitable dry bean (*Phaseolus vulgaris* L.) and sugarbeet (*Beta vulgaris* L.) crops.

Production of dry beans in alkaline or calcareous soils is affected by iron (Fe) and zinc (Zn) deficiency chlorosis. Chlorosis is the yellowing of plant leaves with prominent green veins. Symptoms of Fe chlorosis vary from mild yellowing of the leaf tissue between the veins to severe yellowing of the entire leaf. This may lead to the death of leaves, reduced plant vigor, delayed crop maturity, and reduced yields. Soil conditions such as high pH, high free calcium carbonate (lime), and low soil organic matter favor development of Zn and Fe deficiencies. Chelated forms of micronutrient fertilizers are considered a best management option for Fe and Zn deficiency because they are soluble and readily available to plants compared to other micronutrient forms. Soygreen® (produced by West Central Inc., Willmar, Minnesota), a dry water-soluble powder containing 6% ortho-ortho Fe-EDDHA, is reported to prevent iron deficiency in soybeans grown in soils where Fe uptake may be limited (Ferguson and Slater, 2010). Soygreen and Redline™, a liquid fertilizer formulation from West Central Inc. (6% nitrogen [N], 12% phosphorus [P], 3% potassium, 1% Zn, and 0.03% Fe) are also reported by the manufacturer to improve sugarbeet yields.

Objectives

The overall objective of this study is to evaluate chelated micronutrient fertilizers Soygreen and Redline for managing Fe chlorosis in dry beans. The study is also to determine the effectiveness of Soygreen and Redline on sugarbeet productivity and yield.

Materials and Methods

Sugarbeet study: Treatments in this study consisted of a control, three application rates of Soygreen® (1, 2, and 3 pounds per acre), and two application rates of Redline (2 and 3 gallons/acre). All treatments were applied in-furrow on May 3, 2012, after sugarbeet planting. All plots had 50, 75, and 10 lbs/ac of N, P, and sulfur (S) application before seeding of sugarbeets. An additional 50 lbs/ac of N was applied through sprinkler irrigation.

Dry bean study: Treatments were a control, three Soygreen® application rates (1, 2, and 3 lbs/ac), and Redline applied at 3 gal/ac. The micronutrient products were applied in-furrow at planting or post-emergence. In-furrow application was performed May 31, 2012. Post-emergence application occurred June 14, 2012 (two weeks after planting) and July 12, 2012 (six weeks after planting), using a backpack sprayer. All experimental plots received N, P, and S fertilizer applications broadcasted at 30, 50 and 10 lbs/ac, respectively. The fertilizer was broadcasted and disked into the soil before seeding pinto beans on May 31, 2012.

Results and Discussion

Regardless of the timing of product application, applying Redline® at 3 gal/ac and Soygreen® at the lowest application rate (1 lb/ac) significantly increased dry bean yield (Table 1). The application of either product had no significant effect on sugarbeet yield and sugar content. Based on preliminary results, using higher Soygreen® application had no significant impact on dry bean yield, and timing of product application also had no significant impact on bean yield.

Acknowledgments

We acknowledge staff at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) for their assistance. The project is funded by West Central Inc., Willmar, Minnesota.

Table 1. Effects of micronutrient (Redline or Soygreen) application on dry bean yield in the 2012 growing season at SAREC.

	Application Method		
	In-furrow	Post-emergence	Average
	Yield (lbs/ac)		
Control	2906	2906	2906
Redline @ 3 g/ac	3912	3703	3807
Soygreen @ 1lb/ac	3751	3306	3528
Soygreen @ 2lbs/ac	3532	3585	3559
Soygreen @ 3lbs/ac	3720	3350	3534
Average	3564	3370	3467
LSD (0.05)	833	744	538

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Key words: soil fertility, dry beans, sugarbeet

Reference

Ferguson, R.B., and G.P. Slater. 2010. Evaluation of iron chelate starter fertilizer use for irrigated soybean, Merrick County, 2010. University of Nebraska–Lincoln, 10 p. http://scal.unl.edu/fertility/Soybean%20Chlorosis%20Study%202010.pdf

Optimizing Camelina Production for Fallow Replacement in Dryland Cropping Systems

A.K. Obour[1] *and T. Foulke*[2]

[1]James C. Hageman Sustainable Agriculture Research and Extension Center; [2]Department of Agricultural and Applied Economics.

Introduction

The desire for energy security and a cleaner environment has stimulated interest in *Camelina sativa* as an alternative fuel source. This alternative dryland crop was originally used as a source of oil for food, medicinal use, and lamp oil. It now shows great potential as a bioenergy feedstock for biodiesel and jet fuel production.

Our previous research at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) showed that using camelina as a partial replacement of summer fallow in wheat production systems in Wyoming has great potential; however, current production costs and lack of markets limit production profitability of camelina, a member of the mustard family commonly known as false flax or gold-of-pleasure.

Our research is part of a recently funded National Institute of Food and Agriculture's Biomass Research and Development Initiative project between Kansas State University, Montana State University, and the University of Wyoming.

Objectives

Our objectives are (1) to evaluate production strategies that will optimize camelina production in a wheat-based cropping system and 2) enhance economic viability of camelina as a bioenergy feedstock in Wyoming and the northern Great Plains.

Materials and Methods

In fall 2012, field research plots were initiated at SAREC (Figure 1), the Sheridan

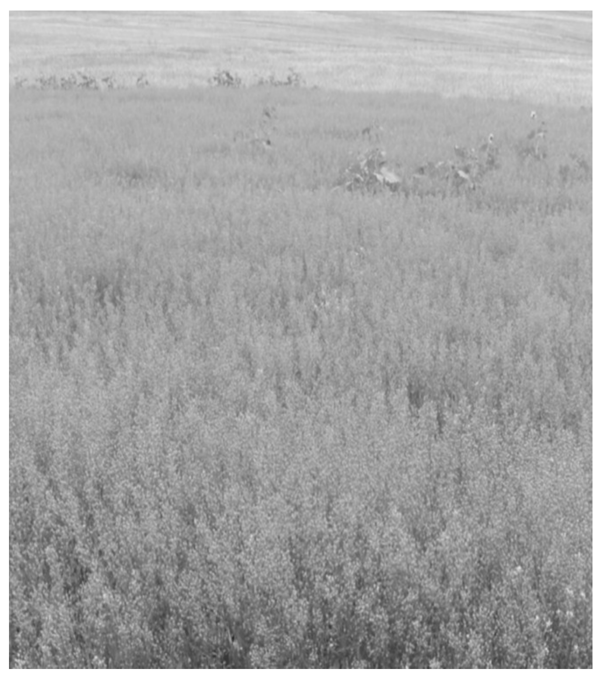

Figure 1. Camelina growing at SAREC.

Research and Extension Center (ShREC), and a collaborating producer's field near Ranchester, northwest of ShREC.

Camelina plots will be harvested at physiological maturity using a small-plot combine (Figure 2). The purpose was to evaluate production strategies and agronomic performance of spring- and winter-seeded camelina varieties and also incorporate camelina into dryland winter wheat cropping systems. The two winter-type camelina varieties are Bison and BSX-WGI, and the spring types are Blaine Creek, Pronghorn, and Shoshone. The experiments will also include a water use component to evaluate if camelina water use contributes to yield reduction in a subsequent winter wheat crop rotation. Nitrogen and sulfur fertility requirements of camelina will also be studied. Thomas Foulke in the University of Wyoming's Department of Agricultural and Applied Economics is the economist on the project and will conduct economic analyses of the different camelina–wheat production systems.

Figure 2. Harvesting camelina with a small-plot combine at SAREC.

Results and Discussion

This is an ongoing study, and successful completion will identify optimum camelina production systems and alternative uses for camelina meal and oil that will increase demand and profitability of the crop. Winter wheat–camelina rotation has potential to enhance the economic and ecological sustainability of farms in Wyoming and the northern Great Plains through the production of biodiesel and bio-based jet fuels in addition to animal feeds and developing high value bio-based co-products.

Acknowledgments

We acknowledge SAREC and ShREC farm managers (Robert Baumgartner and Daniel Smith, respectively) and the farm crews for their assistance.

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Key words: crop production, biofuels, camelina

SAREC Wind Turbine

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Introduction

The wind turbine at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) was installed as a wind energy demonstration tool in 2010. SAREC was able to purchase the turbine with an educational discount, with total installation costs of about $13,000. The goal of the project was to determine the production costs for small-scale wind energy in southeast Wyoming. We also wanted to provide decision tools for landowners interested in adopting this sort of technology.

Turbine Information

The SAREC turbine is a Skystream 3.7® from Southwest Windpower. The optimal wind speed for production ranges from 8 to 60 miles per hour. The optimum power generation occurs at 29 mph, and the turbine is rated to withstand winds up to 140 mph. The SAREC turbine is net metered, meaning electricity generated offsets actual annual electricity usage.

SAREC Wind Turbine Production

From June 2010–March 2013, the turbine produced 7,245.86 kilowatt hours (kWh) of electricity. The maximum one-day production is 55.43 kWh, the minimum is negative 0.14 kWh, while the daily average is 7.35 kWh. The turbine can have a negative daily output because it internally requires some power to run its computers even when the turbine is not turning. Daily and monthly average energy production are in Table 1. The highest production month was January 2012 when the turbine produced 537.39 kWh; the lowest was August 2011 with 50.5 kWh.

Economics

According to the U.S. Energy Information Administration, the average Wyoming household used 903 kWh per month during 2011. As of March 2013, the SAREC wind turbine produced enough energy to power a Wyoming household for a little over eight months. The Wyoming average price per kWh in 2011 was $0.0911, with the average in Goshen County as of March 7, 2013, being $0.147 for electricity provided by the Wheatland Rural Electric Association (WREA). Assuming an installation cost of $17,000 and 2011 electricity prices, not adjusted for inflation, it would take more than 100 years for this turbine to break even (includes an estimate of $100 per year for maintenance costs). At the 2013 WREA price of $0.147, not adjusted for inflation, it would take approximately 57 years to hit the breakeven point, assuming the same maintenance costs. However, if there are no annual maintenance costs, these payback periods fall to 68 and 43 years for 2011 and 2013 electricity prices, respectively. It is important to note that these calculations are based on stable electricity prices, and a wind turbine may be viewed as a way to hedge against potentially increasing energy costs. With a 20-year expected lifespan, the SAREC wind turbine will generate electricity at a cost of 32 cents per kWh.

Additional Information

Landowners may be eligible for a 25% U.S. Department of Agriculture Rural Development grant. They may also be able to use "modified accelerated cost recovery system" depreciation if the turbine is connected to a commercial account. Renewable energy valuation tools are at: http://www.uwyo.edu/barnbackyard/_files/documents/magazine/2010/summer/renewable-energy-analysis-summer-2010.pdf

Results and Discussion

While this turbine may have a rather long payback period, energy production is site-specific and depends on location of installation. Site selection is one of the most important steps to wind production. As this is designed as a demonstration tool, site location was chosen for public access, not optimal production. In fact, while this turbine is not in a poor resource region, its poor site location has a large impact on the poor electricity generation and economic performance. For a turbine with better site location, we would expect a much shorter payback period. If output is twice that of the SAREC turbine, even with annual maintenance costs included, payback falls to 25 years at 2013 electricity prices. This is an ongoing research project, and SAREC wind turbine energy production information can be accessed at www.uwyo.edu/uwexpstn/centers/sarec .

Table 1. SAREC wind turbine average energy produced, June 2010–February 2013.

Month	Daily Average kWh produced	Monthly Average kWh produced
January	14.31	440.40
February	11.65	330.06
March	10.69	301.36
April	11.60	347.93
May	8.41	260.57
June	5.38	176.80
July	2.58	79.87
August	2.15	66.57
September	2.77	83.09
October	5.09	157.90
November	8.15	252.62
December	8.09	250.76

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Key words: wind energy, sustainable energy production, wind turbine

Molasses Lick Tubs for Increasing Omega-3 Fats in Forage-Finished Cattle

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[1]Department of Animal Science.

Introduction

Grass-fed beef offers consumers a lean product with a fatty acid profile that generally reflects that of the forage consumed. Grass-fed beef producers market this product, in part, on the contents of *omega*-3 fatty acids. Although concentrations of these essential fatty acids are higher in meat of grass-fed beef than in feedlot-finished beef, their concentrations reported in scientific literature do not suggest that grass-fed beef is a particularly rich source of these acids.

The more important polyunsaturated *omega*-3 fatty acids are the ones found in fish oil, namely EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid). Attempts to increase the tissue concentration of EPA and DHA by fish oil supplementation have shown mixed results, largely because of their conversion to saturated fatty acids while in the rumen. By using a bypass source of EPA and DHA, the concentration of these fatty acids could be increased in beef; however, the extent to which supplemental *omega*-3 fatty acids can be increased in tissues of grass-fed beef has not been reported. Calcium salts of unsaturated fatty acids were shown to provide ruminal bypass characteristics. When fed as a dry mixture, however, palatability was highly variable. Furthermore, for a useful supplement, the delivery must be of low labor intensity, and the palatability must be optimal.

Objectives

The objectives were to supplement calcium salts of fish oil fatty acids as a dried molasses lick tub to Angus cattle finished on harvested forage, and measure EPA and DHA in muscle.

Materials and Methods

Fourteen heifers and 14 steers (Angus, initial body weight 518.7 ± 0.4 pound and 589.3 ± 7.3 lb, respectively) were allotted randomly by weight so that seven steers and heifers each were represented in the two dietary supplement treatments.

Within each treatment, cattle were group fed so that variation in muscle ALA (alpha-linolenic acid, the major *omega*-3 fatty acid in forage lipids), EPA, and DHA could be determined when a producer-oriented, group-grazing system was employed. Cattle were provided free-choice harvested forage composed of 65% alfalfa/bromegrass hay and 35% alfalfa/bromegrass haylage mixture (CP=15.18%) in dry lot. Dried molasses lick tubs (250 lb) that were formulated to contain 35% calcium salts of fish oil or palm oil were offered continuously for 220 days. Cattle were harvested and 12th rib longissimus muscle sampled 14 days postmortem. Fatty acid composition was determined by gas–liquid chromatography. The original plan was to supplement cattle while on unimproved pasture; however, because of the drought, no regrowth occurred, forcing use of dry lot and finishing on harvested forage.

Results and Discussion

Weight percentage (mg/100 mg fatty acids) and concentration (mg/100 g fresh muscle) of ALA, EPA, and DHA were greater ($P=0.05$ to 0.001) in muscle of cattle supplemented with fish oil than with palm oil. Steers contained greater ($P=0.05$) weight percentage of DHA and greater ($P=0.05$) concentration of EPA than heifers. Standard deviations were 0.09 to 0.24 for weight percentages and 1.09 to 3.34 for concentration values.

We conclude that the dried molasses lick tub delivery system is effective for increasing *omega*-3 fatty acids in muscle of forage-finished steers and heifers. Additionally, the variation in muscle concentrations was substantially lower in cattle fed the calcium salts of fish oil when using the dried molasses lick tub delivery system than when feeding as a loose supplement.

Feeding the supplement in a group setting with less variation suggests that all cattle had access to the supplement, and that palatability was more uniform because of the molasses in which the calcium salts of fish oil were embedded. Analysis of uterine and ovarian tissues from the heifers will be analyzed to evaluate supplementation strategies to increase reproductive efficiency.

Preliminary studies showed that basal diet impacted the outcome. In cows grazing low-quality forage, serum EPA and DHA were high. When fed to feedlot cattle, no EPA or DHA could be detected, indicating that these fatty acids were degraded. Forage quality effects on digestibility of calcium salts of fish oil also need to be tested.

Acknowledgments

We thank the crews at the James C. Hageman Sustainable Agriculture Research and Extension Center and Department of Animal Science for their devotion to this project. We also acknowledge Ridley Block Operations, Hubbard Feeds, and Virtus Nutrition for providing supplemental fat and dried molasses lick tubs. The project was funded in part by the Wyoming Agricultural Experiment Station.

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Key words: Omega-3 fatty acids, fish oil, muscle, cattle

Rhizoctonia Root and Crown Rot Management Comparing Foliar-Broadcast and Foliar-Banded Fungicide Applications in Sugarbeet

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[1]Department of Plant Sciences.

Introduction

Rhizoctonia root and crown rot (RRCR) continues to be a major disease problem for sugarbeet producers in Wyoming and beyond. Increased RRCR disease loss is associated with warm, wet soil conditions after establishment as well as the planting of susceptible cultivars. RRCR can be effectively managed with banded fungicide applications. Banding of fungicides allows growers to effectively concentrate the fungicide directly over the plant rather than applying the same fungicide amount over the entire acre. Some growers, however, have been reluctant to adopt banding application and continue to broadcast fungicide treatments for RRCR.

Objectives

The objective was to compare the relative effectiveness of banded vs. broadcast fungicide applications for RRCR management.

Materials and Methods

Plots were located at the James C. Hageman Sustainable Agriculture Research and Extension Center near Lingle. Plots were planted May 3, 2012, in a randomized complete block design with four replicates. Fungicide was applied either in a 7-inch band to plant crowns or as a broadcast on June 21 (Table 1). Ground barley infested with *Rhizoctonia solani* was then introduced onto each plant crown (12-leaf stage). Plots were then cultivated to move soil onto the crown and watered to improve infection.

