MONTANA STATE UNIVERSITY

MONTANA AGRICULTURAL EXPERIMENT STATION

Growing Small Grains in Central Montana:

Optimizing Management & Improving Soil Health

Field Day

Noon Meal sponsored by Cargill, Stricks Ag, & BASF InVigor

Wednesday, July 10, 2019

Central Agricultural Research Center

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Weather Summary
(1 September, 2018 – 1 July, 2019)

Simon Fordyce (CARC)

Above-average rainfall and cool temperatures occurred in fall, 2018, ending a dry period which persisted through the months of July and August. While the rains were welcome, the cool and wet conditions from September through November delayed harvest of late-maturing crops like safflower and prevented timely planting of some 2019 winter crops. December and January of 2019 were characterized by relatively warm and dry conditions, though this pattern ended abruptly in early February. A high of 53°F on 2 February was followed by a high of -5°F on 3 February, after which cool and wet conditions persisted through the month of May. An average air temperature of 3.3°F in the month of February made it the second coldest on record. From February through May, the CARC received 7.42 inches of precipitation, or 2.39 inches above normal, as well as 972 growing degree days, or 264 below normal. This pattern largely explains why heading dates for winter crops of 2019 were nearly one week behind those of 2018 and two weeks behind those of 2017. Heavy frosts occurring in late April and early May also disproportionately set back winter crops, particularly early-seeded winter wheat. The CARC received 5.58 inches of rain in April and May alone, or 1.72 inches above normal. These wetter-than-average spring conditions delayed planting of some 2019 spring crops. Light hail was observed at the CARC on 27 June, though damage to field crops was minimal.

Hard Winter Wheat Variety Trials

Jed Eberly, Eva Magnuson, and Jenni Hammontree (CARC)
Phil Bruckner and Jim Berg (Dep. Plant Sci. & Plant Pathology)

Problem

Montana is a major producer of winter wheat. Growers are constantly facing challenges to production due to drought, disease, and pests. New and improved varieties are needed to meet these challenges and to ensure economically sustainable wheat production in the state. The objective of this ongoing project is to identify varieties that are superior to those currently being grown for yield, quality, and resistance to disease and pests.

Study Description

The study is located in a field at CARC that had a pea/lentil cover crop the previous year. Additional trials are in place at Belt, Highwood, Geraldine, and Denton. Over 194 varieties and experimental lines were compared for heading date, height, lodging, yield, test weight, and protein content. Each variety was planted in three 5 x 16 foot plots in a randomized experimental design to determine differences between varieties. Agronomic data collected throughout the growing season included heading date, plant height, lodging, disease and insect pressure. Experimental plots will be trimmed, measured, and harvested with small plot combines. The grain will be weighed for yield and test weight.

The winter wheat trials were sprayed with Vendetta at a rate of 24 oz/ac to control broadleaf weeds. Starter fertilizer (20:30:20:10) was applied at planting at a rate of 50 lbs/ac. Nitrogen was applied in the spring using ESN (44-0-0) at a rate of 120 lbs/ac.

Applied Questions: **What was the average yield of the entries in the trial in 2018?**

The average yield for all winter wheat trials (including experimental lines) at Moccasin in 2018 was 66 bu/ac. Average yield at the Belt, MT location was 71 bu/ac. while Highwood was 36 bu/ac. Average yield at Geraldine for all varieties was 71 bu/acre while Denton averaged 54 bu/ac.

What were the top performing varieties in 2018?

Differences in yield were not statistically significant between varieties at CARC, Belt, and Denton last year. The top performing varieties at Highwood were Judee (50.8 bu/ac), SY Monument (46.4 bu/ac), SY Clearstone (45.9 bu/ac), Decade (45.2 bu/ac), Warhorse (43.3 bu/ac). Top performing varieties at Geraldine were Keldin (85.7 bu/ac), LCS Jet (82.9 bu/ac), SY Clearstone 2CL (81.1 bu/ac), Loma (80.0 bu/ac), Decade (79.7 bu/ac).

Spring Wheat Variety Trials

Jed Eberly, Eva Magnuson, and Jenni Hammontree (CARC)
Luther Talbert and Hwa Young Heo (Dep. Plant Sci. & Plant Pathology)

Problem

Spring wheat is an important crop throughout central Montana. Ongoing breeding programs are focused on improving the performance of spring wheat varieties. Performance targets include yields that are superior to the most commonly grown varieties, higher protein content, and increased resistance to pathogens and insects.

Study Description

The study is located in a field at CARC that had a pea/lentil cover crop the previous year. Over 169 spring wheat and durum varieties and experimental lines were compared for heading date, height, lodging, yield, test weight, and protein content. Each variety was planted in three 5 x 16 foot plots in a randomized experimental design to determine differences between varieties. Agronomic data collected throughout the growing season included heading date, plant height, lodging, disease and insect pressure. Experimental plots will be trimmed, measured, and harvested with small plot combines. The grain will be weighed for yield and test weight.

Vendetta was applied at a rate of 24oz/ac to control broadleaf weeds. Starter fertilizer (20:30:20:10) was applied at planting at a rate of

50 lbs/acre. Nitrogen was applied in the spring using ESN (44-0-0) at a rate of 120 lbs/ac.

Applied Questions: **What was the average yield and protein for entries in the 2018 trial?**

At Moccasin the average yield for spring wheat was 45 bu/ac. Denton was 29 bu/ac, Geraldine was 71 bu/ac, and the yield at Highwood averaged at 38 bu/ac. There were no significant differences in yield between varieties at each location.

Average protein at Moccasin was 10.0%. Denton was 14.0%, Geraldine at 11.0%, and protein at Highwood averaged at 14.0%. There were no significant differences in protein between varieties at each location.

What were the top performing spring wheat varieties in 2018?

Differences in yield not statistically significant between varieties at CARC, Denton, Geraldine or Highwood last year. The top variety for protein was Camaro at 12.6%

Barley Variety Trials

Jed Eberly, Eva Magnuson, and Jenni Hammontree (CARC)
Jamie Sherman (Dep. Plant Sci. and Plant Pathology)

Problem

Barley is an important agriculture commodity in Montana for feed, food, and malt. Barley ranks second only to wheat in the total number of acres grown in Montana. The MSU barley breeding program is focused on developing improved varieties of both hulled, hull-less, and winter barley varieties for food and feed. Winter barley is of particular importance since incorporating more fall planted crops in rotation provides growers with more options for weed and pest control.

Study Description

The study in 2019 is being managed almost identically as the study in 2018. That year, the barley variety trial tested the agronomic performance and potential of 150 varieties and experimental lines. An additional study contained 16 hull-less barley varieties and experimental lines. A new winter barley study is also in place. Results from a similar trial in Bozeman last year did not produce a yield under a conventional till system, where CARC did produce a yield under a no-till system. The winter barley study this year will compare winter barley varieties under tilled and no-tilled systems. All barley trials were

located in a field at CARC that had a pea/lentil cover crop in 2018.

The barley variety trials were treated with Vendetta at a rate of 24oz/ac to control broadleaf weeds. Starter fertilizer (20:30:20:10) was applied at planting at a rate of 50 lbs/acre. Nitrogen was applied in the spring using ESN (44-0-0) at a rate of 60 lbs/ac.

Applied Questions: **What was the average yield of the entries in the trial in 2018?**

At Moccasin the average yield for barley was 42 bu/ac. Average yield at Denton was 49 bu/ac, and Geraldine averaged at 93 bu/ac. The average protein concentration for all varieties at Moccasin in 2018 was not calculated. Average protein at Denton was 8.6% while Geraldine averaged 10.5%.

What were the top performing barley varieties in 2018?

