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Contents

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OFF-SITE RESEARCH

RBM20 deficiency prevents angiotensin II induced-hypertension and heart failure progression by regulating titin size in smooth muscle

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Introduction

RNA binding motif protein 20 (RBM20) is a muscle specific splicing factor that has been implicated in heart failure. Titin is one of the major targets of RBM20. RBM20-regulated titin size changes have been identified as one of the major determinants of myocardial wall stiffness in heart disease. The deficiency of RBM20 leads to increased titin size and decreased myocardial wall stiffness. Titin also presents in smooth muscle, but it is unknown if RBM20-controlled titin size could contribute to arterial stiffness. Arterial stiffness is closely linked to raised blood pressure in patients with hypertension, which is recognized as a potential therapeutic target. Therefore, we hypothesis that RBM20-deficiency results in larger titin size in smooth muscle that decreases arterial wall stiffness and thus reduces blood pressure in hypertension.

Objectives

The objectives of this study are to examine RBM20-regulated titin size in smooth muscle and determine smooth muscle stiffness in RBM20-deficiency rats.

Materials and Methods

Male wild type (WT) (Sprague-Dawley × Brown Norway) rats (n=10) and Rbm20 knockout (KO) rats (n=10) were subcutaneously implanted with osmotic mini-pump to continuously infuse angiotensin II (Ang II) at a rate of 400 ng/kg/min for 28 days. Blood pressure (BP) was measured by noninvasive tail-cuff system every week. Pulse wave velocity (PWV) was measured as an indicator of arterial stiffness by Doppler system. Atomic force microscopy (AFM) was used to measure the stiffness of individual vascular smooth muscle cells (VSMCs). Cardiac geometry and function were evaluated by echocardiography. Biochemical assays were performed to assess collagen and elastin content in aorta.

Results and Discussion

Titin size is increased in KO smooth muscle. Basal blood pressures (BP) were the same in WT and KO rats. However, the KO rat had a significantly lower BP than the WT rat after Ang II infusion. Pulse wave velocity (PWV) results showed a significantly decreased blood velocity in KO rat at the end of treatment period, which indicates the aortic stiffness of KO rats is lower than that of WT rats. Vascular smooth muscle cell (VSMC) stiffness was measured by atomic force microscope (AFM). The AFM results demonstrated that the stiffness of KO VSMC was lower than WT VSMCs. Cardiac hypertrophy and fibrosis were induced by Ang II, however, they were both alleviated in the KO heart. Overall, these results indicate that RBM20 deficiency prevents Ang II induced hypertension by mediating smooth muscle stiffness. RBM20 could be a new potential target for the treatment of hypertension and hypertension-induced cardiac hypertrophy.

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Keywords: RBM20, titin size, smooth muscle stiffness, hypertension

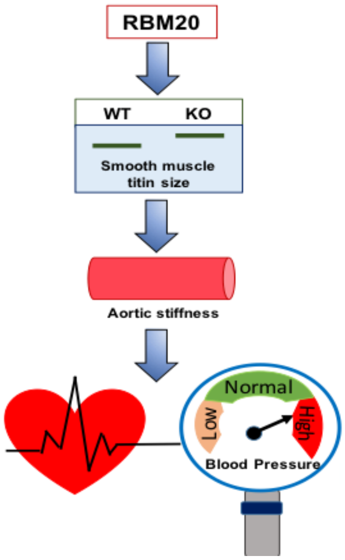

Figure 1. *RBM20-controlled titin size change in regulating smooth muscle stiffness in hypertension. RBM20 KO increases titin size and thus reduces aortic stiffness against hypertension progression.*

RBM20 deficiency impairs skeletal muscle regeneration

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Introduction

Skeletal muscle injuries are extremely common during sports or athletic endeavor and impaired muscle function or increased risk of recurring injury is accompanied after the recovery. Satellite cells, the quiescent skeletal muscle stem cells orchestrate the regeneration of the myofibers during recovery. RNA binding motif 20 (RBM20) is a splicing factor with specific expression in striated muscles. It regulates muscle-specific gene splicing and expression. Previous studies indicated that RBM20 is associated with myoblast differentiation.

Objectives

In this study, we evaluated whether RBM20 regulates muscle differentiation and regeneration in rat muscle injury model.

Materials and Methods

Muscle injury model was made with 9-week-old male wild type (WT) and RBM20 deficient (KO) rats by injecting 0.5ml of 1.2% barium chloride in tibialis anterior (TA) and normal saline as control. Tibialis anterior muscles are harvested at 18 hours, 3 days, 5 days, 7 days, 14 days, and 30 days post-injury (n=5 per time point) and used for western blot, histological and immunofluorescence analysis.

Results

Without injury, the 22-week-old KO rats exhibited increased percentage of centrally nucleated myofibers and elevated fibrosis in skeletal muscle. With injury we observed the mean cross-sectional area (CSA) of the regenerating myofibers after 7 days, 14 days and 30 days post-injury was significantly smaller in KO compared to WT. Further, we found that fibrotic area and TGFβ1 signaling were significantly increased in KO as compared to WT after 14 days and 30 days post-injury. These data validated RBM20 deficiency delays skeletal muscle regeneration. To test whether RBM20 affects satellite cell proliferation and differentiation, we evaluated the expression level of Pax7, MyoD, and myogenin at 7 days post injury. We found no changes in Pax7 and myogenin expression, however, MyoD expression was significantly reduced in KO rats. The myoblast fusion process was also ablated in the KO rats. Additionally, we found the expression of embryonic myosin heavy chain persisted longer in KO rats, especially in fibers with smaller cross-sectional area, which indicates delayed myofiber. The maturation process was also delayed in KO rats postnatally. Finally, we investigated the sarcomere assembly during regeneration by α-actinin immunofluorescent staining, but we did not find any difference between WT and KO rats.

Conclusions

Our data indicates that RBM20 mediates skeletal muscle regeneration by regulating expression of MyoD, myoblast fusion and maturation process.

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Keywords: RBM20, skeletal muscle regeneration, myofiber

Phosphorylation of RNA binding motif 20 is a novel target to reduce myocardial stiffness in diastolic dysfunction

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Introduction

With the disease of Heart Failure with Preserved Ejection Fraction (HFpEF), the wall of the heart could become stiff which reduce its efficiency to pump blood out for our body. Until now, there is no effective therapeutic option to reduce the stiffness for this type of disease. Previously, it was reported that RNA binding motif 20 (RBM20) improved ventricular stiffening through altering titin sizes in HFpEF, thus understanding how RBM20 is modified could be a potential strategy to adjust the stiffness of heart wall in HFpEF.

Objectives

Investigating the modification of RBM20 and understanding how it is related to the stiffness of the heart wall.

Materials and Methods

To understand the modification of RBM20, insect cell expression system was utilized for RBM20 expression and purification. Then, purified RBM20 was subjected to the middle-down mass spectrometry (MS) analysis. To verify whether the modification of phosphorylation is important to RBM20's function, the identified phosphorylation sites were mutated for in vitro splicing assay and dual luciferase splice reporter assay through co-transfection with titin mini-gene. To find out which kinases are important for the phosphorylation of RBM20, in vitro kinase and the co-IP assay was performed to identify the kinases that interact with RBM20. Since phosphorylation is also important for translocation of RNA binding proteins, the confocal microscope was applied to cell cultures transfected with mutated RBM20.

Results and Discussion

Sixteen phosphorylation sites with four of them on the SR domain of RBM20 were identified with the middle-down MS. In vitro splicing and dual luciferase splice reporter assays revealed that two phosphorylation sites on SR domain play a major role in titin mini-gene splicing. In vitro kinase assay and co-IP experiment indicated that kinases SRPK, CLK, and AKT could all phosphorylate RBM20, and co-IP experiment confirmed the interaction between kinases and RBM20. In vitro splicing assay with co-transfection of these kinases with RBM20 and titin mini-gene found that splicing pattern was changed by comparing to mutated RBM20. Most interestingly, mutated RBM20 on these two phosphorylation sites facilitated RBM20 trafficking from the nucleus to the cytoplasm, suggesting the new role of RBM20 phosphorylation in diastolic dysfunction. These results suggest that RBM20 phosphorylation plays an important role in titin splicing, which is a potential target to treat diastolic dysfunction. RBM20 trafficking could be another pathway to contribute to the development of HF and treatment for HFpEF.

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Keywords: heart failure, protein modification

Potassium and harvest management effect on alfalfa production under controlled conditions

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Introduction

Fertilization is an important management practice in alfalfa (*Medicago sativa* L.) production systems for establishing an efficient forage system. Among the major nutrients, potassium (K) is the nutrient alfalfa requires in the greatest amount for satisfactory growth and development. It increases winterhardiness and prolongs the stand life to improve forage yields and nutritive value. Previous studies have shown that alfalfa's response to K varies with soil type, initial soil K levels, growing conditions, harvest management, and target yield. This suggests that alfalfa production in association with K fertilization is reliant on existing management practices and growing conditions. However, information on alfalfa's response to K along with harvest management is limited.

Objective

To determine the interaction effect of K and harvest time on growth and dry matter yield of alfalfa under controlled conditions.

Materials and Methods

The study was conducted at the greenhouse complex at the University of Wyoming Laramie Research and Extension Center (LREC) from July 2018 to March 2019. There were two treatments (a) five K rates: 0, 50 100, 150 and 200 pounds K_2O per acre, and (b) two harvest times: early harvest (late bud to early [10%] bloom), and late harvest (7 to 10 days after early harvest). The experiment was set up in a 2 × 5 factorial in a randomized complete block design with six replications. This resulted in a total of 60 pots, each measuring 2.5 liters. Each pot was filled with 4.4 pounds of 3:1 peat and mortar sand premium mix soil. Soils in each pot were leached thoroughly with 10 liters of irrigation water to make the growth media low in K. Inoculated seeds (10 to 15 seeds) of 'Hi-Gest 360' alfalfa were seeded (July 31, 2018) in each pot and after 7 days, the emerged seedlings were gradually thinned down to 5 plants per pot. The quantity of K was determined based on soil test K level (~ 14 ppm) and applied to the pots as solution. All other nutrients were managed for adequacy. Four cuts were made at 30 to 35 days interval under each harvest time from November 2018 to March 2019. Growth data (plant height, vigor, and stem count) were taken at each harvest time. Plant samples were oven dried for 72 hours at 140°F to determine dry matter.

Results and Discussion

Plant height, plant vigor, and dry matter were affected by K and number of cuts but not harvest time. When results from all four cuts were combined over the two harvest times, 200 pounds K_2O per acre produced the highest plant height (6.8 in) and plant vigor (6.3), whereas 0 pounds K_2O per acre produced the lowest plant height (5.5 in) and plant vigor (5.2) (Table 1). This clearly shows that high K rate is required by alfalfa to boost its physiological process for increased growth and development. Average plant height and plant vigor were higher at late harvest than at early harvest due to further growth and maturation of the plants. Number of stems was not affected by K, however, harvest time affected number of stems. Early harvest produced higher number of stems (6.6) compared to late harvest (5.9). It was apparent that effect of K on plant height and plant vigor reflected in the total dry matter of alfalfa such that

200 pounds K_2O per acre produced the highest yield (0.689 g per plant), whereas 0 pounds K_2O per acre produced the lowest yield (0.496 g per plant) (Table 1). On the average, late harvest had higher dry matter (0.622 g per plant) than early harvest (0.591 g per plant). Compared to the second and third cuts, the first and fourth cuts provided generally higher growth and dry matter. This is attributed to stress condition due to deficiencies of sulphur, boron and iron (observed during the study), which might have reduced alfalfa's ability to absorb growth resources for adequate growth and development prior to the second and third cuts. It is apparent from this study that alfalfa requires higher K rate for optimum production. The study will be repeated to confirm this result.

Table 1. Effect of potassium, harvest time, and number of cuts on growth, and dry matter of Hi-Gest 360 alfalfa under controlled conditions at LREC from July 2018 to March 2019

Potassium (K_2O) (pounds per acre)	**Plant height** (inch)	**Plant vigor**	**Stem count** Number per plant	**Dry matter** (g per plant)†
0	5.5c‡	5.2b	6.2a	0.496d
50	6.2b	5.9a	6.1a	0.585b
100	6.5ab	6.2a	6.4a	0.672ab
150	6.5ab	6.1a	6.4a	0.590b
200	6.8a	6.3a	6.3a	0.689a
Average	6.3	5.9	6.3	0.607
Harvest time				
Early harvest§	6.3a‡	6.1a	6.6a	0.591a
Late harvest¶	6.3a	5.9a	5.9a	0.622a
Average	6.3	5.9	6.3	0.607
Number of cuts #				
1	7.3a‡	6.4b	6.7b	0.817a
2	3.1b	2.9c	4.9c	0.417b
3	7.6a	7.3a	4.6c	0.340c
4	7.4a	7.4a	8.8a	0.854a
Average	6.3	5.9	6.3	0.607

Plant vigor: 1-10 scale; 1=poorest, 10=highest;
† 1g = 0.04 ounce;
‡ Within each column, means followed by the same lower-case letters are not significantly different at $p>0.05$;
§ Early harvest (late bud to early [10%] bloom stage
¶ Late harvest (7 to 10 days after early harvest);
 # Different times for cutting;
1=November 13, 2018 (early harvest), November 21, 2018 (late harvest);
2=December 27, 2018 (early harvest), January 3, 2019 (late harvest);
3=January 28, 2019 (early harvest), February 4, 2019 (late harvest);
4=March 5, 2019 (early harvest), March 12, 2019 (late harvest).

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Keywords: alfalfa, potassium, harvest time

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

Competitive ability of native and non-native grasses with cheatgrass

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Introduction

Cheatgrass, initially assumed as a potential forage, is a native plant to Eurasia and is one of the most competitive and invasive weeds in the western US. Cheatgrass has been problematic, especially in the rangelands of North and South America and prevails in various ecosystems. Cheatgrass has competitive advantages over desirable species due to its winter growth habit. This helps the species establish in early spring and outperform the vegetation in its surrounding. Some native and non-grasses are identified that could better compete with cheatgrass and improve the disturbed grassland in western US. However, limited information is available about their competitive ability with cheatgrass.

Objective

The objective of this study is to assess competitive ability of perennial native and non-native grasses to suppress growth of cheatgrass.

Materials and Method

The experiment was initiated in January of 2019 at the Laramie Research and Extension Center (LREC) greenhouse complex. The study was conducted using modified replacement method. Three desirable species (tall fescue 'Texoma', crested wheatgrass 'Hycrest', basin wildrye 'Magnar') were grown in neighborhood of cheatgrass, the target species for the study. All species were seeded in mid-January and were transplanted into pots in end of January (after 2 weeks). Each pot had 6 plants in total. There were seven treatments in the study. Four of them were monoculture of cheatgrass, tall fescue, crested wheatgrass, and basin wildrye (6 seedlings per pot). Remaining three treatments were 50:50% mixture of desirable species and cheatgrass (3 seedling of desirable species and 3 seedlings of cheatgrass). The experimental design was completely randomized with four replicates. Number of tiller (shoots arising from base of grass) and height of the plant were collected in two weeks interval. The plants were harvested on March 24, 2019 to determine shoot and root biomass.

Result and Discussion

Presence of perennial grass reduced the height of cheatgrass, but the height of perennial grasses was not affected by presence of Cheatgrass (Figure 1a and 1b). On the other hand, presence of cheatgrass in the neighborhood reduced the tillers of crested wheatgrass while it was not different for basin wildrye (Figure 1c). Tall fescue had higher tiller number in mixture with cheatgrass as compared to monoculture. Overall, there was reduction in tiller number of cheatgrass when grown with desirable species as compared to monoculture. Lowest number of tiller of cheatgrass was observed when it was grown with tall fescue (Figure 1d).There was a negative correlation between height and tiller number (Figure 2), which could be a tradeoff among the grasses for their survival. This tradeoff could be crucial for grasses to determine the competitive ability of the species. Based on the preliminary results of the study, basin wildrye and tall fescue might have potential to effectively compete with cheatgrass. However, further investigation in needed to confirm this trait.

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Keywords: cheatgrass, competitive effect, native and non-native grasses

PARP: III:5, XII:1

Potential of seed production of photoperiod-sensitive and photoperiod-insensitive popping bean lines of *Phaseolus vulgaris* under greenhouse conditions during the winter months

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Introduction

American consumers currently fall short of dietary guidelines for a variety of nutrients including dietary fiber and have experienced increasing rates of overweight/obesity. Consumption of high fiber, plant-based foods such as dry beans promote healthy weight and chronic disease prevention. Nuña beans (*Phaseolus vulgaris* L.) are a class of common beans originated in the Andean region of South America and cultivated in the highland areas of Peru at elevations from 1500 to 3000 meters. They are unique as an edible bean due to their characteristic of "popping" or expanding after exposure to heat, producing a toasted, softtextured edible snack. Most of the nuña seed accessions from the USDA-GRIN collection (a.k.a., Plant Introductions or PI's) are short-day plants which means they only flower and produce seed under short-days (typically 13 h or less). Most of these lines were collected from Peru where the photoperiod is relatively short. Additionally, fuel required for cooking beans conventionally (by boiling in water for one hour or longer) is often in short supply in the highlands of Peru so an alternative method of preparing beans for consumption is required. For these beans, a short duration (2 min or less) of high heat appears to denature the anti-nutritional lectins within bean seed and allows human consumption. Other lines that are essentially day-neutral but possess the popping trait have been bred and developed by groups in Colorado and Wisconsin by crossing and backcrossing the Peruvian lines with lines adapted to temperate climates found in those two states (Pearson et al., 2012; Vorwald and Nienhuis, 2009).

Objectives

Objectives of the project include: 1) measuring growing characteristics of nuña beans, 2) evaluating advanced breeding lines of nuña beans for popping characteristics and desirable agronomic characteristics within the Wyoming growing environment, 3) introducing nuña beans to growers and consumers in the state as an alternative dry bean market class and nutritious source of protein and dietary fiber, and 4) evaluating consumer perception of sensory qualities.

Methods

Four day-neutral popping bean lines (CO 49957, CO 49956, WI 19, WI 21) and two short-day PI's (PI 298824, PI 577678) from the USDA *Phaseolus* collection were grown in the greenhouse in 3-gallon pots with a mixture of native LREC soil, pine bark mix, and sand (1:1:1; v,v,v). Seeds from CO 49957, CO 49956, WI 19, WI 21 were harvested 74 days after planting. Seeds from PI 298824, PI 577678 were harvested 135 days after planting. Seeds were shelled, weighed, and kept in dry, room temperature storage for 25-30 days before popping analysis. Popping analysis was performed using 3 methods (finalized based on preliminary popping testing) including 1) cast-iron skillet on gas range using canola oil, 2) cast-iron skillet on gas range using lard, and 3) air popper. Two different fat sources were utilized for popping in the cast-iron skillet based on commonly consumed oils in the U.S. (canola) and similarity to fat source available in traditional environments in the highlands of Peru (lard, an animal fat). To assess popping percentage, ten seeds from each pot of each line (CO 49956 n=60; CO 49957 n=40; WI 19 n=60; WI 21 n=60, PI 298824 n=50; PI

577678 n=60) were heated under all 3 methods from 45 seconds to 1 minute 30 seconds until all beans were heated without burning. Consumer introduction and response to nuña popping beans will be evaluated in year 2 of the project.

Results and Discussion

Seeds from CO 49957, CO 49956, WI 19, WI 21 achieved 100% popping percentage for all 3 methods. Seeds from PI 298824, PI 577678 achieved 90-100% popping percentage using the cast-iron skillet on a gas range and 80-100% popping percentage using the air popper. Popping percentage did not differ significantly but the day-neutral popping bean lines had slightly higher performance. Seed size and weight did not significantly impact popping percentage.

References

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Keywords: popping beans, beans, seed yield, fiber, consumer

PARP: VII, VII.10

Figure 1. *From left to right, popped beans, unpopped adapted CO line, an unpopped dark maroon PI line, and an unpopped butterscotch-colored PI line.*

The effect of two nitrogen sources (and rates) on seed yield of six greenhouse-grown common bean genotypes that express the 'popping' trait

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Introduction

In an earlier bulletin we demonstrated the ability of several nuña bean (*Phaseolus vulgaris* L.) genotypes to produce "pop-able" beans (Keith and Heitholt, 2019; this issue and citations therein). However, there is a need to quantify seed yield and maturity within these lines when grown under our greenhouse conditions.

Objectives

Objectives of the project include: 1) measuring growing characteristics of nuña beans, 2) evaluating advanced breeding lines of nuña beans for popping characteristics and desirable agronomic characteristics within the Wyoming growing environment, 3) introducing nuña beans to growers and consumers in the state as an alternative dry bean market class and nutritious source of protein and dietary fiber, and 4) evaluating consumer perception of sensory qualities. The specific objective here is to compare six existing lines.

Methods

Four day-neutral popping bean lines and two short-day PI's (refer to Table 1) from the USDA *Phaseolus* collection were sown on 30 July 2018 in the greenhouse in 3-gallon pots with a mixture of native LREC soil, pine bark mix, and sand (1:1:1; v,v,v), inoculated (commercial rhizobia specific for *Phaseolus*), and seedlings were thinned to three per pot. Seed were advanced during the winter of 2017 to 2018 in the greenhouse in order to generate enough seed for this study. At 16 days after planting, three pots of each entry were fertilized with a common fertilizer (high N) or with an organic fertilizer (low N), both slow-release. Thus, the fertilizer source was confounded with rate. Flowering and maturity (65% of pods mature) dates were recorded for each pot and mature pods were excised as they matured. Yield and yield components were calculated on air-dried seed. The experimental design was a CRD and sources of variation were Entry (5 df), Fertilizer (1 df), and Entry-by-Fertilizer (5 df). The error df was 20 (not 24) due to four missing pots.

Results and Discussion

Seed yield among the entries did not differ significantly but the common fertilizer (high N) outyielded the organic treatment (low N) by 89% (Table 1). Seed size was unaffected by fertilizer but pod number per pot was 58% greater in the high N treatment and the remaining yield difference was explained by a 21% greater seed per pod with high N treatment. One of the PIs had the largest seed (458 mg) and Wisc 21 had the smallest (328 mg). PI 298824 and PI 577678 flowered at 95 and 92 dap, respectively, and the four adapted lines flowered at around 30 dap (data not shown). No EntrybyFertilizer interactions were detected.

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Figure 1. *Photo of one of the popping bean lines during podfill in an LREC greenhouse.*

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Keith, J. and J. Heitholt. 2019. Potential of Seed Production of Photoperiod-Sensitive and Photoperiod-Insensitive Popping Bean Lines of *Phaseolus vulgaris* under Greenhouse Conditions during the Winter Months. Wyo. Agric. Exp. Stn. Field Day Bulletin. p. 11.

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Keywords: popping beans, beans, seed yield, fiber, consumer

PARP: VII, VII.10

Table 1. Yield, yield components and maturity of six *Phaseolus vulgaris* genotypes (with the popping trait grown) in the greenhouse during the summer 2018 through winter of 2018 in Laramie.

Fertilizer	Entry	Seed Yield	Seed Size	Seed Per Pod	Maturity
		g per pot	mg	no.	dap
Organic Low N	CO 49956	26.1	424	3.38	80
	CO 49957	23.1	484	3.48	80
	PI 298824	10.3	421	1.99	160
	PI 577678	25.6	329	4.23	153
	Wisc 19	29.1	350	2.49	80
	Wisc 21	31.1	320	3.25	81
Average		25.2	381	3.22	104
Com. Fert High N	CO 49956	46.2	434	3.66	79
	CO 49957	49.1	427	4.02	82
	PI 298824	50.8	494	2.45	150
	PI 577678	45.0	347	6.55	148
	Wisc 19	46.9	366	2.97	79
	Wisc 21	48.9	337	3.32	87
Average		47.5	394	3.90	103
LSD (0.05)†		16.5	54	2.08	10

† *LSD applies to the 12 treatment means and does not apply to the averages-across-entries row.*

Year-round greenhouse and high tunnel specialty cut flower production

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Introduction
Diversification of Wyoming's economic base should include agricultural crops, more specifically horticultural crops. In order to boost this effort, we are encouraging owners of greenhouses and high tunnels in Wyoming to grow specialty cut flowers for local markets.

Objectives
We propose to demonstrate that growing fresh cut flowers is feasible in Wyoming greenhouses and high tunnels, using five different species from May 2018 through September 2019.

Materials and Methods
Five species of cut flowers have been under production since spring 2018: strawflower 'Double Mix', calendula 'Princess Golden', stock 'Lucinda Mix', ornamental carrot 'Dara', and celosia 'Celway Mix'. Seeds of all five were sown in April 2018, transplanted to #1 containers and placed in the greenhouse and two high tunnels in early May. Cut flower stems were harvested about every two days through early September. Another group of the same five species was sown in August 2018 and transplanted and placed in the greenhouse in September for a winter greenhouse crop. The 2019 summer crop will be sown and transplanted as it was in 2018.

Results and Discussion
For the summer 2018 crop, days to harvest and stem lengths varied by species. Stock produced less than one flower stem per plant, taking at least 84 days from sowing. Strawflowers produced about 25 stems per plant, and took at least 116 days. For celosia, each plant produced an average of about 38 stems and took at least 123 days from sowing. Calendula produced a maximum of 40 stems per plant, taking at least 107 days. The ornamental carrot produced the largest number of stems at about 43 per plant in a minimum of 98 days from sowing. Stem lengths varied from 28 cm for stock to 49 cm for ornamental carrot.

  

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Keywords: horticulture, cut flowers

PARP: I:12

2019 All-America Selections annual and perennial flowers

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Introduction

The All-America Selections (AAS) program (http://www.all-americaselections.org/) exists "to promote new garden varieties with superior garden performance judged in impartial trials in North America." AAS was founded in 1932 and new winners have been introduced each year since 1933. The program promotes the best of the best flowering annuals, vegetables, and herbaceous flowering perennials. There are currently almost 200 AAS Display Gardens in the United States and Canada; the UW garden is the only AAS site in Wyoming.

This year, 2019, is the eighth growing season for our UW All-America Selections (AAS) Display garden. For the past two years graduate student Samantha Nobes has coordinated seeding and transplanting of the AAS plants. The main location for the flowering annuals and perennials is just west of Old Main on the UW campus in Laramie. We have a secondary site at the UW Laramie Research and Extension Center greenhouse complex.

Objectives

Our goal is to showcase new and improved annual and perennial flowering plants for the high-altitude Wyoming climate. We also test new, unsold cultivars; inform gardeners and landscapers about AAS winners; and earn gardeners' and landscapers' trust in AAS winners.

Materials and Methods

Starting in February, seeds of AAS selections are sown in the Laramie Research and Extension Center (LREC) greenhouse. After germination, seedlings are all transplanted and grown in the greenhouse. Plants are transferred outdoors to the gardens the first week in June. For 2019, new AAS winners include: Begonia 'Viking XL Red on Chocolate F_1', Marigolds 'Big Duck Gold F_1' and 'Big Duck Yellow F_1', Petunia 'Wave Carmine Velour F_1', and Zinnia 'Holi Scarlet F_1'. Previous winners we'll display in 2019 include Canna 'South Pacific Orange F_1', Dianthus 'Jolt Pink F_1', Salvia 'Summer Jewel White' and 'Summer Jewel Lavender', and Zinna 'Profusion Red', among others.

Results and Discussion

Since its inception at UW in 2012, our AAS Display Gardens have been viewed by thousands of students, faculty, and the public. As in previous years, we are growing AAS annual and perennial flowering plants in raised beds just outside the greenhouses at the LREC as well as at Old Main.


Acknowledgments

Our thanks to LREC greenhouse staff Ryan Pendleton and Jemma Woods, and volunteer Mark Panter. This work is supported by U.S. Department of Agriculture Hatch funds.

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Key Words: flowers, annuals, perennials

PARP: I.12

Overview of Powell Research and Extension Center
July 18, 2019

By Jim Heitholt and colleagues at PREC

History

The Research and Extension Center at Powell (PREC) is a leading irrigated agricultural research and extension center that serves the citizens of the region, state, and nation. Research and outreach projects include agronomic weed control, irrigation, cropping systems, variety testing, and alternative crops. Barley, sugar beet, and dry bean is a common rotation for the region. Powell is located in the Bighorn Basin of Wyoming and crop seed production is a major industry in this region. Due to the seed industry's need for effective weed management, external support for weed science research is strong. PREC is also home to the Wyoming Seed Certification Service and the Wyoming Seed Analysis Lab and these two divisions routinely work closely with the weed science projects. Powell is also the home of Northwest College (NWC), a two-year institution with seven associate programs in agricultural disciplines. NWC students often complete internships at PREC. Elevation of Powell is 4,374 feet and annual precipitation is seven inches. The Center has 175 acres of irrigated cropland.

Mission

For crops being grown in the Bighorn Basin and the Intermountain West, we strive to provide producers and industry representatives with performance data on existing and new varieties and their responses of those crops to fertilizer, plant protection products, tillage, and irrigation management.

Research and Extension Programs

- Effect of Cultivar, Management, and their Interactions on Crop Performance
- Quantify Evapotranspiration in Barley, Sugar Beet and Dry Bean
- Soil Moisture Network – Sensors Installed in Alfalfa Seed Fields (six northwest Wyoming Locations: Powell, Heart Mountain, Cowley, Worland, Riverton, and Pavilion)
- Wyoming Sugar Beet Trials – Worland (Wyoming Sugar Coop.)
- Barley Trials (Industry Partners are Miller-Coors and Breiss)
- Emmer, Spelt, Sugar Beet N Fertility Tests
- Dry Bean and Corn Variety Trials (Wyoming Bean Commission and Simplot)
- Collaborations with 13 External Partnering Agencies, Companies, or Commodity Groups

New Emphases

- Flax – Safflower - Chickpea – Hops - Hemp (anticipated 2020)
- Contribute to the teaching of UW and NWC Courses

Dry bean trial at PREC with barley maturing in the background.

Graduate student and summer intern calibrating irrigation system.

Integrating livestock and cover crops into irrigated crop rotations

Jay Norton, Urszula Norton, John Ritten, Taylor Bush, Dixie Crowe

Issue

Sugar beet-barley rotations are notoriously destructive to soil health because of intensive tillage, long periods of bare soil, and the every-other-year frequency of resource-consumptive sugar beets. Several research papers have shown that the less often sugar beets are grown, the healthier the soil. Farmers are realizing that the early harvest of barley creates a window of opportunity. Barley can be replanted right behind the combine to grow a tall, green forage crop before freeze up. Some farmers irrigate and fertilize to maximize forage production. Others include a mix of other cover crop species to benefit both the soil and livestock. More information is needed on the benefits of replanting barley, adding other cover crop species, and on soil-health trade-offs associated with grazing or haying fall cover crops in irrigated production areas of northwestern Wyoming and south-central Montana.

Goal

This project will provide producers with the knowledge to implement soil-building practices for more sustainable irrigated cropping systems.

Objectives

Specific objectives include quantifying and comparing effects of three types of cover crops (volunteer barley, replanted barley, and a cover crop mix) and three residue treatments (hay, grazed, and no harvest) on subsequent crops, soil health, forage quality/quantity, water use efficiency, and costs and benefits.

Expected Impact

Results should assist growers in designing soil-building cropping systems that include cover crops in rotations by providing information about the benefits of replanting barley and adding other cover crop species, and on soil health tradeoffs associated with grazing or haying fall cover crops.

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Keywords: sugar beet, barley, irrigated cropping systems, soil health, cover crops

PARP: I.1,3,6,7,9,13,15,18,19; II.5,6,7,9

2018 Briess barley variety performance evaluation

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[1]Department of Plant Sciences, [2]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 Big Horn 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 2018. Fertilizer was applied March 27 at the rate of 170 lb/ac of nitrogen (N) and 25 lb/ac of P2O5. The experimental design of all trials was randomized complete block with three replications. On March 27, 30 barley varieties were established 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, lodging, grain yield, test weight, and kernel plumpness (lodging is the bending or kinking of stems at or near ground level causing the barley plant to fall over). Subsamples, 5.3 by 15 feet, were harvested August 8 using a Wintersteiger plot combine.

Results and Discussion

Results from 2018 are presented in Table 1. The highest yielding Briess variety in the small plot trial was 'Laudis' at 145 bu/ac, which was significantly higher than the regional checks. Complete results are posted online at http://www.uwyo.edu/uwexpstn/research-results-impacts/variety-trials/index.html.

Acknowledgments

Appreciation is extended to the PREC staff and summer crew for their continuing support throughout the 2018 season.

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Keywords: variety trials, malting, barley

PARP: I.12

Table 1. Results from 2018 small plot trials. Each variety was replicated 3 times. Bolded varieties are regional checks.

Variety	Height (in)	Yield (bu/ac)	Plump (6/64)	Plump[2] (5.5/64)	Thin	Lodging (1-9)	TWT[3] (lb/bu)
Laudis	38	145	85%	93%	7%	7	49
Odessey	34	141	93%	96%	3%	4	49
Steptoe[1]	**34**	**140**	**91%**	**96%**	**4%**	**5**	**48**
Synergy	38	140	96%	98%	2%	3	51
Bojo	36	139	95%	97%	3%	2	52
Sienna	36	135	92%	96%	4%	5	50
GemCraft	38	132	86%	94%	6%	9	49
Opera	29	131	85%	93%	7%	5	47
Baronesse	**37**	**125**	**92%**	**97%**	**3%**	**3**	**52**
Malz	31	125	94%	97%	3%	4	51
Barke	35	124	93%	96%	3%	6	50
AC Metcalfe	39	121	92%	96%	3%	6	51
Harrington	39	109	78%	88%	7%	8	49
Villa	36	105	93%	97%	3%	5	52
Location Mean	36	129	90%	95%	4%	5	50
Checks Mean	37	124	88	94	4%	6	50
LSD (0.05)[4]	5	20	6%	4%	2%	2.9	1.5

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

2018 Elite malt barley variety performance evaluation

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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 does spring barley variety performance. Data on grain yield, test weight, and protein are important to local and regional producers, as some malt varieties may not perform in some areas.