Rhizoctonia root and crown rot (RRCR) incidence was rated for plants on July 4 and 17, and August 17. Incidence ratings were expressed as a percentage of the initial plant stand (determined June 4) to standardize disease ratings. Infected beets were those that had rapidly wilting leaves, darkened petioles, and/or decayed crowns evident with necrotic leaves present.

An area under the disease progress curve (AUDPC) was calculated. The AUDPC is a direct measure of season-long disease incidence. Decreased disease severity and/or later disease onset will contribute to a lower AUDPC value. All data were analyzed via ANOVA (ANalysis Of VAriance). On September 24, one of the two treated rows (20 ft) was lifted, and beet root yields were determined.

Results and Discussion

On July 4, all fungicide treatments—regardless of application placement—

reduced RRCR incidence compared to the non-treated inoculated check (*P*≤0.05). As the season progressed, the broadcast applications lost efficacy compared to their paired banded application. On August 17, disease incidence levels in all broadcast application treatments were the same as the non-treated inoculated check (*P*>0.05). The Moncut- and GWN-numbered banded treatments had less overall disease incidence than the Quadris-banded treatment (*P*≤0.05). Root yields were low for broadcast treatments and were not different from the non-treated inoculated check (*P*>0.05). Data reveal that banded fungicide application was more effective than broadcast application for reducing losses due to Rhizoctonia in sugarbeet.

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Key words: sugarbeet, Rhizoctonia, fungicide

Table 1. Effects of fungicide application method to sugarbeet for Rhizoctonia disease suppression.

Treatment, rate, and application method (ai as indicated)[Z]	RRCR incidence (% of stand)			AUDPC	Beet yield (tons/A)
	Jul 4	Jul 17	Aug 17		
Non-treated, non-inoculated check	0.0 b[Y]	0.0 c	3.6 e	56.5 e	20.2 a
Non-treated, inoculated check	28.2 a	95.9 a	99.3 a	4029.1 a	1.2 e
Moncut 70WP (1.4 lb/A concentrated in band)	0.0 b	7.5 cd	96.0 a	1652.7 bc	0.0 e
Moncut 70WP (1.4 lb/A broadcast)	0.0 b	0.0 d	23.9 c	370.0 d	15.3 b
GWN-9935 (1.4 lb/A concentrated in band)	0.0 b	7.7 cd	95.4 a	1646.7 bc	2.1 e
GWN-9935 (1.4 lb/A broadcast)	0.0 b	0.5 d	15.3 cd	246.3 de	8.4 cd
GWN-10052 (1.4 lb/A concentrated in band)	0.4 b	16.7 b	97.9 a	1888.9 b	1.3 e
GWN-10052 (1.4 lb/A broadcast)	3.1 b	1.2 d	21.6 cd	402.6 d	12.5 bc
GWN-10186 (1.4 lb/A concentrated in band)	0.0 b	2.7 d	96.7 a	1558.9 c	0.0 e
GWN-10186 (1.4 lb/A broadcast)	0.0 b	1.6 d	13.0 de	237.0 de	8.6 cd
Quadris 2.08SC (0.15 oz/1000 ft in band)	0.7 b	13.8 bc	78.5 b	1528.9 c	6.9 d

[Z] Applications were made June 21 in a 7-inch in-furrow band in 1.21 gal/1000 row ft (45 psi boom pressure). Broadcast applications were made in a total volume of 43 GPA at 30 psi boom pressure. Inoculation with *Rhizoctonia solani* AG2-2 was June 21 after fungicide application. Disease was measured as seedling decay (stand loss) and Rhizoctonia root and crown rot (RRCR).

[Y] Treatment means followed by different letters differ significantly (Fisher's protected LSD, *P*≤0.05).

Post-Fire Resource Evaluation and Forest Regeneration at the Rogers Research Site

S. Williams[1], A Garcia y Garcia[2], and J. Freeburn[3]

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

Introduction

The Rogers Research Site (RRS)—in the Laramie Mountains southeast of Laramie Peak—was threatened by wildfires in late June and early July, 2012. The largest of these, the Arapaho Fire, burned across the RRS on July 1. Post-fire evaluation showed that the burn was a hot ground fire on about half of the RRS and a crown fire on the balance. More than 90% of the ponderosa pine and aspen burned.

Objectives

The objectives of this report are to (1) discuss pre- and post-fire characteristics of the site, and (2) indicate details of a larger study being established to evaluate different methods of ponderosa pine regeneration as well as erosion control treatments and longer-term nutrient cycling.

Materials and Methods

Evaluation of Soils: During May and June 2012, eight 0.62-acre plots were established at the RRS. Four plots were established in ponderosa pine forests, two in aspen, one in a riparian forest, and one on shallow soil over granite. Vegetation and surface features were mapped, and a soil pit was excavated in the center of each. Soil field characteristics were noted and samples taken from each for laboratory analysis.

Erosion, Pine Regeneration, and Slash Removal: A large study is being planned to examine grass/forb plantings to control erosion, to test various ways of regenerating ponderosa pine, and to see how leaving slash on the plots will impact long-term rejuvenation of the area. Each experimental plot will be 0.62-acre in size.

Results and Discussion

The fire of early July 2012 burned most of the vegetation on the RRS (Table 1). Of the surface area of the RRS, 309 acres were native vegetation (Seymour, 2007), and 11 acres constituted a pond, roads, cabin, rock outcrop, and other features. Of the vegetated area, all but 16 acres burned in the fire.

Evaluation of Soils: Soils sampled pre- and post-fire showed dramatic changes in pH (increasing 1.2 pH units or becoming less acid in surface soils), and in electrical conductivity or soil saltiness ([EC] tripling in all soils and more than quadrupling in surface soils). Phosphorus quadrupled in all soils and increased by a factor of nine in surface soils. Increases in pH are explained by the increases in cations (sodium, potassium, calcium, and magnesium) post-fire (Table 2).

Fertilizer/Compost Tea and Erosion, Pine Regeneration, Slash Removal Studies: These studies are mostly in the planning phase, and results will be reported in the future.

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Key words: forestry, best management practices, fire effects

Reference

Seymour, M. 2007. Vegetation mapping of Rogers Research area, northeast Albany County, Wyoming, using high resolution AEROCam photography, Wyoming Geographic Information Science Center internal report, 12 p.

Table 1. Pre-fire and post-fire areas of vegetation at RRS.

Vegetation type	Pre-Fire Area	Post-Fire area
	Acres	
Dense Ponderosa Pine	201	11
Sparse Ponderosa Pine	53	0
Mixed Grass/Shrubs	35	0
Aspen	13	1
Willow	2	1
Aspen/Willow	4	2
Ponderosa/Aspen/Willow	1	1
Totals	309	16

Table 2. Pre-fire and post-fire soils analysis.

	Pre-Fire		Post-Fire	
	All Soils, all depths	Surface only	All Soils, all depths	Surface only
pH	6.00	6.02	6.50	7.24
EC, dS/m	0.24	0.26	0.81	1.22
Phosphorus	26.22	24.57	109.06	216.84
Sodium	0.75	0.78	0.37	0.37
Magnesium	0.48	0.52	2.86	4.59
Calcium	1.21	1.39	6.75	11.32
Potassium	0.26	0.27	0.75	1.28
Sodium adsorption ratio	0.99	0.95	0.25	0.18

For pre-fire and post-fire, n is 16. For surface samples only, n is seven.
All cations (sodium, magnesium, calcium, and potassium) are in Meq per liter. Phosphorus is in mg/Kg.

Sheridan Research and Extension Center

V.D. Jeliazkov[1]

[1]Director, Sheridan Research and Extension Center.

Introduction

The Sheridan Research and Extension Center's dryland field station is seven miles east of Sheridan. ShREC also has facilities at the Joe and Arlene Watt Agriculture Center and the Adams Ranch, which are both adjacent to Sheridan College (SC). ShREC is in the U.S. Department of Agriculture's (USDA) Plant Hardiness Zone 4, with an average growing season of 120 days. Average annual precipitation is 15 inches. ShREC farms approximately 300 acres at its facility east of Sheridan, and all crops are produced by dry-farming methods. Since ShREC's beginnings, its aim has been to promote research useful to Wyoming farmers and ranchers. In the last 5–6 years, ShREC initiated additional projects in other research areas including horticulture and turf grass. The research in horticultural specialty crops expanded in 2011–2012 and is geared not only to farmers and ranchers, but also to homeowners, golf course greens keepers, horticulturalists, and others.

Exciting New Developments

In 2012, the Watt Agriculture Center was purchased by the University of Wyoming to become ShREC's "new home" (Figure 1). The Watt center is on the SC campus and will allow for close cooperation between

Figure 1. The Joe and Arlene Watt Agriculture Center at Sheridan College is the new home of ShREC. Pictured are, from left, Daniel Smith (farm manager), Valtcho Jeliazkov (ShREC director), Sadanand Dhekney (assistant professor in horticulture), Rochelle Koltiska (office associate), Jeremiah Vardiman (research associate), Andrew Burkhardt (graduate student), Lyn Ciampa (summer student), and Rebecca Moreland (part-time employee).

UW and SC faculty and students. In January 2013, ShREC took over management of the Adams Ranch, an approximate 480-acre property of which 250 acres are under irrigation. Adams Ranch is owned by Whitney Benefits, a Sheridan-based educational foundation established by the late Edward Whitney.

ShREC Mission

The mission of ShREC is to serve Wyoming's applied research, education, and extension needs in horticulture, range reclamation, water remediation, and forage management.

ShREC Areas of Distinction

Horticulture: The goal is to develop research, extension, and educational programs to evaluate, manage, and enhance selected high-value crops. Initially, programs will focus on edible, ornamental, medicinal/nutraceutical, and turf grass plants with emphasis on sustainable methodologies, protected cultivation (including greenhouses and high tunnels), and practices to extend the growing season.

Range reclamation and water remediation: The goal is to develop programs to enhance methods for reclamation and restoration of rangeland and for utilization of coal-bed methane (CBM) water for irrigation. Programs will include evaluation of ecosystems associated with remediation of water and soils, propagation and production of native plants, and limited supplemental irrigation during the reclamation process.

Forage management: The goal is to develop research, extension, and education programs for optimal utilization of land resources for forage management and alternative crops. Initial programs will concentrate on evaluation of improved forages under irrigated systems that are suitable for grazing livestock, hay production, and production of biomass for biofuels.

Current Research

Current research projects include:
1) evaluation of alfalfa; 2) small grain variety trial; 3) sainfoin variety trial;
4) homeowner turf trial; 5) biofuel crops study; 6) utilization of CBM discharge water; 7) establishment of mints as a specialty crop for Wyoming; and
8) optimization of high and low tunnel organic vegetable systems for the Sheridan area. A new project involves the evaluation of table and wine grape cultivars for Wyoming. The goal is to identify promising grapevine cultivars for Wyoming, thus overcoming obstacles to initial vineyard establishment, resulting in increased production and early returns.

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Evaluating Table and Wine Grape Cultivars in High Tunnels for Yield and Quality Improvement

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Introduction

High tunnels typically offer uninterrupted growing periods for specialty crops in addition to protection from spring frosts, unseasonal hail, and foraging pests. The potential benefits of wine grape production in high tunnels are currently being evaluated in Pennsylvania and Michigan.

Objectives

The goal of this new study in Wyoming is to evaluate the growth and production of table and wine grape cultivars in high tunnels so that the cultivars could be sold at local farmers' markets and other venues in Wyoming and beyond.

Materials and Methods

A kit for a 96- by 30-foot high tunnel was purchased from FarmTek® and established on the grounds of the Sheridan Research and Extension Center (ShREC; Figure 1). Materials and installation costs were estimated at $6,500. Following construction of the high tunnel, a 5-feet-tall trellis system with four rows (7 feet between rows) was established using 12.5-gauge aluminum wire and wooden posts spaced 18 feet apart. End posts were securely anchored in the ground with 40-inch earth anchors. The tension on the wires for the trellis system was adjusted using a wire vise tensioning tool.

Year-old 'Bronx Seedless', 'Delaware', 'Edelweiss', 'Fredonia', 'Himrod', 'Interlaken', 'Kay Gray', 'Ontario', 'Orion', 'St. Croix', 'Thomcord', 'Venus', and 'Vidal Blanc' grapevines were planted in existing soil at 5-feet spacing within rows in 11.8-inch-deep holes (Figure 2). Vines were irrigated with a sprinkler system during periods of dry weather. Grapevines entered dormancy following periods of low temperatures in October.

Figure 1. High tunnel construction.

Results and Discussion

From the second year on, grapevines will be pruned in early spring for fruit production. Dates for bud burst and initiation of flowering, time required from flower initiation to berry set, berry growth and development, maturity, and ripening will be recorded for individual cultivars.

Conditions in the high tunnel will be monitored and data recorded for any potential problems including flowering and fruiting disorders, diseases, and pests. Cultural practices such as fertilizer application, weeding, and spraying for pests and diseases will be carried out as required throughout the life of the experiment.

Once berries ripen, yields, individual berry weights, number of clusters and berries per cluster, number of seeds per berry (for seeded cultivars), and berry “total soluble solids” will be recorded.

Taste evaluation will be conducted by volunteers from ShREC and Sheridan College, and fruit from individual cultivars will be evaluated for wine quality by collaboration with local winemakers. A cost–benefit analysis of growing table and wine grape cultivars in high tunnels would help serve as a guide for potential growers seeking to invest in an intensive, high-value horticultural enterprise.

Acknowledgments

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Key words: grape, high tunnel, wine

Figure 2. Grapevines growing inside the high tunnel.

Evaluating Winter Injury Damage to Grapevines in Wyoming Vineyards

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Introduction

Grape production in Wyoming evinces strong interest from producers seeking viable alternatives to traditional crops and homeowners with backyard plantings. Low winter temperatures, late spring frosts, and a short growing season, however, limit the cultivation of popular bunch grape cultivars in the state. With the development of new cold-hardy grape cultivars, the scope for grapevine production in colder regions of the United States, including Wyoming, is rapidly expanding.

Successful vineyard establishment and grape production is influenced by a number of factors including vineyard site, regional and local climate, cultivar, and vine age and health. Winter damage to dormant grapevines is frequently observed in areas experiencing freezing winter temperatures below 0°F (Zone 6 or below on the U.S. Department of Agriculture's Plant Hardiness Zone Map). Assessing winter injury to grapevines will help enable growers to make decisions on the timing and extent of pruning to be carried out for maximizing productivity.

Objectives

The goal of this study was to estimate the amount of winter damage caused to cold-hardy grape cultivars at different locations in Wyoming.

Materials and Methods

Dormant year-old canes (mature wood) were obtained from grape cultivars 'Brianna', 'Frontenac', 'Frontenac Gris', 'King of the North', 'La Crosse', 'Marquette', and 'Valiant' from vineyards in northwestern Wyoming near Basin and Worland on March 18, 2013.

Each cane had at least 15 dormant buds, which were individually excised using a scalpel to expose the primary, secondary, and tertiary buds. The number of alive and dead buds was estimated based on observed tissue color. Green-colored tissues indicated live buds, while buds suffering from cold damage were characterized by severe tissue browning. Percent damage to dormant buds was calculated to estimate winter injury on canes.

Results and Discussion

Preliminary data indicate that 'Lacrosse' vines exhibited the lowest bud damage (15%), followed by 'Valiant' (41%), and 'Marquette' (53%). The highest bud damage was observed in 'Frontenac Gris' (71%). In general, winter damage to dormant vines was higher in the Worland vineyard compared to the Basin vineyard. Such differences may be attributed to the vineyard site and use of specific trellis and pruning systems.

We are collecting dormant canes from vineyards in additional locations (southeastern Wyoming near Huntley and Wheatland, western Wyoming near Riverton, and north-central Wyoming near Sheridan) to study the interaction of vineyard location and winter vine damage. Estimating cold injury at various locations will assist in providing recommendations on how to prune grape plants when they are dormant to help ensure maximum growth and productivity.

Acknowledgments

The study is being supported by the U.S. Department of Agriculture, National Institute of Food and Agriculture's Specialty Crop Research Initiative funds through the Wyoming Department of Agriculture.

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Key words: grape, vineyard, winter injury

Genetic Engineering of Grapevine Cultivars and Rootstocks for Drought and Salinity Tolerance

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Introduction

Drought and salinity are major factors limiting grapevine production in semiarid regions of the United States. Grapevine genetic improvement for abiotic stress tolerance is paramount for the viticulture (study of grapes and their culture) industry worldwide.

Improved grape cultivars and rootstocks are traditionally developed by conventional breeding. The genetically diverse nature of the grapevines limits the number of traits that can be inserted into cultivars without disrupting existing fruit and wine characteristics. Additionally, seedling vines obtained by breeding take between 5–7 years for flowering and fruiting, which makes screening of new selections time consuming.

Genetic engineering offers a potential alternative to improve stress tolerance of elite cultivars without changing existing desirable characteristics. Such cultivars would be suitable for production in semiarid regions of the United States, including Wyoming.

Objectives

The goal of this study was to introduce traits conferring drought and salinity tolerance in elite grape cultivars using genetic engineering technology.

Materials and Methods

The experiments are being carried out at the Sheridan Research and Extension Center (ShREC). Leaves of grapevine cultivars ‘Bronx Seedless’, ‘Himrod’, ‘Interlaken’, and *Vitis vinifera* ‘Thompson Seedless’ were used to establish plant tissue cultures.