Differences in yield were not statistically significant between varieties at CARC, Denton, and Geraldine last year. Some of the top performing varieties at CARC were Opera 62 bu/ac, Sienna 61 bu/ac, and Hockett at 53 bu/ac. At Denton, Accordine 59 bu/ac, Haxby 56 bu/ac, and Blaster 55 bu/ac. At Geraldine, Merit 57 111 bu/ac, Esma 105 bu/ac, and Haxby 102 bu/ac.

Organic Barley Nursery Trial

Patrick Carr, Sally Dahlhausen,
Sherry Bishop, and Heather Fryer (CARC)
Jamie Sherman (Plant Sci. & Plant Pathology)

Problem

Historically, small-grain crop varieties have not been developed specifically for organic production in Montana. Jamie Sherman, MSU barley breeder, has begun selecting for barley germplasm adapted to certified organic production. A barley nursery has been established in an organic field at the CARC for this purpose in 2019.

Study Description

The study is located in a field where a grass/alfalfa stand had been maintained for several years prior to 2018. That year, a wide sweep (i.e., noble blade) was used to kill alfalfa, grasses, and weeds that had become established in the grass/legume sward. In spring, 2019, the area was disked twice and then leveled using a field cultivator to kill surviving alfalfa, grass, and weeds and prepare the seedbed for planting. Fifteen barley varieties and five experimental lines were planted in plots on 05 June. The late planting date reflects the need for multiple cultivations to kill alfalfa plants that persisted in the plot area.

Applied Questions

Which barley varieties will be adapted to organic production?

We don't yet know. Our objective is to answer this question. However, varieties that emerge quickly, have good seedling vigor, produce a thick vegetative canopy, grow taller, and mature earlier may have an advantage over shorter, less vigorous and later maturing varieties since those former traits should allow plants to be more competitive with weeds. Weed density in organic environments generally is greater than in conventional environments.

Will selection for superior performing barley experimental lines and varieties be continued beyond 2019?

We plan on working with Jamie Sherman, our barley breeder located on campus, in conducting an organic barley nursery for the next several years at the CARC. We hope to expand this effort to include other crops in the future.

Acknowledgments

We are grateful to the Montana Agricultural Experiment Station and the Brewers Association for providing funding for this trial.

Proso Millet Nursery Trial

Patrick Carr, Simon Fordyce, Sally Dahlhausen,
Sherry Bishop, and Heather Fryer (CARC)
Dipak Santra (Univ. of Nebraska)

Problem

Less than 5000 acres of proso millet was grown for grain in Montana during 2018. We are interested in it as a warm-season, annual grass crop that can add rotational diversity if incorporated into wheat-based cropping systems. The objective of this research is to determine if experimental lines and newly released varieties are adapted as grain crops in central Montana.

Study Description

The study is located in a field that was planted to spring pea in 2018. Five named varieties (Earlybird, Huntsman, Sunrise, Horizon, Plateau) and 25 experimental lines were planted on 29 May, following a pre-plant burndown of glyphosate.

Applied Questions

Is proso millet adapted to central Montana growing conditions when grown for grain?

Preliminary results suggest that proso millet will be a risky grain crop when grown in central Montana. Warm temperatures (i.e., adequate heat units) are needed for proso millet to reach physiological maturity and produce grain. In addition, mid- and even late-summer rains are needed for high grain yields in the shallow soils found in central portions of the state.

Grain yield averaged less than 400 lb/ac for the 25 entries in the proso millet variety trial in 2018, but the late arrival of seed delayed planting until mid-June and explains partially the low grain yield. An experimental line produced almost 800 lb grain/ac, and Plateau, a 2014 release from the University of Nebraska, produced 650 lb grain/ac. Even so, a break-even yield of ~2000 lb grain/ac was estimated for proso millet by agricultural economists at North Dakota State University 2018, indicating much greater yields will be needed than those produced in 2018 for this crop to be grown profitably.

How much longer will you continue testing proso millet lines/varieties?

Grain yields will be determined for all entries in 2019. If yields are again low (i.e., less than 1500 lb/ac for all entries), we will re-evaluate our plans to maintain a proso millet nursery at the CARC in the future.

Acknowledgments We are grateful to Dipak Santra at the UN Panhandle Research and Extension Center in Scottsbluff, NE, for supplying seed for this study and for the Montana Agricultural Experiment Station for providing funding for this research through the USDA National Institute of Food & Agriculture, Hatch project 1012796.

Spring Field Pea Variety Trial

Chengci Chen, Bill Franck (EARC)
Patrick Carr, Sally Dahlhausen, Simon Fordyce (CARC)

Problem

Montana led the nation in dry pea acreage two of the last three years. However, yields were consistently lower than national averages. For example, Montana's statewide pea yields were 820 and 1,200 lb/ac in 2017 and 2018, compared to 1,350 and 1,972 lb/ac nationwide. Selection of varieties adapted to local growing conditions can help to improve pea yields in Montana.

Study Description

Twenty-seven varieties and experimental lines are being compared for height, propensity to lodge, vine length, date of 50% flowering, grain yield, protein, test weight, and seed weight. Each cultivar was planted in four, 5x15 ft plots in an experimental design to determine varietal differences. The study is located in a field where an alfalfa/grass mix had been established for several years prior to cultivation in fall of 2018. Peas were planted on 23 April at a depth of 1 inch and at a rate of 8 PLS/ft^2 using a low-disturbance, double-disc plot drill. Soil temperature at time of planting was 48°F. Broadleaf and grass weeds were controlled with a pre-plant burn down of RT3 (i.e., glyphosate) at 36 fl oz/ac on 18 April and a single application of Raptor (i.e., imazamox) at 4 fl oz/ac tank mixed with Basagran (i.e., generic bentazon) at 13 fl oz/ac was made on 11 June.

Grizzly Too at 1.9 fl oz/ac was applied on 23 May for the control of pea leaf weevil.

Applied Questions

What were the top performing spring pea varieties at the CARC in 2018?

In 2018, five cultivars yielded statistically equivalent to the top performer, Nette 2010 (54 bu/ac). These were AAC Carver (50 bu/ac), Navarro (51 bu/ac), Delta (51 bu/ac), Jetset (52 bu/ac), and Hampton (54 bu/ac).

How have two-year average seed yields compared at the CARC?

Based on 2-yr averages, Hampton (32 bu/ac) was the highest yielding cultivar among green types and Nette 2010 (37 bu/ac) was the highest yielding cultivar among yellow types.

Which cultivars are susceptible to lodging at the CARC?

In 2018, cultivars exhibiting the highest percent lodging were Salamanca (20%), Nette 2010 (20%), Majoret (22.5%), Aragorn (30%), and Hampton (35%).

Acknowledgements

Thanks to Montana Agricultural Experiment Station for funding this research through the USDA National Institute of Food and Agriculture, Hatch project 1012796 and to the Montana Pulse Advisory Committee.

Spring Lentil Variety Trial

Chengci Chen, Bill Franck (EARC)
Patrick Carr, Sally Dahlhausen, Simon Fordyce (CARC)

Problem

Montana's spring lentil yields are consistently depressed relative to those of other states. For example, Montana yields were 650 lb/ac and 1,080 lb/ac in 2017 and 2018, compared to 870 lb/acre and 1,370 lb/ac in North Dakota. The development of new varieties that are adapted to local growing conditions can help to close the yield gap with other states.

Study Description

Ten varieties and experimental lines are being compared for height, propensity to lodge, vine length, date of 50% flowering, grain yield, test weight, and seed weight. Each variety was planted in four, 5x15 ft plots in an experimental design to determine varietal differences. The study is located in a field where an alfalfa/grass mix had been established for several years prior to cultivation in fall of 2018. Lentils were planted on 19 April at a depth of 1 inch and at a rate of 12 PLS/ft^2 using a low-disturbance, double-disc plot drill. Soil temperature at time of planting was 48°F. Broadleaf and grass weeds were controlled with a pre-plant burn down of RT3 (i.e., glyphosate) at 36 fl oz/ac on 18 April. A single application of Assure II (i.e., quizalofop) at 12 fl oz/ac was made on 30 May for additional control

of grass weeds. Plots were hand-weeded thereafter.