Materials and Methods

The experiment was located at the Powell Research and Extension Center (PREC) during 2018. Fertilizer was applied March 27 at the rate of 170 lb/ac of nitrogen (N) and 25 lb/ac of P2O5. The experimental design of all trials was randomized complete block with three replications. On March 28, 30 barley varieties were established 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, lodging, grain yield, test weight, and kernel plumpness (lodging is the bending or kinking of stems at or near ground level causing the barley plant to fall over). Subsamples, 5.3 by 15 feet, were harvested August 8 using a Wintersteiger plot combine.

Results and Discussion

Results from 2018 are presented in Table 1. The highest yielding malting entry was 'M69' at 157 bu/ac. Entries in bold in Table 1 are regional checks. Results are posted annually at http://www.uwyo.edu/uwexpstn/variety-trials/index.html.

Acknowledgments

Appreciation is extended to the Powell Research and Extension staff and summer crew for assistance during 2018.

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Keywords: variety trial, malting, barley

PARP: I.12

Table 1. 2018 Elite Malt Barley Trial Results.

Cultivar	Yield bu/ac	TWT[2] lb/bu	Height in	Lodging 0/9	Plump[3] (6/64)
M69[1]	**157**	**51**	**32**	**0.7**	**94%**
13ARS107-4	155	51	38	0.7	95%
2Ab07-X031098-31	148	51	40	1.3	96%
11ARS162-8	148	50	38	1.0	96%
13ARS105-4	147	51	34	2.3	94%
10ARS191-3	146	52	41	1.3	96%
10ARS144-1	145	51	40	2.0	96%
2Ab04-X01084-27	144	51	36	4.7	93%
13ARS102-5	143	51	37	0.7	91%
10ARS061-2	141	51	37	1.0	97%
AC Metcalfe	**140**	**52**	**39**	**0.7**	**96%**
11ARS162-4	139	51	39	0.3	94%
2Ab08-X05M010-82	135	52	38	3.3	93%
Merit57	135	50	40	0.3	93%
12ARS061-2	135	52	36	0.7	97%
08ARS116-91	134	51	35	1.0	93%
13ARS069-6	133	52	44	1.0	95%
11ARS183-9	133	51	39	0.0	97%
12ARS057-1	133	52	40	0.3	96%
13ARS072-6	132	50	45	1.0	98%
Voyager	**127**	**51**	**39**	**2.0**	**97%**
Harrington	**127**	**51**	**38**	**5.0**	**94%**
08ARS012-79	126	50	39	2.0	95%
CDC Copeland	**125**	**52**	**39**	**3.7**	**97%**
13ARS093-3	123	51	35	2.7	93%
Gem Craft	**121**	**51**	**36**	**4.7**	**93%**
13ARS076-5	109	52	38	2.3	96%
Conrad	**109**	**52**	**36**	**0.3**	**96%**
13ARS071-3	80	51	41	3.0	94%
08ARS028-20	76	52	36	0.3	94%
Location Mean	136	51	38	1.7	95%
Checks Mean	135	51	37	2.2	95%
LSD (0.05)[4]	7 (%CV)	1	4	1.9	2%

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

2018 Western regional spring barley nursery performance evaluation

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[1]Department of Plant Science, [2]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 and feed barley grown under all climatic conditions in Pacific Northwest and Northern Great Plains regions, including Wyoming. Our state's climatic conditions vary greatly as does spring barley variety performance. Data on grain yield, test weight, and protein are important to local and regional producers, as some malt varieties may not perform in some areas.

Materials and Methods

The experiment was located at the Powell Research and Extension Center (PREC) during 2018. Fertilizer was applied March 27 at the rate of 170 lb/ac of nitrogen (N) and 25 lb/ac of P_2O_5. The experimental design of all trials was randomized complete block with three replications. On March 27, 30 barley varieties were established 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, lodging, grain yield, test weight, and kernel plumpness (lodging is the bending or kinking of stems at or near ground level causing the barley plant to fall over). Subsamples, 5.3 by 15 feet, were harvested August 8 using a Wintersteiger plot combine.

Results and Discussion

Results from 2018 are presented in Table 1. The highest yielding entry was 08ARS028-20 at 157 bu/ac. This entry is a malt variety and was in the top 20% in 2017 for yield. Entries in bold in Table 1 are regional checks. Results are posted annually at http://www.uwyo.edu/uwexpstn/variety-trials/index.html.

Acknowledgments

Appreciation is extended to the Powell Research and Extension staff and summer crew for assistance during 2018.

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Keywords: variety trial, barley

PARP: I.12

Table 1. 2018 Western Regional Spring Barley Nursery Results

Cultivar	Row Type	Grade	Yield bu/ac	TWT[2] lb/bu	Height in	Lodging 0/9	Plump[3] (6/64)
08ARS028-20	2 row	Malt	157	51	37	3.7	93%
UTSB11301-1	6 row	Feed	155	49	35	2.3	95%
11WA-107.43	2 row	Feed/Malt	148	52	35	3.0	94%
2IM14-7830	2 row	Malt	148	51	35	4.3	91%
UTSB10905-72	6 row	Feed	147	49	36	3.7	94%
2B13-6991	2 row	Malt	146	51	36	3.7	93%
2B11-4949	2 row	Malt	145	50	35	4.0	90%
11WA-107.58	2 row	Feed/Malt	144	53	26	3.3	96%
MT124134	2 row	Feed/Malt	143	51	33	2.0	96%
HO515-555	2 row	Feed	141	51	34	2.3	91%
Steptoe[1]	**6 row**	**feed**	**140**	**48**	**34**	**5**	**91%**
2IM14-7765	2 row	Malt	139	50	38	4.0	93%
13WAM-101.2	2 row	Feed/Malt	135	50	36	4.3	93%
10ARS191-3	2 row	Malt	135	52	43	6.0	92%
CDC Bow	2 row	Malt	135	52	36	2.0	96%
HO515-510	2 row	Feed	134	51	38	5.3	88%
2ND32529	2 row	Malt	133	50	34	5.0	94%
2IM14-8212	2 row	Malt	133	51	35	3.3	92%
CDC Fraser	2 row	Malt	133	51	39	2.0	96%
MT124112	2 row	Feed/Malt	132	51	33	2.0	96%
11ARS162-4	2 row	Malt	127	50	38	3.7	90%
08ARS116-91	2 row	Malt	127	51	35	4.0	89%
13WAM-149.2	2 row	Feed/Malt	126	50	32	7.0	86%
Baronesse	**2 row**	**feed**	**125**	**52**	**37**	**3.3**	**92%**
MT124069	2 row	Feed/Malt	123	51	34	6.0	93%
AC Metcalfe	**2 row**	**Malt**	**121**	**51**	**39**	**6.3**	**92%**
MT124128	2 row	Feed/Malt	109	50	31	3.3	96%
Harrington	**2 row**	**Malt**	**109**	**49**	**39**	**8.0**	**78%**
2ND32829	2 row	Malt	80	47	37	5.0	91%
13WAM-135.26	2 row	Feed/Malt	76	53	34	7.3	92%
Location Mean			132	51	36	4.2	92%
Check Mean			124	50	37	5.7	88%
LSD (0.05)[4]			32	2	8	3.3	5%

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

Dry bean growth and yield relationships in response to irrigation gradient in the semi-arid climate of Wyoming

Abhijit Rai[1], Vivek Sharma[1,2], Jim Heitholt[1,2]
[1]Department of Plant Sciences, [2]Powell Research and Extension Center

Introduction

Dry edible beans are one of the most important pulse crops in Wyoming. It is projected that the demand and trade for dry beans and other pulses in Wyoming will continue to increase in the future. However, the resources required to meet this increasing demand are limited. Therefore, it is crucial to increase production by improving productivity per unit of land and water used. Increasing productivity will require careful assessment of the factors that affect yield. Crop growth is the most critical factor that decides the yield. The most common parameters used to assess growth are leaf area index (LAI), normalized difference vegetative index (NDVI), and plant height (PHt). For detailed information on LAI and NDVI, please refer AES 2018 bulletin *"Dry bean dynamics in response to deficit irrigation under surface and sprinkler irrigation system"*. Understanding the relationship between crop growth and yield in response to irrigation under the two most prominent irrigation system (furrow and sprinkler) in Wyoming would help producers develop more effective strategies to increase productivity per unit of water and maximize return.

Objectives

1. Understand the relationship between growth and grain yield.
2. Evaluate the effect of irrigation on dry bean growth parameters under furrow- and sprinkler irrigation systems.

Materials and Methods

Field experiments were conducted in 2017 and 2018 at the Powell Research and Extension Center (PREC). For detailed agronomic practices, please refer to AES 2019 Bulletin *"Dry bean yield dynamics in response to irrigation gradients under sprinkler and furrow irrigation"* (this issue). LAI, NDVI, and PHt were measured weekly throughout the dry bean growing season. Maximum values of each parameter, irrespective of the timing of occurrence then related to yield to understand the relationship between growth and grain yield. For Yield, an area of 10 feet long by two rows wide was hand-harvested from three locations from each replication for grain yield at maturity.

Results and Discussion

The dry bean yield under sprinkler and surface irrigated increased linearly with an increase in LAI (Figure 1a), and PHt (Figure 1c), however, a curvilinear relationship was observed for dry bean yield and NDVI (Figure 1b). The Curvilinear relationship with NDVI is due to the saturation of NDVI values after 0.85. Clear differences existed in plant height between dry bean grown under furrow and sprinkler irrigation. The plant height was higher under furrow irrigation, but this did not result in higher yields than sprinkler grown dry bean. Overall, the magnitude of aboveground biomass under furrow irrigation was within a short range for different irrigation treatments, i.e., the growth was less sensitive to irrigation gradients in comparison to sprinkler irrigation.

The relationship between irrigation amount and growth parameters are presented in Figure 1d,1e,1f. It was observed that under both sprinkler and surface irrigation, an irrigation range of 10-13 inches promotes optimum growth (Leaf area/plant height) and higher grain yield. Irrigation beyond 13 inches did not lead to no significant increase in plant growth. In case of surface irrigated dry beans irrigation amount beyond the threshold leads to a decline in the growth of dry beans in comparison to optimum irrigation and causes significant yield reduction. In general, furrow irrigated dry beans are generally at risk of excess water stress, non-uniform distribution of water, nutrient leaching, erosion, and waterlogging condition. The irrigation management range mentioned above needs to be adopted as per the weather conditions; in cooler growing season lower irrigation may be required, whereas, in hotter growing season higher irrigation may be required.

Acknowledgment

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PARP: IV:3, 4

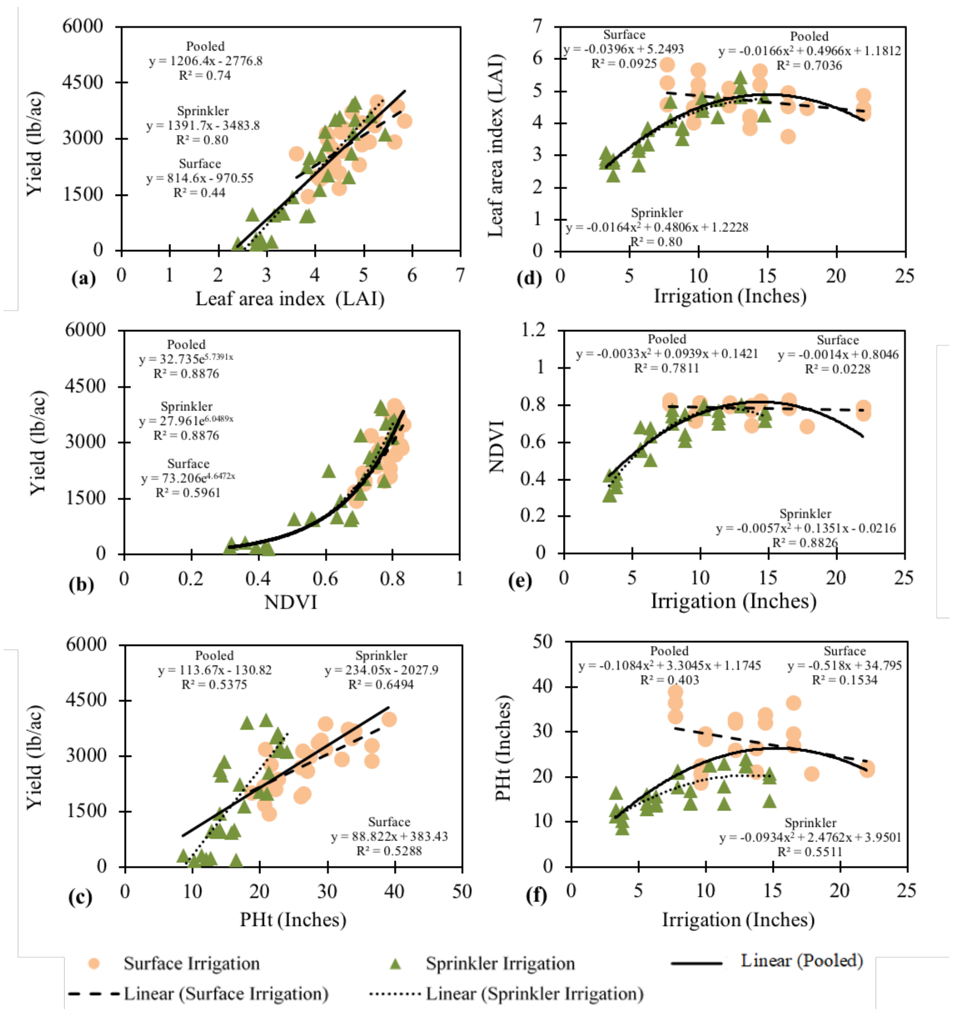

Figure 1. *Relationship between, (a) Yield and LAI, (b) Yield and NDVI, (c) Yield and Plant height (PH), (d) LAI and Irrigation, (e) NDVI and Irrigation, (f) Plant Height (PHt) and Irrigation.*

Dry bean yield dynamics in response to irrigation gradients under sprinkler and furrow irrigation system

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Introduction

Water is the most critical resource for dry bean production in Wyoming. In recent years, Wyoming producers have faced issues pertaining to water availability and climate variability. An understanding of the dry bean grain yield and yield component in response to irrigation and method of irrigation can help efforts aimed at selecting traits that are less sensitive to drought. Additionally, this research can (1) lead to more effective and efficient irrigation management and improved farm income.

Objective

Evaluate the impact of irrigation method and amount on dry bean grain yield, seeds per pod, pods per plant, 100-seed weight, and pod harvest index (PHI).

Materials and Methods

Field experiments were conducted in 2017 and 2018 at the Powell Research and Extension Center (PREC). Dry bean cultivar 'Othello' was planted under sprinkler- and furrow-irrigation systems in 22-inch row spacing at 90,000 seeds/ac. The experiments were laid out in a randomized block design under five irrigation gradients: full irrigation treatment (FIT), 75% FIT, 50% FIT, 25% FIT, and 125% FIT (excess irrigation), with three replications. At maturity, an area of 10 feet long by two rows wide was hand-harvested from three locations from each replication for grain yield. Also, two-plant samples were collected from each location to quantify seeds per pod, pods per plant, and pod harvest index (PHI).

Results and Discussion

The average dry bean grain yield, seeds per pod, pods per plant, 100-seed weight and pod harvest index (PHI) in response to irrigation gradient under the sprinkler and furrow/surface irrigation system for 2017, 2018, and the average of two seasons is presented in Table 1. Under sprinkler irrigation, grain yield and yield components increased up to FIT but 125% FIT provided no further benefit in either year. Yield differences were associated with number of pods per plant and number of seed per pod.

Under surface irrigation, yield differed with irrigation gradient ($p < 0.05$) in both growing seasons. However, the differences in yield components were not significant ($p > 0.05$) in either year, except for pods per plant in 2017. In 2017, 75% FIT achieved the highest yield as opposed to FIT in 2018. Grain yield was reduced by 26% and 43% for FIT and 125% FIT in comparison to 75% FIT in 2017, respectively. However, in 2018, no yield reduction was observed for FIT, but a yield reduction of 8% was observed for 125% FIT in comparison to FIT. Low yield for FIT plots in 2017 is likely due early-season flooding-like stress.

For the three deficit irrigation treatments, grain yield and all yield components were higher under furrow than the sprinkler irrigation system. This indicates that in the semi-arid climate of the Big Horn Basin, reducing furrow irrigation amounts may have less impact on yield compared to sprinkler irrigation. In contrast, yield under FIT was 11% lower in furrow irrigated plots. Higher yields in 2018 in both sprinkler and furrow irrigated dry beans was due to cooler temperatures and higher mid-season precipitation in 2018.

Acknowledgment
Authors thank USDA-SCBGP and Wyoming Department of Agriculture for funding. The authors thank PREC crews for help with field work.

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PARP: IV 3, 4

Table 1. Effect of Irrigation amount (IA), irrigation method (IM) on grain yield (lbs/ac), pods plant^{-1}, seeds pod^{-1}, 100-seed weight, and pod harvest index (PHI) for 2017, and 2018 growing season under sprinkler and furrow irrigation systems.

		2017					2018					Average				
	Treatment	Grain Yield (lbs/ac)	Pods Plant^{-1}	Seeds Pod^{-1}	100-seed weight (ounce)	PHI (%)	Grain Yield (lbs/ac)	Pods Plant^{-1}	Seeds Pod^{-1}	100 seed weight (ounce)	PHI (%)	Grain Yield (lbs/ac)	Pods Plant^{-1}	Seeds Pod^{-1}	100-seed weight (ounce)	PHI (%)
Sprinkler	25% FIT	236	6.6	2.1	0.9	71.7	248	4.1	2.9	1.0	77.0	242	5.4	2.5	0.9	74.4
	50% FIT	969	12.8	2.6	0.9	72.4	977	8.6	2.5	1.2	74.7	973	10.7	2.6	1.1	73.6
	75% FIT	2056	13.5	2.9	1.2	73.6	2062	13.2	3.3	1.3	76.5	2059	13.3	3.1	1.3	75.0
	FIT	3238	16.9	3.0	1.3	75.2	3410	16.5	3.6	1.4	77.4	3324	16.7	3.3	1.4	76.3
	125% FIT	2950	16.6	2.9	1.3	75.0	3413	15.6	3.7	1.4	78.4	3181	16.1	3.3	1.3	76.7
	p-value	<0.001	<0.001	<0.05	<0.001	>0.05	<0.001	<0.001	<0.001	<0.001	>0.05	<0.001	<0.001	<0.05	<0.001	>0.05
Furrow	25% FIT	-	-	-	-		2835	15.67	3.83	1.3	77.1	2835	15.7	3.8	1.3	77.2
	50% FIT	2145	16.5	3.57	1.2	75.33	2978	18.28	3.80	1.3	77.5	2561	17.4	3.7	1.3	76.4
	75% FIT	2989	17.38	3.58	1.3	75.87	3445	18.72	4.15	1.3	78.2	3217	18.0	3.9	1.3	77.1
	FIT	2193	11.64	3.5	1.2	73.98	3726	19.39	4.24	1.4	78.8	2960	15.5	3.9	1.3	76.4
	125% FIT	1691	11.65	3.38	1.3	73.55	3431	19.67	4.11	1.4a	78.3	2561	15.7	3.7	1.3	75.9
	p-value	<0.001	<0.001	>0.05	>0.05	>0.05	<0.001		>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05
	IM†	NS	NS	**	NS	NS	**	**	**	**	*	**	**	**	*	NS
	IA x IM†	**	**	NS	*	NS	**	*	NS	**	NS	**	**	NS	**	NS

Within columns, means followed by the same letters are not significantly different at p<0.05.

** means significant at p < 0.05, and ** means significant at p < 0.001.*

NS stands for non-significant.

† *Measured data for all parameters were pooled for the growing season together based on irrigation method for analysis of variance for Irrigation method (IM) and two-way analysis of variance between Irrigation amount (IA) and Irrigation method (IM).*

Water-budget of sprinkler and furrow irrigated dry beans in Wyoming

Vivek Sharma[1,2], Abhijit Rai[1]
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Introduction

The water available for crop production is becoming scarcer. The emphasis on efficient use of water is increasing for promoting water resource sustainability and maximum economic returns. In Wyoming, many producers are facing water availability and allocation issues, with the majority of crop production possible only with irrigation, either sprinkler or furrow systems. Under these conditions, knowledge of soil water balance components [i.e., crop evapotranspiration (ETc), soil water content, and losses such as runoff (RO) and deep percolation (DP)] is critically important in developing effective irrigation management strategies that enhance water use and minimize water loss.

Objective

Quantify crop water use and water balance components for sprinkler- and furrow-irrigated dry beans in Wyoming.

Materials and Methods

Field experiments were conducted in 2017 and 2018 at the Powell Research and Extension Center (PREC). Dry bean cultivar 'Othello' was planted under sprinkler- and furrow-irrigation system in 22-inch row spacing at 90,000 seeds/ac. The experiments were laid out in a randomized block design under five irrigation gradients: full irrigation treatment (FIT), 75% FIT, 50% FIT, 25% FIT, and 125% FIT (excess irrigation) with three replications. ETc was calculated using soil water balance approach:

$$ET_a = P + I + U - RO - DP \pm \Delta S$$

where P is precipitation, I is irrigation, U is upward water flux (assumed zero), RO is a runoff, DP is deep percolation, and ΔS is change in soil moisture content in the effective dry bean root zone. Precipitation value was taken from a nearby weather station located at PREC. For both irrigation systems irrigation amount was quantified for each irrigation event. Changes in soil moisture (was calculated on weekly or bi-weekly basis using a field-calibrated neutron probe soil moisture meter at 1, 2, and 3 feet depths. For sprinkler irrigation, RO was calculated using the USDA-NRCS curve number procedure (USDA-SCS, 1972) and for furrow irrigation, trapezoidal flumes were installed in each irrigation treatments on upstream and downstream side to monitor water influx and RO. For both irrigation systems, DP was measured using soil water balance considering soil water depletion, runoff, and irrigation and precipitation amounts.

Results and Discussion

The average of water balance parameters (P, I, ΔS, RO, DP, and ETc) for different irrigation treatments under sprinkler and furrow irrigation systems are presented in Table 1 and Figure 1. In general, the ETc increased with increase in applied irrigation under both sprinkler and furrow irrigation systems. Under sprinkler irrigation, the amount of irrigation applied for FIT was 10.8 inches and crop evapotranspiration of 14.12 inches was achieved, whereas under furrow irrigation, the amount of irrigation applied was 33% higher and corresponding crop evapotranspiration was 3% higher as compared to sprinkler irrigated dry beans. In general, higher irrigation application in furrow irrigation systems is required to achieve higher irrigation uniformity that results in significantly higher runoff and deep percolation losses. Under furrow irrigation, the total losses (runoff plus deep percolation) were approximately 14%, 30%, 41%, and 57% for 50% FIT, 75% FIT, FIT and 125% FIT of the total irrigation water applied, respectively. However, as expected for sprinkler irrigated dry beans, the total losses were approximately less than 5% of the total irrigation applied across different irrigation treatments. The excess irrigation under furrow irrigation negatively impacted the ability of dry bean to use water. However, 50% FIT and 75% FIT were able to achieve similar ETc to FIT under furrow irrigation and could be viable deficit irrigation strategies to save water, whereas, under sprinkler irrigation system, irrigation equal to the crop water demand is required and reduction in irrigation can reduce ETc significantly.

In summary, the higher application efficiency and uniformity of sprinkler irrigation systems allow for higher water savings in comparison to furrow irrigation systems. The losses under furrow irrigation can be significant; and in general, excess irrigation can have a detrimental effect on dry bean production.

Acknowledgement
Authors would like to thanks PREC personnel for assistance. This project is supported by the grant funds from USDA-SCBGP and Wyoming Deparmtment of Agriculture and USDA-hatch funds.

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Keywords: evapotranspiration, irrigation, dry beans

PARP: IV.3 and IV.4

Table 1. Average rainfall (R), Irrigation (I), Storage (S), Runoff (RO), Deep percolation (DP), and water use (ETa) under different irrigation gradients for sprinkler and furrow irrigation system.

	Sprinkler						Furrow					
Treatment	**R** (Inch)	**I** (Inch)	**S** (Inch)	**RO** (Inch)	**DP** (Inch)	**ETa** (Inch)	**R** (Inch)	**I** (Inch)	**S** (Inch)	**RO** (Inch)	**DP** (Inch)	**ETa** (Inch)
25% FIT	2.18	3.55	1.06	0.00	0.23	7.42	--	--	--	--	--	--
50% FIT	2.18	5.97	0.78	0.00	0.23	9.87	2.18	9.78	2.98	0.62	0.77	13.91
75% FIT	2.18	8.39	0.58	0.00	0.23	12.10	2.18	12.95	2.60	1.31	2.58	14.21
FIT	2.18	10.81	0.40	0.01	0.23	14.12	2.18	16.12	2.49	2.14	4.56	14.46
125% FIT	2.18	13.88	-0.02	0.03	0.44	16.69	2.18	19.21	2.25	3.93	7.20	13.09

**All values were averaged across replications and years for each treatment.*

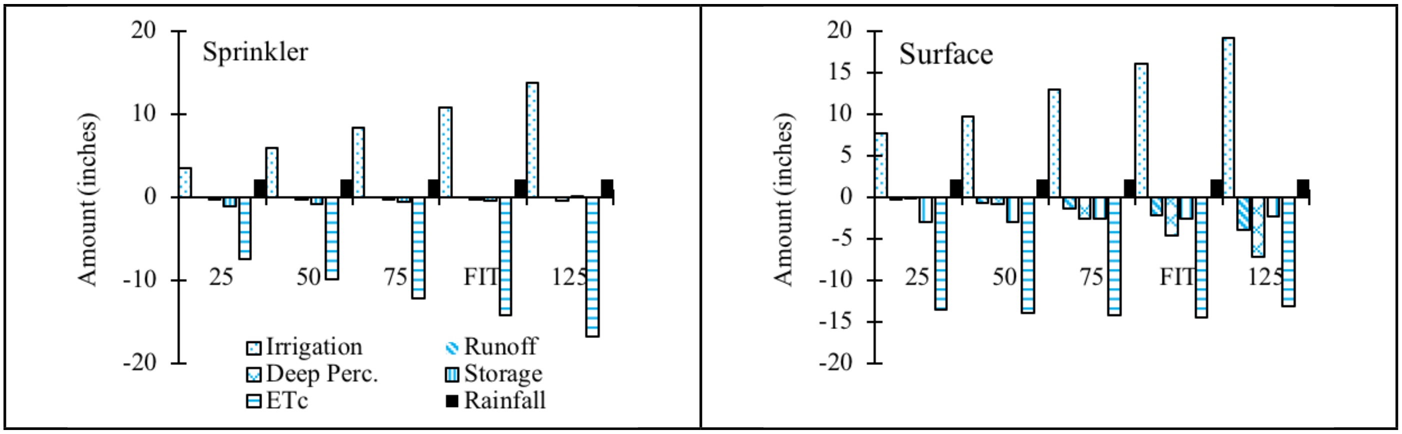

Figure 1. *Graphical representation of the seasonal rainfall (R), Irrigation (I), Storage (S), Runoff (RO), Deep percolation (DP), and water use (ETa) (average for two dry bean growing season) under different irrigation gradients for sprinkler and furrow irrigation system.*

Effects of seeding-rates and row-spacing on dry bean yield under full and deficit irrigation

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Introduction

Dry edible beans (*Phaseolus vulgaris* L.) are a major agricultural crop in Wyoming growing approximately 30,000 acres in 2018 (USDA). Traditional dry bean cultivars grown in Wyoming are predominately viney and produce dense canopies on 22-inch (northwestern Wyoming) and 30-inch (Southeast Wyoming) row spacing. These dense canopies are generally associated with poor aeration, excessive moisture and prolonged periods of dampness. These environmental conditions are often associated with the development of white mold (*Sclerotinia sclerotiorium*), which is an economically important disease for dry bean. Disease problems associated with dry bean can be significantly reduced by adopting the optimum combination of plant density and row spacing with controlled irrigation rates.

Objectives

The objective of this study is to evaluate the effect of different planting densities, row spacing, and irrigation treatments on dry bean yield and crop productivity in Wyoming.

Methods

Split-plot design with three dry bean cultivars at five population densities and two row spacing under three irrigation rates (main plots) i.e. full irrigation treatment (FIT), 80% FIT and 60% FIT was arranged at PREC in 2018. Three pinto dry bean cultivars (indeterminate to upright, i.e., Poncho, Sundance, and La Paz) were used in this study. The target dry bean seeding rates of 50,000; 75,000; 90,000; 105,000; and 120,000 plants per acre on 22-inch and 7.5-inch row spacing were sown on 4 June 2018 at PREC. Irrigation timings were based on the soil water content of well-watered treatment. Plots were prepared with conventional tillage and were fertilized according to soil test recommendations.

Results and Discussion

Significant row spacing vs. cultivar interaction was observed on dry bean yield. Averaged across three cultivars and all seeding rates, 7.5-inch planted dry bean had 15% higher grain yield compared to 22-inch planted dry bean (2930 vs. 2552 lbs/a, respectively).

Significant difference in yield was also observed among cultivars (average across all irrigations, row spacings, and seeding rates). Average yield of 3154, 2665, and 2405 was observed for Poncho, COSD7 (a.k.a.,Sundance or Rocky Mountain #7), and La Paz, respectively. For both row spacings, Poncho performed best under 22inch and 7.5-inch row spacing with average yield of 3060 and 3247 lbs./ac, respectively. However, lower yield was observed for La Paz (1958 lbs/ac) under 22-inch and for COSD7 (2691 lbs/ac) under 22inch row spacing.

As expected, for both row spacings, yield increased linearly with increasing irrigation rate with higher yields were for FIT under both 22-inch and 7.5-inch row spacing (Fig. 1c). On average, FIT yield was 14% and 26% higher than 80%FIT and 60%FIT yields. Greater difference in yield was observed for 22-inch row spacing compared to 7.5-inch row spacing among different irrigation treatments. For 22-inch row spacing, yield was reduced by 16% and 30% under 80%FIT and 60%FIT, respectively.

Surprisingly, no difference in yield was observed for different seeding rates for both 22inch and 7.5-inch planted dry bean. For both row spacings, there was a slight non-significant trend for lower yield with the higher seeding rates. Lower yields for higher seeding rate might be due to higher leaf area index (LAI) that results in less light penetration into the mid-canopy and this could reduce canopy photosynthesis. Other reasons for a slight yield decline with the high seeding rates could include excessive soil water depletion which is common at higher densities.

Acknowledgements
Authors would like to thank PREC personnel for assistance. This project is supported by the grant funds from Wyoming Bean Commission.

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Keywords: dry bean, plant density, row spacing

PARP: Goal 1

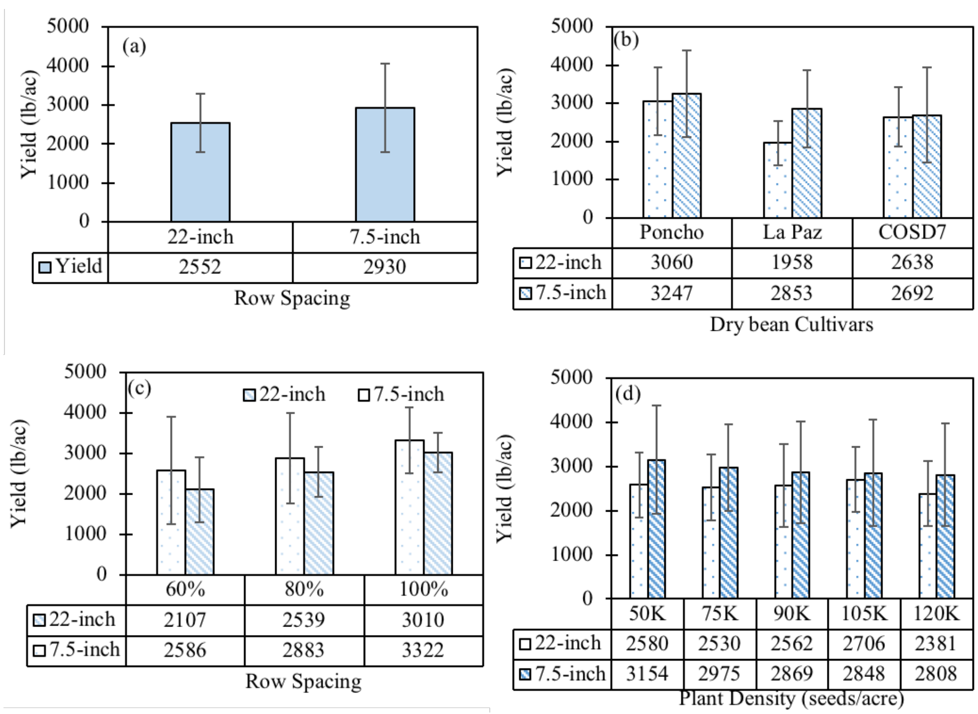

Figure 1. *Effect of (a) row spacing, (b) cultivar, (c) irrigation, and (d) planting density (average across all cultivars) on dry bean yield. Planting density is in seeds per acre.*

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

William Stump[1], Kyle Webber[1], Wendy Cecil[1]
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Introduction

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

Objectives

The objectives are to evaluate an integrated management approach on managing soil-borne disease by combining different tillage options, locally adapted cultivars, and in-furrow fungicides.

