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WYOMING AGRICULTURAL EXPERIMENT STATION

University of Wyoming, Dept. 3354
1000 E. University Ave.
Laramie, WY 82071-2000
contact: aes@uwyo.edu, (307) 766-3667
www.uwyo.edu/uwexpstn

RESEARCH & EXTENSION CENTERS

Laramie (LREC)

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

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contact: sarec@uwyo.edu, (307) 837-2000
www.uwyo.edu/uwexpstn/centers/sarec

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contact: mdmoore@uwyo.edu, (307) 754-9815 or 800-923-0080

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3401 Coffeen Ave.
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contact: shrec@uwyo.edu, (307) 673-2856
www.uwyo.edu/uwexpstn/centers/sheridan

Contents

Pigs: A Clinically Relevant Animal Model for Diabetic Wound Healing

Anne Chenchar, School of Pharmacy

Brenda M. Alexander, Department of Animal Science

Sreejayan Nair, School of Pharmacy

Introduction

Diabetes affects 10% of the U.S. population with 34.2 million Americans suffering from this disease. Even more alarming is the 88 million Americans diagnosed with pre-diabetes. Those with diabetes are at greater risk of developing diabetic foot ulcer. Many of these ulcers become non-healing wounds, potentially leading to amputation. Diabetic wounds heal at a slower rate due to decreased blood flow, chronic inflammation, and a dysregulation of cellular function within the wounds[1].

Non-healing wounds have enhanced protease activity[2]. Proteases are enzymes that breakdown proteins including collagen. Collagen is the major matrix protein that facilitates wound repair. Cathepsin K is a potent protease that degrades collagen. Studies from the Nair lab have determined increased cathepsin K and decreased collagen in diabetic skin from human subjects. This suggests cathepsin K may represent a potential target for treating diabetic wounds.

Wound healing studies often rely on rodent models. Pigs, however, are a superior model for human wound healing since skin anatomy of pigs closely resembles that of humans. Rodents are loose skinned and heal primarily by wound contraction. Pigs, like humans, are tight skinned and heal primarily through cell migration and proliferation across the wound[3].

For the diabetic model, pigs are made diabetic by injecting a drug that selectively kills the pancreatic insulin producing cells. Once diabetic, the pigs exhibit disease processes that mimic human diabetes with similar blood glucose concentrations[4]. As a larger animal, the greater skin surface allows for placing several wounds for cross-comparison between wounds within an animal. This makes the study design stronger and requires fewer animals for these studies.

Objectives

The objective of this study was to determine the effect of inhibiting cathepsin k in healing diabetic wounds.

Materials and Methods

Pigs were made diabetic at three months of age by treatment with streptozocin. Diabetes was confirmed by blood glucose concentrations greater than 350 mg/dL. Pigs were maintained for one month after onset of diabetes. At one month, pigs were anesthetized, and wounds were placed down their back. Wounds were treated with odanacatib, a known cathepsin K inhibitor, or saline on the day of injury, day 7, and 14. Wounds remained covered during the healing process. Tissues were collected on day 21 following wounding, or when full healing had occurred.

Results and Discussion

Diabetic pigs treated with odanacatib, the cathepsin K inhibitor, had improved wound healing compared to those treated with saline. Wounds treated with odanacatib showed approximately 93% wound closure by day 21, while those treated with saline had approximately 70% healing during the same time-period. Wounds treated with a high dose of odanacatib healed completely as early as day 25 with the saline group showing full healing at approximately day 30.

Inhibition of the protease action of cathepsin K with odanacatib facilitated wound healing in diabetic pigs. Our studies suggest that cathepsin K inhibition may be an attractive treatment target for diabetic wounds.

Acknowledgments

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Contact

Sreejayan Nair, sree@uwyo.edu

Brenda Alexander, balex@uwyo.edu

Keywords

diabetes, cathepsin K, wound healing

Citations

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Effects of Environmental and Prophylactic Interventions on Udder Health Parameters in Semi-Extensively Managed Ewes

R. M. Knuth, Department of Animal Science

K. L. Woodruff, Department of Animal Science

G. L. Hummel, Department of Animal Science

J. D. Williams, Department of Animal Science

W. C. Stewart, Department of Animal Science

B. Bisha, Department of Animal Science

H. C. Cunningham-Hollinger, Department of Animal Science

Introduction

Mastitis, defined as the inflammation of mammary tissue, often results from bacterial infection and can occur at any time from lambing to weaning. Subclinical mastitis is prevalent, although on-farm diagnosis is difficult, especially in non-dairy animals due to lack of visible clinical signs, and bacterial culture remains the standard diagnostic tool. Proper hygienic management of housing environment, and dry-off management at the cessation of lactation may affect the prevalence of subclinical mastitis. For example, withholding feed from ewes for 48 hours following weaning with an additional 2 weeks of low-energy, low-protein feed is recommended in the Sheep Production Handbook.

Objectives

The objectives of this study were to:

- Quantify the prevalence of and identify bacteria related to subclinical mastitis shortly after lambing (24 and 48 hours postpartum) and weaning (68 days postpartum)

- Determine the effectiveness of weaning treatments to mitigate subclinical mastitis

Hypothesis

We hypothesized most ewes would present subclinical mastitis around weaning because milk, a nutrient rich substrate for bacteria, is no longer fully removed from the udder by the suckling lamb as they transition to a hay and concentrate diet; thus, bacteria can rapidly reproduce. We further hypothesized most bacteria found in milk would be susceptible to most antibacterial drugs, and resistance to these drugs would be low in the absence of prolonged treatment with antimicrobials.

Materials and Methods

Animals were used from the University of Wyoming Laramie Research and Extension Center sheep flock. Prior to lambing during spring 2020, 48 first or second parity commercial Rambouillet ewes, were randomly assigned to one of two individual bonding pen (jug) bedding treatment groups to assess the effects of bedding environment on subclinical mastitis. These treatment groups were: (i) soiled bedding and manure were removed from the jug and barn lime and fresh straw were added before the fresh ewe and her lamb(s) entered and (ii) fresh straw was added on top of previously soiled bedding before the ewe and her lambs entered the jug. Milk was sampled at 1 and 2 days

post-lambing. These samples were further analyzed for culture-based bacterial identification, antimicrobial resistance analysis, and bacterial identification through microbial DNA sequencing.

Prior to weaning, the same ewes were assigned to one of three treatment groups to assess the impact of weaning management practices on subclinical mastitis. These treatment groups were: (i) intramuscular injection of penicillin at weaning; (ii) dry-off ewes by removing concentrate feeds and restricting hay intake for 48 hours prior to weaning; and (iii) dry-off ewes by removing concentrate feeds and restricting hay intake for 48 hours prior to weaning + intramuscular injection of penicillin at weaning. Milk was again sampled at weaning and 3 days post-weaning to assess milk bacteria populations and efficacy of these weaning treatments.

These post-lambing and weaning treatments are commonly used in Wyoming and U.S. sheep production systems, yet have not been evaluated in regards to bacterial community population and subclinical mastitis in ewes during early lactation.

Results and Discussion

The following results will focus on subclinical mastitis prevalence and cultivable bacterial identifications from ewe milk samples. In total, 65 unique bacterial species were identified across pre-weaning (days 1, 2, and 28) and weaning (days 69 and 72) milk samples (Tables 1 and 2). Additionally, there was no statistical evidence to support a jug treatment effect on inferred subclinical mastitis incidence pre-weaning at days 1, 2, or 28. However, weaning treatment did impact subclinical mastitis incidence around weaning ($P \leq 0.04$), where ewes treated with penicillin had a lower occurrence of subclinical mastitis. Pre-weaning, between 85 and 95% of milk samples contained cultivable bacteria depending upon day (d 1, 2, or 28). At weaning, 91% of milk samples indicated ewes had subclinical mastitis, which decreased to 81% three days post-weaning.

Conclusions and Future Directions

The results of the present study shows bacteria are very common in ewe milk collected post-lambing and at weaning, suggesting subclinical mastitis has unnoticed impacts on ewe health and performance. A high incidence of subclinical mastitis may have significant production impacts on reduced ewe and lamb performance, which could reduce flock revenue. Furthermore, facility and animal management practices may be a practical and affordable way of reducing the prevalence of subclinical mastitis in ewes. However, accurate on-farm diagnosis of subclinical mastitis remains elusive.

In addition to milk, other samples that were subject to microbial DNA sequencing were teat swabs, ewe and lamb rumen fluid, lamb cheek swabs, and bedding. Sampling occurred on days 1, 2, 28, and ~69-72 (weaning). These samples will allow for further investigations of ewe, lamb, and environmental sources of bacterial communities that may cause or enable subclinical mastitis. Additionally, bacteria isolated from milk will be subjected to antibacterial susceptibility testing to identify which bacteria species are resistant to commonly used antimicrobial drugs. The culmination of this data will help identify management practices that promote animal health and welfare while encouraging judicious use of antimicrobial drugs to prevent antimicrobial resistant bacteria or “superbugs” from entering the field of human medicine.

Table 1. Number of samples collected, subclinical mastitis prevalence, and estimated species frequency within and between jug treatments of pre-weaning (days 1, 2, and 28 postpartum) milk samples.

	Jug Treatment[1]		
Item	**Clean**	**Dirty**	**Overall**
No. sample	85	39	124
No. positive (%)	77 (91%)	33 (85%)	110 (89%)
Species[2]			
Acinetobacter	0.03	0.09	0.05
Advenella	0.05	0.03	0.05
Aerococcus	0.01	0.06	0.03
Arthrobacter	0.03	0.06	0.04
Bacillus	0.40	0.33	0.38
Brevibacterium	0.00	0.03	0.01
Corynebacterium	0.06	0.12	0.08
Escherichia coli	0.04	0.00	0.03
Enterococcus	0.05	0.03	0.05
Klebsiella oxytoca	0.01	0.00	0.01
Mannheimia haemolytica	0.03	0.12	0.05
Moraxella	0.00	0.03	0.01
Paenibacillus	0.03	0.06	0.04
Pantoea	0.05	0.06	0.05
Pseudomonas	0.03	0.03	0.03
Rothia	0.03	0.00	0.02
Staphylococcus	0.47	0.52	0.48
Streptococcus	0.06	0.18	0.10

[1]Treatment: Clean = bedding and manure was removed from jug between ewes and lambs, jug was treated with barn lime and fresh straw between ewe/lamb pairs. Dirty = soiled bedding was not removed and was covered with fresh straw between ewe/lamb pairs.

[2]Only identified species that occurred at an overall frequency ≥ 0.01 are presented.

Table 2. Number of samples collected, subclinical mastitis prevalence, and estimated species frequency within and between weaning treatments of milk samples (day 69, weaning and day 72, post-weaning).				
	Weaning Treatment[1]			
Item	**Penicillin**	**Fasting**	**Combo**	**Overall**
No. sample	30	26	28	84
No. positive (%)	22 (73%)	23 (88%)	27 (96%)	72 (86%)
Species[2]				
Acinetobacter	0.00	0.04	0.00	0.01
Aerococcus	0.05	0.00	0.04	0.03
Bacillus	0.68	0.70	0.81	0.74
Brachybacterium	0.05	0.00	0.00	0.01
Brevibacillus	0.00	0.04	0.00	0.01
Corynebacterium	0.00	0.00	0.04	0.01
Enterococcus	0.00	0.09	0.00	0.03
Mannheimia haemolytica	0.05	0.04	0.19	0.10
Moraxella	0.00	0.04	0.04	0.03
Staphylococcus	0.27	0.39	0.22	0.29
Streptococcus	0.14	0.09	0.07	0.10

[1]Treatment: Penicillin = intramuscular injection of penicillin at weaning. Fasting = dry-off ewes by removing concentrate feeds and restricting hay intake for 48 h prior to weaning. Combo = dry-off ewes by removing concentrate feeds and restricting hay intake for 48 h prior to weaning + intramuscular injection of penicillin at weaning.

[2]Only identified species that occurred at an overall frequency ≥ 0.01 are presented.

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Contact

Hannah Cunningham-Hollinger, hcunnin6@uwyo.edu

Keywords

bacteria, diagnostic methods, sheep, subclinical mastitis

Effects of Mixing Herbicides and Insecticides on Alfalfa and Weeds of Alfalfa

Micah McClure, Department of Plant Sciences

Randa Jabbour, Department of Plant Sciences

Andrew Kniss, Department of Plant Sciences

Introduction

Timing of insecticide application in alfalfa can be a challenging balancing act based on pest populations, weather, and planned harvests. Some producers have turned to applying early-season insecticides for alfalfa weevil mixed with herbicides for early season weeds rather than two separate applications at two times. This method reduces the number of passes as well as avoids the busy time of year for standard alfalfa weevil control. However, mixing pesticides together can potentially cause different efficacy on the target weeds. The effect of mixing the commonly used herbicides and insecticides in Wyoming alfalfa is largely unknown.

Objectives

To analyze the effects of mixing herbicides glyphosate (Roundup Powermax) or imazamox (Raptor) with the insecticides lambda-cyhalothrin pyrethroid (Warrior II) or chlorpyrifos (Lorsban Advanced) on downy brome and common lambsquarters, earlyseason weeds of alfalfa.

Materials and Methods

This study was conducted at the University of Wyoming greenhouses in Laramie, WY. The two herbicides glyphosate and imazamox were applied at 5 different rates either alone or mixed with insecticides lambda cyhalothrin or chlorpyrifos. This design allowed us to determine if combining insecticides and herbicides in mixture has any effect on herbicide efficacy on weeds. The insecticides were included at the recommended rate for alfalfa weevil control. All treatments were applied to Roundup-ready Alfalfa (*Medicago sativa*), downy brome (*Bromus tectorum*), and common lambsquarters (*Chenopodium album*). The study has been conducted twice: the first run included 4 to 5 replicates depending on species and in the second run, 8 replicates were included for all three species. Injury, above ground dry biomass, and survival were assessed at 21 to 28 days after herbicide treatment.

Preliminary Results

Data is still being analyzed, but it appears that downy brome control may be influenced by the addition of insecticides to the imazamox herbicide Raptor. When the mixture is applied, downy brome survival decreased at a higher rate (solid line with circles) than when no insecticide is mixed (dotted line with plus signs) or when mixed with lambda-cyhalothrin (dash line with triangles). In contrast, there appears to be no influence of insecticides in mixture with glyphosate on downy brome control. Data for both examples appears in Figure 1. To confirm these effects, an additional trial of the experiment should be conducted.

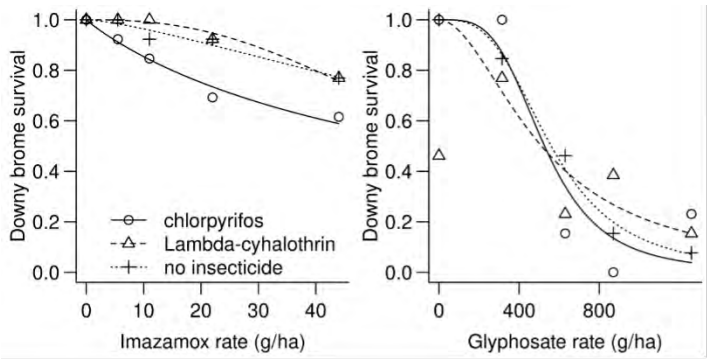

Figure 1. Survival rate of downy brome when exposed to insecticide mixtures with imazamox and glyphosate.

Acknowledgments

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Contact

Randa Jabbour, rjabbour@uwyo.edu, (307) 766-3439

Keywords

mixing pesticides, alfalfa, early-season weeds

PARP III.5

Greenhouse Investigations of *Cercospora* Leaf Spot Biology in Sugar Beet

Amanda Koch, Department of Plant Sciences

William Stump, Department of Plant Sciences

Introduction

Cercospora leaf spot (CLS) is a polycyclic disease caused by the fungus *Cercospora beticola Sacc* and is the most destructive foliar pathogen of sugar beets (*Beta vulgaris* L.). Management of CLS typically relies on multiple foliar fungicide applications. Repeated use of fungicides in many production areas have selected for insensitive fungi that can cause disease and yield loss even when fungicide was properly applied. Sometimes these insensitive fungal strains can have alterations in biology when compared to the sensitive strains. The relative fitness of benzimidazole (Thiophanate-methyl) and strobilurin (Pyraclostrobin) insensitive *C. beticola* isolates will be compared to a fungicide sensitive isolate on development on CLS tolerant and susceptible sugar beets in the greenhouse. By measuring relative fitness, we can better understand potential persistence of fungicide insensitive isolates in the *C. beticola* populations. Earlier work at UW has indicated benzimidazole insensitive isolates were no different from benzimidazole sensitive isolates. This in part would explain why these insensitive isolates have persisted in the High Plains sugar beet production region in the absence of benzimidazole applications. However, the fitness of strobilurin insensitive isolates has not been investigated from this region. Additionally, it is unknown how these isolates would develop on CLS tolerant and susceptible sugar beet varieties. Fitness parameters measured included lesion number and size.

Objective

The objective of this greenhouse study is to further compare the fitness of benzimidazole insensitive, strobilurin insensitive, and a benzimidazole/strobilurin sensitive isolates on *Cercospora* leaf spot tolerant and susceptible hybrids.

Materials and Methods

In a complete block design on the greenhouse bench, two varieties of Hilleshög sugar beets were planted into 15 cm diameter pots and grown for four months. One variety was tolerant to CLS, the other being susceptible to CLS. Pots were divided into four quadrants, one quadrant for each isolate and one quadrant for a control. After four months growth, the sugar beets were inoculated with a spore suspension from 1 of 3 different isolates using a hand atomizer. The isolates were benzimidazole insensitive, strobilurin insensitive, and the final one was benzimidazole and strobilurin susceptible. The control was sprayed with distilled water. The sugar beets were placed in a mist chamber with continuous mist for 24 hours. After this time period, the chamber was switched to mist the plants every 2 minutes for 30 second intervals to maintain the humidity for 4 days. The sugar beets were then monitored for 24 days post inoculation for lesion development and expansion over time.

Results and Discussion

The benzimidazole-insensitive isolate was the most virulent of the three isolates grown under greenhouse conditions causing the most lesions overall followed by the strobilurin-insensitive isolate (Table 1). Surprisingly, the susceptible isolate had the least number of lesions developed overall. As expected, there were significantly more lesions on the susceptible variety with almost 2 times as many lesions on the susceptible variety compared to the tolerant variety. Overall lesion expansion was greatest on the susceptible variety vs the tolerant but there were no overall differences in expansion between the isolates. This is an ongoing research project, our objective is to be able to determine how

strobilurin- and benzimidazole-insensitive and fungicides-ensitive *Cercospora beticola* isolates will infect, grow, and reproduce on a resistant and susceptible sugar beet variety in the greenhouse.

Acknowledgments

We would like to thank the LREC greenhouse personnel for assistance in watering, fertility, and maintenance of this study. This study was supported by Western Sugar funds.

Contact

William Stump, wstump@uwyo.edu, (307) 766-2062

Keywords

Cercospora leaf spot, sugar beet, fungicide resistance

PARP I:11

Table 1. Main effects of *Cercospora beticola* isolate and sugar beet cultivar on overall CLS lesion development and expansion.

CLS Isolate	Mean Number of Lesions	Mean Lesion Diameter (mm)
Benzimidazole-resistant	7.33 a*	2.16 a
Strobilurin-resistant	4.04 b	1.95 a
Susceptible	1.63 c	2.19 a
LSD	1.2488	NS
Beet Cultivar		
CLS-sensitive (HM9295RR)	5.83 a	2.52 a
CLS-tolerant (HM9027RR)	2.83 b	1.68 b
LSD	1.5295	0.3282

**Treatment means within the same column followed by different letters differ significantly (Fisher's protected LSD, P≤0.05)*

Pollinator Visitation to Specialty Cut Flowers in High Tunnels

Samantha Nobes, Department of Plant Sciences

Judith Herreid, Department of Plant Sciences

Karen Panter, Department of Plant Sciences

Randa Jabbour, Department of Plant Sciences

Introduction

Insects provide a variety of beneficial services in agroecosystems including pollination. Specialty cut flower production has the potential to simultaneously enhance pollinator activity and provide economic benefits to growers. In our high-altitude, short-season growing conditions of the semi-arid High Plains, plants require protection from potential frosts, high winds, and large day-to-night temperature swings. High tunnels are used for season extension, to increase yield, and to improve the quality of crops such as cut flowers.

Objective

To evaluate pollinator visitation to six ornamental cut flower species, within a small-scale high tunnel environment.

Materials and Methods

The experiment was conducted in two high tunnels at the University of Wyoming Laramie Research and Extension Center complex in Laramie, WY. The two high tunnels used in this study were 12 x 16 ft. with an arch roof style. They are covered in a double layer of 6-mil uninflated polyethylene plastic with double-walled polycarbonate for each end wall. Both tunnels utilized manual roll-up sides, up to about 3 ft. from ground level to provide ventilation and temperature control. High tunnel sides were kept open when temperatures rose above 40°F and closed when temperatures fell below 40°F.

Flowers were grown over the 2020 summer growing season from early June through late September. The plants used in this study included *Calendula officinalis* 'Princess Golden', *Matthiola incana* 'Lucinda Mix', *Helichrysum bracteatum* 'Double Mix', *Daucus carota* 'Dara', *Celosia argentea* 'Celway Mix', *Zinnia hybrida* 'Profusion Yellow', and *Zinnia elegans* 'Peppermint Stick.' Flowers were selected to span a range of types and families used in floral arrangements. We created 1m^2 plots of each flower species to compare pollinator visitation between flower species.

Timed observations were used to count the number of unique plant-pollinator interactions during a total of 360 minutes for each flower species. Observations took place between 10am and 2pm about every two weeks throughout the growing season starting 7 June 2020 and ending 23 September 2020. We recorded observations of bumble bees, honeybees, other native bees, wasps, butterflies and moths, flies, and beetles.

Results and Discussion

We observed 1,833 insects during timed observations throughout the growing season (Fig. 1). The total number of bees made up 24.8 percent of all of the observed insects in these groups. Bumble bees were 67.3 percent of the total number of observed bees, other native bees were 31.9 percent, and honey bees were 0.9 percent. *C. officinalis* and *H. bracteatum* had 60 percent of all native bee visits throughout the season. Flies were most often observed on *D. carota*. Wasps were most often observed on the *Zinnia* species.

Many different species can be grown for cut flower use. The six flower species we chose are nonnative, have various floral forms, and span a diversity of plant families. When we produced these flowers for cut flower stems in past experiments, we harvested three to four times per week throughout the season, in contrast to this experiment where our aim was to observe pollinators, and so we only harvested when flowers were spent. There is likely some trade-off between harvesting and resource provision to bees. It is feasible and marketable for diversified farm managers to incorporate growth of these cut flowers in their operation, offering not only an additional crop to market but also a resource for pollinators on their farms.

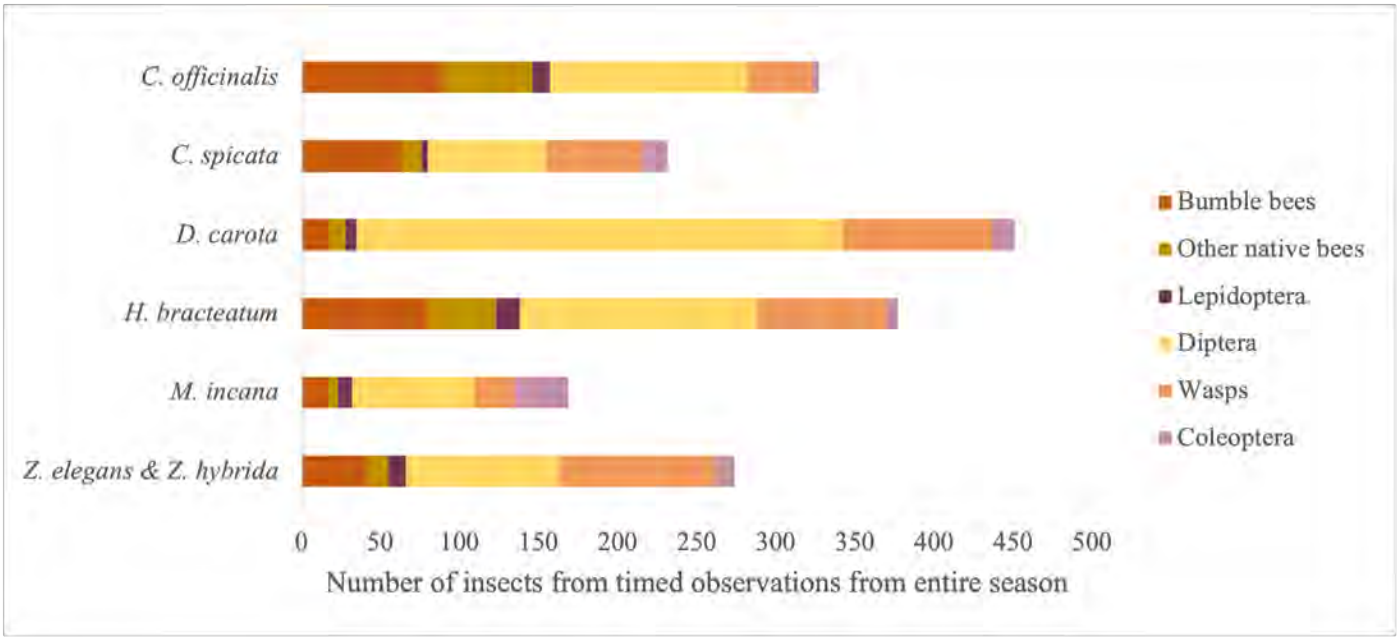

Figure 1. Insect observations of specialty cut flower species over the 2020 growing season including bumble bees, other native bees, butterflies and moths (Lepidoptera), flies (Diptera), wasps, and beetles (Coleoptera).

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Contact

Karen Panter, kpanter@uwyo.edu, (307) 766-5117

Randa Jabbour, rjabbour@uwyo.edu, (307) 766-3439

Keywords

cut flower, bees, pollinators, high tunnel, beneficial insect

PARP I.1, X.1

2020 Conventional Alfalfa Variety Trial, Powell, WY

Samual George, Research Associate, Powell Research and Extension Center (PREC)

Jim Heitholt, Dept. Plant Sciences and PREC

Steven Camby Reynolds, Farm Manager, Powell Research and Extension Center

Introduction and Objective

Compare the performance of different conventional (non-glyphosate tolerant) alfalfa hybrids in northwest Wyoming, taking two cuttings per year over a three-year period. Results provide information regarding which hybrids are better adapted to local growing conditions. 2020 was year 1 of 3.

Materials and Methods

The soil at the site was a Garland loam (OM: 1.6, pH: 8.1), and was broadcast fertilized with 70, 170, 0, and 50 units of N, P, K, and S, respectively on April 7th. No N fertilizer will be added in year 2 or 3. Alfalfa was planted 10 April 2020, at a rate of 20 lbs. per acre with a plot seed drill planter. Seed that was not pre-inoculated was inoculated with a commercial rhizobia. The trial was furrow irrigated, and water was supplied according to crop needs (approximately once every 14 days between cuttings). Raptor (4 oz/acre) and Buctril (1 pint/acre) were applied for weed control on 3 June 2020 and 29 July 2020. Plots were 6.1 feet wide by 18 feet long and arranged in randomized complete block design with four replications. Yields were determined by harvesting and weighing 18 feet from the center 4.8 feet of each plot with a plot forage harvester on 20 July (first cutting) and 17 September (second cutting). One pound of fresh sample was gathered from each plot at the time of harvest, was frozen, and then overnighted to the University of Wisconsin soil and forage lab for analysis. All reported yields were adjusted to 0% moisture. Yield and quality results can be found below (Tables 1, 2, 3, 4).

Results

Significant differences in protein, TDN, ADFNIR, NDFNIR, fat, P, Ca, and Mg were found among varieties mostly on the second cutting (Tables 1-4). Yield was similar among varieties.

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Contact

Samual George, sgeorg14@uwyo.edu

Keywords

dairy, forage, hay, livestock, quality

Table 1. Yield performance, protein concentration, and total digestible nutrients (TDN) of 17 conventional varieties grown at the University of Wyoming Powell REC in 2020. Harvest dates were mid-July and mid-Sept.

Variety	First Cut	Second Cut	Total	Protein[1]	Protein[2]	TDN[1]	TDN[2]
	---------- tons/acre ----------			---------- % ----------			
6453Q	1.32	1.14	2.46	20.6	16.4	62.3	62.0
6585Q	1.23	1.05	2.28	22.2	17.0	64.1	63.8
Ameristand 428TQ	1.28	0.78	2.06	20.8	17.4	32.8	62.8
C0415C3364	1.38	0.87	2.25	20.4	18.0	62.3	63.2
DKA 44-18	1.59	0.84	2.43	20.8	18.1	61.9	61.6
FF 42.A2	1.25	1.12	2.36	21.2	18.7	64.2	66.1
FSG 415BR	1.43	1.14	2.58	20.9	17.1	62.9	63.4
FSG 423ST	1.20	0.93	2.13	21.1	17.1	63.1	63.2
FSG 426	1.35	0.84	2.18	21.5	18.1	62.6	64.6
MPIII MaxQ	1.32	0.99	2.31	20.7	17.7	62.6	64.1
Nimbus	1.38	0.87	2.25	21.3	17.7	63.0	63.8
SGS 47M	1.29	0.87	2.16	21.9	18.6	64.0	65.4
SW 4517	1.31	1.09	2.40	22.0	17.3	64.1	64.0
SW 5614	1.38	1.30	2.68	21.1	16.7	63.2	63.4
SW 5615	1.45	0.91	2.36	22.0	18.2	63.9	63.9
WL 349HQ	1.42	0.97	2.40	20.8	17.5	62.1	64.6
WL 377HQ	1.31	0.92	2.22	21.3	17.1	63.5	62.9
LSD(0.05)	0.25	0.378	0.502	1.2	1.3	1.8	1.7
P-value	0.368	0.381	0.667	0.127	0.026	0.186	0.001
CV (%)	13.3	27.4	15.3	4.1	5.1	2.0	1.9

[1] Protein concentration and total digestible nutrients on 21 July 2020

[2] Protein concentration total digestible nutrients on 17 Sept 2020

Table 2. Acid detergent fiber (ADFNIR), neutral detergent fiber (NDF), and fat of 17 conventional varieties grown at the University of Wyoming Powell REC in 2020. Harvest dates were mid-July and mid-Sept.

Variety	ADFNIR[1]	ADFNIR[2]	NDF[1]	NDF[2]	Fat[1]	Fat[2]
	---------- % ----------					
6453Q	30.0	32.0	36.5	37.7	1.72	1.81
6585Q	28.1	30.2	33.9	36.2	1.81	1.79
Ameristand 428TQ	27.9	30.7	35.0	36.9	1.78	1.79
C0415C3364	30.4	30.3	37.4	36.4	1.65	1.84
DKA 44-18	29.3	31.4	34.8	36.1	1.63	1.75
FF 42.A2	28.5	27.2	34.3	32.9	1.74	1.87
FSG 415BR	29.9	30.7	36.3	37.2	1.72	1.72
FSG 423ST	29.2	30.8	35.6	38.2	1.71	1.65
FSG 426	29.3	29.0	35.7	35.1	1.76	1.82
MPIII MaxQ	30.2	29.8	37.6	35.4	1.68	1.85
Nimbus	29.2	30.1	35.5	36.7	1.73	1.74
SGS 47M	28.2	28.1	34.6	33.3	1.72	1.89
SW 4517	28.4	30.3	34.3	36.2	1.80	1.79
SW 5614	29.3	31.1	35.4	37.0	1.75	1.75

[1] ADF, NDF, and Fat on 21 July 2020

[2] ADF, NDF, and Fat on 17 Sept 2020

Variety	ADFNIR[1]	ADFNIR[2]	NDF[1]	NDF[2]	Fat[1]	Fat[2]
SW 5615	29.1	30.1	34.0	36.3	1.79	1.76
WL 349HQ	29.4	29.2	36.4	35.0	1.78	1.84
WL 377HQ	29.6	31.3	35.6	37.7	1.72	1.71
LSD (0.05)	2.2	2.0	2.7	2.5	0.10	0.09
P-value	0.547	0.002	0.234	0.004	0.046	0.002
CV (%)	5.3	4.7	5.4	4.8	4.3	3.54
[1] ADF, NDF, and Fat on 21 July 2020						
[2] ADF, NDF, and Fat on 17 Sept 2020						

Table 3. Concentrations of P, Ca, and Mg in forage of 17 conventional varieties grown at the University of Wyoming Powell REC in 2020. Harvest dates were mid-July and mid-Sept.

Variety	P[1]	P[2]	Ca[1]	Ca[2]	Mg[1]	Mg[2]
	%					
6453Q	0.287	0.262	1.21	1.33	0.307	0.302
6585Q	0.297	0.267	1.22	0.29	0.297	0.300
Ameristand 428TQ	0.280	0.267	1.28	1.31	0.302	0.310
C0415C3364	0.287	0.275	1.13	1.34	0.297	0.307
DKA 44-18	0.292	0.253	1.09	1.25	0.277	0.319
FF 42.A2	0.287	0.285	1.24	1.37	0.327	0.322
FSG 415BR	0.290	0.270	1.19	1.78	0.307	0.277
FSG 423ST	0.287	0.282	1.18	1.15	0.292	0.277
FSG 426	0.287	0.280	1.22	1.31	0.295	0.307
MPIII MaxQ	0.290	0.270	1.15	1.35	0.305	0.307
Nimbus	0.292	0.280	1.17	1.25	0.292	0.287
SGS 47M	0.292	0.275	1.19	1.39	0.315	0.325
SW 4517	0.295	0.270	1.24	1.27	0.312	0.292
SW 5614	0.282	0.262	1.23	1.24	0.312	0.287
SW 5615	0.285	0.280	1.21	1.26	0.312	0.292
WL 349HQ	0.287	0.265	1.21	1.33	0.290	0.312
WL 377HQ	0.287	0.272	1.19	1.21	0.307	0.292
LSD (0.05)	0.023	0.107	0.10	0.08	0.026	0.018
P-value	0.949	0.001	0.112	0.001	0.097	0.001
CV (%)	4.4	3.2	6.0	4.3	6.1	4.3
[1] P, Ca, and Mg on 21 July 2020						
[2] P, Ca, and Mg on 17 Sept 2020						

Table 4. Relative forage quality, milk yield per ton, and ash of forage from 17 conventional varieties grown at the University of Wyoming Powell REC in 2020. Harvest dates were mid-July and mid-Sept.

Variety	RFQc[1]	RFQc[2]	Milk	Milk	Ash	Ash
			------ per ton -----		---------- % ---------	
6453Q	171	160	2788	2730	10.9	9.3
6585Q	190	175	2926	2883	10.9	8.9
Ameristand 428TQ	179	168	2821	2805	11.2	9.5
C0415C3364	168	170	2798	2826	10.9	9.3
DKA 44-18	173	166	2720	2705	10.8	10.7
FF 42.A2	191	202	2942	3070	10.7	8.9
FSG 415BR	175	169	2844	2855	10.8	8.8
FSG 423ST	180	165	2855	2850	10.9	8.7
FSG 426	174	182	2799	2942	10.9	8.9
MPIII MaxQ	169	178	2819	2896	10.7	8.9
Nimbus	177	174	2835	2892	10.9	8.8
SGS 47M	188	196	2938	3009	11.1	9.2
SW 4517	189	177	2934	2909	10.9	9.1
SW 5614	179	170	2857	2859	10.7	8.9
SW 5615	189	176	2909	2896	11.0	9.1
WL 349HQ	169	184	2766	2946	11.0	8.8
WL 377HQ	180	166	2889	2814	11.1	9.0
LSD (0.05)	20.5	18.9	153	143	0.3	0.6
P-value	0.309	0.005	0.145	0.001	0.863	0.001
CV (%)	8.1	7.6	3.8	3.5	3.6	1.3

[1] Relative forage quality (RFQc, calculated), Milk per Ton, and Ash on 21 July 2020.

[2] Relative forage quality (RFQc, calculated), Milk per Ton, and Ash on 17 Sept 2020.

2020 Roundup Ready Alfalfa Variety Trial, Powell, WY

Samual George, Research Associate, Powell Research and Extension Center, PREC

Jim Heitholt, Department Plant Sciences and PREC

Camby Reynolds, Farm Manager, Powell Research and Extension Center

Introduction and Objective

The objective of this study was to compare the performance of different Roundup Ready alfalfa varieties in northwest Wyoming while taking 2 cuttings per year across a 3-year period. Results provide information on which varieties are better adapted to local growing conditions. 2020 was year 1 of 3.

Materials and Methods

The soil at the site was a Garland loam (OM: 1.6, pH: 8.1), and was broadcast fertilized with 70, 170, 0, and 50 units of N, P, K, and S respectively on 7 April. No N fertilizer will be added in year 2 or 3. Alfalfa was planted 10 April, at a rate of 20 lbs. per acre with a plot seed drill planter. Seed that was not pre-inoculated was inoculated with a commercial rhizobia. The trial was furrow irrigated, and water was supplied according to crop needs (approximately once every 14 days between cuttings). Raptor (4 oz/acre) and Buctril (1 pint/acre) were applied for weed control on 3 June and 29 July. An additional application of Roundup (32 oz/acre) was applied on 6 July. Plots were 6.1 feet wide by 18 feet long and arranged in a randomized complete block design with 4 replications. Yields were determined by harvesting and weighing 18 feet from the center 4.83 feet of each plot with a plot forage harvester on 21 July (first cutting) and 17 September (second cutting). One pound of fresh sample was gathered from each plot at the time of harvest, was frozen, and then overnighted to the University of Wisconsin soil and forage lab for analysis.

Results

Yield and quality results can be found below (Tables 1, 2, 3, and 4).

Discussion

Yields were about as expected but did not differ among cultivars. Forage from HVX Driver ranked the highest as far as protein concentration and TDN. Data from this trial could help provide hay producers in the Bighorn Basin with some guidance on what alfalfa varieties to grow.