Applied Questions

What were the top performing spring lentil varieties at the CARC in 2018?

In 2018, Avondale (2,330 lb/ac) and CDC Maxim (2,177 lb/ac) were significantly higher yielding than all other named varieties. Avondale (12.1 inches) and CDC Richlea (11.2 inches) were the tallest lentil varieties at flowering stage, while CDC Maxim (15.8 inches) and CDC Impala (15.4 inches) were the tallest at maturity.

How have two-year average seed yields compared at the CARC?

Based on two-year averages, Avondale (1,566 lb/ac) was the highest yielding cultivar and CDC Impala (1,165 lb/ac) was the lowest, though statistical differences between these varieties were not assessed.

How do flowering dates compare at the CARC?

The earliest flowerer, Avondale, reached 50% bloom on 24 June, 60 days after planting. CDC Impala, the last to reach 50% bloom, did so four days later.

Acknowledgements

Thanks to the Montana Agricultural Experiment Station for providing funding for this research through the USDA National Institute of Food and Agriculture, Hatch project 1012796 and to the Montana Pulse Advisory Committee.

Chickpea Variety Trial and Nursery

Chengci Chen, Bill Franck (EARC)
Kevin McPhee (Dep. Plant Sci. & Plant Pathology)
Patrick Carr, Sally Dahlhausen, Simon Fordyce (CARC)

Problem

In 2018, US farmers seeded 860,000 acres of chickpeas. Montana alone accounted for 390,000 acres, or nearly half of the national total. Yet, for the third straight year, Montana chickpea yields were well below national averages. Development of varieties well suited to the many diverse growing conditions of the state is a logical first step toward improving chickpea yields in Montana.

Study Description

Twenty-seven varieties and experimental lines in two separate trials are being compared for height, propensity to lodge, vine length, date of 50% flowering, grain yield, protein, test weight, and seed weight. Each variety was planted in four, 5x15 ft plots in an experimental design to determine varietal differences. The study is located in a field where an alfalfa/grass mix had been established for several years prior to cultivation in fall 2018. Chickpeas were planted on 29 May at a rate of 5 PLS/ft^2 using a double disc drill. Soil temperature at time of planting was 56°F. Broadleaf and grass weeds were controlled with a pre-plant burn down of RT3 (i.e., glyphosate) at 36 fl oz/ac on 18 April.

Applied Questions

Why is chickpea seed size important?

Chickpea price received typically decreases with seed size, falling off drastically at sizes below 7 mm. Desi types are much smaller than Kabuli types, while Large Kabuli types are slightly smaller and darker in color than Large Café Kabuli types.

What were the top performing chickpea varieties at the CARC in 2018?

Three Large Kabuli types and one Large Café Kabuli type yielded statistically equivalent to CDC Orion (2,014 lb/ac), the top yielder and a Large Kabuli type. These were CDC Leader (1,725 lb/ac), Nash (1,748lb/ac), CDC Frontier (1,787 lb/ac), and CDC Palmer (1,788 lb/ac).

How did flowering dates compare at the CARC in 2018?

The earliest flowering variety, CDC Orion, reached 50% bloom on 2 July, 54 days after planting. The last varieties to reach 50% flowering, CDC Frontier and Royal, did so six days later.

Acknowledgements

We are grateful to the Montana Agricultural Experiment Station for providing funding for this research through the USDA National Institute of Food and Agriculture, Hatch project 1012796 and to the Montana Pulse Advisory Committee.

Spring Canola Variety Trial

Patrick Carr, Sally Dahlhausen, Simon Fordyce (CARC)

Problem

Canola acreage in Montana is trending upward, despite a 23% reduction in planted acres from 2017 to 2018. The reduction in 2018 acreage may have been a 'hangover' from drought-induced crop failures in 2017, when Montana's average yields were just 860 lb/acre and 18,000 planted acres went unharvested. Montana acreage is projected to increase again in 2019. Selection of varieties adapted to local growing conditions is one way to minimize risk associated with canola production and could help canola farmers avoid a repeat of 2017.

Study Description

Spring canola variety trials are established at six locations across the state, including one at the CARC. This trial includes fifteen GMO & non-GMO cultivars being compared for height, propensity to lodge, days to 50% flowering, grain yield, test weight, seed weight, and oil content. Each variety was planted in four, 5x15 ft plots in an experimental design to determine varietal differences. The study is located in a field that was planted to hard red spring wheat in 2017 and flax in 2018. Canola was planted on 23 April at a depth of 0.75 inches and at a rate of 14 PLS/ft^2 using a low-disturbance, double-disc plot drill. Windy conditions at seeding led to within-row gaps and poor stands in certain plots. Broadleaf and

grass weeds were controlled with a pre-plant burn down of RT3 (i.e., glyphosate) at 36 fl oz/ac on 19 April. Sequential applications of Stinger (i.e., generic clopyralid) at 8 fl oz/ac and Assure II (i.e., quizalofop) at 12 fl oz/ac were made on 30 May for in-crop broadleaf and grass control, respectively. Plots were hand-weeded thereafter.

Applied Questions

How have two-year average seed yields compared at the CARC?

Based on 2-yr averages, HyCLASS 955 (821 lb/acre) was the highest yielding cultivar and C5507 (661 lb/ac) was the lowest, though statistical differences were not assessed.

How did flowering dates compare at the CARC in 2018?

The earliest flowering cultivar, 11H4030, reached 50% bloom on 14 June, just 49 days after planting. The last cultivars to reach 50% bloom, 4187 RR and 6090 RR, did so nearly eight days later.

Acknowledgments

We are grateful to the Montana Agricultural Experiment Station for providing funding for this research through the USDA National Institute of Food and Agriculture, Hatch project 1012796, and to BASF, BrettYoung, Dekalb, Cargill Global Edible Oil Solutions, Winfield United, Meridian Seeds, and Photosyntech.

Spring Camelina Variety Trial

Patrick Carr, Sally Dahlhausen, Simon Fordyce (CARC)

Problem

Camelina is a cool-season oilseed with minimal fertility requirements (i.e., less than one-third those of canola) and strong frost tolerance ratings. In 2017, US farmers harvested fewer than 1,000 acres of camelina nationwide, with nearly 800 of those harvested in Montana. Selection of varieties adapted to local growing conditions can improve the economics of camelina production for Montana farmers.

Study Description

Twenty experimental lines are being compared for height, propensity to lodge, days to 50% flowering, days to maturity, grain yield, test weight, seed weight, and oil content. Each cultivar was planted in three, 5x15 ft plots in an experimental design to determine varietal differences.

The study is located in a field that was planted to hard red spring wheat in 2017 and flax in 2018. Camelina was planted on 23 April at a depth of 0.75 inches using a low-disturbance, double-disc plot drill. Windy conditions at seeding led to within-row gaps and poor stands in certain plots. Broadleaf and grass weeds were controlled with a pre-plant burn down of RT3 (i.e., glyphosate) at 36 fl oz/ac on 19 April. Plots were hand-weeded thereafter.

Applied Questions

What are the top performing cultivars of camelina at the CARC?

No variety trials have been established at the CARC in past years. However, camelina fertility trials were established in no-till systems following both chemical fallow and barley at the CARC in 2013. When averaged across fertilizer treatments, seed yields for the cultivar Blaine Creek were 1,500 and 1,172 lb/ac following fallow and barley, respectively, while seed yields for the cultivar Suneson were 1,670 and 1,158 lb/ac.

What are the N requirements of camelina at the CARC?