Genes that confer drought and salinity were used in genetic engineering studies. The gene sequences were optimized and transferred to grape tissue cultures by infecting them with a bacterial vector (*Agrobacterium tumefaciens*). This bacteria causes crown gall disease in grapes under natural conditions but is modified in the laboratory to act as a vector for gene transfer.

Following infection and gene transfer, plant tissue cultures were treated with antibiotics to eliminate remaining bacterial cells and then grown on tissue culture medium for multiplying transgenic cells and, ultimately, producing transgenic plants that confer drought and salinity tolerance.

Results and Discussion

A wide variation in the production of transgenic cells was observed in different cultivars. Tissue cultures exhibiting vigorous growth are currently being grown to produce plants. We will analyze transgenic plants using various molecular techniques prior to testing them in a greenhouse and the field. Transgenic plants may eventually provide improved agricultural resources adapted to climates and soils in Wyoming and surrounding regions.

Acknowledgments

We thank Rochelle Koltiska and Daniel Smith for assistance with laboratory and field experiments.

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Key words: grape, drought, salinity

Optimizing Tissue Culture Protocols for Cold-Hardy Grape Cultivars and Rootstocks

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Introduction

Grapevine cultivars and rootstocks are conventionally propagated vegetatively using hard- or soft-wood cuttings, budding, layering, or grafting. Vegetative propagation of grapevines is influenced by a number of factors including initial availability of stock vines, land and water resources, and seasonal fluctuations, which can limit the amount of new vines that can be produced. Plant tissue culture technology, which involves propagation of plants in a laboratory, allows for rapid production of clean, disease-free, and vigorous plant material in a shorter time period compared to conventional propagation techniques.

Objectives

The goal of this study is to optimize plant tissue culture protocols for newly developed grape cultivars and rootstocks that are suitable for production in colder regions of the United States, including Wyoming.

Materials and Methods

Experiments were carried out at the Sheridan Research and Extension Center (ShREC). Dormant vine cuttings of grape cultivars 'Bronx Seedless' ES-8-2-43, 'Himrod', 'Interlaken', 'Seyval Blanc', and 'St. Croix', and rootstocks 'Couderc 3309' and 'SO_4', were obtained from the U.S. Department of Agriculture's Plant Genetics Resources Unit of the National Clonal Germplasm Repository, Geneva, New York.

Cuttings were immersed in a 25% commercial bleach solution for 5 minutes and then washed in sterile distilled water. Vegetative growth was forced from dormant cuttings by transferring them to glass containers filled with sterile distilled water. Cuttings were then placed under cool-white fluorescent lights at 16-hour day-length and a 77^{o}F temperature (Figure 1A).

After six weeks of growth, tips of actively growing shoots were excised and selected as explants (starting material) for initiating tissue cultures (Figure 1B). Explants were surface-sterilized by immersion in 70% alcohol followed by washing them in sterile distilled water. Explants were then washed in 25% bleach solution for 5 minutes followed by three 5-minute washes in sterile distilled water. Following surface-sterilization, the growing shoot tip was isolated (Figure 1C) and transferred to plastic petri dishes containing a growth medium (Figure 1D). Tissue cultures were placed under lights as described above and multiplied by transferring single nodes to fresh medium at four-week intervals. The numbers of shoots obtained from each explant were counted prior to each transfer.

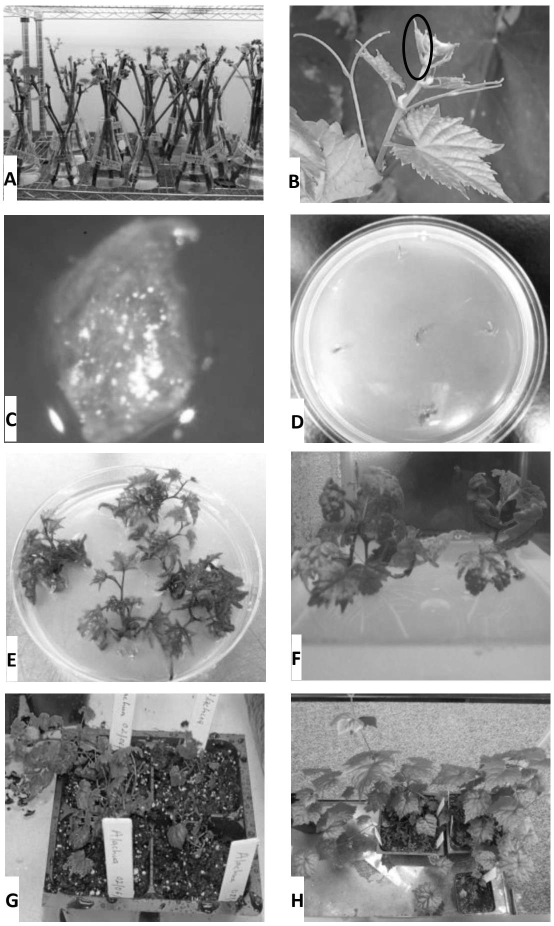

Figure 1. Micropropagation of grapevine. A. Forcing growth in dormant cuttings; B. Explant selection; C. Explant surface-sterilization; D. Culture initiation; E. Culture multiplication; F. Rooting; G. Transfer to potting mix; H. Acclimatized plants.

After 12 weeks of culture multiplication, resulting shoots were transferred to fresh medium to induce root formation. Well-developed plants were transferred to soil under conditions of 100% relative humidity. Plants were placed under lights as described above for three weeks before being transferred to a greenhouse.

Results and Discussion

A high rate of shoot multiplication was observed among the various cultivars and rootstocks studied. For instance, 'Himrod' cultures produced eight shoots per explant after four weeks of culture, which increased to 152 following transfer of culture to fresh medium (Figure 1E). A 100% rooting rate was observed among proliferated shoots (Figure 1F). High plant survival rates were observed during the acclimatization phase and following transfer to a greenhouse (Figure 1G–H). We are currently studying multiplication rates for additional cultivars. Regenerated vines will be screened along with vegetatively propagated vines for their performance under field conditions.

Optimizing tissue culture protocols for cold-hardy grape cultivars will help ensure adequate availability of disease-free, healthy planting materials for grape growers in Wyoming and perhaps beyond.

Acknowledgments

We thank Rochelle Koltiska and Daniel Smith for assistance with laboratory and field experiments.

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Key words: grape, micropropagation, tissue-culture

Optimizing Somatic Embryogenesis in Cold-Hardy Seedless Grape Cultivars

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Introduction

Somatic embryogenesis involves the production of plants from somatic or non-sexual tissues in a laboratory. This is in contrast to seedling-derived plants, which arise from sexual reproduction. Somatic embryos are similar to seed-derived embryos; however, plants obtained through somatic embryogenesis are identical to the parent plants from which starting tissues were obtained.

Plant regeneration through somatic embryo development (or embryogenesis) is an essential prerequisite for inserting desired traits in elite grapevine cultivars using genetic engineering. Somatic embryogenesis is influenced by a number of factors including cultivar, the growth medium used, and growth conditions in the laboratory.

Objectives

The goal of this study was to optimize somatic embryogenesis in cold-hardy seedless table grape cultivars.

Materials and Methods

The experiments are being conducted at the Sheridan Research and Extension Center. Leaf explants of grape cultivars 'Bronx Seedless', 'Himrod', 'Interlaken', and 'Thompson Seedless' were obtained from plant tissue cultures. Leaves were placed on a growth medium in the dark for seven weeks and then transferred to light. Following transfer to light, somatic embryogenesis in each cultivar was recorded. Somatic embryos were transferred to a development medium for embryo development and then to germination medium for obtaining plants. Well-developed plants were acclimatized in plastic domes under high relative humidity and transferred to a greenhouse.

Results and Discussion

Somatic embryogenesis was initiated from leaves of all cultivars. The highest production was observed in 'Thompson Seedless' (34%), followed by 'Bronx Seedless' (20%) and 'Himrod' (16%).

Somatic embryo development and proliferation were also observed from all cultivars studied. Cotyledonary-stage somatic embryos were germinated to obtain plants. Embryogenic cultures are currently being established from additional cultivars and will be used as target tissues in genetic engineering studies.

Acknowledgments

We thank Rochelle Koltiska and Daniel Smith for assistance with laboratory and field experiments.

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Key words: grape, somatic embryogenesis, cold-hardy

Production of Disease-Free Grapevines Using Plant Tissue Culture Technology

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Introduction

A number of grapevine bacterial and viral diseases are primarily transmitted through infected propagation materials used for vineyard establishment. Plant tissue culture techniques such as "micropropagation" are routinely utilized for production of insect- and disease-free plants from infected stock vines. Micropropagation utilizes the rapidly growing shoot tips of vines and somatic embryogenesis (the use of non-sexual vine tissues for plant propagation in the laboratory).

Objectives

The goals of this study were to optimize micropropagation and somatic embryogenesis protocols for production of disease-free plants from grapevines infected with grapevine fanleaf virus (GFLV) and *Agrobacterium tumefaciens* (the causal agent of crown gall disease).

Materials and Methods

The experiments were carried out at the Sheridan Research and Extension Center (ShREC). Dormant cuttings were obtained from field-grown grapevines exhibiting visual symptoms of crown gall caused by *A. tumefaciens* and GFLV. One-foot long cuttings were surface-sterilized by agitation in 25% commercial bleach solution for five minutes followed by washing in sterile distilled water. Vegetative growth and flowering were forced from dormant cuttings by transferring them to 17-ounce flasks containing 8.5 ounces of sterile distilled water. The cuttings were then placed under grow lights in a temperature-controlled room (77°F).

After six weeks of growth, tips of actively growing shoots were excised and selected as explants for culture initiation. After disinfecting shoot tips, the actively growing core (known as the meristem), whose cells are known to be disease-free, was isolated and transferred to a growth medium. Cultures were placed in the dark for four days to allow the core to recover from the excision shock followed by transfer to grow lights as described above.

For three subsequent sub-cultures at intervals of four weeks, the cores from developing cultures were excised and transferred to a fresh medium with antibiotics. Following the fifth sub-culture, single nodes were transferred to fresh medium for culture proliferation. Shoots from proliferating cultures with three nodes were excised and transferred to a growth medium that stimulated rooting. Well-developed plants were acclimatized and transferred to a greenhouse.

To establish embryogenic cultures, inflorescences from cuttings were obtained and surface-sterilized as described above. Floral tissues were excised from individual flowers and placed, along with the pistil, on growth medium. Cultures were then put in the dark for seven weeks at 79°F. Resulting callus cultures were then transferred to light and screened weekly for development of embryogenic callus.

The resulting embryogenic callus was transferred to a medium for somatic embryo development. Fully developed embryos were germinated to obtain plants, which were acclimatized and transferred to a greenhouse. Nucleic acid sequences, which aid in the detection of the pathogens in plants produced through tissue culture, were obtained from a nucleic acid synthesis facility for analyzing disease status of regenerated grapevines. The presence of viral pathogens will be detected using ELISA, short for enzyme-linked immunosorbent assay.

Results and Discussion

Grapevine plants have been regenerated by micropropagation and somatic embryogenesis. Following active growth, DNA will be isolated from regenerated plants and infected stock vines growing in a greenhouse. A nucleic acid-based technique (polymerase chain reaction) will be utilized for detecting the presence of *Agrobacterium*. To detect the presence of GFLV, vines will be sent to a commercial facility for testing purposes using ELISA. The efficiency of micropropagation and somatic embryogenesis for production of disease-free grapevines will be estimated by comparing the number of clean plants obtained by each technique.

Once disease-free status of tissue culture-produced grapevines is confirmed, they will be transferred to the field. The technique now enables us to test potential infection occurring in grapevines from Wyoming vineyards with an end result of producing disease-free plants.

Acknowledgments

We thank Rochelle Koltiska and Daniel Smith for assistance with laboratory and greenhouse activities.

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Key words: grape, micropropagation, somatic embryogenesis

Screening Grapevine Cultivars for Adaptability to Soil and Climatic Factors in Wyoming

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Introduction

A strong interest in grape production is expressed by Wyoming producers seeking viable alternatives to traditional crops and homeowners with backyard plantings. Low winter temperatures, late spring frosts, and a short growing season limit the cultivation of popular bunch grape cultivars in the state. With the development of new cold-hardy grape cultivars, the scope for grapevine production in colder regions of the United States, including Wyoming, is rapidly expanding.

The Wyoming grape industry, which started with two growers, has now expanded to about 20 producers growing grapes on 25–30 acres with an annual fruit production of 40–45 tons. Grape production and quality is governed by the complex interaction of cultivars with prevailing soil and climatic conditions. Thus, choice of cultivar(s) is a critical factor for successful vineyard establishment. Favorable weather conditions during the growing season can ensure vigorous, disease-free vine growth and high-quality fruit production if suitable cultivars for the state can be identified.

Objectives

The goal of the project is to identify promising grapevine cultivars for Wyoming, thus overcoming obstacles to initial vineyard establishment, resulting in increased production and early returns.

Materials and Methods

A grape germplasm composed of 52 cultivars and rootstocks was established in 2012 in a greenhouse at Sheridan College (Figure 1). Stock vines were vegetatively propagated in a mist chamber to produce plants for the field trial.

A one-acre vineyard site was established near Sheridan College at the Adams Ranch, which is managed by the Sheridan Research

Figure 1. Establishment of a grape germplasm at Sheridan College.

and Extension Center (Figure 2). A five-foot-tall high-wire cordon trellis system was constructed using wooden posts (8 feet tall) spaced at 20-foot intervals within rows. End posts were securely anchored in the ground using 40-inch earth anchors. Two wires (12.5-gauge aluminum) were installed at 3 and 5 feet, and wire tension on rows was adjusted using a wire vise tensioning tool. Vines will be planted at 10-feet X 7-feet spacing. A smaller test site was established at the Powell Research and Extension Center to test 10 grape cultivars.

Results and Discussion

Growth parameters including date of bud burst and flower initiation, number of flowers per vine, and pruning weight will be recorded for individual cultivars. Yield and quality will be recorded as vines mature and bear to full potential. The project addresses critical needs of current and future grape growers and citizens interested in home gardening. It comes at a time when the Wyoming grape industry seeks to expand, and our research should provide a source of reliable information for successful vineyard establishment and production.

Acknowledgments

Financial assistance from the University of Wyoming's College of Agriculture and Natural Resources and the Wyoming Agricultural Experiment Station is acknowledged. The project is also supported by the Wyoming Department of Agriculture and U.S. Department of Agriculture's Specialty Crop Block Grant Program

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Key words: grape, viticulture, vineyard

Figure 2. Vineyard establishment at the Adams Ranch near Sheridan College.

Testing the Relative Contribution of Genetic Diversity and Local Adaptation to Restoration Seeding Success

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Introduction

Seed source is an important consideration for ecological restoration because many native plant species occupy wide geographic ranges, and populations are often adapted to local environmental conditions. To avoid introductions of seeds not suited to restoration sites, guidelines call for the use of "genetically appropriate" native seeds. A genetically *diverse* seed source may be equally important to provide the raw material for survival at degraded sites and to adapt to changing environmental conditions.

Objectives

To improve restoration success, this project will test the use of multiple or single seed sources of local or commercial origin in restoration efforts. We predict that multiple seed sources of each species will represent greater genetic diversity and could subsequently lead to greater success at restoration sites. In addition, multiple *local* sources will represent genetic diversity adapted to local environmental conditions, and these seed sources are expected to have the greatest revegetation success (Figure 1).

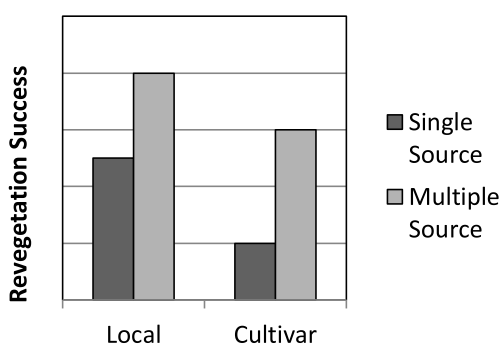

Figure 1. Predicted success rate using multiple local seed sources or multiple cultivated seed sources.

Materials and Methods

At each of two field locations near Sheridan and Laramie, we will establish plots planted with the following treatments representing one target species: 1) single local seed source, 2) single commercial seed source, 3) three local sources, and 4) three commercial sources. Each of the four treatments will be replicated in three randomly selected plots. This design will be repeated for each of three native plant species to assess consistency of results for restoration guidelines. Plant species include Sandberg bluegrass, prairie sagewort (also known as fringed sage), and the forb scarlet globemallow (Figure 2). These species are composed of diverse populations throughout their geographic range. Sage and bluegrass are wind-pollinated species while bees pollinate scarlet globemallow.

We will monitor seed germination and seedling establishment for two or more years.

Figure 2. Scarlet globemallow photographed at Pawnee National Grassland in Colorado.

Results and Discussion

Project outcomes may have immediate applications for ecological restoration and native plant propagation practices in the region. Plant establishment at most restoration sites in Wyoming is challenging due to generally poor soil conditions, harsh climate, and the presence of noxious weeds like cheatgrass. If we discover that use of multiple seed sources of the same species improves the probability of establishment of each species at restoration sites, recommendations would be to increase the genetic diversity of seed sources for planting. The simplest means to increase genetic diversity is to increase the number of different geographic sources of seeds (locally collected or commercially grown) of each species before planting. Within the region, contribution to the understanding of the relative importance of genetic diversity versus local adaptation may assist the growers of native plant material in seed increase planning. For example, if genetic diversity contributes to the establishment and germination of plants in revegetation efforts, suppliers may choose to diversify their stock or collaborate with other suppliers to provide more genetically diverse mixes. Or, if local adaptation is found to be the most important factor for planting success, suppliers might consider increasing the number of local, wild collections in propagation efforts.