Materials and Methods

The study was established in 2018 at the Powell Research and Extension Center (PREC). A randomized complete block design with variety and fungicide treatments in factorial arrangements and tillage as a split-plot component was established on 8 June with a Kincaid planter/sprayer. Sub-plots were six rows (22-inch row centers), 20 feet long with a five-foot inrow buffer. The conventional tillage treatment included conditioning passes whereas the deep tillage treatment included a deep soil ripping chisel treatment prior to conditioning. Disease due to *Rhizoctonia solani* and *Fusarium* spp. was endemic but not quantified. Fungicides were applied in-furrow at planting using labeled rates. The field plot area received fertility, weed control, and irrigation appropriate for dry bean production. All data were collected from the middle 4 rows. Parameters measured included compaction ratings, stand counts, vigor rating, incidence of root rot, NDVI (Normalized Difference Vegetation Index) rating, and bean yield.

Results and Discussion

Tillage treatments did not result in significant differences for soil compaction, but there was a trend in the data of reduced soil compaction with deep tillage (Table 1). On measured crop stands and disease severity, there was no effect of tillage treatment but there was a significant effect of variety on stands. Othello had the greatest stand and Long's Peak the lowest. There was a 100% disease incidence in all sampled plants toward the end of the season. Disease encountered was primarily due to *Fusarium* species and some *Rhizoctonia solani*. Fungicide treatments had no significant effect on measured disease but there were significant differences of disease severity between varieties. Othello had the highest amount of disease severity and Sundance had the least. Tillage overall had a slight effect on plant vigor with less overall vigor with deep tillage. Overall vigor was higher for the Headline® fungicide treatment compared to the untreated check. Some differences were noted with the NDVI readings, but they were mainly limited to differences between varieties. Tillage and fungicide had no effect on bean seed yield; however, variety did have a significant effect on seed yield. Interestingly, despite having greater disease severity, Othello was the highest yielding and Long's Peak was the lowest.

Acknowledgments
We thank PREC field crews for assistance in plot establishment, maintenance, and termination. The study was supported by the Wyoming Bean Commission.

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Keywords: dry bean, soil-borne disease, tillage

PARP: I:11

Table 1. Effects of treatments for management of root diseases of dry bean with a systems approach of varietal selection, in-furrow fungicides, and tillage treatments at PREC in 2018.

Main Treatments	Stand Count (# per 80 ft) 5 Jul	Compaction (in. penetrated)[1] 8 Jun	Severity (0-4)[2] 2 Aug	Vigor (0-100%)[3] 12 Aug	NDVI[4] 12 Sep	Bean yield (lb/ac)
Tillage						
Conv. Tillage	194.1 a[5]	11.8 a	2.8 a	102.9 a	0.6626 a	640.9 a
Deep Tillage	181.6 a	16.6 a	2.9 a	101.1 b	0.6530 a	585.9 a
Fungicide						
Untreated	189.6 a	--	2.9 a	100.0 b	0.6585 a	626.7 a
Headline	192.7 a	--	2.8 a	104.0 a	0.6502 a	618.8 a
Proline	181.3 a	--	2.8 a	102.0 ab	0.6647 a	594.8 a
Cultivar						
Long's Peak	158.9 c	--	2.7 c	--	0.6900 b	515.8 c
Montrose	178.7 b	--	3.0 b	--	0.6716 b	625.7 b
ND Palomino	215.6 a	--	2.9 b	--	0.7733 a	636.1 b
Othello	212.9 a	--	3.2 a	--	0.5207 d	702.5 a
Sundance	173.3 bc	--	2.5 d	--	0.6333 c	587.1 b

[1]Number of inches penetrated into the soil at a constant pressure (Dickey-John).
[2] Severity scale (0-4): 0=no disease, 1=individual, localized lesions on roots or hypocotyls or up to 25% of root surface necrotic, 2=multiple root or hypocotyl lesions coalescing or 26-50% of root surface necrotic, but no rotting of internal pith tissues, 3=51-75% of root system rotted and, 4=>75% of root system rotted.
[3]Within each rep, each variety was compared to its respective control (no fungicide) which was assigned a 100%.
[4]NDVI=Normalized Difference Vegetation Index quantifies vegetation by measuring the difference between near infrared (which vegetation strongly reflects) and red light (which vegetation absorbs).
[5]Treatment means followed by different letters differ significantly (Fisher's protected LSD, ($p \leq 0.05$).

Sustainable production practices for edible dry beans

Jay Norton[1], Jim Heitholt[2]
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Introduction

Inclusion of edible dry beans in crop rotations increases diversity, creates potential for biological N_2 fixation (BNF), and may improve farm income through the production of a high-value specialty crop. However, typical tillage and harvest practices create conditions for rapid mineralization and loss of organic material potentially contributed by dry bean roots and residues, including BNF. Recent improvements in sugar beet varieties that have increased yields and decreased acreage, along with a transition to sprinkler irrigation, have created opportunities for more diverse rotations, including expanding the acreage of edible dry beans. Conservation tillage and direct harvest may represent sustainable production practices, but more information is needed about the effects of these practices on bean yield, BNF, and soil properties.

Objectives

Our objective was to assess yield and BNF of four varieties (Poncho, COSD-7, Monterrey, and Windbreaker) in a conservation tillage system under and full/deficit irrigation.

Materials and Methods

We established trials set in the dry bean phase of a long-term sugar beet dry bean-barley rotation experiment at the Powell Research and Extension Center. Each of the four varieties was planted in one-planter-width strips (6 rows) under minimum- and conventional-tillage across three sub plots and two sprinkler irrigation levels (full and 75% of plant needs; 48, 11- by 100-ft plots). Conventional tillage included moldboard plowing, disking, and roller mulching in the fall following sugar beet harvest, and disking in the spring to incorporate dry granular urea and MAP (applied according to early spring soil-test-based recommendations). Minimum tillage included fall strip tillage and direct planting in the spring. Dry beans in the conventional tillage plots were harvested by undercutting and windrowing, while those in the minimum tillage plots were direct-harvested. Prior to harvest, two 10-foot sections of each row were hand harvested in each plot to determine “true yield.” Whole-plant samples and root subsamples for quantification of BNF were collected at the mid-pod stage from one foot of row in each plot (root biomass was calculated based on typical shoot:root ratio of 4.2 for dry beans). Non-N_2-fixing weeds were also collected from each plot. Biological N_2 fixation was determined by the ^{15}N-isotopic method (Peoples et al., 1989). In this method, BNF is determined by quantifying the difference between the $^{15}N/^{14}N$ ratio in the non-N_2-fixing plants, which derive all of their N from the soil, and legumes, which derive much of their N from the atmosphere, based on the fact that ^{15}N isotope abundance is higher in soil N than in atmospheric N. Plant samples were oven-dried at 60°C, weighed, and analyzed for total and ^{15}N in the University of Wyoming Stable Isotope Facility.

Results and Discussion

Hand-harvested grain yields ranged from 950 to 3889 pounds per acre and varied significantly by cultivar and irrigation level, but not between the two tillage systems (Fig. 1). Poncho had the highest grain yield under both irrigation levels, while Monterrey was least affected by deficit irrigation.

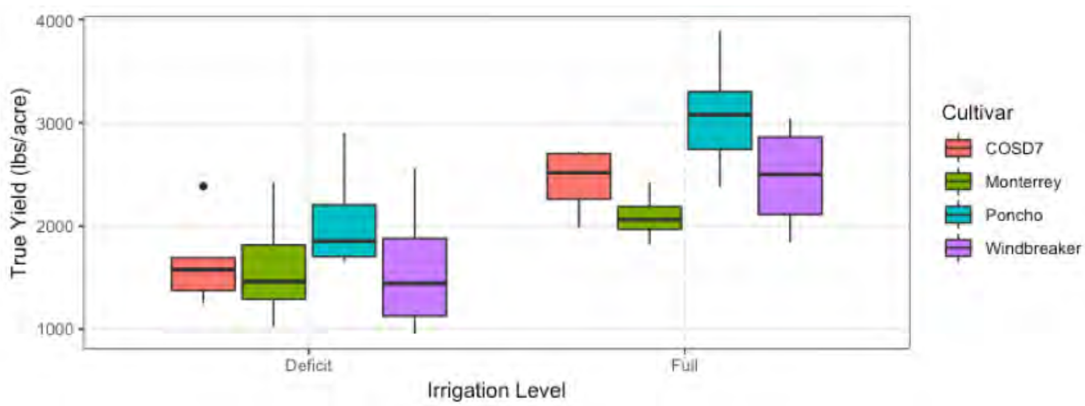

Figure 1. *2018 hand-harvested dry bean yields. Tillage system did not significantly affect yields. Horizontal lines = means, box = standard deviation, and vertical lines = the range of values.*

The amount of N_2 fixed by the dry beans varied from 15 to 66 pounds per acre, and BNF by the four varieties responded differently to tillage and irrigation. Preliminary data presented in Figure 2 indicates a weak inverse relationship between pounds BNF per acre and bean yield from Figure 1 (R=0.38), with Poncho yielding the most beans but fixing the least N2. No clear relationships among tillage, irrigation level, and BNF are evident in this preliminary data.

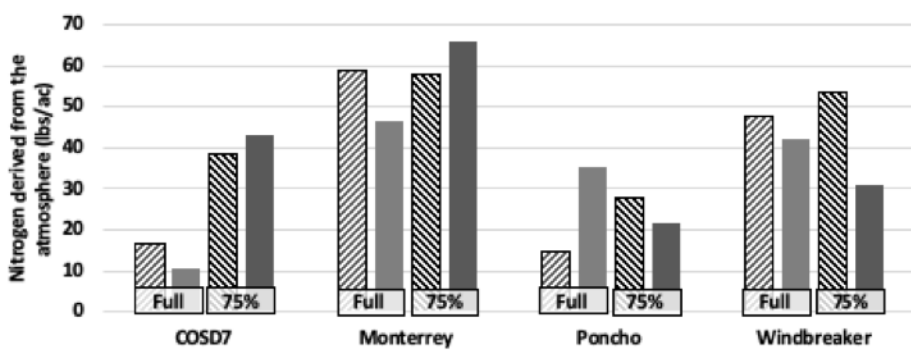

Figure 2. *Preliminary results of 2018 BNF by four different dry bean varieties under two tillage systems and two irrigation levels (Full and 75%). Hatched bars represent conventional tillage and solid bars represent minimum tillage.*

These 2018 results indicate that tillage did not affect bean yield and that all four varieties fixed appreciable N_2 that could be credited in fertilizer recommendations. Further data analysis will indicate whether direct harvest caused appreciable yield losses.

Acknowledgments

Thanks to the field crew at PREC. This work is funded by a Wyoming Department of Agriculture Specialty Crops Grant and the Wyoming Bean Commission.

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Keywords: edible dry bean production, minimum tillage, biological nitrogen fixation

PARP: I., II.6,7,9,10, IV.3.

2018 Dry bean performance evaluation

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

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

Objectives

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

Materials and Methods

Weed control consisted of a preplant-incorporated treatment of 14 oz of Outlook® and 2 pints Sonalan®. The plots received 20 units of nitrogen, 30 units of phosphorous, and five units of zinc per acre. The plot design was a complete randomized block with four replications. The seeding rate was four seeds per foot of row, on 22-inch rows. The three-row by 20-foot plots were planted May 22. Visual estimates were made for the number of days to reach 50% bloom (50% of plants with a bloom) and days to maturity (50% of the plants with one buckskin pod). Subplots of one row by 10 feet were pulled by hand and threshed with a stationary plot thresher.

Results and Discussion

Stand establishment was good, with warm soil and good moisture at planting. Summer temperatures and precipitation were reasonable, and all entries matured prior to the first frost. Flowering dates, maturity dates, and yield components are presented in the table (page 2).

Acknowledgments

This study was conducted with the assistance of PREC staff.

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Keywords: dry bean, performance evaluation, yield trial

PARP: Goal 2

Table 1. Agronomic data, 2018 dry bean performance evaluation, Powell, Wyoming.

Name	Market Class	Bloom Days after Planting	Buckskin Days after Planting	Yield lbs/A	Seeds per Pound
ACUG 16-NDP1	NDP	55	84	1920	1226
La Paz	Pinto	58	88	2800	1255
Othello	Pinto	56	76	1960	1204
PT16-18	Pinto	56	86	2190	1231
PT11-13B	Pinto	57	85	2266	1077
NE2-17-18	SLD	54	86	2219	1048
NE2-17-39	SLD	53	87	2197	1110
ND Palomino	SLD	55	81	2435	1116
NE1-17-10	GN	57	85	2751	1184
ACUG-15-B4	Black	56	88	2963	2053
Eclipse	Black	58	84	2654	2074
AAC Shock (14-1)	Navy	54	82	2026	2046
AAC Argosy	Navy	53	84	2458	1870
Yeti	WK	53	85	1333	971
Dynasty	DRK	53	84	2067	901
Inferno	LRK	53	85	1800	870
CELRK	LRK	53	77	1478	987
LRK 6	LRK	53	81	2280	1099
OAC Rosito	Sm Dark Red	56	85	2375	2120
SR10-2-1	Small Red	54	86	2627	1183
PK7-4	Pink	54	83	2519	1330
B8006282	Black	58	84	3014	2207
Y2033307	Yellow	56	83	1659	1163
Ruby	Small Red	57	86	3064	1525
Black Tail	Black	57	85	2879	2086
	Mean	55	84	2317	1398
	LSD	2.8	2.6	611	106
	CV	3.6	2.2	19	5.4

NDP - Non-darkening pinto
SLD - Slow darkening pinto
GN - Great Northern
DRK - Dark red kidney
LRK - Light red kidney
WK - White kidney

Performance of segregating progeny from a pinto-by-pink dry bean cross in the Bighorn Basin of Wyoming

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Introduction

Dry bean yields per acres have been relatively stagnant in Wyoming for several years. Traditionally, many of the most popular lines grown in Wyoming are from the pinto market class although popularity of black, navy, and Great Northern types have gained traction in recent years.

Objective

The objective of this study was to characterize performance of a set of F2-derived F4 sister lines developed from a pinto-pink cross for flowering date, maturity, height, lodging, and yield.

Materials and Methods

During 2015 and 2016, a pinto-pink cross was made and seed from several single F2 plants were collected and advanced through 2017 at PREC in order to generate enough F2derived F4 seed for a 2018 trial. The different lines were designated LPID #1, LPID #2, etc. Seed were sown in three-row plots, 22-inch rows (20-foot plot length), at approximately 100K seed per acre on 31 May 2018. Plots for three check cultivars were included. The number of replicates ranged from two to six (CRD, depending on amount of seed). Pre-emerge herbicides were applied on 8 June 2018 (Prowl H2O and Outlook). Surface irrigation was provided as needed. Flowering, buckskin pod color, and upright status were recorded during July, August, Sept. Yield was collected by hand-harvesting two rows (10-feet each) from each plot and threshing with an Almaco plot thresher. Moisture was only recorded on a random set of samples and was typically 6%.

Results and Discussion

Results are found in Table 1. LPID #3, LPIC #11, and LPID #34 had numerically higher yield than the highest-yielding check (La Paz). Canopy temperatures did not differ among the entries so those data are not presented. Based on yield, maturity, and upright status (and results from Lingle that are not shown here), we will retain eight (LPID #3, #6, #7, #9, #11, #28, #29, #34) of the 17 entries for further observation in 2019 and discard the others. Several of these lines being retained are not from a recognized market class and for those, we will eventually cross those with adapted public types in order to recover a recognized-market type.

Acknowledgements

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Table 1. Apparent market class, yield, seed size, flowering date, maturity date, upright status (visual), and height (visual) of 17 dry bean entries (LPID) and three check cultivars grown at Powell in 2018. Entries in blue are being further studied in 2019.

Entry	Mkt Cls	Yield	Seed Size	Flower	Mat‡	Upright§	Height
		lbs/ac	g per 100 seed	dap †	dap	visual	visual
# 1	Beige, Pink	2990	44.0	50	91	6	Med
# 2	Beige, Med-Pinto	2510	40.0	48	90	7	Short-Med
# 3	Beige, Pink, Med-Pinto	3280	47.6	48	89	7	Med
# 4	Beige, Light-Pinto, Dark-Pinto	2581	43.7	48	90	7	Short-Med
# 6	Beige, Light-Pinto, Dark-Pinto, Pink	3075	44.2	51	94	4	Short-Med
# 7	Verm.-Pinto	2900	39.0	48	87	8	Med-Tall
# 9	Pink	3130	43.3	51	91	7	Tall
# 11	Light-Pinto, Dark-Pinto, Pink	3270	45.5	48	88	6	Med-Tall
# 16	Med-Pinto	2750	44.0	48	89	7	Med
# 27	Beige	2610	41.3	46	89	7	Med-Tall
# 28	Beige	3155	47.5	46	87	5	Tall
# 29	Beige	2570	40.3	50	90	6	Med
# 30	Light-Pinto, Dark-Pinto	2570	39.0	48	89	6	Med
# 31	Beige	2990	42.3	52	94	5	Med-Tall
# 32	Pink	3350	39.0	51	93	4	Med-Tall
# 33	Pink	2440	47.7	49	93	5	Med-Tall
# 34	Pink	3330	47.0	49	92	7	Med-Tall
La Paz	Pinto	3210	36.5	52	90	8	Tall
Poncho	Pinto	2600	40.5	48	87	6	Med
Sundance	SD-Pinto	2530	37.5	51	90	9	Med-Tall
LSD (0.05)	na	690	3.4	3	4	2	na

Evaluation of goji berries for Wyoming

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Introduction

This publication explains the results of a study that evaluated goji as a potential high value cash crop for Wyoming. Goji, also known as goji berry, wolfberry, boxthorn and matrimony vine, is a slightly thorny deciduous woody shrub that reaches approximately 12 feet in height and produces single red berries that are high in antioxidants. Goji is in the Solanaceae family, meaning it is related to nightshade and tomato plants.

Goji is known as a super fruit because it contains 19 different amino acids and more vitamin C than an orange. Among known foods, goji possesses some of the highest concentrations of carotenoids (antioxidants), essential fatty acids, betaine, vitamin E and vitamin B. Demand for crops such as the goji berry has increased due to the increased popularity of health foods in the U.S. The current goji berry supply in our health food market is being vastly supplied by Chinese production in the forms of powders, juices and dried fruits.

This study found that goji is suitable for cultivation in Wyoming's climate. Once the plant is established, it grows and thrives very well. Some plants are even able to produce fruit in the establishment year; however, first year yields are usually unmeasurable. Once the plant was established, it produced fruit the following year and continued flowering and setting fruit until temperatures dropped around 24°F in the September or October time period depending on the year.

Materials and Methods

Cultivation of the goji berry was studied in two locations, the Sheridan and Powell R&E Centers in Wyoming from 2016 to 2018. There were 100 plants in the study, with 50 plants per site. The goji plants were planted in the grape vineyards at each location with a highfenced perimeter for pest control. The phenological stages of 100 goji plants were evaluated by recording the percentage of live plants each spring, date of bud break, flowering and fruiting dates and yield of each plant. The goji plants received the same irrigation and fertilization as the grapes within the vineyard.

Results

All phenologic data and stages documented in this bulletin were obtained from the 50 plants at the Powell R&E Center; plants at the Sheridan R&E Center had poor establishment issues from being planted too shallow. Since the plants in the Sheridan site were poorly established they did not flower or fruit.

Over the three years of production, there was a survival rate of 98 percent (a loss of one plant). Plants broke dormancy between March 25 and April 5, early freezes and cold weather did not appear to affect the growth and development of the plants. The average number of shoots per plant was 11, with a range of 3 to 22 shoots per plant. Plants initiated flowering starting May 20 through June 5 and continued flowering into October. At the end of June, plants averaged two flowers per shoot, the middle of June averaged three flowers per shoot, and the beginning of August had four flowers per shoot.

Fruit set started as early as June 15 and resulted in two harvest periods at the end of September and October. The first harvest in September resulted in an average of 0.22 pounds of fruit per plant, with a range of 0.03 to 0.66 pounds. The

October harvest resulted in 0.34 pounds of fruit per plant, with a range of 0.005 to 1.8 pounds. The total yield for the Powell vineyard was 14 pounds, which is an average of 0.28 pounds per plant. Killing frost appeared to coincide with temperatures of 22 to 24°F.

Conclusions

This project demonstrates that goji plants can be grown in parts of Wyoming and that established plants will produce fruit. Goji plants break dormancy earlier, at least one month before other berry crops in Wyoming, such as grapes and continue fruiting later in the fall (end of October to early part of November). To maximize yield production in Wyoming, more research is needed to understand fertility and irrigation requirements, pruning and trellising techniques and cultivation spacing.

A few concerns were observed during this study. Goji berries are a labor-intensive crop, especially during harvest. The flowering and fruiting of goji is a continual process that began around August and continued until the killing frost at the end of October to the early part of November. Ripe fruit from each plant would need to be picked during this long period (possibly weekly) which increases the demand for labor. Labor concerns could be a limiting factor for cultivation and production for Wyoming.

The second concern was the bird and insect damage to ripened berries, which makes harvest timing critical to save as much yield as possible. Netting can be beneficial; however, this can also increase harvest loss with the constant removal and placement of the net.

The last concern observed was the spread of goji plants within the plot. Once the goji plants were established at the end of 2016, suckers were seen in 2017 and 2018. These suckers were seen growing in empty spaces, gaps within the canopy of, alongside grape plants, and along the edges of the vineyard. These suckers indicate that goji is rhizomatous and the maximum distance seen was approximately four feet away from the parent plant.

Acknowledgements

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Yield response of reduced lignin and conventional alfalfa cultivars to potassium

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Introduction

Alfalfa (*Medicago sativa* L.) is the best forage crop in the world. Several farms and ranches depend on it for hay production due to its ability to produce higher forage yield and nutritive value. Recent studies have shown that, reduced lignin alfalfa cultivars have greater ability to optimize production regardless of harvest time. Alfalfa requires high amount of potassium (K) for high productivity. Frequent harvest and baling deplete soil nutrients, particularly K, which negatively affects alfalfa's productivity in subsequent growing seasons. Therefore, replenishment of K is essential to sustain soil K levels for optimum forage yield and nutritive value of alfalfa. Type of cultivar, time of harvest, and levels of soil K have profound influence on alfalfa's productivity. Paying attention to these factors when making decisions on K recommendations could help sustain higher alfalfa production. Unfortunately, limited information is available of the effect of K and harvest time on alfalfa productivity.

Objective

To determine the effect of K and harvest time on forage yield of reduced lignin and conventional alfalfa cultivars.

Materials and Methods

The study was conducted at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) from 2016 to 2018, under irrigated conditions. Treatments included (a) four K rates: 0, 50, 100, and 150 pounds K_2O per acre; (b) two recently released cultivars: 'Hi-Gest 360' (reduced lignin) and 'AFX 457' (conventional); and (c) two harvest times: early harvest (late bud to early [10%] bloom), and late harvest (7 days after early harvest). The experiment was organized in a 4 × 2 × 2 factorial in a randomized complete block design with four replicates. Muriate of potash was used as a source of K. All other nutrients were managed for adequacy before planting. Inoculated alfalfa seeds were planted (September 8, 2016) at a seeding rate of 20 pounds pure live seed per acre. Four cuts were made under each harvest time about a month interval from June to October in 2017 and 2018. Forage samples were oven dried for 72 hours at 140°F to determine forage yield on dry matter basis.

Results and Discussion

Forage yield was not affected by cultivar or harvest time but was influenced by the interaction effect of K × cultivar × number of cuts. For each year, when results from all four cuts were summed over the two harvest times (early and late), Hi-Gest 360 produced the highest total annual yield under 150 pounds K2O per acre, whereas AFX 457 produced highest total annual yield under 100 pounds K2O per acre (Figure 1). This indicates that a moderate level of K is required for AFX 457, while high level of K is required by Hi-Gest 360 for higher forage yield production. Variations in lignin composition of the cultivars might have influenced the level of K required for optimum yield. In general, forage yields were greater in 2017 than in 2018 for both cultivars (Figure 1). This was probably due to unfavorable (hot and dry) weather conditions in 2018 compared to 2017. Similar K effects in both years indicate that alfalfa yield can be increased with appropriate rate of K based on the cultivar used.

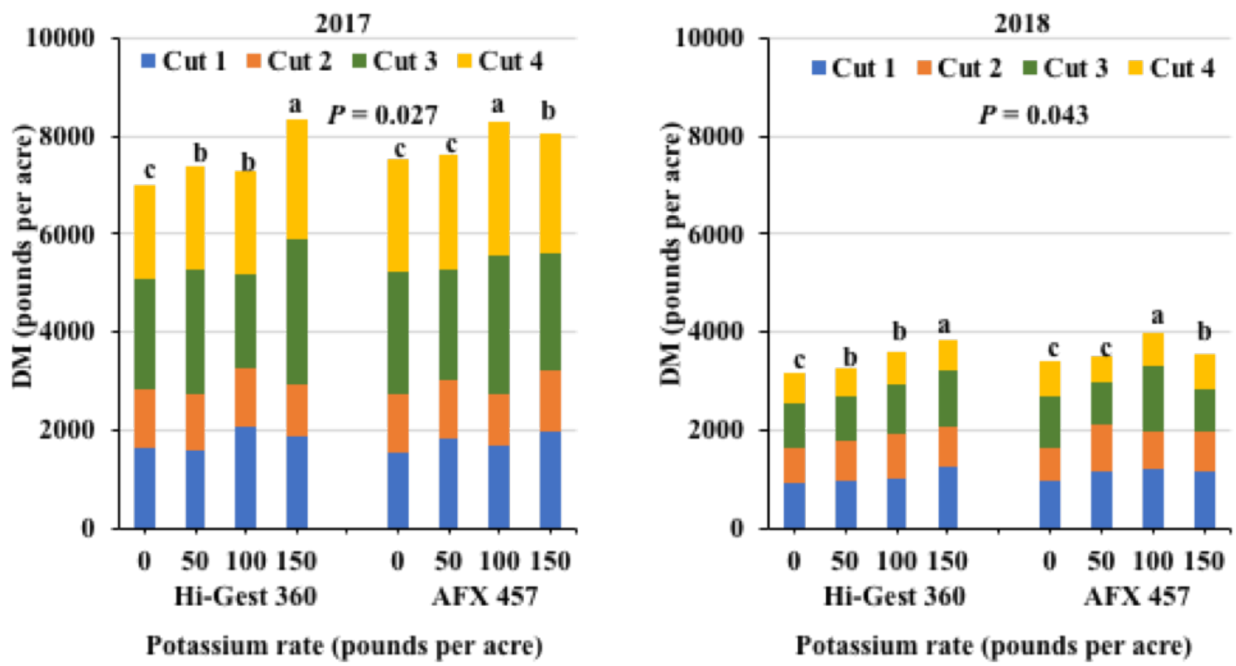

Figure 1. *Potassium and cultivar effect on forage dry matter (DM) yield of Hi-Gest 360 and AFX 457 alfalfa at SAREC in 2017 and 2018. Within each cultivar, same lowercase letters are not significantly different at P>0.05.*

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Keywords: alfalfa, potassium, harvest time

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

Management of root diseases of beans with in-furrow fungicides

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Introduction

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

Objectives

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

Materials and Methods

Research plots were established on 27 June, 2018, at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Seven in-furrow fungicide treatments were compared to non-treated inoculated and non-treated non-inoculated checks (Table 1). A randomized complete block design with four replicates was established. Each treatment plot was 20 feet long and six rows wide with a five-foot in-row buffer between plots. Plots were inoculated with a mix of *Rhizoctonia solani* and *Fusarium solani* grown on barley grain incorporated into the soil. Plots were planted with the variety Othello using the Kincaid planter/sprayer. Fungicide spraying occurred directly as seed was planted and rows closed immediately. The field plot area received fertility, weed control, and irrigation appropriate for dry bean production. Parameters measured were stand counts, plant vigor, percent stand decline due to disease, incidence of root rot, and bean yield.

Results and Discussion

There were no treatment effects on crop emergence, phytotoxicity, number of dead plants, and leaf drop observed on the dry bean crop (data not shown). Effects of in-furrow fungicide applications on the bean crop and root rot are shown in Table 1. Beans exhibited some chlorosis and stunting in the Propulse® in-furrow treatment. This phytotoxic response was not significant and disappeared over time; however, this Propulse® treatment did have reduced vigor compared to the untreated checks and most treatments, as measured on 24 July.

On 5 September, plants were pulled for root disease evaluations. Root disease was quite extensive on the bean main taproots and all roots sampled had some measure of necrosis due to root infection, primarily by *Fusarium* spp. and *Rhizoctonia solani*. Endemic populations of these pathogens were significant since there was no difference in disease severity with inoculation versus without. Fungicide treatments of in-furrow Propulse®, Vellum Prime®, and Priaxor® had significantly less disease severity on sampled roots at the end of the season compared to non-treated checks and all other treatments except Proline®. Treatments had no effect on bean seed yield. Lack of treatment effects on yield was most likely due to complications of high disease pressure, presence of some bacterial disease, and a destructive hail event on 8 September. Results show that there is some potential for some fungicides applied in-furrow at planting to protect against the effects of soil-borne diseases.

Acknowledgments

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

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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 fungicides.

Treatment and rate/A, and timing[1]	Crop vigor (0-100%)		Root disease rating (0-4)[2]	Bean seed yield (lb/A)
	5 Jul	24 Jul	5 Sep	1 Oct
Non-treated non-inoculated check	90.0 a[3]	95.0 ab	3.7 ab	3890.8 a
Non-treated inoculated check	92.5 a	96.3 a	3.9 a	3703.5 a
Propulse (6 fl oz) A Endura (8 fl oz) B	77.5 a	78.8 c	2.8 c	3655.3 a
Velum Prime (3.2 fl oz) A Endura (8 fl oz) B	95.0 a	93.3 a	2.8 c	3345.6 a
Proline 480 SC (5 fl oz) A	92.5 a	90.0 ab	3.2 bc	3662.7 a
Priaxor (7.1 fl oz) A	93.8 a	91.3 ab	3.1 c	3571.8 a
Quadris (14.3 fl oz) A	88.8 a	90.0 ab	3.9 a	3766.6 a
Headline (9 fl oz) A	87.5 a	85.0 bc	3.6 ab	3462.4 a
Serenade ASO (64 fl oz) A	95.0 a	85.0 bc	3.8 a	6544.0 a

[1]*Treatment rates (per acre) were concentrated in-furrow. Application dates were as follows: A=27 Jun (in-furrow), B=22 Aug (foliar broadcast).*

[2]*Based on visual estimates of root surface affected with disease of 10 plants. Root disease rating scale (0-4), where 0=no disease and 4=100% affected with disease.*

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

Evaluating chickpea cultivars at different nitrogen rates for forage and grain production

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Introduction

Grazing animals require forage as basal feed for increased productivity. Chickpea (*Cicer arietinum* L.), a popular annual pulse crop in U.S., is a relatively cheap source of crude protein. It adapts well in semi-arid regions, produces higher grain yield, and has potential to provide the flexibility required in livestock diets. However, poor soil fertility and lack of improved cultivars account for low productivity of chickpea. Although the legume-rhizobia association in chickpea plant fixes nitrogen (N), low to moderate levels of N needs to be available in the soil for plant uptake to facilitate its establishment and growth until the onset of N-fixation. This helps the plant to mature uniformly and increase its production. Interest in this crop as an alternative forage crop has rapidly increased, particularly in areas with marginal rainfall. However, information on the use of chickpea as a forage crop is limited.

Objective

To evaluate forage yield, grain yield, and nutritive value of different chickpea cultivars at various rates of N fertilizer.

Materials and Methods

The experiment was conducted at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) in 2018. Treatments consisted of (a) five chickpea cultivars: 'Garbanzo large white seed'; 'Garbanzo large cream seed'; 'Kabuli medium cream seed SWAD'; 'Kabuli medium cream seed ANKUR'; and 'Desi small brown seed', and (b) three N rates: 0, 10, and 20 pounds N per acre. The study was established in a randomized complete block design with four replications. Seeds were treated with fungicide (Maxim 4FS) at a rate of 2.4 ml of active ingredient per 243 pounds of seeds before they were inoculated (*Mesorhizobium cicer*) at a rate of 3.1 grams of inoculant per 1.4 pounds of seeds. Planting was done on June 4, 2018 at seeding rates of 280 pounds pure live seed (PLS) per acre (Garbanzo large white seed and Garbanzo large cream seed), 230 pounds PLS per acre (Kabuli medium cream seed-SWAD and Kabuli medium cream seed-ANKUR), and 180 pounds PLS per acre (Desi small brown seed). Nitrogen (urea; 46% N) was applied at early flowering stage and all other nutrients were managed for adequacy. The plants were harvested on September 14, 2018 for dry matter. The plant samples were oven dried at 140°F for 72 hours to determine dry matter. Forage nutritive value was determined by using Near Infrared Reflectance Spectroscopy. The entire plots were harvested (October 18, 2018) at physiological maturity for grains and they were processed to determine grain yield.

Results and Discussion

Cultivar had a significant (P = 0.003) effect on dry matter, and grain yields. Compared to the other cultivars, Desi small brown produced higher dry matter (5,435 pounds per acre) and grain (1,895 pounds per acre) yields. In general, Garbanzo large cream gave the lowest dry matter (2,547 pounds per acre) and grain (177 pounds per acre) yields (Table 1). This clearly indicates that higher forage and grain yields are attainable with Desi small brown. This is associated to the high viability (87% germination; Table 1) of seeds of Desi small brown which influenced higher forage and grain production. Nutritive value differed among the cultivars such that Garbanzo large cream had the highest nutritive value. For example, CP: 25.9%, NDF: 26.5%, IVDMD: 77.4%, and RFV: 198%. Whereas Desi small brown gave the lowest nutritive value (Table 1). Addition of N did not affect dry matter and grain yield, and nutritive value probably due to the time of N application and high residual N in the soils. The legume-Rhizobia association might have initiated N-fixation long before the flowering stage of the plants and therefore, it blocked out the effect of N on the cultivars. Overall chickpea shows promise in respect to dry matter and nutritive value and could be a better alternative for forage production, especially when availability of forage is limited in the late fall. However, N fertilization may not be beneficial to high productivity of chickpea. Desi small brown seed produced higher forage and grain yields at the expense of forage nutritive value. In contrast, Garbanzo large cream seed produces higher forage nutritive value and compensate for forage and grain yields. The study will be repeated in 2019 and data will be collected to further explore N levels and their effect of chickpea production.