Based on results of a 2013 camelina fertility trial, when growing Suneson after barley in a no-till system, there are no additional yield benefits after 90 lb N/acre, as long as 20 lb P/acre, 20 lb K/acre, and 25 lb S/acre have also been applied. In this scenario, dropping to 60 lb N/acre will result in a significant ($p < 0.01$) yield reduction of approximately 420 lb/acre.

Acknowledgments

We are grateful to Global Clean Energy for funding this research.

Safflower Variety Trial

Patrick Carr, Simon Fordyce, Sherry Bishop, and Heather Fryer (CARC)

Problem

Safflower was grown on 43,000 acres in 2018. It is an attractive rotational crop because of its deep taproot which can extract water and nutrients from greater soil depths than many other grain/seed crops that are grown in the state, Seed harvest is later than wheat, pea, and most other annual crops grown in central Montana, preventing harvest conflicts. The objective of this trial is to identify superior performing safflower varieties under dryland management in central Montana.

Study Description

The study is located in a field that was planted to foxtail millet in 2017. Safflower was planted on 26 April into a high-residue, no-till seedbed using a planter with low-disturbance disk openers. A pre-plant burndown of glyphosate was used to control grass and broadleaf weeds prior to seeding plots.

Applied Questions

What are the top yielding safflower varieties in the trial?

Yields were lower in 2018 (avg. yield = 671 lb/ac) compared to 2017 (avg. yield = 820 lb/ac). Baldy spineless safflower was among the highest yielding varieties/hybrids in 2018, averaging 844 lb/ac. Others relatively high yielding varieties/hybrids in 2018 included (Cardinal (778 lb/ac), Hybrid 1601 (813 lb/ac), Hybrid 200

(Hybrid 726 lb/ac), Hybrid 446 (824 lb/ac), and Rubis Red (748), another spineless variety. A break even yield of 1135 lb/ac for safflower grown in the northern Great Plains was suggested by NDSU ag economists for 2018.

What are the top safflower oil producers at CARC?

Seed oil content was not determined for entries in the 2018 trial. NutraSaff golden safflower produced seed with the highest oil content in both 2016 (48%) and 2017 (47%). STI 1201 also produced seed with relatively high oil content (44%), though less than NutraSaff. By comparison, seed oil content of entries in the trial averaged 36% in 2017.

Acknowledgments

We are grateful to the Montana Agricultural Experiment Station for providing funding for this research through the USDA National Institute of Food & Agriculture, Hatch project 1012796, and to North Dakota State University for providing seed for this trial.

CoAXium® Wheat Production System driven by Aggressor® herbicide

Edward Davis (Dep. Land Res. Environ. Sci.)
Chad Shelton (Albaugh, LLC)

Problem

Montana winter wheat producers have been challenged by winter annual grass weeds for decades. Group 2 herbicides (starting with Maverick "*sulfosulfuron*" 1990), provided effective post emergence herbicide options for control or suppression of annual bromes in winter wheat. Unfortunately, these selective group 2 post-emergence herbicides (Maverick, Olympus, Osprey, Powerflex) are not as effective at controlling jointed goatgrass or volunteer cereal rye. That changed with the introduction of ClearField® wheat in 2001 which allowed for the incrop application of Beyond (imazamox) herbicide. Unfortunately, all of these post-emergence herbicide options use group 2 chemistry or mode of action and, over time, resistant grassy weed populations developed.

The CoAXium® wheat production system utilizes the same non-transgenic breeding methods used to develop the ClearField® Wheat Production System except using a group 1 non-selective grass herbicide. Aggressor® herbicide (Quizalofop) is the registered herbicide that is used with CoAXium® wheat and is marketed by Albaugh, LLC.

Study Description

Several trials have been established across winter wheat growing regions of Montana to evaluate the efficacy of the CoAXium® wheat Production

System and Aggressor® herbicide for controlling downy brome, volunteer cereal rye and jointed goatgrass. The site at the CARC specifically targets downy brome infestation in "PlainsGold Incline AX" winter wheat. Different Aggressor® herbicide use rates, different adjuvants, and wheat growth stage timing at applications are being studies, along with broadleaf herbicide tank-mix partners.

Data from previous trials over 3 years have demonstrated the CoAXium® Wheat Production System and Aggressor® herbicide will be extremely valuable for control of these problematic grass weeds in winter wheat and with conscientious stewardship this technology can be preserved for several decades providing a new tool for effective management of winter annual grass weeds in winter wheat.

Applied Question: **Does the CoAxium Wheat Production Ssytems have a place in Montana?**

Data from these trials over 3 years have demonstrated the CoAXium® wheat production system and Aggressor® herbicide can be extremely valuable for controlling these problematic grass weeds in winter wheat. This technology can be preserved for several decades providing a new tool for effective management of winter annual grass weeds in winter wheat.

Integrating Little Hammers: Crop Variety, Crop Diversification, Cover Crops, & Targeted Grazing To Chip Away At Multiple Herbicide Resistant Weeds

Tim Seipel, Mei Ling Wong, Fabian Menalled
(Dep. of Land Res. & Environ. Sci.)
Pat Carr (CARC)
Erin Burns (Michigan State Univ.)

Problem

The selection for multiple herbicide resistance weeds is an ongoing and increasing problem threatening no-till cereal cropping systems when herbicides become less effective. Creating integrated weed management strategies for weeds is crucial for long-term economic and environmental sustainability.

Study Description

We are combining field studies with population modelling to evaluate the potential of integrating increased crop competition during the wheat phase, increased crop diversification, and, if available to farmers, targeted grazing of forage crops to manage herbicide resistant kochia and wild oat. In the field trials conducted in 2018 and 2019, we assigned 10 treatments randomly to plots arranged in blocks replicated four times. There are four wheat treatments where a tall or short version of Amidon are planted at 60 and 90 lb/ac, Richlea lentils, tilled fallow, and spring barley/forage pea (spring seeded) or triticale/Austrian winter pea forage (winter seeded) crops.

Applied Questions

How much weed seed and weed biomass is produced in each of the different cropping treatments?

Weed biomass and the number of seeds produced varied among the different treatments in 2018. Wild oat biomass was lowest in tilled fallow and second lowest in forage crops that were terminated in mid-July. When forage crops were hayed or grazed in late June, wild oat had enough time to regrow and produced more biomass and seed than in plots terminated in mid-July. Wild oat biomass and seed production was lower at higher the lower seeding rate but did not vary in response to wheat height.

Kochia biomass and seed production were higher in tilled fallow, wheat and lentils compared with forage plots. The individual plants were smaller in wheat and lentils than in tilled fallow, but the tilled fallow had fewer plants. Termination of forage crops in mid-July reduced kochia as it did with wild oat. Initial results suggest that forage crops in a rotation have the potential to reduce seeds produced of wild oat and kochia. Higher wheat seeding rates resulted in competitive wheat crops that limit weeds.

Acknowledgments

We are grateful to the USDA-NIFA and the Montana Wheat and Barley Committee for providing funding for this research study.

CREEP STOP: An IWM Approach
For Creeping (Canada) thistle and Field Bindweed Control

Patrick Carr and Jed Eberly (CARC)
Fabian Menalled, Perry Miller & Tim Seipel
(Dep. Land Res. Environ. Sci., MSU)
Zach Miller (WARC)
Anton Bekkerman & Kate Fuller
(Dep. Ag. Econ. & Econ., MSU)
And Nine Others

Problem

Organic farmers have identified creeping (Canada) thistle and field bindweed as two particularly pernicious weeds when growing grain crops. Creeping or Canada thistle also is a growing problem on conventional farms. The objective of this project is to develop effective integrated weed management strategies for controlling both species that does not depend on extensive tillage.

Study Description

The study includes three trials at MSU research facilities (CARC, WARC, Ft. Ellis Research Farm), and experiments on several organic farms across central and western parts of the state. Experiments also are being conducted on farms in North Dakota and Washington.

