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MONTANA AGRICULTURAL
EXPERIMENT STATION

2018 ANNUAL REPORT

Central Agricultural Research Center

ACKNOWLEDGEMENTS

Research at the MSU Central Agricultural Research Center (CARC) is only possible through the hard work of a dedicated staff at the center, and through the generosity and support of the farmers and ranchers throughout central Montana and the citizenry of the state, among others. We receive grant funding support from a growing number of public and private entities, as well as individuals, to supplement the state and federal funds which enable us to conduct research at the CARC. Much of this support is acknowledged in the summaries of research at CARC throughout this report. Those providing funding support that is not tied to a specific research project or study are listed below, but we extend a sincere thanks to all those providing funding support, whether it is project-directed or given for more general use in support of the research program at the CARC. We also are grateful for the interaction we have, and suggestions we receive, from CARC advisory board members, and from others who provide comments to us on the research that we are conducting. We welcome suggestions from others at any time.

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INTRODUCTION

The 2018 MSU Central Agricultural Research Center (CARC) summarizes much of the research that was completely recently or is ongoing at the CARC over the past 12-month period. Our goal is to provide those results in an easy-to-understand format that is readily accessible by farmers and anyone interested in the research conducted at the CARC. A limited number of copies of the report are printed each year; however, it can be accessed on the web at http://agresearch.montana.edu/carc/reports-pdf/2018%20Annual%20Report.pdf.

There are several people who deserve credit for this year's annual report. Simon Fordyce, a research associate in the cropping systems program at the CARC, was a major contributor, being the lead author and creator of several sections and tables that are contained within it. He also provided valuable suggestions on formatting and improving overall design, and assisted in proof reading its' content. He was capably assisted by Eva Magnuson, a research associate in the small-grain variety testing and soil microbiology program at the CARC. Dr. Jed Eberly, Assistant Professor of Agronomy and Microbiology at the CARC, provided the sections summarizing results of small-grain crop variety trials at the research center and at associated off-station locations, along with soil microbiology research being conducted. Heather Fryer, a research associate at the CARC, helped organize and compile the report, and once again contributed a section summarizing the use of social media at the CARC. Heather also lined up the printing of this year's report. Lorrie Linhart, administrative assistant III, contributed to sections of the report and took on additional day-to-day office tasks so that others could work on compiling and printing this report.

Others at the CARC who deserve credit for its content include Sally Dahlhausen, research assistant III in the cropping systems program, and Sherry Bishop, research assistant III with responsibilities in grain/seed/ forage processing. Darryl Grove, the CARC farm manager, and Tim Bishop, the CARC farm mechanic, both assisted in the management of field experiments during the 2017-18 growing season, as did Jenni Hammontree. Heidi Harris, a student at Andrews University in Michigan, assisted us as a student intern this summer. Finally, Hayden Hammontree, Alyssa and Zach Thomas, and Jordan Nees, four Hobson high school students (two of whom graduated in 2018), assisted the research group in collecting data and managing field experiments throughout the summer. Andy Burkhart, a graduate student at MSU, assisted in the soil sampling at the CARC as part of his Ph.D. research project.

A special thanks is extended to Drs. Darrin Boss, Head of the Department of Research Centers, and to Charlie Boyer, Dean of the College of Agriculture and Director of MAES, for their capable leadership of MSU-directed research conducted at CARC and across the state.

I hope you find this report useful as a source of information for some of the research conducted at the CARC during the 2017-18 growing season. Feel free to call, send an email, or let me know face-to-face what you think about it. You are always welcome at the MSU Central Agricultural Research Center!

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USEFUL STATISTICAL TERMS AND DEFINITIONS

Simon Fordyce and Patrick Carr

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Observation: The measured value of a particular variable, such as grain yield, test weight, soil nitrate, daily precipitation, etc.

Variable: An attribute describing some entity (person, place, thing, idea) with values that 'vary' from one entity to the next. For instance, if variable *x* represents crops on a farm, then *x* can take on the value 'winter wheat' in one case and 'barley' in another. In experimental design, two major variable types exist: dependent and independent. The independent variable is manipulated to determine its relationship (if any) to the dependent variable.

Factor: An independent variable such as seeding date or crop variety that can be manipulated by the experimenter. Factors always have two or more levels.

Factor Levels: Different values of a factor. For example, if our factor is 'seeding date', one factor level might take on the value September 15th and the other October 1st.

Treatments: Combinations of factor levels. The table below shows factors, factor levels, and treatments for a hypothetical experiment which tests the effects of seeding date and variety on winter wheat performance.

Table 1. Hypothetical experiment testing effects of seeding date and variety on crop performance.

Seeding Date	**Variety**		
	Keldin	Loma	Yellowstone
September 1st	Treatment 1	Treatment 2	Treatment 3
October 1st	Treatment 4	Treatment 5	Treatment 6

In this experiment there are two factors: seeding date and variety. The variety factor has three levels: Keldin, Loma, and Yellowstone. The seeding date factor has two levels: September 1st and October 1st. Thus, the experiment has six total treatments. Treatment 1 is *Keldin seeded on September 1st*, Treatment 2 is *Loma seeded on September 1st*, and so on.

NOTE: If we eliminate the seeding date factor from the above experiment, our treatment number drops from six to three—one treatment for each factor level. Because the experiment now contains a single factor with factor levels represented by individual varieties, we refer to the experiment as a variety trial. Variety trials are a type of single-factor experiment in which treatments are represented by the varieties themselves, i.e., the different levels of the variety factor.

Replicate: Experimental groups to which each treatment is randomly assigned. Experiments led by the Central Ag Research Center typically include three or four replicates. Replication is necessary to account for variation among treatments.

Treatment Mean: Treatment observations averaged across replicates. Cell values of summary tables in this report often represent treatment means. For example, Table 15 (Pg. 35) reports grain yield treatment means for several spring lentil varieties. The reported yield of the CDC Richlea variety, for instance, is an average of yields from three different plots seeded to CDC Richlea in three separate treatment groups or replicates.

Grand Mean, Mean, or Average: An average of treatment means. By definition, 50% of treatment means are greater than the overall mean, and vice versa. In Table 15 (Pg. 35), a summary of spring lentil variety trial results shows that average grain yield of the CDC Richlea variety is much greater than the overall mean, (reported as 'Mean' in the lowermost section), while test weight for the same variety is much less than the (test weight) overall mean.

***P*-Value**: A measure of statistical significance. A *P*-Value of 0.05 indicates that 19 times out of 20, a difference would be detected among treatment means if the study was repeated. A *P*-Value of 0.001 probability indicates that 999 times out of 1000, a difference would be detected among treatment means if the study was repeated.

Coefficient of Variation (CV): A statistic used as an indicator of variation of large and small treatment observations among replicates. Larger CVs indicate more variation and vice versa. At the Central Ag Research Center, grain yield CVs of 15% and greater are considered to be problematic. In most cases, the grain yield LSD value will be replaced by 'NS' for 'non-significant', meaning grain yield treatment differences are not likely to be real.

Least Significant Difference (LSD): A statistic used to determine whether treatment means are significantly different from one another. In Table 15 (Pg. 35), note the LSD value for test weights. Since the test weight of the CDC Impala CL variety, for instance, exceeds that of the CDC Maxim CL variety by an amount *greater* than the LSD value, we may conclude that—all else constant—CDC Impala CL is expected to outperform CDC Maxim CL with regard to test weight under conditions similar to those that occurred during the trial in 2017. Conversely, the test weight of the CDC Impala CL variety exceeds that of the CDC Imvincible CL variety by an amount *smaller* than the LSD value, so we can have little confidence that CDC Impala CL will outperform CDC Imvincible CL under similar environmental conditions.

WEATHER SUMMARY

Simon Fordyce

Montana State University, Dep. Research Centers, Central Agricultural Research Center, Moccasin, MT

Above-average precipitation (132% of 109-yr average) and cooler-than-average temperatures (0.7°F below 107-yr average) characterized the 2018 crop year at the Central Ag Research Center (CARC), leading to strong yields for both winter and spring crops. Winter crops took advantage of above-average precipitation from October through March (167%), while both winter and spring crops benefited from higher-than-average growing degree days (124%) and precipitation (146%) in the month of May. Precipitation in June also surpassed the long-term average (144%), which likely buffered any negative impacts of suppressed rainfall in the months of July (68%) and August (50%).

The last recorded temperature below 32°F was observed on 2 May (25 days earlier than the long-term average) while the first recorded temperature below 32°F in fall was observed 28 August (10 days earlier than the long-term average), equating to a frost free period of 118 days, or 105% of the 107-yr average. A light frost (35°F) was observed on 11 June, 2018, exactly one year after a similar frost event damaged warm-season crops and late-flowering canola varieties at the CARC. While some late flowering lentil varieties exhibited tissue damage from the 2018 event, yields were likely unaffected. The minimum winter temperature was observed on 22 February (-22°F), while the maximum summer temperature was observed on 12 August (103°F). Annual minimum and maximum temperatures were respectively 3°F and 6°F higher than those observed last year. However, this year's annual average temperature was a full 2.4°F below that of 2017.

Table 2. Observed air temperature, growing degree days, and precipitation summarized by month with long-term averages and anomalies (Δ), 2018 crop year.

MONTH	- - AIR TEMPERATURE - -			- -GROWING DEGREE DAYS- -			- - PRECIPITATION - -		
	1912-2018	2018	Δ	1912-2018	2018	Δ	1910-2018	2018	Δ
	----------------(°F)---------------			----------------(GDD$_{32}$)-------------			-------------(in)-------------		
September	54.9	55.9	1	694.9	719	24.1	1.4	2.6	1.2
October	44.9	43.1	-1.8	458.8	414.5	-44.3	0.9	0.6	-0.3
November	32.9	32.5	-0.4	227	214.5	-12.5	0.6	1.2	0.6
December	24.9	23.1	-1.8	136.3	137.5	1.2	0.5	0.9	0.4
January	21.8	25.2	3.4	119	127.8	8.8	0.5	0.3	-0.3
February	24.7	13	-11.7	123.6	23	-100.6	0.5	1.8	1.4
March	30.6	31.8	1.2	195.5	151	-44.5	0.7	1.5	0.8
April	40.8	37.2	-3.6	343.7	285.5	-58.2	1.2	1.2	0
May	50.2	55	4.8	575.7	715	139.3	2.6	3.8	1.2
June	57.9	58.5	0.6	776.7	796	19.3	3.1	4.5	1.4
July	66	65.5	-0.5	1050.4	1039.5	-10.9	1.6	1.1	-0.5
August	65	65.6	0.6	1019	1034.5	15.5	1.6	0.8	-0.8
Avg/Tot	42.90	42.20	-0.7	5720.60	5657.80	-62.80	15.30	20.30	5.00

SMALL GRAIN VARIETY TRIALS

WINTER WHEAT VARIETY TRIAL

Jed Eberly[1,2], Eva Magnuson[1,2], and Jenni Hammontree[1,2] (CARC Project Personnel)
Phil Bruckner[1,3], and Jim Berg[1,3] (MSU Winter Wheat Breeding Program)

Montana State University[1]; Dep. Research Centers, Central Agricultural Research Center, Moccasin, MT[2]; Dep. Plant Sciences and Plant Pathology[3]

Summary

Agronomic performance was evaluated for 49 winter wheat varieties and experimental lines. Average yield for the winter wheat trial at Moccasin in 2018 was 65.5 bu/ac and average protein was 12.2%. Top yielding varieties at Moccasin included two new MSU releases; Ray (78.9 bu/ac) and four0six (70.0 bu/ac). The top varieties for protein were Brawl CLP (13.6), Decade (13.0%), Judee (12.7%), and SY Wolf (12.7%).