Acknowledgment

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Contact

Samual George, sgeorg14@uwyo.edu

Keywords

dairy, forage, hay, livestock, quality

PARP Goal 2

Table 1. Performance of 12 glyphosate-tolerant alfalfa varieties grown at the University of Wyoming Powell REC in 2020. Harvest dates (cuts) were mid-July and mid-Sept. Yields were correct to 0% moisture.

Variety	First Cut	Second Cut	Total	Protein[1]	Protein[2]	TDN[1]	TDN[2]
	---------- tons/acre ----------			---------- % ----------			
6427R	1.22	1.37	2.59	21.5	17.8	63.6	63.5
6547R	1.22	1.53	2.75	20.7	17.1	62.4	63.0
DKA40-21HVXRR	1.30	1.42	2.72	22.3	16.9	61.9	62.2
DKA40-51RR	1.19	1.44	2.63	22.2	17.4	61.9	63.6
DKA43-18RR	1.32	1.48	2.80	22.5	17.2	62.0	61.8
FF 4319.A2 RR	1.18	1.47	2.63	20.9	17.6	63.0	64.5
FSG 438RR	1.21	1.45	2.67	21.3	17.0	62.3	63.3
HVX Driver	1.20	1.23	2.48	22.7	18.3	62.5	64.7
INTEGRA 8444R	1.24	1.53	2.77	21.1	16.2	62.9	61.6
RR Saltiva	1.17	1.42	2.59	20.7	16.1	62.2	62.4
RR Tonnica	1.15	1.49	2.64	21.0	17.3	62.4	62.8
WL 372HQ.RR	1.20	1.43	2.63	21.0	16.9	62.3	62.8
LSD (0.05)	0.15	0.13	0.23	1.0	0.9	1.3	1.3
P-value	0.596	0.043	0.306	0.001	0.004	0.333	0.001
CV	8.9	6.4	6.1	3.3	3.8	1.5	1.4

[1] Protein concentration and TDN on 21 July 2020.

[2] Protein concentration and TDN on 17 Sept 2020.

Table 2. Acid detergent fiber (ADF), neutral detergent fiber (NDF), and fat concentration of forage from 12 glyphosatetolerant alfalfa varieties grown at Powell REC.

Variety	ADFNIR[1]	ADFNIR[2]	NDF[1]	NDF[2]	Fat[1]	Fat[2]
	---------- % ----------					
6427R	29.7	29.9	36.3	35.5	1.67	1.86
6547R	31.5	30.7	38.0	37.0	1.60	1.77
DKA40-21HVXRR	29.2	29.9	33.7	34.5	1.65	1.82
DKA40-51RR	28.9	28.9	33.5	33.4	1.65	1.86
DKA43-18RR	29.3	30.3	34.1	34.2	1.66	1.88
FF 4319.A2 RR	30.7	28.7	37.3	34.9	1.61	1.83
FSG 438RR	31.2	30.1	38.4	36.2	1.60	1.81
HVX Driver	29.1	28.6	34.1	32.0	1.64	1.94
INTEGRA 8444R	30.9	32.6	37.6	39.1	1.61	1.73
RR Saltiva	31.9	31.9	38.4	37.6	1.57	1.73
RR Tonnica	31.2	30.9	38.1	36.9	1.61	1.79
WL 372HQ.RR	31.5	30.9	38.4	37.1	1.59	1.76
LSD (0.05)	1.4	2.0	1.6	2.5	0.09	0.09
P-value	0.001	0.006	0.001	0.001	0.377	0.001
CV	3.3	4.6	3.1	4.9	3.8	3.6

[1] ADF, NDF, and Fat on 21 July 2020.

[2] ADF, NDF, and Fat on 17 Sept 2020.

Table 3. Concentrations of P, Ca, and Mg in forage of 12 glyphosate-tolerant alfalfa varieties grown at the University of Wyoming Powell REC in 2020. Harvest dates were mid-July and mid-Sept.

Variety	P[1]	P[2]	Ca[1]	Ca[2]	Mg[1]	Mg[2]
	---------- % ----------					
6427R	0.280	0.275	1.32	1.38	0.367	0.315
6547R	0.265	0.265	1.25	1.25	0.350	0.292
DKA40-21HVXRR	0.292	0.254	1.19	1.31	0.305	0.319
DKA40-51RR	0.295	0.263	1.14	1.37	0.280	0.324
DKA43-18RR	0.297	0.256	1.23	1.32	0.272	0.311
FF 4319.A2 RR	0.265	0.272	1.26	1.31	0.360	0.307
FSG 438RR	0.275	0.265	1.23	1.28	0.342	0.300
HVX Driver	0.292	0.264	1.15	1.41	0.290	0.333
INTEGRA 8444R	0.272	0.252	1.27	1.21	0.357	0.290
RR Saltiva	0.270	0.250	1.25	1.23	0.355	0.297
RR Tonnica	0.277	0.265	1.28	1.27	0.355	0.302
WL 372HQ.RR	0.267	0.267	1.21	1.23	0.345	0.287
LSD (0.05)	0.014	0.015	0.08	0.08	0.029	0.016
P-value	0.001	0.056	0.001	0.001	0.001	0.001
CV	3.5	4.2	4.4	4.5	6.1	3.8

[1] P, Ca, and Mg on 21 July 2020

[2] P, Ca, and Mg on 17 Sept 2020.

Table 4. Relative forage quality, milk yield per ton, and ash of forage from 12 glyphosate-tolerant varieties grown at the University of Wyoming Powell REC in 2020. Harvest dates were mid-July and mid-Sept.

Variety	RFQc[1]	RFQc[2]	Milk	Milk	Ash	Ash
			----- per ton -----		---------- % ----------	
6427R	177	178	2900	2874	10.4	9.9
6547R	164	168	2799	2825	10.1	9.2
DKA40-21HVXRR	178	176	2715	2753	11.5	10.8
DKA40-51RR	176	188	2699	2862	11.1	10.4
DKA43-18RR	175	174	2716	2697	11.2	10.7
FF 4319.A2 RR	171	184	2851	2939	10.5	9.2
FSG 438RR	164	173	2794	2847	10.4	9.4
HVX Driver	181	206	2790	2991	11.6	11.6
INTEGRA 8444R	169	153	2849	2705	10.3	8.9
RR Saltiva	163	164	2790	2777	10.4	9.2
RR Tonnica	165	169	2804	2812	10.3	9.5
WL 372HQ.RR	163	167	2798	2812	10.4	9.3
LSD (0.05)	13	16	112	109	0.5	0.6
P-value	0.039	0.001	0.035	0.001	0.001	0.001
CV	5.2	6.6	2.8	2.7	3.2	4.1

[1] Relative forage quality (RFQc, calculated), Milk per Ton, and Ash on 21 July 2020.

[2] Relative forage quality (RFQc, calculated), Milk per Ton, and Ash on 17 Sept 2020.

2020 Briess Barley Variety Performance Evaluation

C. Eberle, Dep. Plant Sciences and James C. Hageman Sustainable Agric. Res. & Ext. Ctr.

S. George, Powell Research and Extension Center

Introduction

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

Objectives

The purpose of the trial is to evaluate the performance of new malting barley varieties against locally grown check varieties for Briess Malt and Ingredients Co. With the growing number of small or custom breweries across the United States, demand is increasing for new and unique malting ingredients including malt barley. The Bighorn Basin region's climatic conditions vary greatly as does the performance of malting barley varieties. Data on grain yield, test weight, and protein are important to local and regional producers, as some malting varieties may not perform in some areas.

Materials and Methods

The experiment was located at the Powell Research and Extension Center (PREC) during 2020. The experimental design of all trials was a randomized complete block with three replications. Barley varieties were sown on 30 March and 7.3 by 20 feet plots were established using double disk openers set at a row spacing of 7 inches. The seeding depth was 1.5 inches, and the seeding rate was 110 pounds of seed per acre. Weeds were controlled by a post application of Husky® 15 oz/ac. Measurements included height, heading date, lodging, grain yield, test weight, and kernel plumpness (lodging is the bending or kinking of stems at or near ground level causing the barley plant to fall over (0 = no lodging; 9 = 90% lodged). Subsamples, 5.3 by 15 feet, were harvested using a Zurn plot combine.

Results and Discussion

Results from 2020 are presented in Table 1. The highest yielding Briess variety in the small plot trial was 'Gemcraft' at 158 bu/ac. There was a lot of variation between plots so while yield averages ranged from 158-110 bu/a, the LSD was 29.0, so any averages within 29.0 bu/a of each other are not considered statistically different because of variation.

Acknowledgments

Appreciation is extended to the PREC staff and summer crew for their continuing support throughout the 2020 season.

Keywords

variety trials, malting, barley

Contact

Samual George, sgeorg14@uwyo.edu, (307) 754-2223

PARP I.12

Table 1. Results from 2020 small plot barley trials in Powell. Each cultivar was grown in 3 replicated plots.								
Entry	**Height (cm)**	**Lodging Score (1-9)**	**Yield (bu/a)**	**Moisture (%)**	**TWT (lbs/a)**	**Plump 6[2]**	**Plump 5**	**Thin**
Gemcraft	77	2.3	158	10.5	52.3	91%	97%	3%
Genie	66	2.3	153	11.5	53.6	94%	98%	2%
AAC Synergy[1]	76	1.3	152	10.8	53.0	95%	98%	2%
Opera	74	1.0	149	10.1	51.3	92%	97%	2%
Malz	68	1.3	147	11.2	54.2	97%	99%	1%
CDC Copeland	90	3.0	144	11.3	55.3	95%	98%	1%
Sienna	70	1.7	136	10.5	52.7	94%	98%	1%
ABI Voyager	84	2.0	132	11.9	53.8	97%	99%	1%
Barke	69	3.0	129	10.6	53.7	96%	99%	1%
Filler	56	1.0	129	11.4	51.8	91%	97%	3%
ND Genesis	85	1.0	124	11.5	53.6	95%	99%	1%
AC Metcalfe	80	1.7	120	12.3	53.9	93%	97%	3%
Bojos	78	1.0	119	11.4	54.2	97%	99%	1%
Laudis	81	1.0	115	10.2	52.7	92%	98%	2%
Synergy	70	1.0	110	10.9	52.0	95%	99%	1%
Location Mean	75	1.6	134	11.1	53.2	94%	98%	2%
LSD[3]	12.2	1.18	29.0	1.00	n/a	n/a	n/a	n/a

[1]Grey shaded varieties are regional checks for Powell, WY

[2]Plump is % above screen

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

2019 Elite Malt Barley Variety Performance Evaluation

Carrie Eberle, Dep. Plant Sciences and J.C. Hageman Sustainable Res. Ext. Ctr.

S. George, Powell Research and Extension Center

C. Reynolds, Powell Research and Extension Center

Introduction

The Wyoming Agricultural Experiment Station (WAES) at Powell conducts barley variety performance trials as part of an ongoing research program. In cooperation with the USDA-ARS Nursery and private seed companies, WAES evaluates a wide range of germplasm each year.

Objectives

The purpose of this nursery is to evaluate the performance of malting barley grown under all climatic conditions in Pacific Northwest and Northern Great Plains regions, including Wyoming. Our state's climatic conditions vary greatly as do spring barley variety performance. Data on grain yield, test weight, and protein are important to local and regional producers, as some malt varieties may not perform in some areas.

Materials and Methods

The experiment was located at the Powell Research and Extension Center (PREC) during 2020. The experimental design of all trials was a randomized complete block with three replications. Barley varieties were established on 30 March in plots 7.3 by 20 feet using double disk openers set at a row spacing of 7 inches. The seeding depth was 1.5 inches, and the seeding rate was 110 pounds of seed per acre. Weeds were controlled by a post application of Husky® 15 oz/ac. Measurements included height, heading date (data provided elsewhere), lodging, grain yield, test weight, and kernel plumpness (lodging is the bending or kinking of stems at or near ground level causing the barley plant to fall over; 0 = no lodging; 9 = 90% lodged). Subsamples, 5.3 by 15 feet, were harvested using a Zurn plot combine.

Results and Discussion

Results from 2020 are presented in Table 1. The highest yielding malting entry was '13ARS093-3' at 187 bu/ac. There was much variation between plots so while yield averages ranged from 187-146 bu/a, the LSD was 35.5, so any averages within 35.5 bu/a of each other are not considered statistically different because of variation.

Acknowledgments

Appreciation is extended to the Powell Research and Extension staff and summer crew for assistance during 2020.

Contact

Samual George, sgeorg14@uwyo.edu, (307) 754-2223

Keywords

variety trial, malting, barley;

PARP I.12

Table 1: 2020 Elite Malt Barley Trial Results from Powell REC					
	Yield	**TWT**	**Height**	**Lodging**	**Plump[1]**
Cultivar Name	bu/ac	lb/bu	cm	0/9	(6/64)
13ARS093-3	187	-	84	6.7	-
13ARS075-1	184	-	95	2.3	-
10ARS191-3	183	-	92	3.0	-
15ARS002-2	182	54	83	4.3	94%
ABI Eagle	180	55	81	1.7	96%
15ARS194-3	179	54	87	5.0	91%
GemCraft	177	53	83	4.7	91%
15ARS194-6	177	54	84	7.3	91%
14ARS147-1	177	53	91	6.7	86%
CDC Copeland	175	55	98	6.0	94%
15ARS182-1	174	53	85	3.0	89%
11ARS183-9	173	-	92	5.0	-
13ARS111-5	173	54	83	5.7	91%
M69	172	54	71	4.7	92%
13ARS105-4	171	52	85	6.0	92%
15ARS191-3	168	54	83	5.3	92%
15ARS174-5	167	53	87	4.7	93%
11ARS162-4	165	52	87	1.7	91%
15ARS175-6	165	-	83	4.0	-
Voyager	159	53	87	2.3	92%
15ARS019-5	155	53	83	6.3	92%
15ARS191-2	155	53	88	5.0	89%
Harrington	155	53	93	6.0	92%
13ARS076-5	154	-	89	1.7	-
ACMetcalfe	153	54	97	3.7	94%
15ARS020-3	152	53	91	1.7	92%
Merit57	151	54	94	3.3	91%
15ARS010-5	151	54	81	2.7	94%
13ARS115-5	148	-	77	3.0	-
13ARS095-1	146	-	75	2.7	-
Location Mean	167	54	86	4.2	92%
LSD[2]	35		8	2.9	

[1]Plump is % above screen

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

2020 Western Regional Spring Barley Nursery Variety Performance Evaluation

C. Eberle, Dep. Plant Sciences and J.C. Hageman Sustainable Agriculture Res. & Ext. Ctr.

S. George, Powell Research and Extension Center

Introduction

The Wyoming Agricultural Experiment Station (WAES) at Powell conducts barley variety performance trials as part of an ongoing research program. In cooperation with the USDA-ARS Nursery and private seed companies, WAES evaluates a wide range of germplasm each year.

Objectives

The purpose of this nursery is to evaluate the performance of malting barley grown under all climatic conditions in Pacific Northwest and Northern Great Plains regions, including Wyoming. Our state's climatic conditions vary greatly as do spring barley variety performance. Data on grain yield, test weight, and protein are important to local and regional producers, as some malt varieties may not perform in some areas.

Materials and Methods

The experiment was located at the Powell Research and Extension Center (PREC) during 2020. The experimental design of all trials was randomized complete block with three replications. Barley varieties were established on 30 March in plots 7.3 by 20 feet using double disk openers set at a row spacing of 7 inches. The seeding depth was 1.5 inches, and the seeding rate was 110 pounds of seed per acre. Weeds were controlled by a post application of Husky® 15 oz/ac. Measurements included height, heading date (not presented here), lodging, grain yield, test weight, and kernel plumpness (lodging is the bending or kinking of stems at or near ground level causing the barley plant to fall over (0 = no lodging; 9 = 90% lodged). Subsamples, 5.3 by 15 feet, were harvested using a Zurn plot combine.

Results and Discussion

Results from 2020 are presented in Table 1. The highest yielding malting entry was 'UTSB10905-72' at 166 bu/ac. There was a lot of variation between plots so while yield averages ranged from 166 to 96 bu/a, the LSD was 37.1, so any averages within 37.1 bu/a of each other are not considered statistically different because of variation.

Acknowledgments

Appreciation is extended to the Powell Research and Extension staff and summer crew for assistance during 2020.

Contact

Samual George, sgeorg14@uwyo.edu, (307) 754-2223

Keywords

variety trial, malting, barley

PARP I.12

Table 1: 2020 Western Regional Spring Barley Nursery at Powell.

	Yield	TWT	Height	Lodging	Plump[2]
Cultivar Name	**bu/ac**	**lb/bu**	**cm**	**0/9**	**(6/64)**
UTSB10905-72	166	51.1	75	1.3	96%
UTSB11301-1	164	52.4	81	1	95%
2IM15-9456	163	53.6	76	1	92%
2ND32529	162	54.3	76	1	96%
2IM14-8212	154	51.3	76	1	93%
AAC Synergy	152	53	76	1.3	95%
12WAM-120.23	150	54.2	83	2.3	94%
MT16M00209	148	51.9	77	1	97%
10ARS191-3	147	53.8	76	1	87%
CDC Copeland	144	54.5	90	3	95%
MT16M00406	144	52.8	81	1	97%
ABI Eagle	143	53.7	69	1	91%
Baronesse	143	54.7	82	2.7	94%
11WAM-107.22	143	54.8	71	1	93%
MT16M01801	142	53.3	87	1	97%
CDC Churchill	139	53.3	75	1	93%
11WAM-107.16	137	54.5	72	1	92%
11ARS183-9	136	53.2	87	2	94%
HO516-579	135	52.9	61	1	87%
HO516-536	135	54.1	75	1	90%
11ARS162-4	133	52.1	85	1	94%
ABI Voyager	132	53.5	84	2	97%
2IM15-9386	131	53.8	72	1	95%
2ND32184	129	52.7	76	1	96%
13ARS076-5	129	53.5	81	1.3	96%
AAC Connect	126	52.8	71	1	95%
ND Genesis	124	53.1	85	1	95%
MT16M01405	123	52.6	78	1	96%
AC Metcalfe[1]	119	53	80	1.7	93%
10WAN-107.8	96	59.5	76	1.3	84%
Location Mean	140	53.5	78	1.3	93.6%
LSD ($\alpha = 0.05$)[3]	37.1	1.5	10.2	0.9	

[1] Grey shaded varieties are regional checks for Powell, WY.

[2] Plump is % above screen.

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

2020 Simplot and Axis Seed Grain Corn Hybrid Trial, Powell, WY

Samual George, Research Associate, Powell Research and Extension Center

Jim Heitholt, Dept. Plant Sciences and PREC

Steven Camby Reynolds, Farm Manager, Powell Research and Extension Center (PREC)

Objective

Compare performance of different grain corn hybrids in northwest Wyoming. Results provide information regarding which hybrids are better adapted to local growing conditions.

Materials and Methods

The soil at the site was a Garland loam (OM: 1.6, pH: 8.1), and was broadcast fertilized with 100, 40, 0 units of N, P, K respectively on April 9th. Corn was planted May 6, at a rate of 38,000 seeds per acre with a Kincaid plot planter at 22" row spacing. Trial was furrow irrigated, and water was supplied according to crop needs (approximately once every 10 days). Roundup Weather Max® at 32 oz./a was applied for weed control when corn was 5 to 6 inches tall, on June 3 and 25. A 32% nitrogen solution at 30 gal/a, was applied July 27 resulting in an additional 110 units of N. Plots were 11 feet wide by 50 feet long and arranged in randomized complete block design with 3 replications. Corn plant stands were recorded 20 days after planting, by counting the number of plants present in six 10 ft. row sections from each plot. Grain yields were estimated by harvesting 10 ft. from the two center rows from each plot on 3 Nov. Grain moisture was measured from each plot using a Zurn plot combine (Harvest Master software); all reported yields were adjusted to 15.5% grain moisture, and reported bushels were based on 56 lb. / bushel. Results can be found on page two.

Results

The results are found in Table 1.

Acknowledgments

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Contact

Samual George, sgeorg14@uwyo.edu, (307) 754-2223

Keywords

kernel, maize, test weight, yield

Table 1. Yield, test weight, and moisture of 18 corn hybrids grown at PREC in 2020.

Hybrid	Grain Yield †	Test Weight A	Test Weight B ‡	Moisture
	bushels per acre	lbs/bu@ raw moisture	lbs/bu@ 15.5% moisture	%
A8728VT2PRIB[x]	176	54.0	52.6	13.3
A8737VT2PRIB[x]	197	52.2	51.2	14.0
A9137VT2PRIB[x]	151	49.0	48.3	14.3
AV6190AM[x]	153	50.9	50.2	14.3
B8548RR[x]	196	55.2	53.5	12.8
36H55RIB SS[y]	156	51.0	50.5	14.7
42P55RIB SS[y]	140	50.7	49.5	13.4
45A55RIB SS[y]	171	50.9	50.3	14.4
LSD (0.05)	48 §	1.2	1.1	0.9

† *Corrected to 15.5% moisture using 56 pounds per bushel*

‡ *Test Weight B, Corrected test weight calculated per the following equation:*
Test Weight B = [(84.5/(100-Moisture)] × TestWeightA — https://www.agry.purdue.edu/ext/corn/news/timeless/TestWeight.html

§ Yields were not significantly different among hybrids (P = 0.175); LSD provided for convenience; CV was 16.5%.

x Hybrid from Simplot

y Hybrid from Axis Seed

2020 SIMPLOT Silage Corn Hybrid Trial, Powell, WY

Samual George, Research Associate, Powell Research and Extension Center

Jim Heitholt, Crop Physiologist and Director, Powell Research and Extension Center

Camby Reynolds, Farm Manager, Powell Research and Extension Center

Objective

Compare performance of eleven different silage corn hybrids in northwest Wyoming. Results provide SIMPLOT comparative information regarding which hybrids are better adapted to local growing conditions.

Materials and Methods

The soil at the site was a Garland loam (OM: 1.6, pH: 8.1), and was broadcast fertilized with 100, 40, 0 of N, P, K, on 9 April 2020. Eleven silage corn hybrids were planted on 6 May 2020, at a rate of 38,000 seeds per acre except for hybrid 35U78RR2, which was planted at 28,000 seed per acre at the company's request. All seed was planted with a Kincaid plot planter at 22-inch row spacing using a randomized complete block design with three replicates. Plots were 11 feet wide (6 rows) by 50 feet long. The trial was furrow irrigated, and water was supplied according to crop needs (approximately once every 10 days). Roundup Weather Max® (glyphosate) at 36 oz. / a, was applied for weed control when corn was 5 to 6 inches tall on the June 3 and June 25. A 32% nitrogen solution at 30 gal/a, was applied on July 27, 2020, as additional N fertilization, which is approximately 110 units of N. Corn heights were recorded prior to harvest. Silage yields were determined by harvesting two rows, 10-feet long in the center of each plot on the 14 Sept 2020. The (fresh) harvested biomass was weighed, and a sub-sample of approximately one pound was collected from each plot and sent for quality analysis (Univ. Wisc). Sample moisture ranged from 53 to 72% (i.e., 47 to 28% dry matter). Specifically, protein was measured via near-infrared spectroscopy; net energy, milk yield, and TDN were calculated.

Results

The eleven hybrids differed significantly in fresh biomass yield, ADF, height, milk yield, and net energy lactation 3X. Dry matter yield, moisture, and crude protein were similar (Tables 1 and 2). EstHDP, NDFD48, starch, fat, TDN, Ca, Mg, and ash differed among hybrids (Table 3 and 4).

Acknowledgments

The authors thank Brad May and Keith Schaefer for assistance.

Contact

Samual George, sgeorg14@uwyo.edu, (307) 754-2223

Keywords

forage, minerals, quality, yield

Table 1. Yield and quality of eleven silage corn hybrids grown at Powell in 2020. †

Hybrid	Yield (fresh)	Yield (dry)	Moisture	Height
	tons/a	tons/a	%	inches
35U78RR2 [x]	27.7	12.7	53.8	125
36H55RIB SS [x]	33.6	12.3	63.2	117
42P55RIB SS [x]	33.0	12.7	61.4	117
45A55RIB SS [x]	31.3	13.0	58.4	117
A8728VT2PRIB [y]	31.6	12.7	59.8	119
A8737VT2PRIB [y]	31.0	12.6	59.6	115
A9137VT2PRIB [y]	28.4	11.9	58.1	118
AV6190AM [y]	33.3	11.4	65.8	116
B8548RR [y]	28.4	17.5	39.6	111
INTSTP5191 [z]	35.9	10.1	71.9	140
IMTSP5500 SS RIB [z]	37.1	13.1	64.9	136
LSD (0.05)	5.4	6.3	18.2	6
Prob > F	0.033	0.750	0.173	0.001

† *Results were subjected to ANOVA with sources of variation being Block (2 df), Hybrid (10 df), and error (20 df).*

x Axis Seed

y Simplot

z Wilbur-Ellis

Table 2. Quality of eleven silage corn hybrids grown at Powell in 2020. †

Hybrid	Crude Protein	ADF	Milk Yield	Net Energy Lactation3x
	%	%	lbs per ton	Mcal per pound
35U78RR2 [x]	7.78	21.8	2596	0.60
36H55RIB SS [x]	7.03	23.0	2981	0.66
42P55RIB SS [x]	6.99	23.7	2654	0.61
45A55RIB SS [x]	7.10	21.2	2828	0.63
A8728VT2PRIB [y]	7.38	23.9	2759	0.62
A8737VT2PRIB [y]	7.15	21.4	2970	0.66
A9137VT2PRIB [y]	7.23	19.1	3073	0.67
AV6190AM [y]	6.70	24.4	2882	0.64
B8548RR [y]	7.12	23.0	2888	0.65
INTSTP5191 [z]	6.51	31.1	2247	0.54
IMTSP5500 SS RIB [z]	7.19	29.3	2604	0.60
LSD (0.05)	0.87	3.4	296	0.04
Prob > F	0.371	0.001	0.001	0.001

† *Results were subjected to ANOVA with sources of variation being Block (2 df), Hybrid (10 df), and error (20 df).*

x Axis Seed

y Simplot

z Wilbur-Ellis

Table 3. Effect of corn hybrid on various digestibility traits of corn silage from Powell 2020.

Hybrid	EstHDP †	NDFD48 ‡	Starch	Fat	TDN 1x
	%	%	%	%	%
35U78RR2	0.32	66.8	26.7	2.59	58.9
36H55RIB SS	0.35	65.0	27.7	2.68	64.0
42P55RIB SS	0.34	60.2	25.3	2.49	59.5
45A55RIB SS	0.30	67.4	29.4	2.61	61.8
A8728VT2PRIB	0.37	61.2	26.5	2.70	61.2
A8737VT2PRIB	0.31	66.3	31.2	2.80	63.9
A9137VT2PRIB	0.28	67.3	36.1	3.03	65.4
AV6190AM	0.35	62.1	26.1	2.49	62.8
B8548RR	0.33	65.2	28.7	2.75	62.9
INTSTP5191	0.40	56.9	12.9	1.89	54.0
OMTSP5500 SS RIB	0.39	65.2	17.9	2.19	58.9
LSD (0.05)	0.06	5.6	7.2	0.27	4.1
Prob > F	0.011	0.020	0.001	0.001	0.001

† *EstHDP indicates estimated heat damaged protein*

‡ *NDFD48 indicates digestible fraction (%NDF) at 48h.*

Table 4. Effect of corn hybrid on various mineral nutrient traits of corn silage from Powell 2020.

Hybrid	P	Ca	K	Mg	Ash
	%	%	%	%	%
35U78RR2	0.21	0.22	1.18	0.17	5.27
36H55RIB SS	0.20	0.20	1.11	0.16	6.12
42P55RIB SS	0.21	0.22	1.13	0.15	6.24
45A55RIB SS	0.20	0.20	1.05	0.16	4.94
A8728VT2PRIB	0.21	0.21	1.20	0.15	6.73
A8737VT2PRIB	0.20	0.19	1.04	0.16	5.02
A9137VT2PRIB	0.20	0.18	1.00	0.16	5.10
AV6190AM	0.20	0.20	1.00	0.17	5.71
B8548RR	0.20	0.20	1.16	0.14	5.07
INTSTP5191	0.21	0.25	1.17	0.17	6.01
OMTSP5500 SS RIB	0.21	0.23	1.25	0.16	6.01
LSD (0.05)	0.01	0.03	0.16	0.01	1.02
Prob > F	0.337	0.010	0.071	0.003	0.023

Response of Six Chickpea Cultivars to Irrigation and Phosphate Fertilization in the Bighorn Basin

Jim Heitholt, Dept Plant Sciences and PREC

Vivek Sharma, formerly, UW; now Univ. Florida

Carrie Eberle, formerly, UW, now USDA-ARS, Morris, MN

Introduction and Objectives

There are few data on the performance of chickpea varieties under different management practices in the Bighorn Basin. Our lack of knowledge is especially conspicuous with regard to an optimal watering regime for chickpea. Thus, our objective was to conduct a trial to establish baseline responses for chickpea production in our region.

Materials and Methods

The study consisted of six half-acre sections, two for each of three different irrigation treatments that was delivered via a lateral overhead sprinkler system. The preplant soil test indicated that available P was 8 ppm and 145 pounds of P_2O_5 was the recommended value. Soil NH_4^+-N was 4 ppm and soil NO_3-N was 16 ppm. Thus, within each of the six sections, P was added to selected strips in the field (0 to 200 pounds P_2O_5 equivalent per acre). Within each phosphate strip, six cultivars (Frontier, Leader, Marvel, Orion, Palmer, Sierra) were sown on 26 May 2020. Each seed packet included the granular inoculant Primo GX2. Each plot was six-rows wide and 15 feet long. Seeding rate was 200k per acre and a 22-inch row spacing was used. The experimental design was a "modified" split-split plot with irrigation the main treatment, phosphate fertilization rate the subplot, and cultivar the sub-subplot. Thus, there were a total of 180 plots. Multiple ecophysiological measurements were recorded for this study, but in this report, we only present the yield and canopy temperature. A frost occurred on the morning of 8 Sept and that event appeared to have a slight negative effect on seed development of the 80% and 100% irrigation treatments but not on the 60% irrigation treatment (data not shown). Yield was collected by harvesting three of the center rows with a research plot combine.

Results

An analysis of variance on yield indicated that there were several treatment interactions that affected yield (details of those interactions are discussed only briefly in this report). Averaged across P rates and cultivars, yields were 2,440 pound per acre for the 60%, 2,781 pounds for the 80%, and 2,502 pounds for the 100% irrigation. A significant irrigation-by-P fertilizer rate interaction was detected, possibly explained by the high P rates reducing yield in the 60% irrigation treatment (Table 1). There was also a significant irrigation-by-cultivar interaction which can be explained by Frontier performing well under deficit irrigation and Palmer performing well under the 80% and 100% irrigation regimes (Table 2). Canopy temperature was recorded on six dates during mid-season and the severe stress treatment was substantially warmer for the final five samplings (data not shown). Averaged across P-rates and cultivars, the 60% irrigation plots matured in 81 days after planting (dap) whereas the 80% and 100% irrigation plots matured at 97 and 103 dap, respectively.

Discussion

This is one of the first reports of chickpea trials in the Bighorn Basin with varying management practices. One take-home lesson, albeit anecdotal and no surprise to chickpea growers across the northwestern US, is that chickpea appears to be more drought tolerant than our other crop species grown in the Basin. Although it is just one year of

data, the cultivars Frontier and Orion appear to be the best adapted as far as yield. The effect of P fertilization is unclear based on the 2020 data.

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Contact

Jim Heitholt, jim.heitholt@uwyo.edu

Table 1. Effect of irrigation rate and P fertility rate on the yield of chickpea grown in Powell in 2020. Data are averaged across six cultivars. The Irrigation Rate-by-P fertilization rate interaction was significant (*P* = 0.031).

	Irrigation Rate			
P Rate	**60% ET**	**80% ET**	**100% ET**	**Average**
	---------- lbs per acre ----------			
0	2659	2501	2602	2587
40	2628	2512	2738	2623
80	2716	2995	2577	2763
120	2134	3010	1971	2372
160	2165	2403	2967	2512
200	2319	3269	2172	2587
Average	2437	2782	2504	2574
LSD (0.05)	---------- 574 ----------			332

Table 2. Effect of irrigation rate and cultivar on yield of chickpea grown in Wyoming in 2020. The Irrigation Rate-by-Cultivar interaction was significant (*P* = 0.001).

	Irrigation Rate			
Cultivar	**60% ET**	**80% ET**	**100% ET**	**Average**
	---------- lbs per acre ----------			
Frontier	3074	3156	2136	2789
Leader	2040	2821	2188	2350
Marvel	2131	2042	1760	1978
Orion	2840	3441	3337	3206
Palmer	2463	2949	2959	2790
Sierra	2073	2280	2647	2333
Average	2437	2781	2504	2574
LSD (0.05)	---------- 321 ----------			193

2020 Dry Bean Performance Evaluation

Mike Moore, Wyoming Seed Certification Service

Kyle Webber, Wyoming Seed Certification Service

Jim Heitholt, Dep Plant Sciences and Powell Research and Extension Center (PREC)

Camby Reynolds, PREC

Introduction

In 2017, Wyoming ranked tenth nationally in dry bean (*Phaseolus vulgaris* L.) production, and fifth in the production of pinto beans. In the same year, Wyoming growers produced 933,000 hundred-weight of pinto beans on 39,000 harvested acres, averaging 23.9 hundred-weight per acre. The University of Wyoming Seed Certification Service coordinates the dry bean variety performance evaluation at the Powell location in a continuous and on-going program. In cooperation with the National Cooperative Dry Bean Nursery, and with funding from the Wyoming Bean Commission, a wide range of germplasm is evaluated each year, assisting producers in selecting varieties best suited for Wyoming soils and climate. Please note that this report represents only the Powell CDBN. The Lingle CDBN was not conducted in 2020.

Materials and Methods

The experiment was located at the University of Wyoming Research and Extension Center in Powell, Wyoming. The soil, a Garland clay loam, (fine, mixed, mesic: Typic Haplarid), was prepared by roller harrow and leveled in the spring. Chemical weed control consisted of a preplant incorporated chemical treatment of 2 pints of Sonalan and 1 pint of Outlook applied on April 29, and 32 ounces of Roundup on May 26. The plots received 45 units of N, 135 units of P, 40 units of K, and 40 units of sulfate per acre on April 29. The plots were planted on May 21 in three-row plots that were 5.5 feet wide by 20 feet long. IH 185 planter units with cone attachments were used, set on 22-inch row spacing. The experimental design was a randomized block with 29 genotypes and 4 replications. Cultivation occurred during the growing season when appropriate. Furrow irrigation was applied on June 10, June 24, July 8, July 22, and August 5, and August 17. Visual estimates for days to 50 percent bloom (50 percent of plants at second bloom) and days to maturity (50 percent of the plants with one buckskin pod) were made. Subplots of one row by 10 feet were pulled by hand, and those plants were threshed with an Almaco stationary plot thresher. The seed was hand-picked to remove dirt clods and seed mixtures. Samples were then weighed for clean seed yield per plot and seeds per pound.

Results and Discussion

Stand establishment was good, with excellent soil and weather conditions. The growing season had no days over 100 degrees but was consistently in the mid to upper 90s, with warm nights, potentially impacting pod length and fill. Flowering, maturity, seed size, and yield data are presented in Table 1 on page 2.

Acknowledgments

This nursery was possible only with significant assistance of the Powell R & E Center assistant farm managers Brad May and Keith Schaefer. The authors also thank the Wyoming Bean Commission for financial support and USDA-NIFA multistate project WYO-624-21.

Table 1. Market class, flowering date, maturity date, seeds per pound, and yield of 29 dry bean genotypes grown at PREC during the summer of 2020.

Name	Market Class	Bloom Days after Planting	Buckskin Days after Planting	Seeds per Pound	Yield lbs/A
AAC Knight Rider	Black	53	84	2409	1728
ND Twilight	Black	52	73	2305	1986
Eclipse	Black	52	77	2265	2009
NE14-18-4	Black	52	75	1978	1632
AC Portage	Navy	50	74	2189	1352
GN16-7-3	GN	52	76	1330	1985
ND Pegasus	GN	52	79	1276	2555
NE1-17-36	GN	51	75	1195	1714
NE1-17-19 GN	GN	52	77	1235	2344
PK16-1	Pink	51	73	1507	2703
SR16-2	SR	51	76	1619	2029
NE2-17-37	Pinto	49	74	1386	1416
NE4-17-6	Pinto	49	74	1177	2234
NE4-17-10	Pinto	50	74	1239	1449
PT16-9	Pinto	53	79	1291	1933
PT11-13-1	Pinto	53	77	1191	2052
PT11-13-31	Pinto	53	78	1107	2777
ND Falcon	Pinto	54	81	1305	2053
ND Palomino	Pinto	50	75	1199	1958
La Paz	Pinto	54	78	1222	2039
Othello	Pinto	48	70	1415	2402
ND Whitetail	WK	52	85	1097	1280
AAC Scotty	CB	49	75	1035	1646
Cal Early	LRK	48	74	1024	1777
Cowboy	Pinto	52	76	1145	2005
Monterrey	Pinto	52	76	1289	2342
Torreon	Pinto	52	74	1213	1950
Claim Jumper	Yellow	52	85	1091	1040
CSU pinto line	Pinto	50	75	1152	2021
	Mean	51	76	1410	1945
	LSD	2	2	125	852
	CV	2	2	6	31

SR - Small Red. GN - Great Northern. LRK - Light Red Kidney. CB - Cranberry. WK - White Kidney.

Contact

Mike Moore, mdmoore@uwyo.edu

Keywords

cultivar, legume, market class, maturity, pinto, variety, yield

PARP Goal 2

Effect of N and P Fertilization on Yield of Ten Dry Bean Genotypes at Powell – 2020

Jim Heitholt, Dept. Plant Sciences and Powell Research and Extension Center

Austen Samet-Brown, PREC

Samual George, PREC

Introduction

This study is part of a broader project where we are trying to identify and/or develop superior varieties for Wyoming that use less fertilizer. Thus, we are testing popular varieties along with experimental lines that we developed. Our PREC breeding program has been funded separately by the Wyoming Department of Agriculture but that project and this particular Wyoming Bean Commission project have shared objectives.