Table 1. Cultivar and nitrogen effect on forage and grain yield, seed germination at harvest, and forage nutritive value of chickpea at SAREC in 2018

	Yield		**Seed germination**	**Forage nutritive value**					
Cultivar	**Forage (lbs/acre)**	**Grain (lbs/acre)**		**CP%**	**NDF%**	**ADF%**	**IVDMD%**	**TDN%**	**RFV%**
Garbanzo LWS	3903b †	679bc	39c	22.9b	28.7b	34.9b	75.7b	70.4a	178b
Garbanzo LCS	2547b	177c	8.7d	25.9a	26.5c	32.4c	77.4a	72.8a	198a
Kabuli MCS (SWAD)	3063b	285c	15d	24.5a	28.0b	34.2b	77.1a	71.2a	184b
Kabuli MCS(ANKUR)	3918b	1172b	65b	22.6b	28.4b	35.2b	76.5b	70.7a	178b
Desi SBS	5435a	1895a	87a	19.2c	32.7a	37.5a	72.9c	65.9b	159c
Average	3773	842	43	23.0	28.9	34.9	75.9	70.2	179
N rate (pounds per acre)									
0	3752a	975a	44a	22.3a	35.5a	29.4a	75.8a	69.5a	176a
10	3560a	825a	43a	23.6a	34.8a	28.8a	76.2a	70.3a	179a
20	4068a	896a	42a	23.3a	34.3a	28.4a	75.8a	70.7a	183a
Average	3793	899	43	23.0	34.9	28.9	75.9	70.2	179

LWS, large white seed; LCS, large cream seed; MCS, medium cream seed; and SBS: small brown seed.
CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; IVDMD, in vitro dry matter digestibility; TDN, total digestible nutrient; and RFV, relative feed value.
† *Within column for each parameter, means followed the same lower-case letter are not significantly different at* $p > 0.05$.

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Keywords: chickpea, nitrogen, forage and grain production

PARP: I:2,9,12, II:2, VII:5, X:1

Management of cercospora leaf spot with foliar fungicide applications

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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.

Objectives

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

Materials and Methods

The study was established 14 May, 2018, at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Three 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 six rows wide with a five-foot, non-treated, in-row buffer between plots. To augment natural disease inoculum, on 9 August plots the two middle rows of each inoculated plot were inoculated with 10 grams of dry *Cercospora beticola*-infected leaf material. Parameters measured included CLS leaf counts and CLS severity, as measured by an area under the disease progress curve (AUDPC), and sugar yield (Table 1). Plots were harvested on 13 September.

Results and Discussion

CLS developed late in 2018, but disease development did result in moderate severity by season end. The inoculation method was successful, resulting in 46% more overall disease, as measured by AUDPC value, compared to the non-treated non-inoculated check (Table 1). All fungicide programs significantly reduced CLS lesion numbers by 22 August compared to the non-treated inoculated check. Results demonstrate that a biological fungicide (Serenade ASO) can be successfully substituted for a conventional fungicide in a spray program and still provide the same level of disease control. Treatments did not significantly affect the recoverable sucrose yield. Lack of yield effect was probably due to the late onset of disease and hail defoliating the crop late in the season.

Acknowledgments

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Keywords: biofungicide, 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; 2018).

Treatment and product/A	Application timing[1]	CLS Lesion counts per leaf		AUDPC[2]	Lbs of extractable sucrose/A
		22 Aug	4 Sep		
1. Nontreated non-inoculated check	NA	4.7 b[3]	37.8 b	427.2 b	4465.4 a
2. Nontreated inoculated check	NA	13.7 a	65.3 a	796.4 a	4993.7 a
3. Propulse (13.6 fl oz)	ABC	2.5 bc	5.4 c	109.3 c	5070.7 a
4. Proline 480 SC (5.7 fl oz)	ABC	0.6 c	5.1 c	63.7 c	5086.7 a
5. Proline 480 SC (5.7 fl oz) 5. Serenade ASO (OMRI) (32 fl oz)	AC B	0.5 c	8.5 c	118.3 c	4804.8 a
LSD		2.8637	18.89	207.53	NS

[1]Application dates were as follows: A=9 Aug, B=22 Aug, and C=4 Sep. All treatments but the checks and Serenade ASO, included the surfactant Induce® 90 SL at 0.085 fl oz/A.

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

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

Forage yield of cool season grasses planted in fall under irrigated and dryland conditions

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Introduction

Forage grasses are the basis of livestock production systems. They are the major group (75%) of forage crops and produce large volumes of palatable and nutritious feed for livestock. An essential component of an efficient pasture and/or forage system are cool season forage grasses. In addition to their high adaptability and performance in the Northern Great Plains, these species grow vigorously during spring and fall. However, most producers prefer to plant in the spring, because they find it as the best time to guarantee adequate stand establishment to optimize forage production due to higher moisture availability in spring than in fall. With increases in the number of irrigated farmlands, forage establishment in fall could be an expedient option. Wheatgrasses and fescues are among the popular cool season grasses widely grown in Wyoming. It is, therefore, important to identify cultivars of wheatgrasses and fescues of higher productivity under fall planting in Wyoming's conditions.

Objective

To evaluate forage yield of different cultivars of tall fescue and wheatgrass planted in fall under irrigated and dryland conditions in Wyoming.

Materials and Methods

The study was established in 2008 at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Treatments were eleven species of cool season grasses: (a) seven tall fescue cultivars: 'PDF 584', '97TF1 584', 'Jesup Max', 'Fawn', 'TF Soft', 'Enforcer', and 'Barolex'; (b) three cultivars of tall wheatgrass: 'NFTW 6001', 'NFTW 6020', and 'Jose'; (c) one cultivar of western wheatgrass: 'Barton'. The experiment was set up in a randomized complete block design with four replications, under irrigated and dryland conditions. Separate plots in nearby areas were selected for both irrigated and dryland trials. All limiting soil nutrients were managed for adequacy. Planting was done in August 2008 and three cuts were done in each year. Forage samples were collected, and oven dried for 72 hours at 140°F to determine forage yield on dry matter basis.

Results and Discussion

Under both irrigated and dryland conditions, forage yield differed among the treatments in each year, except in 2015 and 2018 (Table 1). PDF 584 was consistent in producing higher forage yield in both irrigated and dryland conditions. Whereas Barton and Fawn were consistent in producing low forage yield under irrigated and dryland, respectively (Table 1). This resulted in highest total forage yield for PDF 584 in irrigated (8.9 tons per acre) and dryland (9.1 tons per acre) trials, when annual forage yields were combined. Barton (5.6 tons per acre) and Fawn (5.8 tons per acre) had the lowest total forage yields under irrigated and dryland, respectively. This suggests that PDF 584 adapts very well to environmental conditions in Wyoming and it has greater ability to produce higher forage yields both in irrigated and dryland conditions. This could be associated to improved genetics of the cultivar, which may have enhanced the plant's resistance to unfavorable conditions. Among the species, tall fescue had the highest forage yields compared to that of tall wheatgrass cultivars, while western wheatgrass had the lowest forage yields. However, except for PDF

584, cultivars of tall fescue, tall wheatgrass and western wheatgrass produced similar yields under both irrigated and dryland conditions (Table 1). This clearly indicates that most cool season grasses used in this study have similar ability for forage production. Irrigated condition had higher average total yields (7.3 tons per acre) than dryland condition (6.7 tons per acre) (Table 1). This is associated with the availability of moisture in irrigated conditions which enhanced plant growth and development. Overall, results of the study show that PDF 584 has higher adaptability to Wyoming's conditions than most cool season grasses. Adopting PDF 584 and planting in fall under irrigated or dryland conditions could be viable option for profitable grass hay production in Wyoming.

Table 1. Forage yield of selected cool season grasses planted in fall under irrigated and dryland conditions at SAREC from 2015 to 2018

	Forage dry matter yield (tons per acre)									
	Irrigated					Dryland				
Cultivars	**2015**	**2016**	**2017**	**2018**	**Total**	**2015**	**2016**	**2017**	**2018**	**Total**
Tall Fescue										
PDF 584	1.6a†	2.1a	3.7a	1.5a	8.9a	1.7a	2.4a	3.3a	1.7a	9.1a
97TF1 584	1.4a	1.9ab	3.4ab	1.4a	8.1ab	1.2a	1.3bc	2.3b	1.5a	6.3b
Jesup MaxQ	1.3a	1.8ab	3.2ab	1.7a	8.0ab	1.3a	1.4bc	2.3b	1.5a	6.5b
Fawn	1.1a	1.9ab	3.0b	1.4a	7.4abc	1.3a	1.2bc	1.8c	1.5a	5.8b
TF Soft	1.4a	1.8ab	3.3b	1.4a	7.9abc	1.2a	1.6b	2.4b	1.8a	7.0b
Enforcer	1.4a	1.6b	2.8bc	1.6a	7.4abc	1.3a	1.2bc	2.4b	1.7a	6.6b
Barolex	1.2a	1.5bc	2.8bc	1.3a	6.8abc	1.2a	1.4bc	2.0bc	1.4a	6.0b
Tall Wheatgrass										
NFTW 6001	1.4a	1.1cd	2.3c	1.3a	6.1bc	1.5a	1.1c	2.5b	1.6a	6.7b
NFTW 6020	1.4a	1.1cd	2.7c	1.6a	6.8abc	1.4a	1.2bc	2.5b	1.8a	6.9b
Jose	1.4a	0.8d	2.5cd	1.5a	6.2abc	1.5a	1.0c	2.6b	1.9a	7.0b
Western Wheatgrass										
Barton	1.3a	0.9d	1.9d	1.5a	5.6c	1.5a	1.1c	2.3b	1.5a	6.4b
Average	**1.4**	**1.5**	**2.9**	**1.5**	**7.3**	1.4	1.3	2.4	1.6	6.7

†Within each column for each year, means followed by the same lowercase letters are not significantly different at p *>0.05.*

Acknowledgements
We thank SAREC crew, and UW forage agronomy laboratory members for study assistance.

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Keywords: cool season grasses, fall planting, dryland and irrigated

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

Integration of early harvest with biological control for sustainable alfalfa production

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Introduction

Despite widespread release of biological control agents following alfalfa weevil invasion in the 1900s, insecticides remain the most common control strategy for alfalfa weevil. Although alfalfa producers use “early harvest” often, and sometimes exclusively, few consider it the most effective practice.

Objectives

Our overall goal is to improve sustainability of alfalfa production through science-based recommendations for alfalfa weevil IPM that integrates physical and biological control.

We will accomplish two objectives 1) Test how manipulations of harvest timing affect alfalfa weevil, natural enemies, forage yield and quality, and economics; and 2) Identify impacts of on-farm harvest timing and parasitoid abundance on alfalfa weevil.

Expected Impact

This work will improve recommendations for alfalfa weevil integrated pest management and expand alfalfa crop budgets to include non-chemical pest management approaches.

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Keywords: alfalfa, alfalfa weevil, biological pest control

PARP: I.2

Management of potato early dying syndrome with in-furrow fungicide/nematicides and foliar fungicide combinations

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Introduction

Potato early dying syndrome is due to a complex of various disease agents, but the major pathogens include Verticillium (a soil-borne fungal pathogen) and lesion nematodes. As the name implies, this disease complex causes the potato crop to senesce (die-back) earlier than normal, negatively impacting yields due to a shortened season. The treatments were nematicide/fungicide products used to target nematodes and soil-borne pathogens.

Objective

The objective of this study is to determine the effects of seed treatment, in-furrow and foliar pesticide application combinations on management of potato early dying syndrome.

Materials and Methods

The study was established in 2018 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Three treatments were compared to a non-treated check for the management of potato early dying syndrome. All three treatments included a seed treatment of Emesto Silver®. Two of the seed treated treatments had an in-furrow Velum Prime® application and one also had an additional foliar broadcast of Luna Tranquility®. A randomized complete block design with four replicates was established. Each treatment plot was 20 feet long and four rows wide with a 5-foot non-treated, in-row buffer between plots. A chipping potato cultivar was planted on 6 June. Seed-pieces were spaced 12-inches apart with 36-inch row centers in an open furrow. After seed placement, treatments were applied in-furrow in a 5- to 7-inch band over the seed (Table 1). After application, the furrows were closed with the planter closing discs. The foliar broadcast nematicide treatment was applied 3 and 16 August with the aid of a CO_2-pressurized backpack sprayer. The plot received fertility, weed control, and irrigation appropriate for potato production. Parameters measured were potato emergence, stand counts, visual estimates of foliar necrosis, and yield.

Results and Discussion

The stand counts were collected on 5 and 25 July from the middle two rows of each plot (40 row ft. in total). The in-furrow treatment applications had no effect on potato stands (Table 1). On 22 August, there was visible necrosis beginning in the plots; however, treatment effects on stand necrosis were negated due to crop defoliation by the 8 September hailstorm before any appreciable necrosis could occur. On 26 September, two rows by 10 feet were harvested with a two-row mechanical digger. Treatments had no significant effect on overall tuber yields.

Acknowledgments

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

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Keywords: lesion nematodes, potato early dying syndrome, fungicide

PARP: I:11

Table 1. Management of potato early dying syndrome with seed, in-furrow and foliar treatments.

Treatment, rate (product/A), and timing[1]	Stand count (40 ft row)	Potato early dying (% foliar necrosis)	Total tuber yield (cwt[2]/A)
	25 Jul	22 Aug	26 Sep
Non-treated check	33.8 a[3]	7.5 a	260.9 a
Emesto Silver (0.31 oz/cwt) A	33.3 a	6.0 a	259.2 a
Emesto Silver (0.31 oz/cwt) A Velum Prime (6.5 oz) B	31.5 a	5.0 a	266.6 a
Emesto Silver (0.31 oz/cwt) A Velum Prime (6.5 oz) B Luna Tranquility (11.2 oz) C, D	31.8 a	1.0 a	294.6 a

[1]*Treatment application dates A-D, respectively: 5 Jun (seed treatment), 6 Jun (in-furrow), 3 and 16 Aug (foliar broadcast). Listed in-furrow rates were adjusted to rates per 1000 row ft. with 36-inch row spacing.*
[2]*cwt = hundredweight.*
[3]*Treatment means followed by different letters differ significantly (Fisher's protected LSD,* $p \leq 0.05$*).*

Evaluation of pulse crops for Wyoming dryland

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Introduction

Winter wheat-fallow has dominated the southeastern Wyoming area for the last 90 years (Lyon et al. 1998). The 14-month fallow phase exposes the soil to erosion from wind and water which lowers the already low soil fertility. Southeastern Wyoming's low soil fertility is due in part to the cool and dry climate which leads to low amounts of organic matter build. Introducing pulse crops like chickpeas, lentils, dry peas, and guar into the rotation in replacement of this fallow period will allow for additional organic matter to be added to the soil which can increase the nutrient availability, water holding capacity, and microbial activity of the soil. Pulse crops fix nitrogen, which can increase soil nitrogen available in the rotation. Pulse crops also offer another crop option to farmers in this area where the number of cash crops is already limited.

Objectives

Crops of chickpea, lentil, guar, and dry peas will be evaluated for their agronomic production potential and the sustainable value of these crops will be assessed by measuring soil fertility parameters as well as soil moisture.

1. Identify maximum yield expectation for lentil, chickpea, grain pea, and guar crop
2. Measure soil nitrogen contribution of each pulse crop
3. Measure soil water recharge of each pulse crop compared to fallow
4. Determine how timing of termination of pulses affects soil moisture and nitrogen availability

Materials and Methods

The study was initiated at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) in the spring of 2018. Chickpeas (*Cicer arietinum*), lentils (*Lens culinaris*), dry peas (*Pisum sativum*), and guar (*Cyamopsis tetragonoloba*) were planted in the Gillespie dryland in plots measuring 5ft by 20ft. Conventional and short season varieties of each crop were planted on 3 different planting dates (early, standard, late) at seeding rates shown in Table 1. In total, there were 24 individual treatment groups with a fallow control. The field layout was blocked by crop type with 12 cropped plots per block and a fallow control in each block. This was replicated three times for a total of 84 plots.

Table 1. Plant populations and pounds of seed per acre planted for each crop variety.

Crop	Variety	lb. seed/ac.	plants/ac.
Chickpea	Orion	168	200,000
	Frontier	148	200,000
Dry Pea	Early Star	152	390,000
	Carver	201	390,000
Lentil	Richlea	56	525,000
	Maxim	40	525,000
Guar	Kinman	7.1	120,000
	Monument	8.5	120,000

Before planting, soil samples were taken to determine soil nitrogen as well as the gravimetric water in the soil. Seeds were treated with a fungicide (Apron Maxx RTA) and inoculated with Verdesian N-charge premium high-adhesion peat inoculum. After planting, Watermark soil moisture meters from Irrometer® were installed at 1 and 2 ft depths. These sensors were programmed to take readings hourly. PR2 access tubes from Dynamax were installed to a depth of 39 inches. Weekly measurements included the PR2 access tube readings, NDVI to measure canopy development, and growth stage documentation. Stand counts were done approximately 2 months after planting and samples were taken from each plot for nodule counting. For chickpea and lentil, half of each plot was chemically terminated as a cover crop to compare how the timing of termination affected soil moisture and nitrogen.

After the plants were mature, hand samples of yield were taken, and the rest of the plot was combined with a Kincaid XP-8 small plot combine. Soil moisture cores were taken after harvest to determine the water available after the pulse crop and before planting winter wheat to determine soil moisture recharge prior to wheat. Soil nitrogen was also measured prior to planting the winter wheat crop. Hard red winter wheat 'Spur' was planted into these plots in the fall of 2018 and will be harvested in the summer of 2019 when the wheat yields will be determined.

Results and Discussion

The average yields for chickpeas, lentils, guar, and dry pea were 24.8 bu/ac, 5.4 bu/ac, 4.9 bu/ac, 27.8 bu/ac (respectively) with no significant difference in the varieties ($p = 0.72$) or planting dates ($p = 0.50$; Table 2).

Table 2. Average yields from hand harvest samples for crop varieties and planting dates. 'Richlea' lentil yields for the late planting date were not available due to lack of available seed at planting.

	Average Yield (bu./ac.)							
	Chickpea		Dry Pea		Lentil		Guar	
	Orion	Frontier	Early Star	Carver	Richlea	Maxim	Kinman	Monument
Early	21.9	25.6	28.2	26.0	1.4	4.7	5.4	12.1
Mid	28.1	23.0	34.5	30.6	4.8	4.7	5.5	1.2
Late	30.3	20.0	23.5	23.8	N/A	10.7	3.1	3.8
Average	26.8	22.9	28.7	26.8	3.4	6.5	4.5	5.3

At wheat planting the average percent soil moisture was significantly affected by crop type ($p = 0.0002$; Figure 1). Soil moisture was not different between varieties at harvest so only the conventional variety was sampled before wheat planting. Soil moisture following chickpea was significantly lower than pea and fallow. Dry pea water use was not different than fallow which could be due to the early maturation date of peas allowing for more soil water recharge. Guar was excluded because of a late maturation date leading to a late wheat planting date.

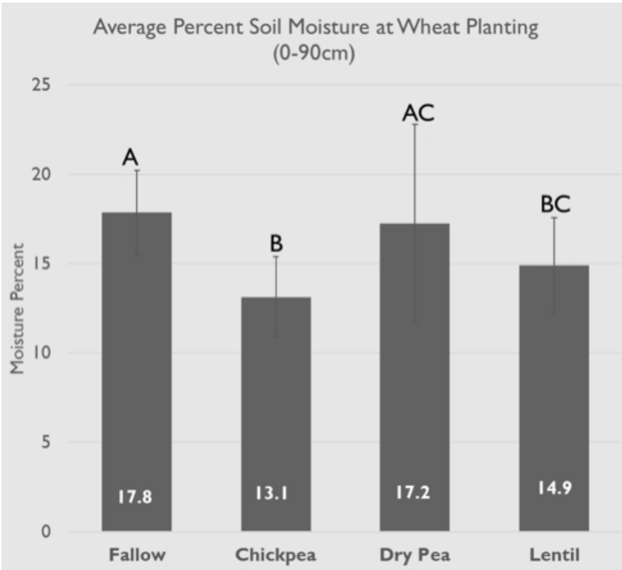

Figure 1. *Average soil moisture percentage in 0-90 cm before wheat planting. Letters indicate significant differences at p= 0.05. Error bars show standard deviations.*

This study will be repeated in 2019. Based on first year results, average yield for chickpea and dry pea were similar to previously reported dryland yields. Dry pea may be a better suited than chickpea to replace the fallow since the earlier maturation allowed for more soil recharge.

Acknowledgments

Thanks to the SAREC farm crew, staff, and interns as well as our seed sources. Meridian Seeds provided the dry pea and chickpeas, Safflower Tech supplied the lentil seeds, and Texas A&M and Texas Tech provided guar seeds. Funding for this project came from the Wyoming Department of Ag Specialty Crop Block Grant Program, a Western SARE Graduate Grant, and the Robert L. Lang Graduate Fellowship at UW SAREC.

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Keywords: dryland farming, pulse crops, sustainable farming, chickpea, lentil, field pea, guar

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

Establishment of cool-season perennial grasses and legumes in disturbed environments

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Introduction

Revegetation of grasslands invaded by alien species and energy mine spoils reduces the negative impact of land degradation. This also adds value to existing condition through improved soil properties and benefits wildlife, pollinators, and soil environment. Perennial forbs and cool-season grasses are effective in restoring disturbed areas due to their deep root system, which provides stability to soil. Similarly, legumes improve the soil nutrient status by fixing atmospheric nitrogen. They also provide good ground cover in the disturbed sites which inhibits spread of invasive species. Some of the promising grass and legume species have potential to establish in disturbed environment. They can perform well if they are planted at favorable time and could compete with the invasive species if managed during early establishment period.

Objective

To evaluate the establishment of cool-season perennial grasses and legumes in harsh environments.

Materials and Methods

The study was conducted at the James C. Hageman Sustainable Agriculture Research Center (SAREC) in 2018. Treatments were: (a) 15 treatments of native grasses, non-native grasses, shrub and legume genotypes, and their mixtures; (b) three planting times (late spring, early fall, and late fall), and (c) two environmental conditions (irrigated and dryland). The experiment was set up in a split plot design with four replications. The planting time was the main plot with combination of grass, legume and shrub in monoculture or mixtures as the sub plots within the main plot. Seeding was done on June 1 (late spring planting), August 15 (early fall planting), and November 15 (late fall planting) in 2018 under dryland and irrigated conditions. Plots were managed (e.g., weeding) throughout the study. Emergence data was collected for late spring and early fall plantings.

Results and Discussion

Emergence of the plants were affected by the treatments. There was significantly higher emergence under irrigated than in dryland conditions (Figure 1). Compared to early fall planting, legume monocultures and legume mixtures had higher emergence in late spring planting (Figures 1 and 2). Whereas, non-native cool-season grasses had higher emergence in early fall planting than in late spring planting (Figure 2). This could be explained by the exposure of the plants to longer period in warm weather during spring and cold weather in fall. As a result, legume mixtures planted in late spring performed better than legumes mixtures planted in early fall. However, cool-season grass mixtures in fall planting had lower emergence than at late spring planting probably due to their exposure to low temperatures. Preliminary results suggest that species and planting time in conjunction with environmental conditions play a major role in plant establishment and growth, particularly when the plants are managed adequately. The study is on-going, and data will be collected on forage yield, nutritive value, and persistence of the plants to further explore their potential as a reclamation tool while providing forages for livestock and wildlife.

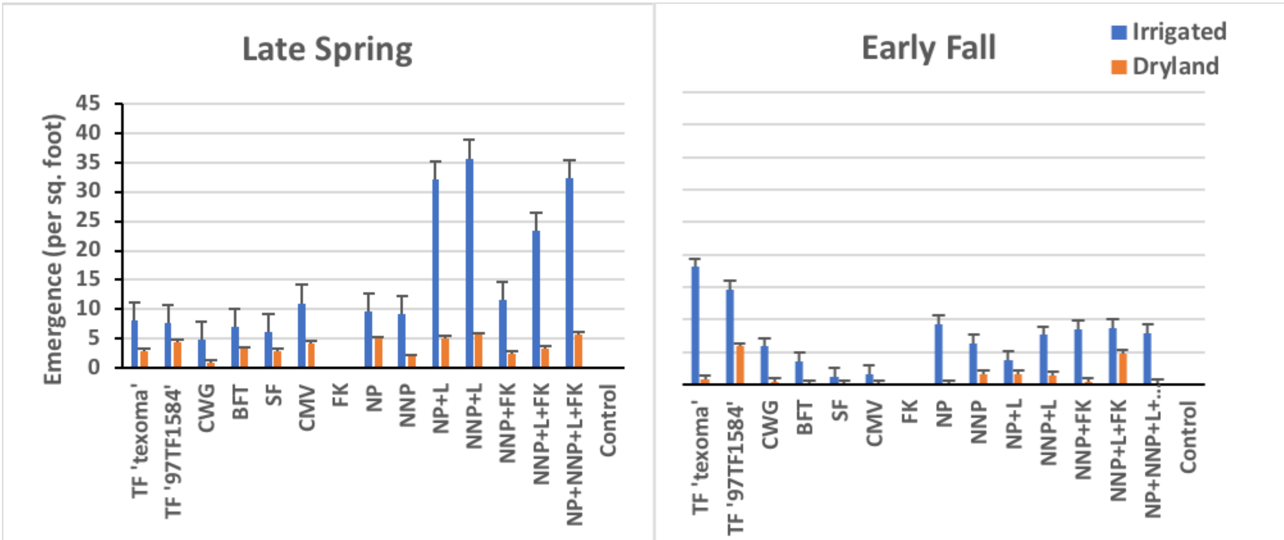

Figure 1. *Emergence of cool-season perennial grasses, legumes, and mixtures of grass-legume in late spring and early fall planting in irrigated and dryland conditions at SAREC in 2018. TF: tall fescue; CWG: crested wheatgrass; BFT: Birdsfoot trefoil; SF: sainfoin; CMV: cicer milkvetch; FK: forage kochia; NNP: Non-native perennial (TF 'texoma', TF '97TF1584', and CWG; L: legume (BFT, SF, and CMV); NP: native perennial (thickspike wheatgrass, bluebunch wheatgrass, western wheatgrass, and basin wildrye)*

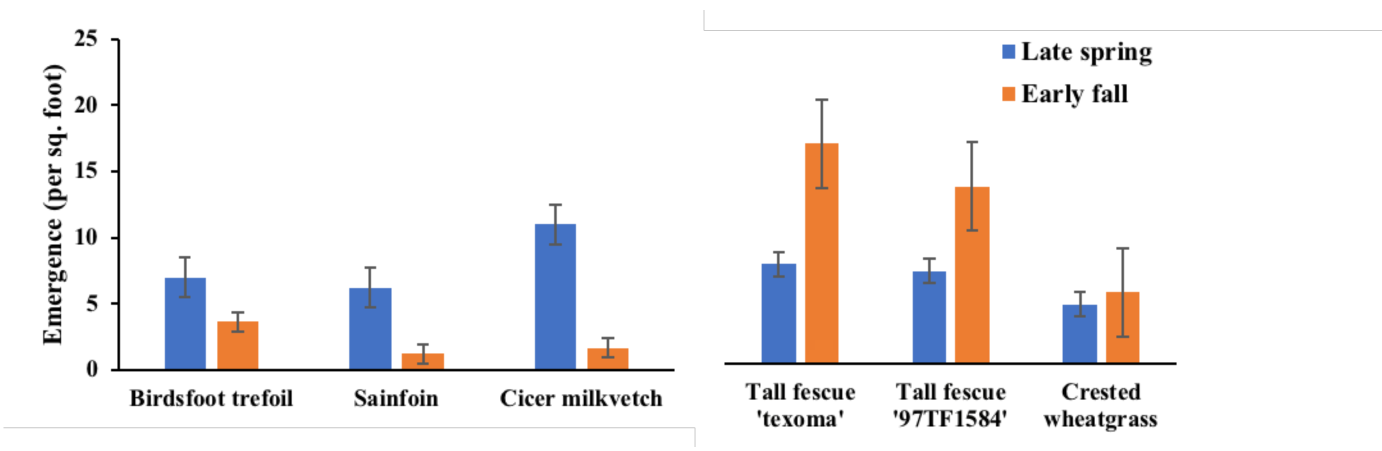

Figure 2. *Emergence of non-native cool-season grasses and legumes in irrigated condition in late spring and early fall planting at SAREC in 2018.*

Acknowledgements

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Keyword: disturbance, cool-season grasses, legumes, planting time

PARP: I:1,2, X:2,3, XII:1

Evaluation of Roundup Ready alfalfa for adaptability to Wyoming conditions

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Introduction

Alfalfa (*Medicago sativa* L.) is the world's premier forage crop and the third most valuable (over $ 9.3 billion) crop in the United States. In Wyoming and surrounding states, it is the mainstay for livestock production systems which is commonly fed to dairy and beef cattle, sheep, and horses. Over the past few decades, alfalfa has been the focus of scientific research and as a result, several advances have been made to improve its genetics to develop adapted and resistant cultivars for optimum forage production. Weeds in alfalfa production systems have a negative impact of alfalfa's productivity and thus, employing an effective weed management system is necessary for an efficient and productive forage system. Glyphosate-resistant (Roundup Ready) technology has successfully been incorporated into alfalfa and they have been released in the market. Using Roundup Ready (RR) alfalfa could potentially improve the level of weed management through the elimination of crop injuries and reduction of costs while increasing forage yield, nutritive value and other corresponding benefits.

Objective

To evaluate forage yield, nutritive value, and adaptability of RR alfalfa cultivars under irrigated conditions in Wyoming.

Materials and Methods

The experiment was established at the University of Wyoming James C. Hageman Sustainable Research and Extension center (SAREC) in 2013. Treatments included 25 RR alfalfa cultivars. Each cultivar was replicated four times in a randomized complete block design. Seeds of each cultivar were planted at a seeding rate of 20 pounds pure live seed per acre. Glyphosate was uniformly applied to all plots at 3 trifoliate seedling stage to control weeds during the establishment stage. Three cuts at 30 to 45 days interval (depending on plant growth) were made in each year. Forage samples were oven dried at 140°F for 72 hours to determine forage yield on dry matter basis. Nutritive value was determined using Near Infrared Reflectance Spectroscopy.

Results and Discussion

Cultivars did not vary for forage yields. However, numerically, forage yield was higher (14.8 tons per acre) for R59Hg217, and lower (11.5 tons per acre) for WL372HQ.RR when forage yields from 2015 to 2018 were summed (Table 1). Weed free RR alfalfa plots were achieved from early application of glyphosate. The cultivars have similar ability to maintain higher or comparable forage yields whiles improving weed control in alfalfa production systems. Annual forage yield was higher in 2016 (3.7 tons per acre) and 2017 (4.4 tons per acre) than in 2015 (1.9 tons per acre) and 2018 (2.9 tons per acre) (Table 1). This could be attributed to the effect of abiotic stress on the plants due to variations in soil moisture, and temperature which is likely to have interrupted plant growth at certain stage of development in a particular year. Nutritive value was similar among the cultivars. In general, forage nutritive value was high in all cultivars (e.g., average crude protein 28%; relative feed value 223). Overall, results from the study suggest that RR alfalfa cultivars are adaptable to conditions of Wyoming with potential of high yield and quality.