Introduction

Montana is one of the leading producers of winter wheat and the development of new and improved varieties is important for enhancing the economics of wheat production in the state. The objective of this study was to identify new varieties with enhanced yield, quality, and resistance to disease and pests compared to the most commonly grown varieties in central Montana.

Methods

On-farm winter wheat performance trials were established at Moccasin, Denton, Belt, Highwood, and Geraldine. Varieties were compared for height, propensity to lodge, heading date, yield, test weight, and protein. Each variety was planted in three 5 x 15 ft plots in a randomized experimental design to determine differences between varieties. Seeding dates were 12 October 2017 at Denton, 10 October at Highwood and Belt, 9 October at Moccasin, and 16 October at Geraldine. Planting depth was 1 inch at a rate of 20 seeds/ft^2. Starter fertilizer, 20-30-20-10 NPKS, was applied at seeding at a rate of 50 lb/ac. An additional 180 lb/ac of urea was broadcast applied at the CARC location on 16 May. Broadleaf and grass weeds were controlled with a burndown of glyphosate at 1.25 pt/ac prior to planting. Trials were also sprayed 15 May with Curtail M at 28 oz/ac for Canada thistle and broadleaf control. Plots were harvested with a small-plot harvester on 8 August at Moccasin, 23 August at Denton, 16 August at Geraldine, and 7 August at Belt and Highwood.

Results and Discussion

Table 3 shows average heading date, yield, test weight, and protein for all named varieties tested. Winter wheat yields are reported at a moisture content of 13.5%. Average yield for all winter wheat trials (including experimental lines) at Moccasin in 2018 was 65.5 bu/ac. Top yielding varieties at Moccasin included two new MSU releases; Ray (78.9 bu/ac) and four0six (70.0 bu/ac). Differences in yield were not significant among the top 7 varieties (Table 3). Average protein was 12.2%. The top varieties for protein were Brawl CLP (13.6%), Decade (13.0%), Judee (12.7%), SY Wolf (12.7%). Average test weight was 62.8 lb/bu. Average heading date was 14 June and Brawl had the earliest heading date on 9 June. No lodging was observed with any of the varieties.

Gross returns per acre were also calculated for each variety and location based on prices and protein premiums and discounts obtained from United Grain Corporation on 6 September, 2018. Average gross return at Moccasin was $292.00 per acre. Differences in gross return were not significant between the top 11 varieties. Note that this calculated return does not account for any expenses but does account for dockage and premiums associated with the test weight and protein.

Average yield at the Belt, MT location was 70.9 bu/ac and varietal differences in yield were not significant among the top 7 varieties (Table 4). Average protein was 12.2%, and the varieties with the highest protein were Brawl CLP (13.6%) and Keldin (13.3%). Average test weight was 61.2 lb/bu. Gross return averaged $333.27 and differences in gross return were not significant between varieties.

Average yield at Denton, MT was 53.7 bu/ac and differences in yield were not significant among any of the varieties (Table 5). The highest test weight was FourOsix (62.0 lb/bu), a new MSU release. The top variety for protein was Yellowstone (11.6%), variations in protein were not statistically significant between named varieties. Gross return averaged $230.00/ac but violated statistical assumptions so an LSD could not be computed.

At Geraldine, average yield was 71.2 bu/ac. Top performers for yield included 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) (Table 6). Average protein was 12.1% and the top performer for protein was Brawl CLP (13.5%). Average test weight at Geraldine 63.3 bu/ac. Average gross returns were $369.50/ac for all varieties at Geraldine.

Average yield at Highwood was 36.4 bu/ac (Table 7). Top performing varieties were Judee (50.8 bu/ac), SY Monument (46.4 bu/ac), SY Clearstone 2CL (45.9 bu/ac), Decade (45.2 bu/ac), Warhorse (43.3 bu/ac). Top varieties for protein were Brawl CLP (15.4%), Keldin (14.9%), Northern (14.8%), and Loma (14.6%). Average test weight was 63.2 lb/bu and the variety with the highest test weight was Judee (64.4 lb/bu). Average gross returns were $174.20/ac, but violated statistical assumptions so an LSD could not be computed.

Acknowledgements

MSU winter wheat breeder Phil Bruckner and associate breeder Jim Berg coordinated the selection of entries and the preparation of seed for the on-farm variety trials. This work was supported by the Montana Wheat & Barley Committee and the Montana Agricultural Experiment Station for providing funding for this research through the USDA National Institute of Food and Agriculture, Hatch project 1015780. Additional information on variety trials can be found at http://agresearch.montana.edu/carc/.

Table 3. 2018 winter wheat variety trial, Moccasin, MT.

CULTIVAR	YEAR OF RELEASE	SOURCE	HEADING DATE	HEIGHT	TEST WT	PROTEIN	GROSS RETURN	- - - - - GRAIN YIELD - - - - -			
								2016	2017	2018	AVG
			(julian)	(in)	(lb/bu)	(%)	($/ac)	--------------- (bu/ac) ------------			
Brawl CLP	2017	CO Research	**160.7**	26.0	**64.2**	**13.6**	268.72		61.4	59.1	40.2
Decade	2010	MAES/NDSU	165.0	31.0	62.5	**13.0**	268.78	38.2	58.2	59.3	38.9
FourOsix	2018	MAES	165.0	29.0	**63.7**	12.6	**317.27**			70.0	35.0
Judee	2011	MAES	166.0	29.7	**63.9**	**12.7**	262.11	32.6	59.7	57.9	37.5
Keldin	2011	Seed Linc./Westbred	167.0	28.7	63.2	12.1	**298.95**	47.4	71.5	66.3	46.3
LCS Jet	2015	Limagrain Cereal	171.0	26.0	59.5	11.2	**307.00**			**70.7**	35.4
Loma	2016	MAES	171.0	27.7	62.4	11.8	**300.74**	41.5	55.7	68.0	41.3
Northern	2018	MAES	171.0	29.7	62.8	12.2	**297.85**	39.3		66.5	39.4
Ray	2015	MAES	172.0	**37.3**	59.7	11.6	**299.92**		60.5	**78.9**	42.3
SY Clearstone	2012	Syngenta	171.0	32.0	62.0	11.6	**299.52**	44.4	68.5	**67.8**	45.2
SY Monument	2017	Syngenta, 2015	**164.0**	28.3	63.0	11.7	**315.82**		61.6	**71.5**	44.4
SY Wolf	2010	AgriPro/Syngenta	**162.0**	26.3	**64.0**	**12.7**	**279.66**	40.6	63.3	61.7	41.4
Warhorse	2013	MAES	167.7	28.3	62.5	12.6	**274.57**	39.3	57.8	60.6	39.4
Yellowstone	2005	MAES	169.0	31.7	62.3	11.7	**303.44**	42.0	63.1	**68.7**	43.4
Mean			165.9	29.3	62.8	12.2	292.00	40.5	60.3	65.5	
CV%			1.3	4.6	0.8	4.6	10.1	10.8	10.0	10.4	
LSD			3.5	2.2	0.8	0.9	47.8	8.1	NA	11.1	
P-Value			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		0.1119	0.0006	

Bold = top performer(s)

Bold = statistically equivalent to top performer(s)

Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

Table 4. 2018 winter wheat variety trial, Belt, MT.

CULTIVAR	YEAR OF RELEASE	SOURCE	HEIGHT	TEST WT	PROTEIN	GROSS RETURN	- - - - - - GRAIN YIELD - - -		
							2017	2018	AVG
			(in)	(lb/bu)	(%)	($/ac)	------------(bu/ac) ------------		
Brawl CLP	2017	Colorado Research	28.3	**62.1**	**13.6**	285.7	60.0	57.4	58.7
Decade	2010	MAES/NDSU	**32.7**	**61.9**	12.5	342.3	49.5	73.5	61.5
FourOsix	2018	MAES	30.6	**61.7**	12.0	303.9		71.4	71.4
Judee	2011	MAES	**32.6**	**62.2**	12.7	322.4	47.0	70.2	58.6
Keldin	2011	Seed Linc./Westbred	30.4	60.8	**13.3**	352.2	50.6	72.7	61.7
LCS Jet	2015	Limagrain Cereal Seeds	27.7	58.2	11.8	330.6		69.6	69.6
Loma	2016	MAES	29.9	**61.6**	11.8	363	45.4	80.3	62.8
Northern	2018	MAES	31.9	61.1	12.8	337.8	51.6	70.3	60.9
Ray	2015	MAES	**35.3**	59.5	11.8	324.1		65.6	65.6
SY Clearstone	2012	Syngenta	**34.9**	60.8	11.5	342.1	56.4	73.5	65.0
SY Monument	2017	Syngenta, 2015	29.8	60.5	11.8	380.9	50.5	79.1	64.8
SY Wolf	2010	AgriPro/Syngenta	27.1	**62.0**	12.8	323.1	52.7	68.4	60.6
Warhorse	2013	MAES	**32.8**	61.4	12.8	357.7	45.0	73.7	59.3
Yellowstone	2005	MAES	**32.5**	60.9	11.7	304.6	53.7	68.7	61.2
Mean			31.7	61.2	12.2	333.30	51.1	73.9	
CV%			6.2	1.0	4.0	50.91	55	11.3	
LSD			3.2	1.0	0.8	N.S.	N.S.	N.S.	
P-Value			<.0001	<.0001	<.0001	0.4	0.084	0.1	

Bold = top performer(s)

Bold = statistically equivalent to top performer(s)

Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

Table 5. 2018 winter wheat variety trial, Denton, MT.

CULTIVAR	YEAR OF RELEASE	SOURCE	HEIGHT	TEST WT	PROTEIN	GROSS RETURN	- - - - - GRAIN YIELD - - - - -		
							2017	2018	AVG
			(in)	(lb/bu)	(%)	($/ac)	--------------(bu/ac)--------------		
Brawl CLP	2017	Colorado Research Foundation, 2011	31.0	61.1	11.1	237.9	49.0	54.7	51.9
Decade	2010	MAES/NDSU	28.7	61.7	11.1	253.2	41.9	58.2	50.0
FourOsix	2018	MAES	28.3	62.0	11.2	220.1		50.6	50.6
Judee	2011	MAES	30.0	60.8	11.0	224.5	37.3	51.6	44.5
Keldin	2011	Seed Linc./Westbred LLC	31.3	40.7	7.5	136.5	46.0	30.4	38.2
LCS Jet	2015	Limagrain Cereal Seeds	28.3	61.1	11.1	256.2		58.9	58.9
Loma	2016	MAES	30.7	61.9	11.1	244.5	22.1	56.2	39.1
Northern	2018	MAES	29.3	61.4	11.1	230.6	37.3	53.0	45.1
Ray	2015	MAES	29.3	61.7	10.9	208.0		48.6	48.6
SY Clearstone 2CL	2012	Syngenta	30.3	61.3	10.8	261.9	40.3	61.2	50.8
SY Monument	2017	Syngenta, 2015	30.3	61.6	11.4	231.9	36.1	53.3	44.7
SY Wolf	2010	AgriPro/Syngenta	32.3	61.6	11.2	220.1	50.5	50.6	50.5
Warhorse	2013	MAES	28.0	61.5	11.2	238.4	34.3	54.8	44.5
Yellowstone	2005	MAES	29.0	61.7	11.6	229	40.3	51.8	46.0
Mean			30.2	60.6	10.9	230.00	39.2	53.7	
CV%			11.2	11.6	14.1	100.80	12.8	22.5	
LSD			N.S.	N.S.	N.S.	N.S.	8.2	N.S.	
P-Value			0.932	0.4	0.8	2.12	<0.0001	0.5	

Bold = top performer(s)

Bold = statistically equivalent to top performer(s)

Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

Table 6. 2018 winter wheat variety trial, Geraldine, MT.