Applied Questions

Can creeping thistle and field bindweed be controlled without herbicides?

Past research indicates that both creeping perennial weed species can be controlled by repeated tillage, but soil degradation also occurs.

Our goal is to combine limited tillage, crop rotation, and animal grazing into a system that suppress both weed species successfully when growing wheat, as well as to develop biological inoculants that suppress growth and spread of creeping thistle.

Will results of this project have application only in organic systems?

Results of this project should have application in conventional as well as organic farming systems. Weed species that are resistant to synthetic herbicides are becoming a greater problem in Montana, and elsewhere. The integrated weed management strategies developed by this project can be used to control resistant weed populations on conventional farms.

Acknowledgments We are grateful to the USDA-NIFA Organic Research and Extension Initiative (OREI) program for providing the funding for this research.

Inoculant Trials

Jed Eberly, Eva Magnuson, and Jenni Hammontree (CARC)

Problem

Studies are underway testing microbial inoculants for their ability to improve plant health and yield. Inoculations may be another cost-effective way to increase agronomic gains from crops, in addition to variety selection, fertilizers, etc. Naturally occurring bacteria and fungi applied to crops may improve plant vigor, nutrient allocation, disease/pest resistance and as a result, produce higher yields. The purpose of this work was to evaluate the effectiveness of these inoculants on the agronomic performance of winter wheat and spring wheat.

Study Description

Inoculant studies are underway testing different beneficial microorganisms for their ability to improve plant health and yield. Winter and spring wheat studies were established to evaluate the effectiveness of several microbial inoculants. An additional study was established to evaluate the performance of soil inoculants on irrigated alfalfa hay and grass pasture. Inoculant formulations contained members of the N-fixing genera *Bradyrhizobium*, free-living N-fixing *Azospirillum*, phosphorous solubilizing *Pseudomonas*, and general plant growth promoting *Bacillus*. Additional studies are also evaluating complex microbial blends containing 20 or more species. Each treatment was planted in three 5 x 16 foot plots

in a randomized experimental design to determine differences between treatments. Agronomic data collected throughout the growing season included heading date, plant height, lodging, disease and insect pressure. Experimental plots will be trimmed, measured, and harvested with small plot combines. The grain will be weighed for yield and test weight. Soil samples will also be collected for measuring the abundance and diversity of microorganisms in the soil. This information will be used to determine if the microorganisms that were added were able to survive and will also be used to assess their impact on the native microbial community.

Applied Questions: **How did inoculants impact wheat performance in 2018?**

No significant differences were observed in preliminary trials between treatments and the control in either the winter wheat or spring wheat inoculant trials for any of the reported agronomic traits last year.

Igniting the Soil Microbiome: Plant and Soil Community Response to Introduced Microbial Communities from Compost in Organic Dryland Agriculture Production

Molly Haviland, Graduate Student, Dep. Land Res. Environ. Sci.
Jed Eberly and Pat Carr, LREC
Tony Hartshorn, Dep. Land Res. Environ. Sci

Problem

Many agricultural soils have become degraded due to decades of conventional agricultural practices that have negatively impacted nutrient cycling and biological activity. Composts applied once at high rates have been found to have persistent effects on yield and soil quality in organic dryland growing systems that remain ~ 12 years after application. Compost additions can increase carbon sequestration, water availability, and nutrient cycling. The goal of this study is to determine how the application of locally sourced compost affects organic dryland agricultural production, soil microbial communities, and soil health indices such as soil organic matter, aggregate stability, and bulk density.

Study Description

This study was established in the spring of 2019. Compost was made on-farm from 60% cattle manure, 20% hay, and 20% straw using a windrow compost turner and watered via natural winter precipitation following United States Department of Agriculture (USDA) compost guidelines. Compost was applied at 0, 3, 9, and 30 tons/acre. Plot size was 3 x 6 m with a 3-m buffer between

plots. Vida spring wheat was planted for the 2019 crop year and will be followed with a fall cover crop. Agronomic data collected throughout the growing season include heading date, plant height, lodging, disease and insect pressure. Crop yield and protein will also be determined. Soil sampling will also be performed to measure soil health and microbial abundance and diversity.

Applied Questions: **How do compost applications impact crop performance and the soil microbial community?**

This is the first year of the study and data collection will occur throughout the summer and fall.

Evaluating the Effects Of Seeding Rates and Inoculant Performance on Nodulation, Weed Suppression, and Relative Yields Of Different Lentil Varieties Grown in The Northern Great Plains

Joseph Kibiwott, Graduate Student (Dep. Plant Sci. & Plant Pathology)
Jed Eberly and Pat Carr, CARC
Kevin McPhee (Dep. Plant Sci. & Plant Pathology)

Problem

Lentils are important for diversifying wheat-based cropping systems and are also beneficial in enhancing soil health. These benefits have contributed to the exponential growth in pulse crop acreage in the northern Great Plains. There are several challenges facing organic lentil production. Lack of approved herbicides for use in organic pulse crop production is a challenge to weed management. Little is known about the optimum seeding and appropriate inoculation rates to improve crop growth, nutrient acquisition, weed management, and yield potential for lentils in organic systems.

Most organic lentil growers in the northern Great Plains base the seeding rates of all lentil varieties on a target population of 130 plants m^{-2} which is borrowed from conventional farming systems. However, crop management strategies and inputs used in organic system differ from those used in conventional cropping systems. For example, while conventional lentil growers can use a number of approved synthetic seed treatment and weed management products, these are not approved for

use in organic systems. Organic growers are often encouraged to seed densely to account for the loss of stand due to seed and soil pathogens and achieve desired plant density in the field. More research is needed given the wide range of seeding rates in lentil growing regions around the world and there is a need for better seeding rate recommendations

Study Description Lentil seeding and inoculant rate trials were planted at Geraldine, Belt, and Rudyard, MT on certified organic farms. Seeding rates were 100, 200, 300, and 500 plants m^{-2}. Large green, French green, and black beluga lentils were planted and 2 different inoculant rates (standard and 2X) were used.

Applied Question: **How do seeding rates, inoculants, and variety selection impact organic lentil performance?**

This is the first year of the study and data collection is just beginning. Early season observations suggest weed density is greater at the lower seeding rates as expected. Weed species also differ between locations with the Geraldine location being predominately wild buckwheat while the Rudyard location had a mix of kochia and broadleaf weeds. In Belt, the predominant weed pressure is from volunteer clover.

Lentil Underground – Agronomy Trials

Patrick Carr, Simon Fordyce (CARC)
Perry Miller, Syd Atencio, Clain Jones, Jeff Holmes (Land Res. & Env. Sci.)
Mary Burrows, Collins Bugingo (Plant Sci. & Plant Pathology)
Maryse Bourgault (NARC)
Chengci Chen (EARC)

Problem

Lentil surged to >700,000 acres in Montana in 2017 on the strength of good price forecasts for lentil and poor for wheat. Due to the historical small acreage for lentil in Montana, there has been very little 'local' agronomic research invested. Mary Burrows noted that disease infection levels in seed samples submitted to MSU-Bozeman over the years were increasing generally in all pulse crops. She was especially concerned about the knowledge void for fusarium root rot of lentil, a very damaging and persistent soil-borne pathogen. Agronomic field trials are underway to determine the impact of different agronomic practices on lentil performance and fusarium root rot.

Study Descriptions

Three studies are being conducted at four locations in Montana (MSU-Bozeman, CARC, EARC, and NARC) and at three locations in North Dakota. A fourth study is being conducted only at three of the four MT locations (EARC is excluded). The trials including a fertility trial, a fungicide seed treatment trial, a variety trial and, at the three MT locations, a seeding rate x rolling timing trial.