Materials and Methods

The study was designed using randomized complete split plots with N/P fertility as the main plot(s) and cultivar as the subplot at the Powell REC in 2020. In May, twelve 11-foot wide strips were established in the field and N rate and P rate were varied. N was applied at either 0 or 50 pounds of N per acre as urea and P_2O_5 was applied at either 0, 67, or 135 pounds per acre as triple superphosphate. There were two randomly-located strips for each unique combination of N-P fertilizer. Within those strips, early- and late-maturing cultivars were sown on 27/28 May (one block each day) in six-row plots using 22-inch row spacing (11-foot-wide plots). Flowering, maturity, NDVI/NDRE (normalized difference vegetation index), were recorded throughout the season. NDVI provides a gauge on canopy greenness and health (higher values are healthier). Leaf blade samples collected on 22 July 2020 and soil samples were collected on 31 July 2020 for mineral analysis. Height, upright stature, yield, and seed size were determined at maturity. Results of NDVI and leaf/soil analysis are not presented in this bulletin.

Results

Yields were down somewhat compared to previous years due to the hot summer in 2020 (Table 1). Some of our UW experimental lines competed successfully with several of the commercial checks. In the previous year's (2019) study, La Paz outyielded all other lines but that was not the case in 2020. As far as numerical ranking for yield in 2020, the experimental line LPID-3 ranked first in yield followed by PT9-5-6 (a pinto line bred USDA-ARS, Prosser, WA) as second and Windbreaker third. Other traits such as flower/maturity date, seed size, upright stature/height differed among entries as expected. As for the effects of the N and P fertilizer rates on yield, none were found (Table 2). Additionally, no genotype-by-fertilizer interactions were found to affect yield.

Discussion

Although one of our breeding lines shows promise (LPID-3), one of its problems is its poor upright stature rating (i.e, it lodges and tends to be prostrate). We are uncertain whether this a fatal trait as far as LPID-3 being a germplasm release. Poncho is a successful variety, and it has a poor upright rating (very prostrate). LPID-3 appears to be relatively early maturity and that would be a good trait for Wyoming (in most years). The good performance of PT9-5-6 is not a new observation here in the Bighorn Basin and we hope to include PT9-5-6 in future tests going forward. The lack of genotype-by-fertilizer interaction is a common theme that we have observed for several years. The other take-home message that we have often seen in recent years is that dry bean yield is not responding to

fertilizer N. Obviously, dry bean is an N_2-fixing legume and our related observations (not shown here) indicate that N_2 fixation or soil N mineralization during the growing season, not subsoil N or N in the irrigation water, is supplying adequate N. There has been no observed penalty for the addition of N (as least within the ranges we have tested) and thus, growers choosing to apply N fertilization are not risking a yield loss.

Table 1. Yield, seed size, flowering date, maturity date, upright stature (0=prostrate; 10=fully upright), and height of three LPID lines developed by this project as compared to one of the parental lines (Long's Peak), two public lines, and five commercial check cultivar of the screening trial grown in Powell during 2020. All entries were subjected to two levels of N fertilizer (0 and 50 lbs per acre) and three levels of P fertilizer (0, 67, and 135 pounds of P_2O_5 per acre). Values are averaged across N/P rates (i.e., n=12 distinct plots. The effect of fertilizer treatment was detected only for seed size (NRate-by-PRate interaction, P = 0.003; The high N Rate and Med P rate had seed size 5% greater than the other five treatment combinations).

Entry	Yield	Seed Size	Flower Date	Maturity Date	Upright Stature	Height
	lbs per acre	mg	dap	dap		cm
La Paz	2532	317	55	90	9	76
Long's Peak	2336	328	54	89	9	68
LPID-3	2889	385	47	85	6	67
LPID-7	2401	229	49	85	7	71
LPID-9	2766	372	50	92	5	85
Poncho	2580	351	46	81	3	82
PT11-13-1	2338	332	53	90	9	66
PT9-5-6	2772	311	52	92	8	72
Sundance	2446	331	48	88	8	67
Windbreaker	2764	363	52	91	6	63
LSD (0.05)	271	15	2	3	1	6

Table 2. Effect of two fertilizer-N rates and three fertilizer-P on yield of dry bean of the ten-entry trial grown in Powell during 2020. Source of N was urea. Source of P was 40-rock. Values are averaged across 10 entries. No differences were found. P-values associated with yield for the following sources of variation were: NRate (0.485), PRate (0.923), NRate-by-PRate (0.800), NRate-by-Genotype (0.689), PRate-by-Genotype (0.891), and NRate-by-PRateGenotype (0.134).

Fertilizer N Rate (lb N/a)	Fertilizer P Rate (lb P_2O_5/a)		
	0	67	135
	---------- Yield (lbs/a) ----------		
0	2509	2441	2558
50	2671	2654	2528

Acknowledgments

The authors thank the PREC staff for technical assistance and the Wyoming Bean Commission and the Wyoming Department of Agric Specialty Crop Program for financial support. Support was also provided by USDA-NIFA multistate project WYO-624-21 and USDA Hatch Project WYO-604-19.

Contact

Jim Heitholt, jim.heitholt@uwyo.edu

Keywords

breeding, maturity, mineral nutrition, nitrate, phosphate, soil fertility

Summary of Dry Bean Planting Date Study at Powell – 2020

Jim Heitholt, Dep Plant Sciences and Powell REC

Samual George, Powell REC

Camby Reynolds, Powell, REC

Introduction and Methods

The study was designed using randomized complete split plots with planting date as the main plot and cultivar the subplot with five replicates. One planting date was late May; the other two were in June. Six cultivars were included. Seeding rate was 100K per acre and row spacing was 22-inch. Plots were six rows wide and 28 feet long. The study was furrow irrigated approximately every ten days.

On 8 Sept 2020, cold temperatures essentially terminated development of all plots (some had already matured). The cold temperature was considered a killing frost. Due to the cold snap, maturity date was difficult to assess accurately for plots that still had green pods (which turned light green in mid-Sept and remained that way for weeks, and many pods failed to produce normal seed).

Seed yield was determined by uprooting mature plants from 10-feet of the two center rows during morning hours, placing them on the ground for about four hours in the sun, and threshing with a research plot combine that afternoon. Plots that were severely frost damaged were not harvested. Flowering dates, maturity dates, and seed size data were collected but not presented here.

Results

Yields were unaffected when the 10 June planting was compared to the early 27 May planting (Table 1; Fig. 1). There was a non-significant trend for the two early-maturing cultivars (Poncho and Blackfoot) to yield higher when planted on 10 June vs. 27 May. When planting was delayed until 25 June, however, yield was cut in half across all six cultivars compared to earlier planting dates. No PD-by-cultivar interaction was detected for yield (despite appearing to be there). Seed sizes responded as expected with smaller seed harvested from the later plantings (Table 2; Fig. 2).

Summary

With this study representing only one season of data and because of the 8 Sept frost, few sweeping conclusions can be made. However, the data support the idea that if planting late in the Bighorn Basin (during mid-June), an early-maturing cultivar might be more competitive than a late-maturing cultivar. Of course, this idea is expected but this is one of the first reports documenting this observation in the Bighorn Basin with these cultivars. Smaller seed sizes found in the late-maturing cultivars for the early-June planting and for all six cultivars for the late-June planting would obviously be a market concern unless those seed are removed during the commercial seed cleaning process.

Table 1. Yield of six dry bean cultivars sown on three dates in Powell in 2020.

	Planting Date			
Cultivar	**27 May**	**10 June**	**25 June ¶**	**Mean**
	---------- lbs per acre ----------			
Blackfoot	1828	2101	1116	1682
La Paz	2207	1764 §	627	1533
Monterrey	2120	1890	1017	1676
Poncho	2518	2950	1731	2400
Sundance	1941	2005	1313	1753
Windbreaker	1615	1574	1022	1404
Mean †	2038	2047	1137	1741
LSD (0.05) ‡	---------- 536 ----------			310

† *The LSD (0.05) for comparing the means for the three planting dates was 594.*

‡ *The LSD (0.05) of 536 pertains to the planting date-by-interaction means; the 310 at the end of this row is the LSD (0.05) for cultivar means averaged across planting dates. The overall CV was 22.6%.*

§ Only 4 plots out of 5 were harvested for the La Paz 10 June planting. When not harvested, the plot was considered a missing value, not zero.

¶ Not all plots were harvested for the 25 June planting. This decision was based on visual assessment of all plots for presence/absence of normal seed in the pods in late September. Several plots had very few filled pods and thus, were not harvested. The number of plots harvested for the 25 June planting (out of a possible 5) were: Blackfoot (3); La Paz (1); Monterrey (1); Poncho (5); Sundance (5); Windbreaker (3). Unharvested plots were considered missing data, not zero.

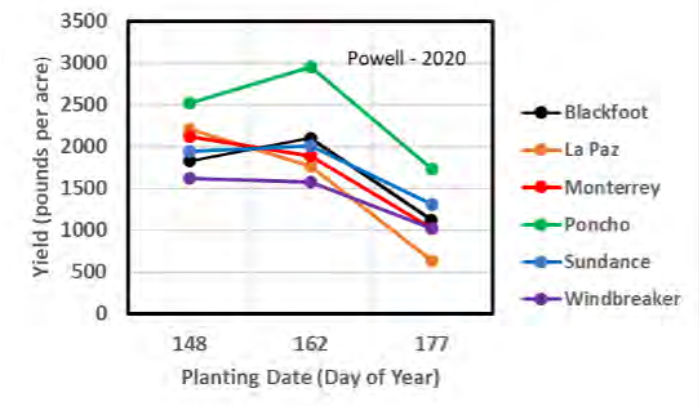

Figure 1. Yields of six dry bean cultivar in response to planting date. Day of year conversions are 27 May (148), 10 June (162), and 25 June (177).

Table 2. Seed sizes from the harvested grain for the six dry bean cultivars at three different planting dates.

	Planting Date			
Cultivar	**27 May**	**10 June**	**25 June**	**Mean**
	---------- mg ----------			
Blackfoot	333	341	281	318
La Paz	372	366	270	336
Monterrey	404	302	271	326
Poncho	382	393	333	369
Sundance	360	355	261	325
Windbreaker	426	353	271	350
Mean	379	352	281	337
LSD (0.05) †	---------- 34 ----------			20

† *LSDs (0.05) listed in this row were for the PD-by-Cult interaction (34) and the Cultivar means (20). The CV was 7.8%. The LSD (0.05) for the three planting date means (379 mg vs. 352 mg vs. 281 mg) is 17 mg indicating that all three plantings differed. The PD-by-Cultivar interaction on seed size was highly significant (P = 0.001).*

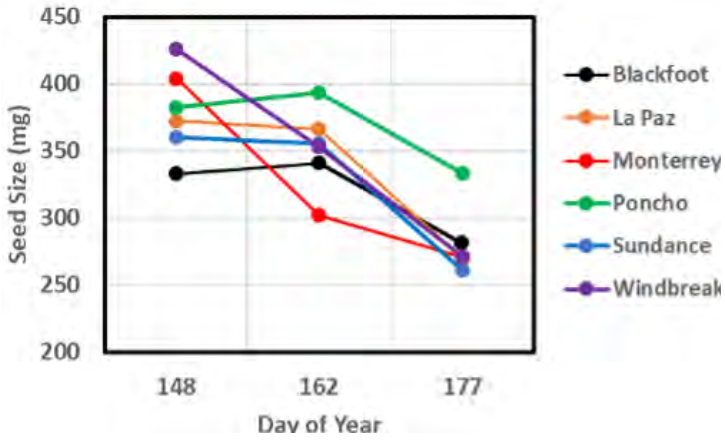

Figure 2. Effect of planting date on seed size of six dry bean cultivars.

Acknowledgment

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Contact

Jim Heitholt, jim.heitholt@uwyo.edu

Keywords

earliness, frost tolerance, maturity, podfill, seed development

PARP 1a

Summary of Dry Bean Planting Configuration Studies at Powell – 2018 to 2020

Jim Heitholt, Dept. Plant Sciences and PREC

Eric Oleson, Dept. Plant Sciences

Vivek Sharma, Univ. of Florida (formerly PREC)

Introduction

Much of the dry bean production in the Bighorn Basin uses 22-inch rows, a seeding rate of around 100,000 seed per acre, and full irrigation. Most dry bean acres in the Basin are furrow irrigated. Obviously, this planting configuration and irrigation strategy has proven successful, but questions remain as to whether alternative management practices might prove more successful. During the past few years and with the greater adoption of sprinkler irrigation, research data for other planting configurations in the Bighorn Basin has become available. Some of the findings suggest that narrower row spacings and reduced seeding rates might be more profitable. Deficit irrigation has not proven to improve profit but sprinkler irrigation has allowed producers to use water more efficiently. Planting configuration studies with cultivars varying in plant architecture are also needed. Challenges and risks accompany these alternative configurations such as susceptibility to reduced stand from disease. Harvest options for narrow rows appear to be less effective than the standard windrowing and threshing. Nevertheless, we propose that producers will benefit from having data on side-by-side comparisons of the commonly used 22-inch rows vs. alternative configurations.

Methods

In 2018 and 2019, three cultivars (Poncho, Sundance, La Paz) were grown in all combinations of the following configurations and irrigation levels (% ET = EvapoTranspiration with amount applied):

Seeding Rates	Row Spacings	Irrigation	2018 applied	2019 applied
50 K	7-inch	60% ET	10.0 inches	10.0 inches
75 K	22-inch	80% ET 10.8 inches	10.8 inches	
90 K		100% ET	11.6 inches	11.6 inches
105 K			13 events	14 events
120 K				

Yield data for 2018 and 2019 were collected and presented in text format below with Results. In 2020, the study was conducted differently with two cultivars (Blackfoot and Windbreaker), and three row spacings (7-inch, 15-inch, 22-inch). Planting occurred on 29 May 2020. There were three distinct and separate studies involved in 2020 (60 plots each); one study with 60% ET irrigation, one at 80% ET, and a third at 100% ET, all applied with sprinkler. For 2020, final plant densities ranged from 27K to 84K per acre depending on the plot. To assess yield, each plot was divided/split into two components (A&B) and plant density and area were determined for each component. Yield for Component A was determined by pulling plants and tossing them into a research plot combine. Yield of Component B was determined by direct harvest of intact plants with the same combine.

Percent loss associated with direct harvest = [(YieldA - YieldB) / YieldA] × 100.

Average seed size was determined by weighing 100 seed from all plots. A hard freeze occurred on 8 Sept 2020 which compromised the seed development of the late harvesting cultivar Windbreaker.

Results and Discussion

For the 2018-2019 studies (which were identical studies), the data presented below were averaged across years. Yield was 4220 pounds per acre for the 100% ET irrigation, 3810 pounds per acre for the 80% irrigation, and 3550 pounds per acre for the 60% irrigation. This indicated that the deficit irrigation had its intended effect. Averaged across cultivars and irrigations, and seeding rates, the 7-inch rows out yielded 22-inch rows by 3990 to 3600 pounds per acre. The narrow-row yield increase was consistent across cultivars but only for the two deficit irrigation regimes. For the 100% ET irrigation, yields of Poncho and La Paz were unaffected by row spacing. For Sundance, narrow rows increased yield by 13% (2018) and 8% (2019) under 100% ET irrigation. Averaged across all treatments, Poncho (4060 pounds per acre) outyielded Sundance (3700 pounds per acre) and La Paz (3630 pounds per acre). Yield was unaffected by seeding rate and this is an observation that we have noticed for several growing seasons now.

In the 2020 study, the narrowest row spacing (7-inch) appeared to have greater yield potential than 22-inch rows (Table 1). In all six side-by-side comparisons, the 7-inch row yield was greater than its 22-inch counterpart. The narrow-row yield advantage ranged from 5% to 64% and was greater under deficit irrigation. This 2020 narrow-row deficit-irrigation yield observation was consistent with what we observed in 2018 and 2019. Deficit irrigation reduced yield and seed size in 2020 as expected and is provided here to document that irrigation targets were indeed achieved (but not for statistically comparing between them). It is unclear why the yields of the 15-rows did not consistently fall in-between the two extreme row spacings (7-inch and 22-inch). From a visual standpoint, the 15-inch plots appeared the healthiest and most uniform of all three row spacings which reminds us that appearance does not always equate to end-of-season success. The percent yield loss due to direct harvest averaged about 24% across all plots and there was little difference between the two cultivars and among row spacings (Table 1).

Table 1. Yield, average seed size, and percent yield loss due to direct harvest (PLDH) of all 18 combinations of irrigation, cultivar, and row spacing of the dry bean study grown at Powell in 2020. Means are averaged across 8 plots where plant density varied from 27K to 84K plants per acre. Yield is averaged across the two values obtained from conventional and direct harvested components of each plot. Statistics for each irrigation rate was analyzed separately.

Irrigation	Cultivar	Row Space	Yield	Seed Size	PLDH
			lbs/acre	mg	%
100%	Blackfoot	7	2274	319	24
		15	1724	328	29
		22	1859	312	39
100%	Windbreaker	7	2215	420	27
		15	1672	411	31
		22	2115	422	12
LSD (0.05)			427	15	14
80%	Blackfoot	7	1651	307	21
		15	1307	311	19
		22	1462	301	25
80%	Windbreaker	7	1650	415	27
		15	1360	407	29
		22	1328	427	13
LSD (0.05)			260	4	13

Irrigation	Cultivar	Row Space	Yield	Seed Size	PLDH
			lbs/acre	mg	%
60%	Blackfoot	7	1307	284	19
		15	822	287	26
		22	988	284	28
60%	Windbreaker	7	1050	382	30
		15	826	362	26
		22	638	396	7
LSD (0.05)			181	19	8
Irrigation					
100%			1981	379	29
80%			1466	367	22
60%			961	334	23
Averages					
Row Space		7	1691	354	25
		15	1285	351	27
		22	1398	357	21
Cultivar		Blackfoot	1488	304	25
		Windbreaker	1428	405	22

Figure 1. Photo of the seeding rate and row spacing study in 2020. The foreground area is a buffer strip separating the different irrigation areas and is not part of the study. The middle is the 60% ET irrigation area. Behind that is another buffer strip and behind that is the 80% ET irrigation area. The picture was taken while standing in the 100% ET section.

Summary

For all three years, seeding rates and/or plant densities in the range of 50K per acre appeared to be adequate to optimize yield. However, there does not appear to be any penalty for using higher seeding rates up to 100K when

full irrigation is employed. Seeding rates of 100K may also provide "insurance" for growers for early season stands compromised by disease/frost/hail. Any yield advantage for narrow rows (7-inch) as compared to 22-inch rows appeared to be associated with deficit irrigation and/or the use of short/upright cultivars (Sundance and Blackfoot). Yield losses associated with direct harvest averaged around 23% but we did not see any differential effects for cultivar, row spacing, seeding rate, and irrigation.

Acknowledgment

The authors thank PREC staff for field plot establishment. The authors also acknowledge funding USDA-NIFA Hatch projects WYO-604-19 and WYO-624-21 as well as funding from the Wyoming Bean Commission and Wyoming Dept of Agriculture Specialty Crop Program.

Contact

Jim Heitholt, jim.heitholt@uwyo.edu

Keywords

canopy architecture, deficit irrigation, leaf area index, light interception, row spacing, seeding rate

PARP 1a

Novelty/Heirloom Dry Bean Trial – PREC

Jim Heitholt, Department of Plant Sciences and Powell Research and Extension Center

Jill Keith, Department of Family and Consumer Sciences

Introduction

In recent years, there has been an interest in dry bean types other than the standard pinto, black, and kidney market classes. Some of the other market classes of interest include the popbean types that are cooked unconventionally on a skillet with oil. Because the semi-arid climate in the Bighorn Basin allows for the potential to grow quality dry beans, we decided to launch a Novelty/Heirloom trial and include several unconventional bean types.

Objective

The primary objective was to collect agronomic data on a wide range of rarely-grown dry bean market class types in the Bighorn Basin. A secondary objective was to document popping percentage of the five popbean-types (aka nuña) lines grown in this trial.

Materials and Methods

Seed of different varieties were acquired from several vendors and collaborators at other universities. An example of one of these novel types from UC-Davis is provided in Figure 1. To generate adequate seed numbers to conduct this trial, several varieties were grown in 2019 for seed increase. The trial was sown on 29 May 2020. Plots were furrow irrigated through early September. The trial utilized a completely randomized design with at least three replicates per variety. Plots were 15 feet long, with 6 rows and a 22-inch row spacing. Seeding rate was 100K per acre. Conventional cultural practices were employed. Tolerance to iron deficiency chlorosis (TIDC) was rated visually during mid-season with fully chlorotic symptoms scoring zero and full green color scoring 10. Flowering date, maturity date, upright stature (rated visually), and main stem height were recorded prior to harvest. At maturity, ten feet of the center two rows were harvested and placed in a 50-gal paper sack and transferred to an enclosed environment. After plants air-dried for several days, yield was determined by threshing with a Haldrup LT-50 stationary unit.

Results

The weather for the 2020 growing season was hot with daytime July temperatures in the 90s (°F). The variety performance results are provided in Table 1. The three popbean types released by Colorado State Univ. (CO-49956, CO-49957, and CO-50004) surprising outyielded our commercial pinto check types. Seed from CO-50004 popped at 100%. Of the five popbean types, Wisc 19 had the lowest popping percentage at 67%. UC-Southwest Red matured earlier than Poncho, an early-maturing commercial pinto often grown in Wyoming. UC-Sunrise appeared to succumb to a disease and did not develop any seed.

Discussion

This 2020 test showed that CO-49956, C-49957, and CO-50004 popbean lines have yield potential here in the Bighorn Basin. However, their high yield ranking in 2020 may be an anomaly associated with their lateness. Our 2021 data will help support or refute that concern. The three surviving UC-Davis lines have virus resistance and earliness and have potential for use in our UW bean breeding program.

Table 1. Agronomic data from a wide range of novelty/heirloom dry bean types grown at PREC in 2020.

Entry	Market Class	Yield†	Seed Size	Flowering	Maturity	Upright‡	Height	TIDC §
		lbs/acre	mg	dap	dap		cm	
CO 49956	Nuña ††	2592	367	42	94	1.7	47	4.7
CO 49957	Nuña ††	2432	455	44	99	3.0	44	4.8
CO 50004	Nuña ††	2886	402	48	103	3.7	49	6.8
Cayenne	Small Red	2114	277	50	87	9.0	55	3.5
La Paz	Pinto	1264	339	55	87	9.3	46	4.1
Poncho	Pinto	1880	343	47	79	4.0	67	5.9
UC-SoWst Gold	Gold Cow	1402	251	48	76	8.0	32	4.7
UC-SoWst Red ¶	Red Cow	1436	245	48	73	8.3	35	4.5
UC-Tiger's Eye ¶	Gold w/ Stripe	932	383	42	74	9.0	41	7.0
UC Sunrise #	Beige Cow	-	-	66	105	7.3	52	4.3
Wisc 19	Nuña ††	1497	354	45	100	6.0	41	5.8
Wisc 21	Nuña ††	1484	350	43	101	6.7	39	3.7
Windbreaker	Pinto	1548	364	51	86	7.6	51	3.3
Yellowstone	Yellow	1994	331	47	92	7.7	39	3.7
LSD (0.05)		722	41	3	5	1.2	13	1.1

† *Grain moisture was measured on random samples and found to be 10%; no corrections or adjustments were made.*

‡ *Upright rating was assessed visually on 18 Aug 2020 and is analogous, but inversely related to, lodging with the higher value representing more upright stature and low values representing prostrate plants.*

§ *TIDC assessed visually on leaf blades (22 June); TIDC indicates Tolerance to Iron-Deficiency Chlorosis. 0 = completely chlorotic; 10 = zero chlorosis.*

¶ *UC-SoWst Gold has a formal name of UC Southwest Gold (doi: 10.1002/plr2.20117).*

¶ *UC-SoWst Red has a formal name of UC Southwest Red (doi: 10.1002/plr2.20092).*

¶ *UC-Tiger's Eye cultivar release info can be found at doi:10.1002/plr2.20084*

 # UC Sunrise appeared to die during mid-to-late season and failed to form normal pods.

†† *The five nuña lines were tested for percent popping in the Keith lab, Univ. Wyoming. Values were: CO 49956, 78%; CO49957, 93%, CO 50004, 100%; Wisc 19, 67%; Wisc 21, 87% (P = 0.069).*

Figure 1. A photo of Tiger's Eye seed originally obtained from UC-Davis.

Acknowledgement
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Contact
Jim Heitholt, jim.heitholt@uwyo.edu

PARP Goal 2

Alfalfa Yield Response to Phosphorus and Potassium in Relation to Calcium, Magnesium and Harvest Time

Michael Baidoo, Department of Plant Sciences

Anowar Islam, Department of Plant Sciences

Introduction

Alfalfa (*Medicago sativa* L.), the 'Queen of forages', is the most cultivated hay crop in Wyoming and other neighboring states. Its potential to produce high yields places the highest demand on soil nutrient, particularly phosphorus (P) and potassium (K). Studies have consistently shown that fertilizing alfalfa with a balance of P and K helps to improve alfalfa productivity. However, in an intensively managed alfalfa production system, applying fertilizer nutrient to the soil depends on the fertility status of the soil. This relates to the soil's nutrient availability and uptake. The levels of K, calcium (Ca), and magnesium (Mg) in the soil have the potential to influence P and K's availability and their uptake by plants. Furthermore, harvest time of alfalfa can influence the amount of available nutrients taken up by the plant for optimum production. With the increasing prices of fertilizers, applying the right combination rates of P and K to alfalfa in association with high Ca and Mg levels, and harvest time would be a worthwhile goal to optimize alfalfa's nutrition for sustainable production.

Objective

Determine the response of alfalfa to combinations of phosphorus and potassium in association with calcium, magnesium, and harvest time.

Materials and Methods

The study was initiated in 2019 at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) under irrigated conditions. Treatments included 10 combinations rates of three P (0, 30, and 60 pounds P_2O_5 per acre), three K (0, 150, and 300 pounds K_2O per acre), two Ca (0 and 500 pounds CaO per acre), and two Mg (0 and 50 pounds MgO per acre); and two harvest times (early harvest, late bud to early [10%] bloom; late harvest, 7 days after early harvest). Treatments were arranged in a randomized complete block design with 3 replicates, resulting in 60 plots in total. After the final land preparation, soils were sampled and analyzed to determine the initial nutrient status of the soil. Inoculated seeds of "Hi-Gest 360" alfalfa were planted at a seeding rate of 20 pounds pure live seed per acre on September 3, 2019. Nutrient combinations of P (in the form of triple superphosphate) and K (in the form of muriate of potash), and Ca (in the form of calcium oxide) and Mg (in the form of magnesium oxide) were broadcast at constant rates on the designated plots on August 23, 2019 before planting. Harvesting started in 2020 with four cuts under each harvest time at about one month intervals from June to September. Forage samples were oven dried at 140°F for at least 72 hours to determine forage yield as dry matter basis.

Results and Discussion

Initial soil test result showed that exchangeable soil K (243 ppm), Ca (3526 ppm), and Mg (328 ppm) was high. Forage yield of alfalfa was significantly ($P < 0.001$) affected by the interaction effect of nutrient combination × harvest time. Phosphorus and potassium combinations gave higher alfalfa yields such that 60 pounds P_2O_5 per acre

and 300 pounds K_2O per acre combination ($P_{60}K_{300}$) produced the highest total forage yield at early harvest, either with or without association of Ca and Mg ($Ca_{500}Mg_{50}$) (Table 1). Similarly, at late harvest, $P_{60}K_{300}$ in association of $Ca_{500}Mg_{50}$ produced the highest total forage yield (Table 1). This could be attributed to high synergistic effect produced from the interaction of high rates of P and K, which might have influenced their concentration in the soil and enhanced their availability for plant uptake at the expense of available Ca and Mg. Overall, preliminary results indicate that applying high rates of P and K to alfalfa along with the appropriate time of harvest has great potential to produce high yield response, even in soils with high levels of exchangeable K, Ca, and Mg.

Table 1. Total forage yield of alfalfa affected by phosphorus and potassium combinations in association with calcium, magnesium, and harvest time at SAREC in 2020

Treatment	Early harvest†		Late harvest‡	
(pounds per acre)	(Tons per acre)	Yield increase (%)§	(Tons per acre)	Yield increase (%)§
P_0K_0	3.7c¶	-	4.1d	-
$P_{30}K_{150}$	5.4ab	46	5.6bc	37
$P_{30}K_{300}$	4.9b	32	5.8bc	41
$P_{60}K_{150}$	5.4ab	46	5.3cd	29
$P_{60}K_{300}$	6.0a	62	6.0b	46
$P_0K_0Ca_{500}Mg_{50}$	3.9c	5	4.4d	7
$P_{30}K_{150}Ca_{500}Mg_{50}$	5.0b	35	4.3d	5
$P_{30}K_{300}Ca_{500}Mg_{50}$	4.9b	32	6.2b	51
$P_{60}K_{150}Ca_{500}Mg_{50}$	5.6ab	51	5.2cd	27
$P_{60}K_{300}Ca_{500}Mg_{50}$	5.7a	54	7.4a	80
Average	5.1	40	5.4	36

† *Early harvest, Late bud to early [10%] bloom stage;* ‡ *Late harvest, 7 days after early harvest.*

§ *Percent yield increase over the control.*

¶ *Means followed by the same lowercase letter within each column are not significantly different at P > 0.05.*

Total forage yield for each treatment is the cumulative value across all four cuts in 2020.

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Contact

Michael Baidoo, mbaidoo@uwyo.edu

Anowar Islam, mislam@uwyo.edu, (307) 766-4151

Keywords

alfalfa, potassium, phosphorus, calcium, magnesium, harvest time, forage yield

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

Potassium and Harvest Time Effect on Forage Production of Old Alfalfa Stands

Michael Baidoo, Department of Plant Sciences

Anowar Islam, Department of Plant Sciences

Introduction

The perennial nature of alfalfa (*Medicago sativa* L.) allows for a long-term cultivation of the plant. However, continual production of alfalfa leads to significant decline of the stand's density due to impact of stresses associated with plant water status, winter injury, poor fertility, harvesting, weeds, diseases, and other factors. Eventually, the stand becomes sparse and cannot maintain satisfactory yields to remain profitable. When the root system is disease-free, weeds can be managed, and in the absence of cellular water deficit, improving productivity of older stands of alfalfa could be possible with appropriate management practices (e.g., fertilizer application). Alfalfa requires potassium (K) in the largest amount for superior growth. As a result, replenishment of K in old stands of alfalfa is necessary to restore soil K levels for improved productivity. Time of harvest, on the other hand, is crucial to alfalfa's productivity due to yield-quality trade-off characteristic of the crop. Therefore, integrating K application with time of harvest cannot only produce an optimized effect of K to impact the plant's growth but also improve its productivity.

Objective

To determine the interaction effect of K and harvest time on productivity of old stands of alfalfa.

Materials and Methods

The experiment was initiated at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) in 2019 using an old stand of alfalfa (over 13 years old). Treatments included (a) six K rates: 0, 50, 100, 150, 200, and 250 pounds K_2O per acre; and (b) two harvest times: early harvest (late bud to early [10%] bloom); and late harvest [7 days after early harvest]). The study was organized in a 6 × 2 randomized complete block design with four replications resulting in a total of 48 plots. Each plot measured 20 ft × 5 ft in size. Upon selection of the alfalfa stand, soils were sampled and analyzed to determine the initial nutrient status. Potassium, in the form of muriate of potash, was broadcast at constant rates on designated plots on October 26, 2019. Plant harvesting started in 2020 and four cuts were made under each harvest time at about one-month intervals from June to September. Forage samples were oven dried at 140°F for at least 72 hours to determine forage yield as dry matter basis. Relative water content (RWC) was determined from the plant leaves using the formula below:

$$RWC = [(\text{fresh weight} - \text{dry weight})/(\text{saturated weight} - \text{dry weight})] \times 100$$

Results and Discussion

Potassium × harvest time × number of cuts interaction had a significant ($P < 0.001$) effect on forage yield. When forage yield from all four cuts in 2020 were pooled across both harvest times (early and late), 200 and 150 pounds K_2O per acre produced highest total forage yield at early harvest and late harvest, respectively (Table 1). This indicates that for an improved yield response, high and moderate rates of K are needed by older stands of alfalfa when harvested early and late, respectively. Variations in maturity stages at which the plants were harvested might

have influenced the level of K rates required for improved forage production of old stands of alfalfa. On average, total forage yield produced under early harvest and late harvest were comparable (Table 1).

Table 1. Forage yield of old alfalfa stand affected by potassium and harvest time at different cutting frequency at SAREC in 2020.

Potassium rate	Early harvest†					Late harvest‡				
	1§	2	3	4	Total	1	2	3	4	Total
	pounds per acre									
0	1454b¶	1427b	1066b	1209c	5157c	1396bc	1169c	1080b	1624a	5268d
50	1575b	2132a	803b	1463b	5973b	1392bc	1700ab	1227b	1686a	6004c
100	1655ab	1709b	1343a	1419bc	6125b	2007a	1227c	1124b	1289b	5647cd
150	1985a	1543b	745b	1494b	5768b	2034a	1896a	2498a	1280b	7708a
200	1552b	2123a	1535a	1918a	7129a	1276c	1512bc	2324a	150ab	6620b
250	1445b	2485a	1530a	1530b	6990a	1526b	1628ab	1307b	1552a	6013c
Average	1611	1903	1171	1506	6190	1605	1522	1593	1490	6210

† Early harvest, Late bud to early [10%] bloom stage;

‡Late harvest, 7 days after early harvest.

§ Cutting frequency, 1, Harvest one; 2, Harvest two; 3, Harvest three, 4, Harvest four; Total, Harvest one + Harvest two + Harvest three + Harvest four.

¶ Means followed by the same lowercase letter within each column are not significantly different at P > 0.05.

A quadratic response was observed when forage yield from all 4 cuts was regressed to relative water content of alfalfa (Figure 1). This suggests that the cellular water status is critical for older alfalfa stands and plant water content has direct influence on alfalfa's forage production potential. Overall, preliminary finding of the study shows that production of aging stands of alfalfa can be enhanced with appropriate rates of K based on harvest time.

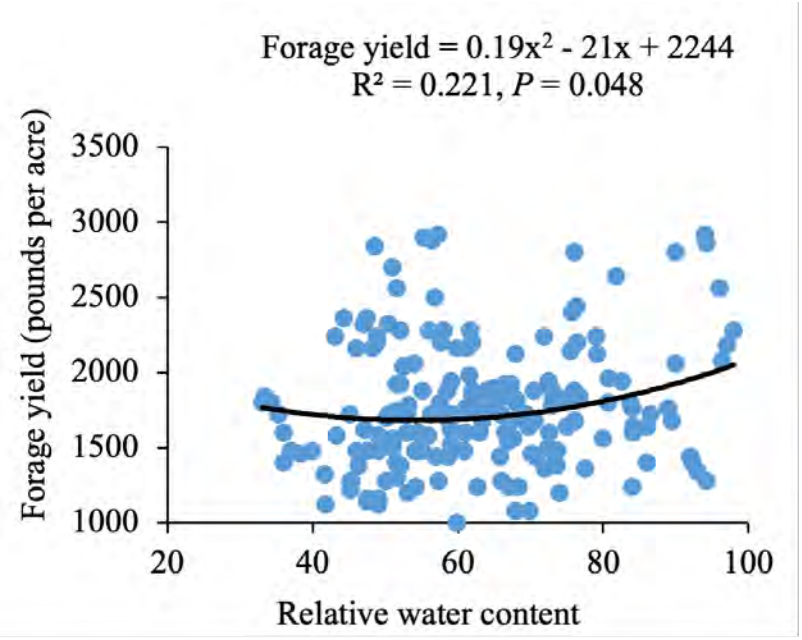

Figure 1. Relationship between forage yield and relative water content of old alfalfa stand at SAREC in 2020.

Acknowledgments
We thank SAREC crew and UW forage agronomy laboratory members for study assistance. The project was funded by USDA NIFA Alfalfa and Forage Research Program and University of Wyoming's Department of Plant Sciences.

Contact
Michael Baidoo, mbaidoo@uwyo.edu

Anowar Islam, mislam@uwyo.edu, (307) 766-4151

Keywords
old alfalfa stand, potassium fertilization, harvest time, forage production.

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

Agronomic Performance of Barricade Grass Mixtures under Wyoming Conditions

Anowar Islam, Department of Plant Sciences

Michael Baidoo Department of Plant Sciences

Chandan Shilpakar Department of Plant Sciences

Mohammed Munkaila Department of Plant Sciences

Introduction

Forage grasses are the major group (75%) of forage crops and produce large volumes of palatable and nutritious feed for livestock. Grass forages are easier to establish and tend to be more dependable and persistent than other forage crops. Barricade grass mixture, a recently released grass cultivar mix, contains the latest forage grass traits including germination, establishment, and growth under low rainfall conditions and are comparable to existing grass cultivars of high yielding traits. Barricade is ideal for interseeding into rangeland, particularly in arid and semi-arid areas, and could be suitable for forage production in Wyoming environments. Currently, there is little to no information available on the adaptability and performance of Barricade in Wyoming and surrounding areas. It is, therefore, important to identify cultivars and/or cultivar mixtures of improved grasses to help improve grass hay production in the region.

Objective

To evaluate the forage production potential of Barricade grass mixture under irrigated and dryland conditions in Wyoming.