CULTIVAR	YEAR OF RELEASE	SOURCE	HEIGHT	TEST WT	PROTEIN	GROSS RETURN	- - - - - - -GRAIN YIELD - - - - - - -			
							2016	2017	2018	AVG
			(in)	(lb/bu)	(%)	($/ac)	---------------(bu/ac) ---------------			
Brawl CLP	2017	Colorado Research	30.3	**65.1**	**13.5**	366.7		83.8	75.5	79.6
Decade	2010	MAES/NDSU	31.7	64.0	12.8	**385.1**	71.8	82.9	**79.7**	78.1
FourOsix	2018	MAES	30.3	63.6	11.9	330.0			70.0	70.0
Judee	2011	MAES	32.3	**64.7**	12.3	379.2	71.6	71.1	78.9	73.9
Keldin	2011	Seed Linc./Westbred LLC	30.0	64.2	12.1	**411.1**	101.1	90.4	**85.7**	92.4
LCS Jet	2015	Limagrain Cereal Seeds	27.3	60.8	12.0	**392.5**			**82.9**	82.9
Loma	2016	MAES	31.0	63.0	11.7	377.2	77.3	75.0	**80.0**	77.4
Northern	2018	MAES	31.7	63.4	12.3	379.3	90.1	84.0	78.7	84.3
Ray	2015	MAES	**37.0**	61.8	12.0	359.4			76.2	76.2
SY Clearstone	2012	Syngenta	**37.0**	62.8	11.8	**390.9**	92.7	82.2	**81.1**	85.3
SY Monument	2017	Syngenta, 2015	29.0	63.2	11.7	370.6		88.1	78.4	83.3
SY Wolf	2010	AgriPro/Syngenta	31.0	64.2	12.3	376.2	94.0	93.6	78.3	88.6
Warhorse	2013	MAES	31.7	63.5	12.8	359.4	80.6	72.0	74.3	75.6
Yellowstone	2005	MAES	33.7	62.8	11.7	350.5	89.8	85.1	74.3	83.1
Mean			31.9	63.3	12.1	369.50	85.4	82.1	76.9	
CV%			5.8	0.4	1.3	23.10	3.8	5.6	5.2	
LSD			3.0	0.5	0.3	31.0	6.0	7.6	6.6	
P-Value			<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<.0001	

Bold = top performer(s)

Bold = statistically equivalent to top performer(s)

Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

Table 7. 2018 winter wheat variety trial, Highwood, MT.

CULTIVAR	YEAR OF RELEASE	SOURCE	HEIGHT	TEST WT	PROTEIN	GROSS RETURN	- - - - - - -GRAIN YIELD- - - - - - -			
							2016	2017	2018	AVG
			(in)	(lb/bu)	(%)	($/ac)	----------------(bu/ac) ----------------			
Brawl CLP	2017	Colorado Research Foundation, 2011	21.1	63.7	15.5	115.8		35.6	25.8	30.7
Decade	2010	MAES/NDSU	**27.1**	63.5	14.5	216.9	55	64.2	48.3	55.8
FourOsix	2018	MAES	24.3	63.5	13.6	179.7			39.5	39.5
Judee	2011	MAES	25.3	64.5	13.5	244.8	66	56.5	53.8	58.8
Keldin	2011	Seed Linc./Westbred LLC	24.5	62.6	15.3	145.0	58.3	55.4	32.3	48.7
LCS Jet	2015	Limagrain Cereal Seeds	22.2	61.1	13.9	185.6			40.8	40.8
Loma	2016	MAES	22.1	63.1	14.2	183.2	55.4	60.9	40.8	52.4
Northern	2018	MAES	22.5	63.7	14.4	166.6	58.5	60.5	37.1	52.0
Ray	2015	MAES	**28.8**	62.6	13.6	150.6			33.1	33.1
SY Clearstone 2CL	2012	Syngenta	**27.2**	63.1	13.0	219.2	68.5	67.6	48.4	61.5
SY Monument	2017	Syngenta, 2015	24.4	63.8	12.4	237.7		65	52.7	58.9
SY Wolf	2010	AgriPro/Syngenta	22.7	63.8	14.7	134.7	43.1	60.4	30.0	44.5
Warhorse	2013	MAES	25.6	63.1	14.2	203.8	68.3	51.2	45.4	55.0
Yellowstone	2005	MAES	24.8	62.9	14.6	159.8	51.2	53.2	35.6	46.7
Mean			24.2	62.4	14.0	174.20	56	57.2	38.8	
CV%			5.2	11.6	8.3	80.20	8.7	8.4	17.9	
LSD			2.2	11.8	1.9	NA	8.7	8.9	11.4	
P-Value			<0.0001	0.3	0.4	<0.0001	<0.0001	<0.0001	<0.0001	

Bold = top performer(s)

Bold = statistically equivalent to top performer(s)

Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

SPRING WHEAT VARIETY TRIAL

Jed Eberly[1,2], Eva Magnuson[1,2], and Jenni Hammontree[1,2] (CARC Project Personnel)
Luther Talbert[1,3] and Hwa Young Heo[1,3] (MSU Spring Wheat Breeding Program)

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Summary

Agronomic performance was evaluated for 24 spring wheat varieties and experimental lines. Average yield for all spring wheat trials at Moccasin in 2018 was 44.5 bu/ac and average protein was 10.1%. Varietal differences in yield were not detected ($P > 0.05$). The top variety for protein were Camaro at 12.6%. Average heading date was 27 June. Average plant height at Moccasin was 27.9 inches and varietal differences in height were not different statistically.

Introduction

Spring wheat is an important crop throughout Montana. Ongoing breeding programs are focused on improving the performance of spring wheat varieties. Performance targets include yield and protein content that are higher than the most commonly grown varieties, as well as increased resistance to pathogens and insects. The higher rainfall received during the 2018 growing season resulted in better overall yields compared to 2017.

Methods

On-farm spring wheat variety trials were established at Moccasin, Denton, Geraldine and Highwood. The Moccasin trials were established at a site that was planted in a pea/lentil cover crop the previous year. Twenty-four varieties were compared for height, propensity to lodge, heading date, yield, test weight, and protein. Each variety was planted in three 5 x 15 ft plots in a randomized experimental design to determine differences between varieties. Seeding dates were 27 April at Moccasin, 7 May at Denton and Geraldine, and 4 May at Highwood. Planting depth was 1 inch at a rate of 20 seeds/ft^2. Starter fertilizer, 20-30-20-10 NPKS, was applied at seeding at a rate of 50 lb/ac. An additional 80 lb/ac of urea was broadcast applied on 21 May. Broadleaf and grass weeds were controlled with a burndown of glyphosate at 1.25 pt/acre prior to planting. Trials were also sprayed 30 May with Curtail M at 28 oz/ac for Canada thistle and broadleaf control. Plots were harvested with a small-plot harvester on 30 August at Moccasin, 23 August at Denton, 16 August at Geraldine and 29 August at Highwood.

Results and Discussion

Table 5 shows the average height, yield, test weight, and protein for all named varieties tested at the Moccasin location. Spring wheat yields are reported on a moisture content of 13.5%. The average yield for the spring wheat trial at Moccasin in 2018 was 44.5 bu/ac (Table 8) and average protein was 10.1%. Differences in grain yield were not significant across the varieties ($P> 0.05$). The top variety for protein was Camaro at 12.6%. The highest test weight was a new variety for 2018, Vitpro at 63.9 lb/bu. The average heading date was 27 June with the earliest varieties heading on 25 June and the average height for all spring wheat varieties at Moccasin was 27.9 inches. Gross returns were calculated based on prices and protein premiums and discounts obtained from United Grain Corporation on 6 September 2018. The Gross return average at

Moccasin was $190.66/ac. Note that this calculated return does not consider any expenses but does account for dockage and premiums associated with the test weight and protein. No lodging was observed with any of the varieties.

Average yield for all varieties at Denton was 29.1 bu/ac (Table 9). No statistically significant difference in yield was observed between the varieties based on the C.V. value. Protein measurements had not been taken when preparing this report and thus protein and gross returns are not reported. Average test weight was 62.3 lb/bu and differences in test weights were not significant among any of the varieties. Average height was 28.9 inches.

Average yield for all varieties at Geraldine was 71.2 bu/ac (Table 10) and differences were not statistically significant among the top eight varieties. Average protein was 10.9% across all varieties. Average test weight was 63.6 lb/bu and the highest test weights were Vitpro 65.6 (lb/bu), Camaro 65.1 (lb/bu), and SY Soren 65.0 (lb/bu). Gross return average for Geraldine was $304.69/ac.

Average yield for all varieties at Highwood was 34.9 bu/ac (Table 11). No statistically significant difference was observed between varieties (C.V > 15%). Proteins had not yet been measured as of the time of this report and thus gross returns could not be calculated. Average test weight was 59.7 lb/bu and differences were not significant among varieties. Table 11 shows the average height, yield, test weight, and protein for all named varieties tested.

Acknowledgements

MSU spring wheat breeder Luther Talbert coordinated the selection of entries and the preparation of seed for the on-farm cultivar trials. This work was supported by the Montana Wheat & Barley Committee and the Montana Agricultural Experiment Station for providing funding for this research through the USDA National Institute of Food and Agriculture, Hatch project 1015780. Additional information on variety trials can be found at http://agresearch.montana.edu/carc/.

Table 8. 2018 spring wheat variety trial, Moccasin, MT.