Results of this study may also be used as a foundation for further research beyond the region and scope of this project. Although specific restoration needs and challenges vary according to location, revegetation and plant propagation needs are similar throughout the West. Furthermore, this research should contribute a significant piece to the larger puzzle of the role of genetic diversity in the successful establishment of sustainable plant populations.

Acknowledgments

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Key words: diversity, restoration, seed source

Irrigated Grass–Legume Mixtures

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Introduction

Forage crops play a major role in providing available forages for the sustainability and profitability of beef cattle and cow–calf operations in the United States. Likewise, forage grasses, especially cool-season perennial grasses, are the backbone of Wyoming livestock production systems. Forages support the well-developed beef and sheep industries in Wyoming. Forage production under irrigated conditions is one of the best ways to supply appropriate nutrition for these two important industries.

Most of the irrigated land in Wyoming is under forages; however, research-based information is lacking on various grass–legume mixtures under irrigated conditions. There is critical need to assess productivity, quality, and long-term persistence of grass–legume mixtures under irrigation.

This study aims to determine the best combination of grass–legume mixtures that will provide a sustainable and an optimum yield and quality of forage in the region. Additionally, comparisons will be made of grass–legume mixtures with different nitrogen (N) regimes.

Objectives

Specific objectives are to: 1) Determine the effects of ratios of grass–legume mixtures and N fertility regimes on growth, yield, quality, and persistence of forages; 2) determine the water use and water-use efficiency of the grass–legume mixtures; and 3) compare the net returns of forage production and per-unit costs of producing qualitative measures such as dry matter, N, etc., when fertilized with commercial N or fertilized naturally by planting legumes into the mixtures.

Materials and Methods

The study will be established in fall 2013 at the Adams Ranch of the Sheridan Research and Extension Center (ShREC) under irrigation. Standard small plots (5′×20′) will be used under the center pivot. Meadow brome, a cool-season perennial grass, will be used as a test grass species. Additionally, three forage legumes (alfalfa, sainfoin, and bird's-foot trefoil), three ratios of grass–legume mixtures (100:0, 50:50, and 70:30%), and three N fertility regimes (0, 50, 100 pounds N per acre) will be used. The variety of forage species will be determined based on local or regional variety trials. N treatments will be "split-applied" only to grass species—the first split will be applied at the beginning of the growing season in early spring, and the second split will be applied in late summer. Each plot will receive a blanket application of potassium and phosphorus based on soil-test results. Standard seeding rates will be used for all varieties, and the study will be planted in three replicates. Therefore, the total number of plots will be 81 (1 grass × 3 legumes × 3 ratios × 3 N regimes × 3 replications).

Establishment/persistence, forage yield, and forage quality will be measured throughout the study. Plots will be harvested two to three times a year depending on forage growth and herbage availability using a forage harvester. Forage quality will be determined at each harvest.

Detailed information on soil moisture characteristics (e.g., water-holding capacity, soil types, etc.) will be obtained at the experimental field at the beginning of the growing season. Soil moisture will be monitored using a neutron probe. Access tubes for the neutron probe will be installed to monitor soil moisture at depths of 6, 12, 18, 24, 30, 36, 42, 48, 54, and 60 inches. Additionally, water use and water-use efficiency will be determined under various treatments performing a water balance at each treatment.

Finally, an economic comparison of grass–legume mixtures with N fertilizer will be performed by comparing input costs and estimated net income generated from grass–legume mixtures.

Results and Discussion

This research will help address the knowledge gap relating to grass–legume mixtures under irrigation. It also will be used as a research, education, and demonstration tool for ranchers and farmers, students at the University of Wyoming and Sheridan College, and others. It is anticipated that developing forage-management options for producers in the state will greatly increase forage productivity and quality and hence improve overall farm income, profitability, and long-term sustainability of the beef cattle industry in Wyoming. The economic analysis will use historical hay and fertilizer prices to offer a long-term comparison of N fertilization and grass–legume mixture options. Study results should be useful to producers in Wyoming, and perhaps beyond, who may be considering forage hay-improvement programs.

Acknowledgments

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Key words: forage, irrigation, economics

Coal-Bed Methane Water Effects on Plant Secondary Metabolites and Plant Physiology

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Introduction

Increasing demand for natural gas has led to increased exploitation of methane from coal seams. To remove the methane, large volumes of groundwater must also be pumped to the surface to reduce the water pressure that is holding the gas in the coal seams. Typically, waste water removed from these seams (referred to as coal-bed methane water or CBMW) is pumped back into the seams, put into holding ponds to evaporate, or utilized as irrigation water. With Wyoming's dry climate, the latter end use is of great interest as an inexpensive irrigation source. However, due to high amounts of dissolved solids and other materials in the water, long-term use of CBMW has been shown to have a deleterious effect on crop yield and plant physiology.

Given the enormous amount of CBMW estimated to be produced (somewhere in the order of billions to trillions of barrels depending on reporting agency and production estimates), it is important to fully understand the effects it may have on the environment and on agricultural lands.

Objectives

The goals of this project are to better understand the impacts CBMW will have on plant secondary metabolites (products of the plant that alleviate stress and injury) and on soil chemical and physical characteristics.

Materials and Methods

The trial was initiated at the Sheridan Research and Extension Center (ShREC) in 2012 and is being continued this year (Figure 1). Six crops—corn, sweet wormwood, Japanese cornmint, 'Native' spearmint, lemongrass, and switchgrass—were planted on previously prepared raised beds covered with black mulch. Each bed had a strip of drip-line irrigation hose buried 1 to 2 inches below the soil surface. Beds received either CBMW or municipal-treated (tap) water as treatments.

Figure 1. Field trial at ShREC.

Four of the crop species (sweet wormwood, Japanese cornmint, 'Native' spearmint, and lemongrass) contain essential oil (secondary metabolites), which was extracted through steam distillation from harvested material. The plant waste generated from distillation was oven dried for nutrient and other analysis. Corn and switchgrass were harvested at physiological maturity and air dried for analysis.

Results and Discussion

Initial results from soil and plant tissue analysis show a significant effect from CBMW on the soil and the plant in terms of soil pH, exchangeable sodium, soluble sodium, sodium adsorption ratio (SAR; Table 1), and leaf tissue sodium. Each of these parameters can indicate elevated levels of salts and sodium in the soil or plant, which can negatively impact soil properties and plant growth. In each case, levels were elevated in the CBMW treatments. This response was anticipated as CBMW often has a high pH along with high amounts of sodium in solution. CBMW's impact on yield has yet to be analyzed, but it is estimated that yield will be impacted negatively under CBMW treatments.

Table 1. Soil SAR for each crop with treatment comparison.

	Water	Average SAR (dS/m)	Standard Deviation
Corn	CBM	4.81	2.3138
	Tap	0.45	0.0265
Japanese Cornmint	CBM	6.54	1.6958
	Tap	0.46	0.0200
Lemongrass	CBM	7.68	3.8529
	Tap	0.41	0.1124
Native Spearmint	CBM	6.38	1.5977
	Tap	0.54	0.0379
Switchgrass	CBM	9.24	0.5950
	Tap	0.47	0.0200
Sweet Wormwood	CBM	5.71	1.3289
	Tap	0.48	0.1159

For soil exchangeable sodium, soluble sodium, and SAR, corn had significantly lower levels, suggesting an increased plant uptake of sodium. pH levels in all three grass species (corn, switchgrass, and lemongrass) were elevated compared to the three broadleaf species. This has yet to be analyzed for significance, and no conclusions can be inferred from this information yet.

Acknowledgments

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Key words: plant secondary metabolites, irrigation, coal-bed methane water

Comparative Productivity of Nine Biodiesel Crops for Wyoming

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Introduction

Biofuels can help offer energy independence, national security, economic and community development, and environmental benefits. They can also provide an additional revenue source for agricultural producers. Because of this, there is need for a side-by-side comparison of oilseed crops that are being grown and could possibly be grown in Wyoming for biodiesel production.

Details on production aspects and the economics of various crops are needed for producers, processors, policymakers, and others in the state and likely beyond to make informed decisions. Following discussions with individual growers, industry groups, Extension personnel, and researchers, the Sheridan Research and Extension Center (ShREC) will compare nine biodiesel crops: soybean, canola, Oriental mustard, crambe, camelina, sunflower, coriander, safflower, and flax.

Sunflower (*Helianthus annus* L.), the only oilseed native to the northern Great Plains, can provide around 102 gallons/acre in some areas of the country. Canola (*Brassica napus* L.) can provide yields of about 98 gal/acre of biodiesel per year. Oriental mustard (*Brassica juncea*) can provide around 65 gal oil/acre; camelina (*Camelina sativa* L.), 62; coriander (*Coriandrum sativum* L.), 57; and flax (*Linum usitatissimum* L.), 51.

Soybean (*Glycine max*) can provide about 48 gal/acre biodiesel and currently is the main oilseed for biodiesel production in the United States. Crambe (*Crambe abyssinica* Hochst.) and safflower (*Carthamus tinctorius*) represent other potential oilseed crops for Wyoming and the region.

Objectives

The long-term goal of this and subsequent projects is to develop sustainable systems for biodiesel production in Wyoming. Specifically, this project is the first step to evaluate agronomic, environmental, and economic feasibility of the production of these nine crops in the state.

The project will build on information collected from farmers who have grown crops for biodiesel, and it will also build on results from two previously conducted projects on biodiesel crops in Wyoming and the region.

Materials and Methods

Establishment of the field trials began in May 2013 at the ShREC dryland farm east of Sheridan, and at the ShREC irrigated farm just south of Sheridan near Sheridan College.

Within each of the locations, four blocks of plots will be established. Our study will also examine various application rates of nitrogen fertilizer. All crops will be planted in the spring, at the optimal planting rate and suggested planting time for each crop. We hope to alleviate bird and deer damage by installing noisemakers and electronic deterrent systems. Seed subsamples from plots at two locations (to reduce the number of samples) will be analyzed for oil content and fatty acid composition.

Results and Discussion

The results from this study are expected to answer specific questions farmers, ranchers, researchers, and others have about potential biodiesel crops. This preliminary study will allow the author to evaluate production-based indicators such as crop development, crop inputs (i.e., fertilizer), seed oil content, and by-products (including seed meal for livestock feed) that would have a direct effect on profit margins. It will also examine potential production issues.

Acknowledgments

This preliminary research is partially funded by a Wyoming Agricultural Experiment Station allocation to Valtcho Jeliazkov's U.S. Department of Agriculture Hatch project on biofuels and by the Department of Plant Sciences.

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Key words: biofuel, biodiesel, crop productivity

Distillation Time Effect on Lavender Essential Oil Yield and Composition

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Introduction

Common lavender has been one of the most popular medicinal, aromatic, and ornamental plants in many parts of the world since ancient times. Lavender essential oil is produced in several regions in Europe, the Middle East, Asia, North Africa, and the United States. Due to its pleasant and refreshing aroma—and antimicrobial properties—lavender oil is utilized by numerous industries including pharmaceutical, beverage, liqueur, perfume, and cosmetics. Lavender is also popular with homeowners for ornamental purposes.

The aroma and the biological properties of lavender oil depend on its chemical composition, which, in turn, is influenced by the environment, genotype, and extraction process. Various industries may require lavender oil with differing chemical compositions and aromas. The hypothesis of this study was that distillation time (DT) may affect lavender essential oil composition.

Objectives

The objectives of this study were to estimate if DT would alter lavender essential oil yield and composition, and to develop a model that describes the relationship between DT and essential oil yield and composition.

Materials and Methods

The experiment was conducted at the Sheridan Research and Extension Center (ShREC) in 2012 using dried flowers of *Lavandula angustifolia* Mill. Each DT was performed in three replicates; the individual sample size was 8.8 ounces of dried flowers. The essential oil was extracted using steam distillation. Oil was extracted at 12 different times: 1.5 minutes, 3, 3.75, 7.5, 15, 30, 60, 90, 120, 150, 180, and 240.

The extracted essential oil from each distillation was weighed and then analyzed for its chemical composition. Individual chemical constituents of the essential oil were identified using chemical standards, retention times, and comparison of mass spectra with those reported in the National Institute of Standards and Technology mass spectral database.

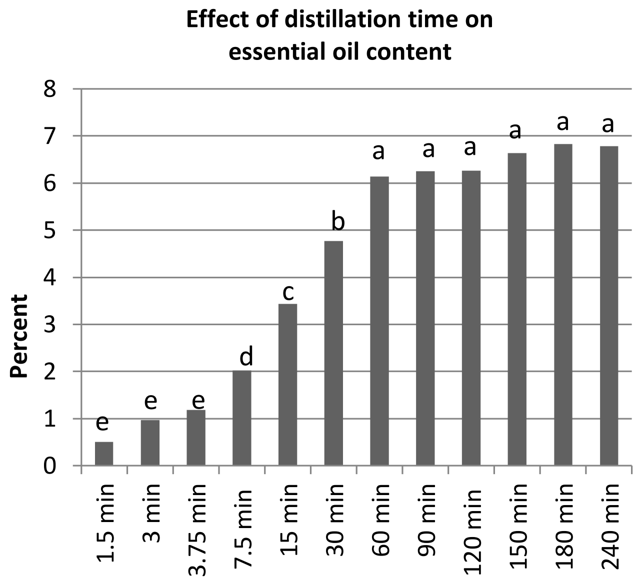

Figure 1. Effect of distillation time (DT) on essential oil content as percentage of dried flowers.

Results and Discussion

The main constituents of lavender essential oil were cineole, fenchol, camphor, and linalool acetate. Distillation time significantly affected essential oil content, which varied from 0.5% (at 1.5 min DT) to more than 6% (at 60–240 min DT) (Figure 1). The concentrations of cineole and linalool acetate showed different trends as a function of DT: cineole decreased whereas linalool increased with an increase of DT (Figure 2).

This is the first report that we're aware of on the effect of DT on lavender essential oil content and oil composition. Our results show that for maximum essential oil yields, dried lavender flowers should be steam distilled for at least 60 minutes. Different distillation times could be used to modify the essential oil composition of lavender and to perhaps obtain oil with targeted desirable characteristics. This report can be used to help predict lavender essential oil composition as a function of DT. The results also demonstrated that authors should report DT when reporting essential oil yield and composition of lavender.

For more information, please see the published article in the *Journal of Oleo Science*: http://dx.doi.org/10.5650/jos.62.195

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Key words: lavender, essential oil, oil extraction

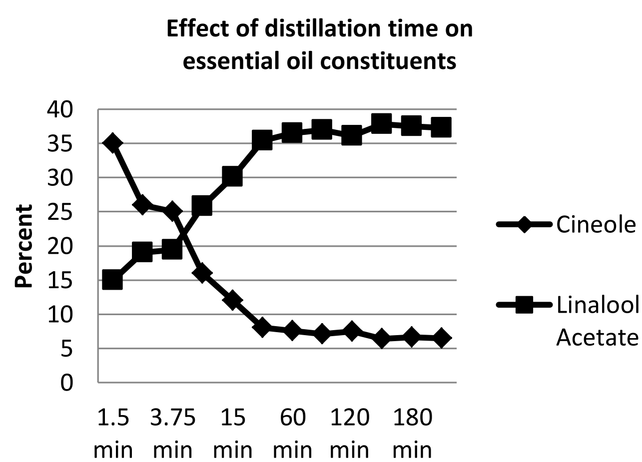

Figure 2. Effect of distillation time on the concentrations of cineole and linalool acetate in the oil (in % of the total oil).

Drying and Shade Effects on 'Native' Spearmint Oil Yields and Composition

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Introduction

Cultivar 'Native' spearmint (*Mentha spicata* L.) is one of the two most widely grown spearmints in the United States and in other countries. 'Native' spearmint is grown mainly for the production of essential oil, which is used in various industries such as pharmaceutical, consumer products including beverages and chewing gum, and eco-friendly pesticides.

Recent studies at the Sheridan Research and Extension Center (ShREC) demonstrated feasibility of spearmint as a cash crop for north-central Wyoming and perhaps beyond. The transportation and energy costs associated with commercial mint production can be reduced by drying the spearmint in windrows in the field for a few days after harvest and prior to the extraction of essential oils. This is a common practice in the traditional mint producing regions, including the Midwest and Northwest; however, it is not known how both the drying period and the drying of plants in full shade (vs. sun) would affect the oil content and composition of 'Native' spearmint.

Objectives

The goal is to develop a sustainable production system for spearmint in north-central Wyoming and possibly other areas of the state and beyond. Specific objectives were to evaluate the effects of drying in days after harvest as well as the effects of full shade and no shade (on the essential oil yield and on the essential oil composition).

Materials and Methods

A planting of 'Native' spearmint was established at ShREC in 2011 using certified virus-free material. Plants were grown in raised beds, with spacing of 1 foot in-row and between the rows, and irrigation was provided with drip-tape. The herbicide Terbacil at 1.78 lb/acre was applied pre-planting for weed control. This herbicide has been used traditionally for weed control in spearmint and peppermint plantations in the United States for several decades. Additional hand-weeding during the summer was necessary to keep plots weed-free.

