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College of Agriculture and Natural Resources
Wyoming Agricultural Experiment Station

# 2020 FIELD DAYS BULLETIN

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# Contents

**LARAMIE RESEARCH & EXTENSION CENTER (LREC) . . . . . 1**

Competitive Response of Perennial Grasses Against Cheatgrass when Grown in Different Soils. . . . . 1

Summary of Multi-Year Field and Greenhouse Experiments of Soil-Applied N on Dry Bean Grain Yield . . . . . 3

Summary of N-by-Genotype Interactions on Different Traits in Dry Bean . . . . . 5

Comparison of N Fertilizer Source on Dry Bean Growth and Yield. . . . . 8

Implications of Cow Nutrition during Late Gestation on the Developing Calf Gut Microbiome. . . . . 11

**POWELL RESEARCH & EXTENSION CENTER (PREC) . . . . . 14**

2019 Briess Barley Variety Performance Evaluation. . . . . 14

2019 Elite Malt Barley Variety Performance Evaluation . . . . . 16

2019 Western Regional Spring Barley Nursery Performance Evaluation . . . . . 18

Wyoming First Grains Project . . . . . 20

Wyoming First Grains Project: Effect of Location, Irrigation and Nitrogen on Crop Growth, Yield, and Quality of Ancient Grains of Wheat in Wyoming. . . . . 22

2019 Grain Corn Hybrid Trial, Powell, Wyoming . . . . . 24

2019 SIMPLOT Silage Corn Hybrid Trial, Powell, Wyoming . . . . . 26

Annual Forages Following Barley in Sugarbeet-Barley Cropping Systems. . . . . 28

2019 Dry Bean Performance Evaluation . . . . . 30

Response of Six Recombinant Inbred Dry Bean Lines and Released Cultivars to Withholding N and P . . . . . 32

Impact of Maturation Stage and Pod Color at Harvest on Popping Percentage of Popping Bean Lines of *Phaseolus vulgaris* . . . . 35

Dry Bean Soil-Borne Disease Management with an Integrated Approach with Tillage, Variety, and In-Furrow Fungicides at PREC. . . . . 38

Alfalfa Variety Trial. . . . . 40

Micronutrient Use in Sugar Beets . . . . . 41

**JAMES C. HAGEMAN SUSTAINABLE AGRICULTURE RESEARCH & EXTENSION CENTER (SAREC) . . . . . . 42**

Evaluation of Roundup Ready Alfalfa for Adaptability on Wyoming Conditions . . . . . 42

Evaluating Alfalfa Cultivars for Adaptability and Forage Yield Production Under Wyoming's Conditions . . . . . 44

Potassium, Cultivar, and Harvest Management for Improved Alfalfa Production . . . . . 46

Response of Alfalfa to Phosphorus and Potassium in Association with Calcium, Magnesium, and Harvest Management . . . . . 48

Response of Alfalfa to Sulphur and Boron Fertilization . . . . . 49

Insecticide Timing Effects on Pest and Beneficial Insects in Alfalfa . . . . . 51

Establishment of Cool-Season Perennial Grasses and Legumes in Disturbed Environments . . . . . 52

Sunn Hemp Biomass Accumulation and Feed Value in South Eastern Wyoming . . . . . 54

Dry Bean Soil-Borne Disease Management with an Integrated Approach with Tillage, Variety, and In-Furrow Fungicides at SAREC . . . . . 57

Managing Root Diseases of Beans with In-Furrow and Foliar Fungicides . . . . . 59

Cooperative Dry Bean Nursery (CDBN) Report – SAREC Lingle 2019 . . . . . 61

In-Furrow Fungicide Application to Manage Rhizoctonia Root and Crown Rot in Sugar Beet . . . . . 64

Management of Cercospora Leaf Spot in Sugar Beet with Foliar Fungicide Applications . . . . . 66

Sugar Beet and Corn Response to Biological Soil Amendments .68
Intensive Irrigated Forage Rotation Compared to Corn on Corn. 71
Cover Crop Suitability for Dryland Winter Wheat (*Triticum aestivum*)-Fallow in Semi-arid Region: Water Use and Competition with Weedy Species 73
Wyoming First Grain Project: Effect of Location, Irrigation and Nitrogen on Crop Growth, Yield, and Quality of Ancient Grains of Wheat in Wyoming. .76
Improving Dryland Winter Wheat (*Triticum aestivum* L.) Performance by the Inclusion of Composted Cattle Manure and Cover Crops .79
Management of Potato Early Blight with Foliar Fungicide Programs .82
Management of Potato Early Dying Syndrome with In-Furrow Fungicide/Nematicides and Foliar Fungicide Combinations .84

**SHERIDAN RESEARCH & EXTENSION CENTER (ShREC) .86**

Growth Regulator Effects on Ventenata Seed Viability. .86
Efficacy of Various Herbicides on Whitetop .88
Influences of Seeding Rate, Timing, and Depth on Green Needlegrass Establishment 90
Cheatgrass Control by Application of Herbicides at Various Timings .92
Herbicide Control of Ventenata at Different Application Times 94
Does Annual Grass Invasion Affect Rangeland Drought Resistance? 96
Comparing Establishment Methods Among Difficult to Produce Native Plant Materials 99
Comparing Establishment Methods for Native Plant Material Production Success 101
Influence of Seeding Depth on Native Species Establishment in the Presence of Indaziflam .103
Perennial Cool-Season Grasses under Irrigation for Hay Production and Fall Grazing .106
Effects of Ventenata Removal on Rangelands of Northeast Wyoming. .108
Wyoming First Grains Project: Effect of Location, Irrigation and Nitrogen on Crop Growth, Yield, and Quality of Ancient Grains of Wheat in Wyoming. 110

**OFF-STATION .112**

Impacts of Gardening Practices on Plant-Available Lead, Cadmium, and Iron in Soil. 112

**WYOMING PRODUCTION AGRICULTURE RESEARCH PRIORITIES—UPDATED JUNE 2018 .115**

# Competitive Response of Perennial Grasses Against Cheatgrass when Grown in Different Soils

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## Introduction

Revegetation attempts in the semi-arid region are negatively affected due to competition from cheatgrass, an annual invasive species. Both native and introduced grass species recommended for the revegetation purpose are based mainly on competition studies conducted under field conditions. Identifying competitive response of desirable species (e.g., ability of plants to resist suppression by surrounding neighbors) can contribute to effective establishment of desirable species in the areas invaded with invasive species. Understanding the competition dynamics in different soil conditions is also crucial as establishment of desirable species is largely dependent on soil nutrient conditions.

## Objectives

Compare the competitive ability of native and introduced perennial grasses when grown with cheatgrass in different soils.

## Materials and Methods

The experiment was conducted at the Laramie Research & Extension Center (LREC) greenhouse complex in fall of 2019. Competition of perennial grass with cheatgrass was tested in simple pairwise mixtures. The grasses were grown in soil collected from three different sites (irrigated pasture, dryland pasture, and degraded ranch). Soils of irrigated pasture had high organic matter compared to dryland pasture and degraded ranch. Basin wildrye, crested wheatgrass, and tall fescue were grown either in monoculture or in 50:50 mixture with cheatgrass in soil from each source. There were six plants in each treatment and the treatments were replicated five times. The pots were arranged in completely randomized design and the plants were grown for six weeks. The study was repeated twice (Study 1 and Study 2).

## Results and Discussion

Soil source had a significant effect on total dry weight of all perennial grasses in both studies. Total dry weight of perennial grasses grown in irrigated soil ranged 0.4-1.4 g plant$^{-1}$, while it was 0.1-0.5 g plant$^{-1}$ in disturbed ranch soil (Figure 1). Total dry weight of basin wildrye was significantly lower in the presence of cheatgrass in irrigated soil. The results from the study showed that resource availability for plants influence traits such as biomass. The perennial grasses grown in soil with higher nutrient availability had higher dry weight. However, the proportional loss of dry weight due to competition was also higher compared to plants grown in low nutrient soil. This could be due to higher growth of cheatgrass in high nutrient condition, which negatively affected growth of perennial grasses in those soil. On the other hand, the total dry weight of perennial grasses when grown with cheatgrass was indifferent in low nutrient condition. Overall, non-native grasses showed better competitive response against cheatgrass in nutrient poor condition while cheatgrass reduced growth of perennial grasses in high nutrient condition. When an adequate resource is available, cheatgrass had the greatest capacity to capture the resources suppressing its surrounding vegetation. However, this simplified competition study suggests that desirable species such as tall fescue and crested wheatgrass can compete with cheatgrass in nutrient poor soil conditions which could be a leverage in establishment of desirable species in nutrient poor degraded sites.

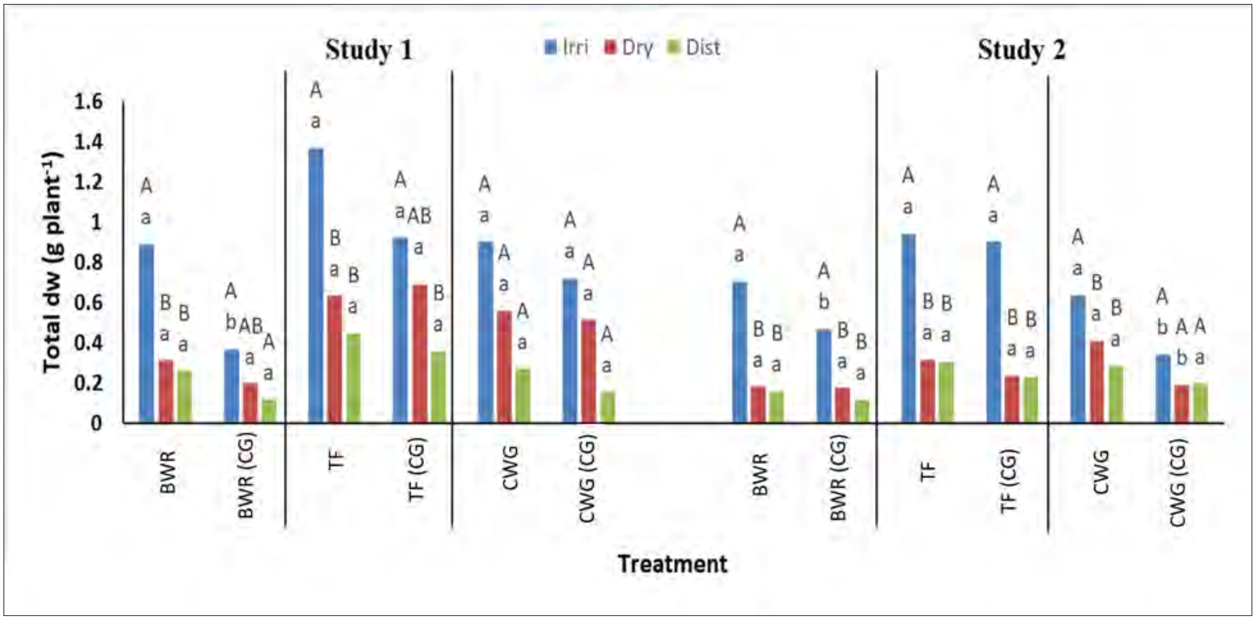


**Figure 1.** Effect of soil source and neighbor species (cheatgrass) on total dry weight of perennial grasses. Means with different uppercase letters are significantly different among the soil source at *P*<0.05, means with different lowercase letters are significantly different among same species within same soil source. Irri: soil from irrigated site; Dry: soil from dryland site; Dist: soil from disturbed site; BWR: Basin wildrye; BWR(CG): basin wildrye + cheatgrass TF: tall fescue; TF(CG): tall fescue + cheatgrass; CWG: crested wheatgrass; CWG(CG): crested wheatgrass + cheatgrass.

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**Keywords:** cheatgrass, competitive response, native and non-native grasses

**PARP:** III:5, XII:1

# Summary of Multi-Year Field and Greenhouse Experiments of Soil-Applied N on Dry Bean Grain Yield


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## Introduction

Fertilizer N is commonly applied to dry bean in much of the North American Dry Bean Belt. The practice is based on the observation that dry bean is a poor $N_2$-fixer but the N-fertilization practice is being reevaluated worldwide for multiple reasons. Although the vegetative growth and leaf chlorophyll response of dry bean to fertilizer N is very consistent, the yield response is extremely inconsistent.

## Objectives

The main objective of this study was to summarize the results of a series of greenhouse and field studies conducted in Wyoming regarding the dry bean yield response to fertilizer N rate.

## Materials and Methods

For the greenhouse, soil was collected from the A horizon from the northwest section of the Laramie REC. Soil was sifted and mixed with sand and a commercial pine bark mix (1:1:1 by volume for each). The soil was analyzed for pH, EC, texture, organic matter (OM), $NO_3$-N, P, K, Zn, Fe, Mn, Cu, B, and S. For the field site at Lingle, soil was analyzed for pH, EC, OM, $NO_3$-N, P, and K. For Powell, soil was analyzed for all traits as Laramie but also included salts, Cl, Na, cation exchange capacity, and $NH_4$-N.

In the greenhouse, all experiments were conducted in 3-gallon pots (11-L) with 17.6 pounds (8kg) of soil media described above. N ($NH_4NO_3$) was applied via four split aqueous applications and seasonal N rates per acre were calculated using 2 million pounds of soil per acre-furrow as a basis. Ten seeds were sown and seedlings thinned to three per pot. In the field at Lingle, seeding rate was 100K per acre and row spacing was 30-inch. At Powell, seeding rate was 100K per acre and row spacing was 22-inch. Fertilizer N rates for the various studies ranged from zero to a high of 120 pounds N per acre.

For the greenhouse, yield per pot was determined by hand-harvesting and hand-shelling mature pods. For the field, grain yield was determined by machine threshing the two center rows of four-row (Lingle) or six-row (Powell) plots. For each experiment, grain yields of all pots or plots receiving nonzero rates of N were averaged together (i.e., the N-fertilized yield) and that value was compared to the zero-N check to calculate a percent increase/change [(Yield with N)/(Yield without N)] × 100.

## Results and Discussion

Locations, soil tests results, and grain yields (fertilized vs. check) are presented in Table 1. Yield increases associated with N averaged 6%. Preplant soil $NO_3$-N appeared to play only a minor role ($R^2$ = - 0.154) in the percent response to fertilizer N (Fig. 1); obviously many other factors are involved. Within tests with multiple cultivars, no significant N-by-genotype interactions on grain yield were found.

**Acknowledgement**
The authors thank the field and greenhouse crews at LREC, SAREC, and PREC. The authors also thank HCED of Iraq, the Wyoming Bean Commission, USDA-NIFA Hatch projects WYO-558-15, and USDA-NIFA Hatch WYO604-19 for financial support.

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**Keywords:** nitrate, seed, fertlizer

**PARP:** Goal 1

**Table 1.** Effect of fertilizer N on yield of dry bean under greenhouse (GH) and field (F) conditions at Laramie, Lingle, and Powell (*Wyoming*) and percent increase or decrease due to N. The number of replicates per test ranged from 2 to 4.

| Year | Location | Cultivar(s) | Soil Test NO3-N | Yield No N | Yield w/N | Increase |
|---|---|---|---|---|---|---|
| | | name or # | ppm | g/pot or kg/ha | g/pot or kg/ha | % |
| 2015 | Laramie (GH1) | 3 † | 7 | 16.1 g | 17.6 g | 9 |
| 2015 | Laramie (GH2) | 4 ‡ | 7 | 18.3 g | 28.0 g | 53 |
| 2016 | Laramie (GH3) | Othello | 10 | 22.3 g | 22.6 g | 1 |
| 2016 | Laramie (GH4) | 15 § | 8 | 14.9 g | 17.5 g | 17 |
| 2016 | Laramie (GH5) | 4 ‡ | 18 | 30.7 g | 32.9 g | 7 |
| 2017 | Laramie (GH6) | 15 § | 25 | 21.6 g | 24.1 g | 12 |
| 2017 | Laramie (GH7) | 2 ¶ | 62 | 19.6 g | 21.1 g | 8 |
| 2017 | Lingle (F1) | Centennial | 42 | 3375 kg | 3668 kg | 8 |
| 2017 | Lingle (F2) | 15 # | 42 | 2435 kg | 2185 kg | -11 |
| 2019 | Powell (F3) | 11 †† | 17 | 4520 kg | 4610 kg | 2 |

† *The 3 dry bean cultivars in Laramie GH1 study during 2015 were CO43648, Rio Rojo, and UI-537.*

‡ *The 4 dry bean cultivars in Laramie GH2 & GH5 studies during 2015 and 2016 were CO43648, Long's Peak, Rio Rojo, and UI-537.*

§ *The 15 pinto bean cultivars in Laramie GH4 & GH6 studies during 2016 & 2017 were BillZ, CO46348, COSD-25, COSD35, Centennial, Croissant, El Dorado, ISB1231-1, La Paz, Lariat, Long's Peak, ND307, Othello, Poncho, and UIP-40.*

¶ *The 2 dry bean cultivars in Laramie GH7 study during 2017 were CO43648 and Poncho.*

# *The 15 cultivars for Lingle 2017 (F2) were Avalanche, CO46348, COSD-35, Eclipse, La Paz, Lariat, Long's Peak, Monterrey, ND-307, Othello, Poncho, Rio Rojo, Stampede, Talon, UI-537.*

†† *The 11 entries for Powell 2019 (F3) were COSD-7, La Paz, Long's Peak, Poncho, UI-537, and six LPID progeny lines.*

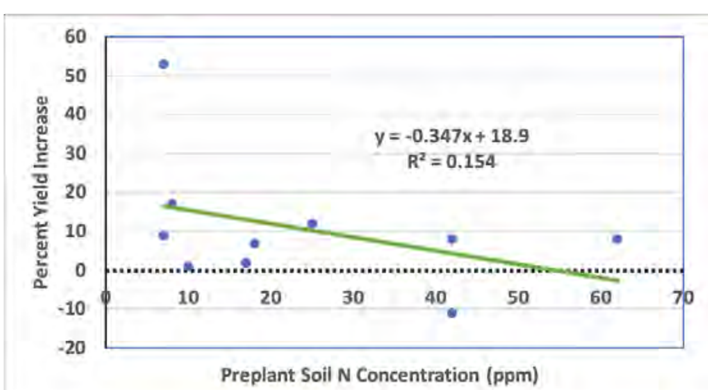


**Figure 1.** Relationship between percent yield increase due to N and preplant soil $NO_3$-N.

# Summary of N-by-Genotype Interactions on Different Traits in Dry Bean

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### Introduction

In order to reduce applied N rates, researchers across the globe have compared dry bean genotypes to different soil-applied N rates in order to identify promising genotypes for low N environments and to identify selection criteria for breeding N-efficiency within *Phaseolus*.

### Objectives

The objective was to quantify plant traits of genotypes where N fertilizer was withheld.

### Materials and Methods

Greenhouse studies with 15 different pinto genotypes were sown on two separate occasions (2016 and 2017) at the University of Wyoming Laramie Research & Extension Center, Laramie (41°14' N, 105°5' W; elevation 2184 m), Wyoming, USA (GH16, GH17). Pots (3 gal, 11-liter, 8 kg) were filled with a mix of native soil (obtained from the A-horizon of a Wycolo-Alcova complex, 3 to 10% slope, fine-loamy, mixed Borollic Haplagids), a pinebark mix (BM Berger), and sand (1: 1: 1, v/v). Guard – N inoculant was applied at sowing to provide rhizobia. N (aqueous $NH_4NO_3$) was applied across four split applications to achieve a seasonal rate of 60 lbs N per acre and compared to pots where N was withheld (i.e., untreated check). N rates were converted to pounds per acre using the assumption of $2 \times 10^6$ pounds of soil per acre. Design was an RCBD with a random arrangement of the 30 treatments within each of two blocks.

Field studies were conducted in Laramie (2015; 9 genotypes; F15) and at Lingle (2016, 18 genotypes; F16; 2017, 15 genotypes; F17). The Lingle site consisted of mixed soil types, a Haverson loam (fine-loamy, mixed, superactive, calcareous mesic Aridic Ustifluvents) and a McCook loam (coarse-silty, mixed, superactive, mesic Fluventic Haplustolls). Sowing dates were 4 July 2015, 27 May 2016, and 2 June 2017. N was applied at 60 lbs per acre as $NH_4NO_3$ at Laramie at 33 dap and as urea at Lingle at 32 dap (2016) and 33 dap (2017). Each field experiment was a split-plot (N the main factor, genotype the subplot), with two (F15) or three replicates (F16, F17). Rhizobia was applied at the Laramie site only. Genotypes and the years/locations are listed in Table 1.

**Table 1.** Genotypes tested for response to soil-applied N in five studies.

| Greenhouse | | Field | | | | |
|---|---|---|---|---|---|---|
| 2016 & 2017 | | 2015 | 2016 | | 2017 | |
| BillZ | La Paz | BillZ | Avalanche | Monterrey | Avalanche | ND-307 |
| CO46348 | Lariat | CO46348 | BillZ | ND-307 | COSD-35 † | Othello |
| COSD-25 | Long's Peak | Croissant | Centennial | Othello | CO46348 | Poncho |
| COSD-35 † | ND-307 | Long's Peak | COSD-35 † | Poncho | Eclipse | Rio Rojo |
| Centennial | Othello | ND-307 | CO46348 | Rio Rojo | La Paz | Stampede |
| Croissant | Poncho | Rio Rojo | Eclipse | Stampede | Lariat | Talon |
| El Dorado | UIP-40 ‡ | Stampede | La Paz | Talon | Long's Peak | UI-537 |
| ISB1231-1 | | Talon | Lariat | UI-259 | Monterrey | |
| | | UI-537 | Long's Peak | UI-537 | | |

† *COSD-35 from Colo. State is now named Staybright.*

‡ *UIP-40 led to a selection/release by Univ. Idaho called 'Twin Falls.'*

*Initial soil [$NO_3$-N] in ppm was: 8, 25, 13, 68, and 42, for GH16, GH17, F15, F16, and F17, respectively.*

## Results and Discussion

Genotypic differences were found among nearly all traits for these five studies and will be published elsewhere. P-values of genotype-by-N interaction, if significant, are provided in Table 2. Except for leaflet width/area and stalk:root ratio, interactions were not significant. The interaction upon leaflet width/area was largely due to the cultivar La Paz not increasing its leaflet area in response to N. Regarding the leaflet traits, one theory we have is that under lower soil N conditions, N-efficient types may be able to partition its limited N into more leaf area with less chlorophyll per unit leaf area in order to capture more light as opposed to maintaining normal chlorophyll concentration and capturing less light. However, our data at this time do not suggest that this theory is very important.

## Acknowledgements

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**Keywords:** synergy, cultivar, yield

**PARP:** Goal 1

**Table 2**. Results of genotype-by-N interaction tests for five dry bean studies (that were described in Table 1).

| Trait | GH16 | GH17 | F15 | F16 | F17 |
|---|---|---|---|---|---|
| ChloroE | ns | ns | ns | ns | ns |
| ChloroM | ns | ns | ns | ns | ns |
| Leaflet Width/Area | 0.040 | 0.041 | - | 0.03/0.04 | ns |
| SLW | ns | ns | - | ns | ns |
| Root Length | ns | ns | - | - | - |
| Root Weight | ns | ns | - | - | - |
| Plant Height | ns | ns | ns | - | ns |
| Nodule Number | - | ns | - | - | ns |
| Nodule Fresh Weight | - | ns | - | - | - |
| Stalk Weight | ns | ns | ns | - | ns |
| Stalk:Root Ratio | ns | 0.019 | - | - | ns |
| NDVI | - | - | - | ns | ns |
| Flowering Date | - | ns | - | - | - |
| Maturity Date | ns | ns | - | - | - |
| Pod Number | ns | ns | ns | - | ns |
| Seed per Pod | ns | ns | - | - | ns |
| Seed Number | ns | ns | - | - | ns |
| Seed Size | ns | ns | - | - | ns |
| Seed Yield | ns | ns | - | - | ns |
| Pod Harvest Index | ns | ns | - | - | ns |
| Seed N Conc. | ns | ns | - | - | ns |
| Seed C Conc. | ns | ns | - | - | ns |

# Comparison of N Fertilizer Source on Dry Bean Growth and Yield

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## Introduction

Although most crop species prefer $NO_3$-N as their predominant source of N, species differ in their response when $NH_4$-N represents a high percentage of the soil N. For most leguminous crops, source of N does not matter because N is rarely applied but dry bean (*Phaseolus vulgaris* L.) is an unfortunate exception. Previous studies have indicated that dry bean prefers a higher ratio of $NO_3$-N than of $NH_4$-N but more observations are needed, especially under the calcareous soil conditions found in Wyoming.

## Objectives

The primary objective of this study was to compare ammoniacal-N to $NO_3$-N fertilizers on the growth and yield of dry bean under greenhouse conditions. A secondary objective was to compare inoculating vs. no inoculant and a third objective was to compare different rhizobia strains.

## Materials and Methods

Greenhouse studies were performed on 15 October 2015, 16 July 2016, and 16 March 2017 at the University of Wyoming Laramie Research & Extension Center, Laramie (41°14' N, 105°5' W; elevation 2184 m), Wyoming, USA.

In the first experiment, 36 pots (11-liter, 8 kg) were filled with native soil (obtained from the A-horizon of a Wycolo-Alcova complex, 3 to 10% slope, fine-loamy, mixed Borollic Haplagids), a pinebark mix (BM Berger), and sand (1: 1: 1, v/v). Three dry bean genotypes (CO 46348, Rio Rojo, and UI-537) with four sources of inorganic N fertilizer (urea, ammonium nitrate, potassium nitrate, and control). Ammonium nitrate ($NH_4NO_3$), urea ($CH_4N_2O$), and potassium nitrate ($KNO_3$) were applied at 60 lb N/acre plus to control treatment; moreover, nitrogen application was applied in a solution of 100 ml per pot. Split N application was used to minimize N loss in 21, 28, 35, and 42 days after planting (DAP). An equivalent amount of K as KCl was applied at 21 DAP for other treatments that did not supply $KNO_3$.

In the second experiment, 30 pots were filled as described before. Five dry bean genotypes (CO 46348, Othello, Poncho, Rio Rojo, and UI537) with two sources of inorganic N fertilizer (urea and ammonium nitrate). Ammonium nitrate and urea (seasonal equivalent of 68 kg N $ha^{-1}$) were applied as a source of inorganic N fertilizer in a solution of 100 ml per pot (17 kg N $ha^{-1}$ per application). A split application of N was used in 18, 23, 28, and 35 days after planting (DAP).

In the third experiment, 36 pots were filled as described earlier. Two inoculation treatments (inoculation and no-inoculation), two pinto bean genotypes (CO 46348 and Poncho) with three rates of N (0, 30, and 60 lb N/acre) were tested. In the third study, two dry bean genotypes (CO 46348 and Poncho) were sown, five seeds from each genotype per pot. Two inoculation treatments (inoculation and no-inoculation) were applied. At emergence stage, plants were thinned to three plants per pot. Hand irrigation was carried out to avoid drought stress. Ammonium nitrate was applied at 0, 30, and 60 lb N/acre in a solution of 50 and 100 ml per pot at 16, 23, 33, and 38 DAP. Split application was used to avoid N loss.

In the fourth experiment, different preparations of rhizobia were compared.

For all four experiments, a completely randomized design (CRD) with three replicates was used. Guard – N inoculant was applied as a source of commercial rhizobia to inoculate seeds at sowing except for Exp 4. Bean plants were thinned to three plants per pot after seedling emergence. N rates were converted to pounds per acre using the assumption of $2 \times 10^6$ pounds of soil per acre. Seed yield was measured at maturity after hand-harvesting and shelling pods. Other traits measured throughout the study are published elsewhere.

### Results and Discussion

Preplant soil test results for the three experiments are provided in Table 1. Seed yield of the three studies is provided in Table 2. Source of N did not affect grain yield response.

**Table 1**. Soil analysis of greenhouse experiments in Laramie before planting.

| Soil properties | 2015 - Exp. 1 | 2016 - Exp. 2 | 2017 - Exp. 3 |
|---|---|---|---|
| pH | 7.9 | 8.1 | 7.1 |
| EC (ms/cm$^{-1}$) | 0.4 | 0.5 | 0.3 |
| Organic Matter (%) | 1.6 | 2.0 | 3.2 |
| $NO_3$-N ppm | 7.0 | 8 | 62 |
| Phosphorus P ppm | 30.1 | 13.9 | 15.4 |
| Potassium K ppm | 324 | 183 | 193 |
| Zinc Zn ppm | 1.8 | 1.4 | 1.7 |
| Iron Fe ppm | 6.4 | 3.3 | 5.9 |
| Sulfur S ppm | 24.1 | 24.1 | 35.7 |

**Table 2**. Effect of different N sources on seed yield of dry bean across four studies.

| Study | N Source | Yield |
|---|---|---|
| | | g per pot |
| **One** | Zero | 16.1 |
| | Urea | 17.9 |
| | $NH_4NO_3$ | 17.5 |
| | $KNO_3$ | 17.4 |
| LSD (0.05) | | ns |
| | | |
| **Two** | Urea | 35.7 |
| | $NH_4NO_3$ | 36.4 |
| LSD (0.05) | | ns |
| | | |
| **Three** | No Inoculant – Zero N | 18.3 |
| | No Inoculant – With N | 21.6 |
| | Plus Inoculant – Zero N | 20.8 |
| | Plus Inoculant – With N | 21.2 |
| LSD (0.05) | | ns |
| | | |
| **Four** | Untreated | 16.7 |
| | USDA 2668 | 17.7 |
| | USDA 2673 | 14.4 |
| | Commercial Rhizobia | 13.5 |
| LSD (0.05) | | ns |

**Acknowledgements**

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**Keywords:** urea, nitrate, ammonium, yield

**PARP:** Goal 1

# Implications of Cow Nutrition during Late Gestation on the Developing Calf Gut Microbiome

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## Introduction

It is well known that management of the cow during gestation has implications on calf development and performance. However, it is not well understood how cow nutrition during late gestation influences the gut microbiome in the calves. The rumen microbiome is crucial to ruminant livestock as it enables the conversion of low quality forages into high quality end-products (milk, meat, etc.) through microbial fermentation. Colonization of these microorganisms begins before the rumen is functional and recent evidence suggests this may even occur during gestation in utero. The early microbiome of the gut is critical to the host animal in several ways including production of fermentation end products crucial to gut tissue development and establishment of host immune system. Furthermore, the early rumen microbiome is a point of interest as previous research suggests that shifts in the rumen microbiome during development can have lasting effects on performance. Thus, understanding what factors influence the early gut microbiome may provide insight into development of management practices to alter the developing microbiome in an effort to influence the mature rumen microbiome and positively influence efficiency. In the Mountain West cows face extreme challenges during late gestation as the nutritional requirement increases often coincide with harsh weather conditions and limited feed availability. Although cows are generally provided with hay and perhaps another supplement during this time, it is plausible that many cows face undernutrition as the cost of providing these feedstuffs to meet requirements could be a limiting factor.

## Objectives

The objective of our research was to determine if nutrient restriction during late gestation would influence the developing calf rumen microbiome and influence performance of these calves long term. We hypothesized that the rumen microbiome of calves born to nutrient restricted dams would have a less robust and diverse rumen microbiome than those born to dams fed to meet requirements.

## Materials and Methods

During late gestation, 60 cows were divided evenly into two nutritional groups. The control group (CON) received 100% of the required intake to meet the requirements of late gestation and early lactation. The second group was the nutrient restricted group (NR) that received 70% of the total intake of the CON group. These feeding levels were introduced for the last 1/3 of gestation through 1 month post-calving. Rumen fluid was collected from the cows three times during late gestation (60 days, 30 days, and 14 days prior to calving, respectively). At calving, rumen fluid and meconium samples were collected from the calf prior to nursing and again at 7 days and 28 days post-calving. Microbial DNA was extracted from these samples and used for metagenomic sequencing to determine the microbial profiles in each of these samples. Data analysis was completed using QIIME2 which can determine differences in diversity (how many different types of microbes are found) and composition (how does the entire community in one sample differ from another) of the microbiome.

### Results and Discussion

The cow rumen microbiome was affected by nutrient restriction where the sample collected 14 days prior to calving from the nutrient restricted cows was less robust and diverse compared to the control cows. This indicates that as cows became more restricted due to limited feed intake (70% reduction in NR compared to CON), their rumen microbiome became less diverse. A more robust and diverse rumen microbiome is associated with increased productivity and health, thus this decrease in diversity from the nutrient restriction could be concerning for cow performance. When comparing the gut microbiome samples from the calves across time, irrespective of dam nutritional treatment, it is evident that stage of development plays a very large role in microbial diversity and composition.