CULTIVAR	YEAR OF RELEASE	SOURCE	HEADING DATE (jul)	HEIGHT (in)	TEST WT (lb/bu)	PROTEIN (%)	GROSS RETURN ($/ac)	- - - - -GRAIN YIELD - - - - - 2016	2017	2018	AVG
								--------------(bu/ac)-------------			
ALUM	2014	WSU	180	27.0	63.3	9.2	217.05	37.5	29.6	48.3	39.0
Barracuda		Meridian Seeds	**177**	26.0	61.8	10.1	186.97			43.7	
BRENNAN	2009	Syngenta/AgriPro	**178**	25.7	63.2	11.6	173.14	31.1	35.2	39.2	37.2
Camaro		Meridian Seeds	**178**	25.7	62.7	**12.6**	162.12		33.4	35.8	34.6
Cheville		Meridian Seeds	**178**	27.3	62.3	9.5	220.48		33.8	49.1	41.5
CHOTEAU	2003	MAES	**178**	26.3	62.2	10.4	184.33	35.9	28.3	43.1	35.7
CORBIN	2006	Westbred, LLC	**179**	28.0	62.6	10.2	196.85	30.3	31.1	46.0	38.5
DUCLAIR	2011	MAES	**178**	27.7	62.0	9.8	227.91	35.4	32.1	50.8	41.4
EGAN	2013	Westbred, LLC	180	28.7	61.6	11.0	189.39	37.4	32.5	43.5	38.0
FORTUNA	1966	MAES/NDSU	179	**35.3**	61.7	10.0	181.66	35.1	39.5	40.5	40.0
LANNING	2016	MAES	**178**	26.3	62.2	9.4	193.20		33.8	43.0	38.4
LCS Pro	2015	LIMAGR	**178**	29.7	61.8	9.3	191.77		30.1	42.7	36.4
NS PRESSER CLP	2016	MAES	183	28.7	61.0	8.9	227.65		32.1	50.7	41.4
ONEAL	2008	Westbred, LLC	180	27.3	62.7	9.2	187.17	33.1	32.1	41.7	36.9
REEDER	1999	NDSU	180	28.3	62.6	9.8	216.47	36.3	33	48.2	40.6
SY INGMAR	2015	Syngenta/AgriPro	**178**	27.7	63.3	10.4	174.01		33.7	40.7	37.2
SY SOREN	2011	Syngenta/AgriPro	**179**	26.7	63.0	10.6	194.51	32.4	31.2	45.4	38.3
VIDA	2005	MAES	180	28.3	61.9	8.9	224.63	33.5	31.1	50.0	40.6
VITPRO	2017	NDSU	**177**	29.7	**63.9**	10.6	189.83			44.4	
WB GUNNISON	2011	Westbred, LLC	**178**	28.7	62.7	9.8	215.34	33.2	32.7	48.0	40.3
Mean			179	27.9	62.4	10.1	190.66	33.9	32.0	44.5	
CV%			0.7	4.4	0.4	3.1	51.0	14.5	8.4	11.4	
LSD			2	2	0.4	0.5	37.3	8.1	N.S.	N.S.	
P-Value			<0.001	<0.001	<0.001	<0.001	0.26		0.3672	0.057	

Bold = top performer(s)

Bold = statistically equivalent to top performer(s)

Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

Table 9. 2018 spring wheat variety trial, Denton, MT.

CULTIVAR	YEAR OF RELEASE	SOURCE	HEIGHT	TEST WT	- - - - - - GRAIN YIELD - - - - - -		
					2017	2018	AVG
			(in)	(lb/bu)	--------------- (bu/ac) ---------------		
ALUM	2014	WSU	29	63.4	18.2	34.1	26.1
Barracuda		Meridian Seeds	27.3	62.8		29.6	29.6
BRENNAN	2009	Syngenta/AgriPro	27.3	63.6	20.5	26.8	23.6
Camaro		Meridian Seeds	27	63.7	26	26.3	26.1
Cheville		Meridian Seeds	27.7	63	35.8	34.9	35.4
CHOTEAU	2003	MAES	27.7	63.2	20.1	28.3	24.2
CORBIN	2006	Westbred, LLC	28.3	63.1	18.2	29.7	23.9
DUCLAIR	2011	MAES	29	62.7	21.8	29.5	25.6
EGAN	2013	Westbred, LLC	28.7	62.5	18.6	25.4	22
FORTUNA	1966	MAES/NDSU	**34.7**	62	16.9	29.7	23.3
LANNING	2016	MAES	29.3	62.7	21.5	29.6	25.6
LCS Pro	2015	LIMAGR	30.3	62.8	19	30.6	24.8
NS PRESSER CLP	2016	MAES	29	62.3	16.6	29.7	23.1
ONEAL	2008	Westbred, LLC	29.7	63	19.6	31.9	25.8
REEDER	1999	NDSU	28.7	63.4	17.2	27.8	22.5
SY INGMAR	2015	Syngenta/AgriPro	29	42.8	16.1	18.1	17.1
SY SOREN	2011	Syngenta/AgriPro	27.7	63.8	17.5	27.9	22.7
VIDA	2005	MAES	30	63	19.8	31.5	25.6
VITPRO	2017	NDSU	30.3	64.8		27.6	27.6
WB GUNNISON	2011	Westbred, LLC	28.7	63.1	19.3	30.5	24.9
Mean			28.9	62.3	20	29.1	
CV%			3.1	12.3	15.2	14.6	
LSD			1.5	12.6	N.S.	N.S.	
P-Value			<0.0001	N.S.	<0.0001	0.05	

Bold = statistically equivalent to top performer(s).Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

Table 10. 2018 spring wheat variety trial, Geraldine, MT.

CULTIVAR	YEAR OF RELEASE	SOURCE	HEIGHT	TEST WT	PROTEIN	GROSS RETURN	- - - - - - GRAIN YIELD - - - - - -		
							2016	2018	AVG
			(in)	(lb/bu)	(%)	($/ac)	-------------- (bu/ac) --------------		
ALUM	2014	WSU	34.3	64.1	9.4	301.86	42.0	67.2	54.6
Barracuda		Meridian Seeds	32.3	64.4	10.5	299.70		70.0	70.0
BRENNAN	2009	Syngenta/AgriPro	32.0	64.6	**11.9**	296.27	35.6	67.0	51.3
Camaro		Meridian Seeds	33.0	**65.1**	**11.5**	277.51		62.8	62.8
Cheville		Meridian Seeds	34.3	64.5	9.7	**356.91**		**79.5**	79.5
CHOTEAU	2003	MAES	34.0	64.1	**11.2**	**344.08**	39.9	**79.1**	59.5
CORBIN	2006	Westbred, LLC	33.7	63.1	**11.2**	**334.03**	36.9	**76.8**	56.8
DUCLAIR	2011	MAES	35.0	63.7	10.1	302.03	41.2	70.6	55.9
EGAN	2013	Westbred, LLC	36.0	63.1	**12.6**	308.40	40.8	68.1	54.4
FORTUNA	1966	MAES/NDSU	**42.7**	63.9	10.7	253.16	34.4	59.1	46.8
LANNING	2016	MAES	34.0	62.4	10.4	302.05		70.6	70.6
LCS Pro	2015	LIMAGR	36.7	63.6	10.8	**313.25**		**73.2**	73.2
NS PRESSER	2016	MAES	36.0	60.4	10.6	**310.96**		**72.7**	72.7
ONEAL	2008	Westbred, LLC	36.0	61.0	**11.3**	304.57	36.0	70.0	53.0
REEDER	1999	NDSU	37.0	62.9	10.6	304.96	38.6	71.3	54.9
SY INGMAR	2015	Syngenta/AgriPro	32.7	64.6	**12.2**	303.27		67.2	67.2
SY SOREN	2011	Syngenta/AgriPro	31.3	**65.0**	**11.4**	**321.63**	36.0	**73.9**	55.0
VIDA	2005	MAES	36.0	62.4	10.6	**350.76**	37.4	**82.0**	59.7
VITPRO	2017	NDSU	35.7	**65.6**	11.1	264.05		60.7	60.7
WB GUNNISON	2011	Westbred, LLC	32.3	61.8	**11.3**	**311.37**	34.9	**71.6**	53.2
Mean			34.7	63.6	10.9	304.69	35.2	71.2	
CV%			3.4	0.7	7.8	40.4	9.9	9.0	
LSD			1.9	0.7	1.4	47.3	5.7	10.5	
P-Value			<0.001	<0.001	0.004	0.0200		0.005	

Bold = top performer(s)

Bold = statistically equivalent to top performer(s)

Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

Table 11. 2018 spring wheat variety trial, Highwood, MT.

CULTIVAR	YEAR OF RELEASE	SOURCE	HEIGHT	TEST WT	- - - - - - GRAIN YIELD - - - - - -			
					2016	2017	2018	AVG
			(in)	(lb/bu)	-------------- (bu/ac) --------------			
ALUM	2014	WSU	9.0	59.4	**46.4**	**37.7**	39.7	41.3
Barracuda		Meridian Seeds	10.2	60.1		-	35.2	35.2
BRENNAN	2009	Syngenta/AgriPro	12.1	59.7	27.6	27.6	32.9	29.4
Camaro		Meridian Seeds	10.9	59.7		17.1	28.7	22.9
Cheville		Meridian Seeds	9.6	59.4		18.6	35.4	27.0
CHOTEAU	2003	MAES	10.7	60.0	35.1	**37.7**	39.8	37.5
CORBIN	2006	Westbred, LLC	10.9	60.6	35.0	28.6	37.2	33.6
DUCLAIR	2011	MAES	10.8	60.8	37.2	32.0	35.1	34.8
EGAN	2013	Westbred, LLC	10.8	59.2	**42.2**	**37.5**	39.9	39.9
FORTUNA	1966	MAES/NDSU	10.7	60.6	28.7	30.1	35.0	31.3
LANNING	2016	MAES	10.2	61.2		**40.3**	37.0	38.6
LCS Pro	2015	LIMAGR	10.5	60.4		31.2	42.1	36.6
NS PRESSER	2016	MAES	10.8	58.8		**34.7**	40.8	37.7
ONEAL	2008	Westbred, LLC	10.0	58.9	30.4	**38.9**	37.0	35.4
REEDER	1999	NDSU	10.9	59.9	37.8	**37.0**	44.7	39.8
SY INGMAR	2015	Syngenta/AgriPro	10.7	60.3		**37.8**	44.8	41.3
SY SOREN	2011	Syngenta/AgriPro	10.7	56.6	29.3	**34.2**	24.3	29.3
VIDA	2005	MAES	11.0	59.2	33.9	**34.9**	36.7	35.2
VITPRO	2017	NDSU	11.0	59.2		-	23.9	23.9
WB GUNNISON	2011	Westbred, LLC	11.3	60.7	29.5	29.7	25.7	28.3
Mean			10.7	59.7	32.4	32.5	34.9	
CV%			12.7	2.6	9.31	13.1	24.0	
LSD			N.S.	N.S.	4.94	7.0	N.S.	
P-Value			0.979	0.4		<0.0001	0.058	

Bold = top performer(s)

Bold = statistically equivalent to top performer(s)

Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

SPRING BARLEY VARIETY TRIAL

Jed Eberly[1,2], Eva Magnuson[1,2], and Jenni Hammontree[1,2] (CARC Project Personnel)
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Summary

Agronomic performance was evaluated for 49 barley varieties and experimental lines. The average yield for all barley varieties at Moccasin was 52.9 bu/ac and differences in yield was not significant between varieties.

Introduction

Barley is an important agriculture commodity in Montana for feed, food, and malt. The MSU barley breeding program is focused on developing improved varieties of both hulled and hull-less barley varieties for food, malting, and feed.

Methods

The barley variety trial tested the agronomic performance and potential of 49 varieties and experimental lines. Both malt and feed varieties were evaluated. On-farm variety trials were established at Denton, and Geraldine. The Moccasin trials were established at a site that was planted in a pea/lentil cover crop the previous year. Varieties were compared for height, propensity to lodge, heading date, yield, test weight, and protein. Each variety was planted in three 5 x 15 ft plots in a randomized experimental design to determine differences between varieties. Seeding dates were 26 April at Moccasin, 7 May at Geraldine, and 8 May at Denton. Planting depth was 1 inch at a rate of 20 seeds/ft^2. Starter fertilizer, 20-30-20-10 NPKS, was applied at seeding at a rate of 50 lb/ac. Broadleaf and grass weeds were controlled with a burndown of glyphosate at 1.25 pt/acre prior to planting. Trials were also sprayed 30 May with Curtail M at 28 oz/ac for Canada thistle and broadleaf control. Plots were harvested with a small-plot harvester on 15 August at Moccasin, 23 August at Denton, and 16 August at Geraldine.