Materials and Methods

The study was initiated at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) in 2019. Treatments were (a) two mixtures of Barricade grass: Barricade mixture (raw seeds); Barricade with 1:1 yellow jacket mixture (coated seeds); and (b) tall fescue "Fawn" (control). These were arranged in a randomized complete block design with three replications under both irrigated and dryland conditions, resulting in a total of 9 plots under each condition. Individual plot was 20 ft × 20 ft in size. Separate plots in nearby areas with similar soil properties were selected for both irrigated and dryland trials. After the final land preparation, soils were sampled and analyzed to determine the initial nutrient status. All limiting soil nutrients were managed for adequacy. Planting was done on June 5, 2019, under both irrigated and dryland conditions. Seeds of Barricade grass (raw seeds) and tall fescue Fawn were planted at 15 pounds of pure live seeds per acre seeding rate whereas, Barricade grass (coated seeds) was planted at a seeding rate of 25 pounds pure live seeds per acre. Harvesting started in 2020 and three cuts were made at about 30- to 45-day intervals (depending on plant growth). Forage samples were oven dried at 140°F for at least 72 hours to determine forage yield as dry matter basis. Forage nutritive value was determined by using Near Infrared Reflectance Spectroscopy.

Results and Discussion

Total forage dry matter (DM) yield differed ($P < 0.05$) among the mixtures under both irrigated and dryland conditions (Table 1). Coated seeds produced the highest DM yield (6423 pounds per acre) and tall fescue produced the lowest DM yield (5710 pounds per acre) under irrigated conditions. Lower forage yield was obtained in dryland conditions than irrigated especially because of single harvest, however the trend was similar (Table 1). This is attributable to the genetics of the cultivars in the mixtures and the impact of their novel traits on forage production.

Table 1. Forage yield of barricade grass mixtures and tall fescue under irrigated and dryland conditions at SAREC in 2020.

Species†	Irrigated				Dryland‡
	1§	2	3	Total	Total
	---------- pounds per acre ----------				
Tall fescue 'Fawn'	2944 b¶	1249 a	1517 a	5710 b	1427 b
BM (raw seeds)	3301 b	1427 a	1249 a	5977 b	1784 b
BM (coated seeds)	3836 a	1249 a	1338 a	6423 a	2409 a
Average	3360	1308	1368	6037	1873

†*BM (raw seeds): Barricade mixture; BM (coated seeds), Barricade w/1:1 yellow jacket mixture.*

‡*The regrowth of Barricade mixtures was low at harvests 2 and 3 under dryland condition.*

§*Harvest frequency; 1, Harvest one; 2, Harvest two; 3, Harvest three; Total; Harvest one + Harvest two + Harvest three.*

¶*Within column, means followed by the same lowercase letter are not significantly different (P > 0.05).*

Except for neutral detergent fiber and relative feed value under dryland conditions, the mixtures generally did not affect ($P > 0.05$) nutritive value under either irrigation (Tables 2 & 3). In general, compared to tall fescue, Barricade grass mixtures produced low nutritive value under dryland conditions and a numerically higher nutritive value under irrigated conditions (Tables 2 & 3). Overall, findings of the study indicate that Barricade grass mixtures, particularly coated seed mixture, has potential for higher agronomic performance in semi-arid regions including Wyoming, and its ability to adapt, persist, and perform well under dryland conditions is promising.

Table 2. Nutritive value of barricade grass mixtures and tall fescue under irrigated conditions at SAREC in 2020.

Species†	Irrigated					
	CP	NDF	ADF	TDN	IVDMD	RFV
	%					
Tall fescue 'Fawn'	15a‡	54a	36a	62a	72a	106a
BM (raw seeds)	16a	56a	38a	60a	73a	98a
BM (coated seeds)	16a	56a	38a	60a	73a	100a
Average	16	56	38	61	72	101

†*BM (raw seeds), Barricade mixture; BM (coated seeds), Barricade w/1:1 yellow jacket mixture.*

‡ *Within column, means followed by the same lowercase letter are not significantly different.*

CP, Crude protein; NDF, Neutral detergent fiber; ADF, Acid detergent fiber; TDN, Total digestible nutrient; IVDMD, in vitro dry matter digestibility; RFV, Relative feed value. Nutritive value under irrigated and dryland conditions were averaged over three harvests and one harvest, respectively.

Table 3. Nutritive value of barricade grass mixtures and tall fescue under dryland conditions at SAREC in 2020.

Species†	Dryland					
	CP	NDF	ADF	TDN	IVDMD	RFV
Tall fescue 'Fawn'	16a	49b	33a	66a	73a	121a
BM (raw seeds)	16a	53a	34a	65a	72a	109b
BM (coated seeds)	15a	56a	35a	63a	72a	103b
Average	16	53	34	65	72	111

†BM (raw seeds), Barricade mixture; BM (coated seeds), Barricade w/1:1 yellow jacket mixture.

‡ Within column, means followed by the same lowercase letter are not significantly different.

CP, Crude protein; NDF, Neutral detergent fiber; ADF, Acid detergent fiber; TDN, Total digestible nutrient; IVDMD, in vitro dry matter digestibility; RFV, Relative feed value. Nutritive value under irrigated and dryland conditions were averaged over three harvests and one harvest, respectively.

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Contact

Anowar Islam, mislam@uwyo.edu, (307) 766-4151

Keywords

barricade grass mixture, forage yields, nutritive value, irrigated condition, dryland condition.

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

Productivity of Alfalfa-Grass Mixtures

Mohammed Munkaila, Department of Plant Sciences

Anowar Islam, Department of Plant Sciences

Introduction

Alfalfa is the most important forage crop in the USA. Often alfalfa is called the "Queen of forages" due to its superior yield and nutritive value. Furthermore, alfalfa is an important component of livestock rations. However, since the early 1990s, yield of alfalfa has stagnated around 3.3 tons per acre. Combining alfalfa with perennial grasses has been mooted as one of the strategies to increase forage yield. Studies have shown that alfalfa-grass mixtures provide higher forage yield compared to monoculture alfalfa. Unfortunately, limited information is available on the most appropriate grass species to combine with alfalfa, the ratio of the mixtures, and the planting configuration.

Objectives

Determine the effect of planting ratio and configuration of grass species with alfalfa for improved productivity.

Materials and Methods

The study is being conducted at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) under irrigation. Treatments included alfalfa monoculture, alfalfa-grass in 75:25 ratio, alfalfa-grass in 50:50 ratio, and alfalfagrass (50:50) in alternate rows. The grass species were orchardgrass ("Pawnee"), tall fescue ("FSG 402TF"), and meadow bromegrass ("Cache"). The experiment was laid out in a randomized complete block design with four replicates. Seeding was done on August 19, 2020. The recommended seeding rates (based on pure live seed) were 20 pounds per acre for alfalfa, 10 pounds per acre for orchardgrass, and 15 pounds per acre for both tall fescue and meadow brome grasses. Mixture ratios were based on the seeding rates of the monoculture. Harvesting started in 2021 and three cuts were made in a monthly interval from June to August. Forage samples were oven dried for 72 hours at 140°F to determine forage yield on dry matter basis.

Results and Discussion

Preliminary results showed that there were significant ($P < 0.001$) differences among the treatments for total forage yield. Alfalfa monoculture (100ALF) produced the highest total forage yield (8553 pounds per acre) over four harvests (Table 1) while alfalfa-tall fescue in alternate rows produced the lowest total forage yield (6697 pounds per acre) over the same period. Forage yield generally decreased from first harvest to fourth harvest. Except for 50:50 and alternate rows of alfalfa and tall fescue mixtures, monoculture alfalfa did not produce significantly higher yield than mixtures, indicating that alfalfa-grass mixtures have potential for not only high productivity but also forage quality. These traits and trend can be confirmed by continuing this study for at least two more years.

Table 1. Forage yield from four harvests in June, July, August and September of 2021 at SAREC.

Treatment	Forage yield (pounds per acre)				
	H1‡	H2	H3	H4	Total
100ALF†	3094 a A	3069 a A	1272 a B	1118 a B	8553 a
75A+25OG	2859 a A	2813 ab A	1325 a B	1207 a B	8204 ab
75A+25TF	2747 a A	2390 bcd A	1606 a B	1102 a C	7845 abc
75A+25MB	3004 a A	2336 bcd B	1340 a C	1072 a C	7752 abc
50A+50OG	2968 a A	2730 abc A	1378 a B	1062 a B	8138 ab
50A+50TF	2793 a A	2043 d B	1280 a C	1008 a C	7123 bc
50A+50MB	2667 a A	2488 bcd A	1303 a B	937 a B	7394 abc
50A+50OG_AR	2830 a A	2397 bcd A	1292 a B	1029 a B	7548 abc
50A+50TF_AR	2725 a A	1954 d B	1074 a C	946 a C	6697 c
50A+50MB_AR	2846 a A	2235 cd B	1544 a C	858 a D	7483 abc
Average	2853	2446	1341	1034	7674

†*ALF, alfalfa; TF, tall fescue; OG, orchardgrass; MB, meadow bromegrass; AR, alternate row planting.*

‡*H1=Harvest one, H2=Harvest two, H3=Harvest three, H4=Harvest four.*

Within columns, means followed by the same lowercase letters are not different at α= 0.05; within rows, means followed by the same uppercase letters are not different at α=0.05.

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Contact

Mohammed Munkaila, mmunkail@uwyo.edu

Anowar Islam, mislam@uwyo.edu, (307) 766-4151

Keywords

alfalfa-grass mixtures, perennial grasses, forage yield potential

PARP I:1,2, IX:2

Dynamics of Soil Carbon in Forage Legume Fields under Irrigated and Rainfed Conditions

Chandan Shilpakar, Department of Plant Sciences

Anowar Islam, Department of Plant Sciences

Introduction

Approximately 60 million acres of agricultural field received irrigation as the primary source of soil moisture in the US in 2017 which 6 million acres were hay and alfalfa field. Soil moisture influences various nutrient cycling processes in agroecosystems which has a direct impact on soil carbon pool. Soil carbon storage rate of legumes is higher than cool-season perennial (C3) grasses as they have higher root mass compared to C3 grasses. Various breeding activities have been focusing on developing plants with deeper and extensive root systems which could improve soil structure and crop yield. Recent breeding work includes gene ontology (GO) initiatives that provide a cellular, molecular and biological context to genes. However, the performance of the improved cultivars may vary based on the availability of soil moisture, which influences soil carbon dynamics along with other soil processes.

Objective

The objective of this study was to compare organic and inorganic soil carbon in forage legume fields under irrigated and rainfed conditions.

Materials and Methods

The experiment was established at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) in 2019. Alfalfa and sainfoin cultivars developed using GO biological process were grown in irrigated and rainfed conditions and compared with existing cultivars. The cultivars included: alfalfa "GO-F/U", sainfoin "GO-S/N", alfalfa "Sholty", and sainfoin "Shoshone". Each cultivar was planted in 7.5 ft × 20 ft plot with four replications. The seeding rate was 10 pounds pure live seed per acre for alfalfa and 30 pounds pure live seed for sainfoin. The borders were planted with tall fescue "Fawn". Three cores of soil were sampled in each plot at three different depths: 0-6, 6-12, and 12-18 inches in May of 2021. Additional soil samples were collected from borders at each replication as control. Organic soil carbon was determined using the Walkley-Black method and total soil carbon was determined using Dumas's combustion method. Statistical analysis was done using the Tukey method at 95% confidence interval.

Results and Discussion

The results showed that irrigated sites had higher total soil carbon and inorganic carbon compared to rainfed sites, but organic carbon did not vary between the sites (Figure 1). Soil organic carbon decreased gradually as the depth of sampling increased for all cultivars while inorganic carbon was the highest at 12-18 inches depth (Table 1). Overall, total soil carbon was higher in both GO cultivars of alfalfa and sainfoin (Table 2). Shoshone sainfoin had the lowest total soil carbon at 0-6 inches depth and control plots had the lowest total carbon at 12-18 inches depth.

Irrigation water acted as a catalyst for biotic and abiotic nutrient cycling processes in the irrigated field which might have contributed to higher soil carbon compared to the rainfed field. On the other hand, topsoil (0-6 inches) being rich in litter and organic matter might have resulted in high soil organic carbon. Low disturbance at 12-18 inches might have resulted in higher inorganic carbon. Alfalfa and sainfoin are both deep-rooted crops, suited for the carbon

sequestration process. Future work on microbial activities in the root zone under each cultivar might help explore the additional effect of irrigation on the soil carbon sequestration process.

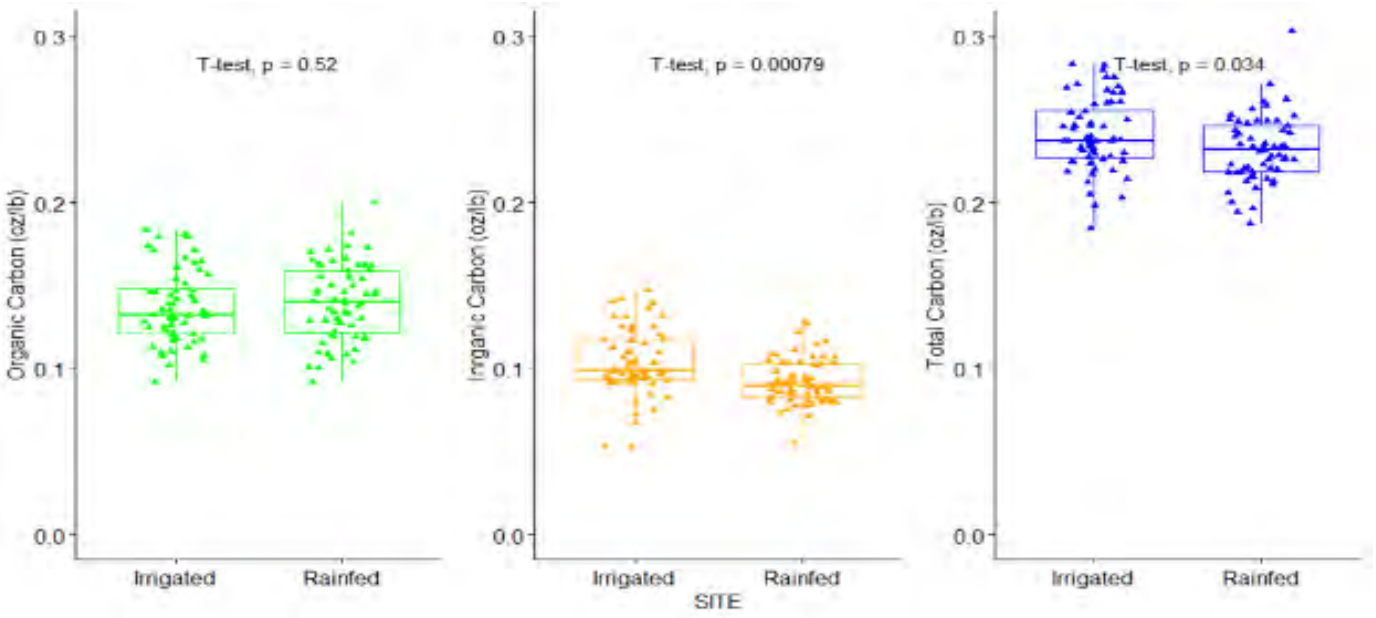

Figure 1. Organic, inorganic, and total soil carbon in irrigated and rainfed legume fields at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center in 2021.

Table 1. Organic and inorganic soil carbon as influenced by cultivars and soil depth at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center in 2021.

	Organic Soil C (oz/lb)			Inorganic Soil C (oz/lb)		
Cultivars	0-6 in	6-12 in	12-18 in	0-6 in	6-12 in	12-18 in
Control	0.16 ab	0.13 a	0.11 a	0.08 ab	0.09 a	0.11 a
Falcata Sholty	0.17 a	0.14 a	0.12 a	0.1 a	0.09 a	0.12 a
Falcata GO-F/U	0.17 ab	0.14 a	0.12 a	0.09 ab	0.09 a	0.12 a
Sainfoin GO-S/N	0.16 ab	0.14 a	0.12 a	0.09 a	0.09 a	0.12 a
Sainfoin Shoshone	0.15 b	0.14 a	0.12 a	0.07 b	0.09 a	0.11 a

Table 2. Total soil carbon as influenced by cultivars and soil depth at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center in 2021.

	Total Soil C (oz/lb)		
Cultivars	0-6 in	6-12 in	12-18 in
Control	0.24 bc	0.22 a	0.21 b
Falcata Sholty	0.27 a	0.23 a	0.24 a
Falcata GO-F/U	0.26 ab	0.23 a	0.24 a
Sainfoin GO-S/N	0.25 ab	0.23 a	0.24 a
Sainfoin Shoshone	0.23 c	0.23 a	0.23 ab

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Contact
Chandan Shilpakar, cshilpak@uwyo.edu

Anowar Islam, mislam@uwyo.edu, (307) 766-4151

Keywords
forage cultivar, carbon sequestration, irrigation

PARP I.12, II.9, X2

Effect of Grass-Legume Mixtures on Forage Productivity and Carbon Sequestration

Chandan Shilpakar, Department of Plant Sciences

Anowar Islam, Department of Plant Sciences

Introduction

Producers aiming for long-term economic success inevitably face issues for sustaining forage production. Productivity declines over time due to continuous monoculture, soil destruction, and intensive harvest. Adopting regenerative agriculture practices contributes to species diversity, produces a high-quality product, and increases carbon drawdown along with other benefits leading to sustainable economic return. Regenerative agriculture practice includes principles that maximize diversity, increase cover, minimize soil disturbance or tillage, promote root growth for microbial activities, and integrate livestock with crops. Grass-legume mixture adopts all the principles of regenerative agriculture practice; however, the contribution of grass-legume mixture might differ based on species used in the mixtures.

Objective

Assess the effect of grass-legume mixtures on forage productivity and soil carbon sequestration.

Materials and Methods

The experiment was established at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) in 2018. Five different types of mixtures (Table 1) were planted in 5 ft × 20 ft plot with four replications. The seeding rates (pounds pure live seed per acre) were 10 for birdsfoot trefoil, 20 for grasses and cicer milkvetch, and 35 for sainfoin. Seeds were mixed in equal proportion in each mixture. Three harvests were done in 2020 to determine forage yield and nutritive value. Three soil samples were collected randomly from each plot in 2021 for soil carbon determination. Additional soil samples were collected from plots with annual weeds as control. Statistical analysis was done using the Tukey method at 95% confidence interval.

Table 1. Description of mixtures and species used in the study at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center in 2021.

Mixtures	Species included
Native cool-season grass mixture	Basin wildrye, bluebunch wheatgrass, thickspike wheatgrass, and western wheatgrass
Introduced cool-season grass mixture	Tall fescue "PDF584", tall fescue "97TF1584", and crested wheatgrass
Native grass + legumes mixture	Basin wildrye, bluebunch wheatgrass, thickspike wheatgrass, western wheatgrass, birdsfoot trefoil, cicer milkvetch, and sainfoin
Introduced grass + legumes mixture	Tall fescue "PDF584", tall fescue "97TF1584", crested wheatgrass, birdsfoot trefoil, cicer milkvetch, and sainfoin
Native + introduced + legumes mixture	Basin wildrye, bluebunch wheatgrass, thickspike wheatgrass, western wheatgrass, tall fescue "PDF584", tall fescue "97TF1584", crested wheatgrass, birdsfoot trefoil, cicer milkvetch, and sainfoin

Results and Discussion

Native grass mixture had the lowest while introduced grass mixture had the highest productivity among the mixtures (Figure 1). There was no difference among the mixtures of grasses with legumes and introduced grass mixture. In general, the incorporation of legumes in grass mixtures increased productivity and quality. The quality

improvement was the greatest in a mixture of native grasses with legumes (18.6% crude protein). No difference in soil carbon content was observed among the mixtures; however, organic soil carbon and total soil carbon decreased as the depth of sampling increased (Tables 2 and 3). This implies that the contribution was higher from organic soil carbon than from inorganic soil carbon to the total carbon pool in the study. Future work on soil health indicators such as belowground biomass and microbial community assay might help understand how grass-legume mixtures can contribute to forage productivity and regenerative agriculture system.

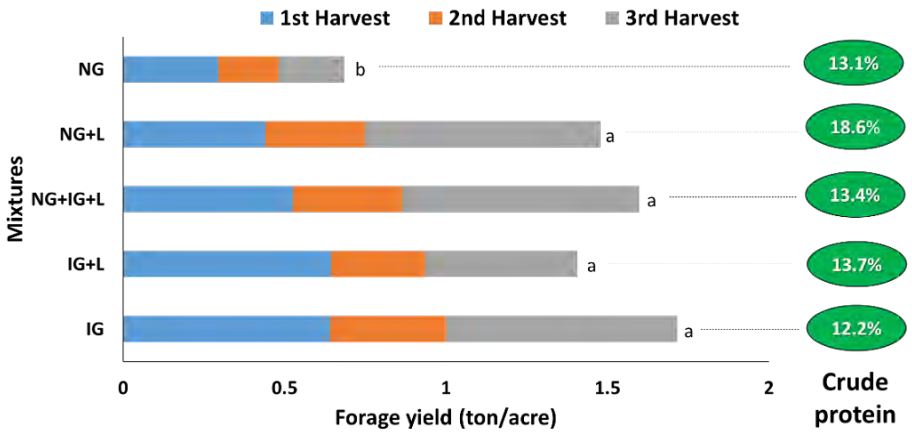

Figure 1. Forage yield and crude protein of different grass-legume mixtures in 2020. Means with same lowercase letter at the right of each bar do not differ at $p > 0.05$. NG, native cool-season grass mixture; IG, introduced cool-season grass mixture; L, legumes

Table 2. Organic soil carbon and inorganic soil carbon as influenced by species mixtures and soil depth at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center in 2021.

	Organic Soil C (oz/lb)			Inorganic Soil C (oz/lb)		
Mixtures	0-6 in	6-12 in	12-18 in	0-6 in	6-12 in	12-18 in
Control	0.19 a	0.14 b	0.09 c	0.08 a	0.09 a	0.07 a
Native grass	0.21 a	0.15 b	0.08 c	0.09 a	0.08 a	0.08 a
Introduced grass	0.19 a	0.15 b	0.08 c	0.08 a	0.10 a	0.08 a
Native grass + Legume	0.19 a	0.14 b	0.10 c	0.08 a	0.08 a	0.09 a
Introduced grass + Legume	0.20 a	0.13 b	0.06 c	0.08 a	0.08 a	0.06 a
Native + Introduced + Legume	0.18 a	0.14 b	0.07 c	0.08 a	0.08 a	0.06 a
Means among soil depths followed by different lowercase letters are statistically different at P ≤ 0.05						

Table 3. Total soil carbon as influenced by species mixtures and soil depth at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center in 2021.

	Total Soil C (oz/lb)		
Mixtures	0-6 in	6-12 in	12-18 in
Control	0.27 a	0.23 a	0.15 b
Native grass	0.29 a	0.23 b	0.15 c
Introduced grass	0.28 a	0.25 a	0.15 b
Native grass + Legume	0.27 a	0.21 ab	0.19 b
Introduced grass + Legume	0.28 a	0.21 b	0.12 c
Native + Introduced + Legume	0.27 a	0.22 a	0.13 b
Means among soil depths followed by different lowercase letters are statistically different at P ≤ 0.05			

Acknowledgments
We thank the SAREC crew and University of Wyoming forage agronomy laboratory members for their assistance in data collection. The study was funded by UW Energy and DOE.

Contact
Chandan Shilpakar, cshilpak@uwyo.edu

Anowar Islam, mislam@uwyo.edu, (307) 766-4151

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forage, grass-legume mixtures, carbon sequestration

PARP I.2, II.9, X2

Effects of Compost and Cover Crops on Soil Health in Organic Wheat Agriculture

Hannah Rodgers, Ecosystem Science and Management

Jay Norton, Ecosystem Science and Management

Linda van Diepen, Ecosystem Science and Management

Introduction

Organic wheat agriculture in the High Plains region of Wyoming is threatened by declining soil nutrients, pushing farmers and researchers to search for economical ways to build long-term soil health. One option is composted manure, which contains concentrated, stabilized nutrients and carbon that release slowly over time and improve soil physical properties. Compost has been found to have long-lasting soil health and crop yield benefits in the semiarid Western US (Reeve *et al.*, 2012). Additionally, cover crops can enhance nutrient retention as compost decomposes, and prevent nutrient losses and erosion associated with fallow (Norton *et al.*, 2018). Combining high rate of compost with short-lived cover crops may balance the water and nutrient needs of organic agriculture and restore the soil health that supports sustainable agricultural systems resilient to climate change and drought.

Objectives

(1) Continue to evaluate cover crops and compost as organic dryland wheat management strategies.

(2) Quantify soil health and yield benefits over many years to help growers justify the costs of compost and cover crops in order to build long-term soil health.

(3) Evaluate which soil organic matter and microbial properties best indicate changes in soil health, carbon sequestration, and crop yield.

Materials and Methods

In 2015, 128 small plots were established at SAREC in order to determine the legacy effects of three rates of compost (15, 30, and 45 Mg/ha) with or without cover crops. The plots were planted in a wheat-fallow rotation, with cover crops planted on half of all plots during the fallow phase. Compost was applied to plots either in 2016 or 2020. By continuing to monitor these plots for soil health and yield, we hope to get a better understanding of the impacts of compost application over the short (1-3 years) and longer (5-8 years) term. Each plot will be analyzed for yield and several soil health indicators (including organic matter, labile pools of carbon and nitrogen, soil protein, and soil structure) as well as microbial properties (enzyme activities, microbial biomass, and community composition).

Results and Discussion

Previous work found that the higher rates of compost can increase soil organic matter, nitrate, dissolved organic carbon and nitrogen, and phosphorus (Badu Brempong et al., 2018; Brempong et al., 2019; Helseth, 2020). After the 2020 compost application, we can now to compare plots with recently applied compost to plots with compost applied five years ago. We found that compost application affects different forms of soil nitrogen in different ways. Nitrate, an inorganic plant-available form of nitrogen, was not affected by compost application, likely because it is rapidly taken up by plants or microorganisms. Mineralizable nitrogen, readily-decomposable organic nitrogen, was increased

only in the plots that received compost in 2020. Soil protein, a more stable organic nitrogen pool, was increased even five years after compost application (Figure 1). Additionally, we found higher concentrations of cellobiohydrolase (a microbial enzyme involved in cellulose decomposition) in the high-rate compost plots, indicating that this enzyme might be useful for detecting soil health improvement in these organic wheat systems (Figure 2). Going forward, results of this study will help us understand legacy effects of compost application and cover cropping in a vulnerable agroecosystem, to find ways to incorporate these practices into Wyoming High Plains organic wheat agriculture.

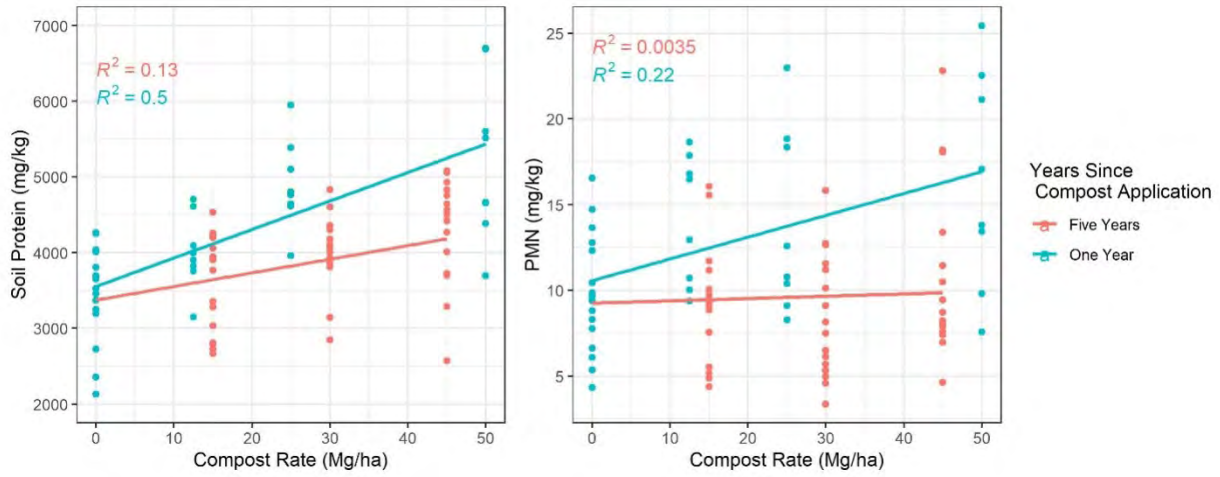

Figure 1. Mineralizable nitrogen (PMN, left) and soil protein (right) both increased as compost rate increased. However, mineralizable nitrogen increased only in plots with compost applied in 2020 (red lines), whereas soil protein increased in all plots, though the increase is greater in plots with compost applied in 2020 (blue lines). The shaded area on both graphs represents a 95% confidence interval for the correlation between compost and the form of nitrogen.

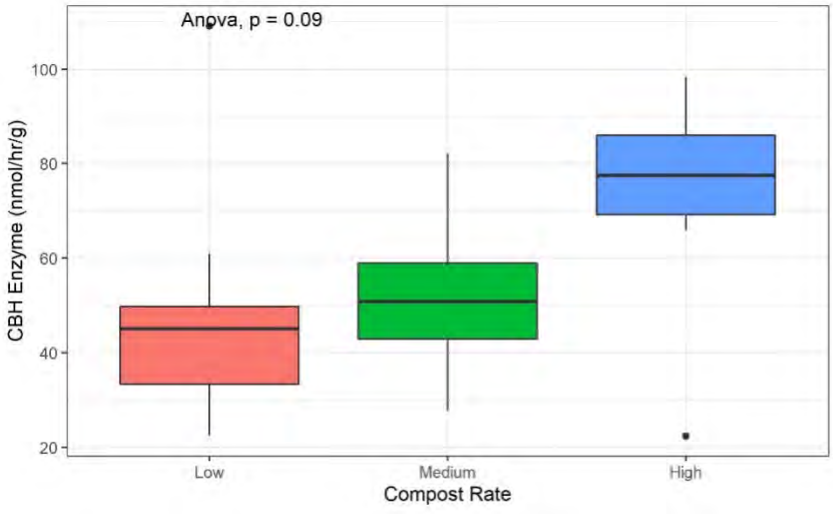

Figure 2. Cellobiohydrolase (CBH) increased in the higher compost rates in plots with compost applied in 2020.

Acknowledgments

We would like to thank the SAREC crew, Organic Agriculture Research and Extension Initiative for funding.

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Contact

Linda van Diepen, lvandiep@uwyo.edu

Keywords

organic wheat, compost, cover crops, soil health, fertility, soil microbiology

Composted Cattle Manure Legacy on Soil Available Phosphorus in Dryland Organic Winter Wheat (*Triticum aestivum*, L.) - Fallow System Five Years after the Application

Tina Helseth, Department of Plant Sciences

Urszula Norton, Department of Plant Sciences

Introduction

Dryland organic winter wheat (*Triticum aestivum*, L.) production in southeastern Wyoming is faced with many challenges. Soils in these areas have low soil organic matter, moisture, and macronutrient concentrations. In addition, organically certified crops are limited to what inputs and management strategies can help improve overall crop production. One way to help increase soil health is to add composted cattle manure (compost). Compost has been widely recognized as a source of multiple benefits. It increases soil organic matter and supplies nitrogen (N) and available phosphorus (AP) that are critical for crop yield and crop quality. Anecdotal evidence suggests however, that low rates of compost applications are not effective. In a study conducted by Reeve *et al.* (2012), benefits of a high rate of compost application to marginally productive dryland soils in Utah were observed even 16 years after. Specifically, AP was significantly higher in plots amended with high compost rate compared with the unamended control. Available phosphorus, next to N, is the most limiting nutrient to crop production. The primary role of AP in a plant is to store and transfer energy produced by photosynthesis for use in growth and reproductive processes (USDA, 2014) and result in crop yield improvement.

Objective

The goal was to determine the optimal rate of a single application of compost (using four different rates between 45 Mg ha^{-1} and 0 Mg ha^{-1}) on AP five years after the compost application.

Materials and Methods

In 2016, 80 small plots in an established organic wheat-fallow rotation at the Sustainable Agriculture Research and Extension Center (SAREC) near Lingle, WY received compost treatments. Compost was added and incorporated at four rates (0, 15, 30, 45 Mg ha^{-1}), each referred to as Control, Low, Medium, and High, respectively. Soils were assessed for AP at two depths (0-5 cm and 5-15 cm).

Results and Discussion

Similarly to what Reeve *et al.* (2012) observed in Utah, the results of the current study concur with their findings in the fifth year of the monitoring. In 2019, the Medium and High rates of compost helped to increase plant-available phosphorus (AP) in the soil (Figure 1). This suggests that larger rates of compost applications can deliver long-lasting legacy after the application event. The fact that AP is still present in soil suggests that organic forms of AP from the compost remain.

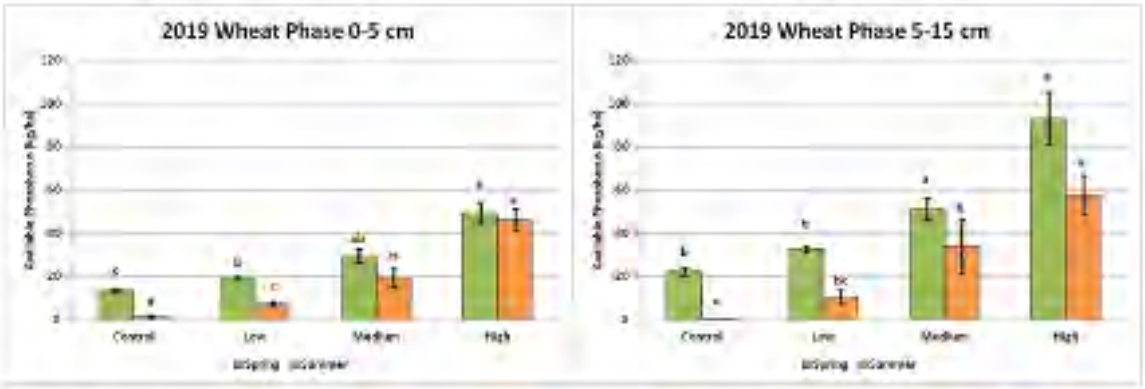

Figure 1: Plant-available phosphorus increases as the compost rate increases in the 0-5 cm (left) and 5-15 cm (right) soil depths in the wheat phase of the rotation for the 2019 growing season. Lower case letters indicate significant differences between different rates across spring or summer at 5% significance level.

Acknowledgments

Our gratitude is given to the SAREC farm crew and the Organic Agriculture Research and Extension Initiative for funding.

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Contact

Urszula Norton, unorton@uwyo.edu

Keywords

nonirrigated crops, plant nutrition

Performance of Livestock Consuming Sunn Hemp in Southeastern Wyoming

Lauren Shortnacy, Department of Animal Science

Steve Paisley, Sustainable Agriculture Research and Extension Center

Carrie Eberle, Department of Plant Sciences

Introduction

Wyoming producers are challenged with limited high quality alternatives to alfalfa when faced with the many factors that hinder forage crop cultivation in the region such as inclement weather, poor soil health, and low soil fertility. To reduce costs and increase profit margins, high-yielding annual forage crops that can be harvested quickly and meet beef cattle nutrient requirements are necessary. *Crotalaria juncea* (sunn hemp), a tropical legume, shows promise as a sustainable crop for Wyoming crop-livestock systems with its reported ability to accumulate large amounts of biomass and fix high rates of nitrogen in a short time frame while being hardy in less-than-ideal growing conditions.

Objectives

Evaluate the potential for utilizing sunn hemp as a viable alternative to alfalfa for Wyoming producers in terms of feed value and livestock performance to increase sustainable success in both crop and livestock production systems.

Materials and Methods

This feeding study was conducted at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) during the winter months of December 2020 – February 2021 using the GrowSafe Feed Intake technology on site. Prior to the study, 500 pounds of inoculated sunn hemp seed was drilled at a depth of 1½ inches with 8-inch row spacing into a 14-acre section of irrigated pivot June 2020 at SAREC. Harvest of sunn hemp occurred at 75 days after planting in August 2020, and the forage was baled (19 bales total) using a Hesston large square baler to be used later in the winter feeding trial. The winter feeding trial was designed as a randomized complete block design with 3 replications per treatment. A total of 63 (27 steers and 36 heifers) weaned Angus × Hereford calves approximately 260 days of age were randomly assigned to 9 pens (7 head per pen). Treatments were three forage sources within diets: 100% alfalfa (*M. sativa*), 100% sunn hemp (*C. juncea*), and 50% alfalfa and 50% sunn hemp. Three isocaloric (similar energy level), isonitrogenous (similar protein level) diets were formulated, composed of the legume hay, cracked corn, corn silage, and protein/mineral supplement to be fed for the duration of the experiment (feed ingredients as %TMR shown in Table 1). Calves were adapted to the GrowSafe feeders for 21 days plus the experimental period of 42 valid intake days. For the duration of the study, the GrowSafe technology measured feed intake and feeding behavior of individual calves according to their unique electronic identification tags. Livestock growth performance and efficiency was evaluated using these data.

Results and Discussion

Feed analysis results of the two forage sources used are shown below (Table 2). Alfalfa hay contained roughly 21% CP, 38% ADF, 38% NDF, and 54% TDN. The sunn hemp hay contained roughly 17% CP, 20% ADF, 46% NDF, and 67% TDN. Forage analysis results showed high quality in both alfalfa and sunn hemp forage. Livestock performance results are shown below (Table 3). Significance was determined at ($P < 0.05$). Neither initial weight nor final weight of calves differed significantly among treatments (Tables 3 and 4). Average daily gain (ADG) of calves was similar between 100% alfalfa and the 50% alfalfa/sunn hemp blend (Table 3). Despite the 100% sunn hemp treatment

resulting in statistical difference, all treatment rations produced respectable ADG values between 2.59-2.92 lbs/day. Feed intakes were similar between 100% alfalfa and the 50% alfalfa/sunn hemp blend (Table 4). Intakes were higher for heifers than steers although not statistically different. Intakes were significantly lower consuming 100% sunn hemp most likely due to the bulk density of the sunn hemp biomass. Calves consuming diets consisting of 100% sunn hemp experienced a significant ($P < 0.05$) decrease in performance in terms of gain (total and ADG); however, calves exhibited similar efficiencies when utilizing feed according to reported Feed:Gain and Gain:Feed ratios as well as residual feed intake (RFI). Overall, results show that sunn hemp can be fed as a supplement to alfalfa and produce results similar to alfalfa alone, and sunn hemp can successfully be fed alone to meet beef cattle requirements.