Plants were treated and harvested in July 2012 at flowering stage (when the content and the composition of the essential oil are the most desirable). Representative fresh biomass samples were dried either in direct sun or full shade for the following days after harvest: 0 (extracted the same day), 1, 2, 3, 4, 7, and 11 days. Plant samples under shade were dried in a large, well-aerated barn.

The essential oil was extracted by steam distillation in 67.6-ounce steam distillation units using approximately 1 pound of fresh or 1/2 lb of dried spearmint biomass, all in three replicates. The extracted oils were analyzed by gas chromatography. Statistical analyses were performed to evaluate the effect of drying time and sun vs. shade on the oil content and the concentrations of beta-pinene, myrcene, limonene, eucalyptol, cis-sabinene hydrate, 4-terpineol, cis-dihydro carvone, cis-carveol, carvone, iso-dihydro carveol acetate, beta-bourbonene, beta-caryophyllene, alpha-humulene/trans-beta-far, and germacrene D in the oil.

Results and Discussion

Treatments (number of days of drying plus sun vs. shade) did not have significant effect on essential oil content. Therefore, drying of 'Native' spearmint under direct sun in Wyoming for up to 11 days after harvest can be used in an effort to reduce transportation and energy costs without affecting oil yields or composition. Occasional rain during the drying period would not affect oil content and composition.

Acknowledgments

This research was funded by the Sun Grant Initiative. We thank Bradley Wood, Lyn Ciampa, and Sydney Waggener for their help with the field trial and oil extraction.

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Key words: spearmint, drying, essential oil

Greenhouse Production of American Mayapple

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Introduction

One of the important natural products found in some wild plant species in the United States is podophyllotoxin. This toxic polycyclic substance is used to produce the drugs etoposide, teniposide, and etopophos, which, in turn, are used for the treatment of various cancers. Currently, podophyllotoxin is obtained from the rhizomes of Himalayan mayapple (*Podophyllum emodi* Wall.) (syn. *P. hexandrum* Royle.), mostly collected in the wild. However, the Himalayan mayapple was declared an endangered species.

American mayapple (synonyms mayflower, umbrella plant, wild mandrake, and wild lemon), a native species that grows in the eastern United States, also contains podophyllotoxin. Unfortunately, the plant's natural distribution is infrequent, and it is an endangered species in some states.

The American mayapple puts on new growth only once a year in the spring, and it produces very low leaf biomass (only one or two leaves per plant). In addition, our previous research found that wild accessions of American mayapple contained various amounts of podophyllotoxin (indicating the presence of chemotypes), with some accessions not containing any podophyllotoxin. Therefore, greenhouse production of selected clones with high podophyllotoxin concentration may be a feasible alternative to collection in the wild.

Objectives

The goal of this study is to explore opportunities for the development of the American mayapple in a greenhouse production system. A specific objective was to evaluate productivity of mayapple when grown in a greenhouse in Wyoming.

Materials and Methods

Greenhouse experiments were conducted at the Sheridan Research and Extension Center (ShREC) greenhouse in 2010, 2011, and 2012. The studies utilized American mayapple rhizomes collected in 2008 along a 444-mile stretch of Natchez Trace Parkway through Mississippi, Alabama, and Tennessee. The rhizomes of 18 accessions were planted in 5-gallon pots filled with growth medium. The pots were placed in a ShREC greenhouse, and the plants were harvested in 2011 and 2012. The samples from the 2011 harvest were dried, ground, and analyzed for podophyllotoxin using high-performance liquid chromatography.

Results and Discussion

Different accessions of American mayapple had dissimilar morphological features (Figures 1–3). Flowers are formed on the reproductive plants only (Figures 2 and 3). The concentration of podophyllotoxin in the 18 accessions varied significantly. Subsequently, the overall yields of podophyllotoxin from the 18 accessions varied widely. The accessions with the highest podophyllotoxin concentration will be used in a plant breeding program.

Acknowledgments

This research was supported by University of Wyoming start-up funds awarded to Valtcho Jeliazkov.

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Key words: American mayapple, podophyllotoxin, natural products

Figure 1. American mayapple accession #1014 in the greenhouse.

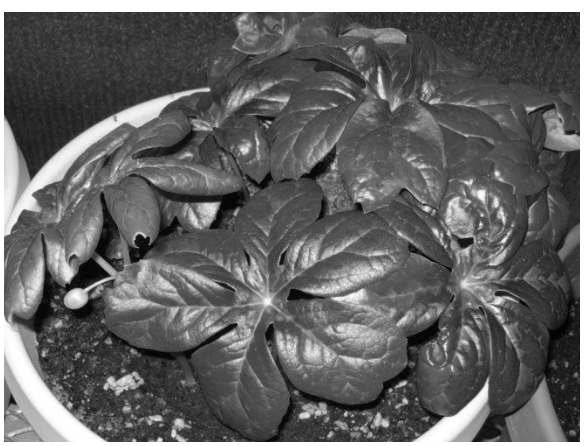

Figure 2. American mayapple accession #1008 in the greenhouse. The fruit (mayapple) is visible on the left side.

Figure 3. The flowers of the American mayapple are white and beautiful, 1–2 inches in diameter, and are formed on the reproductive plants only (most plants are sterile).

Methyl Jasmonate and Extracts of Juniper and Sagebrush can Influence Essential Oil Composition of 'Native' Spearmint

V.D. Jeliazkov[1], T. Astatkie[2], and E. Jeliazkova[1]

[1]Sheridan Research and Extension Center; [2]Dalhousie University, Truro, Nova Scotia, Canada.

Introduction

One of the important essential oil crops in the United States is spearmint (*Mentha spicata* L). Our previous research at the Sheridan Research and Extension Center (ShREC) demonstrated that spearmint cultivar 'Native' could endure the first fall frosts—down to around 19°F—and has potential as a cash crop for northern Wyoming and beyond.

It has been shown previously that some plant hormones including methyl jasmonate, gibberellic acid, and salicylic acid, as well as plant extracts from certain medicinal plants, have the potential to improve essential oil composition and increase oil yield of spearmints when applied as a foliar spray. (Foliar spray is a technique of applying liquid fertilizer or growth hormones to plant leaves.) The hypothesis of this study was that plant extracts from some locally available native plants may also have an effect on spearmint oil yield and composition when applied as a foliar spray.

Objectives

The goals of this project were to develop a method for increasing the biomass and essential oil yields of 'Native' spearmint. Such approaches could be advantageous for the existing spearmint production industry and potential growth in the industry. Most of the current spearmint production is concentrated in the Midwest.

Materials and Methods

'Native' spearmint was planted in 2011 at ShREC fields next to Sheridan College using certified virus-free material. The treatments (as foliar spray) were applied in the summer of 2012. In this study, we utilized plant extracts from Rocky Mountain juniper (*Juniperus scopulorum* Sarg.) and big sagebrush (*Artemisia tridentata* Nutt.). These two plants are among the most commonly found native plants in Wyoming and in other semiarid regions of the West. The treatments were: 1. water (control); 2. water + Tween®20 (surfactant); 3. sagebrush essential oil + Tween 20; 4. sagebrush water extract; 5. juniper essential oil + Tween 20; 6. juniper water extract; and methyl jasmonate. (Surfactants such as Tween 20 are mixes that lower the surface tension between a liquid and a solid.) All were applied as a foliar application a total of three times in June and July.

Results and Discussion

The essential oil yield and oil composition were significantly affected by the treatments. Treatments also affected the concentrations of carvone, beta-caryophyllene, trans-beta-farnesene, and germacrene D in the oil. However, the treatments did not have an effect on the concentrations of other oil constituents such as beta-pinene, myrcene, limonene, eucalyptol, cis-sabinene hydrate, 4-terpineol, neo-dihydro carveol, and cis-carveol.

The application of juniper essential oil + Tween 20 and the application of methyl jasmonate decreased the concentration of carvone in the oil relative to the water control. The concentration of carvone (the main essential oil constituent of spearmint oil) varied between 51–56% of the oil, which was comparable to previous reports and to our previous observations.

Our results showed that sagebrush essential oil, sagebrush water extract, juniper essential oil, and juniper water extract had significant effect on the productivity and oil composition of 'Native' spearmint. Neither of the treatments, however, increased biomass yields or carvone concentration in the oil relative to the controls.

For more information about this study, see the article in the April 2013 edition of *HortScience* at http://hortsci.ashspublications.org/content/48/4/462.full.html?ijkey=zxwNKWliFUwkwbC&keytype=ref

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This research was funded by the Sun Grant Initiative. We thank Bradley Wood, Lyn Ciampa, and Jeremiah Vardiman for their help with field trials and Sydney Waggener for her help with oil extraction.

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Key words: spearmint, hormones, essential oil

Effect of Fall Frosts on Spearmints in Wyoming

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[1]Sheridan Research and Extension Center; [2]U.S. Department of Agriculture–Agricultural Research Service, Natural Products Utilization Research Unit, University of Mississippi; [3]Dalhousie University, Truro, Nova Scotia, Canada.

Introduction

Spearmints are well-known essential oil crops grown in the United States, Europe, Asia, Australia, and New Zealand. Spearmint essential oils are utilized for fragrance in the food and pharmaceutical industries and in various consumer products (toothpaste and chewing gum, for example). In addition to the fine aroma, spearmint oil possesses antimicrobial properties.

Recent research by the authors demonstrates that spearmints can be successfully grown as a cash crop in Wyoming, and there appears to be producer interest in these crops. Spearmints can provide one or two cuts per growing season, depending on the environment. Since the cropping season (including the fall frost-free period) in Wyoming is relatively short, an important question to be addressed is how fall frosts affect biomass and oil yields of spearmint.

Objectives

The overall goal of this project is to develop a sustainable production system for spearmint in Wyoming. Specific objectives were to quantify the effect of the first fall frosts on 'Native' spearmint (*Mentha spicata* L.) yields and the chemical composition of oil.

Materials and Methods

The field experiment was conducted in 2011–2012 at the Sheridan Research and Extension Center; the oil analyses were completed in 2012. The trial was established with virus-free planting material in previously prepared raised beds. The spacing was approximately 1-foot between the plants in a row and also between the rows. Weed control was achieved using Terbacil herbicide at a rate of 1.78 lb/acre and by hand weeding of resistant weeds. During the growing season, we did not observe any harmful pests or diseases. Plants received about 1 inch of water/week through drip-tape.

Spearmint was harvested with a hedge trimmer, and representative fresh biomass samples were extracted immediately by steam distillation. Harvest dates were September 14, 21, and 28, October 5, 12, and 24, and November 1, 2012. During that period, frost occurred on 14 occasions, with low temperatures varying from 19 to 30 degrees F.

Results and Discussion

Harvest date significantly affected fresh biomass yields, oil yields, and oil content. It also had a significant effect on oil chemical composition, especially carvone and limonene. Limonene is a liquid terpene used as a wetting agent and in the manufacture of resins. Carvone is also a member of the family of chemicals called terpenoids. It is used in the food and flavor industry and in air-freshening products. And, like many essential oils, the oils containing carvones are used in alternative medicine and aromatherapy.

Carvone concentration in this study was similar to the one reported previously, indicating that 'Native' spearmint grown in Wyoming can provide desirable oil composition. In this study, fresh biomass yields increased with delay in harvesting; however, the oil content decreased in the later harvest dates.

This study demonstrates that 'Native' spearmint grown in Wyoming can be harvested after the first few fall frosts (down to 19°F) and still provide desirable yields and oil composition. This finding would allow for a wider harvesting period of 'Native' spearmint in Wyoming, which could help improve the distribution of resources related to transportation and oil extraction.

For more information about this study, see the article in the November 2012 issue of *HortScience* at http://hortsci.ashspublications.org/content/47/11/1603.abstract

Acknowledgments

This research was funded by the Sun Grant Initiative. We thank Daniel Smith, Bradley Wood, Lyn Ciampa, and Rebecca Moreland for their help with the field trial and oil extraction.

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Key words: spearmint, plant extracts, essential oil

Developing Weed-Management Strategies to Improve Reclamation of Drastically Disturbed Lands

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[1]Department of Plant Sciences.

Introduction

Direct disturbance of plant communities by natural resource extraction projects is a primary negative impact to wildlife habitat, biological diversity, and forage production for domestic livestock. Successful reclamation of disturbed areas is a critical step in mitigating such negative impacts, but establishment of desirable plant communities on disturbed areas, particularly in Wyoming's more arid and semiarid environments, is typically difficult.

Non-native and undesirable weed species often readily invade areas with bare soils. Widespread growth of invasive and noxious weeds was the second most prevalent event of non-compliance on coal-bed methane (CBM) reclamation sites in northeast Wyoming's Powder River Basin. Perceived benefits of not controlling annual weeds like kochia or Russian thistle (wind protection, encouraging soil microbes) on reclamation sites may drive reclamation practitioners to refrain from controlling them, even though policy encourages management of such weeds. To address this issue, this research seeks to determine the relationship between chemical management of annual weeds and establishment of desirable seeded species.

Objectives

This research addresses the following questions: 1) Does removal of competitive annual weeds with herbicides improve or diminish the establishment of desirable plant species? 2) How do various herbicide treatments affect reclamation success? and 3) Which desirable species are able to successfully establish in areas treated with herbicides applied at different timings?

Materials and Methods

Three field trials were established at the Sheridan Research and Extension Center (ShREC), Laramie Research and Extension Center, and near Ucross in northeast Wyoming, where much CBM activity has occurred in recent years. At each site, 10 different seeding treatments were planted in fall 2011 and spring 2012. Seedings included single-species grass plantings and mixes of forbs and shrubs. The eight single species included: 'Arriba' western wheatgrass at 12 pounds per acre of "pure live seed" (PLS), 'Sherman' big bluegrass at 4 PLS lb/ac, 'Trailhead' basin wildrye at 12 PLS, 'Anatone' bluebunch wheatgrass at 14 PLS, 'Sodar' streambank wheatgrass at 12 PLS, alkali sacaton at 2 PLS, 'Hycrest' crested wheatgrass at 1 PLS, and 'Bozoisky' Russian wildrye at 12 PLS. Forb and shrub species were selected as appropriate for each location and included Wyoming big sagebrush, fourwing saltbush, purple prairie clover, scarlet globemallow, and others. Six pre-emergent herbicide treatments were applied in fall 2011 at the time of fall seeding, and eight post-emergent treatments were applied in spring 2012 (Table 1). Weed control, desirable species establishment and growth, and percent vegetative cover will be observed through the 2014 growing season.

Results and Discussion

First-year results showed minimal emergence of seeded species due to lower-than-normal precipitation, but emergence was commonly better in spring applications. Mechanical effects from the seeding treatment likely had positive effects on seedling emergence and weed control. Some herbicides were found to have good initial control of annual weeds, typically those with aminocyclopyrachlor. No seasonal effect was observed.

Acknowledgments

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Key words: reclamation, herbicide, weed science

Table 1. Herbicides and rates used including trade and chemical names.

Trade Name	Chemical Name	Active Ingredient Rate	Product Rate
Perspective	Aminocyclopyrachlor plus chlorsulfuron	2.17 oz ai/acre 0.869 oz ai/acre	5.5 oz/acre
Perspective	Aminocyclopyrachlor plus chlorsulfuron	1.09 oz ai/acre 0.435 oz ai/acre	2.75 oz/acre
Imprelis	Aminocyclopyrachlor	2.17 oz ai/acre	8.68 oz/acre
Imprelis	Aminocyclopyrachlor	1.09 oz ai/acre	4.36 oz/acre
Milestone	Aminopyralid	1.25 oz ai/acre	3.079 oz/acre
Telar	Chlorsulfuron	0.75 oz ai/acre	1 oz/acre
*Plateau	Imazapic	3.7 oz ai/acre	6.35 oz/acre
*Matrix	Rimsulfuron	1.85 oz ai/acre	3 oz/acre
many names	2,4-D Amine	24 oz ai/acre	51.64 oz/acre
Sharpen	Saflufenacil	0.356 oz ai/acre	1.197 oz/acre

Asterisk(*) indicates chemicals substituted at the ShREC site in place of 2,4-D and Sharpen, all of which were only summer-applied; the first 6 herbicides were applied fall and summer.

Therapeutic Gardening for People with Physical Limitations

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Introduction

Gardening is one of America's favorite leisure outdoor activities. According to the National Gardening Association, more than 91 million U.S. households (28 million of whose members are 56 and older) participate in some type of lawn or garden activity. Most gardeners agree that gardening is good for the body, mind, and soul. Bodies are strengthened through gardening. Minds are refreshed through gardening's therapeutic benefit of connecting with nature. Spirits are renewed through the quiet sanctuary of the garden.

But, for those who experience the effects of arthritis, aging, or other physical limitations, gardening can become challenging and sometimes frustrating. Identifying each gardener's individual needs, adapting his or her garden and gardening practices, and utilizing the wide variety of excellent tools (Figure 1) and techniques available will help ensure that the capabilities of every gardener are maximized. Gardening benefits health and well-being while allowing people to stay active and productive. This type of physical activity also helps prevent osteoporosis and reduces stress levels while promoting relaxation.

Objectives

Participants at the Wyoming Agricultural Experiment Station's 2013 field days will:

- View examples of ergonomic and adaptive garden tools,
- Learn safety tips for gardeners with physical limitations,
- See how garden tools can be adapted to reduce joint pain,
- Learn how to garden safely as one ages,
- Receive materials with ideas on tools for an enabled garden.