Results and Discussion

Barley yields are reported on a moisture content of 14.5%. The average yield for all barley varieties at Moccasin was 41.7 bu/ac, and there was no statistically significant difference in yield between varieties (C.V. > 15%) (Table 12). Average test weight was 56.3 lb/bu, and the average heading date was 5 July. Proteins had not yet been measured at the time this report was prepared. No lodging was observed with any of the varieties. Average plump kernel percentage was 86.8%. The varieties with the highest plumps were Genie (92.5%) and Synergy (86.8%).

Average yield for all varieties at Denton was 48.6 bu/ac (Table 13). There was no significant difference in yield among the varieties. Average protein was 8.6%. Average test weight was 55.2 lb/bu. Average plump kernel percentage was 85.1% and difference in plumps was not significant between the top 11 varieties.

At Geraldine the average yield was 93.0 bu/ac (Table 14) with three varieties (Esma, Haxby, and Merit 57) yielding over 100 bu/ac. Average protein was 10.5% and were not significantly different among varieties. Average test weight and plump kernels were 57.0 lb/bu and 82.7%, respectively and was not statistically different among the top performing varieties.

Acknowledgements

MSU barley breeder Jamie Sherman coordinated the selection of entries and the preparation of seed for the on-farm cultivar trials. This work was supported by the Montana Wheat & Barley Committee and the Montana Agricultural Experiment Station for providing funding for this research through the USDA National Institute of Food and Agriculture, Hatch project 1015780. Additional information on variety trials can be found at http://agresearch.montana.edu/carc/.

Table 12. 2018 spring barley variety trial, Moccasin, MT.

CULTIVAR	YEAR OF RELEASE	SOURCE	HEADING DATE (jul)	HEIGHT (in)	TEST WT (lb/bu)	- - - - - - - - - GRAIN YIELD - - - - - - - - - 2016	2017	2018	AVG	Plumps %
						------------------- (bu/ac) -------------------				
AAC Connect	2016	Meridian	186.0	21.3	56.0			47.7		**78.2**
Champion	2007	Wesbread	187.0	21.7	57.0	57.6	38.3	50.5	48.8	70.2
Haxby	2003	-	183.0	21.3	56.6	60.0	34.3	49.9	48.1	56.6
Hockett	2008	MAES	187.0	22.3	56.6	59.3	34.8	**52.6**	48.9	**82.9**
Merit 57	-	-	188.0	21.3	56.2	52.2	28.8	**53.9**	45.0	**75.3**
Metcalfe	-	Canada	184.0	21.7	56.0	48.4	36.9	45.7	43.7	**74.5**
Opera	-	-	187.0	18.7	54.8			**62.3**		61.0
Sienna	-	-	187.0	22.0	55.5			**61.4**		**81.1**
Mean			183.7	22.2	56.2	48.1	34.3	52.5		81.9
CV%			1.9	6.7	1.7	-	15.8	11.5		8.4
LSD			N.S.	2.4	1.5	-	N.S.	9.7		11.1
P-Value			0.0410	<0.0001	<0.0001	-	0.5901	<0.0001		<0.0001

Bold = top performer(s)

Bold = statistically equivalent to top performer(s)

Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

Table 13. 2018 spring barley variety trial, Denton, MT.

CULTIVAR	YEAR OF RELEASE	SOURCE	HEIGHT	TEST WT	PROTEIN	- - - - - - GRAIN YIELD - - - - - -			PLUMPS
						2017	2018	Avg	
			(in)	(lb/bu)	%	--------------- (bu/ac) ---------------			%
AAC Connect	2016	Meridian	24.0	54.3	**8.3**		48.9	37.9	**89.6**
Accordine			22.3	**56.1**	**8.2**		58.6	46.3	78.7
Balster			25.0	55.1	9.0	27.5	55.3	35.6	**85.4**
Bill Coors 100			20.7	54.2	9.0	19.4	46.3	28.0	77.3
Bow	2014	CDC	25.3	54.4	**8.5**		37.3	29.5	**87.1**
Champion	2007		24.0	**56.4**	9.0	32.6	46.7	34.8	78.3
Conrad	2007		24.3	55.2	9.0	30.1	48.6	34.3	**92.1**
Copeland			23.7	54.5	**8.3**	10.4	43.1	22.2	**91.5**
Esma			21.7	54.6	**7.8**		50.1	39.6	79.6
Fraser	2015	CDC	23.0	54.5	**8.9**		49.1	38.9	82.2
Genie			22.0	**55.8**	**7.9**		50.6	40.0	72.8
Growler			23.7	53.7	**8.7**		50.7	40.1	**88.7**
Haxby	2003	MAES	24.0	**57.0**	**8.9**	31.9	55.5	37.9	**87.9**
Haybet	1989	MAES/USDA	**27.7**	55.0	10.0	29.1	45.1	32.4	80.4
Hays	2003	MAES	24.7	54.5	8.8	26.0	49.0	32.4	**93.7**
Hockett	2008	MAES	24.3	**56.6**	**8.2**	30.6	51.3	35.6	**90.3**
Lavina	1989	MAES/USDA	**26.0**	54.3	9.2	27.5	54.5	35.3	80.6
Merit 57			23.3	54.7	**8.2**	22.9	50.0	31.1	74.6
Metcalfe		Canada	24.3	**57.0**	**8.9**	31.6	45.2	34.2	**88.6**
Moravian 165			**25.7**	**55.7**	9.4	25.7	44.5	30.4	81.1
Odyssey			22.0	55.1	**8.8**	30.1	50.4	35.0	**85.8**
Synergy			25.0	53.9	**7.9**	28.5	49.1	33.7	**88.1**
Aveage			24.1	55.2	8.6	27.8	48.6		85.1
C.V.			5.1	1.7	8	13.3	15.7		6.7
LSD			2.0	1.5	1.1	6.10	N.S.		9.4
P-value			<0.001	<0.001	0.031	<0.001	0.367		<0.001

Bold = statistically equivalent to top performer(s).

Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

Table 14. 2018 spring barley variety trial, Geraldine, MT.

CULTIVAR	YEAR OF RELEASE	SOURCE	HEIGHT	TEST WT	PROTEIN	------ GRAIN YIELD ------			PLUMPS
						2016	2018	Avg	
			(in)	(lb/bu)		--------------	(bu/ac)	--------------	%
AAC Connect	2016	Meridian	32.7	**56.8**	10.2		**97.9**	82.9	**94.2**
Accordine			28.3	**56.9**	9.8		**96.9**	76.9	**84.4**
Balster	-	-	32.7	55.8	10.8		93.6	74.4	**77.7**
Bill Coors 100	-	-	26.3	56.3	10.1		**94.0**	74.7	**77.5**
Bow	2014	CDC	35.7	**57.3**	11.0		82.1	65.3	**93.2**
Champion	2007		33.7	**58.7**	10.6	87.7	**94.6**	81.4	**85.8**
Conrad	2007		33.3	**57.3**	11.0	86.9	**95.9**	80.4	**90.3**
Copeland	-	-	35.7	56.1	11.5		85.6	68.3	75.6
Esma			28.0	**56.9**	9.8		**105.1**	83.5	**89.1**
Fraser	2015	CDC	33.0	56.1	10.3		**99.8**	79.6	**84.8**
Genie	-	-	29.7	**57.4**	10.1		**95.7**	76.2	**78.6**
Growler	-	-	32.3	56.3	10.6		**94.0**	74.6	**80.7**
Haxby	2003	MAES	33.7	**59.0**	10.4	79.3	**101.5**	79.9	**88.4**
Haybet	1989	MAES/USDA	**38.0**	56.7	12.4	58.1	62.9	54.1	54.3
Hays	2003	MAES	34.0	**56.9**	10.8	89.1	89.4	80.2	**78.0**
Hockett	2008	MAES	33.3	**58.4**	10.2	84.1	88.9	77.5	**92.8**
Lavina	1989	MAES/USDA	35.3	54.2	11.9	87.0	81.5	75.9	45.6
Merit 57	-		34.0	**57.9**	9.3	84.1	**111.0**	84.9	**84.9**
Metcalfe	-	Canada	34.0	**57.7**	10.9	79.1	92.4	75.1	**87.1**
Moravian 165	-	-	34.7	**57.2**	10.7		85.0	67.6	**84.8**
Odyssey	-	-	26.7	54.7	10.6		86.7	68.9	65.2
Synergy	-	-	34.3	**56.8**	10.6		92.5	73.7	**93.6**
Mean			32.80	57.00	10.5	80.30	93.0		82.7
CV%			3.90	2.30	9.4	8.10	11.2		12.8
LSD			2.10	2.20	N.S	14.20	17.1		17.3
P-Value			<0.0001	0.009	0.081		0.0030		<0.0001

Bold = statistically equivalent to top performer(s)

Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

ALTERNATIVE CROP VARIETY TRIALS

SPRING FIELD PEA VARIETY TRIAL

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Summary

Montana's dry pea yields are consistently depressed relative to those of other top-producing states. For example, Montana statewide pea yields were 820 and 1,200 lb/ac in 2017 and 2018, compared to 1,800 and 1,900 lb/ac in North Dakota. Selection of varieties adapted to local growing conditions can boost profits for Montana growers and help to close the yield gap with other states. We evaluated performance of 23 varieties (6 green and 17 yellow cotyledon types) and 8 experimental lines in a small plot trial at the Central Agricultural Research Center. The trial averaged 2813.2 lb/ac, which broke the trial record of 2603 lb/ac set in 2015.

Introduction

Spring field pea may be grown economically as a green fallow crop or a grain crop in Montana, and it is a common fallow replacement crop. Field pea improves soil fertility and breaks pest cycles when incorporated into wheat-fallow or wheat-only systems. Research in southwestern Montana has shown that pea green fallow-wheat rotations can reduce uncertainty of economic returns when compared to wheat-only systems. Research at the Central Ag Research Center (CARC) has shown that wheat following pea can outyield wheat following wheat when grown as a green fallow crop, a forage crop, and a grain crop, though significant differences were not observed across all years of this study. The increasing interest among Montana wheat farmers in field pea as viable rotation crops warrants an evaluation of spring pea varietal performance in the state's many growing environments. The objective of this study is to identify spring pea varieties that are superior to those currently being grown for yield and protein in the state.

Methods

Thirty-one varieties and experimental lines were compared for height, propensity to lodge, vine length, date of 50% flowering, grain yield, test weight, and kernel weight. Performance of experimental lines was omitted from this report at the request of the breeder. Each variety was planted in four, 5x15 ft plots in an experimental design to determine varietal differences. The study was located in a field that was planted to forage barley in 2017. Peas were planted on 25 April at a depth of 1 inch and at a rate of 8 PLS/ft^2 using a double-disc drill. Soil temperature at time of planting was 42°F. Broadleaf and grass weeds were controlled with a pre-plant burn down of glyphosate (i.e., Roundup) at 1.25 pt/acre, and plots were hand-weeded thereafter. Grizzly Too at 1.9 oz/ac was applied on 17 May for the control of pea leaf weevil. Plots were harvested on 7 August.