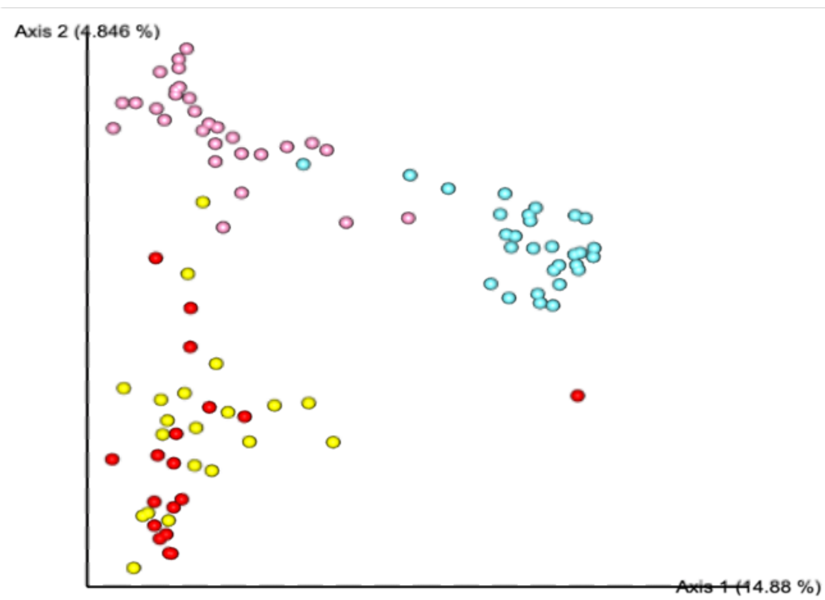


**Figure 1.** Microbial composition from calf meconium (Red), rumen fluid at day 1 (Yellow), rumen fluid at day 7 (Pink), and rumen fluid at day 28 (Blue).

In Figure 1, it is apparent that the meconium (red) and day 1 rumen fluid (yellow) overlap and share similarities in their microbial composition but differ from day 7 (pink) and day 28 (blue). Also, as time progresses the dots (individual microbiomes) become more tightly clustered which implies increased similarity in those individual microbiomes.

When considering cow gestational treatment and the influence on the calf gut microbiome, differences were most apparent at 1 month post-calving. The diversity of the meconium and rumen fluid microbiome collected immediately after birth and 1 week post-calving did not differ between the control and nutrient restricted groups. However, at 1 month post-calving the rumen microbiome did differ between calves born to nutrient restricted dams and calves born to control dams. This suggests that alterations to the rumen microbiome from maternal gestational nutrition are evident once the rumen is functional. These shifts could lead to differences in performance of these calves, but post-weaning data would be required to determine this.

These data indicate that indeed maternal gestation does impact not only the cow rumen microbiome but also the calf microbiome. Future research will determine the impacts of these shifts in the calf gut microbiome on performance in terms of weaning weights and post-weaning performance. These data are promising in that the management and nutrition for the cow during gestation does influence the calf gut microbiome development and thus could be an avenue to create intervention strategies to improve calf health, performance, and efficiency through the microbiome.

**Acknowledgments**
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**Keywords:** efficiency, gestational nutrition, rumen microbiome

**PARP**: V:1, V:8

# 2019 Briess Barley Variety Performance Evaluation

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*Samual George, Powell Research & Extension Center*

*Steven Camby Reynolds, Powell Research & 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 & Extension Center (PREC) during 2019. The experimental design of all trials was randomized complete block with three replications. 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 21, 2019 using a Zurn plot combine.

## Results and Discussion

Results from 2019 are presented in Table 1. The highest yielding Briess variety in the small plot trial was 'Odyssey' at 159 bu/ac, which was significantly higher than the regional checks (Table 1 shaded). There was a lot of variation between plots so while yield averages ranged from 160-117 bu/a the LSD was 22.9, so any averages within 22.9 bu/a of each other are not considered statistically different because of variation. Protein was less than 9% for all varieties.

## Acknowledgments

Appreciation is extended to the PREC staff and summer crew for their continuing support throughout the 2019 season.

**Keywords:** variety trials, malting, barley

**Contact:** Carrie Eberle, carrie.eberle@uwyo.edu, 307-837-2000.

**PARP:** I:12

**Table 1.** Results from 2019 small plot trials. Each variety was replicated 3 times. Shaded varieties are regional checks.

| 2019 Briess Small Plot Trial Results | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | **Yield (bu/a) at 14.5% moisture[1]** | | **TWT (lbs/a)[2]** | | **% Protein[2,3]** | | **Plump 6[2]** | | **Plump 5[2]** | | **Thin[2]** | | **Lodging score[1]** | | **Height[1]** | |
| Odyssey | 159 | cd | 52 | ab | 7.7 | a | 0.94 | abc | 0.98 | ab | 0.02 | ab | 0.2 | a | 69.1 | a |
| Opera | 150 | cd | 50 | a | 7.8 | a | 0.93 | ab | 0.97 | b | 0.03 | b | 0.4 | ab | 68.0 | a |
| **ABI Voyager** | 142 | bcd | 54 | b | | | 0.99 | c | 0.99 | a | 0.01 | a | 0.9 | ab | 87.1 | cd |
| **Baronesse** | 139 | abcd | 52 | ab | | | 0.94 | abc | 0.98 | ab | 0.02 | ab | 0.3 | a | 87.8 | d |
| Gemcraft | 139 | abcd | 53 | b | 8.1 | ab | 0.94 | abc | 0.98 | ab | 0.02 | ab | 0.9 | ab | 83.8 | d |
| Laudis | 139 | abcd | 51 | ab | 7.7 | a | 0.92 | a | 0.98 | ab | 0.02 | ab | 0.0 | a | 83.3 | d |
| **Steptoe** | 137 | abcd | 50 | a | | | 0.96 | abc | 0.98 | ab | 0.02 | ab | 2.4 | c | 86.3 | cd |
| Sienna | 136 | abc | 51 | ab | 8.1 | ab | 0.95 | abc | 0.98 | ab | 0.02 | ab | 0.1 | a | 77.9 | c |
| Genie | 136 | abc | 53 | b | 7.9 | a | 0.95 | abc | 0.98 | ab | 0.02 | ab | 1.1 | ab | 73.4 | b |
| Barke | 134 | abc | 54 | b | 8.4 | ab | 0.95 | abc | 0.98 | ab | 0.02 | ab | 1.0 | ab | 78.7 | c |
| Malz | 131 | abc | 53 | b | 7.8 | a | 0.96 | abc | 0.98 | ab | 0.02 | ab | 0.1 | a | 75.6 | bc |
| Bojo | 130 | abc | 53 | b | 8.8 | b | 0.96 | abc | 0.98 | ab | 0.02 | ab | 0.3 | a | 79.3 | c |
| **Harrington** | 127 | ab | 52 | ab | | | 0.97 | bc | 0.99 | ab | 0.01 | ab | 1.6 | bc | 86.2 | cd |
| Synergy | 126 | ab | 52 | ab | 8.8 | b | 0.98 | c | 0.99 | ab | 0.01 | ab | 0.3 | a | 90.0 | de |
| **AC Metcalfe** | 121 | ab | 52 | ab | | | 0.96 | abc | 0.99 | ab | 0.02 | ab | 0.4 | ab | 86.3 | cd |
| **ND Genesis** | 117 | a | 52 | ab | | | 0.98 | c | 0.99 | ab | 0.01 | ab | 0.2 | a | 91.8 | e |
| **p-value** | **0.10** | | **<.0001** | | **0.002** | | **0.001** | | **0.07** | | **0.08** | | **0.01** | | **<.0001** | |
| **Average** | **135** | | **52** | | **8.1** | | **0.96** | | **0.98** | | **0.02** | | **0.7** | | **81.5** | |

A p-value of less than 0.05 indicates that the statistical model is significant

[1]Letters indicate significant differences between varieties based on the Least Significant Difference test; averages that are within ±LSD are not statistically different. Means within a column followed by the same letter are not significantly different from each other at the 5% probability level.

[2]Letters indicate significant differences between varieties based on the Student-Newman-Keuls test. Means within a column followed by the same letter are not significantly different from each other at the 5% probability level.

[3]Protein was only assessed on Briess varieties, not regional check varieties

Blue shaded varieties are regional checks for Powell, *Wyoming*

# 2019 Elite Malt Barley Variety Performance Evaluation

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*Samual George, Powell Research & Extension Center*

*Steven Camby Reynolds, Powell Research & Extension Center*

## Introduction

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

## Objectives

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

## Materials and Methods

The experiment was located at the Powell Research & Extension Center (PREC) during 2019. The experimental design of all trials was randomized complete block with three replications. 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 Zurn plot combine.

## Results and Discussion

Results from 2019 are presented in Table 1. The highest yielding malting entry was '13ARS084-3' at 159 bu/ac. Yield was not significantly different between any of the varieties. Results are posted annually at http://www.uwyo.edu/uwexpstn/variety-trials/index.html.

## Acknowledgments

Appreciation is extended to the PREC staff and summer crew for assistance during 2019.

**Contact:** Carrie Eberle, carrie.eberle@uwyo.edu, 307-837-2000.

**Keywords:** variety trial, malting, barley

**PARP:** I:12

**Table 1.** 2019 Elite Malt Barley Trial Results

| Cultivar Name | Yield bu/ac | TWT lb/bu | Height cm | Lodging 0/9 | Plump[2] (6/64) |
|---|---|---|---|---|---|
| 13ARS084-3 | 159 | 52 | 84 | 0.0 | 95% |
| 2Ab08-X05M010-82 | 154 | 54 | 88 | 0.1 | 95% |
| 13ARS105-4 | 154 | 53 | 85 | 0.0 | 99% |
| 13ARS084-5 | 151 | 54 | 86 | 0.0 | 98% |
| 13ARS080-5 | 148 | 53 | 86 | 0.0 | 98% |
| 13ARS115-5 | 142 | 52 | 81 | 0.0 | 98% |
| 2Ab04-X01084-27 | 144 | 52 | 84 | 0.0 | 98% |
| 13ARS076-5 | 144 | 53 | 87 | 0.0 | 99% |
| 13ARS102-5 | 144 | 52 | 82 | 0.0 | 96% |
| 13ARS082-4 | 141 | 54 | 86 | 0.0 | 96% |
| GemCraft | 141 | 52 | 87 | 0.0 | 97% |
| 10ARS191-3 | 141 | 54 | 85 | 0.0 | 97% |
| 08ARS116-91 | 141 | 52 | 81 | 0.7 | 97% |
| M69 | 140 | 51 | 76 | 0.0 | 96% |
| 2Ab07-X031098-31 | 140 | 52 | 87 | 0.0 | 97% |
| 13ARS111-5 | 139 | 53 | 85 | 0.0 | 98% |
| Merit57 | 138 | 50 | 77 | 0.0 | 94% |
| 2Ab08-X04M278-35 | 136 | 51 | 85 | 0.0 | 97% |
| 13ARS095-1 | 136 | 54 | 79 | 0.0 | 98% |
| Harrington | 131 | 53 | 86 | 0.0 | 97% |
| Conrad | 129 | 53 | 85 | 0.0 | 98% |
| 08ARS012-79 | 129 | 52 | 84 | 0.0 | 94% |
| Voyager | 129 | 53 | 86 | 0.0 | 99% |
| 11ARS162-4 | 129 | 52 | 85 | 0.0 | 97% |
| 13ARS093-3 | 127 | 54 | 80 | 0.0 | 97% |
| CDC Copeland | 126 | 54 | 83 | 0.1 | 99% |
| 11ARS183-9 | 126 | 52 | 87 | 0.0 | 98% |
| 10ARS061-2 | 123 | 54 | 82 | 0.0 | 99% |
| 08ARS028-20 | 122 | 54 | 82 | 0.0 | 97% |
| ACMetcalfe | 121 | 54 | 84 | 0.0 | 98% |
| **Location Mean** | **137** | **53** | **83** | **.03** | **97%** |
| **LSD** | **27** | **1.3** | **8** | **0.4** | **0.009** |
| **p-value (0.05)[3]** | **ns** | **<.0001** | **ns** | **ns** | **<.0001** |

[2]*Plump is % above screen*

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

# 2019 Western Regional Spring Barley Nursery Performance Evaluation

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*Samual George, Powell Research & Extension Center*

*Steven Camby Reynolds, Powell Research & 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 do spring barley variety performance. Data on grain yield, test weight, and protein are important to local and regional producers, as some malt varieties may not perform in some areas.

## Materials and Methods

The experiment was located at the Powell Research & Extension Center (PREC) during 2019. The experimental design of all trials was randomized complete block with three replications. 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 21, 2019 using a Zurn plot combine.

## Results and Discussion

Results from 2019 are presented in Table 1. The highest yielding entry was H0515-541 at 145 bu/ac. This entry is a feed variety. Bolded entries 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 & Extension staff and summer crew for assistance during 2019.

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**Keywords:** variety trial, barley

**PARP:** I:12

**Table 1.** 2019 Western Regional Spring Barley Nursery Results. Means of any two varieties being compared must differ by at least the LSD (least significant difference) to be considered different at the 5% level of probability of significance. Plump is the % above screen. Entries in bold are regional check varieties. Entries with an * are feed grade, all others are malt grade.

| | YIELD | TWT | HEIGHT | LODGING | Plump | | |
|---|---|---|---|---|---|---|---|
| **Entry** | **Bu/A** | **lbs./Bu** | **in.** | **0-10** | **>2.4mm** | **>2.2mm** | **<2.2mm** |
| HO515-541* | 145.3 | 51.2 | 36.0 | 0.3 | 96.8 | 1.9 | 1.3 |
| 13WAM-101.2 | 144.0 | 51.5 | 33.2 | 0.2 | 95.4 | 3.3 | 2.0 |
| **ABI Voyager** | 142.2 | 51.3 | 34.3 | 0.9 | 98.5 | 0.8 | 0.0 |
| CDC Copper | 142.1 | 49.9 | 33.6 | 0.0 | 97.2 | 1.5 | 1.3 |
| 2IM14-8212 | 141.9 | 49.4 | 32.1 | 0.2 | 97.5 | 1.3 | 1.2 |
| **Baronesse*** | 138.6 | 52.3 | 34.6 | 0.3 | 94.4 | 4.0 | 1.6 |
| 2IM15-9386 | 138.0 | 50.7 | 33.2 | 0.4 | 96.9 | 1.9 | 1.2 |
| **Steptoe*** | 137.4 | 47.8 | 34.0 | 2.4 | 95.9 | 2.3 | 1.8 |
| 13WAM-101.10 | 137.0 | 52.6 | 34.6 | 0.7 | 95.7 | 2.5 | 1.0 |
| 10ARS191-3 | 135.5 | 51.9 | 33.2 | 0.3 | 94.8 | 4.1 | 1.1 |
| 13WAM-135.26 | 135.4 | 53.0 | 30.8 | 0.1 | 97.3 | 1.4 | 2.0 |
| 11ARS162-4 | 135.0 | 50.1 | 34.5 | 0.2 | 96.1 | 2.6 | 1.3 |
| 12WAM-105.2 | 134.8 | 50.8 | 32.4 | 0.2 | 96.2 | 2.3 | 1.5 |
| ABI Eagle (2B11-4949) | 134.1 | 50.4 | 30.9 | 0.0 | 95.5 | 3.2 | 1.3 |
| 08ARS028-20 | 133.1 | 50.8 | 30.6 | 0.0 | 96.7 | 2.2 | 1.1 |
| 11ARS183-9 | 129.4 | 50.6 | 36.9 | 0.8 | 97.5 | 1.6 | 0.0 |
| 13WAM-128.3 | 128.0 | 50.8 | 28.4 | 0.0 | 95.9 | 2.9 | 1.2 |
| 2IK14-8413 | 127.4 | 50.9 | 33.8 | 0.1 | 97.9 | 1.1 | 1.0 |
| **Harrington** | 126.5 | 51.0 | 33.9 | 1.6 | 97.0 | 1.8 | 1.2 |
| 2ND32529* | 122.9 | 49.9 | 32.4 | 0.0 | 97.9 | 1.0 | 1.1 |
| **AC Metcalfe** | 121.3 | 50.7 | 34.0 | 0.4 | 96.4 | 2.3 | 2.0 |
| UTSB11301-1* | 120.4 | 49.5 | 36.6 | 0.6 | 94.9 | 3.3 | 1.8 |
| UTSB10905-72* | 120.1 | 48.4 | 35.4 | 0.2 | 96.0 | 2.2 | 1.8 |
| HO515-525* | 119.5 | 52.5 | 34.6 | 0.0 | 97.0 | 1.9 | 1.1 |
| **ND Genesis** | 116.9 | 50.6 | 36.1 | 0.2 | 97.9 | 1.0 | 1.1 |
| MT124134 | 114.6 | 50.6 | 32.6 | 0.0 | 97.0 | 1.7 | 1.3 |
| MT124112 | 113.6 | 50.3 | 33.7 | 0.0 | 97.7 | 1.0 | 1.3 |
| MT124128 | 110.6 | 50.9 | 30.8 | 0.0 | 97.2 | 1.7 | 1.1 |
| 2ND34634* | 106.7 | 47.2 | 32.9 | 0.0 | 98.5 | 0.5 | 0.0 |
| MT124113 | 106.1 | 48.9 | 31.3 | 0.4 | 95.6 | 2.7 | 1.0 |
| **Mean** | **128.6** | **50.5** | **33.4** | **0.4** | **96.6** | **2.1** | **1.2** |
| **Check's mean** | **130.5** | **50.6** | **34.5** | **1.0** | **96.7** | **2.0** | **1.3** |
| **CV %** | **9.4** | **1.2** | **3.7** | **131.2** | **0.7** | **23.9** | |
| **LSD (.05)** | **16.6** | **0.8** | **1.7** | **0.6** | **0.9** | **0.7** | |
| **Observations** | **3** | **3** | **3** | **3** | **3** | **3** | **3** |

# Wyoming First Grains Project

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*Mike Moore, Wyoming Seed Certification Facility*

*Caitlin Youngquist, Washakie County Extension*

This research is being conducted at PREC, SAREC, ShREC and Off-station locations with private producers.

## Introduction

The Wyoming First-grains project is a UW College of Agriculture and Natural Resources innovative research and economic development project. With this project, we are taking a vertically integrated approach, by using a "business incubator" model in developing products, and in fact, a niche industry around first-grains.

First-grains, sometimes called "ancient" grains, are gaining a lot of public attention these days among more health conscious Americans. But they are surrounded by myth and misinformation, especially online. There are very little first-grains grown in Wyoming, even though there is a thriving wheat industry in the state. Most of Wyoming's current first-grains production is direct marketed by farmers. We are taking a different approach with value-added products, mainly malt but with some grain for flour for artisan bakers. This will build the market for these grains, while increasing demand under our brand. We call this approach, applied supply-chain research.

## Objectives

Our ultimate goal is to grow a profitable niche industry around first-grains that will support growers and our customers in the beverage and baking sectors. We can then hand-off the project as a stand-alone business to the private sector, providing jobs and income to people in the state. University researchers may continue to support the project with additional research as time and funding permit. In conducting this applied research project, we contribute to the economic development and diversification of the state's agricultural sector and educate consumers about more healthy grains with different nutritional and flavor profiles from what they are used to with wheat.

## Materials and Methods

With our new approach, we have trademarked the Neolithic brand name, the petroglyph sun logo, and tagline "One step away from wild" (Figure 1). These are our core brand identities that we will be building around our products. 2020 is also significant for the operation of our de-huller, located at the Wyoming Seed Certification Facility in Powell. Progress on the project was held up due to lack of conventional de-hulling capacity. But with the help of a $50,000 grant from the UW Institute for Innovation and Entrepreneurship we now have the only non-organic de-huller that we know of in any of the surrounding states. This is a key piece of equipment for making this project and the business successful.

## Results and Discussion

In 2020, we are growing spelt (Figure 2) and emmer wheat at three UW research locations and with several private producers. Our target market is brewpubs with these malted first-grains, and artisanal bakers with our grains for flour. We also provided some marketing materials, educational background, nutritional and promotional information to our customers.

**Acknowledgments**
Many thanks to the field crews and farm managers at Powell, Sheridan and Lingle. Camby, Sam, Dan and Kevin, without you and your crews, this project would not happen.

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**Keywords:** spelt, emmer, malt, flour, ancient grains, economic development, applied supply-chain research

**PARP:** IX

**Figure 1.** Trademarked Neolithic Brand logo and marketing slogan.

**Figure 2.** Spelt field at Sheridan Research & Extension Center, June 2020. (Photo: Dan Smith)

# Wyoming First Grains Project: Effect of Location, Irrigation and Nitrogen on Crop Growth, Yield, and Quality of Ancient Grains of Wheat in Wyoming

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### Introduction

Crop diversity in Wyoming is limited by poor soil health, arid conditions, isolation from markets, and high evapotranspiration demands. First grains like einkorn, emmer, and spelt are early predecessors of modern wheat and more adaptable to marginal agricultural land. There has been rapid increase in the market demand of ancient grains due to their desirable characteristics like higher protein (Campbell, 1997), distinct nutrition, and unique taste. First grains are thought to be a viable alternative small grain for Wyoming.

### Objectives

Identify agronomic management practices and fertility needs of spelt, emmer and einkorn. Determine how fertility affects agronomic traits and grain quality under multiple Wyoming growing conditions and locations.

### Materials and methods

This study was conducted at the Powell Research & Extension Center (PREC) in 2019. The experiment was a randomized design with 3 replications. Spelt, emmer, einkorn, and barley were grown under flood irrigation. They were planted on the 16 April at a seeding of 100 lbs/a. Nitrogen treatments of low, medium, and high (25, 50, 80 lbs nitrogen/a respectively) were applied to each plot before planting. Crops were harvested at maturity with a Zurn small plot combine and hulled and dehulled yield was calculated. Percent yield loss when the hull was removed was calculated as [1-(grain yield/hulled yield)].

### Results and discussion

Nitrogen treatments had a significant effect on hulled and naked grain yield (lbs/a) of all crops, with the highest yields in the high N treatment (Table 1). Nitrogen treatment had no significant effect on percent yield loss to hull for either spelt or emmer. However, spelt had higher loss than emmer. When comparing yield of the different grains, the grain yield of barley was higher than emmer and spelt and emmer was higher than spelt. However, lower yield of ancient grains might be offset with their high market demand and price premium.

**Table 1.** Average grain yield (lbs/a) of first grains. Yields are reported for hulled (grain in the hull) and grain (grain only with the hull removed). Percent yield loss [1-(grain yield/hulled yield)] is reported for spelt and emmer (loss). P-values for yield within each crop are given. NS means not significant, ND means no data, and NA means not applicable.

| N(lbs/a) | Barley | | | Spelt | | | Emmer | | | Einkorn | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hulled | Grain | Loss | Hulled | Grain | Loss | Hulled | Grain | Loss | Hulled | Grain | Loss |
| 25 | NA | 4596 ab | NA | 1139 b | 839 ab | 26% | 1847 b | 1451 ab | 21% | 2517 b | ND | ND |
| 50 | NA | 4197b | NA | 1071 b | 762 b | 29% | 1885 b | 1463 b | 22% | 2498 b | ND | ND |
| 80 | NA | 5168 a | NA | 1405 a | 1011 a | 28% | 2223 a | 1740 a | 22% | 3325 a | ND | ND |
| **P-value** | **NA** | **<0.05** | | **<0.001** | **<0.05** | **NS** | **<0.001** | **<0.05** | **NS** | **<0.001** | | |

The Wyoming first grains project will be continued through 2021. Future work includes dehulling of einkorn, grain quality analysis, and analysis of soil nitrogen and nitrogen use efficiency of each crop. Soil nitrogen and grain quality analysis will be used to determine nitrogen use efficiency of first grains. Studies have been repeated for the 2020 crop season. Future work will include studies on seeding rate to optimize yield of the first grains as well as market analysis for small and large acreage production.

**Acknowledgements**

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**Keywords:** ancient grains, agronomy, nitrogen, irrigation

**PARP:** I:2, II:10

# 2019 Grain Corn Hybrid Trial, Powell, Wyoming

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*Samual George, Powell Research & Extension Center*

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

## Introduction

Crop producers in the Bighorn Basin grow substantial acerage of corn for grain. However, few variety trials are conducted on available hybrids. Replicate trials of grain corn hybrids are needed in order for producers to make decisions for their own farms.

## Objectives

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

## Materials & Methods

The soil at the site was a Garland loam (OM: 1.6, pH: 8.1), and was broadcast fertilized with 95, 50, 0 units of N, P, K respectively on April 11th. Corn was planted May 14, at a rate of 38,000 seeds per acre with a Kincaid plot planter at 22" row spacing. Trial was furrow irrigated, and water was supplied according to crop needs (approximately once every 10 days). Roundup Weather Max® at 32 oz./a, plus Widematch at 3 pt/a, was applied for weed control when corn was 5 to 6 inches tall, on June 11th. A 33% nitrogen solution at 33 gal/a, was applied July 2th resulting in an additional 117 units of N. Plots were 11 feet wide by 50 feet long and arranged in randomized complete block design with 3 replications. Grain yields were estimated by harvesting 10 ft. from the two center rows from each plot on Nov 14. Grain moisture was measured from each plot using a Zurn Plot combine (Harvest Master software); all reported yields were adjusted to 15.5% grain moisture, and reported bushels were based on 56 lb. / bushel. Results can be found in Table 1.

## Results

**Table 1.** Yield, test weight, and moisture of 8 corn hybrids grown at PREC in 2019.

| Hybrid | Grain Yield † | Test Weight A | Test Weight B ‡ | Moisture |
|---|---|---|---|---|
| | bushels per acre | lbs/bu@ raw moisture | lbs/bu@ 15.5% moisture | % |
| LR 9880-VT2PRIB | 212 | 47.4 | 49.2 | 18.5 |
| LR 9883-VT2PRIB | 203 | 43.7 | 45.7 | 19.2 |
| LR 9882-VT2PRIB | 202 | 46.6 | 47.4 | 17.9 |
| 47J086-VIP3220 | 175 | 42.8 | 45.9 | 21.1 |
| G89A09-3120 | 172 | 39.1 | 44.0 | 24.9 |
| 40J779-VT2PRIB | 161 | 47.0 | 48.5 | 18.0 |
| G82M47-3220 | 160 | 42.7 | 45.2 | 20.2 |
| 47J988-3120 | 147 | 39.1 | 43.6 | 24.7 |
| **LSD (.05)** | **26** | **1.2** | **1.5** | **1.6** |

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

‡ *Test Weight B, Corrected test weight calculated per the following equation:*

*Test Weight B = [(84.5/(100-Moisture)] × TestWeightA*

*https://www.agry.purdue.edu/ext/corn/news/timeless/TestWeight.html*

### Acknowledgments

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**Keywords:** corn, silage

**PARP:** I:12

# 2019 SIMPLOT Silage Corn Hybrid Trial, Powell, Wyoming

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

## Introduction

Crop producers in the Bighorn Basin grow substantial acerage of silage corn for their livestock operations. However, few variety trials are conducted on available hybrids. Replicate trials of corn for silage hybrids are needed in order for producers to make decisions for their own farms.

## Objectives

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

## Materials & Methods

The soil at the site was a Garland loam (OM: 1.7, pH: 8.2), and was broadcast fertilized with 90, 50, 0 of N, P, K, on 11 May 2019. Five silage corn hybrids were planted on the 23rd of May 2019, at a rate of 38,000 seeds per acre with a Kincaid plot planter at 22" row spacing using a randomized complete block design with three replicates. Plots were 11 feet wide (6 rows) by 50 feet long. The trial was furrow irrigated, and water was supplied according to crop needs (approximately once every 10 days). Roundup Weather Max® (glyphosate) at 36 oz. / a, was applied for weed control when corn was 5 to 6 inches tall, on the 11th of June. A 33% nitrogen solution at 30 gal/a, was applied on the 2nd of July 2019 as an additional nitrogen fertilization, which is approximately 106 units of N. Corn heights were recorded previous to harvest. Silage yields were determined by harvesting two rows, 10-feet long in the center of each plot on the 13th of September 2019. The (fresh) harvested biomass was weighed, and a sub-sample of approximately one pound was collected from each plot and sent for quality analysis (Univ. Wisc). Sample moisture ranged from 72 to 80% (i.e., 20 to 28% dry matter). Specifically, protein was measured via near-infrared spectroscopy; net energy, milk yield, and TDN were calculated.

## Results

In general, the five hybrids were similar in their forage traits (Table 1). One exception was LR9895VT2PRIB which had a low crude protein. Silage yield averaged 35.8 tons per acre (fresh) and 8.8 tons per acre dry. Net energy, milk yield, and ADF averaged 0.71 Mcal per pound, 3430 pounds per ton, and 28%, respectively.

**Table 1.** Performance of five corn hybrids at Powell in 2019.

| Hybrid | Yield (fresh) | Yield (dry) | Moisture | Crude Protein | ADF | Height | Milk Yield | Net Energy Lactation3x |
|---|---|---|---|---|---|---|---|---|
| | tons/a | tons/a | % | % | % | inches | lbs per ton | Mcal per pound |
| 47J086-VIP3220 | 31.36 | 8.45 | 72.7 | 7.99 | 26.2 | 106 | 3430 | 0.72 |
| 47J988-3120 | 37.74 | 8.79 | 76.7 | 7.20 | 28.8 | 110 | 3420 | 0.71 |
| LR 97A89-3011A | 32.55 | 8.86 | 72.8 | 7.46 | 26.0 | 107 | 3420 | 0.71 |
| LR 9895-VT2PRIB | 40.81 | 8.89 | 78.7 | 5.87 | 32.5 | 109 | 3170 | 0.67 |
| LR9492-VT2PRIB | 37.06 | 9.05 | 75.2 | 7.15 | 26.6 | 105 | 3690 | 0.75 |
| **LSD (0.05)** | **3.45** | **ns** | **2.3** | **0.56** | **ns** | **ns** | **ns** | **ns** |
| **Prob > F** | **.032** | **0.957** | **0.029** | **0.016** | **0.272** | **0.066** | **0.513** | **0.495** |

*Results were subjected to ANOVA with sources of variation being Block (2 df), Hybrid (4 df), and error (5 df), due to three missing plots (but with a minimum of n=2 for each hybrid).*

**Acknowledgment**

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**Keywords:** corn, silage

**PARP:** I:12

# Annual Forages Following Barley in Sugarbeet-Barley Cropping Systems

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## Introduction

Sugarbeets and barley are important crops in the Big Horn Basin (BHB) and typically grown on two- or three-year rotations with corn or dry beans. This rotation is often destructive to soil health due to intensive tillage and long periods of bare soil, which contribute to poor soil structure and loss of soil organic matter (SOM), reducing the soil water and nutrient supplying capacity and increasing vulnerability to erosion and drought. Integrating cover crops has become a popular way to improve soil health in many cropping systems, but the short growing season in the BHB makes incorporation of cover crops into sugarbeet-based cropping systems difficult. The best opportunity is following summer barley harvest. Some producers are already using barley regrowth as a soil cover and for fall and winter forage. A few have begun to experiment with adding other species to increase benefits. However, many questions remain about the costs and benefits of cover crops.

## Objectives

To determine whether the extra expense of planting a cover crop mix or replanting barley provides advantages over simply allowing volunteer barley to regrow, with respect to soil health, forage quality, and effects on the yield and quality of the subsequent sugarbeet crop.

## Materials and Methods

We established replicated plots in the barley phase of our long-term reduced-tillage sugarbeet-bean-barley rotation at PREC with treatments including conventional fall tillage, no tillage following barley harvest allowing volunteer barley to regrow, replanting barley right after harvest at 75 lbs/acre, and planting a mix of nematode-control radish, flax, forage collards, and common vetch at 15 lbs/acre (approximately equal number of pure live seeds of each species). Volunteer barley served as a grass species in the cover crop mix. To assess soil health, we measured soil organic matter components that respond relatively rapidly to management changes in October when freezing temperature killed the cover crops and again in the spring prior to sugarbeet planting. To compare forage quality among the cover crop types, we sampled biomass from each at fall freeze up and analyzed them at Ward Lab in Kearney, NE. To determine effects on the subsequent crop, we sampled yield and sugar content of sugarbeets the year following the cover crops. This report covers findings from the first year (2018-2019) of this three-year study.

## Results and Discussion

We did not detect differences in soil health indicators or in sugarbeet yield and sugar content among the treatments. This is likely because this was only the first year of the study; repeatedly following barley with different cover crops could eventually lead to changes in soil health and sugarbeet yields, but will take a long time because, in this rotation, barley is only planted once every three years. For the comparison of forage quality among cover crop types, we found that all three provided abundant forage with adequate nutrition. We were not able to establish a good stand of the cover crop mix, but all species were represented and analyzed. We used that data to calculate differences in forage quality in the event we had been able to establish a better cover crop. Table 1 shows results of calculations with barley and the other four cover crop species making up different proportions of the stand.

The results indicate that the cover crop mix provides much better forage quality and higher yields than stands dominated by barley. The rich mix of all five species would produce over 17% more forage than the barley-dominated stand, which would have 35% more crude protein and 75% higher relative feed value (a measure of digestibility and the amount a cow is able to eat).