Figure 1. Ergonomic handles minimize wrist and hand stress.

Materials and Methods

Examples of ergonomic and adaptive tools for an enabled garden will be displayed along with how to adapt everyday garden tools using material from local hardware stores. Health and safety tips for gardeners with physical limitations and older gardeners will be shared. In addition, written material from Wyoming AgrAbility and the Arthritis Foundation will be available for participants.

Results and Discussion

Limitations can make gardening more difficult and less enjoyable; however, utilizing a few techniques can help enhance the gardening experience despite limitations.

- Know your limits. Be aware of just how much physical activity you can manage.
- Be kind to your body. Gentle stretches loosen joints and help prevent injury.
- Use joint-friendly tools. Long-handled tools allow gardeners to stand, not stoop, and easy-to-grip hand tools reduce wrist and hand strain. Use a kneeling pad or scooter wagon while weeding and performing other tasks.
- Practice correct posture. Let your larger and stronger joints do the work when possible. Keep items close to your body as you carry them. Stand or sit up straight when working, and change positions often.
- Think "inside" the box. Instead of a traditional garden, try a flower box or raised garden to eliminate stooping.
- Take frequent breaks. When gardening, pain can build if joints are not rested. Frequent breaks allow one to appreciate the garden, plan tasks, and get more done before fatigue sets in.

Gardeners with arthritis need to be mindful of the amount of bending or kneeling that is required for large gardens. Scaling back to small containers or raised beds may not produce as much, but they are much less labor-intensive than a large garden plot. To enjoy the therapeutic benefits of gardening, a main goal needs to be the reduction of joint stress and mental stress. Gardening should be done at an easy pace with the goal of enjoying ones' time working with vegetables, fruits, herbs, flowers, and other plants.

Acknowledgments

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Key words: gardening, garden tools, physical limitations

Understanding Epigenetic Mechanisms of Lactation Failure

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Introduction

Wyoming currently has an adult obesity rate of 25.4%. In 2009, obesity-related healthcare costs in the state were estimated at $191 million, and by 2018, predicted medical expenditures for obesity-related health issues are estimated to be a staggering $607 million. These statistics illustrate a growing obesity epidemic that will increase healthcare costs in Wyoming and the entire nation.

Importantly, numerous scientific studies show that breastfeeding decreases obesity rates and the onset of Type 2 diabetes in the mother and the infant. Breastfeeding specifically reduces childhood obesity rates by 30%. Unfortunately, mothers who are obese or overweight are more likely to terminate breastfeeding prematurely due to inadequate breast milk production. This problem is directly related to the hormone prolactin, which normally stimulates milk production in breast cells.

Scientific understanding of how prolactin controls lactation is improving, but currently we do not understand the epigenetic mechanism induced by prolactin to initiate breast milk production. Epigenetics is an exciting new scientific field that examines changes in gene expression that do not involve alterations in the DNA sequence. Epigenetic regulation occurs via large families of enzymes that organize DNA. Our research focuses on one such enzyme family—peptidylarginine deiminases (PADs)—that modifies histones, which in turn organize DNA to regulate gene expression.

Objectives

The goal of this study is to determine if maternal obesity effects lactation via epigenetic mechanisms.

Materials and Methods

Experiments are being conducted in the University of Wyoming's Biological Sciences Building. Our cell culture-based studies utilize mouse mammary cells as a model system. Cells are treated with prolactin for 24 or 48 hours and examined for expression of PAD2 and 4. Induction of obesity in mice is currently underway. One group of mice is receiving a control diet (10% kcals from fat) while the second treatment group receives a high fat diet (60% kcals from fat). Once obese, mice will be bred and mammary tissue collected during pregnancy and lactation to examine changes in milk production. All animals are housed and cared for following approved guidelines by the UW Institutional Animal Care and Use Committee.

Results and Discussion

Our studies show that the hormone prolactin induces expression of the PAD2 and PAD4 enzymes in mouse mammary cells (Figure 1). Normally, prolactin levels rise dramatically at the end of pregnancy to initiate lactation. We believe that the rising prolactin levels stimulate the expression of PAD2 and PAD4. These epigenetic enzymes then help to activate lactation-related genes, which is necessary to produce breast milk.

Our upcoming studies will investigate the signaling pathway that links prolactin treatment with increased PAD expression using specific signaling inhibitors. While obesity is being induced in mice, we have initiated preliminary studies to determine the appropriate methods to examine expression of PAD2 and PAD4 in mouse mammary tissue. Our results indicate that PAD2 and PAD4 are present in the mammary glands from mice during early lactation.

Once obese, female mice will be bred and mammary tissue harvested at different times during pregnancy and lactation. Tissues will be examined for expression of PAD enzymes and histone modifications. Additionally, mammary glands will be studied to examine changes in milk composition between obese versus non-obese mothers.

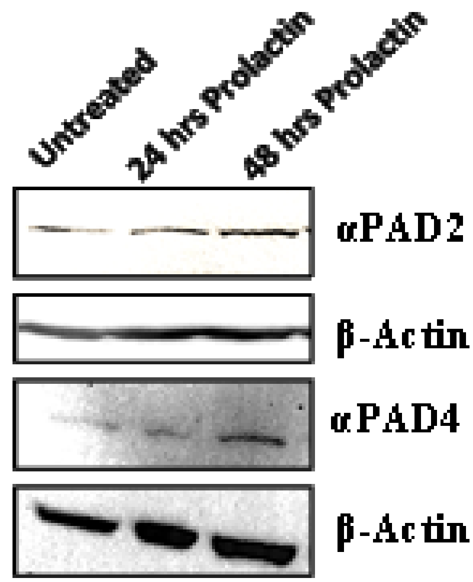

Figure 1. Prolactin induces expression of PAD2 and PAD4 in mouse mammary CID-9 cells.

Our overall goal is to examine if obesity induces changes in the initiation of lactation and milk composition. We believe that our results will provide a scientific rational to promote breastfeeding to combat obesity.

Acknowledgments

Thanks to Amy Navratil and Guangyuan Li for their technical support.

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Key words: lactation, obesity, epigenetics

Payment for Ecosystem Services Market in the Upper Green River Basin

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Introduction

The Upper Green River Basin is the headwaters for the Colorado River System and home to many bird and wildlife species with environmental and recreational significance. In recent decades, the basin has experienced an energy boom from natural gas and oil extraction. This activity has increased economic opportunities in the basin but has also placed development pressures on the natural resource base.

A "Payment for Ecosystem Services" (PES) market is an innovative way to provide financial incentives or compensation to private landholders for engaging in environmentally or socially beneficial activities that might not otherwise be undertaken or continued. Landowners could benefit from PES by implementing practices on their land that maintain or enhance wildlife habitat and water resources (Figure 1). As such, they would be the "sellers." The "buyers" in the market are expected to be energy companies seeking off-site mitigation for their energy-development activities as well as local/national conservation/environmental foundations and second homeowners in the basin looking for ways to support the high-quality recreational and environmental amenities that characterize the basin.

Objectives

The goal of this study was to scope the feasibility of establishing a PES market in the Upper Green River Basin, with an eye toward protecting wildlife habitat (notably greater sage-grouse and mule deer) and riparian function (water quality and timing of flows) in the basin while providing agricultural producers with an additional stream of revenue to help them maintain their ranching operations.

Materials and Methods

Scoping interviews and focus groups were conducted during 2011–2013 in Pinedale,

Figure 1. Artificial wetlands created by irrigation district-return flows in the Upper Green River Basin.

Cheyenne, and Denver with potential sellers (landowners), buyers (energy companies), natural resource managers (Bureau of Land Management, Wyoming Game and Fish Department, U.S. Fish and Wildlife Service, among others), and non-governmental organizations (Trout Unlimited, Pinedale-based Wyoming Land Trust, among others). Pilot transactions to test different aspects of the market are still underway.

Results and Discussion

Based on the interviews, landowners like the idea of a "two-sided" market, where private rather than federal money is used to fund conservation. They also tend to prefer term contracts (of 5, 10, or 20 years) rather than permanent easements. A follow-up survey of landowners in the basin is currently being conducted to better understand landowner preferences for PES market design.

For energy companies to voluntarily participate, they would require assurances from regulatory agencies that the conservation they have undertaken through a PES market would count toward their mitigation requirements for energy development. Natural resource management agencies are primarily interested in ensuring that a PES market is consistent with their goals of protecting the natural resource base and managing public lands for multiple uses.

The approximately 50 people interviewed emphasized the importance of scientific research to help better understand the linkages between conservation actions and ecological outcomes on a site-specific and landscape scale. If the concerns and preferences listed above can be incorporated, a PES market may very well be feasible in the basin.

Project partners have teamed with the Environmental Defense Fund—which has experience establishing PES markets elsewhere in the western United States—to help organize a PES market. The market is called the Upper Green River Conservation Exchange. Several test transactions to explore how this market will work are anticipated in summer 2013.

Acknowledgments

The project was funded by a conservation innovation grant from the Wyoming office of the Natural Resources Conservation Service. Thanks to project partners Melanie Purcell and Eric Peterson (Sublette County Conservation District), Amy Pocewicz and Graham McGaffin (The Nature Conservancy), Esther Duke (Colorado State University), and Anne MacKinnon (A. MacKinnon Consulting).

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Key words: payment for ecosystem services markets, environmental markets, conservation exchange

Distribution and Hybridization Among the Spruces in Western Forests

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Introduction

The spruce (*Picea*) genus is a widely distributed species complex across the forests of western North America. Spruce species have undergone major range shifts due to repeated glacial advances and retreats, which created the opportunity for geographic contact and hybridization between related species.

We have a very limited understanding of the ecological and evolutionary consequences of the interactions among spruce species across the Rocky Mountain region of the United States. Moreover, despite differences, spruces can be difficult to distinguish based on morphology, and in many locations hybrids and parental species can be difficult to recognize (Figure 1). This has led to current descriptions of geographic ranges for spruces that are inaccurate and uncertain.

In this project, we are using genetics, geography, and ecology to build our knowledge of the distribution of spruce species and their hybrids in forests of western North America.

Objectives

Our goals are to describe the current and future distribution of spruce species and their hybrids, and to link genetic data to the environments they occupy across the forests of western North America.

Materials and Methods

Recently, we completed a study of genetic structure within and among natural populations of white spruce, Engelmann spruce, and their hybrids in several mountain ranges in Wyoming. Interestingly, we found many hybrids in locations where they were not expected (because one of the parental species was not known to occur or is thought to be absent). We also discovered white spruce well beyond its current known southern limit. Additionally,

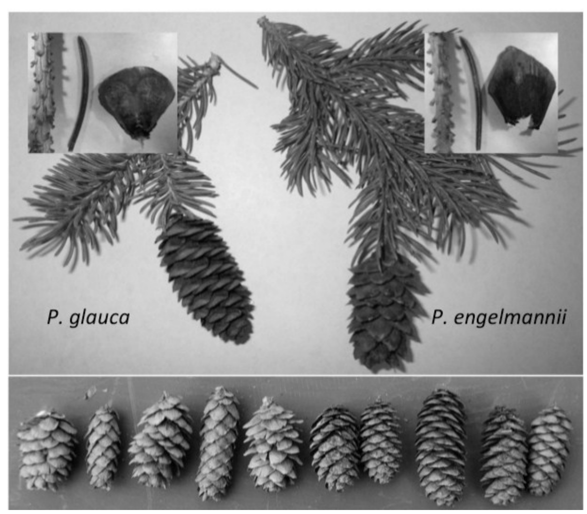

Figure 1. Top: Twigs, needles, and cones of white spruce (left) and Engelmann spruce (right). Bottom: Highly variable cones of hybrids between these species from Shell Creek Canyon in north-central Wyoming's Bighorn Mountains.

we found variation in the frequency of hybrids and species among collection sites, suggesting that within this area of geographic overlap, the interaction of the two species varies extensively.

To build on these results, we are extending the research to additional potentially hybridizing spruce species, and to more extensive geographic sampling across forests of western North America.

We have collected needles as a source of DNA from more than 2,300 individual trees from 145 sites and six species across the mountain ranges in forests of western North America. The sampling was designed to cover the natural distribution of all six species (including gradients in elevation and latitude where possible) across the study region to capture the wide variability in genetics, geography, and environments.

We have generated genetic data by DNA sequencing and will use these data to describe: 1) where there are hybrids; 2) between what species hybridization occurs; and 3) how hybrids and parental species might shift their distributions with a changing climate.

Discussion

Species recognition and the existence of potentially unrecognized hybrids between forest trees play an important role in forest management. This study could substantially advance our knowledge of the genetic variation and geographic distribution of spruce species and their hybrids. It could also provide foresters with important information for managing disturbances such as pest infestations, harvest, or reforestation of these species. One of the challenges for species and hybrid identification in the spruces stems from the relatively small morphological differences between species. It is our goal that this study will provide objective genetic results that can assist in inventories of species composition, or simple knowledge of the existence of hybrids within a geographic region, which can aid future biodiversity assessments and management decisions in the forests of western North America.

Acknowledgments

The project is funded by McIntire-Stennis Cooperative Forestry Research Act Program funds through the University of Wyoming Agricultural Experiment Station to Associate Professor Alex Buerkle and Ph.D. student Monia Haselhorst.

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Key words: spruce, hybridization, species distribution modeling

Effects of Sequential Herbicide Application on Cheatgrass and Native Rangeland Vegetation

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Introduction

Cheatgrass (*Bromus tectorum* L.) is one of the most significant invasive weeds of North America, including Wyoming. It reduces forage availability for livestock and many wildlife species, changes the fire regime, and decreases species diversity. Because eradication may not be a feasible goal, it may be desirable to manage cheatgrass in low-density stands below the "impact" stage of invasion. Little work has investigated managing such stands by single or sequential herbicide applications. Further, many studies focus on results only on the years immediately following herbicide application and fail to address how long a single herbicide application will provide effective cheatgrass control.

Objectives

This study aims to determine at what point following an initial herbicide application a reapplication is needed for continual control of cheatgrass and considers the following: 1) How does the plant community (above and belowground) respond to herbicide reapplications?; 2) Does it respond differently to different herbicides?

Materials and Methods

Beginning in 2006, the Thunder Basin Grasslands Prairie Ecosystem Association (TBGPEA) treated various areas having cheatgrass each year with Plateau® (imazapic) in the fall at 6 ounces product per acre. Since this resulted in a continuum of treated sites, we were able to reapply treatments in plots at five sites that had been treated between 1–5 years prior. Additionally, two sites with cheatgrass were selected to be treated for the first time in 2011. One is needle and thread dominated and the other western wheatgrass and blue grama co-dominated. These three native perennial grasses provide excellent forage for livestock and wildlife.

Herbicide applications were applied in October 2011 prior to cheatgrass emergence. Four treatments were used: Plateau® (imazapic [at both 4 and 6 ounces product/acre]), Canter R+P® (propoxycarbazone-sodium) at 1.2 ounces product/acre, and Matrix® (rimsulfuron) at 3 ounces product/acre. Vegetation response was monitored May and June 2012. Data collected included biomass production and percent cover.

Results and Discussion

Cheatgrass cover was only observed at the five-year retreatment interval site and both new 2011 sites. This may indicate a reinvasion at the five-year site. All herbicide treatments reduced cheatgrass biomass (p<0.0001; Figure 1) and increased perennial grass biomass (p=0.0379) at the needle and thread site. Analysis showed that Plateau® at 6 ounces product/acre increased perennial canopy cover at the wheatgrass/blue grama site (p=0.0008) while both Plateau® treatments reduced cheatgrass canopy cover at the needle and thread site (p=0.0061; Figure 2).

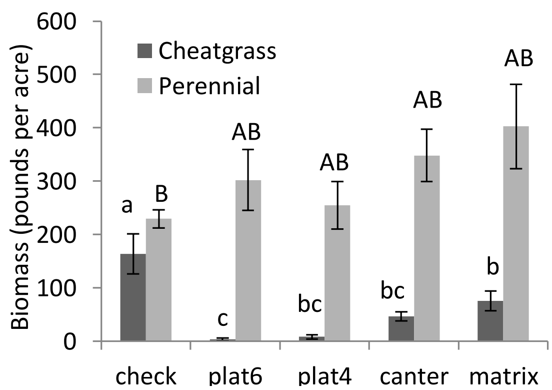

Figure 1. Cheatgrass and perennial grass biomass by herbicide treatment at the needle and thread site (± 1 std error). Letters denote significant differences—lowercase for cheatgrass, uppercase for perennial grasses. Check=untreated, plat6=Plateau 6 oz, plat4=Plateau 4 oz, canter=Canter R+P 1.2 oz, matrix=Matrix 3 oz product/acre.

All herbicide treatments had little effect on vegetation cover at the other sites (p>0.05). Although treated repeatedly with herbicide, desirable native grasses did not show significant damage—and they even showed increased biomass production or percent canopy cover in some instances.