Applied Questions

What are economically optimal agronomic practices for lentil in Montana and North Dakota?

Stay tuned, this is year-1!

How does fusarium root rot interact with agronomic management?

Again, stay tuned!

Acknowledgments

We are grateful to the USDA-NIFA Specialty Crop Research Initiative (National Program) and the Montana Agricultural Experiment Station for providing funding for this research study. **Mary Burrows is to be congratulated for leading such a large interconnected research program that will help secure lentil production in the USA.**

Hemp Variety by Planting Date Trial

Patrick Carr (CARC)
Perry Miller (Dep. Land Environ. Sci.)
Chengci Chen (EARC)
Ian Foley (MT Dep. Agric.)

Problem

Interest in hemp production has exploded in Montana. It has been grown commercially in Canada and there has been limited research done in the U.S. northern Great Plains (North Dakota), and almost none in Montana. It is unknown if basic production practices (e.g., planting date) used in North Dakota or elsewhere (e.g., Canada) should be adjusted for optimum production in Montana.

Study Description

Two hemp cultivars (Katani and CRS-1) were planted in late April, mid- and late-May to determine if early planting was preferred over late planting in central Montana. Vida spring wheat was planted at those same times and is serving as a check treatment in the trial.

Applied Questions

How will hemp seed yields be affected by planting date?

Hemp is considered day length sensitive; flowering is triggered by a critical day length threshold. Hence, planting earlier should result in more, and planting later should result in less, vegetative growth. This is important because hemp planted in late May at the CARC during 2018 failed to produce tall plants and a full canopy that would be

effective in shading the surface and suppressing weed growth.

What sort of seed yields should be expected in 2019?

We really don't know; we were disappointed with seed yields in 2018. Highest yields were produced by Grande (336 lb/ac) and CRS-1 (301 lb/ac). We were hoping for seed yields at least twice that much.

How do hemp plants look so far in 2019?

The hemp trial was established in a field where foxtail millet was grown for seed in 2018. The millet was harvested with a stripper header in 2018, and a lot of residue remained on the surface when the hemp was planted this spring. There was uneven emergence because of the heavy residue covering, but the plants that are developing don't appear taller or more lush than those in 2018; they are shorter than anticipated and the plant canopy is not as full and lush as we had hoped it would be. It will be interesting to learn if planting date impacts seed yield, and if seed yields are greater in 2019 than in 2018.

Acknowledgments We are grateful to the Montana Department of Agriculture for the seed used in this study, as well as for funding from the Montana Agricultural Experiment Station.

Understanding Acidification and Management of Montana Soils

Rick Engel, Clain Jones, Scott Powell (Dep. of Land Res. & Environ. Sci)
Tyler Lane (Chouteau County Extension)
Patrick Carr, Sally Dahlhausen, Simon Fordyce (CARC)

Problem

In 2011, County Extension and Montana Agricultural Experiment Station faculty members were approached by central Montana farmers about declining crop performance in fields under long-term cultivation. Eventually, the problem was identified as aluminum toxicity caused by soil acidification. Since then, cultivated soils of pH <5.5 have been discovered in 23 Montana counties.

Study Description

Nine cultivars of spring canola, spring pea, spring barley, and spring wheat were established in acidic soils under limed (5 ton/acre) and unlimed conditions in an experimental design to determine the efficacy of Aglime for remediation of acidic soils. Additionally, a single cultivar of durum wheat was established under limed and unlimed conditions at five different rates of phosphorous fertilizer to evaluate whether seed-placed phosphorus in combination with Aglime can mitigate aluminum toxicity caused by acidic soils. The trials were established at two locations in Chouteau County: a conventional-till system near Highwood, MT, and no-till system near Geraldine, MT.

Applied Questions

Which cultivars performed well under limed and unlimed conditions in the conventional till system near Highwood in 2018?

Spring canola cultivar DKL 70-10 was a top yielder in both limed (1293 lb/ac) and unlimed (1054 lb/ac) conditions. DKL 70-10 also had the highest test weight in unlimed conditions (51.5 lb/bu) and had among the highest test weights in limed conditions (52.3 lb/bu). Spring pea cultivars Delta, CDC Mozart, and Carousel were among the top yielders under both limed and unlimed conditions, while Agassiz was in the top performing bracket for protein in unlimed conditions and produced the highest protein in limed conditions. Cultivar-dependent lime responses were not observed in spring wheat or barley in the conventional till system.

Does phosphorous fertilizer in combination with lime improve durum performance in low pH soils?

Yes. However, this strategy does not impact or remediate soil pH, but has application where a grower is seeking a short-term benefit (e.g. where the land is being rented under a short-term lease agreement).

Acknowledgements

We are grateful to the Western Sustainable Agriculture Research and Education Program and the Montana Agricultural Experiment Stations for funding this research.

Improving Nitrogen Management in Montana Dryland Soils By Determining the Contribution Of Microbial Mineralization to Nitrogen Availability

Jed Eberly, Eva Magnuson, and Jenni Hammontree, CARC

Problem

Microorganisms in the soil play an important role in soil health and crop health and productivity however it is difficult to measure their activity and to determine responses to specific agronomic practices. One of the important roles of microorganisms in the soil is nitrogen (N) cycling. Appropriate N management is essential for the economic and environmental sustainability of Montana farms. N mineralization is an important part of N cycling since it enhances N uptake by crops and increases the risk of nitrate loss through leaching. The impact of enhanced cropping system diversity on N mineralization, and consequently N availability and nitrate leaching in dryland cropping systems is currently not well known. This work will provide insight into microbial activity throughout the year and N mineralization rates and the temporal variability of those rates in response to greater crop diversity.

Study Description

The study is in an existing crop rotation study that was started in 2004. More recently, the Rotation And Tillage Systems (RATS) study was begun in 2017 to evaluate diverse cropping systems under no-till and conventional-till management.

The cropping systems consist of (1) winter wheat (WW)-Fallow; (2) WW-Barley-Pea; (3) WW-Barley-Lentil (4) WW-spring wheat (SW); and (5) Pea-Proso Millet-Safflower-SW. In fall, 2018, soil respiration chambers, were placed in the spring wheat phase of SW-WW and Pea-Millet-Safflower-SW. We are monitoring changes in microbial activity in response to temperature changes and precipitation events throughout the year. This data will be used to compare differences in community activity between cropping systems and to correlate N mineralization to overall microbial activity.

N mineralization tubes have also been placed in each treatment. These tubes contain packets of resin beads that absorb nitrate as it leaches through the soil. The mineralization tubes will be collected monthly and the nitrate extracted from the resin. This data will be used to establish mineralization rates.

Applied Question: **How does cropping system impact the soil microbe community?**

Initial results indicate higher total N concentrations in pea-proso millet-safflower-SW rotation compared to the SW-WW rotation. However, differences in nitrate-N were not significant. Preliminary results also indicated higher soil respiration rates in SW-WW rotation throughout the fall.

Effects of Geology and Soil Depth on Overwinter Nitrogen Mineralization from Cereal Crop Residues

Simon Fordyce, Sally Dahlhausen, Jed Eberly, Patrick Carr (CARC)
Clain Jones, Adam Sigler, Stephanie Ewing (Dep. Land Res. & Env. Sci)

Problem

Nitrogen (N) is liberated from crop residues during decomposition, making it available for uptake by next year's crop. This process, known as N mineralization, is a function of soil moisture, temperature, and the chemical makeup of the residues themselves. Soil depth and geology may interact to affect rates of N mineralization within and across agricultural fields, rendering these fields and areas within them more or less responsive to N fertilizer.