**Table 1.** Forage quality parameters calculated for different stand compositions from 2018 and 2019 data. Cover crop species other than barley include nematode-control radish, flax, forage collards, and common vetch.

| Forage component | 90% barley, 2.5% all others | 75% barley, 6.25% all others | 50% barley, 12.5% all others | 25% barley, 18.75% all others | 10% barley, 22.5% all others |
|---|---|---|---|---|---|
| Biomass (lbs/acre) | 2178 | 2250 | 2367 | 2493 | 2556 |
| Crude protein (%) | 14.7 | 15.6 | 17.3 | 18.9 | 19.9 |
| Relative forage quality | 120 | 123 | 128 | 133 | 136 |
| Relative feed value | 117 | 133 | 161 | 188 | 205 |

We think that, with control measures for volunteer barley and more experience with the cover crop species, it will not be difficult to grow a rich mixture of the cover crops. However, we do not know if the increases in forage quality and quantity indicated by our data and calculations would be sufficient to cover the added costs of planting the cover crop mixture. Economic analysis is underway to address this question.

**Acknowledgments**
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**Keywords:** cover crops, annual forages, sugarbeet-barley rotation

**PARP:** I:3, I:6, I:13, II:9

# 2019 Dry Bean Performance Evaluation

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*Steven Camby Reynolds, Powell Research & Extension Center*

*Jolene Sweet, Wyoming Seed Certification Service*

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## Introduction

The Wyoming Bean Commission funds and the dry bean variety performance evaluation at the Powell Research & 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 60 units of nitrogen, 60 units of phosphorous, and 25 units of potassium 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, but cool wet spring conditions were followed by a cool summer with light hail events, and sufficient flea beetle damage to require treatment. Flowering dates, maturity dates, and yield are presented in Table 1.

## Acknowledgments

The authors thank the Wyoming Bean Commission for funding the project.  The authors also thank the PREC staff for assistance throughout the study.  The authors also acknowledge the support of USDA-NIFA projects WYO-604-19 and WYO-562-16.

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

**PARP:** Goal 2

**Table 1.** Agronomic data, 2019 dry bean performance evaluation, Powell, Wyoming.

| Name | Market Class | Bloom Days after Planting | Buckskin Days after Planting | Seeds per Pound | Yield Lbs/A |
|---|---|---|---|---|---|
| La Paz | pinto | 56 | 94 | 1234 | 3392 |
| Othello | pinto | 43 | 73 | 1069 | 2784 |
| PT 11-13-1 | pinto | 52 | 95 | 1496 | 4524 |
| PT 16-9 | pinto | 52 | 96 | 1194 | 3716 |
| ND Falcon | pinto | 56 | 99 | 1188 | 3049 |
| NE2-17-37 | pinto | 49 | 82 | 1432 | 3163 |
| NE4-17-6 | pinto | 44 | 80 | 977 | 3969 |
| NE4-17-10 | pinto | 45 | 81 | 1048 | 3399 |
| Eclipse | black | 54 | 95 | 2119 | 3581 |
| OAC Vortex | black | 54 | 97 | 1899 | 4439 |
| MS Knight Rider | black | 54 | 101 | 2182 | 3728 |
| NE14-18-4 | black | 52 | 86 | 1853 | 3226 |
| AC Portage | navy | 49 | 86 | 2273 | 2507 |
| ACUG-16-6 | navy | 52 | 95 | 2366 | 3390 |
| NE13-18-2 | pink | 49 | 85 | 1358 | 3764 |
| Cayenne | SR | 52 | 94 | 1267 | 3668 |
| ND Pegassus | GN | 53 | 99 | 1067 | 3796 |
| NE1-17-36 | GN | 52 | 91 | 1080 | 3659 |
| Cal Early | LRK | 42 | 77 | 756 | 2391 |
| Whitetail | WK | 44 | 84 | 877 | 2339 |
| Red Cedar | DRK | 45 | 90 | 871 | 2300 |
| AAC Scotty | CB | 43 | 77 | 786 | 2799 |
| OAC Racer | CB | 43 | 75 | 712 | 2812 |
| OAC Candycane | CB | 43 | 77 | 716 | 2620 |
| NE9-18-3 | CB | 42 | 76 | 854 | 2720 |
| Cowboy | pinto | 52 | 94 | 1180 | 3829 |
| Ace | black | 53 | 92 | 2103 | 3426 |
| Nugget | yellow | 45 | 93 | 1023 | 2673 |
| Myasi | yellow | 47 | 90 | 941 | 3819 |
| Black Tails | black | 53 | 87 | 2089 | 4113 |
| Spectre | black | 54 | 102 | 1938 | 3074 |
| Ruby | SR | 52 | 95 | 1458 | 4277 |
| Patron | yellow | 45 | 98 | 979 | 3932 |
| | **Mean** | **49** | **89** | **1345** | **3360** |
| | **LSD** | **0.7** | **1.5** | **86** | **998** |
| | **CV** | **2.9** | **3.4** | **13.1** | **21.2** |

*SR - Small Red* *GN - Great Northern* *LRK - Light Red Kidney*

*CB - Cranberry* *DRK – Dark Red Kidney* *WK - White Kidney*

# Response of Six Recombinant Inbred Dry Bean Lines and Released Cultivars to Withholding N and P

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## Introduction

Worldwide, breeders have been trying to develop dry bean lines that require less fertilizer (Chekanai et al., 2018; Wilker et al., 2018). Primary focus has been on N and P. Despite being a $N_2$-fixing legume, N applications have proven profitable due to dry bean being an ineffective $N_2$-fixer. Available soil P varies greatly and genotypes that are more efficient in extracting P from soil have obvious benefits. Although both elements have the potential effect of increasing yield, they can also contribute to eutrophication of fresh waterways.

## Objectives

The objective of this study was to quantify the response of a set of six dry bean sister lines (a.k.a., recombinant-inbred lines) and five commercial cultivars to withholding N and P.

## Materials and Methods

Pre-season soil test indicated that available soil N was 56 pounds per acre; available soil P was 18 pounds per acre. Soil type was a Garland clay loam, (fine, mixed, mesic: Typic Haplarid). Prior to planting in May 2019, 50 lbs N/ac was applied as UAN; 62 lbs P/ac was applied as TSP to selected strips in the field resulting in four treatments (1, No-N, No-P; 2, NoN, Plus P; 3, Plus N, No-P; and 4, Plus-N, Plus-P). Plots were 20-feet long by 11-foot wide with 6 rows per plot and a 22-inch row spacing. The study was sown on 3 June using 11 entries, five released cultivars and six experimental lines referred to as LPID-x. The experimental design was a split-plot with NP strips the main factor and entry the subplot (three replicates, 120 plots total). Plots were furrow irrigated; water stress was never observed. Flowering, NDVI, leaf chlorophyll (SPAD), canopy temperature, leaf N/P concentration, maturity, and yield data were collected.

## Results and Discussion

Yield averaged across all 11 entries is presented in Table 1. Yields were excellent but neither N, P, nor their interaction affected yield. Although not significant, it did appear that withholding both N and P hurt yield more than withholding just one of those elements. The entries differed significantly across all traits (Table 2). The entries did not interact with either N or P. NDVI was reduced but only when both N and P were withheld which is consistent with the yield trends observed (Table 3). Seed yield of the six sister lines was correlated with canopy temperature for two dates in early August.

**Table 1.** Effect of N and P fertility treatment on the yield of dry bean (lbs/a) in Powell in 2019. Values are averaged across the 11 entries. There was no N effect, P effect, nor was there any significant N-by-P interaction. Probabilities of significance for the three factors were: N (P = 0.616), P (P = 0.621), N-by-P (P = 0.289) yield.

| Nitrogen Rate | Phosphate Rate | |
|---|---|---|
| | 0 | 62 lbs/a (140 lbs $P_2O_5$/a) |
| 0 | 3915 | 4160 |
| 50 lbs/a | 4160 | 4070 |

**Table 2.** Flowering date, maturity date, grain yield, height, upright rating, SPAD (2 Aug), leaf [N], and leaf [P] of six experimental lines and five check cultivars grown in Powell in 2019. Upright rating is zero (0) if completely fallen over and 10 if completely upright. Values are averaged across the four combinations of soil-applied N/P.

| Entry | Flowering | Maturity | Yield | Height | Upright | SPAD ‡ | Leaf N § | Leaf P ¶ |
|---|---|---|---|---|---|---|---|---|
| | dap | dap | lbs/a | cm | scale | unit | % | % |
| La Paz | 59 | 98 | 4575 | 75 | 8.4 | 47 | 4.4 | 0.33 |
| Long's Peak † | 51 | 89 | 3915 | 70 | 8.2 | 46 | 3.8 | 0.33 |
| LPID-3 | 48 | 89 | 4220 | 65 | 7.1 | 45 | 3.7 | 0.29 |
| LPID-7 | 52 | 91 | 4210 | 67 | 6.1 | 44 | 4.0 | 0.30 |
| LPID-9 | 55 | 98 | 4110 | 84 | 4.7 | 47 | 4.3 | 0.30 |
| LPID-11 | 51 | 88 | 4060 | 65 | 4.7 | 44 | 3.8 | 0.27 |
| LPID-28 | 51 | 92 | 3590 | 75 | 4.2 | 46 | 4.1 | 0.30 |
| LPID-29 | 52 | 89 | 4040 | 61 | 5.5 | 45 | 3.8 | 0.31 |
| Poncho | 48 | 85 | 4070 | 82 | 5.0 | 52 | 3.7 | 0.24 |
| Sundance | 54 | 91 | 4045 | 48 | 6.6 | 46 | 3.7 | 0.27 |
| UI-537 † | 48 | 84 | 3970 | 56 | 3.9 | 48 | 3.4 | 0.22 |
| **LSD (0.05)** | **2** | **2** | **290** | **7** | **1.1** | **2** | **0.4** | **0.02** |
| **P > F** | **0.001** | **0.001** | **0.001** | **0.001** | **0.001** | **0.001** | **0.001** | **0.001** |

† *Long's Peak and UI-537 are the parental lines to all LPID progeny.*

‡ *Averaged across entries, SPAD was 46.2.*

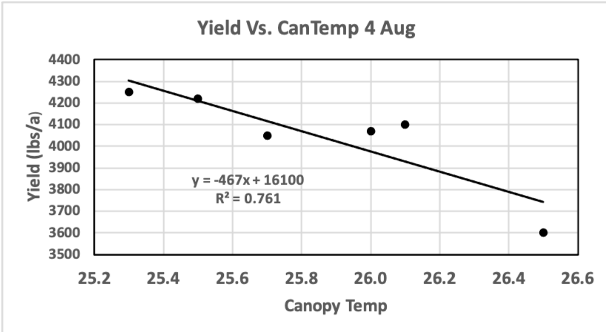
§ *Averaged across entries, leaf N concentration was 3.9%*

¶ *Average leaf P concentration was 0.29%.*

**Table 3.** Effect of N and P treatment on NDVI† on 26 July 2019. The N-by-P interaction was $P = 0.070$.

| Nitrogen Rate | Phosphate Rate | |
|---|---|---|
| | 0 | 62 lbs/a (140 lbs $P_2O_5$/a) |
| 0 | 0.64 | 0.70 |
| 50 lbs/a | 0.69 | 0.67 |

† *The lower values of NDVI are associated with crop stress and/or poor stands (not observed in this test).*



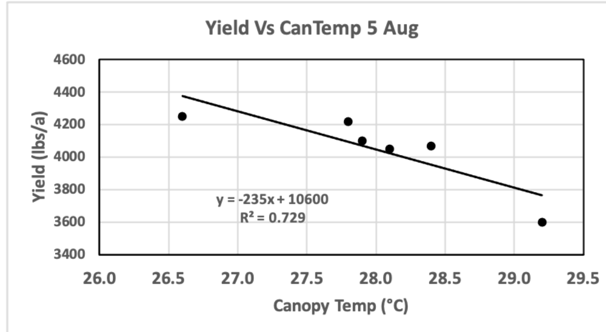




**Figure 4.** Relationship between grain yield and canopy temperature on two dates during mid-podfill of the six sister lines averaged across all N and P rates. Each point represents 12 observations.

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**PARP:** Goal 1

# Impact of Maturation Stage and Pod Color at Harvest on Popping Percentage of Popping Bean Lines of *Phaseolus vulgaris*

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## Introduction

American consumers of all ages currently fall short of dietary guidelines for a variety of foods and nutrients including beans/legumes and dietary fiber. Barriers to regular bean consumption often include unfamiliarity with how to prepare them and lack of time to plan and include them with meals or snacks. 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, soft-textured 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). 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. Important factors for growers would include yield and harvest data for popping beans cultivated in Wyoming. Important considerations for consumers would include popping percentage and sensory attributes of popping beans.

## Objectives

Objectives of the project include: 1) measure the impact of harvest date on popping percentage, 2) evaluate advanced breeding lines of nuña beans for popping characteristics and desirable agronomic characteristics within the Wyoming growing environment.

## Materials and Methods

Five day-neutral popping bean lines (CO 49956, CO 49957, CO 50004, WI 19, WI 21) from the USDA *Phaseolus* collection were sown in the field at PREC on 3 June 2019 using conventional cultural practices. Pods were harvested as they turned brown during mid-September. In late September 2019, we learned of a 25°F prediction for early October and the temperature dropped to 23°F on 3 Oct 2019. Thus, we hand-pulled pods for a two-week period, sorted pods by color (brown, yellow, green) and allowed pods to air dry indoors for approximately six weeks before hand-shelling. Seed batches were then tested for seed size, germination percent (5 Feb 2020) and popping percent (13 Feb 2020). To assess popping percentage, ten seeds from each line and pod color were heated in one teaspoon of canola oil in a cast iron pan until the oil reached a temperature of 250°F for a period of 1.5 to 2.0 minutes to induce popping. Temperature was measured using an infrared thermometer.

### Results and Discussion

Results from the popping testing of each line and pod color are presented in Table 1. Popping percentage of brown and yellow pods from all lines except CO 49956 achieved 90-100% popping. Pod color impacted popping percentage of CO 49957 with green pods have a lower number of seeds that popped. Pod color did not impact popping percentage of other lines. Seed size (i.e., weight per seed) did not significantly impact popping percentage.

**Table 1.** Traits of pop-bean lines of pods hand-harvested on different dates, Fall 2019.

| Line – Plot # | Harvest Date | Pod Color | Seed Size | Germ | Pop |
|---|---|---|---|---|---|
| | | Brn-Yel-Grn | mg | % | % |
| CO49956 brown-striped pinto | 28 Sept | Brown | 435 | 96 | 30 |
| | 28 Sept | Yellow | 507 | 88 | 35 |
| | 28 Sept | Green | 405 | 92 | 25 |
| | 8 Oct | Unknown | 458 | 78 | 95 |
| | | | | | |
| CO49957 black-striped pinto | 28 Sept | Brown | 535 | 76 | 100 |
| | 28 Sept | Yellow | 536 | 78 | 100 |
| | 28 Sept | Green | 406 | 90 | 45 |
| | 8 Oct | Unknown | 601 | 72 | 85 |
| | | | | | |
| CO50004 black-striped pinto | 28 Sept | Brown | 507 | 90 | 90 |
| | 28 Sept | Yellow | 502 | 90 | 100 |
| | 28 Sept | Green | 402 | 92 | 70 |
| | 25 Sept | Unknown | 467 | 88 | 95 |
| | 6 Oct | Unknown | 442 | 74 | 90 |
| | | | | | |
| Wisc 19 purple-black | 28 Sept | Brown | 447 | 80 | 95 |
| | 28 Sept | Yellow | 452 | 56 | 95 |
| | 29 Sept | Yellow | 505 | 70 | 90 |
| | 30 Sept | Yellow | 389 | 68 | 90 |
| | 28 Sept | Green | 343 | 82 | 85 |
| | 29 Sept | Green | 433 | 96 | 80 |
| | 30 Sept | Green | 350 | 92 | 90 |
| | 28 Sept | Brown | 469 | 84 | 100 |
| | 8 Oct | Unknown | 463 | 70 | 95 |
| | | | | | |
| Wisc 21 maroon-crimson | 28 Sept | Brown | 389 | 98 | 100 |
| | 6 Oct | Brown | 430 | 94 | 100 |
| | 28 Sept | Yellow | 435 | 98 | 100 |
| | 1 Oct | Yellow | 440 | 98 | 100 |
| | 28 Sept | Green | 348 | 98 | 95 |
| | 1 Oct | Green | 307 | 98 | 90 |

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

**PARP:** VII.10

# Dry Bean Soil-Borne Disease Management with an Integrated Approach with Tillage, Variety, and In-Furrow Fungicides at PREC

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*Kyle Webber, Wyoming Seed Certification*

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## Introduction

Soil-borne dry bean diseases such as Rhizoctonia and Fusarium root rots 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. This is the second year results of this study.

## Materials and Methods

The study was established in 2019 at the Powell Research & 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 5 June with a Kincaid planter/sprayer. Sub-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, severity of root rot (recorded twice, 16 July and 20 Sept), and bean yield.

## Results and Discussion

Tillage treatments resulted in significant differences for soil compaction, with 39% more compaction probe penetration with deep tillage compared to conventional tillage. However, tillage treatment had no significant effect on measured crop stands, disease severity, vigor and seed yield. Unlike results in 2018, there were no main differences between varieties for all parameters measured. There was a 100% disease incidence in all sampled plants for both rating dates. Disease encountered was primarily due to *Fusarium* species and some *Rhizoctonia solani*. Fungicide treatments had no significant effect on measured disease for all comparisons. After 2 years of this study (at PREC and SAREC) conclusions were that soil compaction can be reduced with deep tillage however this did not necessarily translate to reductions in soil-borne root disease pressures. In-furrow fungicide treatments sometimes slightly reduced disease severity but is probably not worth the extra expense especially when disease pressure was fairly high at these sites. Bean varieties as expected, behaved differently in terms of disease and yields but lower disease did not equate to higher yields.

**Acknowledgments**
We thank the 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 beans with a systems approach of varietal selection, in-furrow fungicides, and tillage treatments at PREC in 2019.

| Main Treatments | Stand Count (# per 80 ft) | Compaction (in. penetrated)[1] | Root Disease Severity (0-4)[2] | | Vigor (0-100%)[3] | Bean yield (lb/ac) |
|---|---|---|---|---|---|---|
| | 24 Jun | 5 Jun | 16 Jul | 20 Sep | 16 Jul | |
| Tillage | | | | | | |
| Conv. Tillage | 212.4 a[4] | 10.3 a | 1.6 a | 3.1 a | 100.0 a | 3636 a |
| Deep Tillage | 210.6 a | 14.3 b | 1.5 a | 3.1 a | 101.1 a | 3914 a |
| Fungicide | | | | | | |
| Untreated | 214.4 a | -- | 1.6 a | 3.1 a | 100.0 a | 3767 a |
| Headline | 213.7 a | -- | 1.6 a | 3.0 a | 101.3 a | 3865 a |
| Proline | 206.3 a | -- | 1.5 a | 3.1 a | 100.4 a | 3693 a |
| Cultivar | | | | | | |
| Long's Peak | 211.1 a | -- | 1.5 a | 3.1 a | | 3763 a |
| Montrose | 193.2 a | -- | 1.6 a | 2.9 a | -- | 3999 a |
| ND Palomino | 219.1 a | -- | 1.5 a | 3.2 a | -- | 3855 a |
| Othello | 221.2 a | -- | 1.7 a | 3.1 a | -- | 3583 a |
| Sundance | 212.7 a | -- | 1.5 a | 3.2 a | -- | 3676 a |

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

# Alfalfa Variety Trial

*Investigators:*

*Samual George, Powell Research & Extension Center*

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

*Steven Camby Reynolds, Powell Research & Extension Center*

**Issue**
Compare different varieties of alfalfa for yield and feed quality results in northwestern Wyoming.

**Goal**
Evaluate different alfalfa varieties to determine which varieties yield the best and have the best feed quality in this specific region.

**Objectives**
Assess alfalfa varieties based on yield and feed quality

**Trial Information**
Two separate experiments were sown in April 2020. One experiment consists of glyphosate-tolerant lines only and the second experiment consists of conventional varieties. Each experiment has four replicates. Both experiments are being grown under furrow irrigation through 2022.

**Impact**
Results from this study will provide growers better decision making information when it comes to what variety of alfalfa they want to plant and its expected yield and feed quality.

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**Keywords:** alfalfa, variety trial, forage, quality, yield, feed, herbicide-tolerance.

**PARP:** II:2

# Micronutrient Use in Sugar Beets

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*Samual George, Powell Research & Extension Center*

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**Issue**

Micronutrients can be the limiting factor in the ability of sugar beet to produce higher yield and/or sugar content.

**Goal**

Evaluate different micronutrient treatments to determine which combination and timing results in the best yield and sugar content.

**Objectives**

Assess micro-nutrient efficacy by determining impact on crop yield and sugar content.

**Trial Information**

Studies were initiated in 2020 comparing untreated check plots with a conventional soil-applied fertility program and a foliar-applied solution containing a combination of N, S, B, Mn, Mo, and S.

**Impact**

Results from this study will provide information the use of micro-nutrients that can potentially be used in the future.

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**Keywords:** sugarbeet, micronutrient.

**PARP:** II:2

# Evaluation of Roundup Ready Alfalfa for Adaptability on Wyoming Conditions

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## Introduction

Glyphosate-resistant Roundup ready (RR) alfalfa was first commercialized in 2005 in the United States. Since then several RR alfalfa cultivars are available in the market. Alfalfa being the most important forage crop, RR alfalfa has added several benefits over conventional cultivars including control of undesirable vegetation and reliable stand establishment. One of the advantages of using RR alfalfa is to keep grass and weeds away from the stand and prolong the forage yield and reduce the cost of replanting. Therefore, selecting a suitable cultivar of RR alfalfa is important.

## Objectives

To evaluate the growth, yield, and adaptability of RR alfalfa cultivars in Wyoming's conditions

## Materials and Methods

The study included 25 RR alfalfa cultivars (Table 1) planted with four replicates at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC), Lingle. Alfalfa seeds were sourced from Forage Genetics International. Seeding was done on 5 ft × 20 ft plots in spring of 2013 using a cone planter under irrigation. Glyphosate was uniformly applied to all plots at 3-trifoliate seedling stage to control weeds in the establishment year. Data collection included weed coverage, plant growth, yield, and nutritive value.

## Results and Discussion

Long term RR alfalfa performance varied year to year depending on external factors such as weather conditions. All the cultivars in the study had the highest growth in the year 2016 and 2017. No variations ($p>0.05$) were observed among cultivars for forage yield. The average yield obtained from 2013 to 2019 ranged from 2.5 (WL 372HQ.RR) to 3.1 (R59Hg217) tons per acre. The average yield of all cultivars from 2013-2019 is 2.8 tons per acre which is close to average alfalfa yield in Wyoming (2.9 tons per acre). Little variation in forage yield among cultivars in the study indicates RR alfalfa can successfully establish in Wyoming conditions. Although the productive age of alfalfa varies 4-8 years depending on management practices and weather conditions, the study shows the adaptation of RR alfalfa cultivars (e.g., R59Hg217) with the potential to extend stand persistence and contribute to above-average yield.

**Table 1.** Forage dry matter (DM) yield of Roundup Ready alfalfa cultivars at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center, Lingle from 2013 to 2019.

| Cultivars | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Average |
|---|---|---|---|---|---|---|---|---|
| | DM (tons per acre) | | | | | | | |
| 6497R | 1.7 | 1.9 | 2.0 | 4.5 | 4.7 | 2.9 | 1.7 | 2.8 |
| 6516R | 1.8 | 2.0 | 2.0 | 4.2 | 5.0 | 3.1 | 1.8 | 2.9 |
| 6547R | 2.1 | 2.1 | 2.1 | 3.8 | 4.5 | 2.7 | 1.6 | 2.7 |
| Ameristand 415NT RR | 2.3 | 1.9 | 2.1 | 4.2 | 4.6 | 2.4 | 1.6 | 2.7 |
| Ameristand 433T RR | 2.1 | 2.0 | 2.1 | 3.5 | 4.8 | 2.7 | 1.6 | 2.7 |
| Ameristand 455TQ RR | 2.0 | 1.9 | 2.0 | 3.8 | 5.0 | 2.8 | 1.7 | 2.7 |
| Consistency 4.10RR | 2.1 | 1.9 | 2.3 | 3.7 | 4.5 | 2.9 | 1.7 | 2.7 |
| Denali 4.10RR | 1.9 | 2.0 | 2.1 | 4.0 | 4.4 | 2.8 | 1.7 | 2.7 |
| DKA46-16 RR | 2.0 | 2.0 | 2.1 | 4.2 | 4.6 | 2.7 | 1.5 | 2.7 |
| Integra 8444 RR | 1.9 | 1.7 | 1.9 | 3.5 | 4.7 | 2.7 | 1.7 | 2.6 |
| Mutiny | 1.9 | 2.2 | 2.1 | 3.0 | 4.6 | 2.7 | 1.7 | 2.6 |
| R312W244 | 1.9 | 1.9 | 1.9 | 3.6 | 5.0 | 2.9 | 1.6 | 2.7 |
| R49W215 | 2.1 | 2.0 | 2.0 | 3.9 | 4.2 | 2.7 | 1.6 | 2.7 |
| R570K217 | 2.1 | 2.0 | 2.2 | 3.8 | 5.0 | 2.7 | 1.7 | 2.8 |
| R58W235 | 2.1 | 1.8 | 2.1 | 4.3 | 4.6 | 2.8 | 1.7 | 2.8 |
| R59Hg217 | 2.2 | 1.9 | 2.2 | 5.1 | 5.1 | 3.5 | 1.8 | 3.1 |
| RR Apha Tron | 2.1 | 2.0 | 2.2 | 4.3 | 5.6 | 3.3 | 1.7 | 3.0 |
| RR Nema Star | 2.2 | 2.0 | 2.1 | 4.8 | 5.1 | 3.0 | 1.7 | 3.0 |
| RR Presteez | 2.0 | 1.9 | 2.0 | 3.4 | 5.5 | 3.0 | 1.7 | 2.8 |
| RR Stratica | 2.0 | 2.1 | 2.3 | 4.2 | 4.9 | 2.9 | 1.8 | 2.9 |
| RR Tunnica | 2.0 | 2.1 | 2.2 | 4.7 | 5.5 | 3.1 | 1.7 | 3.0 |
| WL 355RR | 2.2 | 2.1 | 2.1 | 4.3 | 5.2 | 3.1 | 1.7 | 3.0 |
| WL 367RR/HQ | 2.1 | 2.0 | 2.2 | 4.5 | 4.8 | 3.2 | 1.7 | 2.9 |
| WL 372HQ.RR | 2.1 | 1.9 | 2.0 | 3.4 | 4.2 | 2.7 | 1.6 | 2.5 |
| WL356HQ.RR | 2.0 | 2.0 | 2.1 | 3.9 | 4.7 | 2.5 | 1.6 | 2.7 |
| **Mean** | **2.0** | **2.0** | **2.1** | **4.0** | **4.8** | **2.9** | **1.7** | **2.8** |
| **LSD (0.05)** | **0.3** | **0.3** | **0.3** | **1.1** | **0.9** | **0.7** | **0.2** | **-** |
| **P-value** | **0.06** | **0.61** | **0.70** | **0.08** | **0.081** | **0.44** | **0.999** | **-** |


### Acknowledgment

We acknowledge funding from Forage Genetics International and assistance from SAREC crew for maintaining experimental plots



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**Keywords:** alfalfa, Roundup-ready, cultivars

**PARP:** I:1,2, III:1,2,3,6, VIII:2,4

# Evaluating Alfalfa Cultivars for Adaptability and Forage Yield Production Under Wyoming's Conditions

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*Chandan Shilpakar, Department of Plant Sciences*

## Introduction

Alfalfa (*Medicago sativa* L.) is one of the world's most important perennial forage crops, and the premier cash crop in Wyoming and other neighboring states. It is popularly known as the "Queen of Forages" due to its ability to produce high forage yield with exceptional quality, and it is preferred by livestock compared to forage grasses. In modern management for an efficient alfalfa forage system, the use of improved cultivars is one of the key players for improving alfalfa for a sustainable production. Under Wyoming's conditions, it is therefore necessary to identify alfalfa cultivars of higher productivity to help improve the forage production base of the region.

## Objectives

To evaluate the adaptability and forage yield potential of different cultivars of alfalfa under Wyoming's conditions.

## Materials and Methods

The study was established in 2011 at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Treatments were ten cultivars of alfalfa: "Magnum 7", "Magnum Salt", "WL 354 HQ", "AmeriStand 407TQ", "6422Q", "AmeriStand 405T RR", "AmeriStand 433T RR", "WL 319 HQ", "Vernal", and "Falcata". The experiment was set up in a randomized complete block design with three replications under irrigated conditions. All limiting soil nutrients were managed for adequacy. Inoculated alfalfa seeds were planted on September 20, 2011 at a seeding rate of 20 pounds pure live seed per acre. 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 at least 72 hours to determine forage yield on dry matter basis.

## Results and Discussion

Alfalfa forage yield did not vary among the cultivars. However, numerically, forage yield was highest (12.87 tons per acre) for AmeriStand 433T RR, and lowest (11.19 tons per acre) for AmeriStand 407TQ when forage yields from 2015 to 2019 were summed (Table 1). On average, annual alfalfa forage yield was higher in 2016 (3.79 tons per acre) than in 2017 (2.43 tons per acre), 2015 (2.41 tons per acre), 2018 (1.67 tons per acre), and 2019 (1.64 tons per acre) (Table 1). This slight variation could be associated to abiotic stress and their influence on the plants due to variations in soil moisture, and temperature which is likely to have interrupted alfalfa's growth at certain stage of development in a particular year. Overall, results indicate that the cultivars have similar ability to maintain higher or comparable yields. Therefore, this suggests that the cultivars are adaptable to Wyoming's conditions and they have good potential of improving alfalfa forage production in the region.

**Table 1.** Forage yield of alfalfa cultivars at SAREC from 2015 to 2019

| Cultivar | 2015 | 2016 | 2017 | 2018 | 2019 | Total |
|---|---|---|---|---|---|---|
| | Tons per acre† | | | | | |
| Magnum 7 | 2.50a‡ | 4.16a | 2.59a | 1.81a | 1.78a | 12.85a |
| Magnum Salt | 2.28a | 3.40a | 2.57a | 1.62a | 1.69a | 11.56a |
| WL 354 HQ | 2.34a | 4.33a | 2.21a | 1.54a | 1.57a | 11.99a |
| AmeriStand 407TQ | 2.39a | 3.40a | 2.31a | 1.50a | 1.58a | 11.19a |
| 6422Q | 2.55a | 3.68a | 2.47a | 1.67a | 1.79a | 12.16a |
| AmeriStand 405T RR | 2.32a | 3.28a | 2.27a | 1.63a | 1.78a | 11.28a |
| AmeriStand 433T RR | 2.53a | 4.50a | 2.49a | 1.79a | 1.56a | 12.87a |
| WL 319 HQ | 2.19a | 3.63a | 2.57a | 1.92a | 1.54a | 11.85a |
| Vernal | 2.40a | 4.34a | 2.43a | 1.67a | 1.65a | 12.49a |
| Falcata | 2.57a | 3.15a | 2.44a | 1.59a | 1.47a | 11.21a |
| **Average** | **2.41** | **3.79** | **2.43** | **1.67** | **1.64** | **11.94** |

† *Values are averaged over all three harvests for each year.*

‡ *Within each column, means followed by the same lowercase letters are not significantly different at 0.05 probability level.*

**Acknowledgments**

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

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**Keywords:** adaptability, alfalfa cultivars, forage yields

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

# Potassium, Cultivar, and Harvest Management for Improved Alfalfa Production

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## Introduction

In modern animal farming, growers and livestock producers prefer high forage yields with sustained nutritive value for hay production. Among forage crops, alfalfa (*Medicago sativa* L.) has the greatest potential for meeting this requirement. Potassium (K) is highly required by alfalfa for high productivity. Replenishment of K following frequent alfalfa harvests and baling is, therefore, essential to maintain soil K levels for optimum forage production in subsequent growing seasons. Integrating K application on alfalfa with agronomic managements such as cultivar and harvest time could offer an advantage of optimizing K's effect for an improved and sustainable alfalfa production. Unfortunately, limited information is available of the interaction effect of K, cultivar, and harvest time on alfalfa.

## Objectives

To determine the interaction effect of K, cultivar, and harvest management on forage yield of alfalfa.

## Materials and Methods

The study was established in 2016 at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) under irrigated conditions. Treatments were (a) four K rates (0, 50, 100, and 150 pounds $K_2O$ per acre); (b) two cultivars ["Hi-Gest 360" (highly digestible) and "AFX 457" (conventional)]; and (c) two harvest times [early harvest, late bud to early (10%) bloom; late harvest, 7 days after early harvest]. The experiment was laid out in a 4 × 2 × 2 factorial arrangement 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 prior to 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

There was no significant ($P > 0.05$) effect of cultivar on forage yield throughout the study. However, on average, AFX 457 produced a numerically higher (5710 pounds per acre) forage yields than Hi-Gest 360 (5532 pounds per acre). Potassium × harvest time interaction had a significant ($P < 0.05$) effect on forage yield across the number of cuts. For each year, when results from all four cuts were summed over both cultivars, the highest average total annual yield was produced from 150 pounds $K_2O$ per acre application rate at early harvest (6,350 pounds per acre), and 100 pounds per $K_2O$ per acre application rate at late harvest (6,185 pounds acre) (Table 1). This indicates that for higher alfalfa forage yield production, a moderate level of K is required when alfalfa is cut late, whereas high level of K is required when alfalfa is cut early. The dynamics that exist between plant regrowth rate and their level of root reserve following time of harvest might have influence the level of K required for optimum yield. In general, forage yields were greater in 2017 than in 2018 under both harvest times (Table 1). This was probably due to unfavorable weather conditions in 2018 compared to 2017 and its impact on plant growth. Similar K × harvest time interaction effect on alfalfa in both years (Table 1) suggests that alfalfa yield could be improved for a sustainable production with an appropriate K application rate based on time of harvest.