Table 1. Feed ingredients as percent (%) of total mixed ration (TMR).

	100% Alfalfa	50% Alfalfa & 50% Sunn Hemp	100% Sunn Hemp
Feed Item			
Alfalfa Forage	33.3	16.4	-
Sunn Hemp Forage	-	15.5	31.1
Corn Silage	39.4	39.3	39.3
Corn Grain	24.2	25.8	26.6
Protein Supplement	2.1	2.0	2.0
Fortified Trace Mineral Salt	1.0	1.0	1.0
Note: Alfalfa values reported are for 3rd cutting alfalfa harvest.			

Table 2. Feed analysis of forage sources (hay).

	Alfalfa		Sunn Hemp	
Trait	**As Received**	**Dry Basis**	**As Received**	**Dry Basis**
Moisture (%)	13.45	0.00	14.42	0.00
Dry matter (%)	86.37	100.00	85.58	100.00
Crude Protein (%)	18.30	21.10	14.70	17.10
Acid Detergent Fiber (%)	33.00	38.20	17.10	20.00
Neutral Detergent Fiber (%)	32.50	37.60	39.30	45.90
Total Digestible Nutrients (%)	46.40	53.70	57.60	67.30
Note: Alfalfa values reported are for 3rd cutting alfalfa harvest.				

Table 3. Performance of selected cattle traits as affected by sex.

	Animal Sex		Animal Sex		
Performance Trait	**Steer**	**Heifer**	**Steer**	**Heifer**	***P*-value**
Initial Weight (lbs)	790.3	739.0	11.08	9.59	< 0.01
Final Weight (lbs)	932.2	868.1	12.60	10.91	< 0.01
Gain (lbs)	141.93	129.06	4.503	3.900	0.03
Average daily gain	2.96	2.69	0.094	0.081	0.03
Dry matter intake*	20.50	21.09	0.546	0.473	0.41
Feed:grain ratio	7.14	8.09	0.331	0.287	0.03
Grain:feed ratio*	14.77	12.94	0.573	0.496	0.02
Residual Feed intake*	-0.33	0.24	0.537	0.465	0.42
Note: (*) denotes sex × treatment interaction ($P < 0.05$).					

Table 4 Performance of selected cattle traits as affected by ration.

	Ration				
Performance Trait	**100% Alfalfa**	**50% Alfalfa & 50% Sunn Hemp**	**100% Sunn Hemp**	**Std Error**	**P-value**
Initial Weight (lbs)	756.8	764.3	761.9	12.69	0.91
Final Weight (lbs)	897.0	903.7	886.0	14.43	0.68
Gain (lbs)	140.24a	139.33a	124.14b	5.159	0.05
Average daily gain	2.92a	2.90a	2.59b	0.107	0.05
Dry matter intake*	21.38a	21.59a	19.54b	0.625	0.04
Feed:grain ratio	7.46	7.58	8.01	0.380	0.56
Grain:feed ratio*	13.96	13.55	13.66	0.656	0.90
Residual Feed intake*	0.38	0.66	-1.04	0.616	0.11
Note: (*) denotes sex × treatment interaction ($P < 0.05$).					

Acknowledgments

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Contact

Lauren Shortnacy, lshortna@uwyo.edu

Steve Paisley, spaisley@uwyo.edu

Keywords

sunn hemp, forage, biomass, livestock, alfalfa, performance, gain, efficiency

PARP I.15, II.9, VI.1

Winter Oats Survivability/Crop Feasibility in Southeastern Wyoming

Blaine Magnuson, SAREC

Kevin Madden, SAREC

Alex Mattheus, SAREC

Lance Magnuson, SAREC

Larry Miller, SAREC

Madison LaQua, SAREC

SAREC; J.C. Hageman Sustainable Agriculture Research and Extension Center

Introduction

There is a need to provide more dryland and irrigated crop options in the southeastern region of Wyoming. Winter oats have been mentioned as an alternative to other fall seeded cereal crops, but survivability and yield are unknown. Winter oats provide an interesting alternative to winter wheat due to their ability to mitigate sawfly populations, as sawfly larvae cannot infest oat stems. Oats also provide a different market as direct to feed mills and livestock producers. Flexibility with this crop is also a factor as it can be harvested for grain or hay.

Objectives

Evaluate winter oat survival and yield in southeastern Wyoming under irrigated growing conditions.

Materials and Methods

In September of 2020, a 1.25-acre block under the lateral move irrigation system at SAREC in Lingle, WY, was established to winter oats. The seeding rate was 50 pounds per acre, crop was seeded 1.25 inches deep, and no additional fertilizer was provided as soil test levels were deemed adequate. Crop was harvested in three random blocks within the field in July of 2021 and evaluated for grain yield and test weight.

Results and Discussion

Winter oats survived winter well, although heavy pressure from Canada geese impacted early-season green up. The crop established well in the fall and rebounded in the spring despite this heavy browse pressure. Oats matured evenly and stood well for direct harvest utilizing a standard reel type platform grain head. Grain yields averaged 128.2 bu/a are presented in Table 1. Test weight averaged 35.3 pounds. Oat plant height measured at seven sections ranged from 27 to 31 inches (Table 2). The study will be repeated in 2022 with both dryland and irrigated plots, with evaluation for grain yield as well as hay yield and feed quality.

Acknowledgments

Thanks to SAREC field crew, Dr. Steve Paisley and the various interns that have helped with this project thus far.

Contact

Steve Paisley, spaisley@uwyo.edu, (307) 837-2000

Keywords
cereal, oat, winter oat

PARP I

Table 1. Yield and test weight of oat grown at Lingle and harvested July 2021.

Block	Test Weight	Yield*
	lbs/bu	bu/ac
1	35.3	123.4
2	36.0	123.5
3	34.7	137.7
Average	35.3	128.2

**Yield was collected using a Kincaid 8-XP plot combine equipped Harvestmaster H2 GrainGauge. Areas were randomly selected within seeded area, measuring 5 by 33 feet.*

Table 2. Plant height of oat plants in 2021.

Plant height (inches)*
31
31
29
29
27
27
27

**Heights were taken from ground level to top of panicle at 7 random locations within the seeded area.*

Corn Variety Trial in Southeast Wyoming

Blaine Magnuson, SAREC

Kelly Carrol, SAREC

Kevin Madden, SAREC

Lance Magnuson, SAREC

Erik Tuttle, SAREC

Ryan Gompert, SAREC

SAREC, J.C. Hageman Sustainable Agricultural Research and Extension Center

Introduction

A request was made by Simplot Grower Solutions in Torrington, WY to SAREC to conduct a corn variety trial. Local information was sought on the performance of different varieties of corn from multiple seed corn companies. There was also a need to test different seeding rates with these varieties.

Objectives

Evaluate several corn seed varieties from different corn seed companies for their performance in southeastern Wyoming, as well as at different seeding rates.

Materials and Methods

Planting date was 9 June 2021 and treatments consisted of twelve corn seed varieties from five different seed companies that were planted at two seeding rates. Seeding rates selected were 30,000 seeds per acre and 34,000 seeds per acre. A random block design with six replications with 24 treatments per block was used for plot layout. Each plot consisted of six rows on 30-inch row spacing 25 feet long. Fertilizer, irrigation rate, and herbicide were the same for all treatments. The trial was seeded at the SAREC in Lingle, WY. The center two rows of each plot were harvested on 22 Nov 2021 using a Kincaid 8-XP plot combine equipped with a H2 GrainGage from Harvestmaster. Yields were calculated using weights collected by the H2 GrainGage, corrected to a standard moisture of 15%. Test weight was also collected for each plot.

Results and Discussion

Grain yields ranged from 136 to 213 bu/a (Table 1). Variance in yield was not found to be statistically significant for variety or population using an ANOVA general linear model.

Acknowledgments

Thanks to SAREC field crew, Dr. Steve Paisley and the interns that have helped with this project thus far.

Contact

Steve Paisley, spaisley@uwyo.edu, (307) 837-2000.

Keywords

seeding rate, yield

Table 1. Yield of 12 corn hybrids as affected by seeding rate at Lingle in 2021.

Hybrid	Seeding Rate (per acre)	
	30 K	**34 K**
9227-5222	206	154
9653-5222	138	191
A9436SS	136	156
A9447VT2P	207	186
A9647VT2P	137	185
B01Z88Q	173	212
B92W94AM	168	213
B94Z97Q	194	203
B97G09Q	182	175
DKC42-04RIB	208	161
DKC47-54RIB	173	173
P9188AMXT	190	169
LSD (0.05)	--- ns *---	
** The sources of variation hybrid, seeding rate, and their interaction was not significant, the CV was 18%.*		

Intensive Irrigated Forage Rotation Compared to Corn on Corn

Blaine Magnuson, SAREC Research and Extension Center

Carrie Eberle, Department of Plant Sciences

Introduction

The integrated crop livestock systems in southeastern Wyoming require reliable, high-quality forage and feed production year-round. Currently corn, for silage, earlage, and grain, and alfalfa are primary components of feed rations. However, there is producer interest in the production and use of nontraditional feedstuffs to help lengthen the grazing season and improve the quality and variety of rationed winter diet available to livestock.

Objectives

Evaluate the production potential of a 4-year intensive forage rotation of teff grass, forage soybean, brassica mixtures, annual cereal grasses, sorghum/sudangrass, and grain corn relative to a continuous corn/cornstalks rotation as a feed staple in a farming/livestock operation in southeastern Wyoming. Over a four-year period, both systems will be evaluated based on the feed and feed quality produced, the production economics, and soil health parameters. Preliminary forage and grain yield data is included in this report. Soil health, production economics and overall management will be discussed in subsequent reports.

Materials and Methods

In the fall of 2018, a 65-acre center ½ pivot irrigated field at SAREC in Lingle, WY was divided into four replicate 13-acre wedge-shaped fields with four 3-acre replicate check strips of corn located in between the wedge-shaped fields (Figure 1). A 4-year intensive forage rotation was seeded into the 13acre fields, with each phase of the 4-year rotation present across the four fields within each year. The corn check strips were planted to a continuous corn/cornstalk rotation. The crops were rotated through all wedges from 2019 through 2022, completing a full rotation cycle in each replicate wedge over the four years. The 4-year intensive forage rotation consists of spring and fall planted crops. The rotation was

1. Spring-seeded sorghum sugangrass for hay or silage
2. Fall-seeded peas with a winter cereal for winter grazing and hay in spring
3. Late-spring seeded teff grass
4. Fall-seeded winter cereal/brassica mix for grazing
5. Spring-seeded soybeans for hay or silage
6. Fall-seeded winter cereal with brassicas for grazing
7. Spring-seeded corn for grain
8. Fall-corn stalks for grazing

Each spring/fall seeding made up one year of the rotation. The complete 4-year rotation had seven different crops grown in it. Each year yield was measured from total production per area and feed samples were analyzed for relative feed value, crude protein, digestibility, and energy content. Soil samples were taken annually from geographically fixed locations within the three soil types on the field and compared to the check corn in each soil type. Soil was tested for organic matter, carbon-to-nitrogen ratio, and scored for soil health at Midwest Labs. Every spring, soil samples were taken from each replicate field to determine annual fertilizer needs for each crop. Performance of each crop will be analyzed yearly and at the end of the 4 years, a total rotation analysis will be completed.

Preliminary Results and Discussion

Preliminary results on individual crop yield are reported in Table 1. Fall-seeded cover crops (2, 4, and 6) provided approximately 3-4 tons/acre of additional feed value to the rotation. Winter-seeded winter peas showed poor survival rates and low biomass yield, while spring-seeded grain peas performed more consistently (field observations; data not yet reported). Soybeans proved to be a feasible crop, with the silage yield being approximately 8 tons per acre on a wet basis, but further research is needed into ensiling practices to ensure palatability and storability. Sorghum and soybean yields were highly variable from 2019-2021. While sorghum is an established crop in the area, harvest management and field lodging continue to be an issue with managing the crop. Soybean harvest for silage was problematic and changed to dry baling in 2021, with no harvest in 2020. Soybean is a new crop for the region and challenges with fertility, weed, and harvest management were encountered. Teff grass yielded approximately 2 tons per cutting, although further experimentation with seeding rate and seeding method is needed to maximize efficiency and economic return.

Future Work

Work to still be completed includes soil analysis to assess rotation effect on soil health, forage value analysis to determine feed value of each rotation, and economic analysis of the two rotations.

Acknowledgments

Thanks to SAREC field crew, Dr. Steve Paisley and the various interns that have helped with this project thus far.

Contact

Steve Paisley, spaisley@uwyo.edu, (307) 837-2000

Keywords

forage, soybean, teffgrass, teff, irrigated, sorghum sudan, rotation

PARP I

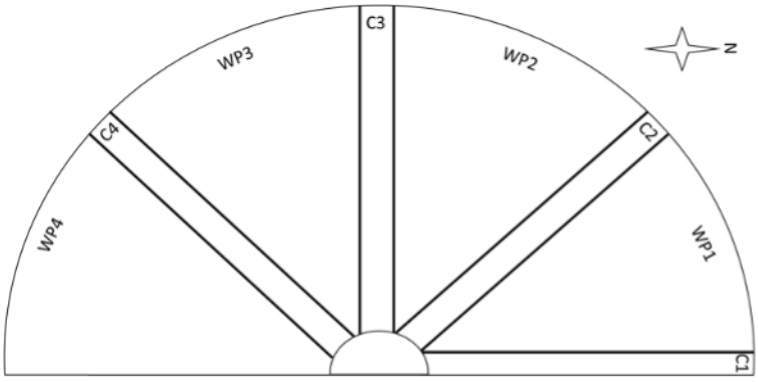

Figure 1. Field layout of the ½ pivot showing 4 wedge replicate fields (WP1-WP4) and 4 continuous corn spokes (C1-C4).

Table 1. Yield of different forage crops from June 2019 through January 2021. Yield is reported for each replicate field for each harvest. NA indicates no data as a result of a failed crop.

Field	Year	Crop	Harvest Method	Yield	Harvest Date	
WP1	2019	1. Sorghum	Silage	20.0	Tons/acre	9/10/2019
WP2	2020	1. Sorghum	NA	NA		NA
WP3	2021	1. Sorghum	Silage	2.3	Tons/acre	8/28/2021
WP3	2021	1. Sorghum	Hay	0.3	Tons/acre	10/6/2021
WP1	2020	2. Rye/Pea	Graze*	1.6	Tons/acre	4/29/2020
WP1	2020	2. Rye/Pea	Hay	1.7	Tons/acre	6/10/2020
WP2	2021	2. Triticale/Pea-Spring	Graze*	1.9	Tons/acre	4/23/2021
WP2	2021	2. Triticale/Pea-Spring	Hay	2.2	Tons/acre	7/11/2021
WP4	2019	3. Teff Grass	Hay	2.0	Tons/acre	9/25/2019
WP1	2020	3. Teff Grass	Hay	2.0	Tons/acre	8/14/2020
WP3	2019	5. Soybeans	Silage	7.3	Tons/acre	9/10/2019
WP4	2020	5. Soybean	NA	NA		NA
WP1	2021	5. Soybean	Hay	3.2	Tons/acre	9/22/2021
WP4	2019	6. Rye	Hay	4.4	Tons/acre	6/17/2019
WP4	2020	6. Rye/Brassica	Graze*	0.9	Tons/acre	4/29/2020
WP3	2020	6. Rye/Turnip	Graze*	1.1	Tons/acre	4/29/2020
WP1	2021	6. Wheat/Brassica	Graze*	0.7	Tons/acre	4/23/2021
WP4	2021	6. Wheat/Brassica	Graze*	0.5	Tons/acre	4/23/2021
WP2	2019	7. Corn	Grain	138.1	Bushels/acre	11/19/2019
WP3	2020	7. Corn	Grain	91.0	Bushels/acre	10/15/2020
WP4	2021	7. Corn	Grain	166.7	Bushels/acre	11/15/2021
C1	2019	Continuous Corn	Grain	120.5	Bushels/acre	11/19/2019
C2	2019	Continuous Corn	Grain	117.6	Bushels/acre	11/19/2019
C3	2019	Continuous Corn	Grain	147.4	Bushels/acre	11/19/2019
C4	2019	Continuous Corn	Grain	132.1	Bushels/acre	11/19/2019
C1	2020	Continuous Corn	Grain	115.8	Bushels/acre	10/15/2020
C2	2020	Continuous Corn	Grain	101.9	Bushels/acre	10/15/2020
C3	2020	Continuous Corn	Grain	107.6	Bushels/acre	10/15/2020
C4	2020	Continuous Corn	Grain	85.1	Bushels/acre	10/15/2020
C1	2021	Continuous Corn	Grain	169.5	Bushels/acre	11/15/2021
C2	2021	Continuous Corn	Grain	180.2	Bushels/acre	11/15/2021
C3	2021	Continuous Corn	Grain	165.9	Bushels/acre	11/15/2021
C4	2021	Continuous Corn	Grain	174.6	Bushels/acre	11/15/2021

**Grazed amounts were collected from an enclosure that prevented animals from grazing within them. In those cases, yield represents the amount of growth that was grazed off during the grazing period.*

Optimizing Cover Crops for Weed Management in Sugarbeet

Andrew Kniss, Dept Plant Sciences

Nevin Lawrence, Univ. Nebraska, Panhandle Res. Ext. Ctr., Scottsbluff

Lovreet Shergill, Montana State Univ., Southern Agric. Res. Ctr., Huntley

Jim Heitholt, Department of Plant Sciences and Powell REC

Jenna Meeks, Department of Plant Sciences

Introduction

To successfully use cover crops for weed suppression one must manage the cover crop for optimal biomass production. Allowing increased cover crop biomass can improve weed suppression. Management recommendations to achieve increased cover crop biomass include: planting the cover crop early (fall if possible); using a high cover crop seeding rate; terminating the cover crop as late as possible; and combining cover crop use with compatible residual herbicides.

Objectives

The objective of this project is to develop cover crop establishment and termination recommendations to optimize the trade-off between weed suppression and sugarbeet yield.

Materials and Methods

The study was established in 2021 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Winter wheat was planted as the cover crop species for several reasons: it is well-adapted to our growing region; it is easy to find and relatively inexpensive (may even be produced on-farm by many growers); and many growers are familiar with this crop. Winter wheat will be seeded as early as possible (target first week of March) to maximize cover crop biomass production and weed suppressive ability by the time sugarbeet is planted. Sugarbeet will be planted between April 25 and May 5. At each termination timing, cover crop biomass, weed density, and weed biomass will be recorded. Sugarbeet will be harvested for yield and quality analysis at the end of the growing season. Following removal of cover crops, all plots will be kept weed free until harvest to ensure only the period early in the season when a cover crop was present is contributing to yield loss. This project will allow us to develop yield loss response curves that incorporate cover crop biomass and termination timing, as well as the weed suppression potential from each treatment.

Results and Discussion

This project was conducted during the 2021 field season and data is currently being collected and analyzed. In this project, we will evaluate cover crop termination timings with a goal of developing a simple decision aid so that growers and ag staff can minimize negative yield impacts while maximizing weed suppression from cover crops. This project will allow us to develop yield loss response curves that incorporate cover crop biomass and termination timing, as well as the weed suppression potential from each treatment. This work will allow producers to optimize cover crop termination timing to maximize weed suppression and minimize crop yield loss.

Acknowledgments

We would like to thank Western Sugar Cooperative for funding this research. We would also like to thank staff at each project site.

Contact
Andrew Kniss, akniss@uwyo.edu, (307) 766-3949

Keywords
sugarbeet, cover crops, weeds

PARP I.1, I.13., III.1., III.2., III.5., III.7., III.9., IX.5., X.2.

In-Furrow and Banded Fungicide Applications to Manage Rhizoctonia Root and Crown Rot in Sugar Beet

William Stump, Department of Plant Sciences

Wendy Cecil, Department of Plant Sciences

Introduction

Rhizoctonia root and crown rot (RRCR) of sugar beet is considered the number one soil-borne disease issue for sugar beet production in the High Plains, including southeast Wyoming. In-furrow applications of conventional and biological fungicides made at planting were evaluated for disease management of this disease.

Objectives

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

Materials and Methods

Research plots were established in 2020 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Immediately prior to planting, the plot area, with the exception of the nontreated non-inoculated plots, was inoculated with *Rhizoctonia solani* AG2-2 grown on barley at a rate of 54 kg/ha. Inoculum was spread with a cyclone spreader and then lightly incorporated with a hand rake. On 7 May plots were planted (sugar beet variety BETA 49RR22) with a John Deere MaxEmerge planter. The two middle rows were planted with open furrows (press wheels were held up) for the in-furrow applications. Immediately after planting, fungicide applications were made in-furrow, then rows were closed with walking foot-pressure. Foliar-banded fungicides were applied on 4 June with beets in the 4–6 leaf stage. Parameters measured were stand counts, plant vigor, percent canopy decline, and sugar beet root and sugar yield. A portion of the data are shown in Table 1.

Results and Discussion

Disease development was significant compared to previous years and there was some endemic disease pressure in the non-inoculated check. Initially on 27 May, treatments resulted in significantly less stands than the non-inoculated check and were not different from the inoculated check. The data would suggest that the in-furrow fungicide applications were not effective on seedling damping-off as they have had in the past. By 4 June (before the Proline banded applications) there was observable canopy decline due to seedling loss and RRCR development. By 3 August, and until end of season, all fungicide treatments reduced canopy decline similarly compared to both checks. This comparison was also true for the AUDPC, a measure of season-long disease. Although no direct comparisons can be made with treatment 5 (due to lack of proper plot randomization), it is difficult to assess how effective QST713 is on its own. There was a trend of more canopy decline when compared to the treatments with Quadris in-furrow alone.

Sugar beet root yields in general were extremely poor. Although there was a positive trend of sugar yield increases with fungicide treatment compared to the inoculated check, there were no significant effects. Lack of yield effect was probably due to weed competition and drought stress experienced in the plots in the latter half of the season.

Acknowledgments

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

Contact

William Stump, wstump@uwyo.edu, (307) 766-2062

Keywords

sugar beet, soil-borne disease, fungicide efficacy

PARP I:11

Table 1. Effects of in-furrow and foliar banded fungicides on plant stands, Rhizoctonia root and crown rot (RRCR) development, and sucrose yield in sugar beet (W.L. Stump and W. Cecil University of WY; 2020).

Treatment and product/A[1]	Application timing[2]	Plant stand	% canopy decline		AUDPC[3]	Lbs of extractable sucrose/A
		27 May	3 Aug	21 Sep	27 Sep	
1. Nontreated non-inoculated check	NA	78.8 a[4]	17.5 b	27.5 b	1671.4 b	717.7 a
2. Nontreated inoculated check	NA	54.3 b	47.5 a	50.0 a	4193.0 a	453.8 a
3. Quadris (9.2 fl oz) 3. Proline 480SC (5.7 fl oz)	A B	44.5 b	5.0 c	8.8 c	724.9 c	634.5 a
4. QST713 HICFU 150FS (12.8 fl oz) + Quadris (9.2 fl oz) 4. Proline 480SC (5.7 fl oz)	A B	49.8 b	5.0 c	3.0 c	491.0 c	961.1 a
5. QST713 HICFU 150FS (12.8 fl oz) 5. Proline 480SC (5.7 fl oz)[5]	A B	65.0	28.8	45.0	2812.4	797.4

[1]Fungicide per acre rates were adjusted to rates per 1000 ft and 30" row spacing.

[2]Application dates were as follows; A = 7 May and B = 4 June.

[3]Treatment means within the same column followed by different letters differ significantly (Fisher's protected LSD, P≤ 0.05).

[4]AUDPC = area under the disease progress curve.

[5]Treatment 5 was not properly randomized in the study so was not included in statistical analysis. Means are provided.

Management of *Cercospora* Leaf Spot in Sugar Beet with Foliar Fungicide Programs

William Stump, Department of Plant Sciences

Wendy Cecil, Department of Plant Sciences

Introduction

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

Objective

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

Materials and Methods

The study was established 7 May 2020 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Seven foliar fungicide programs were compared to a non-treated non-inoculated check and a non-treated inoculated check (Table 1). A randomized complete block design with four replicates was established. Each plot was 20 feet long and four rows wide with a five-foot, non-treated, in-row buffer between plots. To augment natural disease, the two middle rows of each inoculated plot were inoculated with 30 grams of dry *Cercospora beticola*-infected leaf material on 24 July. Parameters measured included CLS leaf lesion counts and season-long CLS severity, as measured by an area under the disease progress curve (AUDPC), and beet root yield (Table 1). Plots were harvested on 22 September.

Results and Discussion

CLS development was light to moderate in 2020. No fungicide treatments caused any apparent phytotoxicity in the beet crop. The inoculation method was successful, resulting in 315% more overall disease, as measured by AUDPC value, compared to the nontreated non-inoculated check. All fungicide treatments significantly reduced CLS lesion numbers on all evaluation dates compared to the nontreated checks ($P \leq 0.05$). All fungicide treatments were equivalent to each other on most ratings and for the AUDPC measurement. Disease pressure no doubt came too late and too light for much differences between individual fungicide programs. All fungicide treatments resulted in significantly higher beet root yield than the checks (approximately a 189% increase.)

Acknowledgments

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

Contact

William Stump, wstump@uwyo.edu, (307) 766-2062

Keywords

Cercospora leaf spot, sugar beet

PARP I:11

Table 1. Effects of foliar fungicide programs on *Cercospora* leaf spot (CLS) development in sugar beet (W.L. Stump and W. Cecil University of WY; 2020).

Treatment and product/A	Application timing[1]	CLS Lesion counts per leaf			AUDPC[2]	Beet root yield T/A
		27 Aug	4 Sep	14 Sep		
Nontreated non-inoculated check	NA	3.7 b[3]	6.3 b	10.1 b	159.8 b	10.0 b
Nontreated inoculated check	NA	16.1 a	14.1 a	30.5 a	503.6 a	8.6 b
Propulse 1.67 SC (13.6 fl oz) + Induce 90 SL (0.125% v/v)	BCE	0.0 c	0.0 c	3.8 cd	19.0 c	18.2 a
Proline 480 SC (5.7 fl oz) + Induce 90 SL (0.125% v/v)	BCE	0.0 c	0.0 c	4.3 cd	21.5 c	16.6 a
Delaro 325 SC (11 fl oz) + Proline 480 SC (1.71 fl oz) + Induce 90 SL (0.125% v/v)	BCE	0.0 c	0.0 c	3.5 d	17.3 c	17.8 a
Provysol (4 fl oz) + Dithane Rainshield 75 DF (2 lb) Priaxor (8 fl oz) + Super Tin 80 WP (4 oz)	B C	0.0 c	0.0 c	3.6 cd	18.3 c	17.9 a
Proline 480 SC (5.7 fl oz) + Dithane Rainshield 75 DF (2 lb) Provysol (4 fl oz) + Kocide 3000 (2 lbs) Priaxor (8 fl oz) + Super Tin 80 WP (4 oz)	B C E	0.0 c	0.0 c	4.2 cd	20.8 c	18.2 a
Priaxor (8 fl oz) + Kocide 3000 (2 lbs) Provysol (4 fl oz) + Kocide 3000 (2 lbs)	A B	0.0 c	0.0 c	3.9 cd	19.3 c	17.3 a
Eminent 125 SL (13 fl oz) + Super Tin 80 WP (4 oz) Headline 2.09 SL (12 fl oz) + Kocide 3000 (2 lbs)	B D	0.0 c	0.0 c	6.4 c	31.8 c	17.3 a
LSD		1.543	2.091	2.808	35.182	2.6919

[1]Application dates were as follows: A=17 Jul, B= 24 Jul, C= 7 Aug, D= 15 Aug, and E= 21 Aug. Applications were made with the aid of a portable (CO_2) backpack sprayer in a total volume of 43 GPA @ 40 psi boom pressure (four #8004 flat fan nozzle spaced at 20 inches).

[2]AUDPC=area under the disease progress curve. AUDPC is a measure of season-long disease control. Smaller values equate to less disease.

[3]Treatment means followed by different letters differ significantly (Fisher's protected least significant difference, P≤0.05).

Cercospora Leaf Spot Management in Sugar Beet with Variable Fungicide Application Methods and Timing

Amanda Koch, Department of Plant Sciences

William Stump, Department of Plant Sciences

Wendy Cecil, Department of Plant Sciences

Introduction

Cercospora leaf spot (CLS) is the most destructive foliar disease of sugar beets worldwide and has the potential to cause up to 50% loss in extractable sucrose. Most management depends on multiple fungicide sprays: typically initiating at first lesion appearance, row closure, or accumulated severity values in CLS prediction models. Sprays are applied aerially or by ground. Fungicide application timing and coverage is critical for optimal disease management. A previous study at SAREC indicated a potential benefit of an early spray application to manage CLS.

Objective

The objective is to compare timing and method of fungicide applications in the hopes to improve CLS management and potentially lower the number of total fungicide applications growers will make during the season.

Materials and Methods

The field study was established 7 May 2020 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC), using Betaseed 36RR50, a *Cercospora* sensitive variety. The statistical design was a randomized complete block design with 4 replications. Each plot was 20 feet long and four rows wide with a five-foot, non-treated, in-row buffer between plots. To augment natural disease, the two middle rows of each inoculated plot were inoculated with 32 grams of dry *Cercospora beticola*-infected leaf material on 24 July. Fungicide applications were made ~2 weeks before row closure, ~1 week before row closure, and at row closure or if the CLS model triggered an application. Backpack spray applications used two different sized spray nozzles to mimic a ground application (#8002) as well as an aerial application (#800067). The fungicide program was identical for all treatment comparisons as shown in Table 1. Parameters measured included CLS lesion counts, area under the disease pressure curve (AUDPC), root yield, and sugar content. Plots were harvested 20 September. A portion of the data is shown in Table 1.

Results and Discussion

Inoculations were successful resulting in significantly more disease in the inoculated check compared to the non-inoculated check. All treatments significantly reduced CLS disease pressure as measured by lesion counts and AUDPC (area under the disease progress curve) compared to both checks in the study. Sucrose yields were also increased between 175-230% with fungicide treatment compared to the inoculated check. Overall effects of early vs. normal (at row closure) fungicide timings resulted in both significant improvements in disease control and sucrose yields (Linear contrast, $P=0.05$). Comparing ground vs. aerial treatments, there were no differences in disease or sucrose yields (Linear contrast, $P=0.05$). Results from this study indicate that early fungicide applications were advantageous for the management of *Cercospora* leaf spot and the manner of application was inconsequential.

Table 1. Effects of foliar fungicide programs on *Cercospora* leaf spot (CLS) development in sugar beet (A.R. Koch, W.L. Stump, W. Cecil University of WY; 2020).

Treatment & Product/A	**Application Timing & method[1]**	**CLS Lesion counts per 5 leaves[2]**		**AUDPC[3]**	**Lbs extractable sucrose/A**
		9/4/20	**9/14/20**		
Nontreated/ non-inoculated check	NA	5.7 b	15.15 b	196.8 b	2102.6 c
Nontreated/ inoculated check	NA	16.55 a	22.70 a	342.9 a	1537.4 d
Eminent (13 fl oz) + Badge SC (2 pt) Topsin 7WP (1 lb) + Super Tin 80WP (5.0 oz)	AA1 AA2 Ground	0.75 d	2.35 d	29.4 d	3486.2 a
Eminent (13 fl oz) + Badge SC (2 pt) Topsin 7WP (1 lb) + Super Tin 80WP (5.0 oz)	AA1 AA1 Aerial	0.65 d	2.70 d	38.3 d	3546.1 a
Eminent (13 fl oz) + Badge SC (2 pt) Topsin 7WP (1 lb) + Super Tin 80WP (5.0 oz)	BB1 BB2 Ground	0.70 d	3.40 cd	37.5 d	2880.5 b
Eminent (13 fl oz) + Badge SC (2 pt) Topsin 7WP (1 lb) + Super Tin 80WP (5.0 oz)	BB1 BB2 Aerial	0.70 d	2.50 d	30.9 d	3197.4 ab
Eminent (13 fl oz) + Badge SC (2 pt) Topsin 7WP (1 lb) + Super Tin 80WP (5.0 oz)	CC1 CC2 Ground	1.50 d	3.80 cd	58.9 cd	3091.8 ab
Eminent (13 fl oz) + Badge SC (2 pt) Topsin 7WP (1 lb) + Super Tin 80WP (5.0 oz)	CC1 CC2 Aerial	2.20 cd	3.65 cd	53.6 cd	3011.0 ab
Eminent (13 fl oz) + Badge SC (2 pt) Topsin 7WP (1 lb) + Super Tin 80WP (5.0 oz)	DD1 DD2 Ground	2.55 cd	3.55 cd	74.0 cd	2698.3 b
Eminent (13 fl oz) + Badge SC (2 pt) Topsin 7WP (1 lb) + Super Tin 80WP (5.0 oz)	DD1 DD2 Aerial	3.90 bc	5.30 c	90.3 c	2716.0 b

[1]Application dates were as follows; AA1 (~2 weeks before row closure) = 1 Aug, AA2 (14 days after AA1) = 15 Aug, BB1 (~1 week before row closure) = 7 Aug, BB2 (14 days after BB1) = 21 Aug, CC1 (at row closure) = 15 Aug, CC2 (14 days after CC1) = 29 Aug, DD1 (at row closure) = 15 Aug, and DD2 (21 days after DD1) = 4 Sep. Applications were made with the aid of a portable (CO_2) backpack sprayer @ 35 psi boom pressure (four #8002 flat fan nozzle spaced at 20 inches for ground mimic, four #800067 nozzles spaced at 20 inches for aerial mimic).

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

[3]AUDPC= Area under the disease progress curve.

Acknowledgments

We would like to thank SAREC field crews for assistance in plot establishment, maintenance, and harvesting, and Western Sugar Cooperative for quality analysis. This study was supported by Western Sugar funds.

Contact

William Stump, wstump@uwyo.edu, (307) 766-2062

Keywords

Cercospora leaf spot, sugar beet

PARP I:11

Management of Root Diseases of Dry Beans with In-Furrow and Foliar Banded Fungicides

William Stump, Department of Plant Sciences

Wendy Cecil, Department of Plant Sciences

Introduction

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

Objectives

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

Materials and Methods

Research plots were established on May 27, 2020, at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Three in-furrow fungicide treatments were compared to non-treated check (Table 1). A randomized complete block design with four replicates was established. Each treatment plot was 20 feet long and four rows wide with a five-foot in-row buffer between plots. Plots relied on endemic soil-borne disease pressure. Plots were planted with the variety Othello using a John Deere planter, with the center two rows planted with an open furrow. Fungicide applications were made to the two open furrows then rows closed immediately with foot pressure. The field plot area received fertility, weed control, and irrigation appropriate for dry bean production. Parameters measured were stand counts, plant vigor, incidence of root rot, severity of root rot, and bean yield. A portion of the data is shown in Table 1.

Results and Discussion

Treatments had no significant effect on plant stands on any of the evaluation dates (data not shown). All fungicide treatments improved crop vigor compared to the nontreated check on 27 August ($P \leq 0.05$).

Treatment effects on disease, as measured by an early and late season destructive root disease rating, is shown in Table 1. Root disease was quite extensive, all roots sampled had some measure of necrosis due to root infection, primarily presumptive infections by *Fusarium* spp and *Rhizoctonia solani*. On 9 July, all fungicide treatments reduced disease severity compared to the check with the Propulse in-furrow followed by Endura foliar banded treatment being significantly better than the other two fungicide treatments ($P \leq 0.05$). At the later season root rating, only the Propulse in-furrow followed by Endura foliar banded treatment resulted in significantly less disease severity than the non-treated inoculated check ($P \leq 0.05$). There were no differences of root disease severity between Quadris (azoxystrobin) and Satori the generic formulation of azoxystrobin.

On average, fungicide treatments resulted in a 1.6X increase in bean seed yield compared to the nontreated check. This positive yield response due to in-furrow fungicide treatment was notable since with the previous 4 other similar fungicide trials there was no yield effect due to treatment.

Acknowledgments

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

Contact

William Stump, wstump@uwyo.edu, (307) 766-2062

Keywords

dry bean, soil-borne disease, fungicide efficacy

PARP I:11

Table 1. Management of stem and root rot diseases of dry bean with in-furrow and foliar fungicides (W.L. Stump and W. Cecil University of WY; 2020).

Treatment and rate	Application timing[1]	Crop vigor (1-9)	Root disease rating (0-5)[2]		Bean seed yield (lb/A)
		27 Aug	9 Jul	27 Aug	19 Sep
Non-treated check	NA	5.0 b[3]	4.46 a	5.00 a	2426.9 b
Propulse (0.34 fl oz/1000 ft) Endura (8 fl oz/A)	A B	7.5 a	1.58 c	3.89 b	3795.9 a
Quadris (0.6 fl oz/1000 ft) Proline (0.21 fl oz/1000 ft)	A B	6.8 a	2.59 b	4.79 a	4044.9 a
Satori (0.6 fl oz/1000 ft) Proline (0.21 fl oz/1000 ft)	A B	6.5 a	2.84 b	4.80 a	3982.6 a

[1]Application codes: A= 27 May in-furrow at planting and B= 25 June foliar broadcast.

[2]Root disease severity ratings, 0= no disease, 1= trace, 2= up to 25% of root necrotic, 3=26-50% root necrosis, 4 = 51-75% root necrosis with some internal pith rotting, 5 = > 75% of root system rotted.