Table 1. Forage dry matter yield and nutritive value of roundup ready alfalfa cultivars at SAREC from 2015 to 2018

	Forage yield					Forage nutritive value †					
Cultivar	**2015**	**2016**	**2017**	**2018**	**Total**	**CP**	**ADF**	**NDF**	**IVDMD**	**TDN**	**RFV**
	Tons per acre					%					
6497R	1.9	4.1	4.2	2.9	13.1	27.5	25.5	42.3	79.2	74.0	218
6516R	1.9	3.8	4.6	3.1	13.3	27.5	25.6	42.9	79.3	73.8	216
6547R	1.9	3.4	4.1	2.7	12.1	27.9	24.8	42.7	80.4	74.7	228
Ameristand 415NT RR	1.9	3.8	4.1	2.4	12.3	27.5	25.2	42.3	80.0	74.2	223
Ameristand 433T RR	1.9	3.2	4.3	2.7	12.1	28.3	24.7	43.1	79.5	74.8	229
Ameristand 455TQ RR	1.8	3.4	4.6	2.8	12.6	27.6	25.2	45.9	76.1	74.3	222
Consistency 4.10RR	2.1	3.4	4.1	2.9	12.5	28.1	24.7	42.7	80.0	74.8	229
Denali 4.10RR	1.9	3.6	4.0	2.8	12.3	28.4	24.6	43.2	79.7	75.0	230
DKA46-16 RR	1.9	3.8	4.2	2.7	12.6	27.5	25.3	42.7	79.1	74.1	219
Integra 8444 RR	1.8	3.2	4.3	2.7	11.9	28.0	24.8	43.5	79.7	74.8	226
Mutiny	1.9	2.7	4.2	2.7	11.5	28.5	24.5	43.3	80.1	75.1	231
R312W244	1.7	3.3	4.6	2.9	12.5	27.5	25.7	42.8	79.1	73.7	218
R49W215	1.8	3.6	3.8	2.7	11.9	27.6	25.6	42.6	79.2	73.9	224
R570K217	2.0	3.4	4.5	2.8	12.7	27.5	25.5	42.4	79.1	73.9	221
R58W235	1.9	3.9	4.2	2.9	12.9	27.2	25.7	42.8	79.5	73.7	217
R59Hg217	2.0	4.6	4.6	3.5	14.8	27.2	25.9	42.6	79.1	73.5	212
RR Apha Tron	2.0	3.9	5.1	3.3	14.3	27.3	25.9	43.3	79.3	73.5	216
RR Nema Star	1.9	4.4	4.6	3.0	13.8	27.8	25.1	43.3	79.6	74.4	223
RR Presteez	1.8	3.1	5.0	3.0	12.9	28.1	24.6	43.3	79.5	74.9	225
RR Stratica	2.1	3.8	4.4	2.9	13.2	28.0	25.0	43.1	79.8	74.5	223
RR Tunnica	2.0	4.2	5.0	3.1	14.4	28.0	25.0	43.5	80.1	74.5	226
WL 355RR	1.9	3.9	4.7	3.1	13.6	28.3	24.9	44.3	80.4	74.6	225
WL 367RR/HQ	2.0	4.1	4.4	3.2	13.7	28.5	24.5	44.0	80.2	75.0	231
WL 372HQ. RR	1.8	3.1	3.9	2.7	11.5	27.9	25.4	42.6	78.8	74.1	223
WL 356HQ. RR	1.9	3.5	4.3	2.5	12.2	27.4	25.7	42.0	79.4	73.8	218
Average	**1.9**	**3.7**	**4.4**	**2.9**	**12.8**	**27.8**	**25.2**	**43.1**	**79.4**	**74.3**	**223**
LSD (0.05)	0.3	1.0	0.8	0.7	10.4	16	14	43	21	36	19

†Values are averaged over all three harvest periods in 2018 only.
CP, crude protein; ADF, acid detergent fiber; NDF, neutral detergent fiber; IVDMD, in vitro dry matter digestibility; TDN, total digestible nutrient; RFV, relative feed value.

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Keywords: Roundup Ready alfalfa, weed management

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

Management of Rhizoctonia root and crown rot disease in sugar beet with biological and conventional in-furrow and foliar-banded fungicide applications

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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

The study was established in 2018 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Seven in-furrow with +/- sequential foliar-banded fungicide or insecticide treatments were compared to both a non-treated inoculated and non-inoculated checks (Table 1). A randomized complete block design with four replicates was established. Each plot was 20 feet long and six rows wide (30-inch row centers) with a five-foot, non-treated, in-row buffer between plots. Prior to planting, the plot area was inoculated with *Rhizoctonia solani* grown on sterilized barley (50 lbs/A). On 2 June, plots were planted and treated with a Kincaid planter/sprayer. Fungicide applications were made in-furrow as seed was planted and rows closed immediately. Serenade® ASO and Serenade QST713 9, a more concentrated version of ASO), were applied as an in-furrow treatment alone or in combination with Quadris®, a conventional fungicide, both as a tank-mix partner. Some of these treatments were followed with a foliar-banded Proline® 480 SC fungicide or Movento® HL insecticide. The field plot area received fertility, weed control, and irrigation appropriate for sugar beet production. All data were collected from the middle two rows of each plot (40 row feet in total). Parameters measured included final crop stand, RRCR disease severity (percent canopy decline), and sugar yield (Table 1).

Results and Discussion

Due to difficulties with the new Kincaid planter/sprayer the study had to be replanted. With wet weather and sprayer mechanical issues the study was replanted at the late date of 2 June and the stands were 50% less than normal, which affected final yields. Surprisingly, because of warmer soils, seedling death due to inoculation did not seem to be an issue and treatments or inoculation had no effect on stands as measured on 24 July. RRCR did develop in the plots with noticeable canopy necrosis by late August. All fungicide treatments reduced disease induced canopy necrosis compared to the inoculated non-treated check. There were some differences in efficacy with treatments containing Propulse® being slightly less efficacious than the other fungicide treatments. This effect however was not consistent with the Propulse® in-furrow plus Movento® HL foliar band treatment that totally suppressed disease development.

There was no significant effect of treatment on beet root yield or recoverable sucrose yields. Lack of yield effect was probably due to the late onset of disease and low plant stand density.

Acknowledgments

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

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Keywords: Rhizoctonia management, biofungicide, sugar beet

PARP: I:11

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

Treatment, product rate/ac, and timing[1]	**Beet stand (40 row ft)**	**RRCR severity (% canopy decline)**		**Extractable sucrose (lb/A)**
	24 Jul	**22 Aug**	**4 Sep**	
Non-treated non-inoculated check	25.8 a[2]	0.0 d	0.0 d	2259.1 a
Non-treated inoculated check	23.0 a	65.0 a	76.5 a	2109.7 a
Propulse (10 fl oz) A	27.5 a	7.3 bc	5.0 bc	1723.9 a
Propulse (13.6 fl oz) A	26.8 a	21.0 b	12.0 b	2297.9 a
Proline 480 SC (5.7 fl oz) A	24.3 a	2.0 cd	3.0 cd	2155.8 a
Quadris (9.2 fl oz) A	23.5 a	8.5 bc	3.0 cd	2509.6 a
Serenade ASO (2 qt) + Quadris (9.2 fl oz) A Proline 480 SC (5.7 fl oz) B	23.8 a	0.0 d	0.0 d	2082.6 a
QST713 HICFU (12.8 fl oz) + Quadris (9.2 fl oz) A Proline 480 SC (5.7 fl oz) B	22.0 a	7.3 bc	3.0 cd	2228.0 a
Propulse (13.6 fl oz) A Movento HL (2.5 fl oz) B, C	24.5 a	0.0 d	0.0 d	2319.3 a
LSD	NS	1.7483	1.7131	NS

[1]*Application dates were as follows: A=2 Jun, B=12 Aug, and C=24 Aug.*

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

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

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Introduction

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

Objectives

The objectives are to evaluate an integrated management approach on managing soil-borne disease by combing different tillage options, locally adapted cultivars, and in-furrow fungicides.

Materials and Methods

The study was established in 2018 at the James C. Hageman sustainable Agriculture Research and Extension Center (SAREC). A randomized complete block design with variety and fungicide treatments in factorial arrangements and tillage as a split plot component was established on 28 June with the Kincaid planter/sprayer. Sub-plots were six rows (22-inch row centers), 20 feet long with a five foot in-row buffer. The conventional tillage treatment included conditioning passes whereas the deep tillage treatment included a deep soil ripping chisel treatment prior to conditioning. Disease due to *Rhizoctonia solani* and *Fusarium* spp. was endemic but not quantified. Fungicides were applied in-furrow at planting using labeled rates. The field plot area received fertility, weed control, and irrigation appropriate for dry bean production. All data were collected from the middle 4 rows. Parameters measured included compaction ratings, stand counts, vigor rating, incidence of root rot, NDVI (Normalized Difference Vegetation Index) rating, and bean yield.

A destructive hail event occurred on September 8.

Results and Discussion

Tillage treatments resulted in significantly less soil compaction with deep tillage compared to the conventional tillage as measured by the penetrometer prior to planting. On measured crop stands, there was no effect of tillage treatment but there was a negative overall stand effect with the Proline treatment. Variety was significant on overall stands. Othello had the highest stands and Long's Peak the lowest. There was a 100% disease incidence in all sampled plants toward the end of the season. Disease encountered was primarily due to *Fusarium* species and some *Rhizoctonia solani*. Fungicide treatments Headline® and Proline® resulted in less disease severity compared to the untreated check. There were significant differences of disease severity between varieties. Othello, ND Palomino, and Montrose had the highest amount of disease severity and then Long's Peak with Sundance having the least (Table 1). Plant vigor was unaffected by tillage but vigor was higher for fungicide treatments compared to the untreated check. Some differences were noted with the NDVI readings, but they were mainly limited to differences between varieties. Tillage and fungicide had no effect on bean seed yield but varieties had significantly different bean yields. Despite having greater disease severity, Othello was the highest yielding and Long's Peak was the lowest.

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Keywords: dry bean, soil-borne disease, tillage

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Table 1. Effects of treatments for management of root diseases of beans with a systems approach of varietal selection, in-furrow fungicides, and tillage treatments, SAREC.

Main Treatments	Stand Count (# per 80 ft)	Compaction (in. penetrated)[1]	Severity (0-4)[2]	Vigor (0-100%)[3]	NDVI[4]	Bean yield (lb/A)
	23 Jul	28 Jun	17 Aug	16 Aug	16 Aug	
Tillage						
Conv. Tillage	219.8 a[5]	11.1 b	2.5 a	102.6 a	0.8358 a	373.2 a
Deep Tillage	214.2 a	20.1 a	2.5 a	102.1 a	0.8521 a	389.3 a
Fungicide						
Untreated	218.4 a	--	2.6 a	100.0 b	0.8447 ab	380.8 a
Headline	222.2 a	--	2.4 b	103.9 a	0.8519 a	393.5 a
Proline	210.4 b	--	2.4 b	103.1 a	0.8352 b	369.4 a
Cultivar						
Long's Peak	193.3 c	--	2.4 b	--	0.8148 c	312.9 c
Montrose	215.3 b	--	2.6 a	--	0.8908 a	350.9 bc
ND Palomino	215.9 b	--	2.5 a	--	0.8627 b	383.9 b
Othello	252.0 a	--	2.6 a	--	0.8580 b	490.6 a
Sundance	208.5 b	--	2.3 c	--	0.7934 d	368.0 b

[1]Number of inches penetrated into the soil at a constant pressure (Dickey-John).
[2] Severity scale (0-4): 0=no disease, 1=individual, localized lesions on roots or hypocotyls or up to 25% of root surface necrotic, 2=multiple root or hypocotyl lesions coalescing or 26-50% of root surface necrotic, but no rotting of internal pith tissues, 3=51-75% of root system rotted and, 4=>75% of root system rotted.
[3]Within each rep, each variety was compared to its respective control (no fungicide) which was assigned a 100%.
[4]NDVI=Normalized Difference Vegetation Index quantifies vegetation by measuring the difference between near infrared (which vegetation strongly reflects) and red light (which vegetation absorbs).
[5]Treatment means followed by different letters differ significantly (Fisher's protected LSD, ($p \leq 0.05$).

Sugar beet response to biological soil amendments

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Introduction

There is growing interest in biologically based soil amendments, fertilizers, and microbial inoculants. The agricultural biologicals market was valued at $6.75 billion in 2017 and according to a recent report from Research and Markets will reach $14.65 billion by 2023(1). There are hundreds of products available on the market but much of the research is proprietary, making it difficult for producers to make informed decisions about product use.

Objective

With this study we tested the efficacy of Insure Organic and Agscitech soil amendments on sugar beets in Wyoming. We tested three soil and one foliar product on sugar beets in the Big Horn Basin and in Southeast Wyoming:

- **Soil Medic (SM):** microorganisms that fix atmospheric nitrogen, decrease pathogen pressure, increase nutrient availability, stimulate root development, and boost plant and soil health. (soil)

- **BioRelease™ (BR):** organically complexed fermentation derivatives made specifically to extend nutrient availability in the soil; rich in organic matter (more than 37% organic components). (soil)

- **AgroThrive™ LF (LF):** organic bio-fertilizer with a guaranteed minimum analysis of 2.5-2.5-1.5 NPK that can be applied through an irrigation system. (soil)

- **Foli-R-Plus™ Bulk-R 0-0-5 (BulkR)**: natural fermentation stimulants, protein and enzyme precursors, and microbial metabolites. (foliar)

Materials and Methods

Plots were established in the fall of 2017 at SAREC, PREC, and on Howard Farms in Worland, WY. Data was collected on sugar beet yield (tons/a) and sugar content (% and tons/a). Each trial location received the following treatments:

- **Control:** plots were fertilized and otherwise managed to meet the "industry standard".

- **Biological Products:** plots were fertilized and otherwise managed identically to the control plots but with the addition of the three to four biological products. SM (1gal/a), BR (1 gal/a), and LF (10 gal/a) were applied once in the fall before the cropping season (F), once in the spring before planting sugar beets (S1), and once after sugar beet emergence at approximately the 5 leaf stage (S2). At SAREC an additional spring treatment was applied just before canopy closure (S3), and a foliar treatment of BulkR (1.25 gal/a) was applied four weeks prior to harvest (BulkR). SAREC also had a number of treatment combinations of the different application times and products (Table 1).

Results and Discussion

None of the soil biologic treatments had a significant effect on sugar beet yield, sugar yield, or sugar content relative to the control treatment in 2018 (Tables 1, 2, and 3). Inclusion of the third spring application and the foliar BulkR application at SAREC also had no significant effect on sugar beet performance (Table 1). This study will be repeated in 2019 and the fields used for sugar beet production in 2018 will have corn produced in 2019 to assess cumulative effect of the products. Additionally, we will analyze soil active carbon to determine if the products have an effect on soil biological activity which can support overall soil health.

Acknowledgments

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Keywords: soil health, fertilizer, sugar beet

PARP: I.19, IX.10, IX.11

Table 1. 2018 SAREC average sugar beet percent sugar, total sugar yield, and total yield. There was no significant difference between any treatments in 2018. Product applied in fall 2017 and spring 2018 was LF at 10 gal/a, SM at 1 gal/a, and BR at 1 gal/a. Product applied in the fall of 2018 was BulkR at 1.25 ga;/a.

Treatment	% Sugar	Sugar (ton/a)	Yield (ton/a)
Control	15.5	4.5	28.9
F-S1-S2-S3-BulkR	15.7	4.2	26.5
F-S1-S2-.-BulkR	14.9	4.7	31.8
F-S1-.-.-BulkR	15.0	4.3	28.6
F-.-.-.-BulkR	15.6	4.5	29.4
F-S1-S2-S3-.	14.5	4.1	27.9
F-S1-S2-.-.	15.0	3.9	25.8
F-S1-.-.-.	15.8	4.2	26.3
F-.-.-.-.	15.1	4.6	30.7
.-S1-S2-.-BulkR	16.1	4.1	25.6
.-S1-S2-.-.	14.9	4.5	30.2
.-S1-.-.-.	15.1	4.4	28.9
Average	15.3	4.3	28.4
LSD	1.2	0.8	6.0
p-value	0.28	0.69	0.54

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.

Treatments: Control; F = Fall Application; S1 = Spring application pre-plant, S2 = Spring application at 4-5 leaf; . = no application

S3 = Spring application on 7/13/18; BR = Bulk R application 4 weeks prior to harvest

Table 2. 2018 PREC average sugar beet percent sugar, total sugar yield, and total yield. There was no significant difference between any treatments. Product applied in fall 2017 and spring 2018 was LF at 10 gal/a, SM at 1 gal/a, and BR at 1 gal/a.

Treatment	% Sugar	Sugar (ton/a)	Yield (ton/a)
Control	13.8	3.9	28.3
F-S1-S2-.-.	14.4	3.9	26.7
Average	14.1	3.9	27.5
LSD	1.3	0.7	3.9
p-value	0.31	0.95	0.40

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.

Treatments: Control; F = Fall Application; S1 = Spring application pre-plant, S2 = Spring application at 4-5 leaf; . = no application

Table 3. 2018 Howard Farm average sugar beet percent sugar, total sugar yield, and total yield. There was no significant difference between any treatments. Product applied in fall 2017 and spring 2018 was LF at 10 gal/a, SM at 1 gal/a, and BR at 1 gal/a.

Treatment	% Sugar	Sugar (ton/a)	Yield (ton/a)
CONTROL	22.4	6.3	27.9
F-S1-S2-.-.	20.1	6.1	30.3
Average	21.3	6.2	29.1
LSD	6.4	2.3	5.0
p-value	0.41	0.83	0.29

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.

Treatments: Control; F = Fall Application; S1 = Spring application pre-plant, S2 = Spring application at 4-5 leaf; . = no application

Evaluation of forage sorghum cultivars under irrigated and dryland conditions

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Introduction

Sorghum (*Sorghum bicolor* (L.) Moench), an important source of fresh fodder and silage, is often grown in western United States as a supplemental forage crop for livestock feed. It has high tolerance to drought and grows very well in wide range of areas where other crops, such as corn are least productive. Forage sorghum has about 88% of the feed value of corn silage which can supply the needed crude protein (CP) and energy to increase animal performance. In semi-arid regions, such as in Wyoming, forage sorghum could be a better replacement for corn silage. Due to limited access to irrigation water in the region, sorghum can serve as a security crop while supplying high feed value for livestock diets. This study aimed at evaluating the performance and adaptation of different hybrids of forage sorghum under irrigated and dryland conditions in Wyoming.

Objectives

To determine forage yield and nutritive value of forage sorghum cultivars grown under irrigated and dryland conditions.

Materials and Methods

The experiment was conducted at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) in 2018. Treatment consisted of 28 sorghum hybrids for dryland trial and 25 sorghum hybrids for irrigated trial. Corn silage was included as a control in both trials. The trials were arranged in a randomized complete block design with three replications. Both irrigated and dryland trials were seeded (June 4, 2018) at a seeding rate of 80,000 and 60,000 pure live seeds, respectively. Urea (56 pounds per acre) was applied (by broadcasting) to irrigated plots, based on soil test results. Urea was not added to plots for the dryland trial due to enough residual nitrogen in the soil. Management practices (e.g., weeding) were equally maintained for both trials throughout the study. The plots were harvested on September 14 (dryland trial) and September 29 (irrigated trial), 2018. The harvested samples were oven dried for 72 hours at 140°F to determine forage yield on a dry matter basis. Nutritive value of the forage samples was determined by using Near Infra-red Reflectance Spectroscopy.

Results and Discussion

Forage yield did not differ among the cultivars for both irrigated and dryland trials. However, average dry matter yield was higher under irrigated conditions (3 tons per acre) than under dryland conditions (1.8 tons per acre) (Table 1). Dry matter yields of the hybrids ranged from 1.5 to 4 tons per acre; and 1.2 to 2.9 tons per acre in irrigated and dryland conditions, respectively. Many hybrids outperformed the corn silage (Table 1). Nutritive value differed among the cultivars except for relative feed value (RFV) in dryland trial. FX18851 BMR had the highest nutritive value (e.g., CP = 17.1%; RFV = 133) in dryland trial. For irrigated trial, ADV XS008 had the highest nutritive value (e.g., CP = 14.0%; RFV = 98) (Table 1). The compositional differences (e.g., genetics) of the cultivars and their influence might have contributed to the variations. Compared to irrigated conditions, average CP and RFV of the forage sorghum cultivars were higher under dryland trial. This could be attributed to the effect of time of harvesting, as the hybrids under the irrigated trial were harvested 15 days after harvesting hybrids under dryland trial. Over 20 hybrids had higher CP compared to that of corn silage. Overall, the study results suggest that sorghum has greater potential than corn silage to produce higher forage nutritive value, and the dry matter yields comparable to dry matter yields of corn under both dryland and irrigated conditions. Growers are, therefore, encouraged to prioritize forage sorghum as an alternative silage crop for livestock ration while reducing irrigation costs.

Table 1. Forage yield and nutritive value of sorghum cultivars under dryland and irrigated conditions at SAREC in 2018

	Forage yield		Forage nutritive value									
Cultivars	Dryland	Irrigated	Dryland					Irrigated				
			CP	NDF	ADF	TDN	RFV	CP	NDF	ADF	TDN	RFV
	(Tons per acre)		(%)					(%)				
ADV XF372	1.6	3.1	17.0	34.1	55.5	63.6	104	11.6	63.1	41.2	55.5	84
AF8301	2.4	3.5	13.4	36.8	58.5	60.6	96	9.9	58.6	39.4	57.6	93
ADV XF033	1.5	3.9	15.5	34.9	58.8	62.7	97	9.5	65.3	40.4	56.5	82
AS6402	1.5	3.1	17.2	36.2	57.3	61.3	98	13.7	60.8	37.3	60.0	92
ADV XS007	1.9	3.0	15.4	39.6	55.8	57.4	97	14.1	62.3	42.3	54.3	84
ADV XS008	1.5	2.1	16.2	35.9	55.8	61.7	102	14.0	57.0	37.0	60.4	98
FX18130 BMR	1.6	3.7	16.9	35.9	54.4	61.7	104	8.4	68.0	38.1	59.2	81
FX18152 BMR	1.9	3.7	15.4	36.8	53.4	60.6	105	9.3	65.9	41.7	55.1	80
705F	1.8	2.6	14.6	36.5	49.3	60.9	119	9.7	64.7	42.7	53.9	80
Super Sile 30	2.4	2.6	13.4	37.2	57.5	60.1	97	9.2	66.1	44.4	51.9	77
FX18878 BMR	1.7	3.4	16.2	33.0	51.7	64.9	114	10.6	62.2	38.8	58.3	88
F74FS23 BMR	2.2	3.1	15.4	35.0	53.9	62.7	107	10.3	63.1	41.1	55.6	84
FX18811	2.9	2.8	14.5	35.0	55.2	62.7	104	7.7	69.7	46.2	49.9	71
FX18851 BMR	1.4	1.5	17.1	32.3	52.7	65.7	113	10.4	62.5	37.2	60.2	89
FX18317	1.9	4.0	15.5	39.0	57.6	58.1	95	10.0	64.2	41.2	55.5	82
Danny Boy BMR	1.5	3.1	15.3	35.7	56.0	61.9	102	12.1	63.7	40.6	56.3	84
Fullgraze BMR	1.8	1.9	15.6	34.2	53.5	63.6	108	12.5	61.6	39.7	57.3	88
GX16921	2.1	2.6	14.8	35.6	58.3	62.0	97	11.3	61.9	40.3	56.5	87
F76FS77 BMR	1.9	2.6	15.1	36.3	56.4	61.2	100	12.4	59.9	36.9	60.4	94
FX18835SS	1.8	3.2	14.7	36.2	57.6	61.3	98	9.1	69.8	45.0	51.3	72
FX18843SS BMR	2.1	2.9	15.3	35.7	54.1	61.8	105	10.6	66.8	43.7	52.7	77
NK300	2.3	3.5	15.6	35.5	57.4	62.1	99	8.7	65.2	42.1	54.6	80
SP4555	1.7	3.0	13.2	36.9	56.8	60.4	99	8.8	67.9	47.3	48.6	71
SS405	1.6	4.0	16.6	33.0	54.8	64.9	107	7.1	71.2	48.8	46.9	67
96BMR	1.8	2.3	15.6	34.0	52.9	63.8	110	10.4	63.9	39.4	57.6	85
Bruiser BMR	1.5	-	16.8	33.5	52.3	64.3	112	-	-	-	-	-
Nutrimaxx BMR	1.2	-	15.4	35.1	53.8	62.5	106	-	-	-	-	-
Excel	1.9	-	16.6	35.2	53.9	62.4	106	-	-	-	-	-
Corn-silage	1.7	3.7	13.8	35.6	57.5	62.0	99	8.6	66.0	37.4	59.9	84
Average	**1.8**	**3.0**	**15.5**	**35.5**	**55.3**	**62.0**	**103**	**10.4**	**64.3**	**41.2**	**55.6**	**83**
LSD (0.05)	1.6	2.4	2.2	3.0	5.1	3.3	29	2.4	4.7	6.7	7.6	11

Bruiser BMR, Nutrimaxx BMR, and Excel were not planted under irrigated conditions.
CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; TDN, total digestible nutrient; RFV, relative feed value.

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Keyword: sorghum cultivars, corn, silage

PARP: I:2, 12, IV:3,4, VI:3

Tall fescue-alfalfa mixtures for improved forage production

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Introduction

Studies have shown that combination of forage legume and forage grass is a convenient approach to enhance yield and nutritive value of hay. Reports also suggest that, with soils of good fertility, alfalfa (Medicago sativa L.) and grass mixtures can out-yield pure alfalfa or monocultures, and it reduces the risk of bloat in ruminants. Alfalfa-grass mixtures could potentially be the best choice of a more balanced ration for livestock. Tall fescue (Schedonorus arundinaceus (Schreb.) Dumort) is one of the best cool-season grasses and suitable for mixtures with alfalfa to optimize hay yields. Both alfalfa and tall fescue have wide adaptation and therefore, knowledge about the right combination of these species could help improve forage production in a long term and can substitute use of nitrogen (N) in forage production systems. However, information on the seeding ratios of grass species with legumes is limited.

Objective

To determine the effect of K and harvest time on forage yield of reduced lignin and conventional alfalfa cultivars.

Materials and Methods

The study was conducted at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) from 2015 to 2018 under irrigated conditions. Treatments consisted of (a) alfalfa monoculture (100% alfalfa), (b) tall fescue monoculture (100% tall fescue) supplied with different N rates (0, 45, 90, 135, 180, and 270 pounds N per acre) in the form of urea (46% N), and (c) 75:25%, 50:50%, and 25:75% mixtures of tall fescue and alfalfa. Each treatment was replicated three times in a randomized complete block design. Seeding rates were determined based on the recommended 22 pounds pure live seed per acre for both tall fescue and alfalfa monocultures. Mixture ratios were based on the seedling rates of the monoculture. Nitrogen was applied to tall fescue in two splits (April and August) each year. Three cuts were made each year at 30 to 45 days interval (depending on the plant growth). Forage samples were oven dried at 140°F for 72 hours to determine forage yield as dry matter basis. Nutritive value was determined by using Near Infrared Reflectance Spectroscopy.

Results and Discussion

Forage yield was affected by the treatments in each year (Table 1). In general, all mixtures produced similar forage yields compared to pure alfalfa or tall fescue with N. In four years total, the 50:50% mixture of tall fescue-alfalfa had the highest forage yield (11.2 tons per acre). This was probably due to an efficient N fixation by the legume species which benefited grasses in mixtures. Equal proportion of tall fescue and alfalfa in the mixture covered enough ground space and reduced weed infestation which might have contributed to higher forage yield. Tall fescue monoculture receiving highest N (270 pounds N per acre) produced the highest yield compared to tall fescue monocultures receiving zero to moderate N rates (Table 1). This indicates that tall fescue responded positively with added N, however the yields were similar to or lower than yields in mixtures. Generally, forage yields were higher in 2017 and 2018 compared to 2015 and 2016, which indicates a persistent production over time. In general, forage nutritive value of mixtures was similar to pure alfalfa or tall fescue with added N (Table 1). Overall, the study results suggest that tall fescue-alfalfa mixtures are beneficial for optimum hay production compared to tall fescue fertilized with N. Therefore, mixing tall fescue with alfalfa can eliminate the need for N fertilizers and reduce the cost of hay production.

Table 1. Forage yield and nutritive value of tall fescue – alfalfa mixtures and tall fescue with different rates of nitrogen (N) at SAREC from 2015 to 2018

Treatment	2015	2016	2017	2018	Total	CP	ADF	NDF	IVDMD	TDN	RFV
	Forage yield					Forage nutritive value †					
	Tons per acre					%					
Alfalfa monoculture	1.9b ‡	2.0a	3.4a	1.6b	8.8b	25.6a	26.3a	31.9c	78.2a	73.0a	202a
TF-ALF (75:25)	1.9b	2.3a	3.3a	3.2a	10.6ab	21.6ab	27.5a	40.8b	77.1a	71.8a	167b
TF-ALF (50:50)	2.4ab	2.4a	3.5a	3.0a	11.2a	22.4a	26.2a	39.6b	79.0a	73.2a	173a
TF-ALF (25:75)	2.1b	2.5a	3.1a	2.6ab	10.3ab	22.8a	26.9a	40.1b	78.3a	72.4a	171a
TF + 0 N	0.8d	1.2b	2.5b	3.1a	7.6bc	15.8b	29.5a	48.1a	74.5b	69.5a	134b
TF + 45 N	1.5b	1.5b	3.0a	2.0b	8.0bc	14.5b	30.5a	51.3a	73.9b	68.4a	122bc
TF + 90 N	1.4bc	1.4b	2.5b	2.3b	7.6bc	15.5b	30.1a	49.2a	75.6ab	68.8a	128bc
TF + 135 N	2.0b	1.7ab	3.1a	2.4ab	9.2b	15.6b	30.2a	49.9a	75.0ab	68.7a	125bc
TF + 180 N	1.7b	2.0a	2.9a	2.4ab	9.0b	18.0b	28.5a	47.5a	77.2ab	70.6a	135b
TF + 270 N	2.8a	2.3a	2.2b	2.7ab	9.9ab	21.7ab	27.0a	42.5ab	78.3a	72.2a	161b
Average	1.8	1.9	3.0	2.5	9.2	19.4	28.3	44.1	76.7	70.9	152

TF, Tall fescue; ALF, Alfalfa; TF-ALF, Tall fescue-alfalfa mixture; 0 N, 0 pounds per acre; 45 N, 45 pounds per acre; 90 N, 90 pounds per acre; 135 N, 135 pounds per acre; 180 N, 180 pounds per acre; 270 N, 270 pounds per acre.
CP, Crude protein; ADF, Acid detergent fiber; NDF, Neutral detergent fiber; IVDMD, in vitro dry matter digestibility; TDN, Total digestible nutrient; RFV, Relative feed value.
† *Values are averaged over all three harvests in 2018 only.*
‡ *Within each column, means followed by the same lower-case letters are not significantly at 0.05 probability level.*

Acknowledgements
We thank SAREC crew, and UW forage agronomy laboratory members for study assistance.

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Keywords: tall fescue-alfalfa mixture, nitrogen, hay production

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

Estimating the potential economic benefits from using genomic testing to improve feed efficiency

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Introduction

Feed inputs comprise one of the largest operational cost categories for beef production both for cow-calf ranches and feedlots. Thus, the economic sustainability of the beef industry can be positively impacted by improving feed efficiency. Genomic testing could be used to select beef animals with increased feed efficiency. As such this management tool offers the potential for economic improvement across the beef supply chain.

Objective

A number of factors impacting feed efficiency have been investigated, but little research has been reported related to the economics associated with genomic testing and its potential to improve feed efficiency. Hence, our research objective is to evaluate the potential economic impact of improving feed efficiency for cow-calf operations, feedlots and for the beef sector as a whole, using genomic testing to improve selection of efficient animals.

Materials and Methods

We use existing data from cattle feeding experiments conducted at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) to motivate our analyses. We conduct firm level budget analyses to estimate the potential economic improvement associated with increasing feed efficiency across both cow-calf and feedlot operations. These firm level analyses are then used in an Equilibrium Displacement Model (EDM) to estimate the overall potential economic gains associated with improved feed efficiency in the U.S. beef sector.

To measure the potential feed efficiency improvement we utilized data from feeding experiments at SAREC. We examined the available data and assumed that the bottom half of the SAREC sample was replaced with animals performing as animals in the top half. The range in feed intake per pound of gain for the sample was 4.32 to 10.18 pounds on a dry matter basis. When the bottom half was replaced by the top half of the sample, the new sample of cattle ate approximately 87% of the amount of feed the original sample did to achieve the same amount of weight gain overall. We also assumed this improvement in feed efficiency for animals placed in feedlots would likely come from genetic selection occurring in the cow-calf sector. Thus, our analyses assumed a 13% reduction in feed intake for both our cow-calf and feedlot budget analyses. It should be recognized that data are not available for cow-calf ranches related to genomic testing and possible feed efficiency gains at this time, and feed efficiency gains in commercial cow-calf herds could be different than this. For our national estimate of economic gains from improved feed efficiency, research on adoption of beef production technology suggests only operators with herd sizes of more than 100 cows utilize improved reproduction technologies. Thus, we assume only operators with a herd size of 100 or more cows will apply genomics testing to improve feed efficiency for our national EDM beef sector analysis.

Results and Discussion

Cow-calf operations: We analyzed ranches with 200 head versus 521 head and analyzed economic benefits from improved feed efficiency that came from cost savings of reduced feed alone, and also from using a reduction in feed per animal to grow the herd, i.e., run more animals with same total amount of feed. According to the first scenario, feed cost savings alone, for the operation with 200 cows, estimated benefit would be approximately $1 per head by the end of year 7. As time passes the benefits increase and after 10 years the benefit would be $36 per head ($/hd). Feed cost savings alone for the 521 cow herd size operation, indicates producers would receive $14/hd by the end of year 7, and after 10 years the benefit would total $55/hd. If ranches chose to increase herd sizes, cow-calf producers with 200 head herd size would receive negative net benefits of -$31/hd with increased cow herd size of 25 head by year 7. Again, as time passes net benefits increase, and by year 10, indicated improvement is $36 per head. Results for operations with beginning herd size of 521 head indicate cow-calf producers would receive a positive benefit of $6/hd by the end of year 7 and after 10 years the total benefit would be $99/hd. It is interesting to note that for producers who have a shorter planning horizon (less than 10 years) regarding management of their operation, they may be better off to not increase herd size and just take improved profits from reduced costs from feed savings. In fact these results suggest that given the assumptions in our analysis, this investment would not garner positive net benefits until after year seven for smaller operations. These results indicate that given operational practices and costs assumed in the budgets, larger operations may very well benefit more from improved feed efficiency than smaller operations.

Feedlots: Again we analyze two scenarios of reduced costs from feed savings versus increased number of head in the feedlot given improved feed efficiency of animals placed in the feedlot. According to the first scenario, feed cost savings without an increase in number of head in the feedlot, feedlot producers would receive a benefit of $76/hd by the end of year 9. The benefit after 12 years would total $124/hd. Our second scenario results indicate that feedlot producers would receive less net benefits in the shorter term with increased number of animals on feed. Total benefit is estimated at $66/hd after year 9 and $112/hd by year 12. Overall, the slightly lower benefit compared to cost savings on feed, for both ranches and feedlots, is driven by the lower profit margin per head received when expanding animal numbers compared to feed cost savings alone. A reduction in feed cost alone does not change other cost categories as total number of animals do not change, but net feed cost per head goes down.