**Table 1.** Total and two-year average forage yield of alfalfa affected by potassium and harvest time in 2017 and 2018 at SAREC

| Potassium ($K_2O$) | 2017 | | 2018 | | Two-year average | |
|---|---|---|---|---|---|---|
| (pounds per acre) | Early cut† | Late cut‡ | Early cut | Late cut | Early cut | Late cut |
| | Pounds per acre§ | | | | | |
| 0 | 7,053b# | 7,722c | 3,248c | 3,595b | 5,151c | 5,659c |
| 50 | 7,071b | 7,970c | 3,546b | 3,694b | 5,308b | 5,832b |
| 100 | 7,079b | 8,529a | 3,475b | 3,841a | 5,277b | 6,185a |
| 150 | 8,146a | 8,030b | 4,553a | 3,832a | 6,350a | 5,933b |
| **Average** | **7,337** | **8,064** | **3,705** | **3,741** | **5,522** | **5,903** |

†*Early cut, late bud to early [10%] bloom stage.*

‡*Late cut, 7 days after early cut.*

§*Values were averaged over all 4 cuts under each harvest time.*

#*Within each column, means followed by the same lowercase are not significantly different at 0.05 probability level.*

**Acknowledgments**
We thank SAREC crew, Alforex Seed Company, and UW forage agronomy laboratory members for study assistance. The project was funded by USDA NIFA Alfalfa and Forage Research Program.

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**Keywords:** alfalfa, potassium, harvest time, forage yield

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

# Response of Alfalfa to Phosphorus and Potassium in Association with Calcium, Magnesium, and Harvest Management

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## Introduction

Sustaining higher alfalfa forage yield for improved hay production is a key consideration of alfalfa growers and livestock producers. However, higher alfalfa yields cannot be sustained until the nutrients removed from the soil as a result of increased crop production are replenished. Replenishment of phosphorus (P) and potassium (K) alone in alfalfa stand might not be enough for a sustainable alfalfa production until their relative levels with secondary macronutrients such as calcium (Ca) and magnesium (Mg) are well balanced to allow for their availability and uptake by alfalfa and their effect being optimized by harvest time.

## Objectives

To determine the interaction effect of phosphorus × potassium × calcium × magnesium × harvest time on alfalfa's productivity.

## Expected impact

Results from this study will help to update the current P and K fertility guide in Wyoming and further improve soil fertility recommendations to establish a novel management practice for an improved and sustainable alfalfa production across the region.

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Keywords: fertility management, harvest time, forage yield, sustainability, hay production

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

# Response of Alfalfa to Sulphur and Boron Fertilization

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### Introduction

Alfalfa (*Medicago sativa* L.) is an important source of hay for animal production because it has low fiber content, high forage quality, and high digestibility. Nutrient removal following alfalfa harvest for hay production is often high such that it can lower alfalfa's productivity in future harvests when the nutrients are not replenished. Secondary and micronutrients such as sulphur (S) and boron (B) are important for nutrient balance to help meet the plant's nutrient needs. Compared to other crops, alfalfa is most sensitive to B deficiency, and therefore it requires higher amount of B for proper growth and development for an efficient forage system. However, reports have stated that in alfalfa production systems, it is rare for B deficiency to occur without S deficiency. Unfortunately, unlike phosphorus and potassium, growers often overlook the application of S and B on alfalfa when making fertilizer application decisions.

### Objectives

To evaluate the effect of sulphur and boron on forage yield and quality of alfalfa.

### Materials and Methods

The experiment was established at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) in 2011 under irrigated conditions. Treatments included (a) three rates of S (0, 10, and 20 pounds per acre); (b) three rates of B (0, 0.5, and 1.0 pounds per acre); and (c) four combinations of S and B (S10B0.5, S10B1.0, S20B0.5, and S20B1.0). Each treatment was replicated three times in a randomized complete block design. Inoculated seeds of "WL 319 HQ" alfalfa was planted at a seeding rate of 20 pounds pure live seed per acre on September 20, 2011. Sulfur (90%) and sodium borate was used as a source of S and B, respectively, and they were applied to alfalfa first at the time of planting and in April of subsequent years. 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 at least 72 hours to determine forage yield as dry matter basis. Forage quality was estimated by using Near Infrared Reflectance Spectroscopy.

### Results and Discussion

Forage yield did not differ among the treatment throughout the study period. When forage yields were summed over 5 years, alfalfa receiving 10 pounds S per acre and 1.0 pound B per acre produced numerically the lowest (14.02 tons per acre) and highest (14.84 tons per acre) forage yields, respectively (Table 1). However, among the S and B combinations, 10 pounds S per acre in combination with 1.0 pounds B per acre produced the numerically lowest (14.25 tons per acre) yield whereas 20 pounds S per acre in combination with 1.0 pounds B per acre produced the numerically highest (14.66 tons per acre) total annual yield (Table 1). This suggests that probably S10B1.0 combination might have produced an antagonistic effect and negatively impacted alfalfa's yield. On the average, the higher alfalfa forage yields produced in 2017 could be associated to the favorable weather conditions that occurred in 2017 and its influence on the nutrient uptake by alfalfa for good growth and development. Average total forage yield was comparable among the treatments, which indicates a persistent production over time. In general, forage nutritive value was similar for all the treatments (Table 1). Applying an appropriate S and B combination to alfalfa could probably improve alfalfa production in the longer term.

Table 1. Sulpher and boron effect on alfalfa forage yield and quality at SAREC from 2015 to 2018

| | Forage yield | | | | | | Forage nutritive value† | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Treatment** | **2015** | **2016** | **2017** | **2018** | **2019** | **Total** | **CP** | **NDF** | **ADF** | **IVDMD** | **RFV** |
| **(pounds per acre)** | **tons per acre‡** | | | | | | **%** | | | | |
| Control ($S_0B_0$) | 2.14a§ | 2.64a | 4.43a | 3.33a | 1.71a | 14.24a | 28a | 37a | 26a | 81a | 199a |
| $S_{10}$ | 2.15a | 2.28a | 4.35a | 3.64a | 1.59a | 14.02a | 28a | 36a | 25a | 81a | 200a |
| $S_{20}$ | 1.96a | 2.39a | 4.47a | 3.87a | 1.70a | 14.39a | 27a | 36a | 25a | 81a | 200a |
| $B_{0.5}$ | 2.11a | 2.37a | 4.51a | 3.57a | 1.71a | 14.26a | 27a | 36a | 26a | 80a | 196a |
| $B_{1.0}$ | 2.21a | 2.64a | 4.92a | 3.39a | 1.67a | 14.84a | 27a | 36a | 25a | 80a | 199a |
| $S_{10}B_{0.5}$ | 2.15a | 2.50a | 4.83a | 3.50a | 1.64a | 14.62a | 27a | 36a | 25a | 81a | 202a |
| $S_{10}B_{1.0}$ | 2.20a | 2.63a | 4.69a | 3.22a | 1.51a | 14.25a | 27a | 36a | 26a | 81a | 199a |
| $S_{20}B_{0.5}$ | 2.00a | 2.00a | 5.51a | 3.22a | 1.56a | 14.29a | 28a | 36a | 25a | 81a | 200a |
| $S_{20}B_{1.0}$ | 2.17a | 2.31a | 5.38a | 3.33a | 1.48a | 14.66a | 27a | 36a | 25a | 81a | 203a |
| **Average** | **2.12** | **2.42** | **4.79** | **3.45** | **1.62a** | **14.40** | **27** | **36** | **25** | **81** | **200** |

*S, Sulfer; B, Boron; $S_0$, 0 pounds S per acre; $S_{10}$, 10 pounds S per acre; $S_{20}$, 20 pounds S per acre; $B_0$, 0 pounds B per acre; $B_{0.5}$, 0.5 pounds B per acre; $B_{1.0}$, 1.0 pounds B per acre*

*CP, Crude protein; NDF, Neutral detergent fiber; ADF, Acid detergent fiber; IVDMD, in vitro dry matter digestibility; RFV, Relative feed value.*

*† Values are averaged over all five years.*

*‡ Values are averaged over all three cuts for each year.*

*§Within each column, means followed by the same lowercase letters are not significantly different at 0.05 probability level.*

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

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**Keywords:** alfalfa, sulphur, boron, forage yield, nutritive value

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

# Insecticide Timing Effects on Pest and Beneficial Insects in Alfalfa

*Randa Jabbour, Department of Plant Sciences*

*Micah McClure, Department of Plant Sciences*

## Introduction

Alfalfa is home to many kinds of pest and beneficial insects. The most problematic pest in Wyoming alfalfa hay is alfalfa weevil. Typically, producers apply insecticide shortly before first cutting, but some producers in southeastern Wyoming have been exploring earlier insecticide timings. If effective, early sprays can take some of the pressure out of last-minute decisions to spray or not, while also deciding on harvest timing in the face of unpredictable weather conditions. Colorado State University colleagues have demonstrated efficacy of early spray timing at their research farm; we wanted to replicate this experiment in Wyoming conditions. We also want to know how different insecticide timings affect beneficial insects such as bees.

## Objectives

Compare early and standard application timing of pyrethroid Warrior II on insects in alfalfa.

## Materials and Methods

Alfalfa was planted in 2 acres at SAREC in Spring 2019. The area was divided into 15 plots, 30 ft x 60 ft in size. We applied three treatments: 1) early pyrethroid application, 2) standard pyrethroid application, and 3) control treatment with no insecticides applied. The early application occurred on May 6, 2020 when the alfalfa was 7 to 9 inches tall. The standard application occurred on May 27, 2020 when alfalfa was at bud stage and 14 to 20 inches tall. At weekly intervals following the early spray application, measurements of alfalfa and insect samples occurred. We will identify common pest and beneficial insects to determine the effect of spray timing throughout the insect community.

## Results and Discussion

We are still counting and identifying insects, so we have no results to report at this time. We look forward to sharing our findings with growers next year! Next year, we will also collaborate with environmental chemists at Utah State University to measure pesticide fate. This will allow us to determine how long early-applied pesticide remains effective.

## Acknowledgments

Thanks to the SAREC crew for assisting with field management, to Albert Adjesiwor and Andrew Kniss for assistance applying insecticide, and to Pete Forster at Syngenta for providing insecticide. This study is funded by the USDA NIFA Alfalfa Seed and Alfalfa Forage System program.

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**Keywords:** alfalfa weevil, bees, pesticide timing

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

# Establishment of Cool-Season Perennial Grasses and Legumes in Disturbed Environments

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## Introduction

Grasslands are invaluable for livestock grazing, wildlife habitat, recreational opportunities, and soil, water and air protection. However, increase in anthropogenic disturbance carried out for economic or development purposes has resulted in degradation of grasslands. Highly adaptive species with potential to establish in these degraded environments can contribute to grassland productivity and improve the land use. Unfortunately, bringing together the strategies for successful establishment of desirable species in harsh environment is still a challenge.

## Objectives

Evaluate the establishment of cool-season perennial grasses and legumes in disturbed environments.

## Materials and Methods

The study was established in 2018 at the James C. Hageman Sustainable Agriculture Research Center (SAREC) near Lingle, Wyoming. The experiment was set up in a split plot design with four replications. Monoculture and combinations of seeding mixture of cool-season grasses and legumes were sown in three planting times (late spring, early fall, and late fall) in two environmental conditions (irrigated and dryland). Each block contained three planting dates and 11 seeding mixtures. Three planting dates included June 1 (late spring), August 15 (early fall), and November 15 (late fall) in 2018. Plant density was recorded in the growing season of 2019 and 2020.

## Results and Discussion

In 2019, dormant planting had highest plant density in both irrigated and dryland sites (Table 1). The plant density was higher in irrigated site in 2020 two years aafter sowing. However, the plant density gradually declined and did not differ among planting time in the dryland site. Further, due to harsh growing conditions, plant density in dryland site was lower compared to irrigated site. Overall, non-native grasses had higher plant density in both sites in 2019. By the mid of 2020, native grass density was higher than that of non-native grasses in irrigated site. In dryland conditions, there was no difference among plant density of legumes, native grasses, and non-native grasses when sown as fall or dormant planting. Native grasses when planted in spring in dryland conditions had plant density similar to that of irrigated site, which was significantly higher than other treatments in dryland. However, the vigor of native grasses was low compared to non-native grasses and legumes in both irrigated and dryland site (data not shown). Low vigor could have reduced the nutrient requirements of native grasses allowing it to survive in harsh environment. In contrast, lack of sufficient nutrients for the non-native grasses could decrease the density of non-native grasses. Additional information about weed, plant cover, and dry matter yield could further elaborate the establishment of desirable species in these growing conditions and enhance management strategies for vegetation establishment in degraded environment. Additional data is being collected and analyzed on these parameters for future presentation.

**Table 1.** Effect of seeding mixture, planting time, and site on combined plant density (plants per square foot) in 2019 and 2020 at SAREC

| | Irrigated | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Spring | | | | Fall | | | | Dormant | | | |
| | 2019 | | 2020 | | 2019 | | 2020 | | 2019 | | 2020 | |
| PDF584 tall fescue | 4 | a A | 3 | bcd A | 6 | a A | 5 | ab B | 8 | abc A | 5 | a B |
| 97TF1584 tall fescue | 3 | ab A | 3 | bcd A | 6 | a A | 4 | ab B | 9 | ab A | 5 | a B |
| Crested wheatgrass | 1 | c A | 2 | cd A | 3 | bc A | 3 | bcd A | 6 | cd A | 4 | ab B |
| Birdsfoot trefoil | 1 | bc A | 1 | d A | 1 | c A | 1 | d A | 3 | e A | 2 | b B |
| Cicer milkvetch | 2 | abc A | 2 | cd A | 3 | bc A | 2 | cd A | 6 | d A | 2 | b B |
| Sainfoin | 2 | abc A | 2 | cd A | 2 | bc A | 2 | cd A | 2 | e A | 2 | b A |
| NG (Native grasses: Thickspike wheatgrass, Western wheatgrass, Bluebunch wheatgrass, Basin wildrye) | 2 | abc B | 5 | a A | 3 | b B | 5 | a A | 6 | cd A | 5 | a B |
| NNG (Non-native grasses: Tall fescue and Crested wheatgrass) | 3 | a A | 2 | cd A | 3 | b A | 4 | abc A | 9 | a A | 5 | a B |
| NNG + legumes | 2 | abc A | 2 | cd A | 4 | b A | 3 | abc A | 7 | bcd A | 5 | a B |
| NG + legumes | 2 | abc B | 4 | ab A | 3 | bc B | 5 | a A | 5 | d A | 6 | a A |
| NNG + NG + legumes | 2 | abc B | 3 | bc A | 2 | bc A | 3 | bcd A | 7 | abcd A | 5 | a B |
| **Mean** | **2** | | **3** | | **3** | | **3** | | **6** | | **4** | |

| | Dryland | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Spring | | | | Fall | | | | Dormant | | | |
| | 2019 | | 2020 | | 2019 | | 2020 | | 2019 | | 2020 | |
| PDF584 tall fescue | 4 | a A | 2 | abcd A | 4 | bcd A | 1 | a B | 8 | ab A | 1 | a B |
| 97TF1584 tall fescue | 3 | ab A | 1 | bcd B | 3 | cd A | 1 | a A | 9 | a A | 1 | a B |
| Crested wheatgrass | 1 | ab A | 1 | cd A | 8 | a A | 3 | a B | 6 | ab A | 2 | a B |
| Birdsfoot trefoil | 0 | b A | 0 | bcd A | 0 | cd A | 0 | a A | 1 | ab | 0 | |
| Cicer milkvetch | 1 | ab A | 1 | bcd A | 2 | cd A | 1 | a A | 3 | ab A | 2 | a A |
| Sainfoin | 1 | ab A | 0 | d A | 1 | d A | 1 | a A | 2 | b A | 1 | a A |
| NG (Native grasses: Thickspike wheatgrass, Western wheatgrass, Bluebunch wheatgrass, Basin wildrye) | 3 | ab A | 5 | a A | 4 | bc A | 3 | a A | 4 | ab A | 3 | a A |
| NNG (Non-native grasses: Tall fescue and Crested wheatgrass) | 1 | ab A | 1 | cd A | 6 | ab A | 2 | a B | 6 | ab A | 1 | a B |
| NNG + legumes | 2 | ab A | 1 | bcd A | 4 | bcd A | 2 | a B | 5 | ab A | 2 | a A |
| NG + legumes | 2 | ab A | 4 | abc A | 4 | bcd A | 3 | a A | 3 | ab A | 2 | a A |
| NNG + NG + legumes | 2 | ab B | 4 | ab A | 4 | bcd A | 2 | a B | 3 | ab A | 2 | a A |
| **Mean** | **2** | | **2** | | **3** | | **2** | | **5** | | **2** | |

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

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

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

# Sunn Hemp Biomass Accumulation and Feed Value in South Eastern Wyoming

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## Introduction

Southeastern Wyoming poses its own unique challenges to the region's producers with its short growing windows, infertile soils, minimal market accessibility, and low availability of low cost, highly nutritive feed sources for livestock. These obstacles hinder the success and sustainability of production systems in the region. The plant *Crotalaria juncea*, commonly known as sunn hemp, is a tropical legume that yields high tonnage biomass and fixes nitrogen. The plant's short growing season, nitrogen fixing and soil improving qualities, and hardiness to less than ideal soil conditions make it a compelling crop to incorporate into Wyoming cropping systems. Furthermore, sunn hemp may serve as a high-quality alternative to alfalfa hay, thereby supporting the livestock industry and providing feed and crop alternatives to producers.

## Objectives

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

## Materials and Methods

This study was conducted at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) during the summer of 2019. Sunn hemp was planted on June 5, 2019 in a randomized complete block design with irrigated and dryland fields. Four separate harvest dates (irrigated: 78, 89, 100, 110 days after planting; dryland: 55, 65, 75, 84 days after planting) were performed. An early season hail storm affected the irrigated plots and caused delayed harvest time. Three cutting heights (6.4, 10.8, and 15.2 cm) for both the irrigated and dryland plots were used at harvest. Biomass yield was collected and recorded on a dry matter basis. Biomass from all plots was combined for each harvest date and sent to Ward Labs for feed analysis. Assessment of feed value was made based on basic nutritive qualities: total digestible nutrients (TDN), neutral detergent fiber (NDF), acid detergent fiber (ADF), crude protein (CP), and lignin in comparison to published quality standards for alfalfa.

## Results and Discussion

Harvest date significantly affected the biomass yield in both irrigated and dryland plots (Table 1). Cutting height, however, did not have a significant effect on biomass accumulation. Biomass (lbs/a on a dry basis) increased over time (Figure 1). As forages mature, fibrous components of the plant (ADF, NDF, and lignin) increase while protein content falls, decreasing the feed quality. Producers need to find a balance between maximizing yield and maintaining feed quality by selecting the correct harvest time. Dryland sunn hemp harvested after 75 days failed to meet the alfalfa quality standard with CP below 18% (Table 2). Irrigated sunn hemp harvested after 100 days failed to meet the alfalfa quality standard with ADF above 32 and lignin above 6.7 (Table 2). Overall, later harvests produced higher biomass yields but lower quality feed. Based on the first year's data we would recommend harvesting dryland fields before 75 days and irrigated fields before 100 days to maximize yield and quality. While these results are both promising and exciting, further experimentation is necessary to confirm these findings. Feeding trials are planned for fall of 2020, and the small plot harvest study will be repeated in 2021.

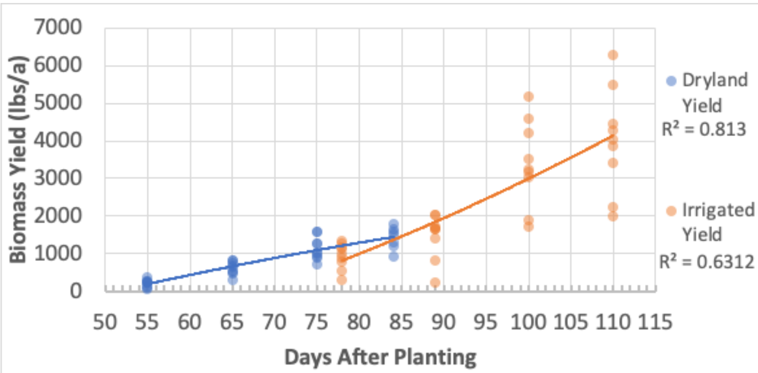


**Figure 1.** Effect of harvest date on biomass yield (lbs/a) of sunn hemp in irrigated (orange) and dryland (blue) plots over time. Within the dryland and irrigated trials all harvest dates were significantly different with yield increasing over time. Data shown are for all harvest heights on each harvest day. Second degree polynomial regression lines and $R^2$ values are given for dryland and irrigated yield. $R^2$ values range from 0-1, and an $R^2$ value closer to 1 indicates a better correlation and fit of the data.

**Table 1.** Significance (p-value) of harvest date (DAP), harvest cutting height (height), and the interaction on sunn hemp biomass production on a dry weight basis for irrigated and dryland trials. A p-value less than 0.05 means that the harvest treatment had a significant effect on biomass production.

| | Irrigated | Dryland |
|---|---|---|
| DAP | 0.03 | <0.0001 |
| Height | 0.43 | 0.88 |
| DAP * Height | 0.90 | 0.61 |

**Table 2.** Feed value of irrigated and dryland plots in comparison to high quality alfalfa. Sunn hemp feed value is a composite sample of all three harvest heights and replications. Sunn hemp with lower ADF, NDF, and lignin and higher TDN and CP values than alfalfa is higher quality.

| | | TDN | ADF | NDF | CP | Lignin |
|---|---|---|---|---|---|---|
| | Alfalfa | 58-60 | 29-32 | 36-40 | 18-20 | 6.7 |
| Irrigated | 78 DAP | 76 | 22 | 27 | 27 | 4.6 |
| | 89 DAP | 68 | 30 | 35 | 25 | 5.7 |
| | 100 DAP | 64 | 33 | 40 | 20 | 7.1 |
| | 110 DAP | 64 | 33 | 41 | 21 | 7.6 |
| Dryland | 55 DAP | 75 | 23 | 24 | 23 | 3.6 |
| | 65 DAP | 68 | 29 | 33 | 22 | 5.6 |
| | 75 DAP | 68 | 31 | 33 | 17 | 5.9 |
| | 84 DAP | 72 | 29 | 28 | 17 | 5.6 |

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**Keywords:** sunn hemp, forage, biomass, livestock, harvest date, height

**PARP:** I:15, II:9, VI:1

# Dry Bean Soil-Borne Disease Management with an Integrated Approach with Tillage, Variety, and In-Furrow Fungicides at SAREC

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*Kyle Webber, Wyoming Seed Certification Service*

*Wendy Cecil, Department of Plant Sciences*

## Introduction

Soil-borne dry bean diseases such as Rhizoctonia and Fusarium root rots 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. This is the second year results of this study.

## Materials and Methods

The study was established in 2019 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 10 June with the Kincaid planter/sprayer. Sub-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, severity of root rot (two ratings), and bean yield.

## Results and Discussion

Tillage treatments resulted in significant differences for soil compaction, with 77% more compaction probe penetration with deep tillage compared to conventional tillage. However, tillage treatment had no significant effect on measured crop stands, disease severity, vigor and seed yield. There was a 100% disease incidence in all sampled plants for both rating dates. Disease encountered was primarily due to *Fusarium* species and some *Rhizoctonia solani*. Fungicide treatments had no significant effect on stands, root disease severity, vigor or yield measured. ND Palomino and Othello had greater stands than the other varieties. There were also significant differences of disease severity between varieties. Sundance had significantly less disease than ND Palomino and Montrose but there was no differences between yield in varieties. After 2 years of this study (at PREC and SAREC) conclusions were that soil compaction can be reduced with deep tillage; however, this did not necessarily translate to reductions in soil-borne root disease pressures. In-furrow fungicide treatments sometimes slightly reduced disease severity but are probably not worth the extra expense especially when disease pressure was fairly high like at these sites. Bean varieties as expected, behaved differently in terms of disease and yields but lower disease did not equate to higher yields.

**Acknowledgments**

We thank SAREC 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 beans with a systems approach of varietal selection, in-furrow fungicides, and tillage treatments, SAREC in 2019.

| Main Treatments | Stand Count (# per 80 ft) | Compaction (in. penetrated)[1] | Root Disease Severity (0-4)[2] | | Vigor (0-100%)[3] | Bean yield (lb/ac) |
|---|---|---|---|---|---|---|
| | 27 Jun | 10 Jun | 11 Jul | 24 Aug | 23 Aug | |
| Tillage | | | | | | |
| Conv. Tillage | 210.1 a[4] | 10.7 b | 2.4 a | 3.2 a | 101.1 a | 1357.8 a |
| Deep Tillage | 207.2 a | 18.9 a | 2.3 a | 3.3 a | 102.9 a | 1530.8 a |
| Fungicide | | | | | | |
| Untreated | 212.6 a | -- | 2.4 a | 3.2 a | 100.0 a | 1637.7 a |
| Headline | 211.1 a | -- | 2.2 a | 3.2 a | 103.1 a | 1329.9 a |
| Proline | 202.3 a | -- | 2.4 a | 3.3 a | 102.9 a | 1365.2 a |
| Cultivar | | | | | | |
| Long's Peak | 199.1 b | -- | 2.2 bc | 3.3 a | -- | 1361.1 a |
| Montrose | 190.3 b | -- | 2.5 ab | 3.3 a | -- | 1316.5 a |
| ND Palomino | 231.2 a | -- | 2.6 a | 3.4 a | -- | 1325.0 a |
| Othello | 230.8 a | -- | 2.2 bc | 3.1 a | -- | 1897.8 a |
| Sundance | 191.9 b | -- | 2.0 c | 3.0 a | -- | 1321.0 a |

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

# Managing Root Diseases of Beans with In-Furrow and Foliar Fungicides

*William Stump, Department of Plant Sciences*

*Wendy Cecil, Department of Plant Sciences*

## Introduction

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

## Objectives

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

## Materials and Methods

Research plots were established on June 20, 2019, at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Eight 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 barley grain infested with *Rhizoctonia solani* (AG 2-2 IIIB) applied with a cyclone spreader then incorporated. Plots were planted with the variety Othello using a John Deere planter, with the center two rows planted with an open furrow. Fungicide applications were made to the two open furrows then rows closed immediately with foot pressure. The field plot area received fertility, weed control, and irrigation appropriate for dry bean production. Parameters measured were stand counts, plant vigor, incidence of root rot, severity of root rot, and bean yield.

## Results and Discussion

Treatments had no significant effect on plant stands on any of the evaluation dates (data not shown). The Serenade ASO in-furrow alone treatment had significantly less vigor than many of the other treatments on 16 August ($P \leq 0.05$). The reason for this was unclear since the other Serenade ASO treatment (with an additional foliar Priaxor treatment) had no ill effect.

Root disease was quite extensive with all roots sampled having 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 between the inoculated and non-inoculated checks. Only fungicide treatments of in-furrow Propulse and Vellum Prime, both followed by a post emergence of Priaxor had significantly less disease severity on sampled roots at the early season rating compared to both non-treated checks ($P \leq 0.05$). At the late season root rating, with the exception of Serenade ASO alone, all in-furrow treatments resulted in significantly less disease severity than the non-treated inoculated check ($P \leq 0.05$).

Treatments had no effect on bean seed yield. Lack of treatment effects on yield is most likely due to complications of levels of disease in all plants, presence of some bacterial disease, and a destructive hail event in mid-summer.

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

**Contact:** William Stump, wstump@uwyo.edu, 307-766-2062.

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

**PARP:** I:11

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

| Treatment and rate, and timing[1] | Crop vigor (1-9) | Root disease rating (0-5)[2] | | Bean seed yield (lb/A) |
|---|---|---|---|---|
| | 16 Aug | 11 Jul | 30 Aug | 19 Sep |
| Non-treated non-inoculated check | 7.0 ab[3] | 2.2 ab | 4.3 ab | 1608.1 a |
| Non-treated inoculated check | 4.8 cd | 2.5 a | 4.6 a | 1855.4 a |
| Propulse (0.25 fl oz/1000 ft) A<br>Endura (8 fl oz/A) BC | 6.5 abc | 2.0 ab | 3.7 bc | 1583.1 a |
| Velum Prime (0.135 fl oz/1000 ft) A<br>Endura (8 fl oz/A) BC | 7.8 a | 1.8 ab | 3.7 bc | 1541.3 a |
| Propulse (0.25 fl oz/1000 ft) A<br>Priaxor (0.3 fl oz/1000 ft) B | 7.3 a | 1.4 b | 3.6 bc | 1555.8 a |
| Velum Prime (0.135 fl oz/1000 ft) A<br>Priaxor (0.3 fl oz/1000 ft) B | 6.8 ab | 1.6 b | 3.6 bc | 1483.3 a |
| Serenade ASO (2.7 fl oz/1000ft) A | 4.3 d | 1.9 ab | 4.2 abc | 1305.1 a |
| Serenade ASO (2.7 fl oz/1000ft) A<br>Priaxor (0.3 fl oz/1000 ft) B | 7.0 ab | 2.0 ab | 3.7 bc | 1599.5 a |
| Priaxor (0.3 fl oz/1000 ft) B | 5.3 bcd | 2.0 ab | 3.8 bc | 1596.6 a |
| Quadris (0.6 fl oz/1000 ft) A | 6.3 abc | 1.9 ab | 3.5 c | 1568.7 a |

[1]*Application codes: A= 20 June in-furrow at planting, B= 14 August and C= 18 Sep foliar broadcast.*

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

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

# Cooperative Dry Bean Nursery (CDBN) Report – SAREC Lingle 2019

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## Introduction

The dry bean breeders located in North America are routinely generating experimental lines that have potential to increase yield and profitability. In order to test these lines, the breeders conducted a series of test coordinated across ten sites from Washington state to New York and Canada is also included. Each site grows identical lines and breeders are able to observe how robust their lines perform across a varying set of environmental conditions. In addition to the core set of lines submitted by breeders, lines that we have developed here in Wyoming can also be compared against the lines submitted by other states.

## Objectives

The objective of this test was to test the performance of 44 dry bean entries for agronomic traits when grown in Lingle, Wyoming.

## Methods and Materials

Seed of 22 CDBN dry bean entries and 22 ad hoc entries were sown on 6 June 2019 in four-row plots, 30-inch rows at 100K seed per acre with four replicates (RCBD) at the Univ. Wyoming SAREC station. Pre-emergence herbicides were applied on 9 June 2018 (Roundup Powermax 28oz, Prowl H2O 32oz, Outlook 16oz, Helfire 6.4oz). Sprinkler irrigation was provided weekly at 0.75 inch or less as needed throughout the season. A large hailstorm (1-inch diameter stones) occurred 5 July 2019 and a minor hail storm occurred in August. Flowering and maturity notes were collected twice weekly. Iron-deficiency chlorosis (IDC) was rated visually (0 to 10; 0=no chlorosis and 10=fully chlorotic) in late August. Upright stature was also rated visually (0 to 10; 0=completely lodged and 10=fully upright) in late August. Grain yield data was collected by taking intact plants from 8 feet of row from the two center rows placing them into a 75-gal paper debris sack when 90% of pods in the plot were buckskin. Those samples were air-dried for approximately one week, and then threshed with a Kincaid research plot combine.

## Results and Discussion

Flowering, maturity, grain yield, seed size, seed per pound, upright status, height, and IDC are presented in Tables 1 and 2.

## Acknowledgements

The authors thank the following for funding: Wyoming Bean Commission, USDA-ARS Hatch project WYO-604-19, the USDA-ARS MultiState Bean Breeding project W-3150, and Wyoming Department of Agriculture. The authors thank Ryan Johnson, Blaine Magnuson, William Fluckiger, Kevin Madden, Larry Miller, and Mike Moore for technical assistance.