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

Emergence Day, Growth Rate, and Biomass Production of Native Perennial Bunchgrasses and Invasive Grasses

Jaycie Arndt, University of Wyoming Extension, Institute for Managing Annual Grasses Invading Natural Ecosystems

Brian Mealor, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Introduction

Introduced annual and perennial grasses pose a severe threat to economic and ecological function of western rangelands. They can alter community composition, disturbance regimes, nutrient and water cycling, and decrease biodiversity. Restoring rangelands from grass invasion requires an understanding of priority effects – the impact of early arrival of one species on later arrivals – and in impact of relative early growth rates. Native, cool-season, small-statured perennial bunchgrasses occupy a similar temporal niche to invasive grasses, which could help them compete and assist in successful rangeland restoration.

Objectives

The objective of this study was to compare emergence day, early growth rates, and biomass production of five invasive grasses and four native cool-season bunchgrasses.

Methods

We conducted two trials of a randomized complete block design. We planted four native species: prairie junegrass ((*Koeleria macrantha* (Ledeb.) J.A. Schultes), muttongrass (*Poa fendleriana* (Steud.) Vasey), squirreltail (*Elymus elymoides* (Raf.) Swezey), and spike trisetum (*Trisetum spicatum* (L.) K. Richt.), and five invasive species: cheatgrass (*Bromus tectorum* L.), Japanese brome (*Bromus japonicus* Houtt.), medusahead rye (*Taeniatherum caput-medusae* (L.) Nevski), ventenata (*Ventenata dubia* (Leers) Coss.) and bulbous bluegrass (*Poa bulbosa* L.) alone in cone-tainers in the greenhouse. We measured emergence day and grew the plants for 76 days before transplanting to 1.2 L pots. Plants grew for another 93 days (2018 trial) and 95 days (2020 trial) in the greenhouse. We harvested aboveground biomass from all plants, dried them in a forced-air oven at 60°C for 48 hours, and weighed to the nearest centigram.

Results and Discussion

Emergence date, growth rate, and final biomass production varied across species in 2018 and 2020 (Fig. 1). Ventenata and bulbous bluegrass emerged later than all other species in 2018 (Fig. 1). The native grasses emerged with similar timing to the remaining invasive grasses in 2018, but in 2020 the native perennials emerged later than all invasive grasses except ventenata (Fig. 1). In 2018, native grasses had slower growth rates than cheatgrass and bulbous bluegrass, but in 2020 they grew slower than cheatgrass, Japanese brome, medusahead, and bulbous bluegrass (Fig. 1). Cheatgrass produced more biomass than all native grasses in 2018, while other invasive grasses produced similar biomass to native grasses (Fig. 1). In 2020, all invasive grasses except ventenata produced more biomass than native grasses. Our findings provide support that early rapid growth rates may be responsible for the success of invasive grasses over native perennial grasses. Although the native grasses were able to emerge with, or closely after, the invasive grasses, their slower growth rates ultimately led to lower biomass production at the end of the study.

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Contact

Brian Mealor, bamealor@uwyo.edu, (307) 673-2647

Keywords

competition, native perennial bunchgrasses, invasive grasses

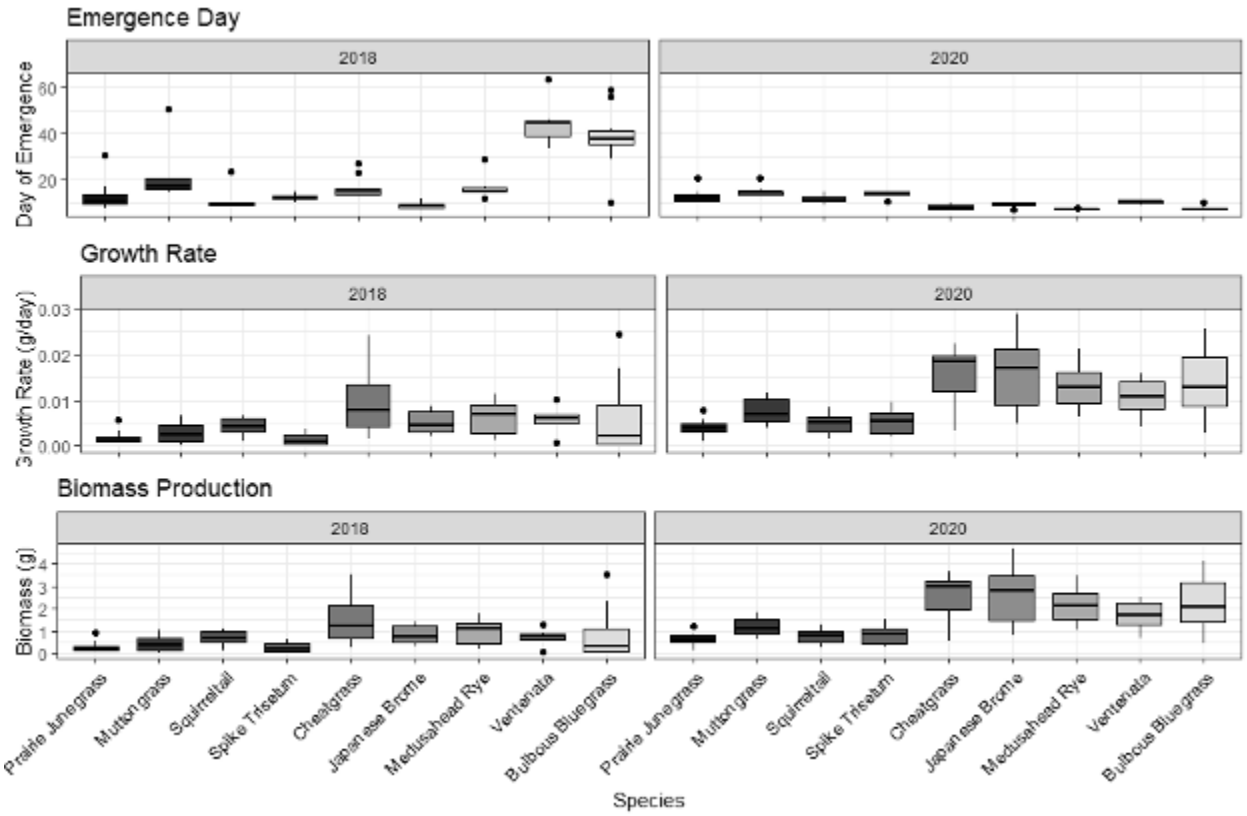

Figure 1. Emergence day, growth rate, and biomass production of four native and five invasive grasses grown alone under greenhouse conditions in 164 ml cone-tainers for 76 days and 1.2 L pots for the remainder of the study. Final biomass was collected at 169 days of growth in 2018 and at 171 days of growth in 2020.

Comparing Root and Shoot Production of Invasive Grasses and Cool-Season Perennial Bunchgrasses

Jaycie Arndt, University of Wyoming Extension, Institute for Managing Annual Grasses Invading Natural Ecosystems

Brian Mealor, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Introduction

Introduced annual and perennial grasses pose a severe threat to economic and ecological function of western rangelands. They can alter community composition, disturbance regimes, nutrient and water cycling, and decrease biodiversity. Native, cool-season, small-statured perennial bunchgrasses occupy a similar temporal niche to invasive grasses, which could help them compete and assist in successful rangeland restoration. Aboveground and belowground growth could influence competition between these two function groups.

Objectives

The objective of this study was to compare root and shoot biomass production of five invasive grasses and four native cool-season bunchgrasses.

Methods

We conducted a greenhouse experiment using a randomized complete block design. We planted four native species: prairie junegrass ((*Koeleria macrantha* (Ledeb.) J.A. Schultes), muttongrass (*Poa fendleriana* (Steud.) Vasey), squirreltail (*Elymus elymoides* (Raf.) Swezey), and spike trisetum (*Trisetum spicatum* (L.) K. Richt.), and five invasive species: cheatgrass (*Bromus tectorum* L.), Japanese brome (*Bromus japonicus* Houtt.), medusahead rye (*Taeniatherum caput-medusae* (L.) Nevski), ventenata (*Ventenata dubia* (Leers) Coss.) and bulbous bluegrass (*Poa bulbosa* L.) alone in 164 ml cone-tainers in the greenhouse. We harvested above and belowground biomass of five replicates of each species at 14, 21, 35, 42, 56, and 63 days after planting.

Results and Discussion

Biomass production, both aboveground and belowground, varied by species (Fig. 1). Bulbous bluegrass and medusahead produced more shoot biomass than native grasses (Fig. 1). Cheatgrass, Japanese brome, and medusahead produced more root biomass than native grasses, but ventenata and bulbous bluegrass had similar root biomass production to the native grasses (Fig. 1). All species show similar growth characteristics, until day 35, when some of the invasive grasses, (cheatgrass, Japanese brome, medusahead, and bulbous bluegrass), begin to rapidly produce root and shoot biomass (Fig. 2). All species, except bulbous bluegrass, show similar growth trends above and below ground (Fig. 2). Bulbous bluegrass rapidly produced aboveground biomass with very little belowground biomass (Fig. 2). As a general trend, invasive species produced more above and belowground biomass than native species.

Acknowledgments

We thank the ShREC staff and interns for assistance during this project.

Contact

Brian Mealor, bamealor@uwyo.edu, (307) 673-2647

Keywords
root and shoot growth, native perennial bunchgrasses, invasive grasses

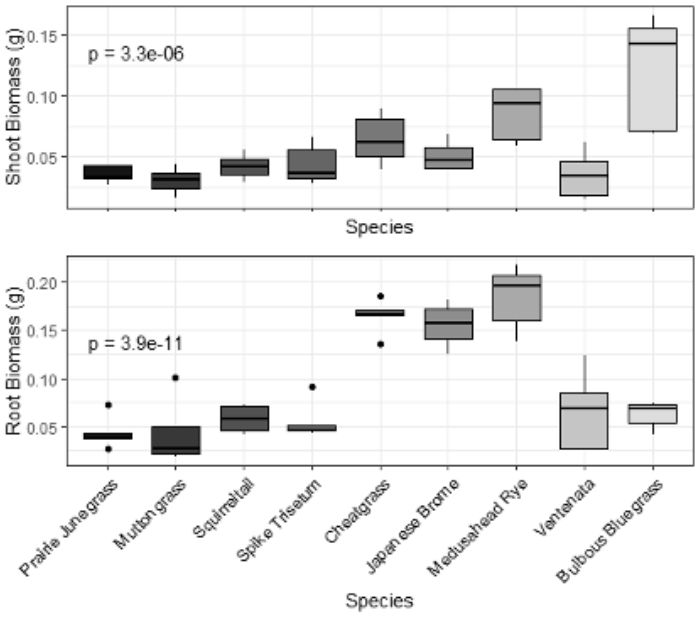

Figure 1. Shoot and root biomass of four native and five invasive grasses grown alone under greenhouse conditions in 164 ml cone-tainers. Biomass was collected 63 days after planting.

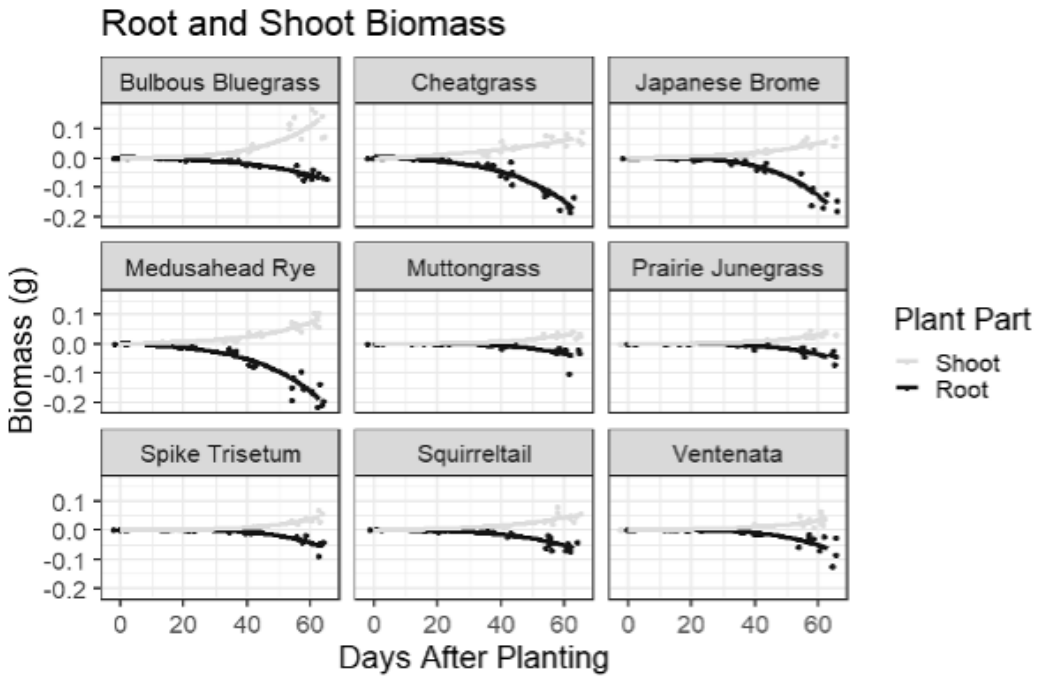

Figure 2. Non-linear regression root and shoot biomass through time for species grown alone under greenhouse conditions in 164 ml cone-tainers. Biomass was collected through destructive sampling 14, 21, 35, 42, 56, and 63 days after planting.

Field Establishment and Seed Production of Native, Cool-season, Perennial Bunchgrasses

Jaycie Arndt, University of Wyoming Extension, Institute for Managing Annual Grasses Invading Natural Ecosystems

Brian Mealor, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Introduction

Native seed production for use in seeding projects has increased in recent years. Prairie junegrass ((*Koeleria macrantha* (Ledeb.) J.A. Schultes), muttongrass (*Poa fendleriana* (Steud.) Vasey), squirreltail (*Elymus elymoides* (Raf.) Swezey), and spike trisetum (*Trisetum spicatum* (L.) K. Richt.) are commonly found native perennials that provide forage for wildlife and livestock, are drought tolerant, and emerge early in the spring. Native, cool-season, perennial bunchgrasses occupy a similar temporal niche to invasive grasses, which could help them compete and assist in successful rangeland restoration.

Objectives

The objective of this study was to assess field establishment and survival of four native cool-season bunchgrasses and assess seed production of five prairie junegrass accessions.

Methods

We seeded each of the native species and crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.) into a retired, dryland, agronomic field at the University of Wyoming Sheridan Research and Extension Center in Wyarno, Wyoming. Crested wheatgrass is a non-native species that is known for emerging well, so it was added to the study as a 'standard' comparison. We used a randomized complete block design with four replicates with seeding rates of: 0.56 kg pure live seed (PLS)/ ha locally (Johnson County) collected prairie junegrass, 0.56 kg PLS/ha 'Ochoco' prairie junegrass, 2.7 kg PLS/ha 'Ruin Canyon' muttongrass, 7.9 kg PLS/ha 'Pueblo' squirreltail, 1.2 kg PLS/ha 'ARC Sentinel' spike trisetum, and 7.3 kg PLS/ha 'Ephraim' crested wheatgrass. Seed was purchased from Granite Seed Company in Lehi, UT. Each plot consisted of six rows 15 cm apart and 1.5 meters long. We planted into the field in April of 2019 with a target seeding depth of 0.635 cm. In August 2019, July 2020, and July 2021 we counted the number of established seedlings in the middle two rows of each plot. We collected seed from all prairie junegrass plots in July of 2020, cleaned the seed, and weighed bulk seed production.

Results and Discussion

As anticipated, crested wheatgrass had the highest establishment and survival throughout the study (Fig. 1). Three of the local varieties of prairie junegrass and squirreltail had higher establishment as well (2-4% avg., Fig. 1). The commercially-available variety of prairie junegrass used in the greenhouse experiments (Ochoco) had very poor field establishment (Fig. 1). Plant density shows similar trends where crested wheatgrass had the highest plant density (>150 plants/m^2) after three years of establishment, followed by squirreltail and three field varieties of prairie junegrass (Fig. 1).

The local accession prairie junegrass 932B had the highest average seed production (46.6 g/m^2) followed by prairie junegrass 030 (16.3 g/m^2, Fig. 2). The commercially available variety (Ochoco) had the lowest seed production (3.05 g/m^2, Fig. 2). Our results indicate that locally adapted seed may establish and produce more seed.

Acknowledgments

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Contact

Brian Mealor, bamealor@uwyo.edu, (307) 673-2647

Keywords

seed production, native perennial bunchgrasses

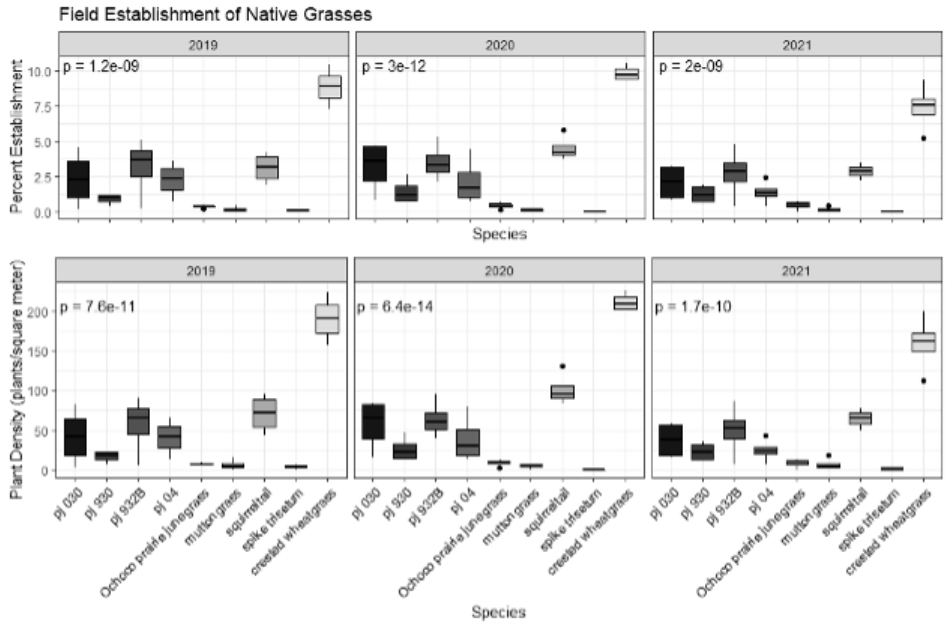

Figure 1. Field establishment of native grasses. Five perennial species, including five varieties of prairie junegrass and one variety of each remaining perennial species, were planted in April of 2019 in Wyarno, Wyoming. Establishment results were collected August of 2019, July 2020, and July 2021.

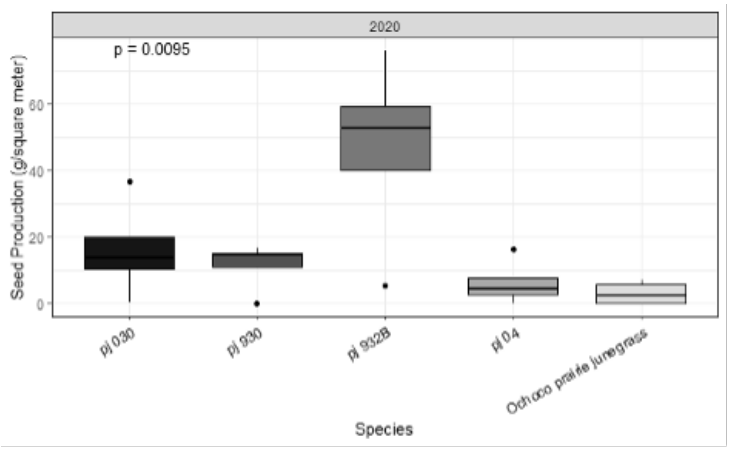

Figure 2. Bulk seed production of for locally collected accessions of prairie junegrass and one commercially available variety. pj=prairie junegrass. Seeds were planted in April of 2019 in Wyarno, Wyoming. Seed was collected July 2020.

Comparing Population Performance of Two Establishment Methods for Sulphur-flower Buckwheat and Desert Biscuitroot

Jaycie Arndt, University of Wyoming Extension, Institute for Managing Annual Grasses Invading Natural Ecosystems

Brian Mealor, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Introduction

Some native species are highly desirable in reclamation and restoration settings, but seed availability is limited because the species is challenging to effectively establish, grow, harvest, clean, and condition. We evaluated seed increase methods of native plants sulphur-flower buckwheat (*Eriogonum umbellatum* Torr.) and desert biscuitroot (*Lomatium foeniculaceum* J.M. Coult. & Rose). Both species provide forage and habitat for sage-grouse, naturally occur in western rangelands, poorly establish following disturbance, and are expensive in restoration.

Objectives

The objective of this study was to analyze the difference in establishment and survival between transplanting and direct seeding establishment methods for desert biscuitroot and sulphur-flower buckwheat.

Methods

Direct Seeding Method: We seeded both species directly into the field on October 31st, 2017 using a push propelled belt seeder. The target seeding depth was ½ inch. We seeded desert biscuitroot at rate of 28 pure live seeds/foot and sulphur-flower buckwheat at a rate of 13 pure live seeds/foot.

Transplanting Method: We soaked desert biscuitroot seeds in distilled water for 24 hours before placing them in containers with moist filter paper in a cooler on February 6th, 2017. On February 17th, 2017, we placed sulphur-flower buckwheat seeds in containers with moist filter paper in a cooler. As seeds germinated, we transferred them into four-inch potting containers in a greenhouse and grew the seedlings for two months before transplanting into the field in May 2017.

Data Collection: We counted and recorded the number of surviving plants in each block in May of 2018-2020. Data were analyzed with a mixed-effects model to test for differences in establishment and survival by planting method for desert biscuitroot and sulphur-flower buckwheat. To look at stage-specific establishment (%) and survival (%), we evaluated differences for each planting method at incremental growth stages. We tested for significance using paired t-tests at each stage.

Results and Discussion

Desert biscuitroot had higher levels of establishment and survival with direct seeding (320.3 plants/block) when compared with transplanting (45.8 plants/block, Figure 1). In the incremental growth stage from seed to establishment and establishment to first year survival, desert biscuitroot was more successful under the direct seeding method. The first year to second year survival and the overall survivorship was equal for both planting methods (Table 1).

Overall, sulphur-flower buckwheat establishment and subsequent survival was higher with transplants (80.9 plants/block) than direct seeding (5.6 plants/block, Figure 1). Sulphur-flower buckwheat had higher establishment in the

seed to establishment stage and higher survivorship with the transplanting method. Establishment to first year survival and first to second year survival was similar between planting methods (Table 1).

Our research suggests that direct seeding is a preferred planting method for desert biscuitroot and transplanting is the preferred planting method for sulphur-flower buckwheat.

Acknowledgments

We thank the ShREC staff and interns for assistance with planting and maintenance of the forbs.

Contact

Brian Mealor, bamealor@uwyo.edu, (307) 673-2647

Keywords

population performance, native species

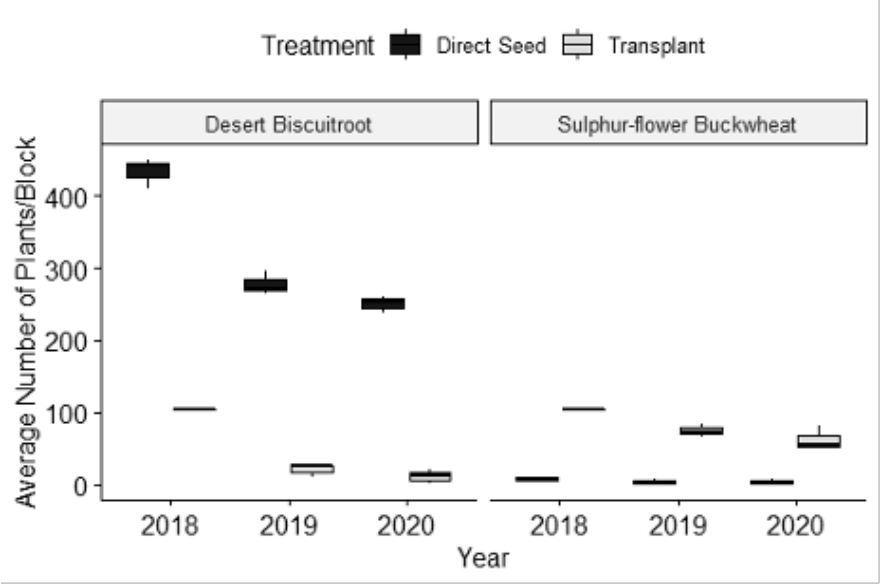

Figure 1. Box and whisker plot showing number of plants per block for desert biscuitroot and sulphur-flower buckwheat using direct seeding and transplanting methods in 2018, 2019, and 2020.

Table 1. Percent of individuals at end of each growth stage and overall survivorship using direct seeding and transplanting methods. P-value from paired t-test at each life stage. p-value <0.05 is significant (S). Data collected May 2018, 2019, and 2020 in Sheridan, Wyoming.

	Desert Biscuitroot			Sulphur-flower Buckwheat		
Growth Stage	**Direct Seeding mean**	**Transplant mean**	**p-value**	**Direct Seeding mean**	**Transplant mean**	**p-value**
	%	%		%	%	
Seed to Establishment	10.0%	36.6%	S	0.3%	51.2%	S
Establishment to Year 1 Survival	63.9%	19.7%	S	65.6%	71.4%	NS
Year 1 to Year 2 Survival	90.6%	47%	NS	100%	82.7%	NS
Survivorship	5.8%	4.1%	NS	0.2%	30.7%	S

Comparing Production Costs of Two Establishment Methods for Sulphur-flower Buckwheat and Desert Biscuitroot

Jaycie Arndt, University of Wyoming Extension, Institute for Managing Annual Grasses Invading Natural Ecosystems

Brian Mealor, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Introduction

Some native species are highly desirable in reclamation and restoration settings, but seed availability is limited because the species is challenging to effectively establish, grow, harvest, clean, and condition. We evaluated seed increase methods of native plants sulphur-flower buckwheat (*Eriogonum umbellatum* Torr.) and desert biscuitroot (*Lomatium foeniculaceum* J.M. Coult. & Rose). Both species provide forage and habitat for sage-grouse, naturally occur in western rangelands, poorly establish following disturbance, and are expensive in restoration.

Objectives

The objective of this study was to analyze the difference in costs between transplanting and direct seeding establishment methods in an agronomic setting.

Methods

Direct Seeding Method: We seeded both species directly into the field on October 31st, 2017 using a push propelled belt seeder. The target seeding depth was ½ inch. We seeded desert biscuitroot at rate of 28 pure live seeds/foot and sulphur-flower buckwheat at a rate of 13 pure live seeds/foot.

Transplanting Method: We soaked desert biscuitroot seeds in distilled water for 24 hours before placing them in containers with moist filter paper in a cooler on February 6th, 2017. On February 17th, 2017, we placed sulphur-flower buckwheat seeds in containers with moist filter paper in a cooler. As seeds germinated, we transferred them into four-inch potting containers in a greenhouse and grew the seedlings for two months before transplanting into the field in May 2017.

Maintenance: Both species were watered during the establishment stage of the study, (64 hours over the span of the first two summers). We applied Roundup WeatherMAX at a rate of 32 oz/ac in 2018 to all treatments using shielded application. In 2019, we applied Vaquero to the desert biscuitroot treatments at 8 oz/ac and Esplanade 200 SC to all treatments at 5 oz/ac. We used mechanical weeding 2017-2019 for any remaining weeds following herbicide applications. We used an 18-inch rototiller to weed the inter-rows, hoes to weed between the forbs, and hand weeding directly around the forbs.

Cost Analysis: We evaluated the cost of each establishment method, including the cost of seed, labor, equipment, and maintenance. We did not include the cost of existing infrastructure, such as greenhouse, cooler, tractor, drill seeder, hoses, rototiller, hoes, or herbicide application equipment. We started by estimating costs for the study area and then scaled to the cost for one acre of seed production. We also determined the cost per surviving plant for the third year of production. Seed was purchased from Granite Seed Company in Lehi Utah at $110 per lb. of pure live seed of sulphur-flower buckwheat and $180 per lb. of pure live seed of desert biscuitroot. We assumed labor costs at $10 per hour for planting in the greenhouse and in the field and for maintenance. Equipment included potting containers, trays to hold the containers, soil, and fuel for the drill-seeder and rototiller. Potting container and tray costs were prorated over a five-year lifetime expectancy. We determined equipment costs from actual unit costs ($0.02/potting

container, $1.51/tray, $27.13/soil bale, $2.20/gal fuel). Although we used a belt seeder for the field experiment, we estimated the cost of fuel for a motorized drill-seeder, which would be used at a one-acre scale. We estimated the amount of water used in one summer through a hose and sprinkler system for the study site and then used the average price of water in Wyoming, $8.64/acre-foot, for final cost calculation. Herbicide application rates were $45/acre for Esplanade 200 SC, 6.70/acre for Vaquero, $7/acre for Roundup WeatherMAX, and $8/acre for non-ionic surfactant.

Results and Discussion

There were more surviving desert biscuitroot plants after 3 years of production when direct seeding was used (53,627 plants/acre). Production was more expensive with the transplanting method ($30,107.33) than with direct seeding ($24,418.88). The cost per plant at the end of three years was cheaper with direct seeding.

After three years of sulphur flower buckwheat production, the direct seeding method had 903 plants/acre while the transplanting method had 12,132 plants/acre. The overall cost for production was lower with direct seeding ($15,978.76) than transplanting ($22,324.51). However, the cost per plant at the end of three years of production was cheaper with transplanting.

Weeding was the highest cost for both planting methods and both species. The labor for transplant planting was also a large expense at $5162.67/acre. Water and herbicide costs did not differ between methods. Seed cost was higher with the direct seeding method for both species. Planting labor and equipment costs were higher with the transplanting method.

Although we found clear differences between methods, available resources and restoration goals should also be taken into account when deciding on a planting method.

Acknowledgments

We thank the ShREC staff and interns for assistance with planting and maintenance of the forbs.

Contact

Brian Mealor, bamealor@uwyo.edu, (307) 673-2647

Keywords

seed production, native species

Table 1.1. Outcomes and costs of desert biscuitroot and sulphur-flower buckwheat production using direct seeding and transplanting methods. Results describe the cost per acre in Sheridan, Wyoming from 2017-2020. May 2019 survival data used to extrapolate to one acre of production.

Species	**Desert Biscuitroot**		**Sulphur-flower Buckwheat**	
Planting Method	**Direct Seed**	**Transplant**	**Direct Seed**	**Transplant**
	Value/acre	**Value/acre**	**Value/acre**	**Value/acre**
Surviving Plants	53,627	2,258	903	12,132
Seed Cost	$1,089	$54.45	$407.58	$30.33
Planting Labor Cost	$10	$5,162.67	$10	$5,162.67
Equipment Cost	$11	$1,581.33	$11	$1,581.33
Weeding Cost	$23,232	$23,232	$15,488	$15,488
Water Cost	$10.18	$10.18	$10.18	$10.18
Herbicide Cost	$66.70	$66.70	$52.00	$52.00
Total Cost/ Acre	**$24,418.88**	**$30,107.33**	**$15,978.76**	**$22,324.51**
Cost/Surviving Plant	**$0.46**	**$13.33**	**$17.69**	**$1.84**

Effect of Various Herbicides on Medusahead Seed Viability

Beth Fowers, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Brian Mealor, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Introduction

Invasive annual grasses cause a multitude of issues including outcompeting native species, increasing fire potential, and potential damage to grazing animals from awns. Herbicides are often the preferred method for control of annual grasses. But the major herbicides are most effective applied pre-emergent. Medusahead wildrye (*Taeniatherum caput-medusae*) is relatively new to Wyoming. Major efforts are in place to work towards complete eradication of the species but if new populations are discovered after emergence other options are of interest. Some growth regulator herbicides can reduce viability of seed produced by annual grasses. This reduction can help control presence and growth of a population of invasive species by reducing seed input. However, not much is known about the impacts of these or similar herbicides on medusahead.

Objectives

Our objectives were to evaluate various herbicides applied at different post-emergent timings in terms of short term seed viability and subsequent annual grass weed control.

Materials and Methods

We applied six different herbicides/rates at two different timings (21 May and 11 June) in 2020 with a total volume of 20 gallons per acre with a CO_2-pressurized sprayer and a 10-foot boom with six 8002 nozzles. Treatments were implemented in 10- by 25- foot plots set in a randomized complete block design with four replicates and a replicated, non-treated check. Treatments included Milestone (4.1 or 6.7 fl oz/ac), Loyant (3.15 or 5.3 fl oz/ac), and Duracor (12 or 20 fl oz/ac). At the first application, annual grasses were 3-5 inches tall and were early boot. At the second application, medusahead was headed out and in the soft dough stage or just prior.

Evaluation in 2020 included whole plot ratings and cover estimates of major species at the whole plot level as well as collection of 30 stems/plot of invasive annual grasses medusahead, Japanese brome (*Bromus japonicus*), and ventenata (*Ventenata dubia*), if present in the plot. We evaluated cumulative germination using 50-seed lots in small containers with filter paper in a growth chamber set at 68° F daytime (12 hour day) and 59° F nighttime temperatures for one month. Data collection in 2021 included whole plot ratings and cover by species using two ¼ m^2 frames per plot.

Results and Discussion

Due to space constraints, we only present information on germination from target invasive annual grass species, and a clear pattern is evident. Herbicide treatments containing aminopyralid (Milestone and Duracor) dramatically reduced germinability of medusahead, ventenata, and Japanese brome when applied at the May timing. No herbicides affected germinability at the June application timing, and Loyant alone did not affect germinability of any target species (Table 1). Our results indicate that aminopyralid-based herbicides may be useful for reducing seed viability of naturally-occurring stands of the three target invasive grasses. Medusahead was particularly susceptible to this treatment.

Table 1. Germination rate from medusahead, ventenata, and Japanese brome seeds collected from plants treated with one of 6 herbicide treatments at one of two timings in May or June 2020. Different letters indicate significant differences ($p>0.05$) within a column.

Name	Rate		Application timing	Medusahead germination (%)	Ventenata germination (%)	Japanese brome germination (%)
Duracor	12	fl oz/a	21 May	0.5 b	3.5 c	9 b
Duracor	20	fl oz/a	21 May	0 b	6 c	2 b
Loyant	3.15	fl oz/a	21 May	97 a	79 b	99.3 a
Loyant	5.3	fl oz/a	21 May	97.5 a	68.7 b	92 a
Milestone	4.1	fl oz/a	21 May	0.5 b	6 c	2.5 b
Milestone	6.7	fl oz/a	21 May	1.5 b	4 c	0 b
Duracor	12	fl oz/a	11 June	94.5 a	95 a	66.7 a
Duracor	20	fl oz/a	11 June	95 a	76 b	80 a
Loyant	3.15	fl oz/a	11 June	95 a	78 b	98 a
Loyant	5.3	fl oz/a	11 June	95 a	76 b	99 a
Milestone	4.1	fl oz/a	11 June	93.5 a	74.7 b	94 a
Milestone	6.7	fl oz/a	11 June	97 a	83 ab	97 a
Nontreated				94 a	71.3 b	100 a

Acknowledgments

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Contact

Brian Mealor, bamealor@uwyo.edu, (307) 673-2647

Keywords

herbicide, invasive plant, seed viability

PARP III, 3, 5, 7

Cheatgrass Control by Application of Herbicides at Various Timings

Beth Fowers, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Brian Mealor, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Introduction

Cheatgrass (*Bromus tectorum*) is an invasive annual grass which causes many negative impacts to ecosystems. Best management options for the species typically include herbicide applications. The impacts of new herbicides can increase effectiveness, but sometimes the timing of application may not be as well known for greatest control and effectiveness of the chemical.

Objectives

The objective of this study was to determine if timing of herbicide application makes a difference in effectiveness of herbicides and if some chemicals are more effective than others.

Materials and Methods

We applied six herbicide mixtures at three different timings (July 2019, August 2019, and March 2020) with a total volume of 20 gallons per acre with a CO_2-pressurized sprayer and a 10-foot boom with six 8002 nozzles. Treatments were implemented in 10- by 25- foot plots set in a randomized complete block design with three replicates and a replicated, non-treated check. Treatments included Rejuvra (5 oz/ac), Plateau 2L (5 oz/ac), Plateau 2L (7 oz/ac), Rejuvra + Plateau 2L (5 + 5 oz/ac), Rejuvra + Plateau 2L (5 + 7 oz/ac), and Esplanade Sure (4.5 oz/ac).

Applications on July 8, 2019 occurred with a 67°F air temperature, 69% relative humidity, 62°F soil temperature at 2 inches deep, and 2.5 mph wind. Applications on August 2, 2019 occurred with a 88°F air temperature, 34% relative humidity, 75°F soil temperature at 2 inches deep, and 1 mph wind. Application on March 27, 2020 occurred with a 47°F air temperature, 47% relative humidity, 45°F soil temperature at 2 inches deep, and 4.5-7 mph wind. Annual grasses were dormant (pre-emergence) at the 2019 applications. At the 2020 application, annual grasses were around 2 inches tall (post-emergence), perennial grasses were green and 4 inches tall while forbs were small and in the rosette stage or with only a few true leaves. We visually evaluated cheatgrass control in 2020 and 2021 by comparing to nontreated plots and by recording cover of all species in two ¼ m^2 frames/plot.

Results and Discussion

In the first growing season, post-emergence application resulted in most herbicides exhibiting reduced control compared to pre-emergence applications. Esplanade Sure consistently provided close to 100% control across all timings. The combined Esplanade and Plateau treatments had the highest degree of control, except in the post-emergence timing where the lower rate showed less control. The other herbicides exhibited over 70% control. However, Rejuvra alone had less than 40% control when applied post emergent in the year of treatment. This study illustrates the importance of herbicide application timing as well as the options that are available for control of cheatgrass. Herbicide application can be very effective at early pre-emergence timings. When post-emergence application is necessary, several options exist for effective tank-mix partners with Rejuvra.