Beef Sector: Our estimates indicate total net benefits could equal nearly $2.5 billion in year 9 alone, and the sum of the benefits for years 3 through 9 is nearly $12 billion. The share of estimated benefits accruing to the cow-calf and feedlot segments are 34% and 66%, respectively.

Acknowledgements

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Keywords: beef cattle, beef genomics testing, economic benefits

PARP: V.1., VII.7., VIII

Performance of segregating progeny from a pinto-by-pink dry bean cross in SE Wyoming after several hail storms

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Introduction

Dry bean yield per acre has been relatively stagnant in Wyoming for several years. Traditionally, many of the most popular lines grown in Wyoming are from the pinto market class although popularity of black, navy, and Great Northern types have gained traction in recent years.

Objective

The objective of this study was to characterize performance of a set of F2-derived F4 sister lines developed from a pinto-pink cross for maturity, lodging, and yield.

Materials and Methods

During 2015 and 2016, a pinto-by-pink cross was made and seed from several single F2 plants were collected and advanced through 2017 at SAREC in order to generate enough F2 derived F4 seed for a 2018 trial. The different lines were designated LPID #1, LPID #2, etc. Seed were sown in four-row plots (16-foot long, with a five-foot alley), 30-inch rows, at approximately 100K seed per acre on 6 June 2018 at SAREC. Plots for three check cultivars were included. The number of replicates ranged from two to six (CRD, depending on amount of seed). Pre-emerge herbicides were applied on 8 June 2018 (Prowl H2O and Outlook). Sprinkler irrigation was provided weekly at 0.75 inch or less as needed throughout the season. Post emergent herbicides were applied 12 July 2018 (Basagran and Raptor). Canopy temperature was recorded once during the season. Hail was experienced just after emergence, again in July, and finally in early September. The September hail caused shattering for most pods that had matured (skewed against the early-maturing lines) and this was also especially evident for the prostrate lines. Flowering, buckskin pod color, and upright status were recorded during July, August, and Sept. Yield was collected by direct harvest from the two center rows of each plot (16 feet, not end trimmed) in late September with a Kincaid plot combine. Seed moisture was only recorded on a random set of samples and was typically 6%.

Results and Discussion

Results are found in Table 1. Obviously, the yields were compromised by the intensity of the September hail storm (not to mention the previous hail storms) although La Paz partially escaped. Canopy temperatures did not differ among the entries so those data are not presented. Based on yield, maturity, and upright status (and results from Powell not shown here), we will retain eight (LPID #3, #6, #7, #9, #11, #28, #29, #34) of the 17 entries for further observation in 2019 and discard the others. Several of these lines that we are retaining are not from a recognized market class and for those, we will cross those with adapted public types in order to recover a recognized-market type.

Acknowledgements

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Table 1. Apparent market class, hail-damaged yield, maturity date, and upright status of 13 dry bean entries and three check cultivars grown at Lingle in 2018.

Entry	**Apparent Market Class**	**Yield** **lbs/a**	**Maturity†** **dap‡**	**Upright§** **visual**
# 3	Pink, Light-Pinto	460	87	6
# 4	Beige, Dark-Pinto	452	86	7
# 6	Pink, Light-Pinto, Dark-Pinto	786	89	5
# 7	Dark-Pinto, Pink	449	90	7
# 9	Pink	665	93	6
# 11	Light-Pinto, Dark-Pinto, Pink	513	91	4
# 16	Pink	463	85	6
# 27	Beige	532	85	5
# 28	Pink-Beige, Dark-Pinto	739	91	5
# 29	Beige	629	87	6
# 30	Med-Dark-Pinto	529	87	5
# 31	Beige	739	91	5
# 34	Beige, Light-Pinto, Pink	558	87	4
La Paz	Pinto	1340	94	7
Poncho	Pinto	305	87	3
Croissant	Pinto	438	91	3
LSD (0.05)	na	690	4	3

Introduction to the Sheridan Research and Extension Center

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Introduction

The mission of the Sheridan Research and Extension Center (ShREC) is to serve Wyoming's applied research, education, and extension needs in horticulture, rangeland restoration, and forage science. We seek to continually improve our performance in all aspects of this mission. Our extension and outreach efforts have significantly increased over the past few years and have included target-specific field days, intensive multi-day workshops, and one-on-one consultations with local producers, land managers, and homeowners. With two field locations (Wyarno, east of Sheridan, and the Adams Ranch, just south of Sheridan College), a research greenhouse, and state-of-the-art laboratory space, we are able to facilitate research ranging from highly technical to very applied. While a lot of research occurs on these sites, ShREC also serves as home base for additional research and educational endeavors around the state and region.

2018-19 Updates

As with much of UW, 2018-19 has been a year of change for ShREC. Our horticulture faculty member and friend, Dr. Sadanand Dhekney, accepted a position with another institution and left our team. On the eve of the 2019 field day, we posted the announcement to begin the search for a new faculty member to fill his vacated position in the E.A. Whitney Endowed Professorship. We hope to have a new colleague in place and engaged prior to next year's field day.

The 2019 field day will give attendees an introduction to the variety of projects under way at the Adams Ranch facility this season: cover crops, weed management, viticulture, small grains, soil fertility, forage agronomy, native plant propagation, community engagement, rangeland restoration, and more. We are thankful to have the opportunity to provide this information to our community!

Acknowledgments

Members of the ShREC team strive to provide a setting where researchers, students, and other partners have access to high-quality research and learning opportunities. Our partnerships with Whitney Benefits, Sheridan College, UW Extension, the ShREC Advisory Board, and others expand our ability to serve the needs of stakeholders in Sheridan County and north-central and northeast Wyoming. We also thank other entities that have provided direct support in multiple forms over the past year: Monsanto Co., Plank Stewardship Initiative, Sheridan County CattleWomen, Alforex™ Seeds, Allied Seed Company, Granite Seed Company, Corteva™ Agriscience, Bayer Crop Science, Plank Stewardship Initiative, Bureau of Land Management, Sheridan County Weed and Pest, USDA-NRCS, and others.

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

Comparing establishment methods among difficult to produce native plant materials

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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. Additionally, propagation methods may directly impact native plant restoration efforts where original seed sources are limited. We evaluated methods for seed increase of native plants sulfur-flower buckwheat (*Eriogonum umbellatum* Torr.) and desert biscuitroot (*Lomatium foeniculaceum* J.M. Coult. & Rose). Sulfur-flower Buckwheat is a native, low growing, woody mat-forming perennial that is important for quail, sage-grouse, and ungulate forage, and for pollinator habitat. Desert biscuitroot is a broad-leaved, herbaceous perennial of the Apiaceae. It is used for medicinal purposes and is an important forage for sage grouse.

Objectives

The objective of this study was to compare establishment between direct-seeding and transplanting containerized seedlings for seed production fields in northeast Wyoming.

Materials and Methods

Transplanting Method: We placed seeds from each species in a cooler (37.27 degrees Fahrenheit) in January of 2017. As seeds germinated in the cooler, we moved them into cone-tainers in a greenhouse (71-50 degrees Fahrenheit) throughout the spring. In May of 2017, we transplanted forbs at 12 inch spacing into 3 separate blocks of 4 rows in the field. We recorded establishment by counting every live plant in June of 2018 and again in June of 2019. We determined establishment success by comparing the number of forbs transplanted to live plants one and two years post transplanting.

Direct Seeding Method: In October 2017 we drill seeded the forbs into 3 blocks of 4 rows. We seeded sulfur buckwheat at 20 seeds/ft and desert biscuitroot at 30 seeds/ft. We recorded establishment by counting every live plant in June of 2018 and 2019. We determined establishment success by comparing the number of pure seeds per row to the number of live plants present.

Results and Discussion

Sulfur-flower buckwheat had better establishment with the transplanting methodology (Table 1). Desert biscuitroot had statistically similar establishment between seeding methods (Table 1). However, the visible establishment of desert biscuitroot within the plot shows that direct seeding has higher establishment. The direct seeding method used more seeds per foot, which led to a lower percentage of survivors, but more actual live plants were present as compared to the transplanted forbs. There appears to be a trade-off between time input and seed input with the desert biscuitroot seeding.

Acknowledgments
We thank the ShREC field crews for assistance with planting and maintenance of the forbs and Granite Seed, Inc. for supplying seed for this research.

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Keywords: reclamation, sage-grouse habitat, native plants

PARP: X.3, XII.1

Table 1. Establishment of sulfur-flower buckwheat and desert biscuitroot one and two years after planting with different planting methods (direct seeding or transplant from greenhouse.

	Establishment (%) with 95% Confidence Intervals			
	One Year After Planting (2018)		Two Years After Planting (2019)	
	Direct Seeding	Transplanted	Direct Seeding	Transplanted
Sulfur-flower buckwheat	0.17%*	71.7% +/- 21%	0.23% +/- 0.4%	58.3% +/- 31.6%
Desert biscuitroot	10.2% +/- 1.5	18.1% +/- 19.4%	6.5% +/- 0.9%	10.1% +/- 21.2%

**Year one of direct seeding of buckwheat has no confidence interval because there was only establishment in one block.*

Indaziflam effects on seed production and viability for various rangeland grasses

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Introduction

Annual weeds negatively impact grass seed production by directly competing for resources and by contaminating seed lots. Herbicide options in grasses grown for seed are relatively limited. Further, for an herbicide to be useful it must provide acceptable weed control with little reduction in seed production and viability. Indaziflam controls annual grasses and other weeds, but little is known about how it affects seed production and germinability.

Objectives

Our objectives were to evaluate the effects of the herbicide indaziflam on seed production and germinability across a range of established perennial grasses.

Materials and Methods

Thirteen grass species/varieties were seeded in a randomized complete block design with four replicates in 2013 at the Sheridan Research and Extension Center (ShREC) property east of Sheridan near Wyarno, Wyoming. We applied Esplanade 200 SC® (5 oz/ac) plus Roundup WeatherMax® (12 oz/ac) to one-half of each grass plot on March 27, 2017, leaving the other half as a non-treated control. Cheatgrass (aka downy brome, *Bromus tectorum*) and several of the perennial grasses were actively growing at the time of application.

We harvested, counted and weighed mature inflorescences (seedheads) mid to late July (as species matured) in 2017 and 2018, from three bunchgrasses per grass + herbicide plot or, if the species was rhizomatous, from three 0.25m^2 (2.7ft^2) frames within each grass plot. We evaluated cumulative germination using 50-seed lots in petri dishes with filter paper in a growth chamber set at 70°F daytime and 50°F nighttime temperatures for one month. We analyzed data as a two-way analysis of variance with plant material and herbicide as the two treatments.

Results and Discussion

Control of annual grasses was still apparent two growing seasons after herbicide application, similar to what was observed in year one. However, the damage observed in the first growing season was largely non-existent by the second year. If a difference between plots occurred, positive increases in production or germinability occurred in herbicide treated areas.

By 2018, the number of the perennial grass inflorescences showed either no difference between the non-treated and herbicide areas, or application resulted in an increase. Species that showed an increase with herbicide included some varieties of wheatgrasses and wildryes (Figure 1). Inflorescence weight mimicked the patterns observed for inflorescence number since weight varied as inflorescence number changed and not because of a difference in the weight of the seed produced.

Total number and weight of inflorescences have a direct relationship to seed production. Because germination was decoupled from overall seed production, we can determine germination regardless of the total amount of seed produced. Germinability of most species was not impacted by herbicide two growing seasons after application (Figure 2). Some bluebunch wheatgrass and basin wildrye varieties showed an increase in germination in the herbicide treated areas, (between 10 and 30% increase). 'Pryor' slender wheatgrass, was the only species/variety to show any negative response to herbicide application with a reduction in germination in 2018. However, even with the reduction, it still had 80% germination which was better than some species and could be acceptable in a seed production system.

Control of annual grasses leads to reduced competition pressure on desirable perennial grasses and is likely why positive impacts were observed in 2018. Negative impacts to the perennial grasses observed in the first growing season after herbicide applications can be attributed to the impacts of glyphosate on established species if application occurs after dormancy has been broken. While data from 2018 allows us to assume most negative impacts in the first year were from glyphosate, it is not possible to separate impacts of either chemical in year one. Subsequent growing season impacts can be attributed to indaziflam impacts since glyphosate does not have a residual time. Data collection from the second growing season has allowed us to begin identifying impacts of indaziflam on seed production and germination of established species and future work will further increase that knowledge as the chemical breaks down.

Acknowledgments
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Keywords: indaziflam, perennial grass, seed production

PARP: III:5, 7, 11

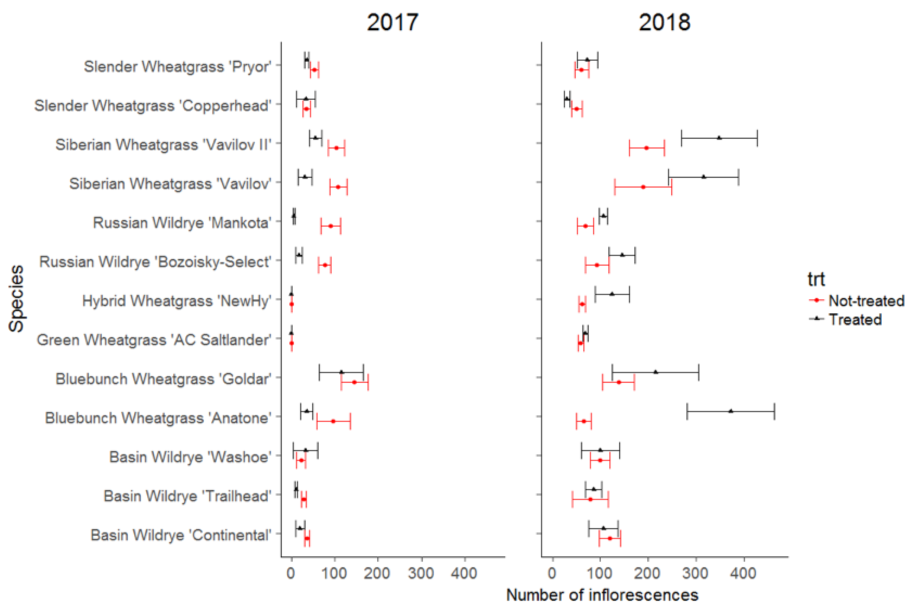

Figure 1. *Total number of grass inflorescences across 14 plant materials (species) from 2017 and 2018 by herbicide treatment (mean +/- se). Glyphosate (420 g ai/ha) and indaziflam (73 g ai/ha) were applied March 27, 2017.*

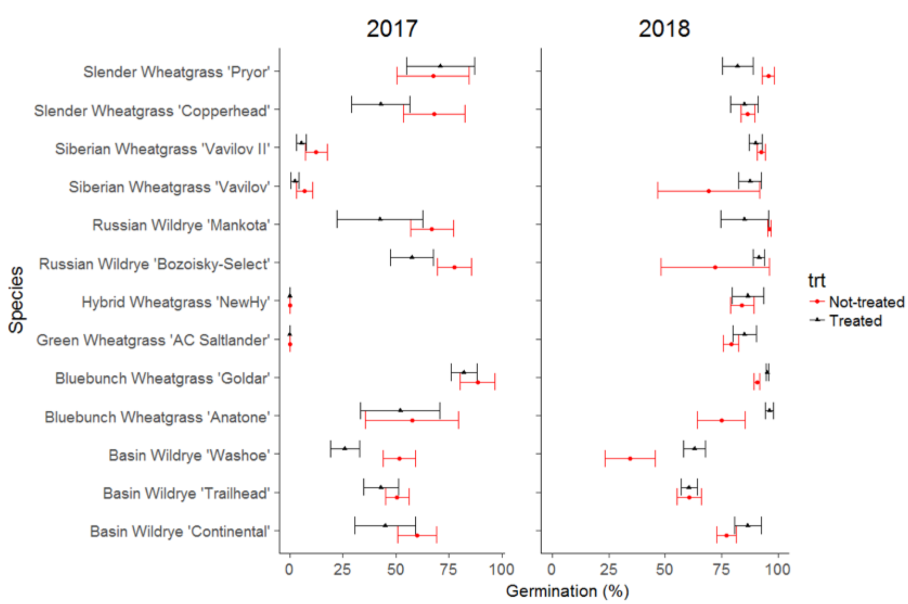

Figure 2. *Cumulative seed germination (4 replicates, 50 seeds per rep) across 14 plant materials (species) from 2017 and 2018 by herbicide treatment (mean +/- se). Glyphosate (420 g ai/ha) and indaziflam (73 g ai/ha) were applied March 27, 2017.*

Effects of ventenata removal on rangelands of northeast Wyoming

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Introduction

Invasive annual grasses have invaded vast areas in the western United States and are a major concern for conservation efforts. In Wyoming and the Great Plains, there are two newly documented species: ventenata (*Ventenata dubia* (Leers) Coss.) and medusahead (*Taeniatherum caput-medusae* (L.) Nevski). These species reduce forage availability and biodiversity, may increase erosion, and accelerate fire cycles in the intermountain west (Hilken and Miller 1980; Washington State Noxious Weed Control Board 2016), but little is known about their biology and ecology in the northern mixedgrass prairie of the Great Plains.

Objectives

Currently, there are landscape scale control efforts by the Northeast Wyoming Invasive Grasses Working Group (NEWIGWG) to contain, control, and eradicate these species from northeast Wyoming. To inform these control efforts, we asked several questions centered around the effects of ventenata removal after herbicide application: How effective were herbicide treatments? Did perennial grasses recover as a result of control? What is the forage quality of invasive grasses compared to perennial grasses? And what is the community level response to ventenata removal?

Materials and Methods

To answer these questions, we sampled sites treated by NEWIGWG paired with adjacent non-treated sites. Treated sites were sprayed aerially with 123 g·ha-1 each of imazapic plus aminopyralid (47 L·ha-1 total solution) in fall of 2016 or 2017 in Sheridan County, WY. We placed three 15.24 m (50 ft) transects, each with three 0.25 m^2 sub-plots, within each block. Along each transect, we conducted a line-point intercept at 0.31 m (1 ft) intervals. In each sub-plot, we collected and sorted all above-ground biomass into the following functional groups: annual grass, annual forbs, perennial grass, and perennial forbs. Each of these groups was dried and weighed before being sent to a lab and analyzed for crude protein and total digestible nutrients (TDN). Data were then pooled at the plot level and analyzed with paired t-tests.

Results and Discussion

Herbicide treatment successfully reduced annual grass biomass ($p=0.002$; Fig. 1) and reduced ventenata cover ($p=0.001$; Table 1). However, there was not an associated increase in perennial or total grass biomass (Fig. 1), which may be due to high variability in responses of perennial grasses. There was also no change in species richness to ventenata removal. The short time since ventenata removal may also explain the lack of response in the plant community and biomass of perennial grasses. There may not have been enough time following removal to allow perennial species to fully recover. However, cover of the most dominant perennial species, western wheatgrass (*Pascopyrum smithii* (Rydb.) Á. Löve) increased ($p=0.04$; Table 1), showing that there was some improvement. Unfortunately, ventenata was observed reestablishing in older treatments (those that had been treated two year prior). This means that full recovery of species richness and perennial forage should not be expected at these sites.

Nutrition analysis of samples showed that perennial grasses have higher crude protein and TDN than annual grasses ($p<0.05$; Table 2). However, this higher nutritional content was not reflected in the amount of crude protein and TDN per acre (Table 1). This may be due to high variability in biomass of perennial grasses. Although there was not a significant difference in the amount of these nutrients between treated and non-treated sites, these nutrients are not necessarily available to cattle or wildlife since ventenata is highly unpalatable.

Acknowledgments

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Keywords: ventenata, forage production, conservation, weed management

PARP: III.7,11; VI.3

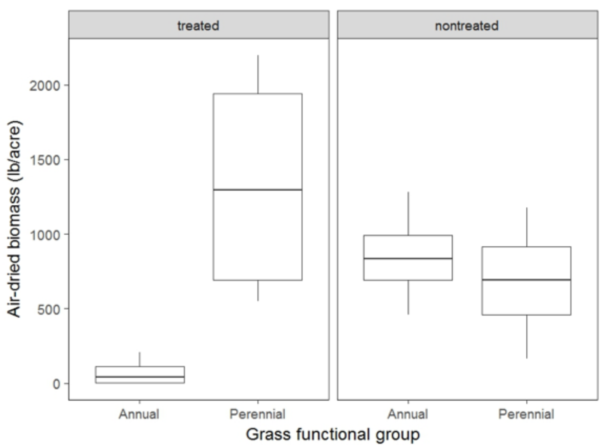

Figure 1. *Mean grass biomass by herbicide treatment in a ventenata-invaded rangeland in northeast Wyoming. Annual grass biomass decreased (p=0.002) while perennial and total grass biomass did not change.*

Table 1. Mean biomass, crude protein, total digestible nutrients (TDN), and cover of ventenata, western wheatgrass, and bare ground by herbicide treatment in northeast Wyoming. Standard error is in parenthesis. Significant findings are bolded ($p<0.05$). *Animal unit month per acre (AUM·ac-1) based on 50% use assuming equal use of annual and perennial grasses.

Treatment (n)	Biomass ($lb\cdot ac^{-1}$)	Available $AUM\cdot ac^{-1}$*	Crude Protein ($lb\cdot ac^{-1}$)	TDN ($lb\cdot ac^{-1}$)	Ventenata Cover (%)	Western Wheatgrass Cover (%)	Bare Ground (%)
Non-treated (5)	1566.3 (274)	0.98 (0.17)	92.4 (17.0)	852.2 (150.9)	**33.8 (5.0)**	**30.8 (2.1)**	**9.0 (2.8)**
Treated (4)	2017.0 (696)	1.26 (0.44)	158.5 (44.5)	1374.5 (443.2)	**8.6 (2.2)**	**42.7 (4.9)**	**23.5 (4.0)**

Table 2. Crude protein and total digestible nutrients (TDN) of non-treated samples of perennial and annual grasses collected July 2018 in Sheridan County, WY. Standard error is in parenthesis. Means between annual and perennial grasses differed for both crude protein and TDN ($p<0.001$).

Functional Group (n)	Crude Protein (%)	TDN (%)
Perennial (5)	**6.84 (0.20)**	**59.32 (0.57)**
Annual (5)	**5.16 (0.32)**	**50.68 (1.01)**

Perennial cool-season grasses under irrigation for hay production and fall grazing

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Introduction

Perennial cool-season grasses comprise nearly 25% of hay field acreage in northeast Wyoming. The most popular grasses used for hay production under irrigation in this region has been smooth or meadow brome. Although these two grasses are productive with good stand persistence, they generally reach anthesis, optimum stage for hay harvest, by mid-June most years in northern Wyoming. For operations with significant acreage this could result in some of the hay being lower in quality than what a lactating beef cow or sheep ewe requires due to the maturity of the grasses at harvest. Likewise, small hay operations dependent upon custom harvesters can have their fields harvested when these grasses are at a later maturity than desired. The opportunity to select perennial cool-season grasses with varying maturity dates could benefit hay producers in being able to furnish good quality hay for their own livestock as well as to their clients.

Objectives

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

Materials and Methods

Perennial cool-season introduced grasses seeded in September 2014 underwent harvests over a three year period to assess their hay yields and regrowth forage yields. Hay harvests occurred on 16, 15, and 20 June in 2016, 2017, and 2018, respectively for 'Manchar' and 'Carlton' smooth brome, 'Paddock' and 'MacBeth' meadow brome, 'Latar' and 'Profile' orchard, and 'Fawn' and 'Texoma MaxQ II' tall fescue; and on 30 June in 2016 and 2017, and on 5 July in 2018 for, 'Luna' and 'Manska' pubescent wheatgrass, 'Oahe' and 'Rush' intermediate wheatgrass, and 'Climax' and 'Tuukka' timothy. Desired stage of maturity for harvest was post-flowering to visible seed development. Regrowth of the grasses underwent a harvest on 10 October 2016, 28 September 2017, and 2 October 2018. The plot area received 150 pounds per acre of nitrogen in November 2015, and in April 2017 and 2018. In addition, 30 and 50 pounds of phosphate was applied in November 2015 and April 2017, respectively.

Results and Discussion

The intermediate and pubescent wheatgrasses produced the most hay (4.4 T/ac), followed by the bromes, 'Latar' orchardgrass, 'Texoma MaxQ II' tall fescue, and 'Tuukka' timothy (3.4 T/ac) (see Table). The two-week harvest delay may have been a contributing factor for why the wheatgrasses produced an extra T/ac of hay each year but they were at the same phenological growth stage as the other grasses when harvested. 'Latar' orchardgrass produced the most regrowth forage among the grasses followed by 'Texoma MaxQ II' tall fescue and then 'Profile' orchardgrass (see Table). Regrowth of the grasses averaged 41% of their hay yields in 2016 but fell to 9.5% and 5.6% in 2017 and 2018, respectively. Furthermore, 2017 and 2018 regrowth yields were 25% and 13% of those in 2016, respectively. A plausible reason for the dramatically lower regrowth yields in 2017 and 2018 compared to 2016 was the amount of moisture (precipitation + irrigation) the plots received in August to the day before harvest. The amounts were 14.0, 7.6, and 7.0 inches in 2016, 2017, and 2018, respectively. We should have applied an additional 7.0 inches of water in 2017 and 2018. This would have especially been true for 2018 as mean daily temperatures averaged 7.6 degrees warmer compared to in 2016 and 2017 which were similar. (See 2017 and 2018 Field Days Bulletins for quality components).

Acknowledgments

We thank ShREC field crews for assistance in harvesting. Study was supported by Wyoming State Agriculture Producer Research Grant Program and UW Agricultural Experiment Station.

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Keywords: Cool season grasses, hay production, regrowth yields

PARP: I:2

Table 1. Hay yields (12% moisture) for the early summer harvests, and regrowth dry matter yields (12% moisture) for the early autumn harvest of the cool-season perennial grasses.

Grass	Variety	Hay yields (T/ac)				Regrowth yields (T/ac)			
		2016	2017	2018	Avg.	2016	2017	2018	Avg.
Smooth brome	Carlton	4.4 b	3.3 e	3.0 e	3.5 b	0.82 f	0.08 e	0.05 e	0.32 g
	Manchar	3.5 c	3.6 cd	2.8 e	3.7 b	1.48 cd	0.21 cde	0.12 de	0.60 de
Meadow brome	MacBeth	3.4 c	3.5 de	2.8 e	3.2 b	1.45 cde	0.43 b	0.16 cde	0.68 cd
	Paddock	4.4 b	3.5 de	2.5 f	3.5 b	1.18 def	0.33 bcd	0.20 cd	0.57 de
Orchard	Latar	2.4 d	3.8 bc	3.5 cd	3.2 b	1.78 abc	0.91 a	0.45 a	1.05 a
	Profile	1.6 e	3.3 e	2.5 f	2.4 c	1.59 bcd	0.49 b	0.37 ab	0.82 bc
Tall fescue	Fawn	1.4 e	3.5 de	3.0 e	1.9 d	1.58 bcd	0.34 bcd	0.27 bc	0.57 def
	Texoma MaxQIITM	2.8 cd	3.8 bc	2.9 e	3.2 b	2.13 a	0.47 b	0.28 bc	0.96 ab
Intermediate wheatgrass	Oahe	4.9 a	4.4 a	3.8 bc	4.3 a	1.48 cd	0.19 de	0.09 de	0.59 de
	Rush	4.8 a	4.4 a	4.0 ab	4.4 a	1.01 ef	0.23 cde	0.17 cde	0.47 efg
Pubescent wheatgrass	Luna	5.1 a	4.5 a	4.2 a	4.6 a	0.91 f	0.11 e	0.07 e	0.36 g
	Manska	4.8 a	4.6 a	3.7 c	4.4 a	1.23 def	0.16 de	0.08 de	0.49 efg
Timothy	Tuukka	2.2 d	4.0 b	3.7 c	3.2 b	1.98 ab	0.39 bc	0.12 de	0.38 fg
	Climax		3.0 f	3.6 cd	3.3 b		0.31 bcd	0.13 cde	0.22 h

Note: Column means followed by same letters do not differ at p<0.05.

Multi-year cheatgrass control a single herbicide application

Brian Mealor[1,2], Beth Fowers[1]
[1]Sheridan Research and Extension Center, [2]Department of Plant Sciences

Introduction

Although current chemical methods for controlling downy brome (aka cheatgrass/Bromus tectorum) are fairly effective, they require relatively frequent re-treatment to maintain cheatgrass suppression on infested sites. Some herbicides not previously used in rangeland settings may provide longer-term control with a single application. Additional tools for suppressing or controlling cheatgrass may improve the ability of ranchers, farmers, land managers, reclamation personnel, and others to restore cheatgrass-impacted rangelands while diminishing potential for developing herbicide-resistant cheatgrass populations by repeated applications of herbicides with the same mechanism of action.

Objectives

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

Materials and Methods

We applied seven herbicide mixtures at two different timings (March and April) in 2016 with a total volume of 20 gallons per acre with a CO_2-pressurized sprayer and a 10-foot boom with six 8002 nozzles. 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 LambientTM (1.2 oz/ac) and Plateau® (7 oz/ac) alone and combined; Esplanade 200 SC®(5 and 7 oz/ac) combined with Roundup WeatherMAX® (16 oz/ac) or combined with Olympus™ (1.2 oz/ac).

Applications on March 3 occurred with a 54°F air temperature, 38% relative humidity, 41°F soil temperature at 2 inches deep, and 5–8 mph wind. Cheatgrass on-site varied from the 1–3 leaf growth stage, and roughly half the plants were purple due to semi-dormancy from cold weather. Applications on April 21 occurred with a 60°F air temperature, 54% relative humidity, 48°F soil temperature at 2 inches deep, and 3 mph wind. Cheatgrass was 2–3 inches tall and actively growing. We visually evaluated cheatgrass control annually 2016-2019 by comparing to nontreated plots.

Results and Discussion

In the season of herbicide application (2016), all Roundup-containing treatments provided very good cheatgrass control (Fig. 1). Second- and third-year control was very good for all treatments containing Esplanade. In 2019, the fourth growing season after herbicide application, Esplanade at 7 oz/acre plus either Roundup or Olympus applied in April maintained near complete cheatgrass control. This longevity of control from a single treatment is outstanding.

Acknowledgments

Many thanks to ShREC team and summer interns over the past four years for contributing to data collection and to Bayer US for supporting this research.

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

Keywords: cheatgrass, weed management, invasive species

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

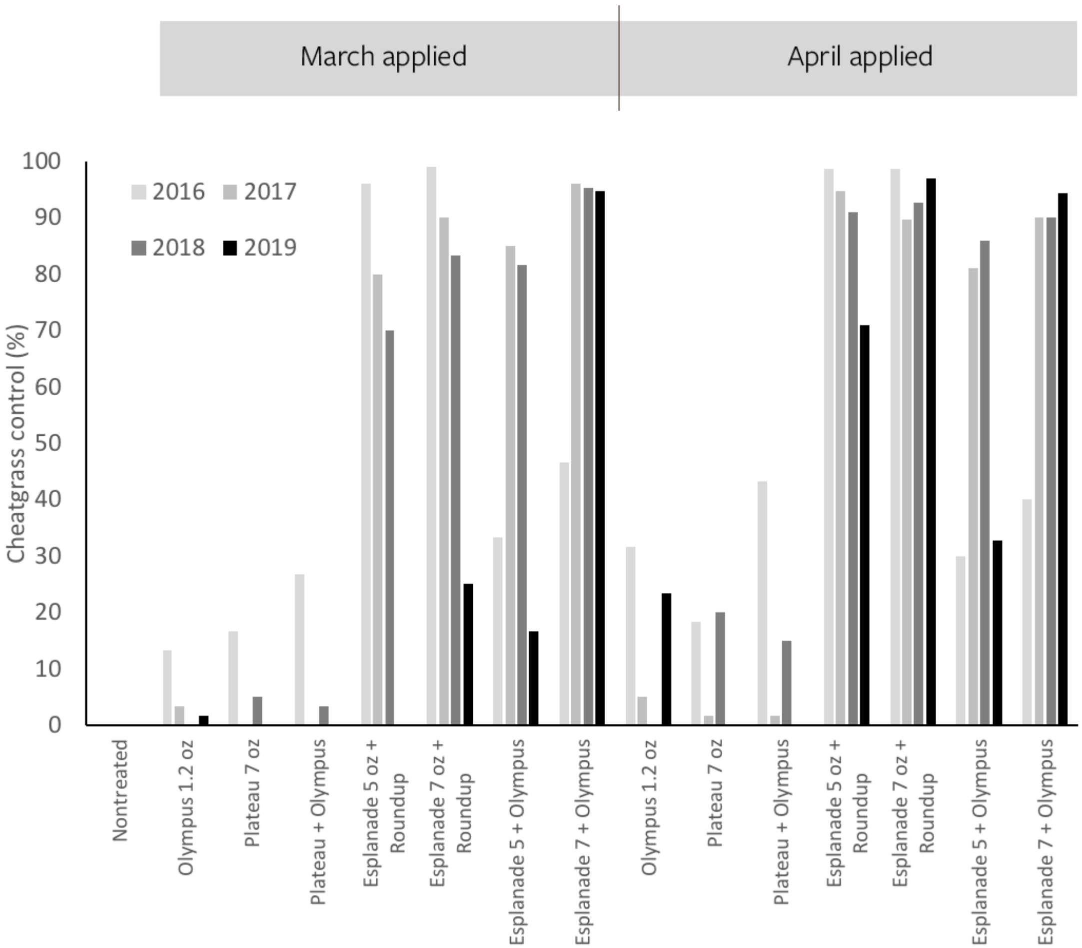

Figure 1. *Cheatgrass control (%) across multiple herbicide treatments applied in March or April 2016.*

Alfalfa weevil growing-degree day calculator part 2 – invalidation of the Harcourt 1981 model for Wyoming

Scott Schell[1], Jeremiah Vardiman[2], Blake Hauptman[3]
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[3]previously at UW Extension/now with Montana Livestock Ag Credit

Introduction

Alfalfa is a very important crop in Wyoming and alfalfa weevil (*Hypera postica*) is currently its worst insect pest. It is important to know when the best time to survey crop pest populations. Survey too early in the growing season and you are either wasting effort or obtaining false negative data. Survey too late and you may suffer a severe crop loss or miss the best pest stage for control.