**Contact:** Jim Heitholt, jim.heitholt@uwyo.edu, 307-754-2223.

**Table 1.** Flowering date, maturity date, grain yield, seed size, no. seed per pound, end-of-season upright stature rating, height, and iron deficiency chlorosis (IDC) rating for a field test with 44 entries (17 entries in Table 1 and 27 entries in Table 2) performed at Lingle in 2019. Market class is indicated as a footnote next to the variety name.

| Genotype † | Flowering | Maturity§ | Yield | Seed Size ‡ | Seed per Pound | Upright | Height | IDC |
|---|---|---|---|---|---|---|---|---|
| | dap | dap ¶ | lbs/a | mg | no. | visual | cm | visual |
| ACC-Scotty [cb] | 54 | 95 | 807 | 423 | 1080 | 7.4 | 29 | 1.2 |
| ACUG-16-6 [nv] | 58 | 94 | 1340 | 149 | 3045 | 5.2 | 50 | 0.5 |
| Ace [bk] | 58 | 93 | 834 | 171 | 2660 | 8.3 | 37 | 6.1 |
| Blacktail [bk] | 66 | 101 | 608 | 159 | 2840 | - | 35 | 5.6 |
| CO-49957 [pop] | 50 | 108 | 692 | 410 | 1110 | - | 33 | 1.4 |
| Cal Early [lrk] | 49 | 89 | 396 | 435 | 1045 | - | 25 | 7.1 |
| Candy Cane [cr] | 52 | 94 | 995 | 461 | 985 | 8.6 | 32 | - |
| Cayenne [sr] | 57 | 91 | 841 | 285 | 1590 | 6.5 | 44 | 1.5 |
| Cowboy [pt] | 55 | 89 | 1230 | 347 | 1310 | 7.2 | 42 | 0.2 |
| Dr Wood [pt] | 66 | 101 | 732 | 323 | 1405 | 6.8 | 40 | 3.9 |
| Eclipse [bk] | 62 | 98 | 791 | 157 | 2895 | 7.8 | 37 | 3.3 |
| Falcon [pt] | 64 | 102 | 690 | 303 | 1500 | 8.2 | 45 | 3.5 |
| Knight Rider [bk] | 64 | 105 | 562 | 162 | 2795 | 7.8 | 34 | 3.0 |
| La Paz [pt] | 60 | 96 | 1460 | 331 | 1375 | 7.2 | 48 | 0.8 |
| Long's Peak [pt] | 57 | 94 | 781 | 317 | 1430 | 6.4 | 55 | 5.1 |
| Myasi [yel] | 55 | 98 | 545 | 304 | 1510 | 7.4 | 30 | 4.7 |
| UI-537 [pk] | 48 | 85 | 1160 | 339 | 1340 | 1.7 | 44 | 0 |
| **LSD (0.05)** | **4** | **5** | **362** | **8** | **156** | **1.8** | **7** | **3.2** |
| **P > F** | **0.001** | **0.001** | **0.001** | **0.001** | **0.001** | **0.001** | **0.001** | **0.001** |

† *Mkt Cls, Market Class Codes: bg = beige (not a recognized market class); bk = black; cb = cranberry; ndp = non- or slow-darkening pinto; lrk = light red kidney; drk = dark red kidney; sr = small red; wk = white kidney; gn = Great Northern; nv = navy; pk = pink; pop = popping bean type; pt = pinto; yel = yellow.*

‡ *Seed Size refers to the average mass per seed (in milligrams) as noted in numerous publications.*

§ *Mat = Maturity (50% of plants have at least one buckskin pod).*

¶ *dap = days after planting.*

**Table 2.** Flowering date, maturity date, grain yield, seed size, no. seed per pound, end-of-season upright stature rating, height, and iron deficiency chlorosis (IDC) rating for a field test with 44 entries (17 entries in Table 1 and 27 entries in Table 2) performed at Lingle in 2019. Market class is indicated as a footnote next to the variety name.

| Genotype † | Flowering | Maturity§ | Yield | Seed Size ‡ | Seed per Pound | Upright | Height | IDC |
|---|---|---|---|---|---|---|---|---|
| | dap | dap ¶ | lbs/a | mg | no. | visual | cm | visual |
| LPID-3 [pt] | 53 | 87 | 947 | 377 | 1200 | 5.4 | 47 | 0 |
| LPID-6 [bg-pt-pk] | 52 | 92 | 1700 | 374 | 1215 | 2.0 | 53 | 2.4 |
| LPID-9 [pk] | 56 | 92 | 882 | 329 | 1380 | 4.0 | 51 | 1.5 |
| LPID-11 [bg-pt-pk] | 58 | 91 | 639 | 348 | 1305 | 3.8 | 39 | 7.6 |
| LPID-28 [bg-pt-pk] | 51 | 88 | 1085 | 380 | 1195 | 2.6 | 50 | 1.6 |
| LPID-29 [bg] | 53 | 87 | 1150 | 338 | 1345 | 3.7 | 42 | 0.8 |
| LPID-34 [bg-pk] | 52 | 87 | 1020 | 344 | 1315 | 4.7 | 48 | 0 |
| NE1-17-36 [gn] | 52 | 90 | 1140 | 366 | 1245 | 7.0 | 47 | 1.6 |
| NE13-18-2 [pk] | 54 | 87 | 931 | 344 | 1320 | 4.5 | 39 | 1.8 |
| NE14-18-4 [bk] | 54 | 91 | 968 | 217 | 2090 | 8.1 | 26 | 3.0 |
| NE2-17-37 [ndp] | 54 | 92 | 1230 | 319 | 1425 | 5.3 | 56 | 4.5 |
| NE4-17-10 [ndp] | 50 | 88 | 1070 | 360 | 1260 | 6.1 | 58 | 1.9 |
| NE4-17-6 [ndp] | 50 | 87 | 837 | 343 | 1330 | 6.7 | 46 | 1.7 |
| NE9-18-3 [cb] | 47 | 97 | 1610 | 469 | 967 | 6.7 | 36 | 1.1 |
| Nugget [yel] | 52 | 90 | 688 | 310 | 1460 | 3.9 | 47 | 1.0 |
| Othello [pt] | 48 | 85 | 909 | 325 | 1400 | 4.8 | 37 | 0.1 |
| PT11-13-1 [pt] | 57 | 92 | 1400 | 319 | 1425 | 7.2 | 45 | 0.5 |
| PT16-9 [pt] | 59 | 96 | 878 | 317 | 1430 | 7.6 | 43 | 3.7 |
| Patron [yel] | 58 | 104 | 958 | 374 | 1215 | 7.1 | 31 | 3.7 |
| Pegasus [gn] | 60 | 98 | 962 | 329 | 1380 | 6.0 | 50 | 2.2 |
| Portage [nv] | 64 | 98 | 357 | 143 | 3180 | - | 27 | 7.9 |
| Racer [cb] | 49 | 90 | 663 | 444 | 1025 | - | 27 | 1.0 |
| Red Cedar [drk] | 56 | 99 | 332 | 348 | 1315 | - | 27 | 4.7 |
| Ruby [sr] | 63 | 99 | 1200 | 238 | 1910 | 5.6 | 47 | 2.0 |
| Spectre [bk] | 62 | 104 | 1030 | 170 | 2680 | 7.3 | 43 | 0.7 |
| UI-537 [pk] | 48 | 85 | 1160 | 339 | 1340 | 1.7 | 44 | 0 |
| OAC Vortex [bk] | 63 | 101 | 1055 | 161 | 2825 | 8.1 | 37 | 1.5 |
| Whitetail [wk] | 56 | 94 | 561 | 351 | 1295 | 7.1 | 30 | 3.0 |
| **LSD (0.05)** | **4** | **5** | **362** | **8** | **156** | **1.8** | **7** | **3.2** |
| **P > F** | **0.001** | **0.001** | **0.001** | **0.001** | **0.001** | **0.001** | **0.001** | **0.001** |

† *Mkt Cls, Market Class Codes: bg = beige (not a recognized market class); bk = black; cb = cranberry; ndp = non- or slow-darkening pinto; lrk = light red kidney; drk = dark red kidney; sr = small red; wk = white kidney; gn = Great Northern; nv = navy; pk = pink; pop = popping bean type; pt = pinto; yel = yellow.*

‡ *Seed Size refers to the average mass per seed (in milligrams) as noted in numerous publications.*

§ *Mat = Maturity (50% of plants have at least one buckskin pod).*

¶ *dap = days after planting.*

# In-Furrow Fungicide Application to Manage Rhizoctonia Root and Crown Rot in Sugar Beet

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*Wendy Cecil, Department of Plant Sciences*

## Introduction

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

## Objectives

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

## Materials and Methods

The study was established in 2019 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Five in-furrow with +/- sequential foliar-banded fungicide 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 15 May plots were planted with a John Deere MaxEmerge planter with the two middle rows planted with open furrows (press wheels were held up). Fungicide applications were made in-furrow to these middle two rows with a single nozzle $CO_2$ equipped backpack sprayer planted and rows closed immediately with walking foot pressure. 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 incidence and severity (percent canopy decline), and sugar yield (Table 1).

## Results and Discussion

Disease development was reduced compared to previous years and there was some endemic disease pressure in the non-inoculated check. Treatments or inoculations had no effect on stands as measured on 3 June. RRCR did develop in the plots with noticeable canopy necrosis by late September. By 22 August all fungicide treatments reduced disease incidence compared to the inoculated non-treated check ($P \leq 0.05$). By season end, all fungicide treatments similarly reduced canopy decline compared to the non-treated inoculated check ($P \leq 0.05$).

The biological-based fungicides Serenade ASO and QST713 HICFU 150FS applied with Quadris did not provide significantly better disease suppression than the Quadris in-furrow treatment alone. The additional foliar-banded Proline also did not provide additional disease suppression compared to Quadris in-furrow alone.

There was no significant effect of treatment on recoverable sucrose yields. Lack of yield effect was probably due to the late onset of disease.

**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/A[1] and timing[2] | Plant stand | RRCR disease incidence (40 ft) | | % canopy decline | Lbs of extractable sucrose/A |
|---|---|---|---|---|---|
| | 3 Jun | 24 Jul | 22 Aug | 27 Sep | 3 Oct |
| Nontreated non-inoculated check | 57.5 a[3] | 8.8 ab | 10.0 ab | 23.5 b | 6456.3 a |
| Nontreated inoculated check | 77.3 a | 12.3 a | 16.3 a | 59.5 a | 5400.2 a |
| Quadris (9.2 fl oz) A | 70.8 a | 5.3 b | 4.0 bc | 15.0 b | 6359.1 a |
| Serenade ASO (2 qt) + Quadris (9.2 fl oz) A | 72.3 a | 3.8 b | 5.0 bc | 21.0 b | 6592.3 a |
| QST713 HICFU 150FS (12.8 fl oz) + Quadris (9.2 fl oz) A | 58.3 a | 2.8 b | 3.3 c | 10.5 b | 6702.8 a |
| Serenade ASO (2 qt) + Quadris (9.2 fl oz) A<br>Proline 480SC (5.7 fl oz) B | 79.0 a | 6.0 ab | 5.5 bc | 12.0 b | 5846.4 a |
| QST713 HICFU 150FS (12.8 fl oz) + Quadris (9.2 fl oz) A<br>Proline 480SC (5.7 fl oz) B | 96.8 a | 4.5 b | 4.3 bc | 10.5 b | 6071.2 a |

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

[2]*Application dates were as follows; A=15 May (in-furrow) and B= 29 June (foliar-banded).*

[3]*Treatment means followed by different letters differ significantly (Tukey's HSD,* $P \leq 0.05$*).*

# Management of Cercospora Leaf Spot in Sugar Beet with Foliar Fungicide Applications

*William Stump, Department of Plant Sciences*

*Wendy Cecil, Department of Plant Sciences*

## Introduction

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

## Objectives

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

## Materials and Methods

The study was established 15 May, 2019 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Eight 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 two middle rows of each inoculated plot were inoculated with 25 grams of dry *Cercospora beticola*-infected leaf material on 23 August. Parameters measured included CLS leaf lesion counts and season-long CLS severity, as measured by an area under the disease progress curve (AUDPC), and sugar yield (Table 1). Plots were harvested on 3 October.

## Results and Discussion

Cercospora leaf spot developed late in 2019, but disease development did result in moderate severity by season end. The inoculation method was successful, resulting in 78% more overall disease, as measured by AUDPC value, compared to the non-treated non-inoculated check (Table 1). All fungicide programs reduced CLS lesion numbers on the last evaluation date compared to the non-treated inoculated check (Table 1, $P \leq 0.05$). All fungicide programs reduced the AUDPC 78-99% compared to the non-treated inoculated check ($P \leq 0.05$). The new product Revysol (BASF), an isopropanol azole and DMI inhibitor, showed excellent promise in the trial, suppressing CLS 96% as measured by the AUDPC, a season-long measurement of disease. 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

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

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**Keywords:** Cercospora leaf spot, sugar beet

**PARP:** I:11

**Table 1.** Effects of foliar fungicide programs on Cercospora leaf spot (CLS) development in sugar beet (W.L. Stump and W. Cecil University of *Wyoming*; 2019).

| Treatment and product/A | Application timing[1] | CLS Lesion counts per leaf | | AUDPC[2] | Lbs of extractable sucrose/A |
|---|---|---|---|---|---|
| | | 9 Sep | 20 Sep | | |
| Nontreated non-inoculated check | NA | 239.3 a[3] | 300.6 b | 10879.4 b | 4559.7 a |
| Nontreated inoculated check | NA | 244.5 a | 534.3 a | 13766.3 a | 5475.3 a |
| Propulse (13.6 fl oz) | BCD | 28.6 b | 20.1 cd | 806.7 cd | 5633.2 a |
| Proline 480 SC (5.7 fl oz) | BCD | 16.0 b | 19.1 cd | 577.4 cd | 5015.2 a |
| Proline 480 SC (5.7 fl oz)<br>Serenade ASO (OMRI) (32 fl oz) | BCD | 114.9 ab | 88.5 c | 3041.4 c | 4845.1 a |
| Propulse (13.6 fl oz)<br>Topsin (20 oz) + Super Tin (8 oz)<br>Proline 480 SC (5.7 fl oz) | B<br>C<br>D | 21.2 b | 9.2 cd | 461.9 cd | 4552.7 a |
| Revysol (5 fl oz) | BCD | 7.3 b | 19.8 cd | 475.9 cd | 6743.0 a |
| Revysol/Headline (9 fl oz) | BCD | 19.8 b | 5.1 d | 362.9 cd | 6230.8 a |
| Minerva Duo (16 fl oz)<br>Kocide 2000 (3.74 lbs)<br>Proline 480 SC (5.7 fl oz) | B<br>C<br>D | 33.8 b | 71.4 cd | 1694.3 cd | 5471.1 a |
| Proline 480 SC (5.7 fl oz)<br>Topsin (20 oz) + Super Tin (8 oz)<br>Headline (12 fl oz) + Dithane (2 lbs) | A<br>B<br>C | 5.4 b | 2.8 d | 135.0 d | 5887.1 a |

[1]*Application dates were as follows: A=14 Aug, B=23 Aug, C=6 Sep, and D= 20 Sep. All treatments with Propulse or Proline, 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,* $P \leq 0.05$*).*

# Sugar Beet and Corn 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. 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.

## Objectives

The purpose of this study was to determine the impacts of AgSciTech soil amendments on the quality and yield of sugar beets and corn in Wyoming. Funding was provided by Agscitech, Inc. (product manufacturer) and InsureOrganics (product distributor) to test products on sugar beets and corn in the Big Horn Basin and in southeast Wyoming.

## Materials and Methods

Research was conducted at PREC and SAREC in 2018 and 2019 (Table 1). Data was collected on stand establishment, sugar beet yield (tons/a), sugar content (% and tons/a), and corn yield (bu/a). Each trial location received the following treatments: Control: plots were fertilized and otherwise managed to meet the “industry standard”.

Biological Products (BIO): plots were fertilized and otherwise managed identically to the control plots but with the addition of the three to five biological products. Soil Medic (SM; 1gal/a), BioRelease™ (BR; 1 gal/a), AgroThrive™ LF (LF; 10 gal/a), Glyphonix (GL; 1qt/a), and BulkR (BU; 1.25 gal/a) (Table 1).

## Results and Discussion

There was no significant difference between field populations of the control and BIO treatments in the UW SAREC trials (Table 2). Product use did not improve stand establishment of either sugar beet or corn. There was no significant difference between any of the sugar beet yield components between the control and BIO treatments in any of the trials (Table 3). Likewise, there was no significant difference between any of the corn yield components between the control and BIO treatments (Table 4). In this trial we did not find any increase in yield or yield quality of sugar beet or corn in either location. The InsureOrganics website recommends product use for 3 years to see measurable results and our trials were only two years, except for the SAREC Trial 2 which was only one year.

**Table 1.** Field actions and dates for SAREC Trials 1 and 2 and PREC Trial 1 from 2017 through 2019. Each trial was conducted in unique fields.

| | Action | SAREC Trial 1 | PREC Trial 1 | SAREC Trial 2 |
|---|---|---|---|---|
| Sugar Beet Crop | LF/SM/BR Application | 11/28/2017 | 10/31/2017 | 11/29/2018 |
| | LF/SM/BR Application | 4/16/2018 | 4/16/2018 | 5/13/2019 |
| | Dry Fertilizer | 5/8/2018 | 4/17/2018 | 5/6/2019 |
| | Plant | 5/10/2018 | 5/15/2018 | 5/15/2019 |
| | Herbicide | 5/31/2018 | 5/25/2018 | N/A |
| | LF/SM/BR Application | 6/6/2018 | N/A | 6/25/2019 |
| | Herbicide | 6/27/2018 | 6/26/2018 | 6/12/2019 |
| | LF/SM/BR Application | 7/13/2018 | 7/5/2018 | 7/17/2019[A] |
| | Herbicide | N/A | N/A | 7/26/2019 |
| | BU Application | 8/24/2018 | N/A | 9/2/2019 |
| | Harvest | 9/17/2018 | 9/24/2018 | 10/2/2019 |
| Corn Crop | LF/SM/BR Application | 11/29/2018 | N/A | N/A |
| | Dry Fertilizer | 5/6/2019 | 4/19/2019 | N/A |
| | LF/SM/BR Application | 5/14/2019 | N/A | N/A |
| | Plant | 5/15/2019 | 4/23/2019 | N/A |
| | Herbicide | 6/12/2019 | 6/7/2019[B] | N/A |
| | LF/SM/BR Application | 7/17/2019 | 7/3/2019[C] | N/A |
| | LF/SM/BR Application | N/A | 7/8/2019[B] | N/A |
| | Harvest | 10/25/2019 | 10/31/2019 | N/A |

[A]*Application was done at one tenth the rate.* [B]*Treatment was Herbicide+GL+BU.* [C]*Treatment was liquid fertilizer.*

**Table 2.** Average stand counts for sugar beets and corn for SAREC trials 1 and 2. P-values compare SCP (control) and BIO treatments within each trial year. A p-value less than 0.05 is considered significant.

| | | Population | | |
|---|---|---|---|---|
| **Trial** | **Crop** | **Control** | **BIO** | **p-value** |
| SAREC Trial 1-18 | Sugar Beet | 33,215 | 31,853 | 0.789 |
| SAREC Trial 1-19 | Corn | 34,848 | 31,037 | 0.953 |
| SAREC Trial 2-19 | Sugar Beet | 42,471 | 51,728 | 0.378 |

**Table 3.** Average sugar beet yield and sugar content for SAREC, PREC, and On-farm trials. P-values compare SCP (control) and BIO treatments within each trial year. A p-value less than 0.05 is considered significant.

| | Yield (ton/a)1 | | | Sugar (%) | | | Sugar (ton/a) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Trial** | **Control** | **BIO** | **p-value** | **Control** | **BIO** | **p-value** | **Control** | **BIO** | **p-value** |
| SAREC Trial 1-18 | 28.9 | 26.5 | 0.294 | 15.5 | 15.7 | 0.773 | 4.5 | 4.2 | 0.648 |
| SAREC Trial 2-19 | 18.7 | 18.9 | 0.897 | 17.2 | 17.3 | 0.787 | 3.2 | 3.3 | 0.829 |
| PREC Trial 1-18 | 28.3 | 26.7 | 0.400 | 13.8 | 14.4 | 0.317 | 3.9 | 3.9 | 0.315 |

**Table 4.** Average yield, % moisture, and test weight (TWT) for control and BIO treatments within each location. P-values compare SCP (control) and BIO treatments within each trial year. A p-value less than 0.05 is considered significant.

| | Yield (bu/a) | | | Moisture (%) | | | TWT | | |
|---|---|---|---|---|---|---|---|---|---|
| Trial | Control | BIO | p-value | Control | BIO | p-value | Control | BIO | p-value |
| SAREC Trial 1-19 | 178.3 | 189.0 | 0.081 | 53.2 | 52.9 | 0.252 | 18.6 | 19.3 | 0.144 |
| PREC Trial 1-19 | 171.8 | 168.5 | 0.362 | - | - | - | - | - | - |

**Acknowledgments**

Funding for this study is provided by Insure Organics and Agscitech Inc.

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Research and Markets. Top Trends in the Agricultural Biologicals Market Industry: Biopesticides (Biofumigants, Bioinsecticides, Bionematicides), Biostimulants, Biofertilizers, Agricultural Inoculants, and Biological Seed Treatment – Global Forecast to 2023. https://www.researchandmarkets.com/research/cnf2zz/the_global?w=4

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**Keywords:** soil health, fertilizer, sugar beet

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

# Intensive Irrigated Forage Rotation Compared to Corn on Corn

*Blaine Magnuson, James C. Hageman Sustainable Research & Extension Center*

*Carrie Eberle, Department of Plant Sciences and James C. Hageman Sustainable Agriculture Research & Extension Center*

## Introduction

There is a need to produce quality forage and feed with a more reliable year-round supply and variety of feedstuffs in southeastern Wyoming. There is interest in the production and use of some non-traditional feedstuffs to help lengthen the grazing season and improve the quality and variety of rationed winter diet available to livestock producers.

## Objectives

Evaluate teff grass, forage soybean, brassica mixtures, annual cereal grasses, sorghum-sudangrass, and grain corn rotation for suitability to replace corn/cornstalks as a feed staple in a farming/livestock operation in southeastern Wyoming. Determine suitability of this rotation economically, practically, and sustainably.

## Materials and Methods

In the fall of 2018, a 65-acre center pivot irrigated field at SAREC in Lingle, Wyoming, was selected for this study. It was divided into four approximately 13-acre fields with four 3-acre check strips of corn located in between the wedge-shaped fields. The crop rotation will consist of spring planted crops followed by a winter cover crop for grazing. The crops will be rotated through all wedges in four years. The rotation is peas with a winter cereal for winter grazing and hay in spring, teff grass, winter cereal/brassica mix for grazing, soybeans for hay or silage, winter cereal with brassicas for grazing, corn for grain, sorghum-sudan grass for hay or silage, peas and winter cereal. Yields will be measured off of total production per area and feed samples will be analyzed for relative feed value, crude protein, digestibility, and energy content. Soil samples will be taken annually from geographically fixed locations within the three soil types on the field and compared to the check corn in each soil type. This will be done by having the soil tested for organic matter, carbon-to-nitrogen ratio, and scored for soil health. Soil will also be analyzed annually for nutrient content and recommendations per crop.

## Results and Discussion

In the first year of this study a great many things were learned (Table 1). Winter seeded winter peas showed poor survival rates to spring along with a very high seed cost. Soybeans proved to be a feasible crop, with the silage yield being approximately 8 tons per acre on a wet basis, but further research is needed into ensiling practices to ensure palatability and storability. Teff grass performed well, yielding approximately 2 tons per cutting, although further experimentation with seeding rate and seeding method is needed to maximize efficiency and economic return. Sorghum-sudangrass and grain corn are established crops in the area and performed as expected. Soil results were analyzed but not enough information is available for any preliminary conclusions.

**Table 1.** Yield of the various crops tested; June 2019 through August 2020

| Field | Crop | Method | Yield/Acre | Date |
|---|---|---|---|---|
| WP4 | Rye | Hay | 13.5 Tons | 6/17/2019 |
| WP3 | Soybeans | Silage | 7.33 Tons | 9/10/2019 |
| WP1 | Sorghum | Silage | 20.02 Tons | 9/10/2019 |
| WP4 | Teff Grass | Hay | 2.0 Tons | 9/25/2019 |
| WP2 | Corn | Grain | 138.1 Bushels | 11/19/2019 |
| C1 | Corn | Grain | 120.5 Bushels | 11/19/2019 |
| C2 | Corn | Grain | 117.6 Bushels | 11/19/2019 |
| C3 | Corn | Grain | 147.4 Bushels | 11/19/2019 |
| C4 | Corn | Grain | 132.1 Bushels | 11/19/2019 |
| WP3 | Rye/Turnip | Graze* | 2203 Pounds | 4/29/2020 |
| WP4 | Rye/Brassica | Graze* | 1732 Pounds | 4/29/2020 |
| WP1 | Rye/Pea | Graze* | 3153 Pounds | 4/29/2020 |
| WP1 | Rye/Pea | Hay | 1.71 Tons | 6/10/2020 |
| WP1 | Teff Grass | Hay | 2.02 Tons | 8/24/2020 |

**Grazed amounts were collected from an enclosure that prevented animals from grazing within them. This represents the amount that was grazed off during the grazing period.*

**Acknowledgments**

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

**Contact:** Blaine Magnuson, bmag@uwyo.edu, 307-837-2000.

**Keywords:** forage, soybean, teffgrass, teff, irrigated, sorghum-sudangrass, rotation

**PARP:** I

# Cover Crop Suitability for Dryland Winter Wheat (*Triticum aestivum*)-Fallow in Semi-arid Region: Water Use and Competition with Weedy Species

*Elizabeth Moore, Department of Plant Sciences*

*Urszula Norton, Department of Plant Sciences*

## Introduction

High altitude/low moisture agriculture has many challenges. Native soil has low organic matter, moisture is limited, and weed competition is high. One way to combat these challenges is the incorporation of cover crops into an agricultural system. By using cover crops, organic matter can be returned to the soil, water evaporation can be reduced, and the cover crops can smother the weeds thus reducing the weed seed bank. There is concern however, that cover crops grown in a fallow can dry down moisture in a soil profile and develop a moisture stress for subsequent winter wheat planting. Understanding the mechanisms of cover crop controls on soil water extraction and competition with weedy species in greenhouse conditions can help design more beneficial cover crop mixes for semiarid dryland agriculture.

## Objectives

Evaluate four cover crop mixes grown in farmland soil sources from SAREC on soil moisture and competition with weedy species.

## Materials and Methods

Study duration: 9 weeks at the University of Wyoming greenhouse.

Cover crop treatments:

| Cold Season Nitrogen Fixing Mix | Cold Season Soil Building Mix | Mycorrhizal Mix | Phacelia |
|---|---|---|---|
| Legumes:<br>Spring peas<br>Chickling vetch<br>Spring lentils<br>Chick peas<br>Common vetch<br>Crimson clover | Spring peas<br>Spring lentils<br>Common vetch<br>Crimson clover | Common vetch<br>Mung bean<br>Spring lentils<br>Berseem clover<br>Persian clover | |
| Grasses:<br>Spring oats | Spring forage barley<br>Oats | Oats<br>Barley<br>White Wonder millet<br>Proso millet<br>Brown top millet | |
| Brassicas:<br>Rapeseed | Rapeseed | | |
| Other broadleaves<br>Sunflower<br>Flax | Sunflower<br>Flax | Phacelia<br>Sunflower<br>Flax<br>Safflower | Phacelia |

Low seeding rate of cover crop mixtures were grown in 1.5 kg of soil amended with above treatments. Each treatment was replicated twelve times for a total of sixty experimental pots.

## Results and Discussion

All cover crop treatments successfully suppressed weed species biomass. The weed biomass declined by 60% on average. This suggests that annual planting of any cover crop mixes will help reduce weed species seed bank, (Figure 1).

Mycorrhizal mix and pure stand of phacelia can draw down soil moisture by as much as 5%. It is a significant decline given the soils in the region from where the soil was sourced have extremely low moisture contents (Figure 2). These results are somewhat counterintuitive because phacelia produced the lowest amount of cover crop biomass. It is also unclear if extending the length of experiment would change the results. Mycorrhizal mix should eventually aid in plants accessing water via hyphal connections.

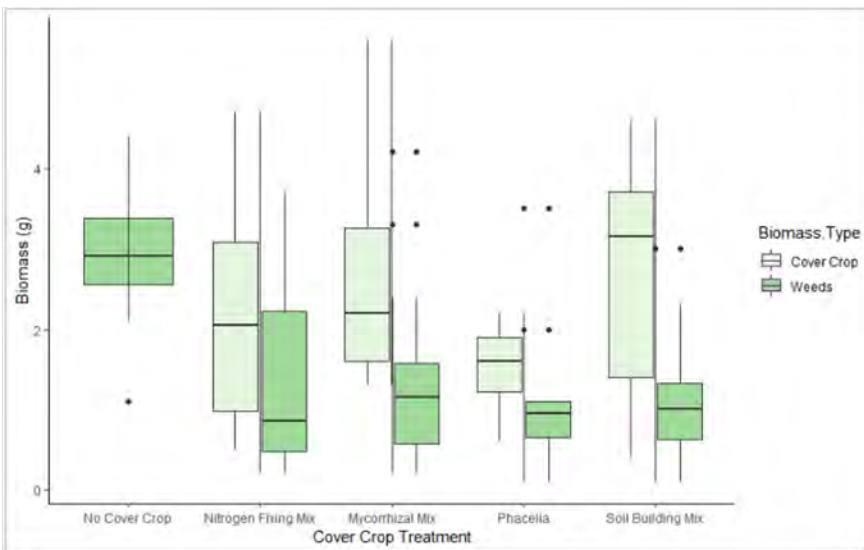


**Figure 1.** Cover crop and weedy species biomass from four cover crop mixes and one no cover crop control.

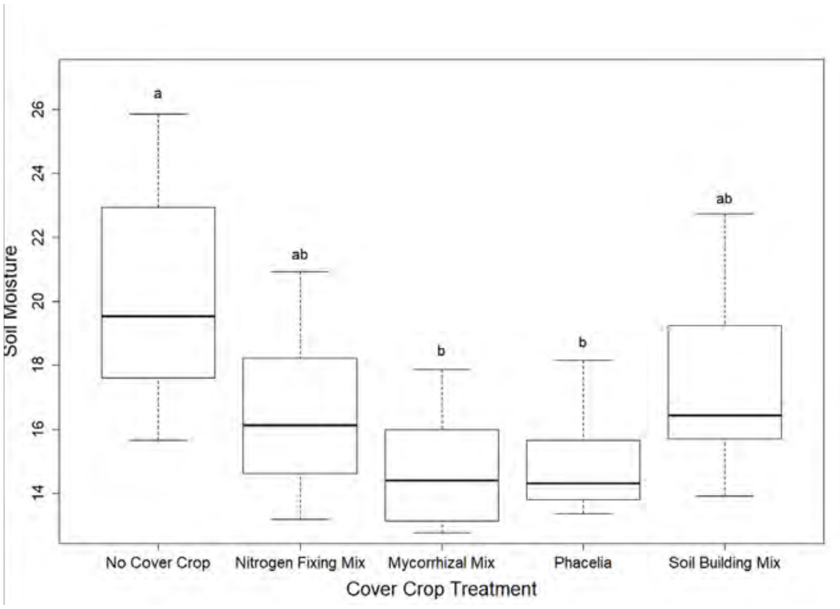


**Figure 2.** Soil available moisture.

**Acknowledgments**

Thanks to Kevin Madden, Blaine Magnuson and the rest of the field crews for their help preparing and planting the cover crop field. The study is supported by U.S. Department of Agriculture Hatch-multistate funds.

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**Keywords:** cover crop, dryland winter wheat, weed suppression

**PARP:** II and III

# Wyoming First Grain Project: Effect of Location, Irrigation and Nitrogen on Crop Growth, Yield, and Quality of Ancient Grains of Wheat in Wyoming

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### Introduction

Crop diversity in Wyoming is limited by poor soil health, arid conditions, isolation from markets, and high evapotranspiration demands. First grains like einkorn, emmer, and spelt are early predecessors of modern wheat and more adaptable to marginal agricultural land. There has been rapid increase in the market demand of ancient grains due to their desirable characteristics like higher protein (Campbell, 1997), distinct nutrition, and unique taste. First grains are thought to be a viable alternative small grain for Wyoming.

### Objectives

Identify agronomic management practices and fertility needs of spelt, emmer, and einkorn. Determine how fertility affects agronomic traits and grain quality under multiple Wyoming growing conditions and locations.

### Materials and methods

This study was conducted at the James C. Hageman Sustainable Agriculture Research Center (SAREC) in 2019. The experiment was a randomized design with 3 replications. Spelt, emmer, einkorn, and modern wheat were grown under different nitrogen application rates in irrigated and dryland fields. Both irrigated and dryland spring trials in SAREC were planted on May 6th, 2019. The irrigated seeding rate was 100 lbs/a and the dryland rate was 60 lbs/a. Nitrogen treatments of low, medium, and high (25, 50, 80 lbs nitrogen/acre for dryland, and 50, 80, 110 lbs nitrogen/acre for irrigated) were applied to each crop before planting. Data on heading date and yield were taken. Crops were harvested at maturity with a Kincaid small plot combine and hulled and dehulled yield was calculated. Percent yield loss when the hull was removed was calculated as [1-(grain yield/hulled yield)].

### Results and discussion

In spring 2019, ancient grains differed from each other and modern wheat in growth pattern and maturity. Einkorn was the slowest to mature heading out about 2 weeks later than spelt and emmer in irrigated field and 18 days later in dryland field (Table 1). When the other crops were ripening, it was still green (Figure 1). Wheat was ready to harvest the earliest first, followed by emmer, then spelt, then einkorn (Table 1). Growth was slower in the dryland than under irrigation as seen by later heading and harvest dates (Table 1). Nitrogen treatment had no effect on crop heading or harvest date. Due to differences in crop growing period and pattern, growing these ancient grains might require some changes in agronomic management practices and alteration in crop rotation.