Results and discussion

Respective averages of green and yellow type cultivars were 2693.2 and 2830.2 lb/ac in this year's trial, compared to 756.3 and 915.6 lb/ac last year. Based on 2-yr averages, Hampton (1,900.1 lb/ac) was the highest yielding cultivar among green types and Nette 2010 (2,198.7 lb/ac) was the highest yielding cultivar among yellow types. In 2018, five cultivars yielded statistically equivalent to the top performer, Nette 2010 (3,242.3 lb/ac). These were AAC Carver (2,967.7 lb/ac), Navarro (3,048.2 lb/ac), Delta (3,065.8 lb/ac), Jetset (3,159.6 lb/ac), and Hampton (3,242.3 lb/ac). Lodging was a factor in this year's trial, averaging 18.6% across cultivars. Specifically, five cultivars were shown to lodge at statistically higher percentages than CDC Inca, CDC Spectra, and Navarro, which exhibited no lodging this year. The lodged cultivars were Salamanca (20%) and Nette 2010 (20%), Majoret (22.5%), Aragorn (30%), and Hampton (35%). CDC Inca was among the tallest cultivars tested, at 36.4 inches. Regarding thousand kernel weight, Navarro (249.2 g) and AAC Comfort (255.8 g) were the top performing cultivars in this year's trial. Shamrock outperformed all other cultivars with a test weight of 65.4 lb/bu. Nette 2010, Aragorn, and Navarro were the first to flower (22 and 23 June) and AAC comfort was the last (3 July). Six cultivars exhibited poor establishment relative to the cultivar with the highest plant count, CDC Saffron (6.3 plants/ft^2). These were CDC Spectrum (4.8 plants/ft^2), Navarro (4.7 plants/ft^2), Salamanca (4.6 plants/ft^2), Spider (4.3 plants/ft^2), Majoret (3.6 plants/ft^2), and Hampton (3.4 plants/ft^2).

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 the Montana Pulse Advisory Committee.

Table 15. 2018 spring pea variety trial, Central Ag Research Center, Moccasin, MT.

CULTIVAR	PLANT COUNT (ft^2)	FLWR DATE (julian)	VINE LENGTH (in)	PLANT HT (in)	LODGE (%)	TEST WT (lb/bu)	1000 KERN WT (g)	- - - - - - - - - -YIELD[1]- - - - - - - - -		
								2017	2018	AVG
								---------------(lb/ac)---------------		
Yellow Types										
AAC Carver	**6**	176.8	**34.7**	**35.4**	**7.5**	63.4	221	824	**2967.7**	1895.9
AAC Profit	**5.3**	179.8	**34.3**	**33.4**	**2.5**	63.1	222.5		2582.9	
AC Earlystar	**5.2**	177	**36.4**	**34.6**	**12.5**	63.1	212	911	2848.8	1879.9
Agassiz	**5.2**	177.8	**34.2**	32.3	**7.5**	62.7	220.8		2736.1	
Bridger	**5**	175.5	**34.3**	31.2	**15**	63.6	217		2898.1	
CDC Amarillo	**5**	180.5	**34.7**	**34.8**	**2.5**	63.2	213.5	746	2513.6	1629.8
CDC Inca	**6**	179.2	**36**	**36.4**	**0**	63	218.2	746	2663.7	1704.9
CDC Saffron	**6.3**	178.5	33	32.4	**10**	63.7	227.8	988	2910.6	1949.3
CDC Spectrum	4.8	179.8	32.1	31.7	**0**	62.5	227.8		2510.4	
Delta	**5.3**	175.5	29.9	29.3	**15**	64.3	230.2	796	**3065.8**	1930.9
DS Admiral	**5.2**	177	**36.2**	**34.7**	**7.5**	63	244.8	1155	2783.6	1969.3
Hyline	4.7	177.2	**34.3**	32.9	**5**	63.6	228.8		2706.9	
Jetset	**4.9**	177	**35.4**	**33.9**	**2.5**	63	231.5	1223	**3159.6**	2191.3
Navarro	4.7	**173.5**	**34.4**	**33.1**	**0**	63.8	**249.2**	612	**3048.2**	1830.1
Nette 2010	**5.4**	**174**	33.7	32.1	20	64	225.8	1155	**3242.3**	2198.7
Salamanca	4.6	177.2	**35.9**	**35**	20	63.5	247.2		2744.7	
Spider	4.3	177.8	**34.6**	**34.7**	**7.5**	64.3	233.2		2731.1	
Green Types										
AAC Comfort	**5**	184	32.3	32.7	**2.5**	62.9	**255.8**		2844	
Aragorn	**5.1**	**173.8**	31.8	29.4	30	62.4	211.5	786	2743.6	1764.8
CDC Greenwater	**5.5**	179.5	33.1	**33.1**	**5**	62.8	217.5	764	2353.8	1558.9
Hampton	3.4	178.8	28.1	27.4	35	63.2	209	636	**3164.2**	1900.1
Majoret	3.6	179.5	32.4	30.3	22.5	63.8	228	839	2358.1	1598.6
Shamrock	**5.2**	179.8	**36.6**	**36**	**10**	**65.4**	217.2		2695.2	
Mean	5	177.4	33.8	31.5	18.6	63.3	226.9	870	2813.2	1857.3
CV%	19.9	0.3	5.6	7.4	73.1	1.1	2.2		8.2	
LSD	1.4	0.8	2.6	3	19.1	1.0	7.1		325.2	
P-Value	0.0003	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	

Bold = statistically equivalent to top performer(s); [1]Adjusted to 13% moisture; *Note: Statistical analyses included entries not listed*

SPRING LENTIL VARIETY TRIAL AND NURSERIES

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Summary

Spring lentil production in Montana is on the rise as more farmers seek to capitalize on the benefits of pulse crops. It is important for growers to select lentil varieties well-suited to the growing conditions of the region. Agronomic performance of 8 spring lentil varieties and 61 experimental lines was assessed at the MSU Central Agricultural Research Center (CARC) in a small plot trial, with the objective of identifying varieties best-suited to this environment. Yields averaged 1876.9 lb/ac this year, breaking the trial record of 1538 lb/ac set in 2013. Yields at the CARC increased 167% from 2017 to 2018, compared to a 57% increase at the state level.

Introduction

Montana typically leads the nation in total lentil acreage, but the state's production on a per acre basis is consistently below national averages. Identifying superior performing varieties for Montana is one way to close this yield gap. The development of new and improved varieties is also important for enhancing the economics of lentil production in the state. The objective of these trials is to identify varieties that are superior to those currently being grown in the state of Montana.

Methods

Eight named varieties and 61 experimental lines in three separate trials were compared for height, propensity to lodge, vine length, date of 50% flowering, grain yield, test weight, and kernel weight. Performance of experimental lines was omitted from this report at the request of the breeder. Each entry was planted in four, 5x15 ft plots in an experimental design to determine varietal differences. The trials were located in a field that was planted to forage barley in 2017. Lentils were planted on 25 April at a depth of 1 inch and at a rate of 12 PLS/ft^2 using a double-disc drill. Soil temperature at time of planting was 42°F. Broadleaf and grass weeds were controlled with a pre-plant burn down of glyphosate (i.e., Roundup) at 1.25 pt/acre, and plots were hand-weeded thereafter. Plots were harvested on 13 August.

Results and Discussion

In 2018, the yield of all varieties in the trial averaged a record-breaking 1876.9 lb/acre. Compare this to 702 lb/ac in 2017. Based on 2-yr averages, Avondale (1565.6 lb/ac) was the highest yielding cultivar and CDC Impala (1164.8 lb/ac) was the lowest, though statistical differences between these varieties were not assessed. In 2018, Avondale (2330.2 lb/ac) and CDC Maxim (2176.8 lb/ac) were significantly higher yielding than all other named varieties. CDC Richlea exhibited the highest thousand kernel weight at 50.8 g, and CDC Impala outperformed all other varieties regarding test weight (66.8 lb/bu). Lodging was a factor in this year's trial, averaging 28.4% across varieties and experimental lines, though no significant differences were detected between the named varieties presented here. CDC 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. The earliest flowerer, Avondale, reached 50% bloom on 24 June, 60 days after planting. No varietal differences in establishment were detected in this year's trial.

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.

Table 16. 2018 spring lentil variety trial, Central Ag Research Center, Moccasin, MT.

CULTIVAR	COLOR	PLANT	FLWR	VINE	PLANT	LODGE	TEST	1000	- - - - - - - - -YIELD[1]- - - - - - - - -		
		COUNT	DATE	LENGTH	HT		WT	KERN WT	2017	2018	AVG
		(ft^2)	(julian)	-------------(in)-------------		(%)	(lb/bu)	(g)	---------------(lb/ac) ---------------		
Avondale	Med. green	11.2	**175**	**12.1**	14	**20**	63.2	48	801	**2330.2**	1565.6
CDC Impala	Small red	10.2	179.2	8.5	**15.4**	**26.2**	**66.8**	26	560	1769.5	1164.8
CDC Imvincible	Small green	10.5	179	9.6	13.4	**10**	65.8	27.5	687	1933.8	1310.4
CDC Maxim	Small red	11.1	177	10.3	**15.8**	**5**	65.3	36.2	642	**2176.8**	1409.4
CDC Richlea	Med. green	9	178	**11.2**	14.1	**11.2**	62.6	**50.8**	824	2103.4	1463.7
Mean		10.9	180	9.5	12.8	28.4	65.7	34.4	702.8	1876.9	1382.8
CV%		14.2	0.4	7.7	8.1	76.5	0.3	4.8		8.2	
LSD		NS[2]	0.9	1.1	1.5	31.1	0.3	2.3		220.8	
P-Value		0.4279	<0.001	<0.001	<0.001	0.0061	<0.001	<0.001		<0.001	

Bold = top performer(s)

Bold = statistically equivalent to top performer(s)

[1] Adjusted to 13% moisture

[2] Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

Note: Statistical analysis included entries not listed

CHICKPEA VARIETY TRIAL AND NURSERY

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[1]Montana State University, Dep. of Research Centers; [2]Eastern Agricultural Research Center, Sidney, MT; [3]Montana State University, Dep. of Plant Sciences and Plant Pathology; [4]Central Agricultural Research Center, Moccasin, MT

Summary

Montana produces more chickpeas than any other US state. Chickpeas can be a challenging crop for growers due to problems with fungal diseases, particularly during periods of cool, wet weather. However, if managed successfully, the crop can be highly lucrative. Selection of varieties well suited to local growing conditions is the first step toward successful chickpea production. We evaluated performance of 9 named chickpea varieties and 30 experimental lines in a small plot trial at the Central Agricultural Research Center. The yield of all entries averaged 1666.1 lb/ac, breaking the trial record of 1155 lb/ac, set in 2015.

Introduction

Montana chickpea farmers typically grow specific chickpea varieties on contract with source companies, but open market options do exist. The objective of this study is to identify open market chickpea varieties that are well suited to growing conditions of central Montana.

Methods

Thirty-nine varieties and experimental lines in two separate trials were compared for height, propensity to lodge, vine length, date of 50% flowering, grain yield, protein, test weight, and kernel weight. Performance of experimental lines was omitted from this report at the request of the breeder. Each variety was planted in four, 5x15 ft plots in an experimental design to determine varietal differences. The trials were located in a field that was planted to forage barley in 2017. Chickpeas were planted on 9 May at a depth of 1 inch and at a rate of 5 PLS/ft^2 using a high-disturbance hoe drill. Broadleaf and grass weeds were controlled with a pre-plant burn down of Roundup at 1.25 pt/acre. Plots were harvested on 7 September.