Because alfalfa weevils start their damage inconspicuously, as tiny larvae feeding inside the tightly folded leaves of stem tips, it is useful to have tool to predict the best date to sample a crop in order to make management decisions. Plant and insect growth is correlated to environmental temperatures. Temperature data is now freely available online and can be used to predict pest and crop development.

D. Harcourt (1981) developed a growing degree-day (GDD) model based on the minimum known temperature for alfalfa weevil larval development in southern Ontario, Canada. It was found to be a useful predictor for alfalfa weevil seasonal occurrence in the Rocky Mountain region in the early 1990s. It has been made available as a web-based application that allows a user to get GDD outputs based on temperature data from weather stations closest to their alfalfa fields. However, the accuracy of the Harcourt GDD model had not been tested in Wyoming recently.

Objectives

We continued work on testing the accuracy of the now internet-based Harcourt GDD alfalfa weevil development calculator. If accurate, it will allow alfalfa producers to use their local weather station data to predict alfalfa weevil larval development.

Materials and Methods

Validation testing of the GDD calculator started in 2017 and was completed in 2018. We compared the Harcourt 1981 GDD model predictions of alfalfa weevil larval developmental stages available at https://pnwpest.org/cgi-bin/ddmodel.us to actual stages observed in pest population samples taken from producers' fields in the Bighorn, Washakie, Fremont, Campbell, Crook, and Sheridan counties over the course of 2 growing seasons.

Results and Discussion

The Harcourt 1981 alfalfa weevil GDD calculator did not accurately predict alfalfa weevil development. The 2017 and 2018 alfalfa weevil samples consistently contained larvae later in development than the model predicted. For example, the same field at the Powell Research and Extension Center had larvae over 200 degree days ahead of the model prediction in both 2017 and 2018.

It is doubtful that the base temperature of 48˚F to trigger alfalfa weevil development has changed to a lower temperature since 1981. We tried changing the parameters of the model to start on January 1 instead of March 1. This resulted in little change of GDD accumulations at the time of the sampling. This rules out milder winter weather allowing weevil egg to develop then.

One explanation for faster than predicted alfalfa weevil development is made by comparing what we have observed in the samples to what is reported about the pest from more eastern and lower elevation states. In states like Oklahoma, adult alfalfa weevil become active during mild fall weather and will deposit eggs in plant stems then. The eggs can then start accumulating

GDD (i.e. begin embryonic development) towards hatch. This quote from an Oklahoma State Univ. factsheet on alfalfa weevil may explain what we are now observing in Wyoming- "During fall, adults leave over-summering sites and enter alfalfa fields to feed and deposit eggs in stems of alfalfa plants. Egg deposition occurs from November to the following April when temperatures exceed 40°F." (Mulder P. 2017). It has been observed that the eggs may die in temperatures below 10°F during the winter if there is no snow cover to insulate them. The variability and the severity of the fall and winter weather greatly influences the timing alfalfa weevil populations in Oklahoma. If it is a severe winter, only adult alfalfa weevil survive it to start depositing eggs when temperature warm up. The Oklahoma State Extension service conducts alfalfa weevil egg surveys at 7 sites across the state in mid-February each year (Seuhs, K., 2019). In mild winter years, they can find viable egg densities of over 400 per square foot during the survey.

At this time, we recommend that Wyoming forage alfalfa producers sample their fields for alfalfa weevil starting when the crop is between 10 to 15 inches high with the bucket method as described in the "When and How to Scout" section of this 2018 extension bulletin from NDSU https://www.ag.ndsu.edu/publications/crops/integrated-pest-management-of-alfalfa-weevil-in-north-dakota. The sample alfalfa stem tips should be closely examined for the tiny first stage of alfalfa weevil. If damaging numbers of alfalfa weevil are found at this stage of alfalfa growth, all methods of control are available to the grower to use before harvest or extensive damage to the crop is done by the pest.

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

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

PARP: n/a

Relative competitive ability of bulbous bluegrass (*Poa bulbosa*) and cheatgrass (*Bromus tectorum*) with perennial grasses

Jordan Skovgard[1,2], Brian Mealor[1,3]
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Introduction
Bulbous bluegrass is an invasive cool season perennial that exists over much of Wyoming's rangelands. Bulbous bluegrass' invasive tendencies could have implications for desirable perennial vegetation. However, little is known about its ecology or its effect on grass species in areas where it has invaded.

Objectives
Our objective was to evaluate bulbous bluegrasses competitive ability compared to cheatgrass, a known competitor, when grown with perennial grasses.

Materials and Methods
This experiment was conducted in the Greenhouse at the Sheridan Research and extension center. We used a replacement series design where we planted different species at varying proportional densities with eight individuals in each ratio: 0:8, 2:6, 4:4, 6:2, 8:0. We used field soil for 6 replicates in this experiment. After 12 weeks we harvested aboveground biomass to calculate the relative yield of each species. Relative Yield (RY) compares the amount of biomass produced when grown with other species to biomass produced when grown alone, which standardizes the data and allows for comparison across different species (Fig.1).

Our target species were bulbous bluegrass and cheatgrass – both undesirable invasive grasses common in northeast Wyoming. Our desirable species were 4 native perennial grasses including western wheatgrass (*Pascopyrum smithii*), bluebunch wheatgrass (*Pseudoroegneria spicata*), bottlebrush squirreltail (*Elymus elymoides*), and Idaho fescue (*Festuca idahoensis*), and 1 introduced perennial grass - crested wheatgrass (*Agropyron cristatum*).

Results and Discussion
All desirable species were suppressed by the presence of cheatgrass on a species level and when pooled together, but bulbous bluegrass had varying impact based on the grass species it was grown with. Western wheatgrass, bottlebrush squirreltail, and crested wheatgrass were not suppressed by bulbous bluegrass presence. This may indicate they could be good species to plant on rangeland restoration or reclamation sites where bulbous bluegrass is prevalent. Poor competitive ability was displayed by bluebunch wheatgrass and Idaho fescue when grown with both cheatgrass and bulbous bluegrass.

Bulbous bluegrass exhibited a neutral impact on perennial grasses when they were pooled as a group (Fig. 2), indicating weak competitive interactions. Cheatgrass showed superior competitive ability when grown directly with bulbous bluegrass when testing their interaction. Although bulbous bluegrass does not have the same high competitive ability as cheatgrass it could potentially displace desirable perennial grasses depending on species composition and other factors (resource availability, disturbance).

Acknowledgments
We thank the ShREC team member for assistance and support in this project.

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Keywords: invasive weeds, native plants, competition, range management

PARP: III.5, VI.3

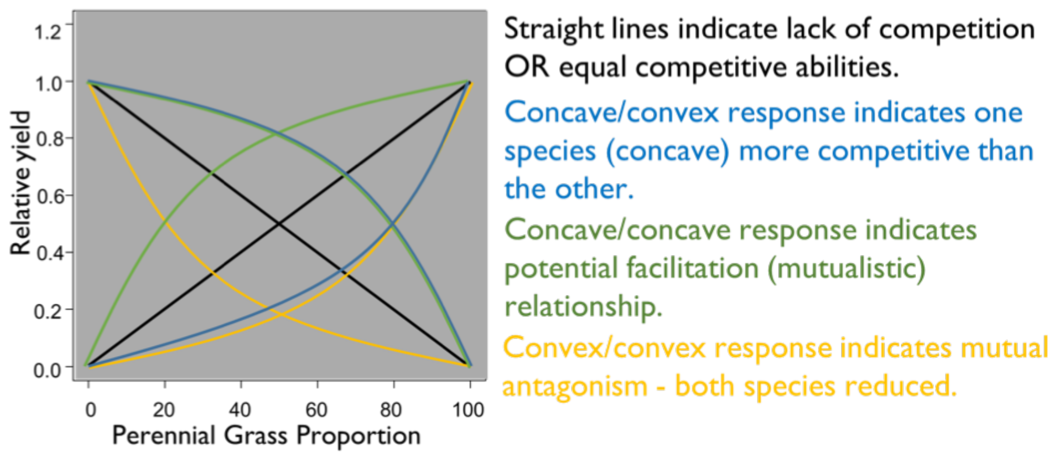

Figure 1. *Conceptual potential responses from our replacement series experimental design demonstrating interpretation of results.*

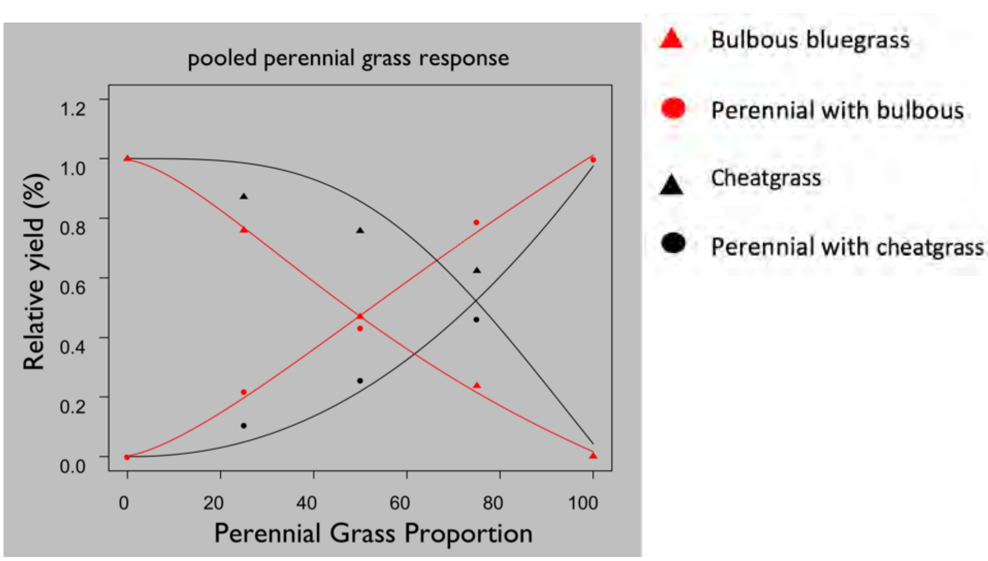

Figure 2. *Relative yield pooled for five perennial grass species with bulbous bluegrass and cheatgrass (downy brome) across 6 mixture/monoculture ratios. Lines are regression lines fit to raw data (6 replicates). Points are means for each ratio/species combination.*

Evaluating efficacy of various herbicides on bulbous bluegrass

Jordan Skovgard[1,2] Beth Fowers[1], Brian Mealor[1,3]
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Introduction

Bulbous bluegrass is an invasive cool season perennial that exists over much of Wyoming's rangelands. Although it has been present (and likely spreading) in Wyoming for many years, we know relatively little about its ecology and management in natural systems.

Identifying suitable chemical control options may be especially difficult for this species since removing a perennial grassy weed from a rangeland system primarily composed of desirable grass species requires selectivity through chemistry, rate, or timing.

Objectives

Our objective was to evaluate multiple herbicides for their efficacy in controlling bulbous bluegrass while maintaining desirable vegetation.

Materials and Methods

We established randomized complete block field experiments at two locations (Sheridan and Rozet, Wyoming) in April 2018. We applied 11 residual herbicide treatments crossed with and without 10 oz/acre Roundup Weathermax® to 10 x 30 foot plots in four replicates at each site. Roundup was applied to 1/3 of each plot following the other herbicide applications.

We collected posttreatment data 30 days after treatment (30 DAT) and 1 year after treatment (1 YAT). Data collected include plant canopy cover by species and visual control for bulbous bluegrass and injury for desirable species. We only present control data from Sheridan in this bulletin due to space limitations.

Results and Discussion

Within-season bulbous bluegrass control (30 DAT) was very good for all treatments when Roundup was included in the treatment (Figure 1). All herbicides except Esplanade at 5 and 7 oz/acre exceeded 90% control in the first season.

By 2019 (1 YAT), the direct effects of Roundup had deteriorated (Fig 1; "Check – Roundup = N"), and bulbous bluegrass control was not distinguishable from the nontreated check. All other treatments except Esplanade (5 and 7 oz) and Plateau still provided excellent control 1 YAT (Fig. 1). Desirable perennial plant injury (primarily crested wheatgrass at this site) was greatest for treatments containing Landmark XP (data not shown).

Acknowledgments

We thank the ShREC team member for assistance and support in this project.

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Keywords: invasive weeds, native plants, competition, range management

PARP: III.5, VI.3

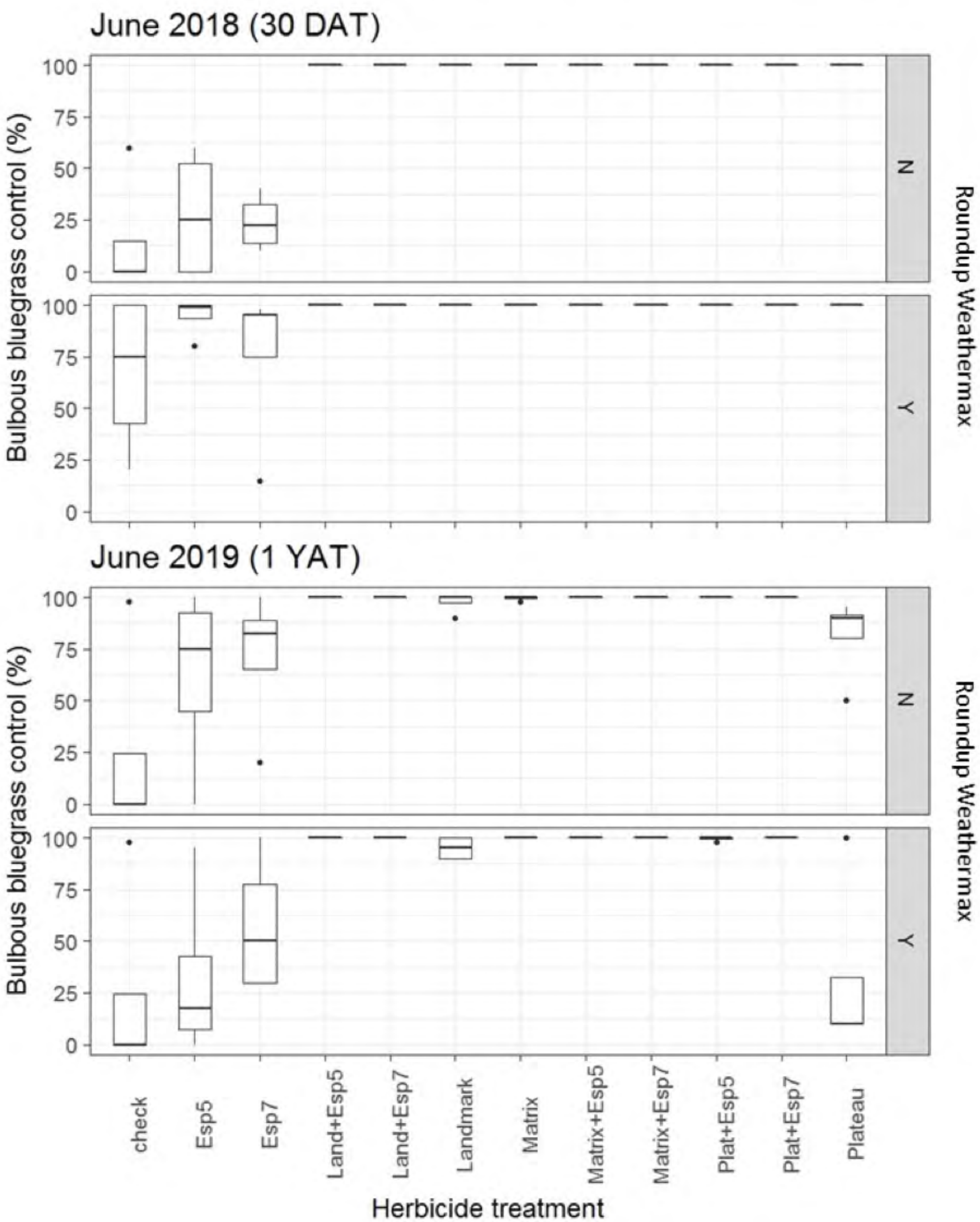

Figure 1. *Boxplots of bulbous bluegrass control 30 days (30 DAT) and one year (1 YAT) after treatment for 11 herbicides crossed with and without Roundup Weathermax® herbicide applied in April 2018. Treatments include Esplanade (5 and 7 oz/acre), Landmark (1.3 oz/acre), Matrix (3 oz/acre), Plateau (7 oz/acre) and the combinations of each with Esplanade.*

Production and forage quality of alfalfa varieties in Sheridan 2018

Daniel Smith[1], Beth Fowers[1], Brian Mealor[1,2]
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Introduction

Alfalfa is one of the most important agricultural crops grown in Wyoming and is of particular interest for both cattle and hay producers in the northeastern portion of the state. Prolific breeding programs have resulted in multiple varieties specifically bred to do well under local conditions. While many producers grow alfalfa, direct comparisons of commercially available varieties in our area have not been common.

Objectives

The objective of this study was to evaluate commercially available alfalfa varieties for forage production and quality in a demonstration setting.

Materials and Methods

In Spring of 2017, we seeded six commercially available alfalfa varieties (Nexgrow “6497R” and “6427R,” Croplan “Graze-n-Hay 3.10 RR,” “RR Tonnica” and “HVX Driver,” and Genuity “4R-416”) at 15 lb/acre into a non-irrigated field in Sheridan, WY. We planted each variety into a single, non-replicated strip approximately ½ acre in size. Soils on the site are a Wyarno clay loam that receives some natural subirrigation due to slope position of the field.

We collected yield data from three subplots of each strip at each harvest event in 2018. We evaluated forage quality for each variety and cutting and report crude protein, total digestible nutrients, and relative feed value in this report. The climatic year was such that a third small cutting was collected in September.

Results and Discussion

Since this was a non-replicated demonstration planting, within-plot averages are presented for each variety. Yields ranged from 4.4-5.23 tons/acre among the varieties, with Geunity “4R-416” providing the highest yield (Table 1). Yield from the first two harvest dates, which would be the normal harvest in most years, was over 4 tons per acre for Croplan “Graze-n-Hay 3.10 RR,” “RR Tonnica,” and Genuity “4R-416.”

Forage quality data from all varieties was very good, especially for the second and third cuttings (Table 1). We plan to expand variety comparisons and evaluations in Sheridan in future years.

Acknowledgments

We thank our cooperators who provided alfalfa seed for the trial and the ShREC field crew for collecting and processing samples.

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Keywords: forage production, hay quality, plant varieties

PARP: VII.6

Table 1. Dry matter yield and forage quality characteristics for 6 alfalfa varieties on dryland in Sheridan, WY.

Cultivar	2018 Hay Harvest at Sheridan Research and Extension Center			
	1st (6/6/18)	2nd (8/9/18)	3rd (9/10/18)	Total Yield/Mean Quality
Nexgrow “6497R”				
dry matter yield (ton/ac)	2.36	1.17	0.84	4.37
crude protein (%)	17.6	24.5	23.4	21.83
total digestible nutrients (%)	59.5	68.5	68.4	65.47
relative feed value (RFV)	119.9	201.8	191.9	171.20
Croplan “Graze-n-Hay 3.10 RR”				
dry matter yield (ton/ac)	2.70	1.56	0.66	4.92
crude protein (%)	19.7	23.5	24.9	22.70
total digestible nutrients (%)	62.9	67.9	69.6	66.80
relative feed value (RFV)	141.2	189.9	208.7	179.93
Nexgrow “6427R”				
dry matter yield (ton/ac)	2.42	1.39	0.84	4.65
crude protein (%)	18.9	23.9	24.3	22.37
total digestible nutrients (%)	61.1	67.1	68.6	65.60
relative feed value (RFV)	129.4	183.7	192.9	168.67
Croplan “HVX Driver”				
dry matter yield (ton/ac)	2.50	1.43	0.79	4.73
crude protein (%)	19.5	23.6	23.7	22.27
total digestible nutrients (%)	61.9	67.5	68.1	65.83
relative feed value (RFV)	134.6	184.4	187.9	168.97
Genuity “4R-416”				
dry matter yield (ton/ac)	2.82	1.66	0.79	5.26
crude protein (%)	19.2	22.2	24.9	22.10
total digestible nutrients (%)	61.5	66.5	69.8	65.93
relative feed value (RFV)	132.9	175.7	211.1	173.23
Croplan “RR Tonnica”				
dry matter yield (ton/ac)	2.76	1.39	0.78	4.93
crude protein (%)	24.4	23.2	18.5	22.03
total digestible nutrients (%)	67.9	67.3	60.1	65.10
relative feed value (RFV)	191.7	183.6	127.3	167.53

Nitrogen requirements of ancient grains in Wyoming

Caitlin Youngquist, Carrie Eberle, Thomas Foulke, Mark Sorrells, Steve Zwinger

Introduction

The state of Wyoming is a challenging place to farm due to low soil fertility and quality, saline and alkaline soils, arid conditions, high crop evapotranspiration demands, and isolation from markets. The soil, climate, geographical, and sociopolitical conditions have historically limited crop diversity and adoption of more common sustainable farming practices like low input alternative crops, reduced tillage, cover crops, and water conservation.

Goal

This project will study the nitrogen and water demands of ancient grains (spelt, emmer, and einkorn), evaluate crop performance in three growing regions of the state, and assess the impact of growing conditions on grain quality.

Objectives

1. Identify best practices for growing einkorn, emmer, and spelt in Wyoming.
2. Communicate best practices for growing einkorn, emmer, and spelt grain in Wyoming.

Expected Impacts

Results of the study will provide recommendations of ancient grains best adapted for growing regions and optimal nitrogen requirements for crop production. Final publications will be completed in the spring of 2021.

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Keywords: ancient grains, Neolithic, Wyoming First Grains, spelt, emmer, einkorn

PARP: I.2, I.19, IX.10, IX.11

Bulbous bluegrass stand demographics

Jordan Skovgard, Brian Mealor

Introduction

Bulbous bluegrass (*Poa bulbosa*) is an invasive, weak perennial grass that occurs over much of Wyoming. This grass produces bulblets rather than seeds - a trait shared by few other species. Although this plant has existed in our local systems historically, little is known about its population dynamics.

Goal

To learn more about the reproductive strategy of invasive bulbous bluegrass.

Objectives

Our objective with this experiment is to determine which proportion of a population regenerates from mature adult plants versus what proportion of the population results from bulblets overwintering in the soil.

Expected Impacts

Summer of 2019 will be the first data collection for this experiment. We will learn about basic reproductive biology in our region, which will inform management practices for trying to control bulbous bluegrass.

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Keywords: invasive grass, weed management, plant biology

PARP: III.5, VI.3

Estimating the potential economic benefits from using genomic testing to improve feed efficiency

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Introduction

Feed inputs comprise one of the largest operational cost categories for beef production both for cow-calf ranches and feedlots. Thus, the economic sustainability of the beef industry can be positively impacted by improving feed efficiency. Genomic testing could be used to select beef animals with increased feed efficiency. As such this management tool offers the potential for economic improvement across the beef supply chain.

Objective

A number of factors impacting feed efficiency have been investigated, but little research has been reported related to the economics associated with genomic testing and its potential to improve feed efficiency. Hence, our research objective is to evaluate the potential economic impact of improving feed efficiency for cow-calf operations, feedlots and for the beef sector as a whole, using genomic testing to improve selection of efficient animals.

Materials and Methods

We use existing data from cattle feeding experiments conducted at SAREC to motivate our analyses. We conduct firm level budget analyses to estimate the potential economic improvement associated with increasing feed efficiency across both cow-calf and feedlot operations. These firm level analyses are then used in an Equilibrium Displacement Model (EDM) to estimate the overall potential economic gains associated with improved feed efficiency in the U.S. beef sector.

To measure the potential feed efficiency improvement we utilized data from feeding experiments at SAREC. We examined the available data and assumed that the bottom half of the SAREC sample was replaced with animals performing as animals in the top half. The range in feed intake per pound of gain for the sample was 4.32 to 10.18 pounds on a dry matter basis. When the bottom half was replaced by the top half of the sample, the new sample of cattle ate approximately 87% of the amount of feed the original sample did to achieve the same amount of weight gain overall. We also assumed this improvement in feed efficiency for animals placed in feedlots would likely come from genetic selection occurring in the cow-calf sector. Thus, our analyses assumed a 13% reduction in feed intake for both our cow-calf and feedlot budget analyses. It should be recognized that data are not available for cow-calf ranches related to genomic testing and possible feed efficiency gains at this time, and feed efficiency gains in commercial cow-calf herds could be different than this. For our national estimate of economic gains from improved feed efficiency, research on adoption of beef production technology suggests only operators with herd sizes of more than 100 cows utilize improved reproduction technologies. Thus, we assume only operators with a herd size of 100 or more cows will apply genomics testing to improve feed efficiency for our national EDM beef sector analysis.

Results and Discussion

Cow-calf Operations: We analyzed ranches with 200 head versus 521 head and analyzed economic benefits from improved feed efficiency that came from cost savings of reduced feed alone, and also from using a reduction in feed per animal to grow the herd, i.e., run more animals with same total amount of feed. According to the first scenario, feed cost savings alone, for the operation with 200 cows, estimated benefit would be approximately $1 per head by the end of year 7. As time passes the benefits increase and after 10 years the benefit would be $36 per head ($/hd). Feed cost savings alone for the 521 cow herd size operation, indicates producers would receive $14/hd by the end of year 7, and after 10 years the benefit would total $55/hd. If ranches chose to increase herd sizes, cow-calf producers with 200 head herd size would receive negative net benefits of -$31/hd with increased cow herd size of 25 head by year 7. Again, as time passes net benefits increase, and by year 10, indicated improvement is $36 per head. Results for operations with beginning herd size of 521 head indicate cow-calf producers would receive a positive benefit of $6/hd by the end of year 7 and after 10 years the total benefit would be $99/hd. It is interesting to note that for producers who have a shorter planning horizon (less than 10 years) regarding management of their operation, they may be better off to not increase herd size and just take improved profits from reduced costs from feed savings. In fact these results suggest that given the assumptions in our analysis, this investment would not garner positive net benefits until after year seven for smaller operations. These results indicate that given operational practices and costs assumed in the budgets, larger operations may very well benefit more from improved feed efficiency than smaller operations.

Feedlots: Again we analyze two scenarios of reduced costs from feed savings versus increased number of head in the feedlot given improved feed efficiency of animals placed in the feedlot. According to the first scenario, feed cost savings without an increase in number of head in the feedlot, feedlot producers would receive a benefit of $76/hd by the end of year 9. The benefit after 12 years would total $124/hd. Our second scenario results indicate that feedlot producers would receive less net benefits in the shorter term with increased number of animals on feed. Total benefit is estimated at $66/hd after year 9 and $112/hd by year 12. Overall, the slightly lower benefit compared to cost savings on feed, for both ranches and feedlots, is driven by the lower profit margin per head received when expanding animal numbers compared to feed cost savings alone. A reduction in feed cost alone does not change other cost categories as total number of animals do not change, but net feed cost per head goes down.

Beef Sector: Our estimates indicate total net benefits could equal nearly $2.5 billion in year 9 alone, and the sum of the benefits for years 3 through 9 is nearly $12 billion. The share of estimated benefits accruing to the cow-calf and feedlot segments are 34% and 66%, respectively.

Acknowledgments: Funded by Wyoming Agricultural Experiment Station competitive grant

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Keywords: beef cattle, beef genomics testing, economic benefits

PARP: V.1, VII.7, VIII

Elder family financial exploitation

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Introduction

Adults 65 and older are expected to be approximately 22% of the population by 2040, up from 14.5% today and compared to only about 5% one hundred years ago. Unfortunately, as the aging population grows, so do opportunities to take advantage of this vulnerable group.

One common method of elder abuse is to misuse a power of attorney that has been granted by an elder. Granting a power of attorney gives a specific person power to make decisions for the elder intended for the benefit of the elder. Elder financial abuse occurs when someone makes actions to disadvantage the elderly person. We generally think of elder family financial exploitation (EFFE) as "the illegal or improper use of the funds, property, or assets of people 60 and older by family."

The stakes are high for this issue since the impacts go beyond lost assets and/or debts that may result, and may include withholding of medical care to "save" money; feelings of shame, embarrassment, loneliness, stress, betrayal; isolation; loss of autonomy, and an earlier death.

Objectives

This research seeks to understand elder financial exploitation within families. Its aim is to identify risk and protective factors that might increase or decrease the likelihood of EFFE occurring. This information can then be used to help families avoid problems before an older relative becomes dependent and the power structure in the family shifts.

Materials and Methods

The research is in two phases. In Phase 1 the research team at UW and at other institutions conducted initial exploratory interviews. The target was family members with elder and family-member power of attorney agents as alleged perpetrators in a financial exploitation situation. This phase is now complete.

In Phase 2 the project moved to use mixed methods and featured a survey (delivered online, by phone, and in person) targeting two populations: the first is family-members from families with no problems. The second was those who have alleged EFFE, with follow-up interviews (in person or by phone). At this point the research is ongoing, and some findings are still being studied. Research began August 2016 and will continue through 2020. Dissemination of results has begun.

Results and Discussion

Perpetrators of elder abuse, including those who misuse powers of attorney, often share common characteristics. Frequently they are family members. They may have a history of substance abuse, mental health issues, or financial problems. They may have a fear of being deprived of an inheritance should the victim spend all their savings on care, or they may have a sense of entitlement and often live off the victim. They may seek to isolate the victim from the community or other family members to have more control over them. Below is a list of factors that may make an elder more susceptible to abuse, and a list of factors that may contribute to a perpetrator's inclination to abuse a power of attorney.

Elder Risk Factors	Perpetrator Risk Factors
Increases with age, but depends on capacity	Addictive behaviors
Cognitive impairment	Relationship problems
Physical function impairment	Lack of empathy, egotism
Lower education	Pattern of blaming others, avoiding responsibility for own actions
Widowed	Controlling/manipulative behaviors
Isolation physically and/or emotionally	Lying or telling half truths
Weak self esteem	Ageist attitude, devaluing elderly people, especially women
Psychological distress, depression	Impulsiveness or self-control problems
Susceptibility to flattery and other means of undue influence	Lack of clearly defined goals or self-centered goals
Loneliness and/or low levels of social support	Identity tied to competitive values
Past experiences of domination/acquiescence	Self-esteem tied to possessions, prestige, status
Unreasonable/unfounded trust generally or in appointed agent(s)	Money management problems, financial instability
Past abuse/financial exploitation	Financial entitlement attitude possibly based on sense of earlier unfair treatment or indulgence
Addiction	
Inadequate planning for late-life dependency	
Lack of knowledge and experience with financial management	

A screening tool of risk factors for families is being developed, and also suggested best practices that can be used when granting a power of attorney.

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

PARP: IX

Managing landowner risk in environmental markets

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Introduction

Voluntary, market-based conservation programs can help land managers and regulators maintain and enhance environmental resources. One such program is a habitat exchange, where a landowner sells conservation "credits" to developers to offset a disturbance on the landscape. Landowner participation is voluntary, so price and contract terms must be sufficiently appealing to induce participation. But the risk that conservation practices do not maintain measurable habitat improvements for the length of time needed to offset the disturbance for which they have been purchased—credit failure risk—can be significant for landowners.

Objectives

Can policies be put in place to reduce this risk for landowners? We investigate effects of three different market characteristics on habitat exchange outcomes: 1) credit failure risk (described above); 2) market structure (spot delivery where sellers incur production costs prior to sale and lose costs on unsold or discounted production versus forward delivery where sellers have a contract in place before production occurs); and a reimbursement mechanism (where conservation credit buyers reimburse sellers for production costs of failed conservation).

Materials and Methods

Since many market-based conservation programs are still in development, real-world conservation credit transaction data is scarce. Research shows that people act similarly in this type of experiment as they do in real life, so laboratory experiments can help us understand how market-based conservation programs may work. We implement a laboratory market experiment to explore how credit failure risk and reimbursement might affect market efficiency, price, transaction volume, and buyer/seller earnings.

Participants are assigned to be either a seller or a buyer. Sellers are given a production cost and buyers a resale or redemption value for each credit available for them to trade. Participants trade in a fictitious currency called "tokens." Tokens are then converted to cash and paid to participants at the end of the experiment. Individual experimental payments depended on the decisions participants made while trading. These experimental markets are not designed to be completely realistic. Rather, they are designed to isolate the key components of environmental markets, to help us understand how market-based conservation programs operate.

Results and Discussion

Findings suggest these three market characteristics (credit failure risk, spot versus forward delivery, reimbursement mechanism) do affect market outcomes. Risk sharing allows market-based conservation programs to operate more efficiently despite the unavoidable presence of credit failure risk. Our results show the importance of implementing risk-sharing mechanisms in market-based conservation programs for market success and improved outcomes for conservation as well as landowners and developers.

Credit failure risk. Credit quantities traded, credit price, total earnings, and seller earnings all drop dramatically when a market contains credit failure risk. Figure 1 demonstrates this dynamic for total earnings by comparing predicted total earnings for forward delivery markets with no credit failure risk (1200 tokens in leftmost column) and with credit failure risk (700 tokens second column). Total earnings is the sum of all participants' earnings within a market. It represents how efficient a market-based conservation program is. If total earnings are low, buyers and sellers are dissuaded from participating and trading in the market-based conservation program, harming how efficiently the market generates conservation, and therefore, earnings.