**Table 1.** Heading date (HD) and harvest date (CD) of first grains in 2019.

| | Dryland | | | | | | Irrigated | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25 lb/a N | | 50 lb/a N | | 80 lb/a N | | 50 lb/a N | | 80 lb/a N | | 110 lb/a N | |
| | HD | CD | HD | CD | HD | CD | HD | CD | HD | CD | HD | CD |
| Wheat | 7/5 | 8/20 | 7/5 | 8/20 | 7/5 | 8/20 | 6/28 | 8/18 | 6/28 | 8/18 | 6/28 | 8/18 |
| Spelt | 7/11 | 9/5 | 7/11 | 9/5 | 7/11 | 9/5 | 7/5 | 8/27 | 7/5 | 8/27 | 7/5 | 8/27 |
| Emmer | 7/11 | 8/23 | 7/11 | 8/23 | 7/11 | 8/23 | 7/5 | 8/23 | 7/5 | 8/23 | 7/5 | 8/23 |
| Einkorn | 7/24 | 9/6 | 7/24 | 9/6 | 7/24 | 9/6 | 7/23 | 9/06 | 7/23 | 9/06 | 7/23 | 9/06 |

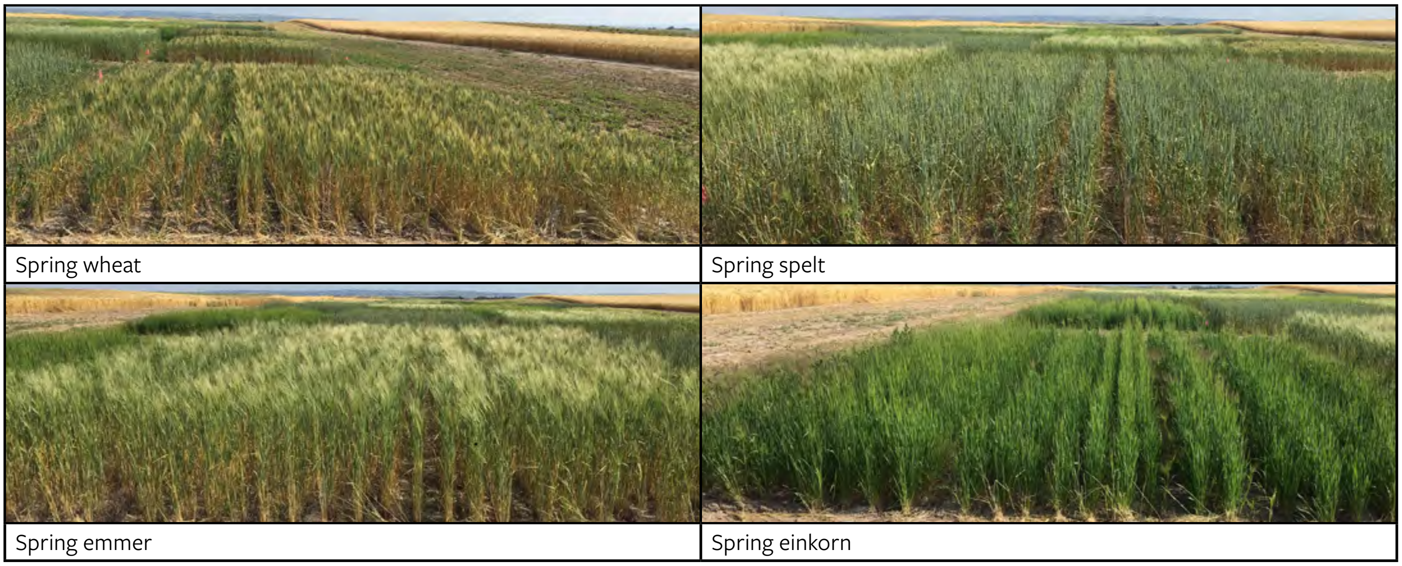


**Figure 1.** Field pictures of wheat, spelt, emmer, and einkorn growing in the SAREC dryland on August 2, 2019, showing maturity differences between the four crops.

**Table 2.** Average grain yield (lbs/a) of first grains. Yields are reported for hulled (grain in the hull) and grain (grain only with the hull removed). Percent yield loss [1- (grain yield/hulled yield)] is reported for spelt and emmer as loss. P-values for yield within each crop are given. NS means not significant, ND means no data, and NA means not applicable.

| | Wheat | | | Spelt | | | Emmer | | | Einkorn | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hulled | Grain | Loss | Hulled | Grain | Loss | Hulled | Grain | Loss | Hulled | Grain | Loss |
| lbs/a N | Dryland | | | | | | | | | | | |
| 25 | NA | 801 | NA | 606 | 331 | 45% | 1017 | 604 | 42% | 243 | ND | ND |
| 50 | NA | 750 | NA | 526 | 320 | 39% | 880 | 537 | 40% | 243 | ND | ND |
| 80 | NA | 793 | NA | 552 | 343 | 38% | 1156 | 719 | 38% | 272 | ND | ND |
| p-value | | NS | | NS | NS | NS | NS | NS | NS | NS | | |
| | Irrigated | | | | | | | | | | | |
| 50 | NA | 947 | NA | 1257 | 517 | 58% | 861 | 505 | 41% | 915 | ND | ND |
| 80 | NA | 1707 | NA | 1192 | 549 | 56% | 751 | 497 | 35% | 979 | ND | ND |
| 110 | NA | 1228 | NA | 1157 | 607 | 49% | 908 | 610 | 33% | 815 | ND | ND |
| P-value | | NS | | NS | NS | NS | NS | NS | NS | NS | | |

Hulled yield, naked grain yield, and percent yield loss to hull of each crop was not affected by nitrogen treatment under irrigated or dryland conditions (Table 2). The lack of yield response to N suggests that either the optimum N was applied even at 25 lbs/a or that there was an error in application and the plots did not have access to the applied

N. Percent yield loss to hull was higher for spelt than emmer under irrigation. When comparing yield of the different grains, the grain yield of modern wheat was higher than emmer and spelt, however, lower yield of ancient grains might be offset with their high market demand and price premium.

The Wyoming first grains project will be continued through 2021. Future work includes dehulling of einkorn, grain quality analysis, analysis of soil nitrogen and nitrogen use efficiency, and market analysis for each crop. Studies have been repeated for the 2020 crop season.

**Acknowledgements**
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**Keywords:** ancient grains, agronomy, nitrogen, irrigation

**PARP:** I2, II10

# Improving Dryland Winter Wheat (*Triticum aestivum* L.) Performance by the Inclusion of Composted Cattle Manure and Cover Crops


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*Christina Helseth, Department of Plant Sciences*

*Jay B. Norton, Department of Ecosystem Sciences and Management*


## Introduction

Producing a successful dryland crop in semi-arid environments can have several challenges. These include nitrogen (N) and phosphorus (P) deficiencies, soil moisture limitations, and high weed competition. One time application of an excessively high rate of composted feedlot manure (compost) in winter wheat (*Triticum aestivum* L.)-fallow system can create long-term benefits that will help overcome earlier mentioned deficiencies. Furthermore, planting cover crops shortly after compost application may help conserve N released from decomposition compost and potential N losses in winter wheat (*Triticum aestivum* L.)-fallow systems.

## Objectives

Test the effect of the presence of cover crops after amending the soil with composted cattle manure on soil nitrogen and winter wheat yield

## Materials and Methods

Study site — 15-year old organically-managed winter wheat-fallow rotation located at the University of Wyoming Sustainable Agriculture Research & Extension Center (SAREC), Lingle, Wyoming (42.14° N, 104.35°W), 1276m elevation (Fig. 1). Soil is sandy clay loam with slightly alkaline pH and <1% SOM content. MAP: 398mm. MAT: 7.5°C

## Approach

Sep. 2015 — Compost was applied during the fallow phase at the rates of 0, 15, 30, 45 Mg/ha (referred to as 0, L, M, H, respectively).

May 2018/2019 — Austrian Winter Pea (*Pisum sativum*) and Oat (*Avena sativa*) cover crop mix planted in the fallow phase for a period of 60 days.

Aug. 2018/2019 — Wheat grain harvested.

Seasonal data collection — Soil samples (0-5cm and 5-15cm depths) using a hand probe.

## Results and Discussion

Elevated levels of crop available N, P and soil moisture at the highest rate of compost application continue to be present in the fourth year of monitoring. Planting cover crops did not have a negative impact on wheat yield (no significant differences between treatments) and the above parameters (Fig. 2). There was no synergy between the compost and cover crops planting suggesting that farmers may be able to avoid costs associated with the seed purchase.

**Acknowledgments**
Thanks to field Lab/Field crew: Nick Andrews; Kelly Andrews; Liana Boggs Lynch; Dixie Crowe; Olanre Ebanks; Tara Geiger; Katherine Hunley; Liz Moore; Leann Naughton; Justin Schomerus; Mary Smith; Amelia Zenerino. The study is supported by U.S. Department of Agriculture OREI and Hatch-multistate funds.

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**Keywords:** dryland winter wheat, organic dryland farming, high rate of compost

**PARP:** I.1.; I.3.; I.5.; I.9;

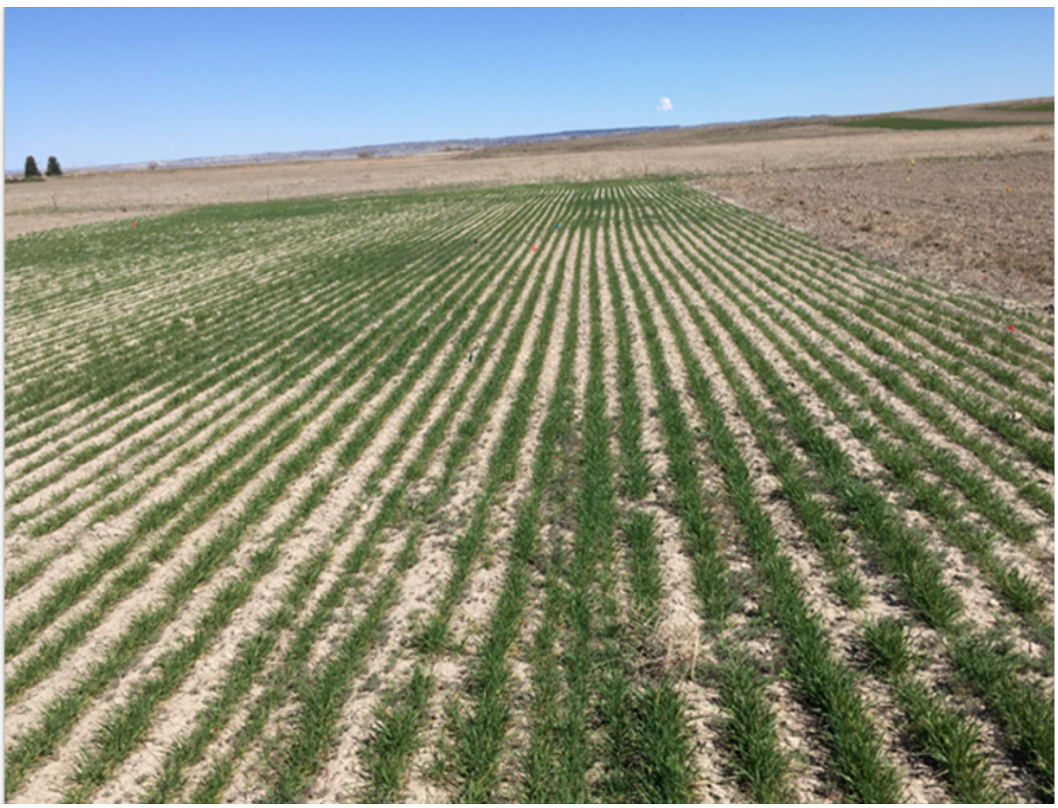

**Figure 1.** Winter wheat spring green-up in plots with different compost rates.

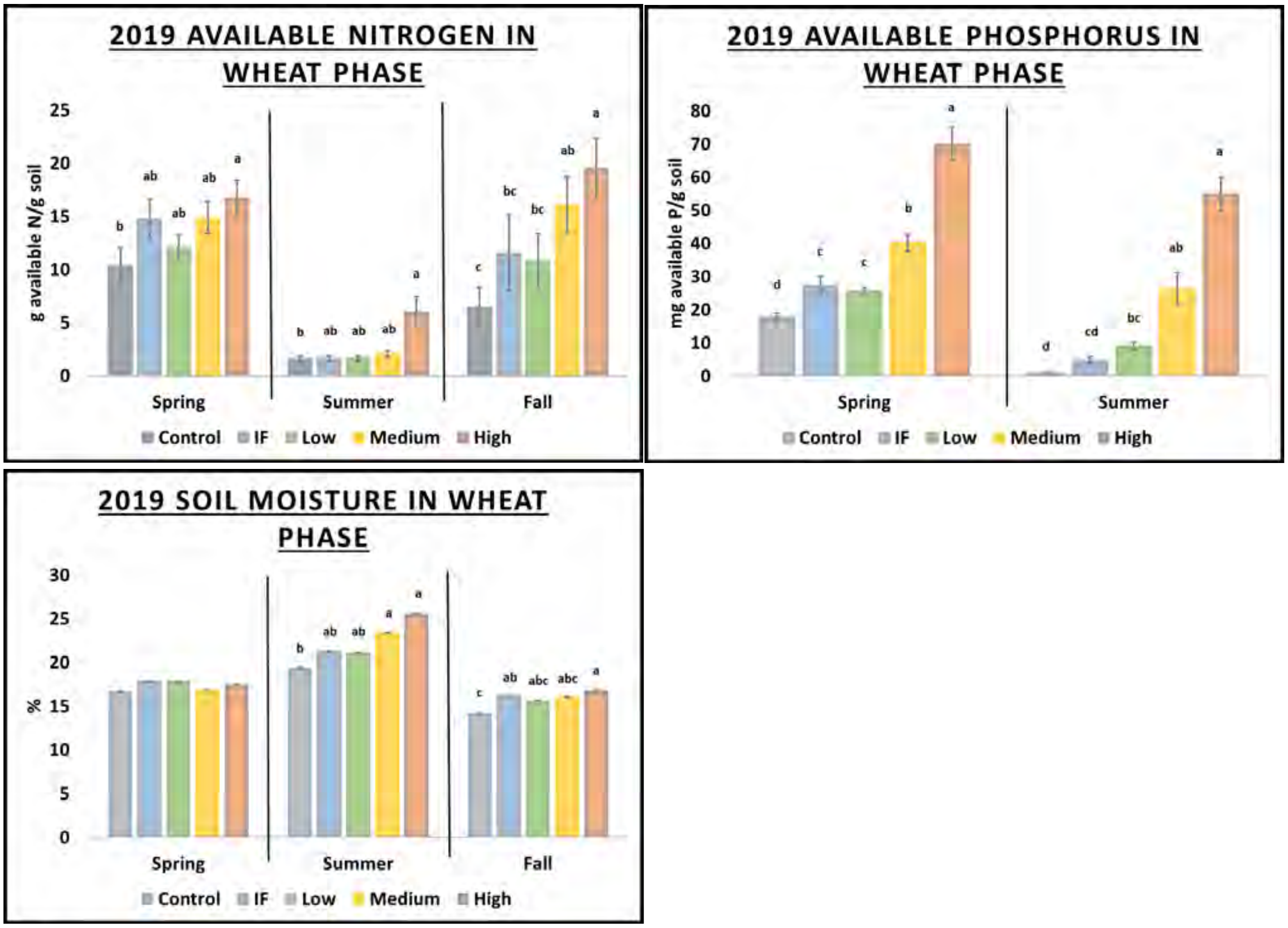


**Figure 2.** Soil available N, P and soil moisture.

# Management of Potato Early Blight with Foliar Fungicide Programs

*William Stump, Department of Plant Sciences*

*Wendy Cecil, Department of Plant Sciences*

## Introduction

Potato early blight is a major foliar disease of potato production. Typically, conventional growers manage this disease effectively with foliar fungicide programs. With emerging fungicide resistance in most production areas, research continues to explore new chemistries and fungicide rotations for early blight control and resistance management.

## Objectives

The objective of this study is to determine the efficacy of foliar fungicide programs on potato early blight management.

## Materials and Methods

The study was established in 2019 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Five treatments were compared to both a non-treated inoculated and a non-treated non-inoculated check for the management of potato early blight. 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 ('Atlantic') was planted on 3 June. Seed-pieces were spaced 12-inches apart with 36-inch row centers. Prior to the second fungicide treatments, the potatoes in the plot area were inoculated with an application of an *Alternaria solani* spore suspension. Foliar fungicide treatments were applied at ca. 7-day intervals starting on 19 August with the aid of a CO2-pressurized backpack sprayer. The plot received fertility, weed control, and irrigation appropriate for potato production. Parameters measured were foliar lesion counts, an area under the disease progress curve (AUDPC) and yield.

## Results and Discussion

A portion of the data is presented in Table 1. Following inoculation on 25 July disease initially progressed slowly then disease was slowed due to extensive defoliation from hail storm in early July. Disease then advanced noticeably in late August resulting in moderate disease development. No phytotoxicity due to treatments was observed on the potato crop. Plot inoculations resulted in significantly greater disease than the non-treated non-inoculated plots ($P \leq 0.05$).

All treatments had significantly reduced early blight equally compared to the non-treated check by 9 September and for subsequent ratings ($P \leq 0.05$). All treatments reduced overall disease as measured by AUDPC, 84-93% compared to the non-treated check ($P \leq 0.05$). For the AUDPC (measure of overall disease) there were no significant differences between fungicide treatments. Fungicide programs had no significant effect on yield and quality most likely due to the late onset of disease.

## 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:** potato early blight, fungicide

**PARP:** I:11

**Table 1.** Management of potato early blight with foliar fungicide programs.

| Treatment, rate (product/A), and timing[1] | Average number of lesions per leaflet | | AUDPC[2] | Total tuber yield (lbs/20 row ft) |
|---|---|---|---|---|
| | 9 Sep | 20 Sep | | 26 Sep |
| Non-treated, Non-inoculated Check | 5.5 b[3] | 23.1 b | 199.2 b | 25.3 a |
| Non-treated, Inoculated Check | 15.4 a | 35.7 a | 405.6 a | 30.7 a |
| Luna Tranquility (11.2 fl oz) + Induce (0.5% v/v) AB<br>Scala 60 SC (7 fl oz) + Echo ZN (24 fl oz) CD | 1.1 b | 1.7 c | 28.2 c | 30.1 a |
| Luna Tranquility (11.2 fl oz) + Induce (0.5% v/v) AC<br>Scala 60 SC (7 fl oz) + Echo ZN (24 fl oz) BD | 1.0 b | 1.7 c | 28.3 c | 23.4 a |
| Luna Tranquility (11.2 fl oz) + Induce (0.5% v/v) AC<br>Serenade ASO (1 qt) B<br>Scala 60 SC (7 fl oz) + Echo ZN (24 fl oz) D | 1.4 b | 1.6 c | 30.5 c | 26.6 a |
| Propulse (10.3 fl oz) + Induce (0.5% v/v) A-D | 1.4 b | 1.8 c | 33.5 c | 36.0 a |
| Echo ZN (32 fl oz) AC<br>Dithane Rainshield (32 oz) BD | 2.4 b | 3.9 c | 66.9 c | 23.4 a |

[1]*Treatment application dates A-D, respectively: A= 19 Aug, B= 26 Aug, C= 2 Sep, and D= 10 Sep.*

[2]*AUDPC= area under the disease progress curve.*

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

# Management of Potato Early Dying Syndrome with In-Furrow Fungicide/Nematicides and Foliar Fungicide Combinations

*William Stump, Department of Plant Sciences*

*Wendy Cecil, Department of Plant Sciences*

## 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.

## Objectives

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

## Materials and Methods

The study was established in 2019 at the James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC). Four treatments were compared to a non-treated check for the management of potato early dying syndrome. 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. The plot was planted on 3 June with seed-pieces 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. After application, the furrows were closed with the planter closing discs. The foliar broadcast pesticide treatment was applied 1 and 15 August with the aid of a CO2-pressurized backpack sprayer. The plot received fertility, weed control, and irrigation appropriate for potato production. Parameters measured were potato stand counts, visual estimates of foliar necrosis, and tuber yield.

## Results and Discussion

A portion of the data is presented in Table 1. The in-furrow treatment applications had no effect on potato stands from the middle two rows of each plot (40 row ft in total) as measured on 16 July. On 6 September, there was minor necrosis beginning in the plots but treatments had no effect on early stand decline. 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 most likely due to light disease pressure.

## 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 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) |
|---|---|---|---|
| | 16 Jul | 6 Sep | 26 Sep |
| Non-treated check | 31.0 a[3] | 3.0 a | 46.0 a |
| Velum Prime (6.5 oz) A | 33.8 a | 0.0 a | 45.5 a |
| Velum Prime (6.5 oz) + Serenade ASO (1 qt) A | 34.5 a | 1.5 a | 38.0 a |
| Velum Prime (6.5 oz) A<br>Movento HL (2.5 fl oz) + MSO (0.5 % v:v) B, C | 33.5 a | 0.5 a | 38.4 a |
| Velum Prime (6.5 fl oz) A<br>Luna Tranquility (11.2 oz/A) + Induce (0.125% v:v) B, C | 36.0 a | 1.0 a | 41.4 a |

[1]*Treatment application dates A-C, respectively: 3 Jun (in-furrow), 1 and 15 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≤0.05).*

# Growth Regulator Effects on Ventenata Seed Viability

*Beth Fowers, Sheridan Research & Extension Center*

*Brian Mealor, Sheridan Research & Extension Center and Department of Plant Sciences*

## Introduction

Introduced annual grass species cause negative ecological and economic impacts such as native species diversity loss and costs associated with fire management and rehabilitation. With the confirmed presence of invasive annual grasses ventenata (*Ventenata dubia*) and medusahead wildrye (*Taeniatherum caput-medusae*) in 2016 in Sheridan County, management has focused on pre-emergent herbicide applications as the most efficient control method. However, some populations are found after emergence of the current year's cohort of plants, which necessitates a different approach. One potential option is to use growth regulator herbicides, which have been observed to cause plant sterility in some annual grasses at post-emergence timings.

## Objectives

The objective of this study was to determine the effects of two growth regulator herbicides, alone and combined, on the viability of introduced annual grasses at two post-emergence timings.

## Materials and Methods

We applied six herbicide mixtures at two different timings (early and mid-June) in 2019 with a total volume of 20 gallons per acre with a $CO_2$-pressured sprayer and a 10-foot boom with six 8002 nozzles. Treatments were implemented in 10- by 25- foot plots set in a randomized complete block design with four replicates and a replicated, non-treated check. Treatments included Milestone (aminopyralid at 4.1 or 6.7 fl oz/ac), Loyant (florpyrauxifen-benzyl at 3.15 or 5.3 fl oz/ac), and aminopyralid+florpyrauxifen-benzyl at 12 or 20 fl oz/ac.

Applications on June 1 occurred with a 73°F air temperature, 48% relative humidity, 72°F soil temperature at 2 inches deep, and 8 mph wind. Japanese brome and ventenata were at the boot to late-boot stage while cheatgrass was in the flower to early purple stage. Applications on June 19 occurred with a 70°F air temperature, 57% relative humidity, 69°F soil temperature at 2 inches deep, and 5 mph wind. Annual grasses were flowering, with a slight shift to purpling, some up to 12 inches tall. We visually evaluated plots with a damage rating by species as well as recording all species cover in two 1/4-meter$^2$ frames/plot. When plants reached maturity, we collected 20 ventenata and Japanese brome plants/plot to assess germination. We counted 50 seeds from the collected plants from each plot and placed them in germination chambers for one month (68°F day, 59°F night, 12 hour day).

## Results and Discussion

In 2019, we observed no statistical differences in visual control. Germination showed that growth regulators differentially reduced viability of seed produced (Figure 1). Milestone effectively reduced seed viability while Loyant did not. Application timing also had a strong impact with earlier application at the boot stage having a greater negative impact on viability. Rate had some effect, but stronger trends occurred with herbicide and timing. We also observed that species responded different: Japanese brome was more susceptible to the herbicides than ventenata.

Growth regulators may offer a post-emergent spring option for initial control of invasive annual grasses if the pre-emergent application window is missed.

In 2020, the trial was repeated on an area dominated by medusahead wildrye with an additional component of ventenata and Japanese brome. Germination trial will occur fall of 2020.


**Acknowledgements**

We would like to thank ShREC team and summer interns for contributions to data collection and to Corteva for their support of the research.



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



**Keywords:** annual grass, herbicides, seed viability


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

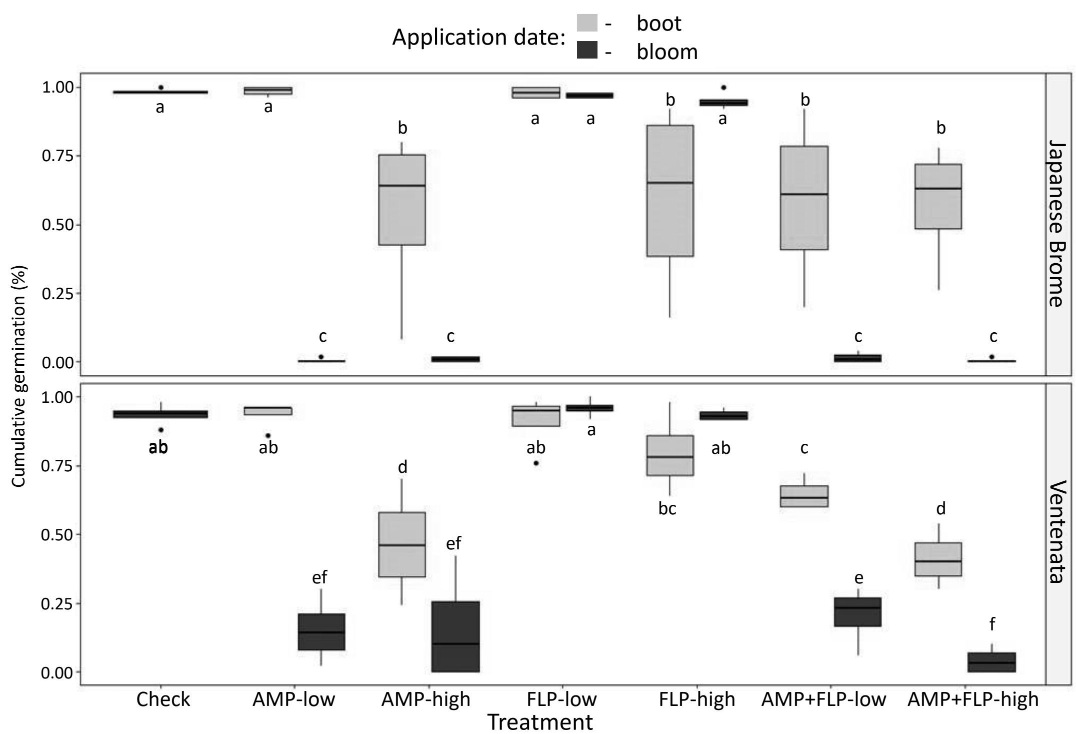


**Figure 1.** Cumulative germination (%) of Japanese brome and ventenata with post-emergence applications (boot - 1 June, bloom - 19 June). Standard error bars shown. Letters indicate statistical significance.

# Efficacy of Various Herbicides on Whitetop

*Brian Mealor, Sheridan Research & Extension Center and Department of Plant Sciences*

*Beth Fowers, Sheridan Research & Extension Center*

### Introduction

Whitetop (*Lepidium draba*) is a state-designated noxious weed that causes meaningful impacts in hay meadows, riparian rangelands, and other sites. It invades areas of native species, forming dense colonies, especially in wetter areas. Some herbicides are available for management, but more effective herbicides may provide additional options for control.

### Objectives

Our objective was to determine the effectiveness of various herbicides and herbicide combinations on whitetop control.

### Materials and Methods

We applied seven different herbicides alone and in various combination (Table 1). Application occurred May 29, 2019 with a total volume of 20 gallons per acre with a $CO_2$-pressurized sprayer and a 10-foot boom with six 8002 nozzles. Treatments were implemented in 10- by 25 foot plots set in a randomized complete block design with four replicates. Application occurred with a 67°F air temperature, 36% relative humidity, 67°F soil temperature at 2 inches deep, and less than 1 mph wind, with occasional gusts up to 6 mph. Whitetop was mostly blooming and roughly six inches tall. We visually estimated damage (%) by plot by comparing to untreated strips surrounding the plot and between the first blocks and block four (nontreated references).

### Results and Discussion

Distinct differences were observed between treatments, which continued into early 2020. Second year control of white top by most herbicides was achieved with over 75% control (Figure 1). Other treatments still provided over 50% control, a degree which may not be considered effective enough for management. Method alone provided around 30% control, illustrating a lack of effectiveness as a whitetop herbicide. New herbicide options are sought to increase options for management and this study supports an increase in knowledge of options for whitetop control.

### Acknowledgements

Thanks to Corteva for support of this research.

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**Keywords:** hoary cress, noxious weed, weed management

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

**Table 1.** Herbicides used for whitetop control including rate and adjuvant.

| Herbicide | Rate | Adjuvant | Adjuvant rate | Treatment |
|---|---|---|---|---|
| aminopyralid+florpyrauxifen -benzyl | 16 fl oz/ac | MSO w/leci-tech | 1 % v/v | 1 |
| aminopyralid+florpyrauxifen -benzyl | 16 fl oz/ac | activator 90 | 0.25 % v/v | 2 |
| aminopyralid+florpyrauxifen -benzyl | 20 fl oz/a | MSO w/leci-tech | 1 % v/v | 3 |
| aminopyralid+florpyrauxifen -benzyl | 20 fl oz/a | activator 90 | 0.25 % v/v | 4 |
| aminopyralid+florpyrauxifen -benzyl | 2.13 oz/ac | activator 90 | 0.25 % v/v | 5 |
| aminopyralid+florpyrauxifen -benzyl+Escort | 20 fl oz+0.25 oz/ac | activator 90 | 0.25 % v/v | 6 |
| aminopyralid+florpyrauxifen -benzyl+Telar | 20 fl oz+0.25 oz/ac | activator 90 | 0.25 % v/v | 7 |
| Escort | 1 oz/ac | activator 90 | 0.25 % v/v | 8 |
| Telar | 1 oz/ac | activator 90 | 0.25 % v/v | 9 |
| XDE-848 BE+Telar | 0.171 oz ai + 0.25 oz/ac | activator 90 | 0.25 % v/v | 10 |
| XDE-848 BE+Escort | 0.171 oz ai + 0.25 oz/ac | activator 90 | 0.25 % v/v | 11 |
| Method 240SL | 8 fl oz/ac | activator 90 | 0.25 % v/v | 12 |
| GrazonNext HL | 32 fl oz/ac | activator 90 | 0.25 % v/v | 13 |
| Chaparral | 3.3 oz/ac | activator 90 | 0.25 % v/v | 14 |

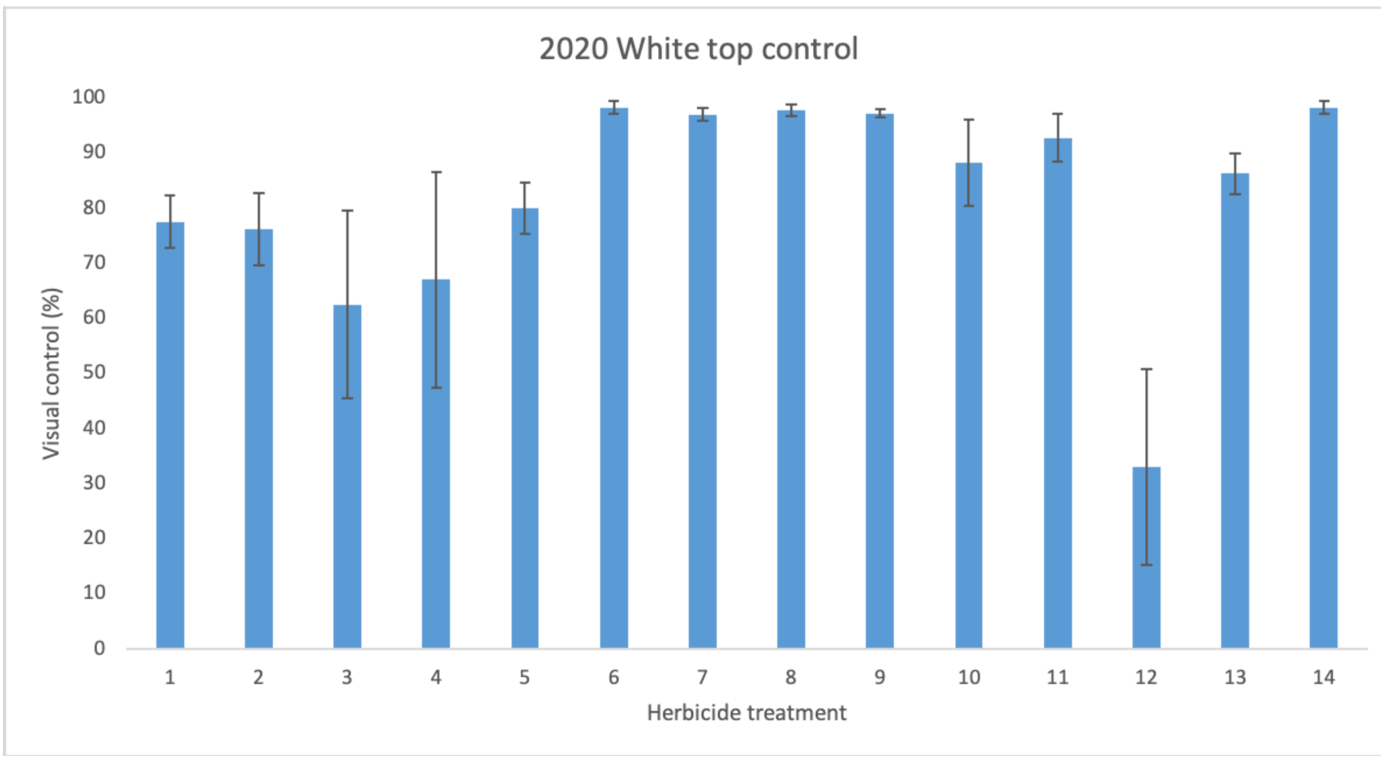


**Figure 1.** Control (%) of whitetop with various herbicide treatments. Treatment numbers correspond to herbicides in Table 1. Error bars shown.