Results and Discussion

When interpreting the results of this trial (Table 17), it is important to note that 1) chickpea prices decrease with seed size, falling off drastically at sizes below 7 mm; 2) Desi types are much smaller than Kabuli types; and 3) Large Kabuli types are slightly smaller and darker in color than Large Café Kabuli types. Recent multiyear averages do not exist for this trial due to excessive grazing by deer and antelope in 2017 and abandonment of the trial in 2016 due to management issues. In 2015, CDC Orion (1477 lb/acre) and CDC Frontier (1337 lb/acre) were among the top-yielders, though yield differences in this trial were not statistically significant. In 2018, the yield of all varieties and experimental lines in the trial averaged 1666.1 lb/ac, breaking the previous trial record of 1155 lb/ac set in 2015. Three Large Kabuli types and one Large Café Kabuli type yielded statistically equivalent to CDC Orion (2014 lb/ac), the top yielder and a Large Kabuli type. These were CDC Leader (1724.9 lb/ac), Nash (1748.4 lb/ac), CDC Frontier (1786.7 lb/ac), and CDC Palmer (1787.7 lb/ac). Among Large Café Kabuli types, Nash (569.5 g) and Royal (551 g) exhibited the highest thousand kernel weight, and no statistical differences were detected among Large Kabuli types. Not surprisingly, thousand kernel weight of the lone Desi type, Myles (199.5 g), was statistically lower than that of all other named varieties in the trial. The Large Café Kabuli type, Sawyer (62.5 lb/bu), and the Large Kabuli type, CDC Frontier (62 lb/bu), exhibited the highest test weights in 2018. Canopy heights of three varieties were statistically equivalent to Royal (19.3 inches), the tallest named variety in the trial. These varieties were Nash (18 inches), Sawyer (18.2 inches), and CDC Frontier (18.4 inches). The earliest flowering variety, CDC Orion, reached 50% bloom on 2 July, 54 days after planting. No statistical differences were detected in plant count or vine length measurements in 2018.

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.

Table 17. 2018 spring chickpea variety trial, Central Ag Research Center, Moccasin, MT.

CULTIVAR	TYPE	PLANT COUNT (ft^2)	FLWR DATE (julian)	VINE LENGTH	PLANT HT	TEST WT (lb/bu)	1000 KERN WT (g)	YIELD (lb/ac)
				-------------(in)	-------------			
CDC Frontier	Large Kabuli	4.1	188.8	19.1	**18.4**	**62**	432	**1786.7**
CDC Leader	Large Kabuli	4.1	187.5	18	16.9	61.4	417.5	**1724.9**
CDC Orion	Large Kabuli	4.8	**183**	18.2	16.9	61.2	449.5	**2014**
CDC Palmer	Large Kabuli	4.9	185.5	18.3	16.3	61.5	435.8	**1787.7**
Myles	Desi	4.8	184.5	17.9	16.7	59.5	199.5	1570.8
Nash	Large Café Kabuli	4.8	188.5	18.1	**18**	60	**569.5**	**1748.4**
Royal	Large Café Kabuli	3.5	188.8	19	**19.3**	60.6	**551**	1473.3
Sawyer	Large Café Kabuli	4.2	186.2	17.9	**18.2**	**62.5**	456.8	1629.3
Sierra	Large Café Kabuli	4.3	187.8	17.7	17.5	60.8	495.8	1259.8
Mean		4.4	186.7	18.3	17.6	61.1	445.2	1666.1
CV%		17.4	0.2	6.4	5.7	0.9	8.5	12.1
LSD		NS^2	0.6	NS^2	1.5	0.8	55	293.4
P-Value		0.177	0	0.7089	0.0064	0	0	0.0016

Bold = top performer(s)

Bold = statistically equivalent to top performer(s)

[1] Adjusted to 13% moisture

[2] Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

Note: Statistical analysis includes varieties not listed

SPRING CANOLA VARIETY TRIAL

Simon Fordyce, Sally Dahlhausen, and Patrick Carr

Montana State University, Dep. of Research Centers, Central Agricultural Research Center, Moccasin, MT

Summary

Canola acreage in Montana is climbing fast, increasing nearly seven-fold since 2010 (Figure 1). The growing interest in canola among Montana farmers creates a need for varietal performance assessments in areas of the state previously dominated by wheat systems. Performance of several canola cultivars was evaluated at six locations across Montana (Conrad, Corvallis, Havre, Huntley, Moccasin, and Sidney) in both dryland and irrigated systems. Average yield of the irrigated site at Corvallis (2570.1 lb/ac) far surpassed that of the other irrigated site, Sidney (1355.4 lb/ac), as well as that of all other sites in the study. Of the four dryland sites, Havre (1925.3 lb/ac) achieved the highest average yield, followed by Conrad (1380.7 lb/ac), Huntley (1234.7 lb/ac), and Moccasin (1013.8 lb/ac). Complete results for all locations will be summarized in a subsequent report. Here, only the Moccasin site (i.e. the Central Agricultural Research Center; CARC) is summarized.

Introduction

Canola acreage in Montana has increased at a rate of nearly 14,000 acres per year since 2010 ($P < 0.01$), while statewide average yields have increased at a rate of 22 pounds per acre per year since 1999 ($P < 0.1$). This translates roughly to a 400 lb/ac increase in average state yields over a 19-year period. Increases in both canola yield and acreage may be explained, in part, by technological advances in hybridization systems, which have led to the release of canola hybrids that are superior to conventional cultivars by virtually all metrics. However, similar to conventional cultivars, hybrids tend to perform well in certain environments and poorly in others. Thus, there is a need to assess performance of these hybrids at multiple locations in Montana.

Methods

Up to twenty cultivars with five different herbicide resistance systems (including two cultivars with no herbicide resistance) from five different sources (Table 18) were planted in randomized complete block designs at six locations across the state, including one at the CARC. Only results from the thirteen cultivars assessed at the CARC are summarized in this report. Cultivars at the CARC were compared for height, propensity to lodge, flowering date, grain yield, test weight, and percent oil. The CARC trial was located in a field that was planted to barley in 2017. Canola at the CARC was planted on 26 April at a depth of 0.75 inches and at a rate of 14 pure live seeds/ft^2 using a double-disc drill. Broadleaf and grass weeds were controlled with a pre-plant burn down of Roundup at 1.25 pt/acre. Stinger® herbicide at 8 oz/acre was applied for in-crop broadleaf control, and plots were hand-weeded multiple times throughout the growing season. Plots were harvested directly (versus swathed beforehand) on 10 August.

Results and discussion

HyCLASS 955 (820.9 lb/ac) was the highest yielding cultivar based on 2-yr averages at the CARC. In 2018, all but four cultivars yielded statistically equivalent to 4187 RR (1133.6 lb/ac), the top yielding cultivar. These were Exp201803 (771.2 lb/ac), 6090 RR (863.9 lb/ac), Exp201801 (895.3 lb/ac), and DKL 35-23 (944.4 lb/ac). Regarding oil percentages, HyCLASS 730 (56.2 %) and HyCLASS 955 (56.2%) were among the top producers at the

CARC this year. HyCLASS 930 (51.4 lb/bu) was among the top performers for test weight. No lodging or shattering was observed in this year's trial. Three cultivars were statistically equivalent in canopy height to 6090 RR (46.5 in), the tallest entry in this year's trial. These were C5507 (44 in), 5545 CL (44.8 in), and 4187 RR (45 in). The earliest flowering cultivar, 11H4030, reached 50% bloom on 14 June, 49 days after planting. This entry also exhibited among the highest plant densities in the trial, with 13.7 established plants/ft^2, or nearly 2 plants/ft^2 above the trial average.

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 Bayer CropScience, BrettYoung™, Cibus™, Dekalb®, Cargill® Global Edible Oil Solutions, and CROPLAN® by Winfield®.

Figure 1. Montana canola acreage and average yield, 1999-2018 (National Agriculture Statistics Service, 2018).

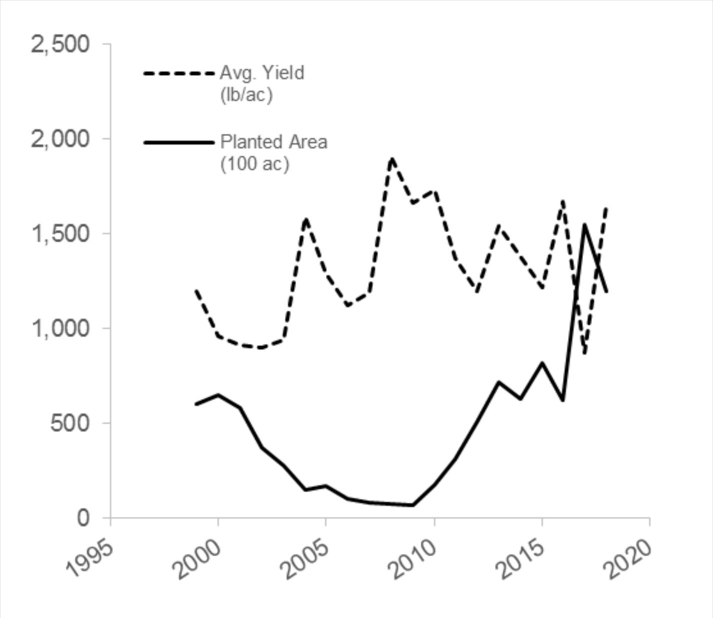

Table 18. 2018 Dryland spring canola variety trial, Central Ag Research Center, Moccasin, MT.

CULTIVAR	SOURCE	HERBICIDE	PLANT	FLWR	PLANT	LODGE[1]	SHTTR[2]	TEST	OIL[3]	- - - - - - -YIELD[3]- - - - - - -		
		RESISTANCE	COUNT	DATE	HT			WT		2017[4]	2018	AVG
			(ft^2)	(julian)	(in)	----------(1-9)----------		(lb/bu)	(%)	-------------(lb/ac) -------------		
5545 CL	BrettYoung	Clearfield	11.6	171.8	**44.8**	1	1	50.8	53.5	428.1	**1010.7**	719.4
4187 RR	BrettYoung	Roundup Ready	**13**	173	**45**	1	1	**51.2**	53.3		**1133.6**	
6074 RR	BrettYoung	Roundup Ready	**12**	171	40.8	1	1	**51**	**54.9**		**1115.1**	
6090 RR	BrettYoung	Roundup Ready	11.1	173	**46.5**	1	1	50.3	**54.6**		863.9	
11H4030	Cargill	Roundup Ready	**13.7**	**165.2**	34	1	1	**50.9**	53.5	438.2	**1098.7**	768.5
HyCLASS 730	CROPLAN by WinField	Roundup Ready	**13.2**	166.2	36.5	1	1	**51.1**	**56.2**		**1035.3**	
HyCLASS 930	CROPLAN by WinField	Roundup Ready	**12.1**	166.5	39	1	1	**51.4**	**54.7**	496	**1057.7**	776.8
HyCLASS 955	CROPLAN by WinField	Roundup Ready	**12.8**	167	37.8	1	1	**51**	**56.2**	557.6	**1084.2**	820.9
DKL 35-23	DEKALB	Roundup Ready	11.3	168.2	38.8	1	1	**51.2**	**55.3**	520.8	944.4	732.6
DKL 70-10	DEKALB	Roundup Ready	11.4	169	40	1	1	50.8	54.2	410.9	**1127.7**	769.3
C5507	Cibus	Sulfonylurea	10.4	171.2	**44**	1	1	50	**54.8**	279.4	**1042**	660.7
Exp201801	Cibus	Sulfonylurea	10.4	172	42.2	1	1	50.8	**55.7**		895.3	
Exp201803	Cibus	Sulfonylurea	11.1	172	42.2	1	1	50.7	54.3		771.2	
Mean			11.8	169.7	40.9	1	1	50.9	54.7	420.3	1013.8	749.7
CV%			12	0.2	4.8			0.7	2		9.9	
LSD			2	0.6	2.8			0.5	1.6		143.5	
P-Value			0.0354	<0.001	<0.001			<0.001	0.0038		<0.001	

Bold = top performer(s)

Bold = statistically equivalent to top performer(s)

[1] 1 = no lodging; 9 = all plants lodged

[2] 1 = no shattering; 9 = all plants shattered

[3] Adjusted to 8.5% moisture

[4] Colum mean includes entries not listed here

SPRING SAFFLOWER VARIETY TRIAL

Patrick Carr, Sherry Bishop, and Heather Fryer (Co-Principal Investigators)

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Summary

Statewide safflower yield averaged 842 lb/ac between from 2013 through 2017. Harvested safflower acreage decreased from a high of 50,000 acres in 2014 to a low of 28,000 acres in 2017 during this same 5-yr period. Safflower can be used to diversify wheat-based cropping systems in central Montana, but widespread adoption will occur only if the oilseed crop can be grown profitably. Safflower cultivars/varieties are compared annually at the MSU Central Agricultural Research Center (CARC) for seed yield and quality, as part of a multi-state testing program coordinated by North Dakota State University. Seed yield averaged only 671 lb/ac across 12 varieties grown under no-till management at the CARC in 2018. In part, the low yields reflect the late planting date (21 May) which, in turn, reflects untimely spring rains and other factors which delayed planting. Highest seed yield was produced by Baldy (844 lb/ac). Seed oil analyses are not yet available since samples still are being processed. Safflower fills an important need for a full-season broadleaf crop in wheat-based cropping systems, and timely planting (mid-April) should optimize the chances of maximizing seed yield in most year.