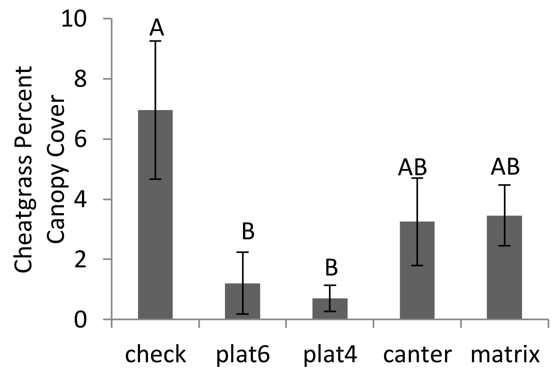

Figure 2. Cheatgrass percent canopy cover by herbicide treatment at the needle and thread site (± 1 std error). Letters denote significant differences. Abbreviations same as in Figure 1.

In 2012, a drought year, peak biomass occurred in late May/early June. The lack of moisture and growth may have impacted our ability to detect differences between treatments. Future work includes evaluating the seedbank response to treatments, evaluating a simulated grazing treatment, and performing an economic analysis.

Acknowledgments

This project is funded by a University of Wyoming School of Energy Resources' graduate assistantship and the Department of Plant Sciences. Thanks to Dave Pellatz, the TBGPEA, Andrew Kniss, John Ritten, and our summer field crew.

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Key words: weed management, cheatgrass, herbicide

Statewide Prioritization of Cheatgrass Infestations in Wyoming

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Introduction

Cheatgrass is an exotic winter annual grass present in North America and prevalent in Wyoming. This invasive species causes many problems, from displacing native plant communities to increasing fire frequency and reducing habitat for wildlife and livestock. Groups of state and federal agencies, as well as producers and other land managers across the state, meet throughout the year to discuss cheatgrass management. Currently, there is no statewide map of cheatgrass distribution for Wyoming that depicts more than presence/absence data.

A statewide map of both distribution and severity of infestation would aid land managers and others by identifying infestation hotspots and providing a common tool for cooperative efforts, including prioritization of areas for management on a landscape scale.

Objectives

The goals of this project are to determine cheatgrass distribution and severity of infestation across Wyoming and develop a model for landscape-scale prioritization. This information will be useful in developing a state-wide management strategy for cheatgrass.

Materials and Methods

This project will encompass the entire state. Existing data will be combined with local expert knowledge, new field surveys, and data from remote sensing technology. Existing information has been gathered in the form of geographic information systems (GIS) data, aerial imagery, and drawings on maps collected at workshops and digitized. Summer field seasons will consist of field surveys to validate gathered datasets and to fill in gaps. Field surveys will be conducted using a "rapid assessment protocol," which involves using a photograph, a GIS waypoint, and visual estimates of size of infestation and of cover for cheatgrass, native species, shrubs, and bare ground. The infestation levels used in this project are in Table 1.

The final compilation of data will be combined via computer modeling to develop a method for prioritizing areas for management. Computer modeling will assist in establishing high-priority management areas by adding in additional factors, such as critical wildlife habitat.

Table 1. Defined infestation levels used to determine cheatgrass severity. Gathering information beyond presence/absence will allow for future management prioritization.

Infestation level	Cheatgrass cover (%)
Cheatgrass-free	0
Trace	1–5
Low	6–25
Moderate	26–50
Dominant	51–100

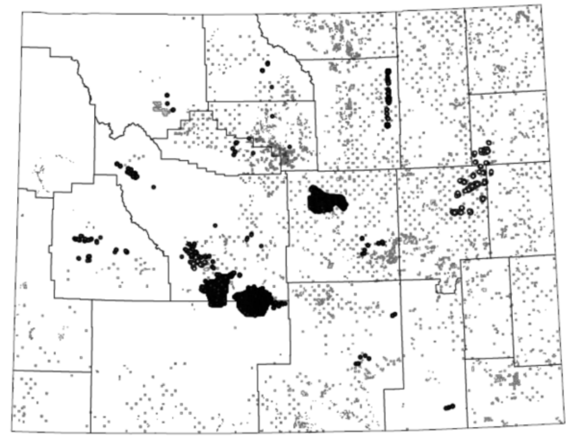

Figure 1. Map of Wyoming depicting a sample of the current datasets provided by different entities across the state and available digitally.

Results and Discussion

This project began in fall 2012 and is still in the early stages. Maps containing drawings from local experts have yet to be digitized, and the development of the survey design for the first summer field season is in progress. Existing datasets have been made available from the Bureau of Land Management, U.S. Forest Service, Wyoming Office of State Lands and Investments, The Nature Conservancy, Thunder Basin Grasslands Prairie Ecosystem Association, and others (Figure 1). We will produce a map of cheatgrass infestation in Wyoming that should be a useful tool for directing statewide efforts to manage this troubling weed.

Landowners and land managers across the state are invited to share their local expert knowledge about cheatgrass infestations by contacting our research group at the University of Wyoming.

Acknowledgments

The project is funded by the Wyoming Reclamation and Restoration Center, Wyoming Weed and Pest Council, Wyoming Agricultural Experiment Station’s Competitive Grants Program, Wyoming Governor’s Office, and the UW Department of Plant Sciences. Thanks to Amy Pocewicz and The Nature Conservancy, Jeff Beck, Travis Decker, and the helpful agencies and local experts across the state.

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Key words: weed management, cheatgrass, rangeland management

Listeria monocytogenes Exopolysaccharide: Structure and Roles in Colonization and Persistence on Produce Surfaces

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Introduction

Listeria monocytogenes is a pervasive foodborne bacterial pathogen that causes hundreds of cases of the potentially fatal disease, listeriosis, in the United States every year. Although listeriosis cases have traditionally been associated with consumption of contaminated dairy and ready-to-eat meat products, infections also are caused by the consumption of contaminated fresh produce.

The 2011 multistate outbreak of listeriosis caused by contamination of cantaloupe was the second deadliest outbreak attributed to a foodborne pathogen in the country in the last 80 years. In all, the bacterium *Listeria monocytogenes* killed 33 people and sickened 147 others in 28 states, according to federal health officials.

The deadliest outbreak occurred in 1985 when approximately 50 people died after consuming contaminated cheese. That tragedy, too, involved *L. monocytogenes*.

A number of beneficial and pathogenic bacteria are known to adhere to and grow on the surface of plants (including fruits and vegetables) by secreting an extracellular substance known as exopolysaccharide (EPS). Through genetic manipulation of *L. monocytogenes*, we previously engineered strains that overproduce or lack a species of EPS that may be involved in produce contamination.

Objectives

The objectives of the research are to determine the structure of the *L. monocytogenes* EPS and its role in attachment to fruits and vegetables and its resistance to disinfectants and other control agents.

Materials and Methods

Since the inception of the project in January 2013, we have evaluated the role of listerial EPS on the susceptibility of the bacterium to two disinfectant agents used in food-processing facilities—sodium hypochlorite (bleach) and benzalkonium chloride (BC). Experiments were conducted using wild-type *L. monocytogenes* EGDe, and EPS-overproducing ($EPS1^+$) and EPS-negative ($EPS1^-$) EGDe derivatives.

In brief, experiments were conducted by exposing the three strains to lethal levels of the agents in phosphate-buffered saline (PBS) for 10 minutes at room temperature and then plating cell survivors on recovery medium using colony counting to assess killing. Control incubations in which cells were exposed only to PBS also were conducted.

Results and Discussion

The results of disinfectant susceptibility testing for the three *L. monocytogenes* strains are presented in Figures 1 and 2.

Of the three strains, the $EPS1^+$ overproducing strain exhibited the highest level of survival (log colony forming units per milliliter [cfu/ml]) after exposure to both bleach and BC. The survival of the $EPS1^-$ strain was comparable to that of the wild-type strain under the conditions used.

These results indicate that the over-expression of EPS protects cells against disinfectant exposure. Possibly, EPS forms a barrier layer around the bacterium in which the agents have difficulty penetrating. In future research, we will investigate the structure of the EPS and test whether it promotes the attachment of *L. monocytogenes* to produce.

Acknowledgments

This project is being funded by the Wyoming Agricultural Experiment Station Competitive Grants Program.

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Key words: *Listeria monocytogenes*, food contamination, disinfectant resistance

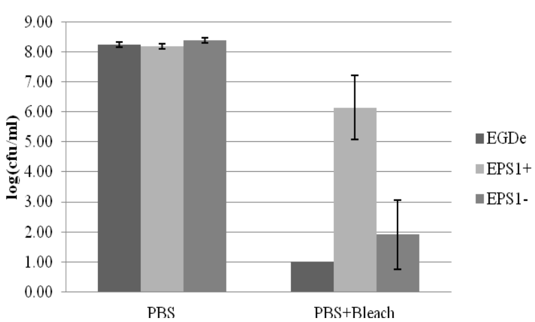

Figure 1. Bleach disinfection experiment.

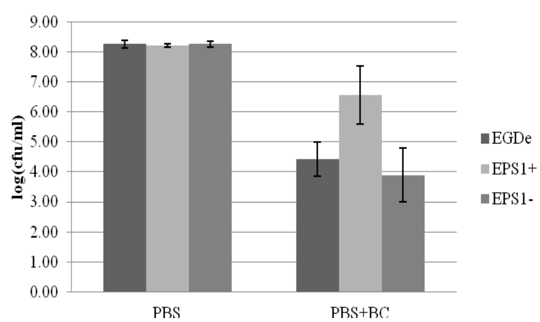

Figure 2. BC disinfection experiment.

Effects of Disturbance of Salt-Affected Soils in a Wyoming Natural-Gas Production Area

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Introduction

Accelerated mining and drilling for energy resources have boosted demand for effective reclamation to restore productivity and ecological functions of disturbed ecosystems. Success in reclamation projects is often most difficult on land disturbed in desert environments having fragile soil and plant communities and cold temperatures.

The largest natural gas operation in Wyoming is near Wamsutter, with more than 2,000 wells in operation and nearly 10,000 more planned, including the nearby Continental Divide–Creston area. Each well creates five to 10 acres of disturbance—plus roads and pipelines—that must be reclaimed. Reclamation sites near Wamsutter often exhibit redistribution of subsurface salts and/or sodium to surface soil, losses in soil structure due to mechanical stripping and stockpiling, and losses in organic matter. For these reasons, "reclamationists" struggle to reestablish native vegetation on calcareous, high-desert soils. Average annual precipitation is approximately 7 inches and is highly variable in this area, further complicating reclamation.

Objectives

The goals of this study were to quantify effects of disturbance on high-desert soils by surveying changes in chemical soil properties across seven well pads reclaimed in summer 2012 and to further evaluate physical and biological properties on two of the seven pads.

Materials and Methods

Data were collected for seven well pads reclaimed in summer 2012. Five 6-inch deep cores were collected from each well pad and adjacent disturbed and undisturbed areas. Samples were analyzed for particle-size, pH, electrical conductivity (indicator of salinity), calcium carbonate content, and base cation concentrations of calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K). Two of the seven well pads were selected for their high sodium levels and were further sampled by collecting five 6-inch deep samples from disturbed and undisturbed sites. Samples were then analyzed for total nitrogen (TN) and soil organic matter (SOM).

Results and Discussion

Overall results indicated that the disturbed soils of the seven reclaimed gas-well pads had more salts and sodium, as well as finer textures than undisturbed soils (Table 1).

Table 1. Average soil properties across seven reclaimed well pads.

Soil Property	U†	D	Diff (%)[a]
Sand, %	29.8	25.0	-16.1
Silt, %	37.0	38.5	4.1
Clay, %	25.0	36.5	46.0
Base Saturation, %	44.9	51.3	14.3 *
pH	7.71	7.64	-0.9
Electrical conductivity, dS m^{-1}	1.14	5.79	408 **
Calcium, $mmol_c$ kg^{-1}	6.65	20.1	202 **
Magnesium, $mmol_c$ kg^{-1}	1.68	16.1	858 *
Sodium, $mmol_c$ kg^{-1}	3.94	27.9	608 *
SAR[b]	3.95	7.85	98.7 *
Lime, %	4.16	4.25	2.20
Exchangeable sodium %	4.96	9.51	91.7 *

†U, undisturbed; D, disturbed. * and **, significant difference at the 95% and 99% confidence levels, respectively (n=7 for all analyses).
[a] Percent differences based on "undisturbed" values.
[b] sodium adsorption ratio (SAR).

Increased salts and clays are due to stripping soil down into subsurface layers containing accumulated clays and salts, then mixing and stockpiling. Thus, when soil is respread onto the site, subsurface salts and clays are moved to the surface.

Average SOM and TN across the two intensively sampled well pads, in both disturbed and undisturbed areas, can be found in Table 2.

Table 2. Average SOM and TN of two sodium-affected well pads near Wamsutter.

Soil Property	U†	D
Organic Matter (%)	0.920	0.335 *
Total N (mg N kg $soil^{-1}$)	675	480 *

†U, undisturbed; D, disturbed; *significant at the 95% confidence level; n=8 for both analyses.

Soil organic matter and total nitrogen contents were significantly lower in the two disturbed soils compared to the two undisturbed soils, which represents dilution and loss of organic matter by decomposition when soil and vegetation are stripped and stockpiled during well pad construction. The redistribution of salts and sodium as well as dilution and decreases in soil organic matter in these disturbed surface soils result in degradation of soil structure and make soil conditions less favorable for germination of native species.

Overall, reclamation practices in Wyoming require consideration of sound ecological science in cooperation with practical management techniques to ensure the successful restoration of disturbed ecosystems. Knowledge of the status of disturbed soils, and of options for reclaiming those soils, can help increase the likelihood of success in these projects.

Acknowledgments

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Key words: sodium, salinity, disturbance

Effects of Mountain Pine Beetle Infestation on Soil Carbon Losses in a Lodgepole Pine Forest Ecosystem in Southeast Wyoming

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Introduction

Approximately 1.4 million acres of northern Colorado and southeast Wyoming forests were impacted by bark beetles in the most recent outbreak. Forest managers and landowners have reported significant losses in timber and recreational values while researchers are predicting impacts on forests' ability to uptake carbon (C), cycle essential nutrients, and maintain water. Bark beetles (mountain pine beetle) burrow under the bark of lodgepole pine (*Pinus contorta)* to feed and lay eggs over the winter. As a result, within two years after bark beetle attack, trees die due to a shortage of water and nutrients. Forests uptake more C (carbon sink) than they respire to the atmosphere. The disturbance of the processes regulating the flux may change the atmospheric carbon dioxide (CO_2) concentration. As forests are devastated by this infestation, large numbers of trees that were C sinks may suddenly become C sources to the atmosphere. Release of C from forest soil—soil respiration—is one of the largest C sources to the atmosphere. Thus, studying soil respiration allows us to achieve a better perspective on how forests contribute to the global C cycle.

Objectives

Our main goals were to learn how soil respiration responds to increasing tree mortality as well as changing environmental drivers (soil temperature and moisture) associated with bark beetle attack.

Materials and Methods

The study site is located at 9,200 feet in the Medicine Bow Range near the Chimney Park Boy Scout camp in southeast Wyoming. We monitored two research-stands since summer 2008, including a stand attacked by bark beetles in summer 2007 (*attacked stand*) and an *unattacked stand*. We measured soil respiration, moisture, and temperature. In each stand, 15 measurements were conducted biweekly from May to October, 2008–2012.

Results and Discussion

Soil respiration in the *attacked stand* was less than half the rate compared to that of the *unattacked stand*. This distinction was maintained during each growing season since the bark beetle attack (2008–2012, Figure 1). However, the relative magnitude of the soil respiration varied by year depending on climate conditions—during the driest year (2012), soil respiration was reduced in both *attacked* and *unattacked* stands.

Because tree root respiration is a significant portion of soil respiration, we investigated how beetle-induced mortality of trees impacts soil respiration. We used a proxy called live basal area (LBA) to determine beetle-induced tree mortality. LBA defines how many live trees are left within a stand. Figure 2 shows that soil respiration and LBA were highly correlated (r^2=0.77). This indicates that soil respiration will continue to decline in attacked stands as the number of surviving trees declines with ongoing mortality.

Soil temperature and moisture are the traditional soil respiration drivers, e.g., an increase in these parameters should increase soil respiration. Soil moisture was almost twice as high in the *attacked stand*, mostly due to reduced water uptake by dead trees, compared to the *unattacked stand*. Beyond two years after the attack, however, we found no effects of soil moisture or temperature on soil respiration.

On the other hand, the research clearly shows that forest die-off due to bark beetle outbreak has a substantial and long-lasting impact on soil respiratory C losses. Finally, our research site is similar to a large area of high-elevation lodgepole pine forests across Wyoming. Thus, the findings from this research may have serious implications for estimating larger-scale forest C balances following beetle infestations in Wyoming and beyond.

Acknowledgments

The project was funded by the National Science Foundation's Hydrological Sciences Program, and supported by the Department of Botany. Special thanks to the Pendall lab group students for field support.

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Key words: forest, soil respiration, mountain pine beetle

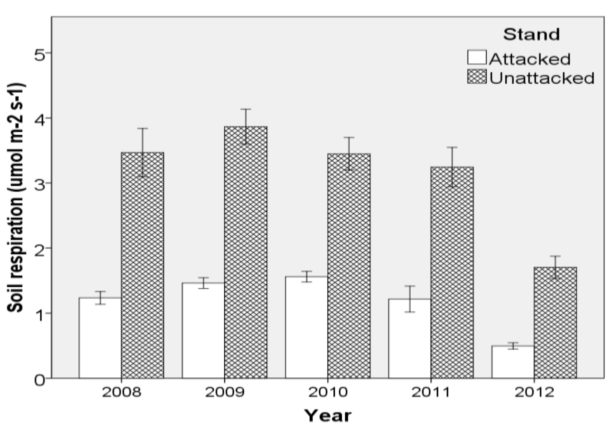

Figure 1. Average growing season soil respiration measured in August 2008–2012.