# Influences of Seeding Rate, Timing, and Depth on Green Needlegrass Establishment

*Brian Mealor, Sheridan Research & Extension Center and Department of Plant Sciences*

*Beth Fowers, Sheridan Research & Extension Center*

## Introduction

The use of native species in reseeding efforts has increased over the past few years leading to increased demand for seed. Green needlegrass (*Nassella viridula*) is a native, perennial, coolseason bunchgrass desirable for establishment on rangelands, revegetation projects, and wildlife habitat as it is palatable and can persist on a variety of soils. However, establishment of the species can be difficult which makes seed production (and supply) problematic.

## Objectives

Our objective was to determine the effect of seeding season, rate, and depth on establishing green needlegrass.

## Materials and Methods

We seeded 'Cucharas' green needlegrass in fall (30 Nov. 2018) and spring (5 April 2019) at shallow (1/4 inch) or deep (>1/2 inch) depths, at one of three rates: 4.5, 6.8, and 9.0 PLS lbs/ac (4.7, 7.1, and 9.4 PLS g/plot). Recommended seeding rate for the species is 6 lbs/ac. A cone seeder calibrated to seed 5 x 20 foot plots, with 4 rows was used in this study. Treatments occurred in a randomized complete block design with four replicates. Fall seeding occurred with an air temperature around 30°F and frozen soils while spring temperature was around 60°F with dry soils. Establishment was determined in 2019 and 2020 by counting the number of individual plants within the middle 18 feet of the center two rows of each plot.

## Results and Discussion

Season and rate had the greatest impact on increasing establishment success. Spring seeding resulted in the highest establishment by 2020 (Figure 1). However, some fall seedings resulted in similar establishment as some of the lower-rate spring applications. An increase in rate also resulted in increased establishment with trends that were consistent across season or depth. Depth only resulted in a difference between spring seeding at the highest and middle rate, with the deeper seeding resulting in greater establishment. In 2020 enough seed was produced to be harvested illustrating success of establishment (plots were not harvested separately). This project shows that efforts to increase knowledge about hard-to-establish species are important and can improve success in seed production systems as well as in other seeding efforts.

## Acknowledgements

We thank ShREC team and summer interns for their assistance with seeding and data collection.

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**Keywords:** seed production, native species

**PARP:** XII:1

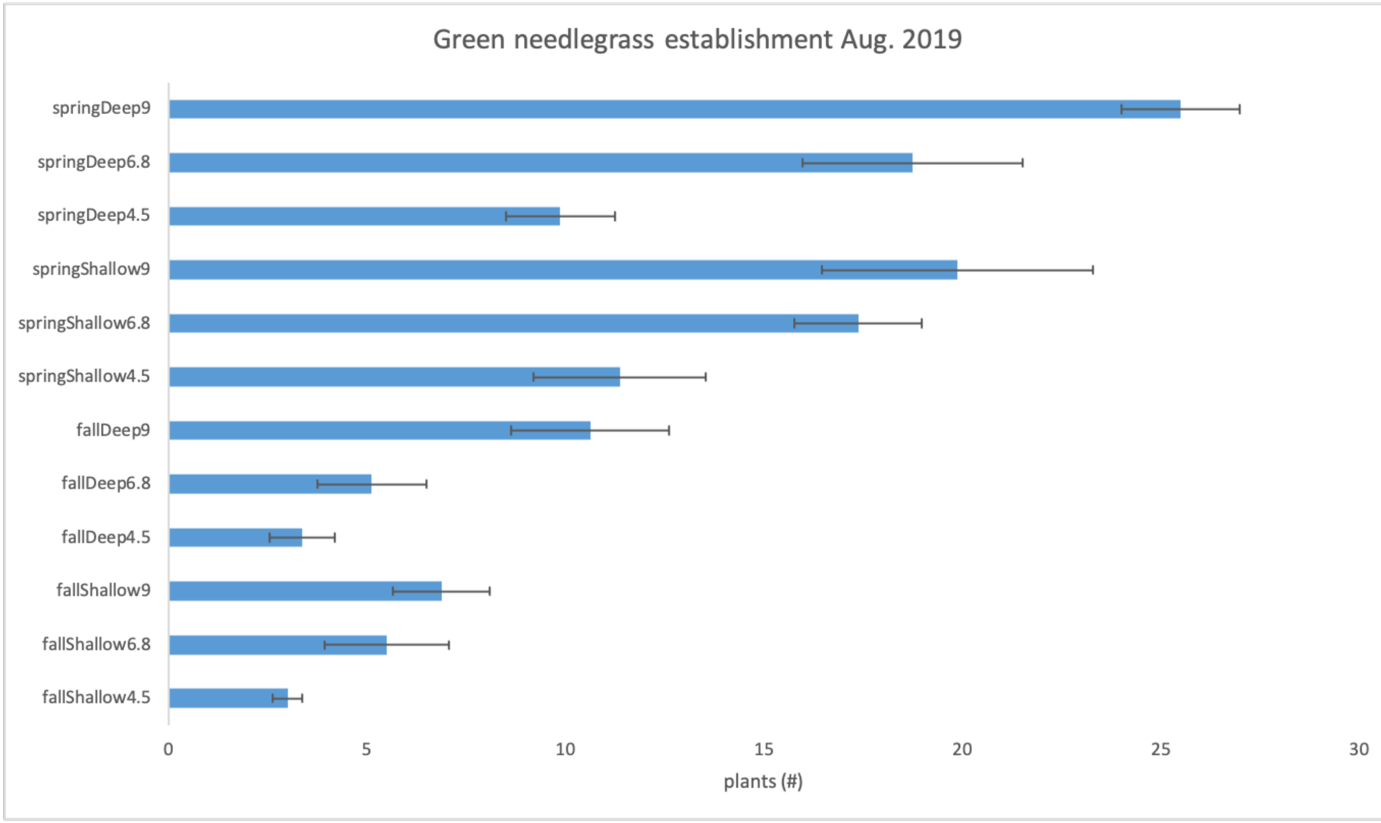


**Figure 1.** Green needlegrass establishment (average) in May 2020, by treatment. Treatment includes season of seeding, depth of seeding, and rate (PLS lbs/ac). Bars show standard error.

# Cheatgrass Control by Application of Herbicides at Various Timings

*Brian Mealor, Sheridan Research & Extension Center and Department of Plant Sciences*

*Beth Fowers, Sheridan Research & Extension Center*

### Introduction

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

### Objectives

The objective of this study was to determine if timing of herbicide application makes a difference in effectiveness of herbicides.

### Materials and Methods

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

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

### Results and Discussion

In the first growing season, post-emergence application resulted in most herbicides exhibiting reduced control compared to pre-treatment applications (Figure 1). Esplanade Sure consistently had close to 100% control across all timings. The combined Esplanade and Plateau treatments had the highest degree of control, except in the post-emergence timing where the lower rate showed less control. The other herbicides exhibited over 70% control. However, Esplanade alone had less than 40% control when applied post emergent. This study illustrates the importance of herbicide application as well as the options that are available for control of cheatgrass. Herbicide application can be very effective at very early pre-emergence timings and when post-emergence application is necessary, there are options which offer excellent control.

### Acknowledgements

We thank ShREC team and summer interns for assistance 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

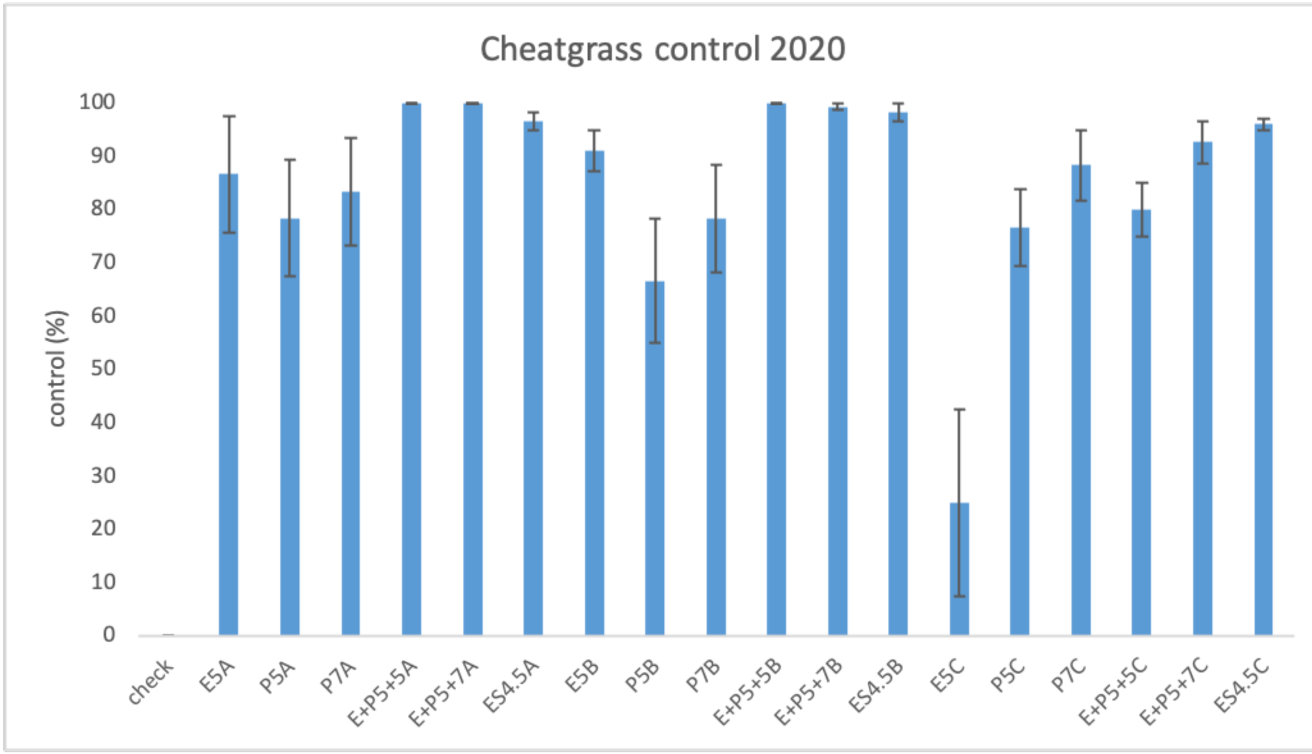


**Figure 1.** Cheatgrass control (%) in 2020. Bars show the amount of control offered by herbicides. Labels indicate herbicide (E=Esplanade, P=Plateau, ES=Esplanade Sure), rate (oz/ac), and application timing (A=July 2019, B=August 2019, C=March 2020). Standard error bars are shown.

# Herbicide Control of Ventenata at Different Application Times

*Brian Mealor, Sheridan Research & Extension Center and Department of Plant Sciences*

*Beth Fowers, Sheridan Research & Extension Center*

### Introduction

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

### Objectives

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

### Materials and Methods

We applied four herbicide mixtures at three different timings (June, July, and August) in 2018 with a total volume of 20 gallons per acre with a CO2-pressurized sprayer and a 10-foot boom with six 8002 nozzles. Treatments were implemented in 10- by 30- foot plots set in a randomized complete block design with four replicates and a replicated, non-treated check. The study was implemented at two sites outside Sheridan, Wyoming. Treatments included Rejuvra (5 oz/ac), Rejuvra (7 oz/ac), Rejuvra + Plateau 2L (5 + 7 oz/ac), and Rejuvra + Matrix (5 + 3 oz/ac). See Table 1 for environmental conditions. We visually evaluated ventenata control annually in 2019 and 2020 by comparing to nontreated plots as well as recording cover of all species at the whole plot level.

### Results and Discussion

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

The ability to extend the period in which applications can occur may allow for an increase in potential application area if there is not a short window in the fall. The ability to increase flexibility in application time may be an important variable with an aggressive management strategy.

### Acknowledgements

We thank ShREC team and summer interns for assistance and support of this research.

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**Keywords:** cheatgrass, weed management, invasive species

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

**Table 1.** Environmental conditions for herbicide application at two sites.

| Site | Date | Air temp. °F | Relative humidity % | Soil temp. °F | Wind (mph) |
|---|---|---|---|---|---|
| Koltiska | 28-Jun-18 | 79 | 62 | 73 | 1 |
| Koltiska | 26-Jul-18 | 60 | 74 | 71 | 2.5 |
| Koltiska | 22-Aug-18 | 66 | 71 | 72 | 4 |
| Kane | 13-Jun-18 | 82 | 39 | 86 | 4.5 |
| Kane | 25-Jul-18 | 77 | 50 | 98 | 3 |
| Kane | 22-Aug-18 | 53 | 84 | 58 | 1.5 |

# Does Annual Grass Invasion Affect Rangeland Drought Resistance?

*Marshall Hart, Department of Plant Sciences*

*Brian Mealor, Department of Plant Sciences and Sheridan Research & Extension Center*

## Introduction

For much of the western U.S., drought is a relatively common and natural occurrence, but is predicted to become more common in the coming decades accompanying larger, but less frequent, rain events (Polley et al. 2013). The effects that these changes will have on ecosystems is difficult to predict and to prepare for. Another common problem is invasive species, many of which have become established in the western U.S. These problematic weeds have caused problems for ranchers by lowering forage production and disrupting other ecosystem processes, goods, and services. Some annual grasses, such as cheatgrass, are a palatable forage for part of the year, and thus offer some replacement as a forage grass. However, annual grasses have been documented showing ten-fold fluctuations in productivity tied to precipitation (Hull and Pechanec 1947). When these annual grasses replace perennial forages, whether or not they can provide a forage base during drought becomes an important question.

## Objectives

To study the interactions among invasion, drought, and forage production.

## Materials and Methods

To evaluate these interactions, we implemented a controlled mesocosm (small, simulated environment) study where three precipitation regimes were developed: 30-year average, drought, and projected changes. We also developed five invasion severity levels using *Ventenata dubia* (Leers) Coss. as our invasive species: 0, 25, 50, 75, and 100%. We applied each combination of these two treatments to blocks of 15 mesocosm rangelands, replicated five times. We planted these mesocosms with a mix of native perennial grass and forb species, along with one big sagebrush shrub each. We installed soil moisture sensors at two soil depths (10 and 30 cm) in one block. We measured sagebrush plants for pyramidal volume in June and will re-measure for growth early October. We collected herbaceous biomass late July.

## Results and Discussion

Data are still being collected and analyzed. We expect perennial forage to decline more rapidly with increasing invasion severity during a drought due to greater competition for water resources from invasives (Figure 1a). We expect annual production to be low during drought (Figure 1b). This would indicate annual grasses being an unstable and insufficient forage replacement. During years of average precipitation, we expect total production to be relatively stable regardless of invasion, as perennial biomass is replaced comparatively with annual biomass (Figure 1c). However, during drought, we expect total production to decline (Figure 1c) owing to a replacement of perennial biomass with unstable annual biomass.

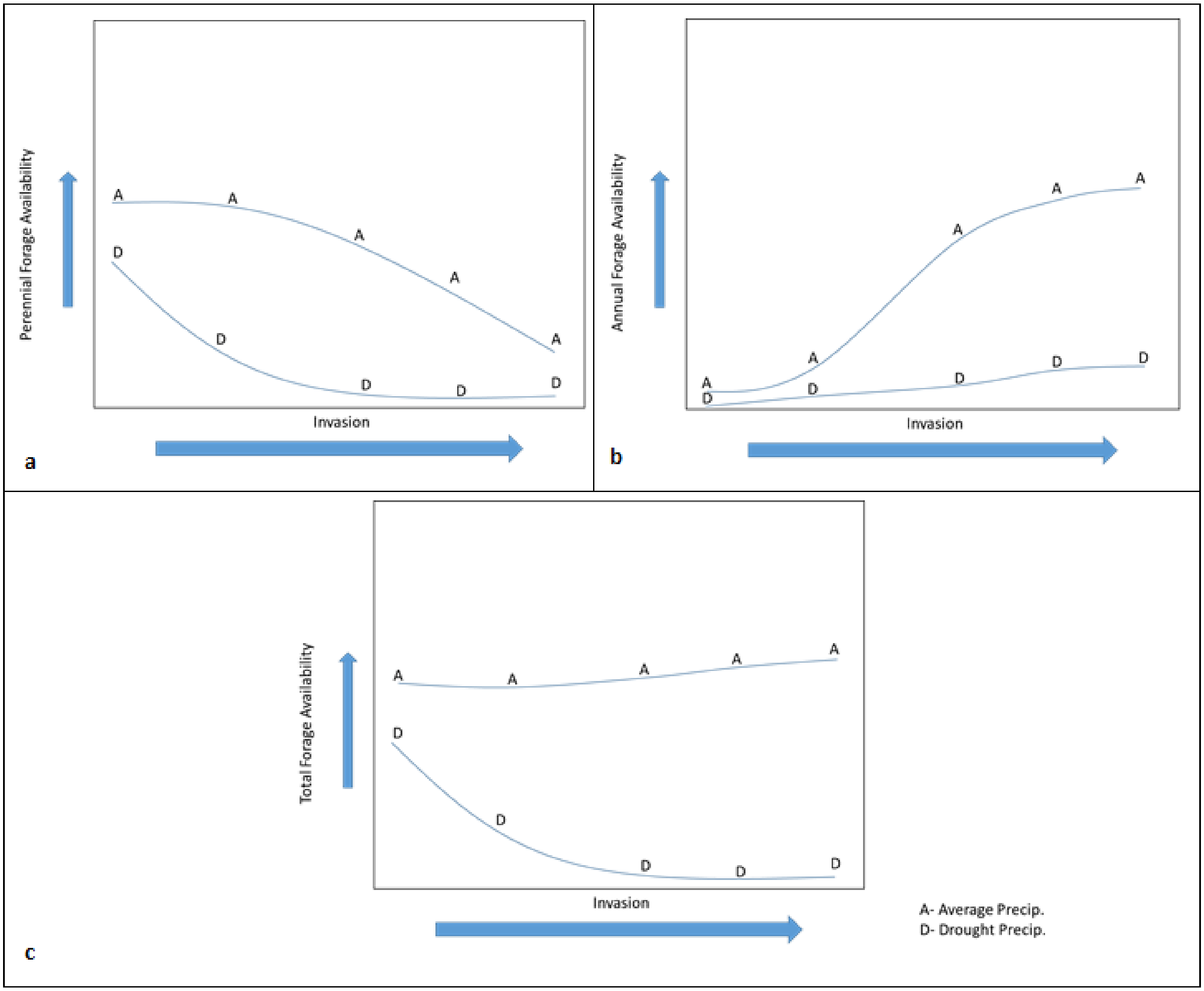


**Figure 1.** a) The hypothesized pattern of perennial forage availability as affected by invasion in average and drought precipitation scenarios. As invasion increases, perennial forage is expected to decline more in drought years than in average years.
b) The hypothesized pattern of perennial forage availability. Annual forage is expected to do poorly during drought years.
c) The hypothesized patterns of total forage availability as affected by invasion in an average and drought scenario. Total forage is expected to remain relatively stable during average years, but decline sharply during drought years.

**Acknowledgements**

We thank Beth Fowers, Shawna LaCoy, Nancy Webb, Kelsey Crane, Heidi Schueler, for their help setting up and maintaining this experiment. We also thank the Sustainable Rangelands Roundtable, Wyoming Agricultural Experiment Station, the Natural Resources Conservation Service and The Nature Conservancy for supporting this research. The Nature Conservancy provided partial support for this work through the Nebraska Chapter's J.E. Weaver Competitive Grants Program.

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**Keywords:** ventenata, forage, drought, precipitation, resistance, resilience

**PARP:** VI:1, VI:3, VI:8, VII:4, IX:1, X:1, X:2, X:3

# Comparing Establishment Methods Among Difficult to Produce Native Plant Materials

*Jaycie Arndt, Department of Plant Sciences*

*Brian Mealor, Department of Plant Sciences and Sheridan Research & Extension Center*

*Beth Fowers, Sheridan Research & Extension Center*

## 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 family. It is used for medicinal purposes and is an important forage for sage grouse.

## Objectives

The objective of this study is to measure production and population success between direct-seeding and transplanting containerized seedlings for seed production fields in northeast Wyoming.

## Methods and Materials

Site: This study took place in a retired agronomic field at the Sheridan Research and Extension Center. Three blocks, each 225 $ft^2$, were used for each method and species.

Direct seeding method — Seeding occurred on October 31, 2017, using a push seeder. The temperature was 50°F with predicted temperatures to remain in the 40's for the following ten days. The target seeding depth was ½ inch. Desert biscuitroot was seeded at rate of 28 pure live seeds/foot. Sulphur-flower buckwheat was seeded at a rate of 13 pure live seeds/foot.

Transplanting method — Desert biscuitroot seeds were soaked in distilled water for 24 hours before being placed in a cooler in containers with moist filter paper on February 6, 2019. On February 17, 2017, sulphur-flower buckwheat seeds were placed in containers with moist filter paper in a cooler. The cooler was set to 37°F and 60% humidity. Germination took approximately two months for both species. As seeds germinated they were transferred into four-inch potting containers in a greenhouse with 61-70°F daytime temperatures and 50-55°F nighttime temperatures. The seedlings grew for two months before being transplanted into the field in May 2017. The field was plowed and seedlings were planted 12 inches apart.

Data collection — Data was collected in May 2018, May 2019, and May 2020. We counted the number of plants per block each year. Data Analysis: To determine a difference between planting methods we compared population results at various stages of growth. We ran a paired t-test for each stage of growth. The stages included (1) seed to establishment, (2) year one survivorship, (3) establishment to year one survival, (4) year two survivorship, (5) year one to year two survival.

## Results and Discussion

**Table 1.** Proportion of desert biscuitroot individuals surviving from three life stages using direct seeding and transplanting methods. P-value from paired t-test at each life stage. **$p < 0.05$, ***$p<0.001$. Values are based on the proportion surviving from the previous stage, i.e. established from seed (mean and actual number of plants). Data collected May 2018, 2019, and 2020 in Sheridan, Wyoming.

| Desert biscuitroot | Direct Seeding | | Transplanting | | |
|---|---|---|---|---|---|
| **Life Stage** | **Mean** | **Plants** | **Mean** | **Plants** | **p-value** |
| Seed to Establishment | 0.1006 | 4308 → 433 | 0.3655 | 287 → 105 | 0.000116*** |
| Year 1 Survivorship (seed to yr 1) | 0.0643 | 4308 → 277 | 0.0719 | 287 → 20 | 0.747 |
| Establishment to Year 1 Survival | 0.6393 | 433 → 277 | 0.1968 | 105 → 20 | 0.019** |
| Year 2 Survivorship (seed to yr 2) | 0.058 | 4308 → 257 | 0.041 | 287 → 11 | 0.508 |
| Year 1 to Year 2 Survival | 0.906 | 277 → 250 | 0.47 | 20 → 11 | 0.135 |

**Table 2.** Proportion of sulphur-flower buckwheat individuals surviving from three life stages using direct seeding and transplanting methods. P-value from paired t-test at each life stage. **$p < 0.05$, ***$p< 0.001$. Values are based on the proportion surviving from the previous stage, i.e. established from seed (mean and actual number of plants). Data collected May 2018, 2019, and 2020 in Sheridan, Wyoming.

| Sulpher-flower buckwheat | Direct Seeding | | Transplanting | | |
|---|---|---|---|---|---|
| **Life Stage** | **Mean** | **Plants** | **Mean** | **Plants** | **p-value** |
| Seed to Establishment | 0.0033 | 2050 → 7 | 0.5121 | 205 → 105 | 0.00000558*** |
| Year 1 Survivorship (seed to yr 1) | 0.0023 | 2050 → 5 | 0.3658 | 205 → 75 | 0.00446** |
| Establishment to Year 1 Survival | 0.6556 | 7 → 5 | 0.7143 | 105 → 75 | 0.783 |
| Year 2 Survivorship (seed to yr 2) | 0.001 | 2050 → 5 | 0.307 | 205 → 62 | 0.024** |
| Year 1 to Year 2 Survival | 1 | 5 → 5 | 0.827 | 75 → 62 | 0.125 |

Desert biscuitroot first year survivorship, second year survivorship, and year one to year two survival is similar between methods. Overall, there was low survivorship of desert biscuitroot seeds, but there was high survival of existing plants into year two. Desert biscuitroot transplanting has higher seed to establishment success but lower first year survival of established plants. Given similar initial establishment and the success of subsequent year's survival with direct seeding, it could be more preferred to use direct seeding as an establishment method for desert biscuitroot.

Sulphur-flower buckwheat first year survival of established plants and year one to year two survival is similar between methods. Overall, once plants were established, they had good survival into subsequent years regardless of establishment method. However, direct seeding had low establishment success to begin with. Transplanting had higher establishment success and higher first and second year survivorship. Given similar subsequent survival and the initial success by transplanting, transplanting may be a preferred method for sulphur-flower buckwheat establishment.

## Acknowledgments

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

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# Comparing Establishment Methods for Native Plant Material Production Success

*Jaycie Arndt, Department of Plant Sciences*

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*Beth Fowers, Sheridan Research & Extension Center*

## 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 family. It is used for medicinal purposes and is an important forage for sage grouse.

## Objectives

The objective of this study is to measure production success between direct-seeding and transplanting containerized seedlings for seed production fields in northeast Wyoming.

## Methods and Materials

Site — This study took place in a retired agronomic field at the Sheridan Research and Extension Center. Three blocks, each 225 $ft^2$, were used for each method and species.

Direct seeding method — Seeding occurred on October 31, 2017, using a push seeder. The temperature was 50°F with predicted temperatures to remain in the 40s for the following 10 days. The target seeding depth was ½ inch. Desert biscuitroot was seeded at rate of 28 pure live seeds/foot. Sulphur-flower buckwheat was seeded at a rate of 13 pure live seeds/foot.

Transplanting method — Desert biscuitroot seeds were soaked in distilled water for 24 hours before being placed in a cooler in containers with moist filter paper on February 6, 2019. On February 17, 2017, sulphur-flower buckwheat seeds were placed in containers with moist filter paper in a cooler. The cooler was set to 37°F and 60% humidity. Germination took approximately two months for both species. As seeds germinated they were transferred into four-inch potting containers in a greenhouse with 61-70°F daytime temperatures and 50-55°F nighttime temperatures. The seedlings grew for two months before being transplanted into the field in May 2017. The field was plowed and seedlings were planted 12 inches apart.

Data analysis — We compared planting methods by using a production-based approach. We scaled the individuals produced at the plot level to one acre and calculated seed, labor, and equipment costs for direct seeding and transplanting methods.

We calculated the cost of pure live seed used, labor, and equipment. Equipment required for transplanting included containers, trays to hold the containers, and soil. The container and tray costs were prorated over a five year lifetime expectancy. Equipment for direct seeding included fuel for the drill-seeder. We assumed that field preparation, water, and weeding labor were similar across methods and therefore, were not included in the production costs.

### Results and Discussion

**Table 1.** Desert biscuitroot production using direct seeding and transplanting method. May 2019 survival data used to extrapolate to one acre of production.

| Desert biscuitroot | Direct Seeding | | Transplanting | |
|---|---|---|---|---|
| Plants/Acre | 53627 | 831 plants/675 $ft^2$ | 2258 | 35 plants/675 $ft^2$ |
| Pure Live Seed Cost | $0.0000979 | 183840 PLS/lb at $180/lb PLS | $0.0000979 | 183840 PLS/lb at $180/lb PLS |
| Seed Cost/Acre | $1089 | Used 12926 seeds/675 $ft^2$ | $54.45 | Used 900 seeds/675 $ft^2$ |
| Labor Cost/Acre | $10 | (1 person x 1 hour x $10/hr)/675 $ft^2$ | $5162.67 | (2 people x 4 hours x $10/hr)/675 $ft^2$ |
| Equipment Cost/Acre | $11 | 5 gallons fuel at $2.20/gallon | $1581.33 | (315 containers at $0.028/container) + (3.2 trays at $1.51/tray) + (2/5 soil bale at $27.13/bale soil) |
| **Total Cost/Acre** | **$1110** | | **$6798.44** | |

**Table 2.** Sulphur-flower buckwheat production using direct seeding and transplanting method. May 2019 survival data used to extrapolate to one acre of production.

| Sulphur-flower buckwheat | Direct Seeding | | Transplanting | |
|---|---|---|---|---|
| Plants/Acre | 903 | 14 plants/675 $ft^2$ | 12132 | 188 plants/675 $ft^2$ |
| Pure Live Seed Cost | $0.00077 | 142830 PLS/lb at $110/lb PLS | $0.00077 | 142830 PLS/lb at $110/lb PLS |
| Seed Cost/Acre | $407.58 | Used 6150 seeds/675 $ft^2$ | $30.33 | Used 900 seeds/675 $ft^2$ |
| Labor Cost/Acre | $10 | (1 person x 1 hour x $10/hr)/675 $ft^2$ | $5162.67 | (2 people x 4 hours x $10/hr)/675 $ft^2$ |
| Equipment Cost/Acre | $11 | 5 gallons fuel at $2.20/gallon | $1581.33 | (315 containers at $0.028/container) + (3.2 trays at $1.51/tray) + (2/5 soil bale at $27.13/bale soil) |
| **Total Cost/Acre** | **$428.58** | | **$6774.32** | |

The success of establishing these species for production depends upon available inputs and preferred outcomes. Using direct seeding to establish desert biscuitroot results in lower production costs overall, but does require higher seed input than transplanting. Transplanting sulphur-flower buckwheat results in higher plant production with lower seed input, but it costs more for labor and materials than direct seeding.

### Acknowledgments

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

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# Influence of Seeding Depth on Native Species Establishment in the Presence of Indaziflam

*Brian Mealor, Department of Plant Sciences and Sheridan Research & Extension Center*

*Jodie Crose, Department of Plant Sciences*

## Introduction

Exotic annual grass invasion in the western U.S. has shifted historic fire-regimes, nutrient cycles, and reduced native species diversity - effectively converting ecosystems to an alternative stable state dominated by annual grasses (D'Antonio & Vitousek 1992). Indaziflam is newly released pre-emergent root inhibiting herbicide available for control of invasive annual grasses in rangelands. Selectivity results from its soil binding properties, confining it to the top few centimeters of soil. This limits injury to established perennial plants whose root systems are below the herbicide layer. Impact on seedling recruitment is not well documented.

## Objectives

Our objective was to evaluate how emergence is influenced by planting depth in the presence and absence of indaziflam and whether a trade-off exists between depth and herbicide presence.

## Materials and Methods

To address these questions, we conducted a greenhouse study to evaluate the effects of seeding depth and indaziflam on emergence and early growth of six native plant species. We ran the experiment as two independent trials. For each trial, we measured and marked twenty-four 5.7 L plastic containers from a determined point at approximately 5 cm deep from the top of the container. Using the 5 cm depth as a baseline, marks were placed from this point upward to represent the following planting depths: 2.5, 1.3, 0.6 and 0 cm.

Field soil was used from the Sheridan Research and Extension Center in Sheridan, Wyoming. Soil was mixed in a 3:1 ratio of field soil:soilless potting medium. We planted the following species: Rocky Mountain beeplant, blue grama, Maximilian sunflower, Wyoming big sagebrush, western wheatgrass, and green needlegrass. We planted species in rows with 12 pure live seeds. We sprayed twelve containers with indaziflam at 0.365 L $ha^{-1}$. The herbicide was watered-in following application to the recommended depth. Greenhouse temperatures fluctuated from 12°C to 19°C for trial 1 and 16°C to 25°C for trial 2. Watering occurred twice weekly for the duration of the study.

We collected data 48 days after planting (DAP). We calculated emergence (%) by dividing the number of emerged plants by the number of pure live seeds planted per row. Approximately 84 DAP, we terminated each trial by collecting biomass, shoot and root length, and length from root crown to first true leaf from up to five plants per row for all species in the study. This was done to inform whether indaziflam had an impact on emerged plants. These samples were processed and weighed following drying.