Acknowledgments
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Contact
Brian Mealor, bamealor@uwyo.edu, (307) 673-2647

Keywords
cheatgrass, weed management, invasive species

PARP III:5, 7

Herbicide Control of Ventenata at Different Application Times

Beth Fowers, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Brian Mealor, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Introduction

Ventenata (*Ventenata dubia*) is an introduced, invasive annual grass relatively new to Sheridan County and has been aggressively managed since its confirmed presence in 2016. Herbicides offering the best control are applied pre-emergence. The duration of time between herbicide application and target species emergence may affect control depending on potential environmental degradation during that time period. For example – if a herbicide partially degrades while "waiting" for ventenata to emerge, then its efficacy will be significantly reduced. Pre-emergent herbicides able to reside in the soil at phytotoxic levels with longer application-emergence durations will give weed managers an expanded temporal opportunity for applications throughout the season.

Objectives

Our objective is to determine if there is a limit to how early various herbicides can be applied pre-emergence and still gain sufficient control against ventenata.

Materials and Methods

We applied four herbicide mixtures at three different timings (June, July, and August) in 2018 with a total volume of 20 gallons per acre with a CO_2-pressurized sprayer and a 10-foot boom with six 8002 nozzles. Treatments were implemented in 10- by 30- foot plots set in a randomized complete block design with four replicates and a replicated, non-treated check. The study was implemented at two sites outside Sheridan, Wyoming. Treatments included Rejuvra (5 oz/ac), Rejuvra (7 oz/ac), Rejuvra + Plateau 2L (5 + 7 oz/ac), and Rejuvra + Matrix (5 + 3 oz/ac). We visually evaluated ventenata control annually in 2019, 2020, and 2021 by comparing to nontreated plots. The first two years, cover by species was recorded at the plot level, in 2021, we recorded cover by species in two ¼ m^2 frames/plot.

Results and Discussion

Near-complete control (>95%) of ventenata was observed in all herbicide-treated plots, irrespective of timing in both 2019 and 2020 (1 and 2 years after treatment). Few, scattered plants were found in a few plots near the edges, but those could have occurred in areas where herbicide application may not have been as consistent due to wind at application. With the release from annual grass dominance, perennial grass species also showed visible positive responses. One site received heavy grazing pressure during the growing season, which likely impacted the species and diversity at the site, but ventenata control was remained very high.

The ability to extend the period in which applications can occur may allow for an increase in potential application area in a given year, which may be an important variable with an aggressive management strategy such as that being implemented for ventenata in NE Wyoming.

Acknowledgments

We thank ShREC interns for their help with project implementation and data collection.

Contact
Brian Mealor, bamealor@uwyo.edu, (307) 673-2647

Keywords
cheatgrass, weed management, invasive species

PARP III: 5, 7,

Evaluating Impacts of Newer Herbicides on Big Sagebrush

Beth Fowers, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Brian Mealor, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Introduction

While sagebrush may offer resources for wildlife habitat, in other areas it is undesirable as it can reduce grass yield for grazing livestock. Large shrubs can also inhibit movement through an area. While herbicide use in controlling sagebrush is common, the impact of new herbicides are of interest. Information about impacts to big sagebrush can help land managers decide which herbicide options are safe for sagebrush in areas where it needs to be conserved and which herbicides may be effective in strategic control of sagebrush in areas where it has become too abundant.

Objectives

Our objective is to determine the impact of various herbicides on sagebrush.

Materials and Methods

We applied seven herbicide mixtures with a total volume of 20 gallons per acre with a CO_2-pressurized sprayer and a 10-foot boom with six 8002 nozzles on 2 June 2021. Treatments were implemented in 10- by 30- foot plots set in a randomized complete block design with four replicates and a replicated, non-treated check. Treatments included Duracor (20 fl oz/ac), Duracor+2,4-D Ester LV (20 fl oz/ac+22.9 fl oz/ac), Duracor+Freelexx (20 fl oz/ac+33.3 fl oz/ac), Duracor+2,4-D Ester LV+Escort WG (20 fl oz/ac+22.9 fl oz/ac+1 oz/ac), Duracor+Freelexx+Escort WG (20 fl oz/ac+33.3 fl oz/ac+1 oz/ac), 2,4-D Ester LV (22.9 fl oz/ac), and 2,4-D Ester LV+Escort WG (22.9 fl oz/ac+1 oz/ac). All treatments included the surfactant Activator 90 at 0.25% v/v. We visually evaluated damage to sagebrush plants 30, 60, and 90 days after application by comparing to nontreated plots.

Results and Discussion

Many of the herbicides and combinations we evaluated showed early injury (10 days after treatment – DAT) to sagebrush. The exception was Duracor alone, which maintained the lowest sagebrush injury throughout the study (Table 1). By 42 and 73 DAT, nearly all herbicides produced similar sagebrush control as 2,4-D low-volatile ester formulation (LVE), which has long been used as an effective sagebrush control herbicide. Given current, widespread emphasis on sagebrush conservation, land managers treating noxious weeds during the Spring with the herbicides included in this study should be aware that injury to big sagebrush is likely. Duracor alone yielded the lowest sagebrush injury, and of the herbicides evaluated here, may provide good noxious weed control with relatively low damage to big sagebrush. For land managers seeking to reduce sagebrush cover, many of the herbicides evaluated here are capable of doing so.

Table 1. Sagebrush control (% visual estimation) 10, 42, and 73 days after treatment (DAT) across 8 herbicide treatments in northeast Wyoming. Means with different lower case letters within a column indicate significant differences ($p < 0.05$).

Herbicide	Rate		Sagebrush Control (%) 10 DAT		Sagebrush Control (%) 42 DAT		Sagebrush Control (%) 73 DAT	
DuraCor	20	fl oz/a	17.5	b	20	bc	33.8	b
DuraCor	20	fl oz/a	57.5	a	62.5	a	87.5	a
2,4-D LVE	22.9	fl oz/a						
DuraCor	20	fl oz/a	55	a	48.8	ab	65	a
Freelexx	33.3	fl oz/a						
DuraCor	20	fl oz/a	60	a	70	a	81.3	a
2,4-D LVE	22.9	fl oz/a						
Escort	1	oz/a						
DuraCor	20	fl oz/a	65	a	70	a	90	a
Freelexx	33.3	fl oz/a						
Escort	1	oz/a						
2,4-D LVE	22.9	fl oz/a	66.3	a	76.3	a	85	a
2,4-D LVE	22.9	fl oz/a	67.5	a	83.8	a	87.5	a
Escort	1	oz/a						
Nontreated			10	b	0	c	0	c

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Contact

Brian Mealor, bamealor@uwyo.edu, (307) 673-2647

Keywords

sagebrush management, herbicide

PARP III:7, VI:11

Evaluation of Nutrafix© for Controlling Cheatgrass

Beth Fowers, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Brian Mealor, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Introduction

Cheatgrass (downy brome, *Bromus tectorum*), is an invasive annual grass that through characteristics such as competition and changes in fire cycles, may become a monoculture. Because of the negative impacts, different methods to manage cheatgrass are desired. The most common method is the application of herbicides. However, negative impacts to any remnant desirable species may occur and some individuals or groups may not want to apply traditional herbicides. Nutrafix is a combination of micronutrients which has been put forth as an alternative option for control of annual grasses.

Objectives

Our objective was to determine the effectiveness of different rates of Nutrafix fertilizer on cheatgrass control.

Materials and Methods

We used an 8' wide tractor-pulled fertilizer spreader to apply Nutrafix Oct 9, 2020 to an area dominated by cheatgrass. Treatments were implemented in 8- by 30-foot plots set in a randomized complete block design with four replicates and a replicated, non-treated check. Rates were: 43.75 lbs/ac, 87.5 lbs/ac, 175 lbs/ac, 350 lbs/ac, 700 lbs/ac, and 1400 lbs/ac. We included running checks between all plots to increase consistency of evaluations. The rates were chosen to exhibit what would be the recommended rate as well as rates higher and lower than recommended.

We visually evaluated cheatgrass control in June of 2021 by comparing to non-treated plots and by recording cover of all species in two ¼ m^2 frames per plot.

Results and Discussion

Initial observations of the site before evaluation appeared to show positive impacts for cheatgrass control. However, by mid-summer, only the highest applications showed continued cheatgrass control (Fig. 1). Those application rates are much higher than recommended and also may potentially lead to damage to any remnant perennial species at a site. This product may offer alternatives for cheatgrass control, however, our results show limited feasibility if such high rates are needed to reduce cheatgrass across large acreages. Additional observation of the site will continue into the future to determine if results change with time.

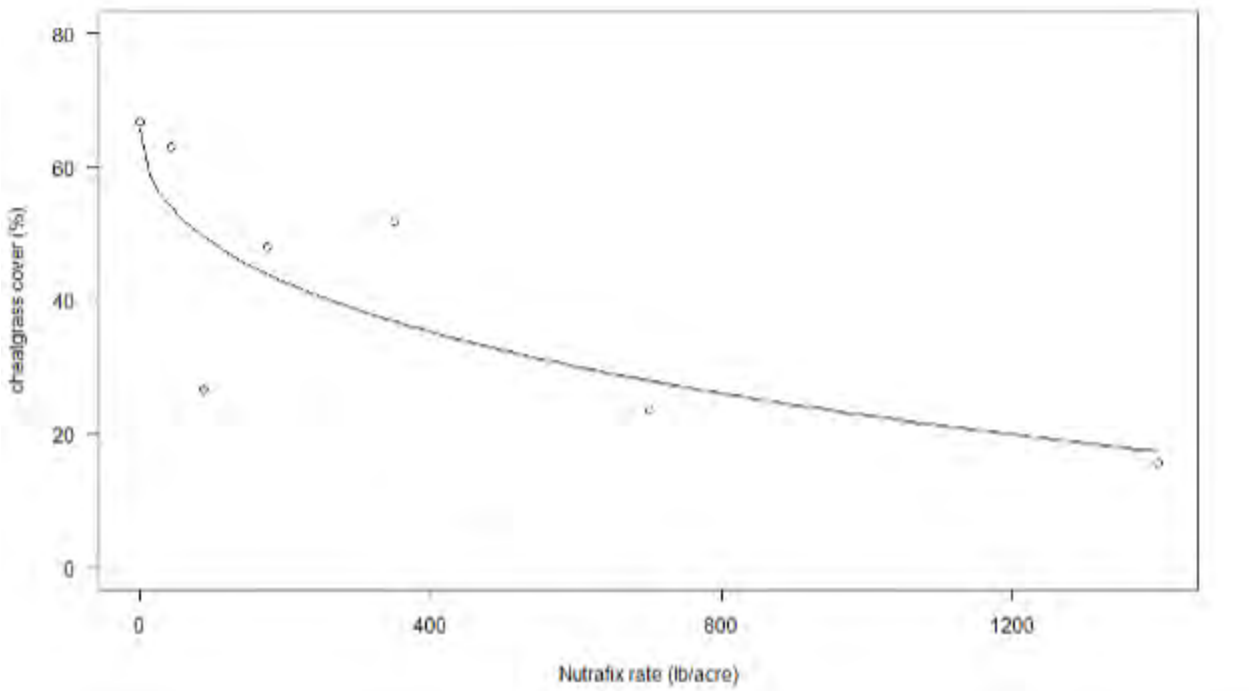

Figure 1. Cheatgrass cover (%) by Nutrafix application rate at a field site near Wyarno, WY in June 2021. Nutrafix was applied in November 2020.

Acknowledgments

We thank ShREC interns for their help with data collection and the application.

Contact

Brian Mealor, bamealor@uwyo.edu, (307) 673-2647

Keywords

weed management, cheatgrass, micronutrients

PARP III: 2, 5, 7, 9

Control of Foxtail Barley with Herbicide Applications

Beth Fowers, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Brian Mealor, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Introduction

Foxtail barley (*Hordeum jubatum*) is a native perennial grass that can reduce hay quality and cause damage to grazing animals because of the awns on the seedheads. Because of the negative impacts of the species, control can be an important component of site management where it occurs. New herbicides may offer additional options for management of the species. However, timing of application may also impact the effectiveness of the herbicides.

Objectives

Our objectives are to determine the effectiveness of different herbicides and application timings on controlling foxtail barley and any negative impacts to desirable species.

Materials and Methods

We applied five herbicides or mixtures at two different timings (29 April and 14 May 2021) with a total volume of 20 gallons per acre with a CO_2-pressurized sprayer and a 10-foot boom with six 8002 nozzles. Treatments were implemented in 10- by 30- foot plots set in a randomized complete block design with three replicates and a replicated, non-treated check. Treatments included Plateau (7 fl oz/ac), Lambient (1.2 oz/ac), Esplanade (5 fl oz/ac), Esplanade + Lambient (5 fl oz/ac + 1.2 oz/ac), and Derigo (1.5 oz/ac). All treatments included the non-ionic surfactant Induce at 0.25% v/v. At the time of the first application, the soil was still saturated with water and a recent snowfall had occurred, plants were 5-6 inches tall and green. At the second application, foxtail barley was around 8 inches tall. We visually evaluated foxtail barley control by comparing to non-treated plots and by recording cover of all species in two ¼ m^2 frames/plot. A third application timing will be added to the trial in fall 2021, randomization of those plots was part of the original project design.

Results and Discussion

Within-season foxtail barley control was high for all herbicides except Esplanade alone (Fig 1.) at both application timings. Desirable grass damage was unfortunately relatively high for many of the herbicides that were effective on foxtail barley (Fig. 2). Desirable grass damage seemed lower at the earlier application in April, suggesting that perennial grasses were able to recover from early suppression by the late June data collection timing. This study will continue into 2022 and will evaluate a fall-timed application for all herbicides as well.

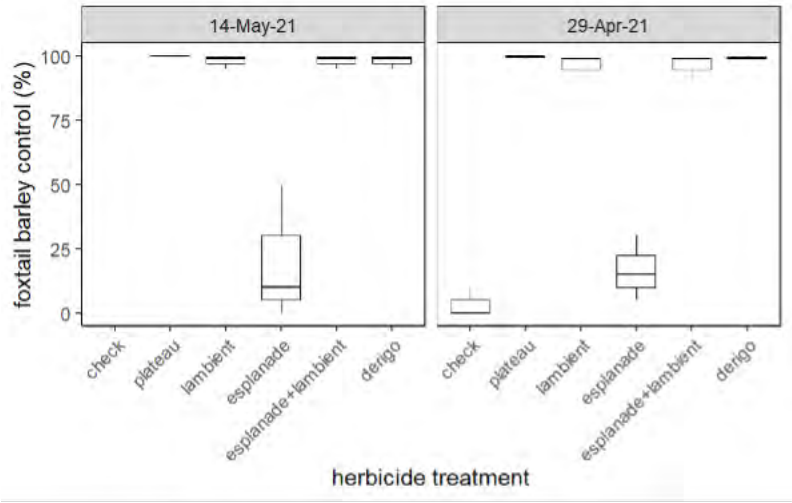

Figure1. Foxtail barley control (%) at two application timings (April and May 2021) for five herbicides and a nontreated check. Evaluations were made in late June 2021.

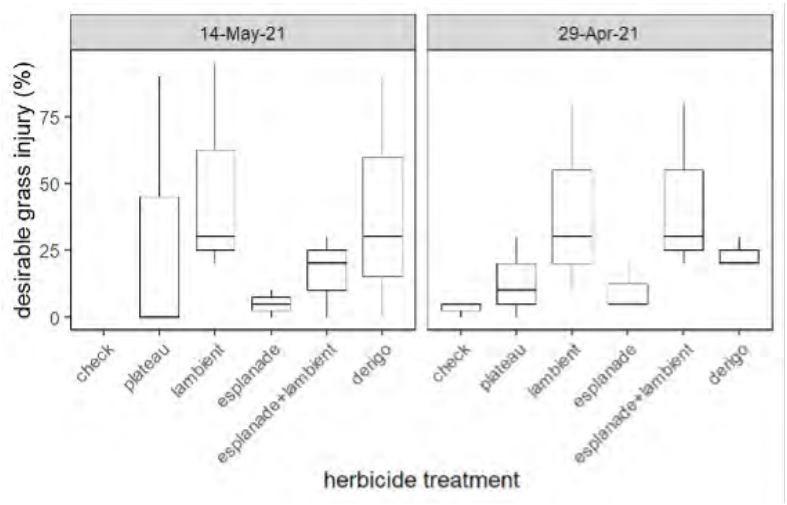

Figure 2. Desirable perennial grass injury (%) at two application timings (April and May 2021) for five herbicides and a nontreated check. Evaluations were made in late June 2021.

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Contact

Brian Mealor, bamealor@uwyo.edu, (307) 673-2647

Keywords

foxtail barley, herbicide, weed management

PARP III: 2, 5, 11

Impact of Indaziflam on Native Species Establishment

Jodie Crose, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Brian Mealor, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Introduction

Indaziflam is a new pre-emergent herbicide with an extended soil residual that is labeled for use in rangeland systems. It is a root-inhibiting herbicide that is selective based on its ability to bind tightly to soil in the upper few cm of the soil profile and effectively control annual species. The role this herbicide has in established rangelands has been evaluated however, less understood is how it may be used in restoration settings. Restoration is a common practice in western rangelands following wildfire, energy development or other disturbances. However, successful restoration can be complicated by invasion of weedy species following disturbance. Indaziflam may be a tool available to control these species providing a window for establishment of planted species.

Objectives

The objective of this study was to evaluate the emergence and establish of various native grass, forb, and shrub species when planted with indaziflam.

Materials and Methods

This study was carried out at the Wyarno Agriculture Experiment station near Wyarno, WY. We applied indaziflam at a rate of 5 oz per acre on July 15, 2019. We applied indaziflam in a split-plot fashion so that either the front or back half of each plot was sprayed. We sprayed all treatments using water as the carrier. We planted forty-five species including both warm and cool season grasses, forbs and several shrubs. All planted species were native except crested wheatgrass. Species we chose to include in this study were determined based on their frequency of occurring naturally in northeast Wyoming and their likelihood of inclusion in restoration projects. We purchased all seed for this study from Granite Seed and Erosion Control (Denver, CO). We planted each species based on its calculated pure live seeding rate. Planting timing was species dependent and took place either in late fall of 2019 or in the spring of 2020 (3 and 8 months after application). We planted species using either a 6-row plot cone-seeder or a single row belt-seeder for shrubs (data not shown). Monitoring of emergence begin in June 2020 (3 and 6 months after planting) and establishment was evaluated in October 2020 (11 and 7 MAP).

Results and Discussion

Native species establishment was always lower with indaziflam. Species that were able to establish despite indaziflam included: basin wildrye, blue grama, bluebunch wheatgrass, bottlebrush squirreltail, crested wheatgrass, green needlegrass, needleandthread, snake river wheatgrass, western wheatgrass, dotted gayfeather, Indian blanketflower, prairie sunflower and rocky mountain beeplant (Fig. 1 &2). Species establishment that was significantly lower ($p < 0.05$) with indaziflam included: blue grama, Indiangrass, muttongrass, and rocky mountain bee plant. Decreased forb density could be a result of less time between herbicide application and planting. The plant-back interval now required for this herbicide is 22 months. Establishment from all species was affected by drought and high temperatures. Forb data should be interpreted cautiously due to grasshopper impact.

Acknowledgments

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Contact

Brian Mealor, bamealor@uwyo.edu, (307) 673-2647

Keywords

indaziflam, restoration, native species

PARP III: 2, 5, 11

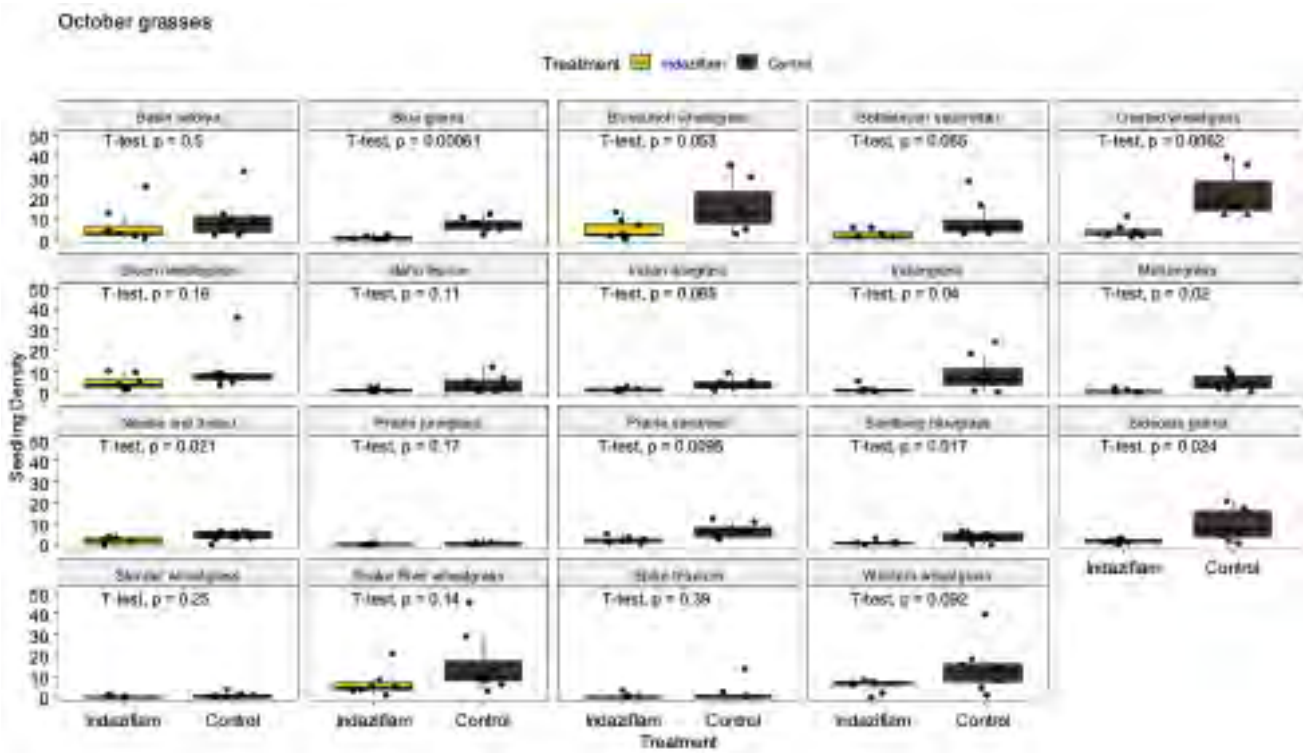

Figure 1: Grass seedling density, by species, with and without indaziflam in October 2020 (7 MAP) at Wyarno, WY.

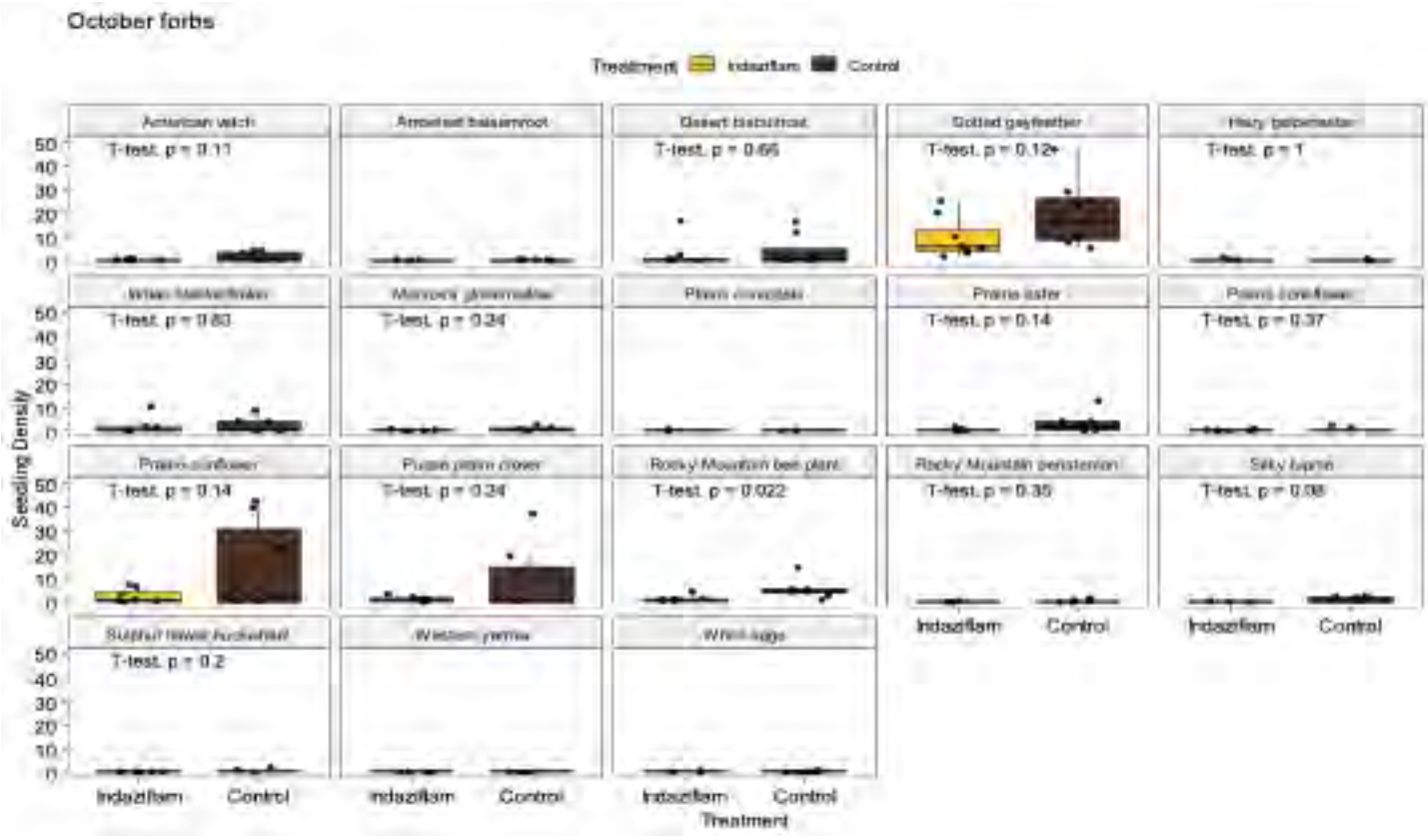

Figure 2: Forb seedling density, by species, with and without indaziflam in October 2020 (11 MAP) at Wyarno, WY.

Does Annual Grass Invasion Affect Rangeland Drought Resistance?

Marshall Hart, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Brian Mealor, Department of Plant Sciences; Institute for Managing Annual Grasses Invading Natural Ecosystems

Introduction

Changes in precipitation, temperature, and CO_2 concentrations are expected for much of the world in the coming decades. Additionally, invasive species have become common in many ecosystems. These changes can have interacting, additive, or opposing effects on ecosystems. Due to the great diversity among invasive species, not all of them will respond the same way in every ecosystem. Whether they are hindered or helped will likely be context dependent and predictions are difficult to make.

Here in Wyoming, forage is one of the most important ecosystem goods due to its importance in the livestock industry. Stability of forage is a necessity for ranchers, especially in drought. Unfortunately, invasive species like cheatgrass and ventenata do not make stable forage bases, but have become common on many of our perennial grass dominated rangelands. As precipitation patterns shift and drought becomes more common, it is unclear whether persisting perennial forages will be enough to maintain the stability of our rangelands.

Objectives

Our objective is to explore the possibility that invasive annual grasses reduce the resistance of rangelands to drought and other predicted changes for northeast Wyoming. We will do this through the lens of cattle production by focusing on forage production.

Materials and Methods

We set up mesocosms of perennial native species under a rain-out shelter. These were subjected to one of three precipitation schedules; normal, drought, and projected changes for northeast Wyoming. Projected changes for this region are larger but less frequent rains than average. They have also been invaded with the invasive annual grass, ventenata, at 0, 25, 50, 75, and 100% invasion. Every combination of precipitation and invasion is represented. We took percent canopy cover and harvested biomass to be dried and weighed.

Results and Discussion

Drought significantly lowered perennial biomass the first year. In the second year, projected changes resulted in higher biomass, while drought and average were similar. A possibility for these patterns is that larger rainfalls in the projected treatment, and a simulated wet spring in the drought treatment, allowed moisture to penetrate deeper into the soil, resulting in less evaporation from the surface. Annual biomass was not affected by precipitation treatments. Unexpectedly, both years of data showed that perennial biomass was not affected by invasion. Explanations for our observations are still being explored.

Acknowledgments

We thank the Natural Resource Conservation Service and the Sustainable Rangelands Roundtable for primary funding of this research. We also thank Amy Cox, Shawna LaCoy, Kelsey Crane, Heidi Schueler, Nancy Webb, Sam Rogaczewski, Rebekah Wells, Cassie Hengel, Rachel Petersburg.

Contact

Brian Mealor, bamealor@uwyo.edu, (307) 673-2647

Keywords

forage, mesocosms, invasion, ventenata, drought

Reproductive Performance of Rams that Failed Breeding Soundness Evaluation: The Need to Reconsider the Evaluation

Brenda M. Alexander, Department of Animal Science, University of Wyoming

Introduction

More than 40 years ago criterion for ram fertility using breeding soundness evaluations was published. These guidelines have been largely unchanged over time. Measures of fertility are difficult to obtain and require large numbers of observations. Because of this, studies necessary to establish fertility are often lacking. A large study analyzing 14,667 breeding soundness examinations determined that approximately 33% of rams were classified as unsatisfactory breeders with almost half of those unsatisfactory due to semen parameters (Van Metre *et al.*, 2012). Semen parameters, similar to those published for bull breeding soundness evaluation, have persisted in spite of a study with 943 rams that reported no difference in pregnancy rates (1:26 ram:ewe) as long as the rams had at least 10% sperm motility (Wierzbowski and Kareta, 1993).

Inflammation of the epididymis, detectable by palpation, is criteria for unsatisfactory breeding soundness and is evidence of *Brucella ovis (B. ovis)* infection. Of the 14,667 breeding soundness examinations, 20% of the rams failed due to inflammation (Van Metre *et al.*, 2012). A subset of rams (n=2317) with epididymitis were tested for serological presence of *B. ovis*. Of those, 10% were seropositive. Of the seropositive rams, 53% had otherwise normal breeding soundness (Van Metre *et al.*, 2012). Epididymal structural changes that accompany *B. ovis* infection are clear. However, influence of infection on flock fertility is lacking.

Breeding soundness evaluations are well-known as best practice management tools, but these evaluations come with costs to the producers. The present data was used to determine the effect on fertility of rams with an unsatisfactory breeding soundness evaluation including being positive for *B. ovis*.

Methods and Results

Rams were evaluated for structural and breeding soundness, presence of *B. ovis*, and palpation for overt epididymitis. Rams were assigned a breeding fitness score (1–4) with 1 = excellent (n=9), 2 = satisfactory (n=28), 3 = questionable (n=3), 4 = unsatisfactory (n=15). Questionable or unsatisfactory rams were determined to have "failed" the breeding soundness examination. Rams with excellent or satisfactory breeding potential "passed" the examination. Following breeding soundness evaluation, rams were managed per producer needs. Rams of various age and experience were placed with ewes in multi-sire breeding pastures. Ram to ewe ratio was approximately 1:30.

At lambing, blood samples were collected from a subset of the ewes (n=379) and at least one of their lambs (n = 468). Paternal genotyping of lambs was determined using microsatellite markers.

Rams that had failed the breeding soundness examination had similar numbers of lambs (8.2 ± 2.3 sem; 95% CI: 3.43 – 12.9) than those that passed (8.7 ± 1.7 sem; 95% CI: 5.37 – 11.98; Fig. 1). Of the 18 rams with failed BSE, 15 were *B. ovis* positive (83% of failed rams). Rams with zero identified offspring did not differ by BSE status. Rams with no identified offspring failed (n=4, 22.2% of failed) as well as passed (n=12, 32.4% of passed) the BSE.

Discussion

Contagious epididymitis is identified as a cause of infertility in rams and has mostly been attributed to infection with *B. ovis*. A computerized economic analysis showed an economic advantage of being *B. ovis* free (Carpenter *et al.*, 1987). Although the decrease in numbers of dry ewe reported by Stobart *et al.* (1992) cannot be solely attributed to the presence of *B. ovis*, Stobart *et al.* did show an advantage of using rams rated as "excellent" using standard BSE criteria and *B. ovis* free. Fertility is variable in *B. ovis* infected rams ranging from excellent to inferior and is likely due to the state of infection and whether the testes are unilaterally or bilaterally affected.

It is likely in a producer's interest to have a flock that is *B. ovis* free, but achieving that status may not be economically attainable. In Wyoming, the estimated flock prevalence of *B. ovis* is 22.5% (Elderbrook *et al.*, 2019). A fouryear selection protocol that removed all *B. ovis* infected rams did not reduce the presence of *B. ovis* in the flock (Marco *et al.*, 1994). Both of those studies suggest that ewes serve as a reservoir for infection which limits the effectiveness of controlling disease spread by only testing and culling rams.

Clearly the ease of measurement, and not necessarily the practical implication of the measure, influences the rate of adoption of the practice. Price (1987) and Fitzgerald and Perkins (1991) established the importance of selecting rams for the expression of sexual behavior, yet the evaluation of ram libido has not been incorporated into any routine evaluation of breeding soundness.

Conclusion

Animal scientists must do more to ensure suggested benefits of recommended practices are indeed backed up by data. The ram breeding soundness evaluation is modeled after the bull breeding soundness evaluation, but may not adequately reflect ram fertility. It may be time to re-evaluate the evaluation for rams and determine if recommended practices adequately reflect production reality.

[Full manuscript available at https://doi.org/10.1016/j.rvsc.2021.09.005]

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Keywords
epididymitis, fertility, sheep

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Contact
Brenda Alexander, balex@uwyo.edu, (307) 766-6278.

Family Risks of Elder Financial Exploitation

Cole Ehmke, Department of Agricultural and Applied Economics;

Virginia Vincenti, Department of Family and Consumer Science (professor emeritus)

Introduction

A common method of elder abuse is to misuse a power of attorney (POA). Elders often name an agent to help make financial decisions, often an adult child or other family member. The powers granted to the agent are intended to benefit the grantor, but agents often make decisions that benefit themselves instead. Elder family financial exploitation (EFFE) is "the illegal or improper use of the funds, property, or assets of people 60 and older by a family member." Unfortunately, many people falsely believe that elder abuse of any kind would never occur in their family despite any family problems they may have.

The consequences go far beyond the lost assets or debts incurred. Some perpetrators also physically, emotionally, psychologically, and even sexually abuse their relatives. Emotional consequences can include fear of loss of care, being put into a care facility, or of physical harm. Family abuse can also lead to feelings of shame, embarrassment, stress, and betrayal. Perpetrators often isolate the principal from others either physically and/or emotionally, leaving them with a very limited or non-existent support system. This results in loss of autonomy, increased health problems, and earlier death.

The findings provide a wakeup call for families to proactively address negative family dynamics. These results are also useful for a person selecting someone to be their agent, as well as to their legal and healthcare advisors as they interact with individuals.

Objectives

Our overarching aim was to answer the question: Why does financial exploitation of elders by family members happen? We believe that it can be prevented by understanding what goes on in families. The specific aim was to identify risk factors which might increase the likelihood of elder exploitation occurring, especially by a family member appointed as a power-of-attorney agent for an older relative.

Materials and Methods

This research interviewed families in which a power of attorney was part of an estate plan, with the aim of uncovering characteristics of families in which the tool was effectively used, as well of characteristics that may have contributed using the tool to exploit an elder. All interviews have been coded. Analysis for different themes continues.

Results and Discussion

Long-term interactions in families can foreshadow later EFFE. However, individual-member traits, family and societal-level cultural norms and economic forces impact how families make decisions and solve problems across the life course. Below is a description of interrelated family factors that may make an elder more susceptible to abuse that may contribute to a perpetrator's inclination to abuse a power of attorney.

General Family Functioning. EFFE families reported poorer general family functioning, perhaps because of enmeshment. Families or dyads within families can be so close that they have boundary issues that enable irresponsible behaviors while still seeing themselves positively. The interviews suggested that repeated large or frequent gifting from the older generation to financially irresponsible children enabled exploitive entitlement attitudes that continued if those adults became POA agents. These adult children enmeshed with their parents, often lived closest to their parents, influencing them to prioritize their relationship and proximity over financial competence and responsibility in choosing these children as fiduciaries. Additionally, distrust or emotional distance, coalitions or alliances within families also seem to be red flags for later EFFE.

Resource Exchange Patterns. Long-established intergenerational resource exchange patterns start with parent-to-child instrumental and emotional support early in the family life cycle and years later may shift to child-to-parent support in some form of caregiving. Families with established histories of older adults gifting resources to younger relatives or having a sense of obligation to leave some type of inheritance to the next generation were slightly less likely to experience EFFE, maybe due to the prevailing sense among younger family members that they will get their fair share in due time.

Conflict About Fairness. This research found EFFE families reported greater earlier conflict over fairness. Families where fairness conflict was reported were four times more likely to allege EFFE. Younger relatives perceiving prior exchanges of time, attention, and monetary resources within their family as being unfair, may be more likely to become perpetrators if given fiduciary power.

Communication/Problem Solving. EFFE families reported worse communication patterns when growing up and currently at the time of the interview. The results suggest that the power of effective communication among families as a means of forming shared understanding of expectations, resolving differences, and solving problems helps prevent EFFE.

Entitlement Attitudes. Though high entitlement expectations by some heirs may be normative because of differences in caregiving contributions, "exploitative entitlement" by certain relatives who think they have more coming to them than others could increase older relatives' risk of EFFE. In follow-up interviews possible motivations were shared that perpetrators may perceive themselves as having unique needs, less financially well off than siblings, and competitively materialistic.

A list of risk factors for families and best practices have been developed that can be used when granting a power of attorney. See the University of Wyoming Extension Bulletin *Abuse of Power of Attorney: Preventing and Addressing Elder Family Financial Exploitation*. https://www.wyoextension.org/agpubs/pubs/B-1368_POA_web.pdf.