Comparing predicted market outcomes to actual ones. Credit failure risk has an even larger impact on market outcomes than one would think simply by calculating predicted outcomes based on the information used by buyers and sellers to make their trading decisions. There is a behavioral element to human decision-making that causes us to act differently in the presence of risk. Figure 1 again demonstrates this dynamic for total earnings. Earnings drop not just to 700 tokens, as predicted (second column), but all the way to 488 tokens (third column).

Reimbursement mechanism. Having buyers reimburse sellers for production costs on failed credits reverses these negative results. Quantities traded, credit price, and total earnings rebound to near the expected levels for a market with no credit failure risk. Total earnings rebound from 488 tokens (third column) to 648 tokens (fourth column) with the addition of reimbursement. Sellers no longer incur costs on failed credits, keeping prices lower and promoting higher trade volume. This increased volume generates more earnings for participants in total.

Acknowledgments: Thanks Rick Matza for technical assistance. The study is supported by the Center for Behavioral and Experimental Agri-Environmental Research.

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Keywords: conservation markets, experimental economics, market risk

PARP: VII.5, IX.7, XII

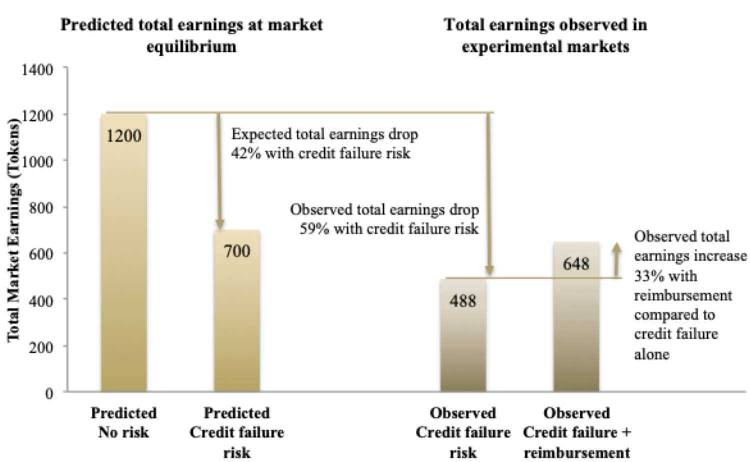

Figure 1. *Total earnings in four experimental treatments, all with spot (not forward) delivery.*

Farm-level economic assessment of alternative groundwater management strategies over the High Plains aquifer in southeastern Wyoming

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Introduction

The eastern half of Laramie County in southeastern Wyoming depends heavily on the Ogallala Aquifer for water, particularly for agricultural use. As is the case across the aquifer, withdrawal rates in this area are higher than recharge rates, causing significant drops in groundwater levels. In 2014, the Laramie County Commissioners convened a steering committee of groundwater users to discuss what – if anything – should be done about the declining aquifer levels. A big question was whether the communities want to stabilize the aquifer at current levels, allow but manage aquifer decline, or recover groundwater to an earlier level. Not knowing the economic impacts of the different proposed goals and strategies was one hurdle the steering committee faced in answering this question.

Objectives

We estimate the farm-level economic impacts of alternative strategies for reducing overall water use, including 1) Allocation, which would restrict irrigators to pumping only a specified number of acre-inches each irrigation season (Nebraska already enforces allocations in several districts across the state); and 2) Buyout, which would ask irrigators to voluntarily relinquish their water rights on some irrigated acres in exchange for a payment (this type of program existed in Laramie County from 2010 to 2015).

Materials and Methods

We use a farm-level dynamic optimization model to determine the potential economic impacts of these two alternative groundwater management strategies (allocation and buyout) relative to a baseline scenario, in which no active strategy is undertaken to maintain or recover aquifer levels. We assume farmers respond to reduced water supplies by either irrigating the same crops with less water, switching to crops that use less water, or switching to dryland farming. The model has economic (optimal crop mixes on five representative farms), hydrologic (dynamic relationships between groundwater use and saturated thickness, depth to water levels, and well pumping capacity), and agronomic (relationships between water application levels and crop yields) components. Figure 1 indicates approximate representative farm locations.

Results and Discussion

We report changes in economic returns over variable costs, water withdrawn, and depth to water for all strategies on an annual basis over a 40-year study period. Outcomes for each management strategy varies for each of the five representative farms, due to local differences in aquifer levels and recharge profiles. Results indicate the trade-off users face between using water today versus conserving it for the future.

Allocation. For farms already feeling the effects of aquifer depletion – maybe as reduced pumping capacity – the economic impacts of an allocation strategy are lower because their farming system is already well-adapted for limited water. Representative farms in this situation experience minimal reduction in water use (between 0 and 6%) and returns over variable costs (between 0 and 7%) relative to a baseline scenario. In contrast, farms not yet feeling the effects of aquifer declines – those currently able to fully irrigate on all of their pivots – would experience larger economic impacts from an allocation strategy. Representative farms in this situation experience more significant reduction in water use (between 20 and 32%) and returns over variable costs (between 11 and 21%) for an allocation of 12 acre-inches applied water per year, relative to a baseline scenario of no action. The more hydrology varies within a community, the more difficult to choose one management strategy that benefits – or at least does not harm – all water users in a community.

Buyout. If an external source of funding is found to support a buyout program, economic returns and water conservation outcomes can both be positive. Buyout price is based on our estimate of the difference in net returns over variable costs between irrigated and dryland crops in the region. Representative farms convert between 40% and 60% of acres more from irrigated production to dryland rotation relative to the baseline by the end of the 40-year study period. This results in between 0 and 32% increased water conservation relative to the baseline. Economic and hydrologic benefits of a buyout program also depend on whether pivots near those enrolled in the program are restricted to historical consumptive use. If there is no restriction, economic benefits to remaining pivots are higher, but hydrologic benefits are lower.

Model results depend upon strong hydrology assumptions; more realistic hydrologic studies are needed to make the economic results more realistic. Further, community-level impacts of alternative management strategies (on for example county-level employment and income levels) have not yet been estimated. Results are nonetheless a first step towards understanding the economic tradeoffs associated with using water today versus conserving it for the future.

Acknowledgments: Thanks to area producers and the Laramie County Conservation District for assistance. The study is supported by the UW Water Research Program.

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Keywords: groundwater management, irrigation economics, High Plains aquifer

PARP: VII.7, IX.1, IX.2

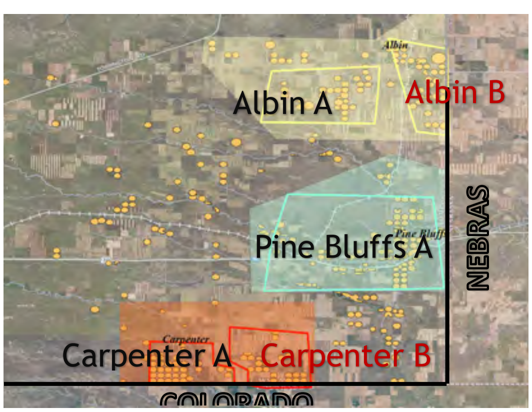

Figure 1. Representative farms (red font indicates less favorable hydrology).

Comparing cattle nutritional plane to forage quality to determine mineral intake and deficiencies.

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Introduction

Knowing nutritional status of range beef cattle through the year can assist ranchers in their decision making regarding grazing management and supplementation practices. With proper nutrient management they could potentially see an increase in livestock pregnancy rates, be able to shorten the breeding/calving seasons, and increase weaning weights due to birth of more robust calves and/or improved milk quality of the cows leading to heavier calf weaning weights.

Objectives

(1) Obtain crude protein and net energy intake estimates for three cow herds using NIRS analysis of their fecal matter and assess if their annual requirements were being met; (2) obtain crude protein and net energy content of human-sampled range forage and assess how similar results are obtained by NIRS analysis of cattle fecal matter; and (3) obtain macro and trace mineral contents of the forage and evaluate if a correction factor in potential intake is needed.

Materials and Methods

The project was conducted at two cooperator ranches: Ranch1 in Johnson County, and Ranch2 near the Johnson/Natrona County line. Ranch2 splits their cows into two herds June–December: One herd on foothill pastures of the southern Bighorns and the other on pastures along the Red Wall. They are combined January–May. Both ranches calve from early April to late May. Fresh fecal matter was collected every four to six weeks from the cow herds for three years (Jul 2015–Oct 2018). The samples underwent Near-Infra-Red Spectrometry (NIRS) analysis by the Grazing Animal Nutrition (GAN) Lab of Texas A&M University to assess dietary intake of crude protein and digestible organic matter (DOM). From DOM values, Total Digestible Nutrients (TDN) and Net Energy for maintenance (NEm) amounts were calculated. In conjunction with fecal sampling, range grasses and grass-like plants were sampled from various areas of the pastures. Plants sampled were of species that the cattle appeared to be utilizing, the five most common being western wheatgrass, needle-and-thread, green needlegrass, bluebunch wheatgrass, prairie Junegrass, and threadleaf sedge. These six plants accounted for 89% of all that were sampled. The plant samples were sent to the Soil, Water, and Forage Lab of Texas A&M University and analyzed for their crude protein, acid detergent fiber (ADF), calcium, phosphorus, potassium, magnesium, sulfur, iron, manganese, zinc, and copper contents. From ADF values TDN and NEm values were calculated.

Results and Discussion

NIRS analysis of the cows' fecal matter indicated that the rangeland forage provided them an adequate amount of crude protein in May and June (early lactation) but not during mid-lactation (Jul–Aug) and late lactation (Sep–Oct) when it averaged 1.7% and 2.5% below their needs, respectively. Once calves were weaned (late Oct/early Nov) dietary protein was generally adequate until mid-December. Thereafter until May dietary protein was below their needs by an average of 3.6%. Crude protein content of all hand-sampled rangeland grasses and grass-like plants averaged 6.3% compared to 6.6% obtained from NIRS analysis of beef cow fecal matter. Plant crude protein content averaged 9% higher April through September compared to that in the cows' diet. This was possibly due to only new growth being clipped by hand whereas it is feasible that the cows consumed some old growth along with new. From October through March plant crude protein content averaged 30% lower than that in the cows' diet. Apparently during the dormant season the cows selected a higher quality diet compared to what plants were selected for hand sampling.

Dietary NEm was sufficient throughout the year, except in February and March 2016 and 2018 at Ranch1 averaging about 0.40 Mcal/lb. below the cows' requirement. The reason for this low intake of NEm was probably due to the very low level of crude protein in their diet (< 4.50%). Low levels of dietary protein, especially the degradable portion, results in rumen microbes not being able to fully degrade the fiber in forages and as a result not all available NEm in the forage is utilized by them and in turn the cow. In addition, this causes the forage to remain in the rumen for a longer period before it passes to the abomasum and out the intestines, restricting forage intake by the cow. During July and August if cow body condition drops to a score of 5.0 or lower, furnishing a protein supplement could be warranted. Provision of a protein supplement is generally needed December through late April. NEm content of the hand-sampled plants averaged 87% of the amount measured from NIRS fecal analysis (0.58 Mcal/lb. vs. 0.66 Mcal/lb.) and was never greater than what was reported to be in the cows' diet.

NIRS analysis of beef cow fecal matter to assess cows' dietary crude protein and energy intake appears to be reliable. Use of adjustment factors to increase the potential amount of minerals consumed by cows during the dormant season and decrease the amount during the growing season would not be warranted. This is a positive outcome as it would be easier to base mineral supplements directly on laboratory analysis of the forage instead of trying to adjust as to whether the cows' intake of minerals was higher or lower. Although a more in-depth examination still needs to be conducted with regard to how mineral levels compare among the grasses and grass-like plants, based on the similarities in their crude protein and NEm contents, ranchers can hand-sample grasses, sedges, and rushes they think their cattle are consuming and combine them for quality analysis. If forbs are a significant component in their cattle's diet they would probably want to have them analyzed separately.

Acknowledgments

We thank our cooperating ranchers for allowing us to conduct this study at their ranches, and the Wyoming Department of Agriculture for financial support.

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Keywords: beef cow nutrition, rangeland forage quality

PARP: V.5.; V.7

Herbicide and grazing effects on floral resources and pollinator communities

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Introduction

Dalmatian toadflax *Linaria dalmatica* is a very competitive perennial invasive weed species. It is self-incompatible and must be cross-pollinated; long-tongued bumble bees are the primary pollinators along with other large bees. Honeybees and short-tongued bumble bees also use Dalmatian toadflax as a nectar resource. Invasive plants can provide floral resources and influence pollinator abundance, diversity, and behavior, as well as gain from the interaction through propagation and persistence. Through competition for pollinators, invasive plants may reduce visitation to native flowers. Pollinator visitation patterns on spotted knapweed differed over the growing season, and it provided ample resources to late season pollinators. Spotted knapweed displaced native plant species and may have indirectly harmed pollinators active before the knapweed bloom or pollinators that preferred native plants. Weed management can affect available floral resources and pollinator dynamics across landscapes. Early and late season livestock grazing in high-elevation grasslands have been shown to decrease arthropod densities.

Objectives

Our goal is to examine how grazing and herbicide management strategies targeting Dalmatian toadflax impacts floral blooms and pollinator insects.

Materials and Methods

Experimental Design: Conducted at F.E. Warren Air Force Base (Cheyenne, WY) in a heavily invaded grassland. Treatments were herbicide, sheep grazing, control, and herbicide with sheep grazing. These were replicated four times in 1.2 acre plots across the site, using randomized complete blocks. Chlorsulfuron 75 was applied in fall 2017 and sheep grazed each summer 2016-2018 for 1-2 weeks during peak bloom. Sample collection was timed around Dalmatian toadflax bloom, with 3 sampling efforts: pre-peak bloom, peak bloom, and post-peak bloom. Teams of two to four people took two days to observe and sample for each sampling effort.

Timed Observations: In each plot, 4 timed observations were made per 55m transect for 3 minutes 40 seconds each to observe and count insects visiting open bloom flowers along transect. The types of pollinator observed (bumble bee, other native bee, honey bee, fly, wasp, beetle, etc.) and the common name of the flower species the pollinator was on (toadflax, globemallow, etc.) were recorded.

Bloom Counts: Bloom counts were conducted in the same 4 strips as the observations. All open blooms within the 1m x 15m strip were recorded by counting the number of open blooms per species of plant.

Results and Discussion

Dalmatian toadflax comprised roughly 3/4 of the total open blooms, followed by yellow sweet clover, scarlet globemallow, and Western tansymustard. Chlorsulfuron 75 application reduced bloom density of Dalmatian toadflax (Figure 1) as well as native forb species. Impacts of grazing on bloom densities were highly variable compared to herbicide treatments.

Bumble bees and other native bees both utilized Dalmatian toadflax as a floral resource; where Dalmatian toadflax and yellow sweet clover were the only species observed with bumble bee visitation (Figure 2).

A weed management plan that also aims to conserve pollinator resources will need to include a strong restoration plan in order to maintain biodiversity. Grazing has a less severe impact on bloom resources compared to herbicide treatments. Subplots in each replicate were reseeded with native forbs to determine whether there are treatment differences in restoration success. We will continue to monitor this site for this part of the project. There are approximately 4,000 species of bees native to North America and future goals include identifying the bees captured in bee bowls at the site. The 2019 field season will focus on observing visitors to Dalmatian toadflax specifically.

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Keywords: pollinators, invasive weeds, bees

PARP: I.1., I.10.

Figure 1. *Dalmatian toadflax bloom density according to experimental treatments.*

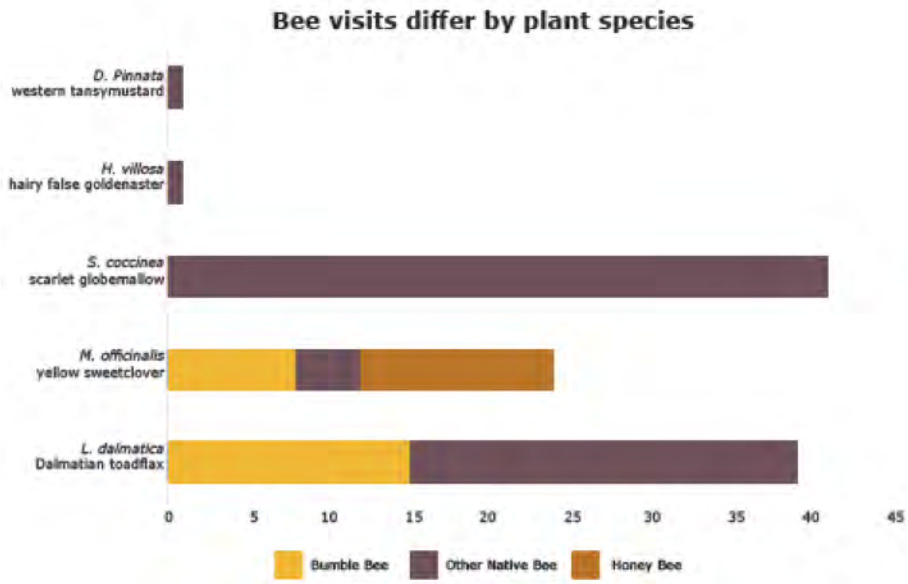

Figure 2. *These plant species comprise the top 98% of all open blooms counted in the experiment.*

Deployment of GPS collars on Wyoming beef cattle: Ranch-scale demonstrations

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Introduction

Managing and understanding livestock distribution has been a persistent challenge for ranchers, rangeland managers, and researchers. New technology in the form of tracking collars have been commonly used over the last few decades, particularly for livestock and wildlife research, but have not been used widely on private ranches with privately owned cattle. Specifically, these tracking collars use GPS (Global Positioning System) and/or VHF (Very High Frequency) signals to remotely quantify animal locations through space and time. Researchers have used this information to better understand (1) cattle response to salt, water, and nutritional supplements (Bailey et al. 2001; Ganskopp 2001); (2) cattle distribution across dry landscapes and use of wetter areas (Larson et al. 2017); and (3) travel distances relative to pasture size (McGavin et al. 2018). Such technology and associated information could be of great assistance to ranchers on working ranches, particularly Wyoming ranchers who operate in complex rangeland environments with variable seasonal and topographical influences.

Objectives

The purpose of our study is to demonstrate GPS tracking technology to Wyoming working ranches and to answer questions about animal distribution across seasons or relative to fencing and water.

Materials and Methods

We placed collars on beef cows on two ranches in Wyoming in 2018 near Dubois, WY (EA; 5 total cows in 1 group) and Sheridan, WY (Padlock; 40 total cows across 4 groups) (Figure 1). Approval for animal use was approved by the University of Wyoming Institutional Animal Care and Use Committee (IACUC) approval 20180529DS00309 and 20181114DS00329. Cattle were fitted with Vectronic (Berlin, Germany) GPS-enabled and satellite accessible neck collars with aid of a commercial head gate and squeeze chute during regular working procedures (i.e., spring branding or fall pregnancy checking). The use of a head gate and squeeze chute is necessary to ensure the safety of both the cattle and human handlers and is part of normal fall working procedures for cattle. On the EA, collars were placed on cows in spring 2018 and removed in fall 2018 and will be placed on cows in a similar time-frame in 2019. On the Padlock, collars were placed on cows in fall 2018 and will stay on cows for 2 years. Collars were set to record GPS fixes every 2 hours.

Results and Discussion

On the EA, we are assessing summer seasonal grazing in different pastures and relative to fencing and water distribution (Figure 1a). Specifically, cattle are managed in the Basin Pasture and the Mountain Pasture (Figure 1a). We will be geo-referencing water locations and will run more sophisticated analyses regarding how cattle are using steeper slopes and areas farther from water and then will determine what type of management, such as placement of salt or other supplement, could optimize cattle distribution on the landscape. On the Padlock, we are assessing grazing across seasons and management units. Data presented here show winter cow GPS locations from one of the management units (Figure 1b). As we move through the spring, summer, and fall, we will compare how cow movement changes due to seasonal changes and then predict bottlenecks from topography or nutritional challenges in this complex landscape.

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Keywords: animal distribution, grazing management, livestock production, rangeland

PARP: I:19, VI:3, VI:5, VI:6, IX:3

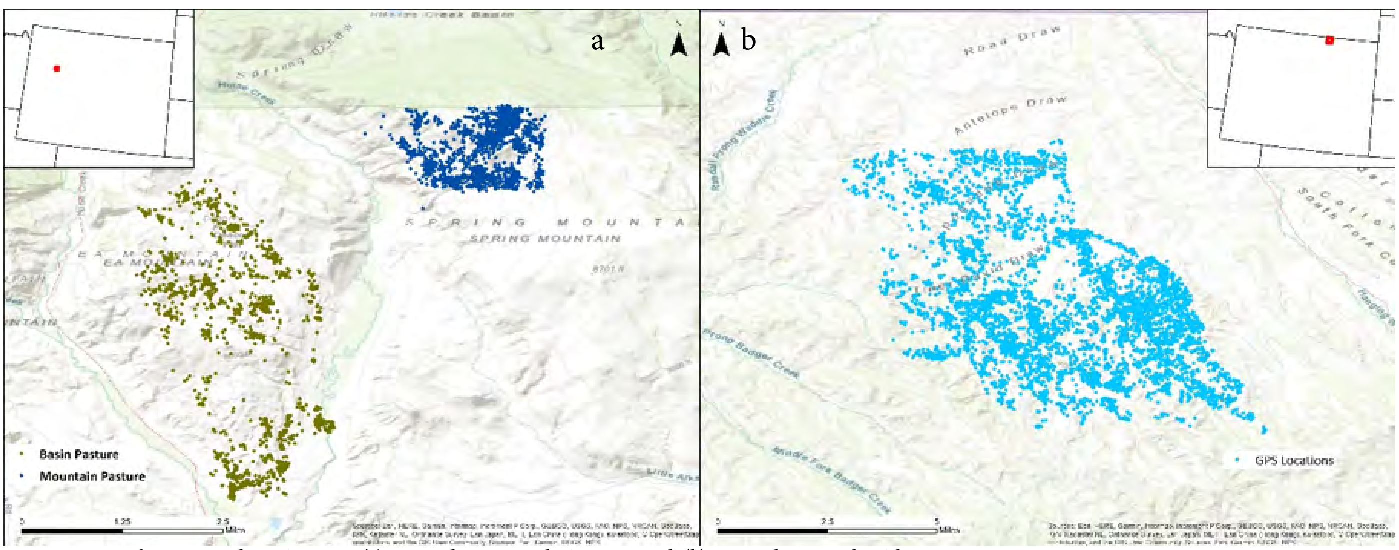

Figure 1. *Beef cow GPS locations on (a) a ranch near Dubois, WY and (b) a ranch near Sheridan, WY.*

Comparing feral horse management in the US to Australia and New Zealand

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Introduction

Feral horses are a complex socio-ecological issue in the United States (US), Australia (AU), and New Zealand (NZ) (Table 1). In all three countries, native horses either went extinct ~10,000 years ago or were never present. However, reintroductions by colonial explorers has led to burgeoning horse populations that are threatening the ecological integrity of the rangelands in these countries. Management of horses in all three countries due to negative ecological impacts is very difficult for four social reasons: (1) the role of horses in each country's national heritage (and in some cases the subsequent federal protections), (2) the intense level of emotion and public outcry against any management (and in some cases against specific management options), (3) the vast and harsh landscapes on which these horses roam are often inaccessible, and (4) the economic burden of unmanaged horses is significant (predicted to exceed $1 billion annually in the US by 2030 unless management changes).

Objectives

My objectives were to: (1) meet with a University rep, a provincial or federal government rep, and an advocacy group rep in AU and NZ, (2) compare and contrast the feral horse issue in the western US (with a Wyoming focus) to the large and extensive feral horse population in New South Wales, AU, and to the small and confined feral horse population on the North Island of NZ, (3) summarize ecological concerns and unique management approaches within the social construct of each country, and (4) synthesize the similarities and differences for US, AU, and NZ feral horse management in an essay type of paper for publication.

Materials and Methods

I convened an international exchange funded through the University of Wyoming's (UW) Agricultural Experiment Station through the "Global Perspectives Grants" program. The exchange allowed me to meet with University researchers, provincial/federal government managers, students, trainers, and advocates in AU and NZ in April of 2018. While in NZ I was able to attend the annual gathering and removal of Kaimanawa horses and while in AU I toured through Kosciuszko National Park which has a variety of ecosystems including alpine, forest, and grasslands and many horses (Figure 1). The field portion of this project, coupled with conversations in the US, allowed for first-hand assessments of horses in all three countries through conversations with > 100 individuals across countries to allow for the comparison and contrasting of feral horse issues in the western US (in a high-desert region with Wyoming as the center) to the large and extensive feral horse population in New South Wales, AU (in mountainous alpine areas) and to the small and confined feral horse population on the North Island of NZ (in high-elevation grassy plateaus and steppe-like areas). Notes from each visit quantified and qualified consistent and unique/emergent themes within the social construct of each country. These themes were then synthesized into broad categories of 'Social', 'Horse Biology', and 'Ecological' and stratified as consistent (i.e., identified in all three countries) or unique (i.e., identified in only one country). Additional data sources included field observations and archival documents.

Results and Discussion

Eleven emergent themes were consistently identified in all three countries, including the following: strong public emotion about horses, politicization of management has challenged action, population growth concerns, negative ecological impact concerns on both plants and wildlife, agreement that horses should be treated humanely, disagreement as to what practices were the most humane, interest and skepticism that fertility control is feasible in the extensive landscapes that horses inhabit, the need for transparency across all stakeholders and management actions, compromise to accommodating horses and acknowledgment of social values, and recognition that collaboration is the only means to achieve both healthy rangelands and healthy horses. One interesting theme unique to NZ was how they empower advocate groups to become part of the solution by running the adoption and rehoming program. This project confirms that the difficulty of managing horses in these countries is attributable to social intricacies rather than biological/ ecological gaps of knowledge.

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PARP: VI.3, VI.4, VI.5, VI.9, X.4

Table 1. *Comparison of free-roaming horse characteristics for Australia, New Zealand, and the USA.*

Characteristic	Australia	New Zealand	United States of America
Population estimate	~ 400,000 hd	< 800 hd	~ 200,000 hd
Government Protection	No	Yes	Yes
Oversight	Variable	Federal, Private	Federal Government
Native?	No	No	Yes, Extinct ~10,000 years
Introduction/ Reintroduced	1788	1814	1493

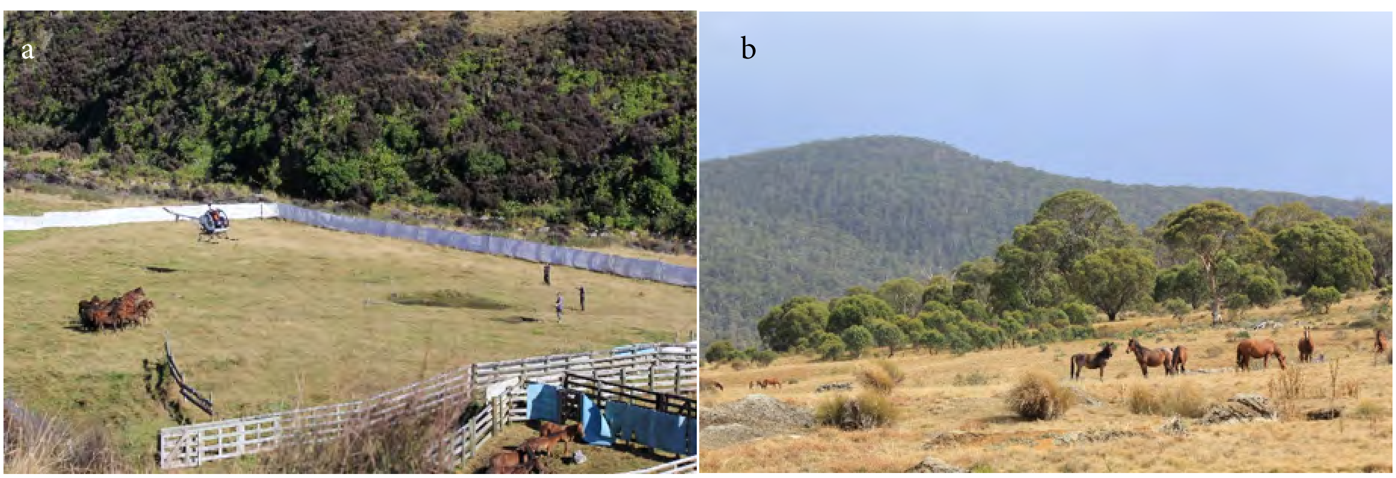

Figure 1. *(a) Kaimanawa horses (feral horses), Waiouru Army Base, North Island, New Zealand and (b) Australian brumbies in Kosciuszko National Park, New South Wales, Australia.*

Statewide assessment of cattle diets using fecal DNA metabarcoding technology

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Introduction

Understanding what cattle are eating is important for rancher decision-making to optimize animal nutrition, to predict outcomes of grazing management decisions, and to identify important plant species to guide management. Unfortunately, quantifying diet composition has been difficult in extensive and complex rangeland environments because (1) animals can be difficult to locate, (2) different plants break down at different rates in the rumen, and (3) identification of plants from bites, the rumen, or fecal material is complex and subject to error (Garnick et al. 2018). Early techniques used direct observation of animal bite counts, more invasive methods used surgical stomach analysis or rumen and esophageal fistulation, and more recent techniques used non-invasive post-digestive techniques such as fecal microhistology and near-infrared reflectance spectroscopy (NIRS). Each of these techniques has a number of problems. For bite counts, plant identification skills are required, animals must be located, and only a single animal is observed at a time. Additionally, determining the exact location of bites and plants consumed from a distance can be difficult and prone to observer error. For surgical techniques, plant material may be chewed/digested beyond recognition, sample size is small, methods are time intensive, and problems can arise from surgical procedures. For fecal microhistology and NIRS, plant material in the feces may not be proportional to that consumed by the animal, trained observers are required, turnaround on sample analyses is slow, bias and errors can be high, and accurate identification at the species-level has been problematic. Reconstruction of diet botanical composition using fecal samples with DNA (fDNA) metabarcoding is a new technology that has recently become available and could overcome many of the difficulties described above (Garnick et al. 2018). fDNA has many advantages including non-invasivity, large sample sizes, and numerous DNA sequences assessed at a single time reducing sample turnaround time. Recent applications have quantified dietary niches among African herbivores, diet fluctuations for bison, and quantified geographical patterns of cattle diets in North America. However, many questions about the utility of fDNA for rancher decision-making persist.

Objectives

To quantify cattle diets on working ranches in Wyoming using fecal DNA metabarcoding to assess dominant plant species and plant functional groups.

Materials and Methods

We invited ranches across Wyoming to participate in this study in the summer of 2017 through the network of county-based Extension educators. Funding for the study was obtained from a Western SARE (Sustainable Agriculture Research & Education) graduate student grant [GW17-059 - Cattle Diets and Performance: Enhancing What We Know with Advanced Plant DNA Technology]. A total of 33 ranches participated in the project with 31 ranches in Wyoming (across 20 different counties) and 2 ranches in western Nebraska (Figure 1a). Fecal samples were mostly taken in June, July, and August. A few samples occurred in September and May. Individual fecal samples were pooled by herd and then frozen. Frozen samples were then thawed and subsampled for analyses at a commercial laboratory for DNA metabarcoding analysis (Jonah Ventures, Boulder, CO). The laboratory procedures extract chloroplast DNA from fecal samples and then trnL c and h primers for PCR amplification. Each of the clustered gene sequences are assigned an

Operational Taxonomic Unit (OTU) number that is referenced to a library of gene sequences. If a sequence was not in the library, the BLAST nucleotide was employed with a 97% base pair matching minimum criteria.

Results and Discussion

Across all ranches, cool-season grasses were the dominant plant functional group in cattle diets comprising 59% of the dietary protein composition (Figure 1b). Forbs, or flowering plants that are also referred to as weeds, were the second most dominant plant functional group in cattle diets at 27%. Shrubs and woody plants were the third most dominant plant functional group in cattle diets at 9.7%. Legumes and warm-season grasses were the least dominant plant functional groups in cattle diets at 2.7% and 1.5% respectively. The most common cool-season grasses were western wheatgrass (Pascopyrum smithii), cheatgrass (Bromus tectorum), and needle-and-thread grass (Hesperostipa comata). The most common forbs were in the Fallopia genus and the Comandra genus. Fallopia is generally lumped with Polygonum and includes species of buckwheat, knotweed, and bindweed. Comandra includes toadflax species. The most common shrubs and woody plants were in the Eriogonum genus (buckwheats) and Salix genus (willows). The most abundant warm season grasses were in the Sporobolus genus which includes dropseeds, alkali sacaton, and sandreed. The most abundant legume was in the Psoralidium genus which includes breadroot and scurfpea.

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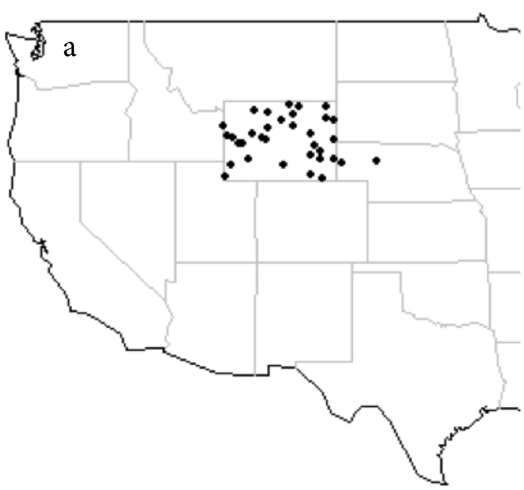

b

Functional Group	Diet % (avg)
Cool-season grass	59.0%
Forb (weed)	27.0%
Shrub/Woody plant	9.7%
Legume	2.7%
Warm-season grass	1.5%

Figure 1. *(a) Ranch locations participating in the statewide diet survey and (b) representation of plant functional groups in cattle diets across Wyoming in 2017.*

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