## Results and Discussion

When no herbicide was applied, western wheatgrass emergence across all depths was approximately 75% for trial 1. Emergence from deeper depths was greater when indaziflam was present for both trials. For both trials, blue grama emergence was greatest at shallower planting depths and decreased as depth increased when indaziflam was not applied. No emergence was observed from grama when indaziflam was applied. Green needlegrass emergence was greater at deeper depths in the presence and absence of indaziflam for both trials. Maximilian sunflower emergence was high across all depths when indaziflam was absent. Emergence was low across all depths when indaziflam was applied for trial 1. A different pattern was observed during trial 2, where emergence was greatest at 1.3 cm in the presence or absence of indaziflam. Emergence from shallower planting depths was low for all species when indaziflam was present. Harvested plant measurements showed no negative impacts due to indaziflam.

Lower emergence from shallower planting depths when indaziflam was applied among all species could be due to herbicide presence in the top few centimeters of the soil profile. Grama consistently preferred shallower planting depths across both trials when no herbicide was applied. Although grama emergence from deeper depths was low, wheatgrass and needlegrass emergence from these depths was greater across both trials. Sunflower emergence patterns between the two trials is less clear and further evaluation is necessary to understand how this species will respond to indaziflam. It is likely that some of the differences observed between the first and second trial are a result of higher greenhouse temperatures consequently leading to faster desiccation of containers. Moving forward, this information can help inform land managers and reclamation projects concerned about annual grass competition. If indaziflam is used, revegetation efforts may be more successful if deeper seeded species are selected. Future research will include evaluating more species as well as manipulating seeding rate to evaluate emergence under similar circumstances.

**Acknowledgments**

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**Keywords:** indaziflam, invasive annual grass, restoration

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

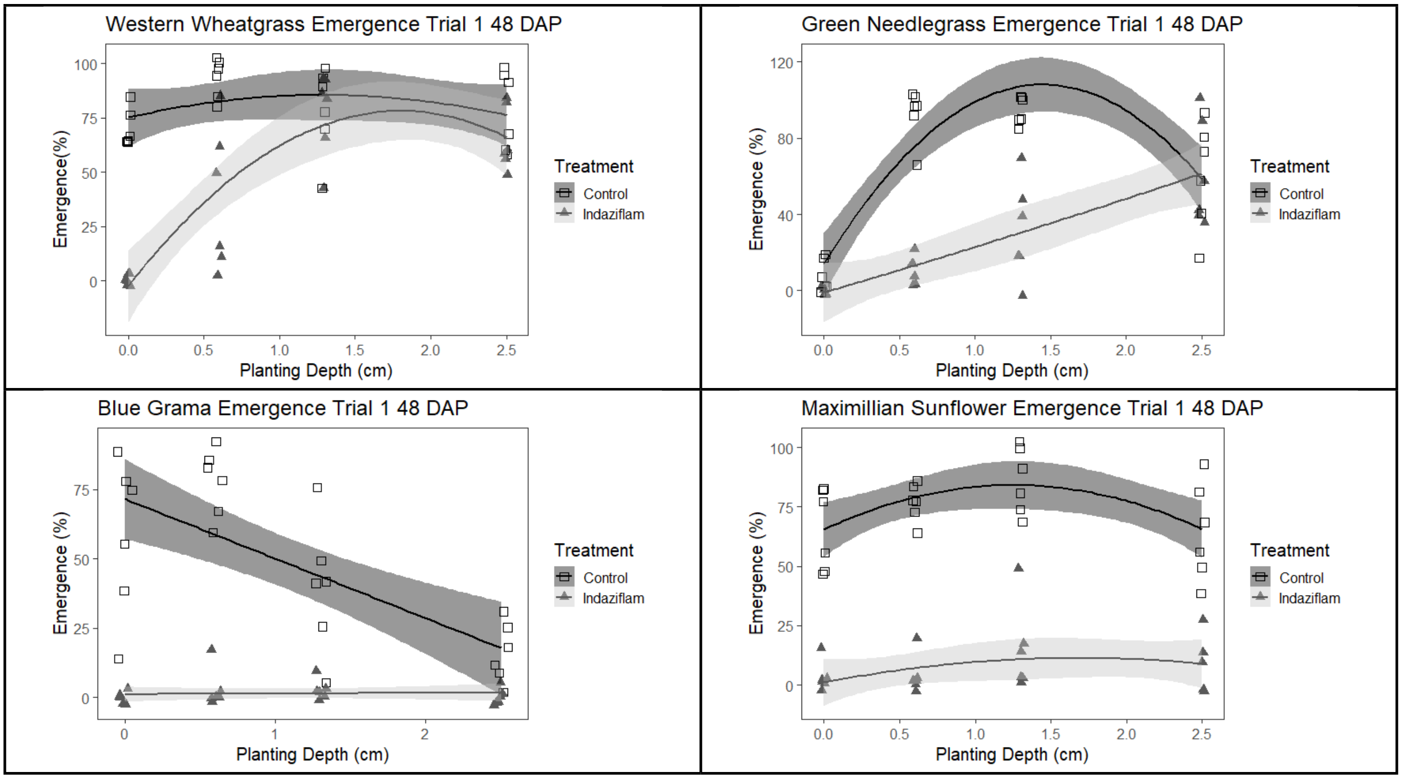


**Figure 1.** Regression curves of emergence (%) for all species evaluated 48 DAP in the presence and absence of indaziflam at four different depths.

# Perennial Cool-Season Grasses under Irrigation for Hay Production and Fall Grazing

*Blaine Horn, Johnson County Extension*

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*Dan Smith, Sheridan Research & Extension Center*

*Valtcho Jeliazkov, Oregon State University*

*Axel Garcia y Garcia, University of Minnesota*

Project conducted at the Sheridan Research & Extension Center Adams Ranch location

## 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

Two objectives of this study were to assess (1) late spring/early summer hay yields of perennial cool-season grasses; and (2) determine forage quality of the hay from these grasses.

## Materials and Methods

Perennial cool-season introduced grasses seeded in September 2014 underwent harvests over a five year period to assess their hay yields. Harvests occurred on 16, 15, 20, 25, and 23 June in 2016, 2017, 2018, 2019, and 2020, respectively for 'Manchar' and 'Carlton' smooth brome, 'Paddock' and 'MacBeth' meadow brome, 'Latar' and 'Profile' orchardgrass, and 'Fawn' and 'Texoma MaxQ II' tall fescue; and on 30 June in 2016 and 2017, and 5, 16, and 7 July in 2018, 2019, and 2020, respectively 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. The plot area received 150 pounds per acre of nitrogen in November 2015, April 2017 and 2018, and early May 2019, and 90 pounds per acre in April 2020. In addition, 30 and 50 pounds of phosphate was applied in November 2015 and April 2017, respectively. Plot area was irrigated with a center pivot system.

## Results and Discussion

The intermediate and pubescent wheatgrasses produced the most hay (4.4 T/ac) followed by the timothies (3.7 T/ac), and then the bromes (3.4 T/ac) (Table 1). 'Fawn' tall fescue and 'Profile' orchard produced the least amount of hay. The two-week harvest delay may have been a contributing factor for why the wheatgrasses and timothies produced an average of a ton per acre more hay compared to the bromes, orchards, and tall fescues but all the grasses were harvested at a similar phenological growth stage. The smooth bromes contained on average the highest levels of crude protein and the wheatgrasses and 'Paddock' meadow brome the least in 2016 and 2017. Thus, the wheatgrasses and 'Paddock' might not provide enough protein for a beef cow in early lactation (10%) and not enough for a sheep ewe in early lactation with a single lamb (11.6%). None of the grasses would provide a sufficient amount of protein if the ewe was nursing twins (15.3%). With regard to total digestible nutrients (TDN) the smooth bromes, tall fescues and timothies contained the highest levels (66.3%) and the wheatgrasses and meadow bromes the least (64%). However, TDN levels in all the grasses were sufficient to meet the needs of beef cattle (maximum 59% for early lactating cow) and sheep (maximum 62% for ewe in early lactation nursing twins).


### Acknowledgments

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**Keywords:** Cool season grasses, hay production, forage quality


**PARP:** I:2

**Table 1.** Hay yields (12% moisture) for the late spring/early summer harvests of the cool-season perennial grasses and their percent crude protein (%CP) and total digestible nutrients (%TDN) contents (average of 2016 and 2017 harvests).

| Grass | Variety | Hay yields (T/ac) | | | | | | Forage Quality | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2016 | 2017 | 2018 | 2019 | 2020 | Average | %CP | %TDN |
| Smooth brome | Carlton | 5.0 | 3.7 | 3.4 | 2.8 | 3.1 | 3.6 bc | 12.8 ab | 66.4 ab |
| | Manchar | 4.0 | 4.0 | 3.2 | 2.8 | 3.4 | 3.5 bcd | 13.1 a | 66.0 bc |
| Meadow brome | MacBeth | 3.8 | 3.9 | 3.2 | 2.3 | 3.0 | 3.3 cde | 10.8 cde | 64.5 def |
| | Paddock | 5.0 | 4.0 | 2.8 | 2.3 | 2.8 | 3.4 bcd | 9.3 e | 64.0 efg |
| Orchard | Latar | 2.7 | 4.4 | 3.9 | 2.5 | 3.0 | 3.3 cd | 12.2 abc | 65.1 cde |
| | Profile | 1.8 | 3.7 | 2.8 | 2.1 | 2.4 | 2.7 f | 11.4 | 65.5 bcd |
| Tall fescue | Fawn | 1.6 | 4.0 | 3.4 | 1.9 | 2.7 | 2.8 ef | 11.8 abc | 66.2 ab |
| | Texoma MaxQII™ | 3.2 | 4.3 | 3.3 | 2.3 | 2.6 | 3.1 de | 11.1 cd | 66.2 ab |
| Intermediate wheatgrass | Oahe | 5.5 | 5.0 | 4.3 | 3.4 | 3.3 | 4.3 a | 9.4 e | 63.9 fg |
| | Rush | 5.5 | 5.0 | 4.6 | 3.2 | 3.1 | 4.3 a | 9.5 e | 63.1 g |
| Pubescent wheatgrass | Luna | 5.8 | 5.1 | 4.8 | 3.4 | 3.7 | 4.5 a | 9.6 de | 63.8 fg |
| | Manska | 5.4 | 5.2 | 4.2 | 3.6 | 3.5 | 4.4 a | 9.6 de | 63.9 fg |
| Timothy | Tuukka | 2.4 | 4.5 | 4.3 | 3.8 | 3.8 | 3.8 b | 10.7 cde | 67.3 a |
| | Climax | * | 3.4 | 4.1 | 3.4 | 3.6 | 3.6 * | 10.5 * | 65.7 * |

*Note: Hay yield average and forage quality means followed by same letters do not differ at the* $p<0.05$.

**Climax timothy was not harvested in 2016 due to poor stands; forage quality values are from 2017 and thus not included in analysis of variance.*

# Effects of Ventenata Removal on Rangelands of Northeast Wyoming

*Marshall Hart, Department of Plant Sciences*

*Brian Mealor, Sheridan Research & Extension Center and Department of Plant Sciences*

## Introduction

Invasive species have major impacts on many ecosystems, including rangelands of the western U.S. (DiTomaso et al. 2017). Ecosystem goods and services, such as providing forage for cattle and wildlife, are often diminished as a result. *Ventenata dubia* (Leers) Coss. is an invasive species that is relatively new to the U.S. It has recently been documented in the Great Plains, where containment and control efforts by the Northeast Wyoming Invasive Grasses Working Group are ongoing. This working group has the goal of removing ventenata from affected rangelands and limiting spread and damage to our ecosystems. Although the damage caused by many invasive species are documented for many goods and services, recovery of these goods and services is often assumed to follow invasive weed management, often without long term study (Sheley et al. 2011). Removal of ventenata by the working group has allowed us to study two conditions; rangelands with uncontrolled ventenata invasion, and invaded rangelands where control efforts have been implemented. This research will aid rangeland managers and decision makers dealing with ventenata and will shed light on the relationships between invasive species, conservation, and ecosystem goods and services.

## Objectives

To test whether ventenata control results in recovery of forage quality, forage quantity, and biodiversity.

## Materials and Methods

We collected biomass in four adjacent treated and non-treated rangeland plots at five sites in Sheridan County, Wyoming. We sampled each plot each month over the growing season. We collected all above-ground biomass and separated the biomass into perennial and annual grasses, and perennial and annual forbs. Samples were dried, weighed, and tested for crude protein and total digestible nutrients. We also took percent canopy cover by species in July.

## Results and Discussion

Removal of ventenata increased the amount and cover of perennial grasses. In addition to being more preferred by livestock and wildlife, these perennial grasses are higher in crude protein and total digestible nutrients. This translates to an increase in the amount of available nutrients. Perennial grasses also have a longer green grazable forage window than annual grasses. Whereas annual grasses have peak biomass early in the growing season and decline quickly, perennial grasses continue to grow well into the growing season (Figure 1). This gives ranchers greater reliability of and control over their forage resources. Biodiversity did not increase as a result of ventenata removal. This unexpected finding highlights the importance of carefully considering the attainability of goals of any restoration or conservation project. When possible, goals should be supported with sound research to ensure long term success of projects.

**Acknowledgements**

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**Keywords:** ventenata, ecosystem goods and services, conservation, biodiversity, forage

**PARP:** III:3, III:11, VI:1, VI:3, VII:4, IX:1, IX:7, X:2

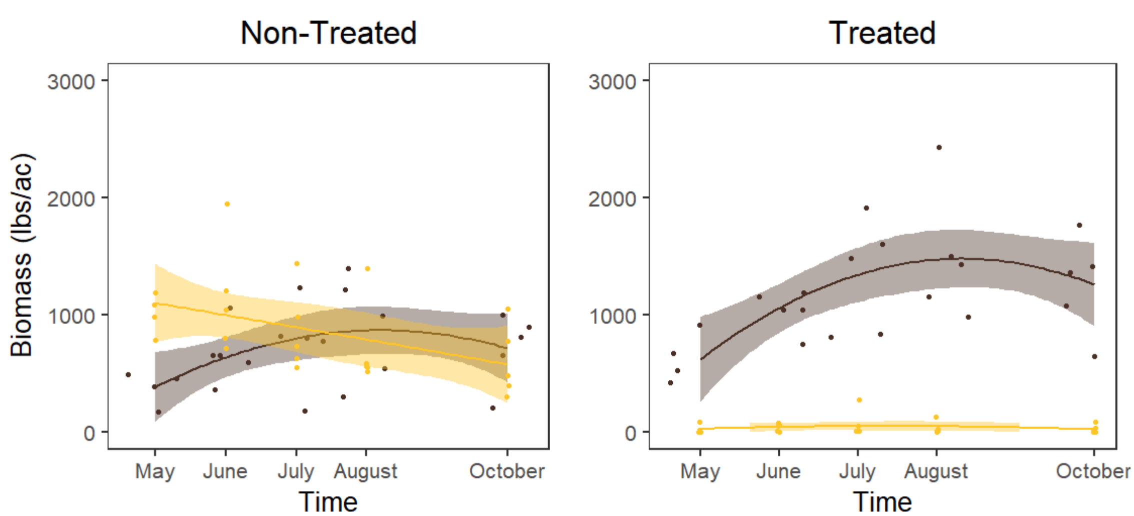


**Figure 1.** Biomass of annual (yellow) and perennial (grey) grasses with and without the application of indaziflam to control annual grasses. Measurements were taken monthly to show patterns through the growing season. Treatment with indaziflam reduced annual grasses to nearly zero. Perennial grass biomass increased due to ventenata removal. Annual grasses have peak biomass early in the growing season, which declines quickly. In contrast, perennial grasses have a much longer green grazable forage window, giving ranchers more reliability of and control over forage resources.

# Wyoming First Grains Project: Effect of Location, Irrigation and Nitrogen on Crop Growth, Yield, and Quality of Ancient Grains of Wheat in Wyoming

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## Introduction

Crop diversity in Wyoming is limited by poor soil health, arid conditions, isolation from markets, and high evapotranspiration demands. First grains like einkorn, emmer, and spelt are early predecessor of modern wheat and more adaptable to marginal agricultural land. There has been rapid increase in the market demand of ancient grains due to their desirable characteristics like higher protein (Campbell, 1997), distinct nutrition, and unique taste. First grains are thought to be a viable alternative small grain for Wyoming.

## Objectives

Identify agronomic management practices and fertility needs of spelt, emmer, and einkorn. Determine how fertility affects agronomic traits and grain quality under multiple Wyoming growing conditions and locations.

## Materials and methods

This study was conducted at the Sheridan Research and Extension Center (ShREC) in 2019. The experiment was a randomized design with 3 replications. Spelt, emmer, einkorn, and modern wheat were grown under different nitrogen application rates in irrigated and dryland fields. Irrigated fields were planted on May 18th at a seeding rate of 100 lbs/a. Dryland fields were planted on May 18 at a seeding rate of 60 lbs/a. Nitrogen treatments of low, medium, and high (25, 50, 80 lbs nitrogen/a respectively) were applied to each crop before planting. Data on heading date and yield were taken. Crops were harvested at maturity with an Almaco small plot combine and hulled and dehulled yield was calculated. Percent yield loss when the hull was removed is calculated as [1- (grain yield/hulled yield)].

## Results and discussion

In spring 2019, ancient grains differed from each other and modern wheat in growth and maturity. Einkorn was the slowest maturing, heading out two weeks later than wheat, 10 days later than emmer, and 5 days later than spelt (Table 1). Wheat was harvested first, followed by emmer, then spelt, and then einkorn in dryland. The irrigated trials were lost to bird damage prior to harvest and no harvest or yield data was collected. Due to differences in crop growing period and pattern, growing these ancient grains might require some changes in agronomic management practices and alteration in crop rotation.

**Table 1**. Heading date (HD) and harvest date (CD) of first grains. NA indicates not available

| | Dryland | | | | | | Irrigated | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25 lb/a N | | 50 lb/a N | | 80 lb/a N | | 25 lb/a N | | 50 lb/a N | | 80 lb/a N | |
| | HD | CD | HD | CD | HD | CD | HD | CD | HD | CD | HD | CD |
| Wheat | 7/9 | 8/27 | 7/9 | 8/27 | 7/9 | 8/27 | 7/10 | NA | 7/10 | NA | 7/10 | NA |
| Spelt | 7/21 | 8/28 | 7/21 | 8/28 | 7/21 | 8/28 | 7/20 | NA | 7/20 | NA | 7/20 | NA |
| Emmer | 7/15 | 8/28 | 7/15 | 8/28 | 7/15 | 8/28 | 7/15 | NA | 7/15 | NA | 7/15 | NA |
| Einkorn | 7/25 | 9/6 | 7/25 | 9/6 | 7/25 | 9/6 | 7/26 | NA | 7/26 | NA | 7/26 | NA |

Hulled yield, naked grain yield, and percent yield loss to hull of each crop was not affected by nitrogen treatments under dryland conditions (Table 2). The lack of yield response to N suggests that either the optimum N was applied even at 25 lbs/a or that there was an error in application and the plots did have access to the applied N. Soil nitrogen analysis, yield from 2020 trials, and grain quality analysis will provide more information on the nitrogen balance in the trial. Percent yield loss to hull was higher for spelt than emmer (Table 2). When comparing yield of the different grains, the grain yield of modern wheat was higher than emmer and spelt; however, lower yield of ancient grains might be offset with their high market demand and price premium.

**Table 2.** Average grain yield (lbs/a) of first grains. Yields are reported for hulled (grain in the hull) and grain (grain only with the hull removed). Percent yield loss [1- (grain yield/hulled yield)] is reported for spelt and emmer. P-values for yield within each crop are given. NS means not significant, ND means no data, and NA means not applicable.

| | Wheat | | | Spelt | | | Emmer | | | Einkorn | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hulled | Grain | Loss | Hulled | Grain | Loss | Hulled | Grain | Loss | Hulled | Grain | Loss |
| lbs/a N | Dryland | | | | | | | | | | | |
| 25 | NA | 1019 | NA | 1313 | 800 | 39% | 1390 | 921 | 34% | 667 | ND | ND |
| 50 | NA | 1671 | NA | 1147 | 664 | 42% | 1139 | 720 | 37% | 503 | ND | ND |
| 80 | NA | 2115 | NA | 1413 | 821 | 42% | 1365 | 954 | 30% | 831 | ND | ND |
| p-value | | NS | | NS | NS | NS | NS | NS | NS | NS | | |

The Wyoming first grains project will be continued through 2021. Future work includes dehulling of einkorn, grain quality analysis, and analysis of soil nitrogen and nitrogen use efficiency of each crop. Soil nitrogen and grain quality analysis will be used to determine nitrogen use efficiency of first grains. Studies have been repeated for the 2020 crop season. Future work will include studies on seeding rate to optimize yield of the first grains as well as market analysis for small and large acreage production.

**Acknowledgements**

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**Keywords:** ancient grains, agronomy, nitrogen, irrigation

**PARP:** I:2, II:10

# Impacts of Gardening Practices on Plant-Available Lead, Cadmium, and Iron in Soil

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## Introduction

The cultural, ecological, and health benefits of gardens are well-documented, and such spaces are especially important in urban settings, where gardening can play a critical role in food access and community-building. However, these benefits must be balanced with an increased risk of exposure to various contaminants, including heavy metals, that are typically higher in urban soils and which can potentially be harmful to human health. This project examines the concentration of lead (Pb) and cadmium (Cd) in urban gardens in Laramie, Wyoming, along with how gardeners' management practices and other factors may influence the availability of these heavy metals in soil. Lead and Cd are among the top three most toxic heavy metals to humans. Both accumulate in plant and animal tissues and can pose health risks, with children being particularly susceptible to Pb poisoning through ingestion of soil. Though not a human health risk, iron (Fe) is also included in this project. Iron is a vital nutrient in plant growth and reproduction, and is commonly deficient in alkaline soils, making its availability to crops an important factor for local growers in Laramie.

## Objectives

The overarching goal of this project is to improve awareness about the presence of heavy metals in soil and to share small-scale management practices with local growers that affect plant availability of metals and improve soil quality. This is achieved through:

- Testing the availability of heavy metals in local, amended soils used to grow produce, and sharing and interpreting results with local gardeners about human and plant health impacts; and

- Investigating whether the types of amendments used by gardeners influence the availability of metals to plants compared to the surrounding native land.

## Materials and Methods

We sampled 25 in-ground gardens from private residences, community garden plots, and urban farms growing commercial produce to analyze the concentration of plant-available Pb, Cd, and Fe in the soil. Further, we collected native, undisturbed soil near each garden with which to compare the amended garden soil for differences in concentrations. To understand the site history and garden soil contents, we conducted interviews with each participating gardener, gathering information on the types of garden amendments they applied. Additional information was collected on each gardener's knowledge of soil contaminants, along with possible barriers to testing soil for contaminants, such as whether the gardener understood where testing services are offered. Finally, we recorded whether the land was used for residential, community garden, or agricultural/rangeland purposes ten or more years prior to becoming a garden space (historical land use).

## Results and Discussion

In general, levels of Pb and Cd did not pose significant health risks to humans or crops.

Significant differences in available Cd based on historical land use were evident, with agricultural/rangeland (AG) soils containing a greater amount of available Cd than residential (R) or community garden (CG) spaces (Figure 2). This may be due to repeated additions of organic amendments in residential and community gardens, which is known to lower soil pH, in turn reducing soil Cd availability.

Nearly all sites sampled were deficient in Fe; however, two outliers – both former agricultural/rangeland soils – were able to significantly improve the availability of Fe relative to other locations sampled with repeated application of organic amendments (Figure 3).

With only 17% identifying heavy metals as a potential concern, gardeners surveyed demonstrated a low awareness of soil contaminants, as well testing/information resources and soil remediation techniques, indicating a need for increased community outreach and testing.

## Acknowledgments

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**Keywords:** heavy metals, urban gardening, bioavailability

**PARP:** IX:4, IX.8, IX.10

**Figure 1.** Example of in-ground garden in Laramie

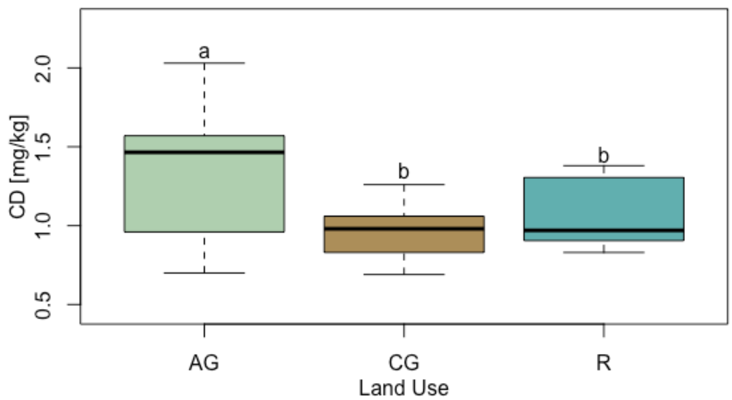


**Figure 2.** Variance in available Cd based on historical land use

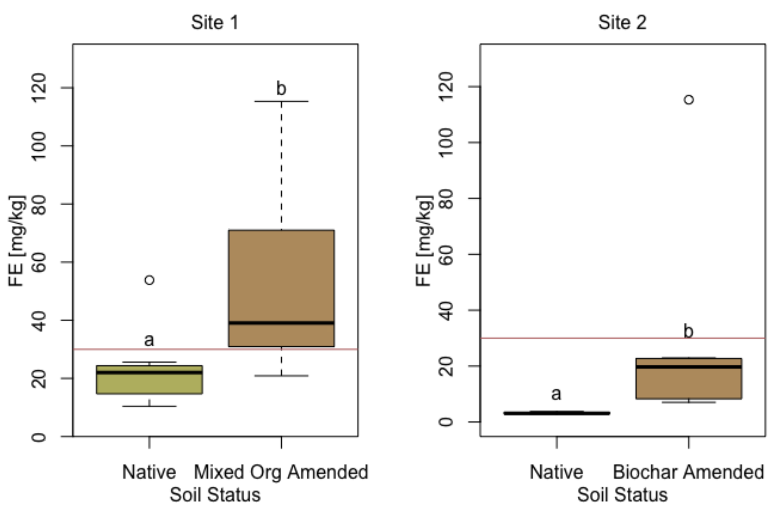


**Figure 3.** Comparison of two sites that are successfully ameliorating Fe deficiency through application of organic amendments. Red line indicates minimum concentration at which phytotoxicity may be observed. Significant at p-values ≤ 0.05. Site 1 p-value of 0.04 (native vs. amended) and Site 2 at 0.09.

# Wyoming Production Agriculture Research Priorities—Updated June 2018

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

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

Following are producer recommendations developed from statewide listening sessions:

**I. Production Systems Objectives**

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

**II. Soil Fertility Management Objectives**

1. Develop methods to ameliorate poor soil pH for crop production. (2014)
2. Investigate effects of fertilizer type, placement, and timing on crop production (e.g., sugarbeets, cereal grains, dry beans, and forages). (2014)
3. Evaluate the efficacy of managing soil nitrogen applied by pivot irrigation. (2014)
4. Determine and categorize nitrogen release times for varied forms of nitrogen. (2014)
5. Discover methods to reduce dependence on commercial fertilizers. (2014)
6. Develop tillage systems that minimize soil disturbance. (2014)
7. Develop cheaper alternatives to commercial fertilizer (e.g., cover crops, legumes). (2014)
8. Test the ability of compost and manure to enhance soil fertility. (2014)
9. Identify plants such as legumes that enhance soil fertility. (2014)
10. Identify crops and varieties that perform best in varied soil types and elevations. (2015)
11. Evaluate effects of aerators on soil productivity. (2015)
12. Identify soils best suited for farming or grazing. (2015)

## III. Weed Control Objectives

1. Develop control methods for weeds resistant to glyphosate (e.g., Roundup) or other herbicides especially in sugarbeet and dry bean production. (2014, revised 2015)
2. Develop methods to control weed emergence that can be applied in the fall.
3. Improve procedures to control noxious weeds, especially milkweed, knapweed, whitetop, curly dock (aka sour dock), and thistle. (2014, revised 2015)
4. Evaluate the efficacy of weed-control chemicals applied before planting in dry bean fields. (2014)
5. Develop chemical and non-chemical methods to control cheatgrass and other noxious weeds. (2014)
6. Coordinate application of glyphosate with precision agriculture. (2014)
7. Optimize use of herbicides economically and environmentally. (2014)
8. Facilitate access to chemicals needed for special uses. (2015)
9. Discover viable alternatives to pesticides. (2015)
10. Determine chemical carryover in no-till production. (2015)
11. Continually monitor unintended consequences of weed control on plants and animals. (2015)

## IV. Irrigation Objectives

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

## V. Livestock Objectives

1. Develop strategies to enhance the efficiency of feed utilization. (2014)
2. Evaluate effects of additives or chemicals to feeds to influence forage and/or weed consumption. (2014)
3. Train livestock to consume alternative feeds such as brush and weeds. (2014)
4. Determine heifer development strategies that optimize reproduction, foraging ability, and cow longevity to maximize profitability. (2014)
5. Identify strategic supplementation protocols that optimize animal production traits with costs of production. (2014)
6. Develop improved methods to control flies. (2014)
7. Determine how to minimize feed costs and maximize profit per unit of production. (2014)
8. Develop genetic markers for feed efficiency and determine their ramifications on important production traits such as reproduction, milk production, pounds of calves produced, and carcass characteristics. (2014, revised 2015)
9. Develop practical estrous synchronization methods for commercial producers.
10. Determine cumulative effects of minerals, ionophores, worming, and implants on animal productivity. (2014)
11. Provide cost/benefit information on grazing of irrigated pastures. (2014)
12. Determine direct and indirect effects of disease and predators on livestock production. (2015)
13. Develop best methods to ameliorate existing and emerging diseases in livestock. (2015)
14. Optimize breeding of first-calf and re-breeding of second calf heifers. (2015)
15. Develop breeding strategies that maximizes the beneficial effects of heterosis in livestock. (2015)
16. Develop criteria for lamb carcasses to decrease variability and increase consumer satisfaction. (2015)
17. Identify and eliminate causes for consumers having poor eating experiences with lamb. (2015)

## VI. Grazing Management Objectives

1. Develop improved forage (e.g., grass/legume mixtures) based livestock production systems. (2014, revised 2015)
2. Demonstrate and evaluate benefits of strip grazing corn stalks. (2014)
3. Increase the carrying capacity of range and pastureland. (2014)
4. Evaluate effects of multi-species grazing on forage utilization and range health and productivity. (2014)
5. Develop alternative grazing strategies to enhance rangeland health. (2014)

6. Evaluate management intensive and rotational grazing strategies in dry environments. (2014)
7. Identify optimum grazing height for alfalfa aftermath and effects of grazing on stand longevity. (2014)
8. Develop forage species that are drought resistant. (2014)
9. Investigate ways to optimize wildlife-livestock interactions and receipt of value for hunting and tourism. (2014, revised 2015)
10. Provide new information on meadow management and irrigated pasture grazing in higher elevations. (2014)
11. Develop economically feasible methods to control sagebrush and greasewood. (2015)

**VII. Production Economics Objectives**

1. Determine the cost-effectiveness of fertilizer alternatives. (2014)
2. Determine the economics of alternative grazing systems. (2014)
3. Determine the cost-effectiveness of vaccines, mineral supplements, and pour-ons in livestock production systems. (2014)
4. Develop practical methods to assign economic values to ecological management procedures. (2014)
5. Identify obstacles and evaluate options and opportunities for marketing. (2014)
6. Identify obstacles and evaluate options and opportunities for marketing Wyoming-produced meat and other products to consumers. (2014, revised 2015)
7. Determine impacts of alternative management strategies on whole-ranch/farm economics. (2014)
8. Provide information on costs per unit of production. (2014)
9. Identify capital management alternatives for new and expanding producers. (2015)
10. Provide tools to facilitate record keeping. (2015)
11. Determine economic potentials for alternative crops (e.g., soybeans, oil crops, forage beets) and varied crop production methods (i.e. organic, no-till, and conventional) in specific Wyoming localities. (2015)
12. Determine economic impacts of grazing vs. harvesting of alfalfa and winter wheat in the fall. (2015)

**VIII. Crop and Animal Genetics and Biotechnology Objectives**

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

**IX. Rural Prosperity, Consumer and Industry Outreach, Policy, Markets, and Trade Objectives**

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

**X. X. Responding to Climate Variability Objectives**

1. Consider regionally unique environmental conditions when designing research studies. (2014)
2. Conduct integrated agricultural systems research that links environment and conservation to production and profitability. (2014)
3. Develop drought resistant plants that fit the extreme environmental conditions of Wyoming. (2014)

4. Devise drought management strategies that minimize detrimental effects of grazing. (2015)
5. Determine effects of climate variability (e.g., lack of freeze vs. a hard winter) on plant and livestock diseases and production. (2015)

**XI. Sustainable Energy**

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

**XII. Landscape-Scale Conservation and Management**

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

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