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Contact

Cole Ehmke, cehmke@uwyo.edu, (307) 766-3782

Virginia Vincent, vincenti@uwyo.edu, (307) 399-9753

Keywords
elder family financial exploitation; power of attorney abuse; elder abuse, intervention

PARP IX.7

Adaptive Sheep Grazing of Plains Larkspur (*Delphinium geyeri*) to Reduce Risk of Poisoning for Cattle: 2021 Plant Density Responses

H. Fraley, Department of Ecosystem Science and Management

J.D. Scasta, Department of Ecosystem Science and Management

W. Stewart, Department of Animal Science

J.D. Derner, USDA-ARS

Introduction

Plains larkspur (*Delphinium geyeri*), a native but toxic perennial plant, can impact turnout dates of cattle in the spring on native mixed-grass prairie due to concerns of animal death loss from consumption. Herbicides have been used for control, but cost, efficacy, grazing restrictions post application, and environmental concerns may constrain application. Historical accounts from the 1950s in southeastern Wyoming suggest that plains larkspur became problematic following the removal of sheep grazing from this region. Plains larkspur has increased in abundance the last several years, possibly due to wetter conditions in the spring, resulting in greater stakeholder interest for applied grazing management strategies to adapt to this plant community change.

Objectives

To quantify density of plains larkspur (*Delphinium geyeri*) relative to sheep grazing treatments.

Materials and Methods

This project is the first year of a multi-year project at the USDA-ARS High Plains Grasslands Research Station (HPGRS) in Cheyenne, Wyoming. Grazing was applied from mid-May to the end of June of 2021 utilizing commercial Dorper ewes and wethers (n =160); age »14 mo; BW 75 lbs ± 1.2 standard error). The first set of treatments (mid-May to early June) had sheep grazing four treatment paddocks of varying sizes to alter stocking density (Figure 1a), within four different pastures. Sheep grazed in a 0.25 hectare (ha) paddock for one day to mimic a high stocking density, then a 0.5 ha paddock for two days as a moderate/high stocking density, and then a 0.75 ha paddock for one day as a low stocking density. Sheep were night penned (≈172 m^2) each night over the course of the four days, before moving to a new pasture, which allowed for an ultra-high stocking density treatment. The second set of treatments entailed sheep grazing four, 1.5 ha paddocks, each for six days (Figure 1c). This mimicked a low stocking density at a moderate stocking rate. Night pens were similarly used. In each paddock, larkspur density was determined using 1 m^2 quadrats strategically placed in areas with known larkspur populations except night pens where all larkspur plants in the night pen were counted. Measurements were taken both prior to (pre) and following (post) grazing in each paddock to observe the response of larkspur density to the different grazing treatments. One hundred twenty-eight individual sheep were weighed (1) prior to beginning the first set of grazing treatments (mid-May), (2) between the first and second set of grazing treatments (early June), and (3) after completing the second set of grazing treatments (end of June) for calculating average daily gains to determine if sheep maintained a positive nutrition plane under the different grazing treatments. Pairwise comparisons to assess larkspur density before (pre) and after (post) grazing were conducted for each grazing treatment with significant differences noted at the 95% confidence level. Animal care and use was approved by the UW IACUC under proposal 20210128DS00481-01.

Results and Discussion

For the first set of grazing treatments, from May 17 through June 3, 2021, plants were primarily in a vegetative stage. Here, larkspur density (plants per m^2) was significantly ($p < 0.05$) reduced by sheep grazing in the 0.25 ha paddock (pre 8.4 ± 0.7; post 1.6 ± 0.6), the 0.5 ha paddock (pre 8.8 ± 1.1; post 0.3 ± 0.3), and the night pen (pre 0.4 ± 0.1; post 0.01 ± 0.01), but not the 0.75 ha paddock (pre 11.4 ± 2.6; post 10.4 ± 2.6) (Figure 1b). For the second set of grazing treatments in the four, 1.5 ha paddocks, sheep grazing was applied from June 5 through June 28, 2021. Plains larkspur plants were initiating stem elongation and flowering at this time. Here, larkspur density was significantly ($p < 0.05$) reduced by sheep grazing (pre 12 ± 1.1; post 0 ± 0) (Figure 1d). Results indicate that sheep will eat plains larkspur but that sheep stocking density may need to be manipulated, particularly earlier in the year, to increase intake of plains larkspur. No sheep displayed clinical signs of toxicosis. In addition, the average daily gain of sheep from mid-May to June was 0.37 lbs. per head per day (range of -9 to +17 lbs) and this decreased during the second set of grazing treatments (early June to late June) to 0.23 lbs per head per day (range -8 to + 21 lbs), with only 6% of the sheep losing or not gaining weight at each date. This indicates sheep can maintain a positive plane of nutrition in our targeted grazing scenarios.

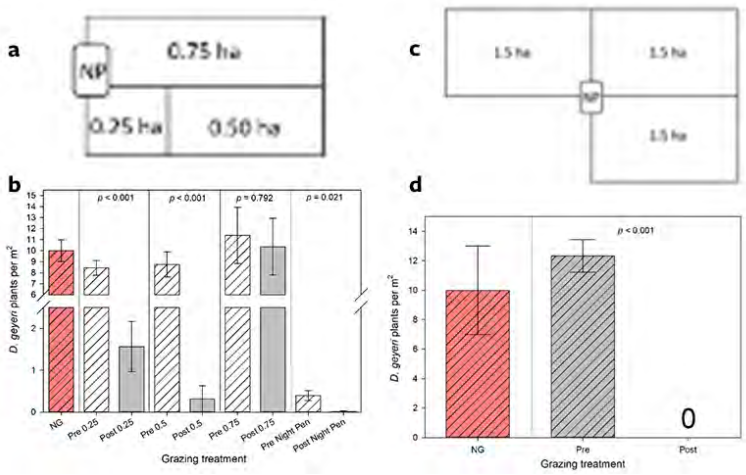

Figure 1. Effects of pre vs. post grazing on larkspur density in different size paddocks for the East Unit (a and b) and the North Unit (c and d) at the USDA-ARS High Plains Grasslands Research Station (HPGRS). NG = Not Grazed, Pre = measured prior to sheep grazing, Post = measured after sheep grazing, NP = Night Pen. Pairwise comparisons (pre versus post) considered significant at $p < 0.05$.

Acknowledgments

Appreciation to USDA-ARS staff for field assistance; Askin Land and Livestock provided sheep.

Contact

John Derek Scasta, jscasta@uwyo.edu, (307) 766-2337

Keywords

poisonous plants; rangeland; toxic plants

PARP I.1, I.17, V.3, VI.3, VI.4, VI.6, VII.2

Economic Assessment of a Water Demand Management Program in the Wyoming Colorado River Basin

Kristiana Hansen, Department of Agricultural & Applied Economics

Roger Coupal, Department of Agricultural & Applied Economics

Ellen Yeatman, American Farmland Trust, former graduate student in Agric & Appl Econ

Drew Bennett, Haub School of Environment and Natural Resources

Introduction

The state of Wyoming is evaluating the feasibility of implementing a water "Demand Management" (DM) program. Under a DM program, water users in the Wyoming portion of the Colorado River Basin (CRB) would be compensated for voluntarily and temporarily reducing consumptive use of water. Colorado, New Mexico, and Utah are also considering a DM program. A DM program could be used to protect Wyoming's water users in the Colorado River Basin by reducing the risk of dropping water levels in Lake Powell. The impact of such low water levels include possible triggering of mandatory reduction of water use in Wyoming ("curtailment") to comply with the Colorado River Compact and loss of hydropower production and revenues.

Participation in a DM program would be voluntary, and participants would be compensated for any savings in consumptive water use they generated. However, there could be other impacts to the region, in addition to the direct positive benefits experienced by program participants. A DM program could have economic impacts that ripple through the regional agricultural economy. For example, a reduction in hay production could result in fewer harvesting jobs on ranch operations throughout the region. There might also be less activity at local businesses off the ranch as a result of reduced hay production. On the other hand, a DM program might also induce additional spending in the local economy, if participants spend the payments they receive locally.

Objectives

The objective of this study is to estimate the regional economic impacts of a Demand Management program, if the consumptive use savings came from agriculture. This study assesses impacts assuming that the reductions in consumptive use occur through reductions in irrigated hay production. Reductions in consumptive use could also come from other sectors of the economy, for example municipal and industrial water users. However, this study is focused on a hypothetical case where all reductions in consumptive use come from the agricultural sector. Regional economic impacts are measured in terms of jobs and income.

Note that because a realistic baseline for an uncertain future has not yet been established, by default, this study evaluates the economic impacts of a DM program relative to a baseline of no curtailment risk.

Materials and Methods

We conducted interviews, focus groups, and a survey of agricultural water rights holders in the Wyoming CRB to understand motivations for participating (or not) in a DM program. Based on this input, we developed hypothetical DM program scenarios and producer participation profiles. Key assumptions include:

- Flooded grass hay acres are enrolled (not alfalfa or pivot grass).

- Management practice is no irrigation for full season. (Partial-season irrigation reductions are preferred by producers but the consumptive use impacts are difficult to quantify).
- Assume 70% yield reduction in enrollment year and 50% yield reduction in next year.
- Temporary and rotational: No acre is enrolled two seasons in a row. (Thus abandonment of water rights is not an issue.)

Then, we estimated regional economic impacts to determine how the participation payment, reduction in hay production, and replacement hay purchases resulting from a DM program would ripple through the regional and local economy. Impacts were estimated for hypothetical programs of three different sizes: 25, 80, and 135 thousand-acre feet (KAF) in consumptive water use reductions over ten years.

Results and Discussion

The net regional economic impacts of a one-year DM program with a target volume level of 25 KAF are estimated to range from a reduction of 3.12% to 6.85% of income in the regional agricultural economy and a reduction of 0.04% to 0.10% of income in the overall regional economy, depending on how producers would change their hay and livestock operations in response to a program.

The results of this study are highly dependent on the inputs (especially assumptions about how yields and consumptive use reductions respond to irrigation reductions). More scientific data is needed for evaluating a potential DM program. Further, the study does not consider the ecological impacts of changes in quantity and timing of flows that would result from implementation of a DM program. A significantly sized DM program could result in significant changes on the landscape, though it is impossible to quantify the full impact of the changes with currently available data.

Further, because a realistic baseline for an uncertain future has not yet been established, by default, the study evaluates the economic impacts of a DM program relative to a "business as usual" baseline rather than to a baseline of heightened risk of curtailment (involuntary and uncompensated reductions in water use to ensure downstream Compact obligations are met), which would be a more realistic comparison. Regardless, policymakers could decide to offset some of the negative regional economic impacts through a mitigation fund.

Acknowledgments

The authors thank the many producers and water managers in the Upper Green and Little Snake Rivers for the time and input into this study. Funding from the Wyoming chapter of The Nature Conservancy is gratefully acknowledged.

Contact

Kristiana Hansen, kristi.hansen@uwyo.edu, (307) 766-5598.

Keywords

Water management, regional economic impacts, water conservation, Colorado River Basin

PARP – IX.1, IX.7

Carbon and Nitrogen Cycling in Surface Soil Horizons of High-Elevation Hay Meadows

Daniel Adamson, Department of Ecosystem Science and Management

Jay Norton, Department of Ecosystem Science and Management

Introduction

Mountain hay meadows form the backbone of many ranches in Wyoming, producing forage integral to the success of overwintering livestock. However, yield and forage quality are often limited by the short growing season and long-term flood irrigation common to these systems. Many meadows are supplemented with large amounts of nitrogen fertilizer to improve yields, however, it appears internal nutrient cycling is limited as a result of saturated soils in spring and summer, and long periods of cold in the winter. This disfavors the microbial community's ability to decompose and recycle plant material and nutrients, leading to the formation of a thick organic horizon of thatch at the soil surface. Previous research has shown that this thatch can accumulate as much as 1,000 to 2,200 lb/ac of organic nitrogen, unavailable to plants, in the top 4 inches of soil (Siemer, 1979). Although storage of soil organic matter is generally advantageous for soil health, lack of decomposition and mineralization of soil organic matter is a concern for forage productivity.

Objective

To understand how carbon and nitrogen are cycled in high-elevation, flood-irrigated, hay meadows, and to determine what soil factors contribute to a healthy meadow soil.

Methods

To determine how long-term management has affected nutrient cycling in hay meadows, four research sites in Laramie Valley, WY, and North Park Valley, CO were established in spring of 2021. At each site, three forage management systems were paired on similar soil types: irrigated and fertilized hay meadow, irrigated and unfertilized hay meadow, and unirrigated natural rangeland. Soil samples were collected in April of 2021 from each management site at two depths: 0-2 in., representing the organic-thatch horizon, and 2-4.5 in., representing the mineral soil directly below. Because rangeland soils do not have an organic horizon, just the top 4.5 in. of soil were sampled. Samples were analyzed for soil organic carbon (SOC), total nitrogen (TN), potentially mineralizable carbon (PMC), and potentially mineralizable nitrogen (PMN). PMC and PMN were chosen as diagnostics of more rapidly cycling forms of soil carbon and nitrogen.

Results and Discussion

Irrigated hay meadows showed significant differences for soil carbon and nitrogen storage according to management and soil horizon. Based on the results, irrigated meadows tend to store their carbon and nitrogen in the thatch layer at the top 2 in. of soil (Table 1). This was true for both soil organic carbon and total nitrogen (SOC, TN), and more rapidly cycling forms of carbon and nitrogen (PMC, PMN), suggesting that a majority of nutrient cycling occurs near the soil surface. However, PMC and PMN represent *potential* nutrient cycling under ideal conditions, and saturated soils combined with cool temperatures common to meadows likely slows these processes, leading to a buildup of carbon and nitrogen as organic matter near the surface (Table 1). In comparison, native rangeland plant communities without irrigation are less productive, but do not accumulate organic matter as thatch, allowing them to better cycle carbon and nitrogen compared to the mineral soil horizons in hay meadows (Table 1).

Table 1. Difference in potentially mineralizable carbon (PMC), potentially mineralizable nitrogen (PMN), soil organic carbon (SOC), and total nitrogen (TN), for irrigated hay meadows and corresponding rangelands at two depths (thatch, 0-2 in; mineral, 2-4.5 in). SOC × 2 ≈ soil organic matter.

Treatment	Soil Horizon	PMC (lb/ac)		PMN (lb/ac)		SOC (%)		TN (%)	
Fertilized Meadow	thatch	9855	a*	173.58	a	15.26	a	1.13	a
Fertilized Meadow	mineral	390	c	4.32	c	2.06	b	0.11	b
Unfertilized Meadow	thatch	6859	a	86.94	a	12.95	a	0.94	a
Unfertilized Meadow	mineral	469	bc	6.18	c	2.01	b	0.11	b
Rangeland	mineral	771	b	27.84	b	2.47	b	0.17	b

**Means in the same column followed by the same letter were not significantly different at p = 0.05.*

Literature Cited

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Contact

Daniel Adamson; dadamson@uwyo.edu

Acknowledgments

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Keywords

meadows, grass hay, nitrogen, soil organic matter

PARP I.2, II.4, II.5, VI.1

Western Wheatgrass Soil Fertility Trial – Park County 2020

Jim Heitholt, Dep. Plant Sciences and Powell Res. Ext. Ctr.

Austen Samet-Brown, Powell Res. Ext. Ctr.

Samual George, Powell Res. Ext. Ctr.

Camby Reynolds, Powell Res. Ext. Ctr.

John Sloan, National Great Rivers Research and Education Center

Keith Schaefer, Powell Res. Ext. Ctr.

Introduction

There is minimal information on soil fertility management associated with seed and straw yields of western wheatgrass in the Intermountain West. Data from a research trial on this grass species could benefit producers of western wheatgrass seed in the Bighorn Basin and beyond.

Materials and Methods

An existing stand of Arriba western wheatgrass in eastern Park County, WY was established on 3 June 2019. The soil type is a Lostwells-Youngston complex (sandy clay loam to silty clay loam). Row spacing was 22-inches and the crop was furrow irrigated during 2019. The field was cut for hay and/or grazed in the fall of 2019. On 18 Sept. 2019, the entire field (both the surrounding field and the test plot area) was fertilized with 100 pounds of N per acre with UAN which was knifed into the soil with a coulter machine. In March 2020, ninety-six 220 sq. ft. plots were established and 32 different combinations of fertilizer were surface-applied by hand and mechanically incorporated. Rates of N, P, and K fertilizer were: N (0, 50, 100, and 150 pounds per acre as urea), P (as TSP at 0, 50, 100, and 150 pounds P_2O_5 per acre), K (as KCl at 24 and 48 pounds of K_2O per acre). All plots received 0.67 pounds of Zn per acre as $ZnSO_4$. Fertilizer application was followed with an application of Prowl H2O. On 20 May 2020, herbicide was applied by a commercial applicator as a tank mix. The following herbicides and rates were used: Widematch @1.33 pts/ac and AgriStar Brox-M @ 1.0 pt/ac. Other additives in this mix were Palisade SE @ 14 ozs/ac and Wetcit, a surfactant marketed by Simplot, at a rate of 4.8 oz/ac. Palisade is a growth regulator that helps reduce plant height and was used because western wheatgrass is prone to lodging. Plots were furrow irrigated at approximately 14-day intervals. Normalized difference vegetation index (NDVI) was collected on 8 April using a RapidScan spectroradiometer (Holland Scientific, Inc.) on both center rows individually (rows 3 and 4) and the average value for each plot was used for the data analysis. The 8 April NDVI reading provided a zero-time value prior to the fertilizer taking effect to see if there was any pre-existing bias. Later, NDVI readings were taken on 10 May, 17 May, 25 May, 12 June, and 20 June. On 24 August 2020, at maturity, a five-foot alley was cut between plots. Then, three center rows of each plot were cut with a forage harvester and the plants were laid down in the middle of their respective plot for drying. No rain fell during the next nine days and the crop dried thoroughly. On 2 Sept 2020, all plots were threshed for seed with a Zurn grain harvester set for wheatgrass seed and straw was dropped in its respective plot. Immediately following threshing, straw from each plot was collected with a Wintersteiger forage harvesting system and weighed and then immediately returned (dropped) to the field area from which it came. Seed for each plot was collected in a paper sack and was later cleaned using a Clipper Office Tester system. Seed size was determined by weighing 250 seed from each plot.

Results

The effects of the 32 treatments on seed yield, seed size, and straw yield are presented in Table 1. The effect of N rate was the only factor that significantly ($P = 0.022$) affected seed yield (Fig. 1). Seed size and straw yields were not affected by any of the treatments. N rate was also the only variable that affected NDVI (data not shown). Straw collected from selected plots indicated that full fertility (full N, P, K) increased straw crude protein and Ca concentration above that of low fertility plots (zero N, zero P, low K) (data not shown). No differences in germination of harvested seed among treatments were apparent at 18-days after starting of the germination test (data not shown).

Summary

Although this report covers just one growing season, it appears that N fertility is the most critical soil fertility factor for western wheatgrass seed yield on this soil. This could be because the other minerals (P, K, Zn) were applied to this field in 2019 during the establishment year. Soil N is often the most labile nutrient and thus, it is logical that N may need to be replenished annually.

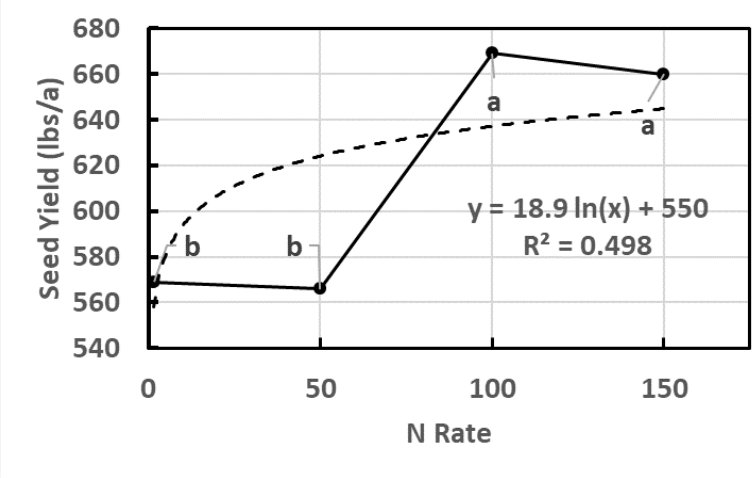

Figure 1. Effect of N rate on seed yield of western wheatgrass in 2020. When the four N treatments were compared statistically, the two high N rates were significantly greater than the two low N rates. The dashed line represents the nonlinear relationship of all four points. Each data point represents the average of 32 plots. Data are averaged across four P rates and two K rates.

Table 1. Seed yield, seed size, and hay yields of Arriba western wheatgrass as affected by N, P, K, Zn fertility in 2020.

N Rate	P_2O_5	K_2O	Seed yield †	Seed size	Straw Yield
# per acre	# per acre	# per acre	lbs/acre	mg	tons/acre
Zero-0	0	24	422	5.96	1.34
Zero-0	0	48	530	5.75	1.93
Zero-0	50	24	656	5.48	1.92
Zero-0	50	48	546	5.97	1.82
Zero-0	100	24	494	5.77	1.75
Zero-0	100	48	588	5.85	1.84
Zero-0	150	24	708	5.46	2.12
Zero-0	150	48	606	5.58	1.89
50	0	24	646	5.86	1.81
50	0	48	678	5.64	1.86
50	50	24	392	5.79	1.95
50	50	48	527	6.13	1.74
50	100	24	539	5.88	2.04
50	100	48	549	5.97	1.64
50	150	24	626	5.93	2.15
50	150	48	571	5.78	1.82
100	0	24	666	5.80	1.89
100	0	48	650	5.98	2.18
100	50	24	712	5.76	2.49
100	50	48	586	6.09	1.82
100	100	24	721	5.91	2.30
100	100	48	643	5.87	2.14
100	150	24	693	5.54	1.75
100	150	48	586	5.86	2.08
150	0	24	684	5.96	1.90
150	0	48	717	5.98	2.20
150	50	24	629	5.87	1.92
150	50	48	697	5.21	2.13
150	100	24	731	5.82	2.01
150	100	48	515	6.06	1.67
150	150	24	625	5.95	1.93
150	150	48	683	5.97	2.10

† *The only significant factor from the ANOVA was N rate on seed yield (P = 0.022).*

Acknowledgment

The authors thank Brad May for help with the harvest, various crop producers of Bighorn Basin who encouraged this project, the Northwest Wyoming Applied Agricultural Research Fund, USDANIFA Hatch project WYO-604-19, and the cooperating producer that allowed this study to go forward.

Contact

Jim Heitholt, jim.heitholt@uwyo.edu

Keywords

forage, mineral nutrition, protein, seed yield, straw

Effect of Hops Variety on Cone Yield and Quality in the Bighorn Basin

Jim Heitholt, Dept Plant Sciences and Powell Research and Extension Center

Brian Lee, Dept Agric Applied Econ, SAREC

Will Rose, Northwest College

Vivek Sharma, Univ. Florida (formerly PREC)

Austen Samet-Brown, PREC

Micah Humphreys, College of the Ozarks (formerly employed at Northwest College)

Introduction and Objective

Hops production in the Bighorn Basin of Wyoming has become more popular in recent years. However, there are very few published data on the effects of variety on yield and quality in this region.

Materials and Methods

Two-hundred hops plants and supporting trellis structures were established in 2017 at the Northwest College pavilion area adjacent to PREC (located just north of Powell, WY). In early 2018, the hops yard was not maintained but it was reclaimed and managed in late 2018 and into 2019. Twenty plants from ten different varieties have been growing (with 3.5 feet between plants), most producing cones. In this article, we use the term "plant" to represent the entire aboveground biomass growing from the base of original location where a rhizome was placed during establishment, and we use the term "vine" to represent one of the shoots that grew from the "plant." The arrangement of plants is/was a randomized complete block with four replications. The experimental unit (aka, plot) consisted of five plants of the same variety located together but spaced 3.5 ft apart from each other. In spring 2020, rhizomes from the variety 'Magnum' replaced 'Willamette' due to the failure of Willamette to overwinter. Plants were managed by irrigating with a drip system and hand-weed control was performed at least weekly. Plants were allowed to produce one to four vines and additional shoots/vines (if greater than four) were trimmed away. Cone yield was collected on 3 and 4 September 2020 using a mechanical hops harvester. In cases where cone numbers were low, we hand-harvested the plants. A portion of the cones from each plot was collected for alpha- and beta-acids including cohumulone and colupulone (AAR Lab, Madison, WI; shipped overnight) and for dry matter percentage. Only about 170 plants produced viable cones in 2020. Yield data presented are the average cone weights per cone-bearing plants within an experimental unit. Plants not producing cones were not used in the calculation(s).

Results

Yield in pounds of cones per vine, average cone size, and dry matter percentage are presented in Table 1. Yields were noticeably variable. Cascade produce the heaviest weight of cones per plant. Magnum and Galena had the greatest weight per cone (i.e., large cone size). Dry matter of the cones averaged 47%. Cones from Centennial had the highest concentration of alpha-acids and cones from Galena had the highest concentration of beta-acids (Table 2).

Discussion

Yields were somewhat below expected due to 2020 being the first recent year that the hops yard was managed aggressively. Cone percent dry matter was somewhat higher than expected possibly due to delays in drying the cone

subsamples. Acid levels appeared normal. Although we discussed marketing the cones with several private entities, none were willing to buy; thus, cones were donated.

Acknowledgments

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Contact

Jim Heitholt, jim.heitholt@uwyo.edu

Keywords

acid, brewing

PARP Goal 2

Table 1. Yield per plant (please see definition of "plant" in Methods) of ten hops varieties, average dry weight per cone, and cone moisture percentage upon harvest. Study was grown in Powell during 2020. Values are the average per plant of the four plots (up to five plants per plot).

Variety	Yield	Fresh Weight Per Cone	Percent Dry Matter
	lbs per plant	mg	%
Cascade	2.03	746	58
Centennial	1.48	621	54
Chinook	0.97	738	55
Columbus	1.51	687	55
Galena	0.92	766	46
Magnum †	-	1031	46
Mt Hood	0.36	415	52
Northern Brewer	1.18	512	54
Nugget	0.44	632	53
Sterling	0.64	440	49
LSD (0.05)	0.96	155	ns

† *Magnum was in the first year of establishment and did not produce enough cones to harvest mechanically.*

Table 2. Quality traits of hops cones analyzed by Advanced Analytical Research lab in Madison, WI.

Variety	Storage Index	Cohumulone	α-Acids	Colupulone	β-Acids	α:β Ratio
		% of α-Acids	%	% of β-Acids	%	
Cascade	0.27	32.7	2.08	52.1	1.78	1.18
Centennial	0.26	23.3	5.30	49.0	1.63	3.25
Chinook	0.26	27.5	4.19	53.1	1.22	3.45
Columbus	0.26	31.6	3.45	56.3	1.41	3.37
Galena	0.26	32.0	4.74	57.2	2.94	1.61
Magnum	0.26	19.7	2.93	33.3	1.72	1.82
Mt Hood	0.23	23.4	2.30	37.6	2.43	0.97
Northern Brewer	0.28	21.6	4.94	15.8	1.24	4.17
Nugget	0.27	19.2	4.18	41.8	1.34	3.12
Sterling	0.25	23.6	2.62	43.3	1.53	1.76
LSD (0.05)	ns	3.8	1.19	7.5	0.44	0.81
† *Magnum was in the first year of establishment and did not produce enough cones to harvest mechanically.*						

Wyoming Production Agriculture Research Priorities—Updated June 2018

GRAND CHALLENGE—Enhance the competitiveness, profitability, and sustainability of Wyoming agricultural systems.

1. **Goal 1**. Improve agricultural productivity considering economic viability and stewardship of natural resources.
2. **Goal 2.** Develop new plant and animal production systems, products, and uses to increase economic return to producers.

Following are producer recommendations developed from statewide listening sessions:

Production Systems Objectives

3. Develop and maintain baseline agriculture production systems to evaluate effects of innovations on the natural resource base, sustainability, and profitability. (2014)
4. Develop best-agronomic management practices for alternative crops such as sunflower seed production and various forages (e.g., perennial and annual legumes, grasses, and legume-grass mixtures) and other oilseed crops. (2014)
5. Identify synergistic effects among crops to improve crop rotation systems. (2014)
6. Develop methods to deal with residue when establishing new stands in crop rotation systems. (2014)
7. Evaluate effects of legumes in dryland wheat production systems. (2014)
8. Evaluate incorporating crops and crop aftermath into livestock production systems. (2014)
9. Evaluate and compare no till versus tillage techniques. (2014)
10. Identify improved harvesting techniques. (2014)
11. Evaluate the use of legumes in rotational cropping systems. (2014)
12. Identify causes for annual losses of bees and other pollinators and develop management procedures that minimize their loss. (2015)
13. Develop best management practices to control diseases in crops. (2015)
14. Conduct crop variety trials to identify varieties best suited to Wyoming localities. (2015)
15. Identify optimal crop rotations for sugarbeet producers. (2015)
16. Identify seed treatments that optimize sugarbeet and dry bean production. (2015)
17. Devise integrated cropping/grazing systems that optimize crop and livestock production with soil health. (2015)
18. Assistance in how to use drone and precision agriculture data to make management decisions. (2018)
19. Evaluate how all of the different specialties of researchers can be combined to benefit producers. (2018)
20. Assist producers in learning what their peers are doing. (2018)
21. Develop better collaboration between researchers and producers with on-farm projects.

Soil Fertility Management Objectives

22. Develop methods to ameliorate poor soil pH for crop production. (2014)
23. Investigate effects of fertilizer type, placement, and timing on crop production (e.g., sugarbeets, cereal grains, dry beans, and forages). (2014)
24. Evaluate the efficacy of managing soil nitrogen applied by pivot irrigation. (2014)
25. Determine and categorize nitrogen release times for varied forms of nitrogen. (2014)
26. Discover methods to reduce dependence on commercial fertilizers. (2014)
27. Develop tillage systems that minimize soil disturbance. (2014)
28. Develop cheaper alternatives to commercial fertilizer (e.g., cover crops, legumes). (2014)
29. Test the ability of compost and manure to enhance soil fertility. (2014)
30. Identify plants such as legumes that enhance soil fertility. (2014)
31. Identify crops and varieties that perform best in varied soil types and elevations. (2015)
32. Evaluate effects of aerators on soil productivity. (2015)
33. Identify soils best suited for farming or grazing. (2015)

Weed Control Objectives

34. Develop control methods for weeds resistant to glyphosate (e.g., Roundup) or other herbicides especially in sugarbeet and dry bean production. (2014, revised 2015)
35. Develop methods to control weed emergence that can be applied in the fall.
36. Improve procedures to control noxious weeds, especially milkweed, knapweed, whitetop, curly dock (aka sour dock), and thistle. (2014, revised 2015)
37. Evaluate the efficacy of weed-control chemicals applied before planting in dry bean fields. (2014)
38. Develop chemical and non-chemical methods to control cheatgrass and other noxious weeds. (2014)
39. Coordinate application of glyphosate with precision agriculture. (2014)
40. Optimize use of herbicides economically and environmentally. (2014)
41. Facilitate access to chemicals needed for special uses. (2015)
42. Discover viable alternatives to pesticides. (2015)
43. Determine chemical carryover in no-till production. (2015)
44. Continually monitor unintended consequences of weed control on plants and animals. (2015)

Irrigation Objectives

45. Test and develop surge, pivot and drip irrigation techniques for specific crops, especially alfalfa, alfalfa seed, dry beans, and sugarbeets. (2014, revised 2015)
46. Test the ability and reliability of moisture monitors to indicate timing of irrigation. (2014)
47. Conduct irrigation management studies to optimize water use for specific crops (e.g., alfalfa seed, dry beans, and sugarbeets) and soils. (2014, revised 2015)
48. Develop methods to maximize (optimize) production with less water. (2014)
49. Improve irrigated pasture production at high elevations. (2014)
50. Test the ability of soil additives (e.g., surfactants) affect water absorption and retention. (2015)

Livestock Objectives

51. Develop strategies to enhance the efficiency of feed utilization. (2014)
52. Evaluate effects of additives or chemicals to feeds to influence forage and/or weed consumption. (2014)
53. Train livestock to consume alternative feeds such as brush and weeds. (2014)
54. Determine heifer development strategies that optimize reproduction, foraging ability, and cow longevity to maximize profitability. (2014)
55. Identify strategic supplementation protocols that optimize animal production traits with costs of production. (2014)
56. Develop improved methods to control flies. (2014)
57. Determine how to minimize feed costs and maximize profit per unit of production. (2014)
58. Develop genetic markers for feed efficiency and determine their ramifications on important production traits such as reproduction, milk production, pounds of calves produced, and carcass characteristics. (2014, revised 2015)
59. Develop practical estrous synchronization methods for commercial producers.
60. Determine cumulative effects of minerals, ionophores, worming, and implants on animal productivity. (2014)
61. Provide cost/benefit information on grazing of irrigated pastures. (2014)
62. Determine direct and indirect effects of disease and predators on livestock production. (2015)
63. Develop best methods to ameliorate existing and emerging diseases in livestock. (2015)
64. Optimize breeding of first-calf and re-breeding of second calf heifers. (2015)
65. Develop breeding strategies that maximizes the beneficial effects of heterosis in livestock. (2015)
66. Develop criteria for lamb carcasses to decrease variability and increase consumer satisfaction. (2015)
67. Identify and eliminate causes for consumers having poor eating experiences with lamb. (2015)

Grazing Management Objectives

68. Develop improved forage (e.g., grass/legume mixtures) based livestock production systems. (2014, revised 2015)
69. Demonstrate and evaluate benefits of strip grazing corn stalks. (2014)
70. Increase the carrying capacity of range and pastureland. (2014)
71. Evaluate effects of multi-species grazing on forage utilization and range health and productivity. (2014)

72. Develop alternative grazing strategies to enhance rangeland health. (2014)
73. Evaluate management intensive and rotational grazing strategies in dry environments. (2014)
74. Identify optimum grazing height for alfalfa aftermath and effects of grazing on stand longevity. (2014)
75. Develop forage species that are drought resistant. (2014)
76. Investigate ways to optimize wildlife-livestock interactions and receipt of value for hunting and tourism. (2014, revised 2015)
77. Provide new information on meadow management and irrigated pasture grazing in higher elevations. (2014)
78. Develop economically feasible methods to control sagebrush and greasewood. (2015)

Production Economics Objectives

79. Determine the cost-effectiveness of fertilizer alternatives. (2014)
80. Determine the economics of alternative grazing systems. (2014)
81. Determine the cost-effectiveness of vaccines, mineral supplements, and pour-ons in livestock production systems. (2014)
82. Develop practical methods to assign economic values to ecological management procedures. (2014)
83. Identify obstacles and evaluate options and opportunities for marketing. (2014)
84. Identify obstacles and evaluate options and opportunities for marketing Wyoming-produced meat and other products to consumers. (2014, revised 2015)
85. Determine impacts of alternative management strategies on whole-ranch/farm economics. (2014)
86. Provide information on costs per unit of production. (2014)
87. Identify capital management alternatives for new and expanding producers. (2015)
88. Provide tools to facilitate record keeping. (2015)
89. Determine economic potentials for alternative crops (e.g., soybeans, oil crops, forage beets) and varied crop production methods (i.e. organic, no-till, and conventional) in specific Wyoming localities. (2015)
90. Determine economic impacts of grazing vs. harvesting of alfalfa and winter wheat in the fall. (2015)

Crop and Animal Genetics and Biotechnology Objectives

91. Improve marker assisted selection procedures to identify plants and animals with desired production traits. (2014)
92. Develop and evaluate genetically modified organisms that enhance desired production traits. (2014)
93. Identify optimum cow size for Wyoming environments. (2014)
94. Increase longevity and production persistence of forage legumes. (2014)
95. Develop viable alternatives for legumes (especially alfalfa) at high elevations. (2015)
96. Develop methods to identify cattle and sheep seed stock that possess desired economic traits. (2015)

Rural Prosperity, Consumer and Industry Outreach, Policy, Markets, and Trade Objectives

97. Analyze economic impacts of farming/ranching management decisions. (2014)
98. Consider input costs, budgets, and market risks by region and crop. (2014)
99. Conduct applied research studies with producers and develop demonstration trials with cooperators to facilitate adoption of new or changing technologies. (2014)
100. Increase dissemination of research results (e.g., Wyoming Livestock Roundup, radio programs). (2014)
101. Work with commodity groups to enhance adoption of new technologies. (2014)
102. Conduct hands-on classes at R&E Centers or with cooperators for young/new producers. (2014)
103. Provide science based information needed by policymakers to make informed decisions. (2015)
104. Educate the public about the impacts of agricultural practices. (2015)
105. Develop alternative markets and uses for agricultural by-products. (2015)
106. Investigate methods for, and impacts of, local food production. (2015)
107. Develop local processing and marketing opportunities for Wyoming livestock and crops. (2015)
108. Form venues to sell Wyoming products in international markets. (2015)
109. Enhance communication between producers, research entities, and regulatory agencies. (2015)

X. Responding to Climate Variability Objectives

110. Consider regionally unique environmental conditions when designing research studies. (2014)

111. Conduct integrated agricultural systems research that links environment and conservation to production and profitability. (2014)
112. Develop drought resistant plants that fit the extreme environmental conditions of Wyoming. (2014)
113. Devise drought management strategies that minimize detrimental effects of grazing. (2015)
114. Determine effects of climate variability (e.g., lack of freeze vs. a hard winter) on plant and livestock diseases and production. (2015)

IX. Sustainable Energy

1. Conduct research on bioenergy/biofuels and bio-based products that are suitable to Wyoming's environment. (2014)

X. Landscape-Scale Conservation and Management

1. Develop improved methods to reclaim disturbed lands. (2014)
2. Evaluate water, soil, and environmental quality using appropriate organisms as indicator species. (2014)
3. Present educational programs on environmental and societal impacts of agricultural innovations. (2015)
4. Develop methods to ameliorate the detrimental effects of poor quality water on crop and livestock production. (2015)

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