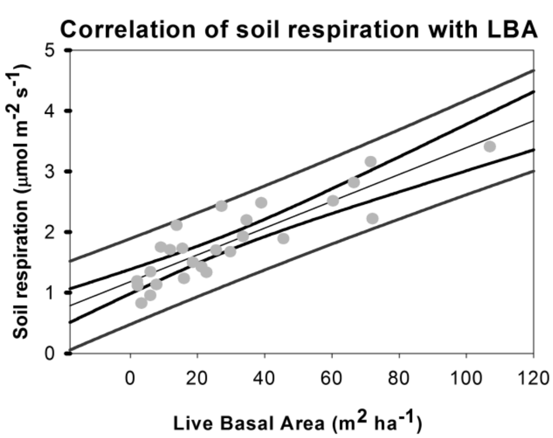

Figure 2. Relationship between soil respiration and live tree basal area from 2008 to 2012.

Corn Production and Seasonal Greenhouse Gas Emissions in Kenya

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Introduction

A University of Wyoming–East Africa team of scientists and farmer collaborators joined the Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program (SANREM CRSP) in 2010 by winning a five-year grant. The purpose is to develop conservation agriculture production systems (CAPS) for eastern Africa and to work on sustainable intensification in one of the most food-insecure world regions. In East Africa, farming practices rely on heavy inversion tillage to grow corn (*Zea mays* L.) intercropped with common bean (*Phaseolus vulgaris* L.) during one or two growing seasons per year. Despite high annual precipitation and temperatures, heavily weathered soils are deficient in many nutrients, mainly nitrogen (N) and phosphorous (P), but small-scale subsistence farmers often cannot afford to buy fertilizers. Previous studies show that the magnitude of N use and fertilizer recovery by crops is low, which suggests high N and carbon (C) losses to leaching and greenhouse gas (GHG) emissions. Quantifying the magnitude of GHG emissions is important to design efficient CAPS practices that aim at reducing the intensity of tillage and improvement of soil tilth. We hypothesize that N and C losses to GHG emissions are very high in East Africa and depend on the frequency of land tillage practices. These losses are greater in areas with two growing seasons compared to areas where crops are produced during one long growing season only.

Objectives

Our goal was to inventory seasonal GHG emissions from corn–bean intercropping grown once or twice during the year.

Materials and Methods

Research was conducted at two locations near the equator: Bungoma and Trans-Nzoia. Locations represent different climatic zones: Bungoma has two growing seasons lasting from April to July and from September to November; Trans-Nzoia has one rainy growing season from April to November. Information on site description and climate are shown in Table 1.

Air sampling was performed three times a year for two consecutive years: during dry period before land preparation (P-P), at corn peak vegetative growth (V8), and before corn harvest at corn physiological maturity (R6). Air samples were analyzed for carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) concentrations at

Table 1. Site Descriptions.

Parameter	Trans-Nzoia	Bungoma
Location		
Elevation	6,890 ft	4,701 ft
MAP	59.1 inches	43.3 inches
MAT	77 °F	86 °F
Soil Properties		
Bulk density	1.6 g m^{-3}	1.7 g m^{-3}
Clay	28%	36%
Silt	20%	16%
Sand	52%	48%
Soil Texture	Sandy clay loam	Clay loam

the University of Wyoming using gas chromatography.

Results and Discussion

Soils from both locations had comparable high CO_2 emissions and low overall CH_4 assimilation. However, the Bungoma location had very high N_2O emissions and slightly greater CH_4 assimilation compared to Trans-Nzoia (Figure 1). These preliminary results point at rapid residue decomposition and low soil N retention in the form of soil organic matter (SOM). Efforts should be made toward designing CAPS aiming at soil fertility improvement especially in areas where crops are raised during two growing seasons. Replacing crops with an N-fixing legume cover crop during the second growing season may be a viable alternative, yet difficult to adopt by subsistence farmers in this area. As in Wyoming, integrating cover crops could help farmers restore soil productivity, but committing resources to crops that feed the soil—not people or livestock—is difficult.

Acknowledgments

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Key words: inversion tillage, N loss, sustainable intensification

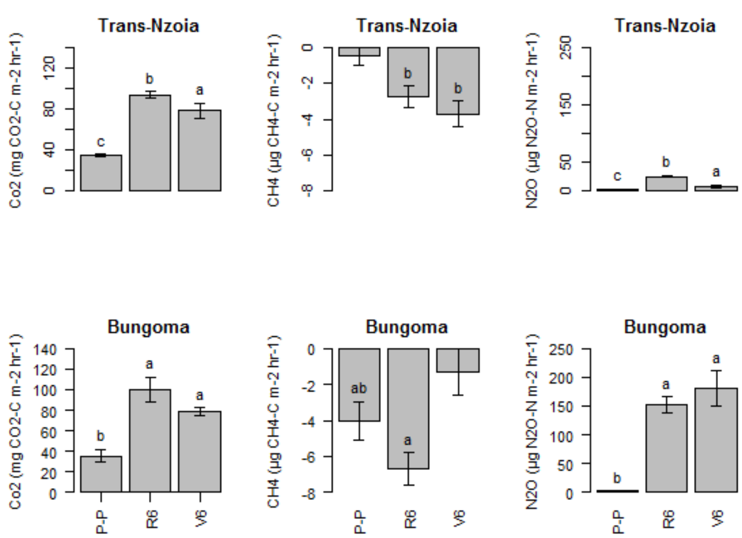

Figure 1. CO_2, CH_4, and N_2O collected before planting (P-P), peak corn vegetative growth (V8), and before harvest at corn physiological maturity (R6). Lower case letters represent cases where differences in gas concentrations have >95% chance of being significant due to differences between the seasons.

Economic Impacts of Climate Change and Drought on Wyoming Ranchers

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Introduction

Climate has major influences on production agriculture. Cattle and calves generated 60% of total sales of agriculture commodities in Wyoming in 2011 (Ballard et al., 2012, page 27). Impacts of climate on livestock production are less studied and harder to predict than impacts on crops, rangelands, and ecosystems. Climate change is a complex threat facing the economic stability of the cattle industry. Current national climate change predictions include changes in temperature, precipitation, snowpack, evaporation, and weather variability and increased occurrences of extreme events (e.g., drought). These potential climate changes will likely affect cattle production through the health, well-being, and performance of crops, pastureland, rangeland, and cattle. Quantification of the nature and severity of these effects on cattle production will help producers implement management strategies to reduce potential negative economic impacts.

Objectives

Specific research objectives are to:

1) Develop relevant ranch-scale economic models of cattle production systems specific to southeastern Wyoming;
2) Aggregate climate change projections from a variety of sources into a suite of regionally relevant scenarios that reflect impacts of temperature and precipitation on cattle production;
3) Analyze potential ranch-scale outcomes of management alternatives using economic models and climate scenarios developed for objectives 1 and 2;
4) Develop regional recommendations of adaptations to climate change for producers; and
5) Share our results with livestock producers via outlets such as the University of Wyoming Extension, media, etc.

Materials and Methods

We will use a multi-period linear programming (MLP) model to quantify impacts of climate change on livestock production. This will provide us with potential benefits and costs of alternative adaptation strategies. Linear programming involves finding an optimum solution to a problem in the face of defined relationships and constraints.

MLP allows us to model best-case responses to weather under various climate scenarios. We will examine economic performance of a typical cow–calf production system observed in the study area, as well as more flexible alternatives (e.g., later calving dates, earlier weaning dates, or retaining yearlings), which may help producers adapt to climate change. We will compare performance of these alternative systems across current and predicted future climate conditions.

Initially, livestock prices in the model are fixed to focus attention on the effects of climate on rate of gain and overall pounds gained at time of sale. This helps determine optimal management strategies in the absence of market risk. We will then include price variation in the model to account for changes in price, in conjunction with climate variation. This helps determine if cattle-management decisions and profits are impacted more heavily by climate variables or market variables.

Information about the physical effects of climate variables, such as temperature and precipitation, on cattle performance are being obtained from long-term research at the U.S. Department of Agriculture, Agricultural Research Service's High Plains Grasslands Research Station (HPGRS) near Cheyenne. Gain-response models from the HPGRS data will be used in the economic model to determine how climate variables affect pounds of gain.

Climatic variables included in the MLP model will affect livestock performance directly, as indicated by the HPGRS gain-response models, but also indirectly through impacts on forage availability.

The MLP model will identify livestock management activities that maximize the present value of net returns over a multi-year planning horizon, given variation in prices, climate conditions, and range conditions. It's our goal to develop and solve short-term (five years) and long-term (20-plus years) versions of the model. This will allow comparison of short-term and long-term adaptation strategies.

Results and Discussion

This research was initiated in January 2013, so model building and data collection are currently underway. Initial results are expected by the summer of 2014.

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Key words: climate change, cattle production, drought

Reference

Ballard, T., et al., 2012, *Wyoming Agricultural Statistics 2012*. U.S. Department of Agriculture, National Agricultural Statistics Service, Wyoming Field Office, 98 p. http://www.nass.usda.gov/wy

Field Testing a New Insecticide for Efficacious Rangeland Grasshopper IPM

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Introduction

Grasshoppers have long been a hazard to Wyoming agriculture. In the days of open range, livestock and wildlife probably migrated away from areas being ravaged with population explosions of grasshoppers to find forage elsewhere. Even though a range cow or buffalo can weigh a million times more than an individual grasshopper, they can't compete with the insects for forage. A cow can starve on a pasture where grasshoppers are abundant and thriving; densities of just 25 adult grasshoppers per square yard can exceed 50 pounds of the insects per acre. The grasshoppers can eat their weight daily in forage as new leaves barely emerge from root crowns, which are too short for cows to graze. The amount of grass grasshoppers consume is only part of the forage loss they cause. They also clip grass blades, making the grass unavailable to other animals.

As the open range period ended in Wyoming and fenced boundaries were established, controlling grasshopper population explosions became necessary. Grasshopper infestations can cover millions of acres, and entire ranches can be devastated by severe forage loss.

Grasshopper infestations are managed more like a "biological wildfire" because of the large scale of the outbreaks and potential for long-range movement en masse. Because vast areas were affected by grasshopper infestations crossing private and administrative land boundaries, the U.S. Department of the Interior in 1876 was directed by Congress to help. Now, the U.S. Department of Agriculture–Animal and Plant Health Inspection Service's Plant Protection and Quarantine (USDA, APHIS, PPQ) helps reduce agricultural losses caused by grasshoppers.

Objectives

The first goal of the test was to establish a low, effective rate of DuPont's™ Prevathon® insecticide (Figure 1). It has very low toxicity to mammals, birds, and fish, and it was

Figure 1. A spray plane applies Prevathon to 40-acre plots as part of an experimental trial to determine the best rate for reducing grasshopper populations to non-economically damaging levels. (Photo courtesy USDA–APHIS' Center for Plant Health Science and Technology [CPHST]).

Figure 2. Long-billed curlews hunting for insects on one of the Prevathon-treated RAAT plots on the AU-7 Ranch. The low toxicity of Prevathon to vertebrates allows the birds to safely aid in reducing remaining grasshopper populations.

recently labeled for rangeland grasshopper control (Figure 2). The second goal was to make sure that Prevathon was compatible with the grasshopper integrated pest management (IPM) strategy's reduced area and agent treatment system (RAAT).

Materials and Methods

In early spring 2012, a large grasshopper infestation was found by Wyoming APHIS–PPQ personnel scouting on the historic AU-7 ranch, owned by Bob Stoddard, southwest of Newcastle. With his permission, 36 40-acre plots in the infestation were surveyed in early June.

Preliminary grasshopper densities on the plots ranged from 12 to 35 per square yard. Uncooperative weather and equipment problems spread the application of the experimental treatments over three weeks. Drought conditions combined with heavy grasshopper feeding made most of the normally productive pastures on the AU-7 look like parking lots.

Results and Discussion

Test plots treated with the insecticide, carbaryl, were used as a standard to compare with plots treated with three rates of Prevathon in both conventional blanket treatments and RAATs. In addition, untreated plots were also monitored to insure that the insecticides were not credited with any naturally occurring grasshopper mortality. The experiment showed that Prevathon insecticide gave excellent control at rates as low as 4 ounces per treated acre and is compatible with RAATs (Table 1).

Table 1. Percent grasshopper mortality (average of 4 plots for each treatment) at AU-7 Ranch Prevathon test site June–July 2012.

Treatment–Rate–Coverage	**7 day post**	**14 day post**	**21 day post**
Carbaryl–12oz–50% RAATs	37	65	67
Prevathon–8oz–Full	95	99	99
Prevathon–8oz–50% RAATs	80	94	99
Prevathon–6oz–Full	93	89	100
Prevathon–6oz–50% RAATs	88	87	92
Prevathon–4oz–Full	95	99	99
Prevathon–4oz–50% RAATs	61	79	87

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We thank APHIS–CPHST and PPQ personnel, and Bob Stoddard*,* AU-7 ranch.

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Key words: IPM, grasshopper, rangeland

Myxobacteria as Biocontrol Agents Against Crop Pathogens

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Introduction

Microbial pathogens destroy more than 10% of the annual U.S. crop production, causing tens of billions of dollars in damage. Although pesticides are used, their usefulness is incomplete, not applicable to organic growers, costly, and harmful to the environment and potentially the consumer. In contrast, some soils are naturally suppressive to microbial diseases, while others are not. The ability of certain soils to suppress disease is largely attributed to the natural microbial flora found in the rhizosphere, a narrow region of soil that is rich in microbial growth caused by plant root secretions.

Investigators have found specific bacterial strains can act as biocontrol agents by antagonizing the growth of plant pathogens. Some of these bacteria have been developed into commercial products. Although useful, existing biocontrol agents are not completely effective and do not cover all plant diseases. Therefore, there is a need for improved and more diverse products. Our proposal seeks to explore whether myxobacteria represent a new class of biocontrol agents.

Myxobacteria offer a number of advantages as they are natural soil inhabitants, are predators of other bacteria and fungi, produce a rich array of antibiotics, offer product stability as spores, and have gliding motility to facilitate dispersion.

Objectives

This study has three goals: 1) conduct a series of pilot plant tests. Initially, a rapid screen will survey the ability of myxobacteria to protect seedlings against a panel of pathogens on agar plates. These results will be used to prioritize promising microbial combinations to be tested in growth chamber or greenhouse assays; 2) examine the ecological applicability of selected myxobacteria to survive and grow in the soil with an emphasis on the rhizosphere; 3) better understand the molecular mechanism by which myxobacteria antagonize and kill plant pathogens. Here, genetic screens will be conducted to identify gene products required for antagonism.

Materials and Methods

Myxobacterial and plant pathogen strains were derived from the collections of the author and the late Gary Franc, professor at University of Wyoming, Department of Plant Sciences. To conduct plant/seedling protection assays, a plant growth chamber was purchased and set up in the Wall laboratory. Microbial growth conditions and +mutagenesis methods follow standard lab protocols.

Results and Discussion

Our data, with a panel of key fungal and bacterial plant pathogens, found that myxobacteria can antagonize fungal pathogens. Figure 1 illustrates how a *Myxococcus xanthus* colony physically blocks the growth and spread of fungal pathogens on petri plates. By extension, myxobacteria grown in soil and the rhizosphere could help protect crops from microbial disease, since they are innocuous to plants. Our future work will directly test the feasibility of this hypothesis.

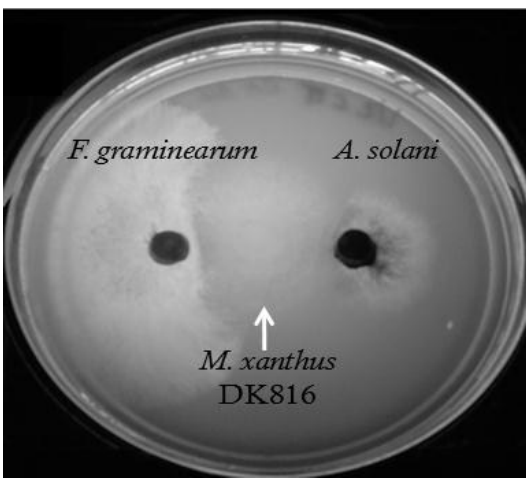

Figure 1. An *M. xanthus* swarm blocks the growth of plant pathogens on agar surface.

Our work has further found that secondary metabolite antibiotics produced by myxobacteria can serve as weapons to antagonize bacterial and fungal plant pathogens. In one strain, we have systematically inactivated all 18 putative secondary metabolite pathways and tested for defects in antagonistic interactions toward key pathogens. These efforts have identified the myxalamid secondary metabolite family as critical for antagonistic interactions against certain fungal pathogens.

We have also discovered that myxovirescin is a myxobacterial-produced antibiotic that kills bacteria by inhibiting an essential enzyme (LspA; type II signal peptidase) involved in lipoprotein processing. Knowledge about how myxobacteria antagonize or kill other microbes allows rational approaches to engineer improved biocontrol agents.

Furthermore, information about how myxobacteria grow in the rhizosphere, as well as how they can be applied to and interact with crops or seeds, offers new opportunities to effectively, safely, and economically protect crops from disease.

Acknowledgments

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Key words: biocontrol, myxobacteria, pathogens

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