Study Description

Soil respiration, plant-available soil N, and N mineralization will be monitored at six commercial farms in Judith Basin County from fall 2019 to spring 2020. Sampling will occur following cereal crops (winter wheat and spring wheat) in deep (>1 ft) and shallow (<1 ft) soils located along a spatial gradient from loess-derived (i.e., wind-blown silt) to shale-derived soils in order to determine whether soil depth and parent material interact to affect soil N dynamics. The discovery of such an interaction would facilitate the development of a geospatial model for predicting springtime plant-available N at high spatial resolutions to guide or replace soil test-based N management practices.

Applied Questions

How much does soil N change from fall to spring?

Results from this study will not be available until spring 2020. However, a three-year study at the CARC found that the change in soil nitrate from September to April can be highly positive or negative, ranging from -13 lb/acre to +54 lb/acre following small grains.

Why not just soil sample in spring to determine plant-available soil N?

Springtime soil sampling is often impractical due to field inaccessibility. Also, heavy springtime workloads for farmers and crop advisors often prohibit soil sampling efforts during this time. Results from a 2019 survey suggest that <20% farmers in Judith Basin and Fergus counties soil sample in spring each year. Even if spring soil sampling is successful, test results can lead to added stress, as fertilizer may not be available or a farmer may feel pressured into making a quick financial decision (namely, a large fertilizer purchase) for which he or she may not have appropriately budgeted.

Acknowledgements

We are grateful to the Western Sustainable Agriculture Research and Education Program for funding this research and the Montana Agricultural Experiment Station for funding this research.

Canola Matrix Trial

Patrick Carr, Sherry Bishop, and Heather Fryer (CARC)
John Miller (WTARC)

Problem

Canola was grown on roughly 112,000 acres in Montana 2018, down from the previous year. Still, it remains the most widely grown dryland oilseed crop in the state. There continue to be questions about where canola fits in wheat-based cropping systems and the impacts it has on wheat and other crops which follow it in a rotation. Our objectives are to determine how canola performance is affected by the crop(s) coming before it in a sequence or rotation, and how it affects the crop which follows.

Study Description

Canola along with barley, lentil, spring pea, and wheat were planted following chem-fallow into a no-till seedbed in 75-ft plots on 25 April, 2019, at a 1-in depth at the research center. These same crops were planted at the MSU Western Triangle Ag. Res. Ctr. around the same time. Each of those crops was planted in 2018 in a direction (east-west) perpendicular to the planting direction in 2019 (north-south), so that a crop matrix occurs where all possible 2-yr crop sequences exist (e.g, canola [yr 1] – barley [yr 2], canola-lentil, canola-pea, canola-wheat, canola-canola, barley-lentil, barley-pea, etc.). Grain/seed yield and additional data (e.g., date of heading or first flower) are being collected. Disease and soil fertility data may be collected in the future, depending on funding.

Applied Questions

Which crop is best for canola to follow in a rotation?

We will have our first preliminary set of data to begin formulating an answer to that question in fall, 2019, after grain/seed is harvested and processed. Our hypothesis is that canola will perform best following lentil and pea initially because of biological N-fixing benefits, but soon thereafter will perform better following grass (i.e., barley and wheat) rather than broadleaf (e.g., lentil and pea) crops because of less disease and weed pressure following the grass crops.

How will wheat do following canola compared with other crops?

We anticipate that wheat performance will be as follows (best to worst): pea > lentil > canola > barley ~ wheat. This ranking is based primarily on the N-fixing associated with pea and lentil. If biological N-fixation is negated by N-fertilizer applications or is compromised in some other way, then wheat could do as well or better following canola than other crops. We won't know until we begin to collect data in 2019 in this multi-year study.

Acknowledgments

We are grateful to Cargill Inc. for providing funding for this study, as well as the Montana Agricultural Experiment Station.

Rotation and Tillage Systems Study (RATS)

Patrick Carr, Darryl Grove, Tim Bishop, Heather Fryer, Sherry Bishop
Simon Fordyce, Sally Dahlhausen, CARC (Co-PIs)

Problem

Wheat dominates grain farming in central Montana. The profit margins for winter wheat have shrunk considerably in the past few years. Lentil and other grain and seed crops are being evaluated for their potential to improve dryland cropping profitability, as are diverse rotations. The goal of this long-term trial is to identify crops that improve the economics when incorporated into rotations with wheat in central Montana.

Study Description

No-till and conventional-till strips were established in two fields at the research center in 1996. The RATS study was established in these strips in 2017. Five different cropping systems are being compared: (1) winter wheat (WW)-fallow; (2) WW-barley-lentil; (3) WW-barley-pea (4); WW-SW; and spring wheat (SW)-spring pea-proso millet-safflower. All crop phases occur each year. Individual plots dimensions are 7.3 by 24.4 m (24 by 80 ft.).

Applied Questions

How do winter wheat yields compare across cropping systems?

It was only the second year of the long-term study in 2018, so the data should be considered strictly preliminary. There was a non-significant trend for grain yield to be higher following lentil (32 bu/ac) and fallow (31 bu/ac) than following pea

(21 bu/ac) in tilled plots (P= 0.05). Winter wheat yield following spring wheat averaged 28 bu/ac. A similar trend occurred under no-till: winter wheat grain yield following lentil was 27 bu/ac, 25 bu/ac following fallow, 23 bu/ac following spring wheat, but 16 bu/ac following pea (P = 0.06). The relative rank of yields following lentil ~ fallow > spring wheat were anticipated; the relatively low yields following pea were not. Imazomox (Raptor) was applied to pea in spring, 2018, and it is possible that there was carryover herbicide damage even though we were past the 3-mo plant back window within which injury would be expected. There also were no obvious herbicide injury symptoms exhibited by pea plants.

How did spring wheat yields compare in the winter wheat-spring wheat system versus the diverse, 4-year spring wheat-millet-safflower system?

It won't be until 2020 that the 4-year diverse rotation has cycled through all four crops for the first time. It is premature to say much about how crop diversity impacts spring wheat yields until then.

Acknowledgments We are grateful to the Montana Agricultural Experiment Station for providing funding for this research through the USDA-NIFA Hatch project 1012796.

Warm-Season Crop Sequence Study

Patrick Carr, Simon Fordyce, Sally Dahlhausen, Sherry Bishop and Heather Fryer (CARC)

Problem

Many Montana farmers are looking to diversify their cropping system portfolio to improve the economics of dryland cropping management. Cool- and full-season pulses (Chickpea, lentil and pea) and cool-season oilseeds (e.g., canola) are grown in central Montana. Conversely, warm-season crops like corn and sunflower are grown only on limited acreage, even though incorporating warm-season crops into wheat-based cropping systems offers considerable pest management benefits. Our objective is to determine if: (1) warm-season crops can be grown successfully for cover, forage, and grain/seed under dryland management in central Montana, and (2) to determine the impact of warm-season crops on a subsequent wheat crop.

Study Description

Eighteen different warm-season crops were planted at the CARC along with two, 2-crop combinations and two, 4-crop combinations in 2016, 2017, and 2018. Two cool-season crops (spring wheat and field pea) and a fallow treatment were included as checks. Winter wheat was planted following harvest of the warm-season crops in 2016. Spring wheat was planted in 2018 following the harvest of warm-season crops the previous summer/fall (2017). Spring wheat was again planted in 2019 following the harvest of warm-season crops the previous summer/fallow (2018).

Applied Questions

Which warm-season crops performed best when grown for cover, forage, and grain/seed?

Results in 2016, 2017, and 2018 indicated that corn and sunflower produced equal or greater amounts of dry matter when grown for cover or forage than other warm-season crops. There were several warm-season crops tested (e.g., cowpea) that showed little potential as either cover or forage crops in central Montana. None of the warm-season species performed particularly well when grown for grain or seed, but neither did the pea or wheat in this study.

How was grain yield affected if wheat was preceded by a warm-season crop?

There was little impact of warm-season crops on grain yield of a subsequent wheat crop during both 2017 and 2018. Wheat yield data are being collected in 2019 to determine if this failure to impact grain yield of a subsequent wheat crop will continue.

Acknowledgments

We are very grateful to the Montana Wheat and Barley Committee for providing funding during the first 3- of this 4-yr study, as well as the Montana Agricultural Experiment Station through the USDA-NIFA Hatch project 1012796. .

Intra-State Winter Cereal Forage Trial

Patrick Carr, Simon Fordyce, Sally Dahlhausen,
Sherry Bishop, Heather Fryer (CARC)
Phil Bruckner (Dep Plant Sci. & Plant Pathology)
Peggy Lamb (NARC)
Emily Meccage (Dep. Animal & Range Sci.)
John Miller (WTARC)
Zach Miller (WARC)
Jessica Torrion (NWARC)

Problem

Annual crops can be grown for high-quality forage if managed properly. The MSU winter wheat breeding program is dedicated to developing winter wheat cultivars which produce large amounts of high-quality forage in central Montana and throughout the state. Dave Wichman, former agronomist and superintendent at the research center, has continued to select for winter triticale lines that could be grown for forage. We are comparing winter triticale and wheat lines/varieties at six locations in the state to identify those most capable of producing large amounts of high-quality forage under dryland conditions.

Study Description

Thirteen winter wheat and winter triticale entries, including the newly released winter-wheat variety Ray, were planted following a pea-lentil cover crop at the MSU Central Ag. Res. Ctr. on 18 September, 2018. A slightly smaller version of the trial was planted in Bozeman, and at MSU researcher centers at or near Conrad, Corvallis,

Havre, and Kalispell. Results will be available in the fall.

Applied Questions

How did Ray compare to Willow Creek winter wheat in 2018?

We were unable to detect a significant difference in the forage dry matter yield of Ray (3.2 tons/ac) compared to Willow Creek (2.5 tons/ac) statistically at the CARC in 2018; a significant advantage did occur for Ray (3.5 tons/ac) compared to Willow Creek (2.8 tons/ac) in 2017. Ray seed yield was consistently higher than that of Willow Creek in both 2018 (57 vs. 33 bu/ac) and 2017 (45 vs. 28 bu/ac). Ray is shorter than Willow Creek (37 vs. 41 inches in 2018) but has equaled or outperformed Willow Creek at the CARC in side-by-side comparisons.

How do winter triticale varieties/lines compare to their winter wheat counterparts?

Winter triticale entries have tended to out yield their winter wheat counterparts in dry matter, though there have been exceptions. However, winter wheat tends to have higher forage quality. There is a trade-off.

Acknowledgments

We are grateful to the Montana Agricultural Experiment Station for providing funding for this research study.

Intra-State Spring Cereal Forage Trial

Patrick Carr, Simon Fordyce, Sally Dahlhausen,
Sherry Bishop, Heather Fryer (CARC)
Jamie Sherman (Dep Plant Sci. & Plant Pathology)
Peggy Lamb (NARC)
John Miller (WTARC)
Jessica Torrion (NWARC)
Chengci Chen (EARC)

Problem

Barley is the most popular spring-seeded annual cereal forage in Montana. 'Lavina' is one of several awnless barley varieties that are grown for forage. Oat, spring triticale, and other small-grain crops are grown by Montana farmers and ranchers. The MSU Ag. Experiment Station compares spring-seeded barley, oat, triticale, and other annual crops for their forage potential each year so informed decisions can be made about which spring-seeded crop to grow for optimum forage production.

Study Description

Seventeen entries (9 barley, 3 spring triticale, 4 oat, and 1 emmer variety) were seeded on 25 April, 2019, at the MSU Central Ag. Res. Ctr. A smaller version of the trial is located at MSU research facilities at or near Bozeman, Conrad, Havre, Kalispell, and Sydney.

Applied Questions

What were the highest yielding spring-seeded cereal species for forage in 2018?

Otana oat, a 1977 release, produced equal or greater amounts of forage (3 tons dry matter

[DM]/ac) than four commercially available barley cultivars included in the trial in 2018 (Haxby, Haybet and Hays each produced 2.9 tons DM/ac while Lavina produced 2.6 tons DM/ac). However, two experimental barley lines equaled Otana in forage DM production (3 tons/ac).

How did forage quality compare among crops and cultivars?

The data still are being generated. We will be looking closely at the nitrate concentration of the forage, since nitrate poisoning is a concern when growing spring-seeded cereals, particularly in the case of oat.

Will the Montana Agricultural Experiment Station be releasing barley forage cultivars in the future?

Yes! Jamie Sherman is actively selecting for barley cultivars suited for forage production, as is Phil Bruckner in winter wheat.

Acknowledgments We are grateful to the Montana Agricultural Experiment Station for providing funding for this research study.

Intra-state Barley Forage Nursery

Patrick Carr, Simon Fordyce, Sally Dahlhausen,
Sherry Bishop, Heather Fryer (CARC)
Jamie Sherman (Dep Plant Sci. & Plant Pathology)

Problem

Barley dominates spring-seeded annual forage production in Montana. Jamie Sherman has established an active program for developing superior performing barley cultivars when grown for forage in the state. The CARC serves as an important location where promising experimental lines are evaluated for their forage and grain production potential.

Study Description

Fourteen barley experimental lines along with Lavina and Hays barley were seeded on 25 April, 2019, at the MSU Central Ag. Res. Ctr. The entries are being compared for forage dry matter (DM) yield as well as grain yield. A host of other agronomic traits (e.g., plant height) are also being determined and compared.

Applied Questions

How will the experimental lines compare to Lavina and Hays for forage yield?

We anticipate that some experimental lines will be lower yielding in both forage and grain yield than both Lavina and Hays. However, we also anticipate at least a few of the experimental lines will produce equal or greater amounts of forage, and perhaps grain, than either Lavina or Hays.

What will be done with the experimental lines that are top performers for forage yield?

They will continue to be tested and may be entered in the state-wide Spring Cereal Forage Trial in 2020 so that data from locations across the state can be collected. Eventually, they could be released for commercial production if they continue to perform well.

Acknowledgments We are grateful to the Montana Agricultural Experiment Station for providing funding for this research study.

Sainfoin Variety and Harvest Date Trial

Patrick Carr, Sherry Bishop, Heather Fryer (CARC)
Kylie Gardhouse (Graduate Student, Dep. Animal & Range Sci.)
Megan Van Emon (Dep. Animal & Range Sci.)
Emily Meccage (formerly Dep. Animal & Range Sci.)

Problem

Sainfoin is a non-bloating, perennial forage alternative to alfalfa. Previous research demonstrated that sainfoin is adapted to dryland growing conditions in Montana. A sainfoin variety testing effort was conducted for several years but discontinued following Dr. Cash's retirement in 2011. A recent revival in interest has led to renewed research on sainfoin. The objective of this study is to determine the best growth stage to optimize forage dry matter yield and quality when growing sainfoin for hay.

Study Description

Four sainfoin (AAC Mountainview, Delaney, Eski, and Shoshone) along with Shaw alfalfa was established in plots at the CARC and in Bozeman in Spring, 2018. The plots were not harvested at the CARC that year. In 2019, subplots of each cultivar are being harvested at 10%, 50%, and 100% bloom. Forage yield and quality are being determined but results are not yet available.

Applied Questions

How will cultivar choice and harvest date affect forage yield and quality?

We are excited to test Mountainview at the CARC, a newer release (2014) out of Canada. We expect Mountainview to perform at least as well as

Delaney (released in 2007) and Shoshone (released in 2005), and considerably better than Eski (released in 1964).

How long will sainfoin stands persist?

Older sainfoin varieties are susceptible to various root and crown rots. We are curious to learn how long plots of newer cultivars will persist at the CARC.

Acknowledgments We are grateful to the Montana Agricultural Experiment Station for providing funding for this research study.