Introduction

Montana ranked third in safflower acreage nationally during 2017 (Sommer, 2018). Safflower planted acreage totaled 39,000 ac that year, with 28,000 ac harvested. This different in planted vs. harvested acres (11,000 ac or 28% of the total) suggests that safflower growers assume greater risk growing this full-season oilseed crop than wheat and other cool-season cereal crops. Safflower can be grown successfully in Montana, with average statewide yields > 1000 lb/ac in some years (Sommer, 2018). However, timely planting (mid- to late-April) is important to ensure that safflower is exposed to sufficient heat units so that seed production is optimized. It also is important to select safflower varieties best adapted to growing conditions under dryland management in this region of the state.

Methods

Twelve commercial safflower varieties/hybrids were direct planted in a field where barley was grown for hay in 2017. Seed was planted in four, 4.5 by 15 ft plots in an experimental design that allowed data to be analyzed statistically. Entries were compared for flowering date, plant height, seed yield and test weight. Seed also is being analyzed for oil content but those data were not available when this summary was written.

Results and Discussion

Wet spring weather and other factors delayed planting the safflower variety trial until 21 May at the CARC during 2018, roughly a month later than is ideal. Safflower began flowering 6 through 9 August, depending on the variety/hybrid (Table 19). Plants in Cardinal plots were taller than those in other plots except for plots of Finch, Nutrasaff, and two hybrids (1601 and 446). Baldy produced more seed (844 lb/ac) than that produced by other varieties/hybrids, except for Hybrid 446 (824 lb/ac), Hybrid 1601 (813 lb/ac), Cardinal (778 lb/ac), Rubis Red (748 lb/ac), and Hybrid 200 (726 lb/ac). Seed test weight was heaviest for Rubis Red (48.1 lb/bu) and Baldy (46.8 lb/bu). Oil analyses were not completed when this report was written so is not included. During 2017, oil content averaged 36% across the varieties/hybrids that were compared. NutraSaff produced seed with the highest oil content (47%) in 2017, while lowest was produced by Rubis Red (31%).

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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.

Table 19. 2018 spring safflower variety trial, Central Ag Research Center, Moccasin, MT.

			PLANT	TEST	- - - - - - - -GRAIN YIELD- - - - - - - -		
CULTIVAR	- - - -FLWR DATE- - - -		HT	WT	2017	2018	AVG
	(August)	(Julian)	(in)	(lb/bu)	------------------(lb/ac)------------------		
Baldy	7	**219**	24	**46.8**	672	**844**	758
Cardinal	9	221	**27**	43.3	1033	**778**	906
Finch	8	220	**25**	44.4	710	609	659
Hybrid 1601	6	**218**	**25**	43	1231	**813**	1022
Hybrid 200	7	**219**	24	45.1	949	**726**	838
Hybrid 446	6	**218**	**26**	45.9	979	**824**	901
MonDak	8	220	24	43.9	840	564	702
Montola 2003	9	221	22	42.5	706	495	600
Morlin	9	221	22	40.6	836	576	706
NutraSaff	7	**219**	**26**	37.4	529	447	488
Rubis Red	7	**219**	**25**	**48.1**	811	**748**	779
STI 1201	8	220	23	38.8	542	629	585
Mean		220	24	43.3	820	671	745
CV%		0.4	7	2.9	15.9	13.5	
LSD (.050)		1	2	2.0	NS[1]	130	
P-value		0.001	0.003	0.001	0.001	0.001	

Bold = top performer(s)

Bold = statistically equivalent to top performer(s)

[1] Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

PROSO MILLET VARIETY TRIAL

Patrick Carr, Sherry Bishop, Heather Fryer, Simon Fordyce, and Sally Dahlhausen (Co-Principal Investigators)

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Summary

Cool-season cereals (e.g., wheat) are well adapted to dryland management in central Montana. Incorporating warm-season cereals into cropping systems can expose farmers to new markets and also create opportunities for the suppression of certain pests (e.g., downy brome). Twenty-five proso millet cultivars/varieties and experimental lines were compared for grain yield and test weight at the MSU Central Agricultural Research Center (CARC) during 2018. Grain yield was disappointing, averaging only 393 lb/ac across all entries in the trial. In part, this reflects planting proso millet outside of (later than) the recommended planting window (i.e., early June). Still, while proso millet can be grown for grain in central Montana, it is a riskier crop than wheat and other cool-season cereals which are better adapted to growing conditions in this portion of the state.

Introduction

Cool-season cereals (e.g., wheat) are well adapted to dryland management in central Montana. The suitability of proso millet, a warm-season cereal, as a grain crop is unknown. We have begun working with a plant breeder at the University of Nebraska to determine if proso millet can be grown consistently for grain under dryland management at the MSU Central Agricultural Research Center (CARC). Seven commercial varieties along with 18 experimental lines were compared for grain yield and test weight at the CARC in 2018.

Methods

Proso millet varieties/experimental lines were direct planted in a field on 21 June, 2018, where flax was grown in 2017. Planting was done roughly 30 weeks later than desired but there was a delay in supplying seed for entries in the trial. Seed was planted in four, 4.5 by 15 ft plots in an experimental design that allowed data to be analyzed statistically. Entries were compared for heading date, plant height, grain yield and test weight.

Results and Discussion

Average heading date of proso millet was 18 August, 2018 (Table 20). Earliest heading entries included Dawn, Sunrise, Plateau, and two experimental lines. Differences were not detected in plant height across entries and averaged 17 inches. The panicles of plants in many plots failed to completely emerge prior to the first killing frost (data not presented). Mean grain yield ranged from 76 to 768 lb/ac for entries in the trial, but high variability (CV% = 30%) in measured yield across plots prevented us from detecting differences statistically between the varieties/experimental lines. Overall grain yield averaged 393 lb/ac, and was disappointing.

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.

Table 20. 2018 millet variety trial, Central Ag Research Center, Moccasin, MT.

CULTIVAR	HEAD DATE (julian)	CANOPY HT (in)	TEST WT[1] (lb/bu)	GRAIN YIELD[2] (lb/ac)
Dawn	**<u>225</u>**	17.8	-	257.8
Sunup	**227**	17.9	40.9	361
Earlybird	**227**	17.4	48.4	551.9
Huntsman	232.8	18.5	43.3	432.2
Sunrise	**228**	16.9	45.1	477.9
Horizon	229.2	16.9	47.2	529.8
Plateau	**<u>225</u>**	20.5	49.3	647.2
PMx11.32-93	232	17.2	-	118
PMx11.35-27	228.2	15.7	-	169.8
PMx11.35-32	235.8	18.3	-	70.3
PMx11.28-13	231.5	16.6	-	216.9
PMx11.26-63	234.2	18.3	-	112.9
PMx11.31-101	231	14.9	-	76.1
PMx11.27-79	228.2	17.3	43.6	495.6
PMx11.23-52	**228**	18.9	44.5	350.6
PMx11.10-5	228.2	16.4	50.2	681.1
PMx11.4-16	230.5	19.1	42.9	555.1
HXR-2-75	230.8	16.2	46.9	544
HXM-12-127	229.5	17.7	44.4	485.6
PMx12.4.2.1	229.5	16.8	48.6	608.6
PMx12.4.2.2	230.2	17.7	44.3	409.2
PMx12.15.1	**228**	17.6	48.3	767.9
PMx11.3-37	229.5	17.8	44.6	506.7
PMx12.10	234.5	17.4	-	157.7
PMx12.1	234.2	16.2	-	231.1
Mean	229.9	17.4	45.8	392.6
CV%	1	13.4		29.5
LSD	3.1	NS[3]		NS[3]
P-Value	<0.001	0.4727		<0.001

<u>Bold</u> = top performer(s)

Bold = statistically equivalent to top performer(s)

[1] Not enough seed to measure test weight for all plots

[2] No moisture adjustment

[3] Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

HEMP VARIETY TRIAL

Patrick Carr, Montana State University, Dep. Research Centers; Central Agricultural Research Center, Moccasin, MT

Summary

Interest in growing hemp for seed is increasing in Montana. Five commercial varieties/cultivars were compared for seed production at the MSU Central Agricultural Research Center (CARC) during 2018. Seed yields were lower than expected, averaging 297 lb/ac. Highest yields were produced by Grandi (336 lb/ac) and CRS-1 (301 lb/ac).

Introduction

Broadleaf crops can be used to diversify wheat-based cropping systems. Recently, interest has grown on growing hemp for seed oil in Montana, even though hemp presently is a regulated crop if grown in the state. Research was initiated at Montana State University to determine the seed yield potential of commercial hemp varieties during 2018.

Methods

Five hemp varieties were direct planted in a field on 28 May, 2018, under dryland management at the CARC into a field that was chem-fallowed in 2017 (a second site was established into a conventionally tilled field near Bozeman during this same time). Seed was planted in four, 4.5 by 15 ft plots in an experimental design that allowed data to be analyzed statistically. Entries were compared for ease of establishment, plant height, seed yield and quality.

Results and Discussion

Five hemp varieties were seeded at a heavier-than-recommended rate because stands are reportedly difficult to establish (, 2018, per. comm). Near-ideal seedbed conditions existed at planting and, coupled with heavy seeding rates, resulted in the establishment of high plant densities. Plant densities > 60 plants/ft^2 were measured (Table 21). Planting hemp in late May resulted in plants that were relatively short, averaging only 19 inches. Seed yield averaged only 297 lb/ac across the five varieties. Grandi (336 lb/ac) and CRS-1 (301 lb/ac) were the highest yielding varieties, while lowest yields were produced by Picolo (271 lb/ac). The low seed yields prevented adequate amounts of seed being available so that statistical analyses of seed test weight could be conducted. Seed test weight averaged 35 lb/bu for the five varieties that were included in the field experiment.

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, to Ian Foley at the MT Department of Agriculture for his assistance in enabling us to conduct variety testing on this regulated crop, and to Jeff Kostuik with Hemp Genetics International for providing seed for testing.

Table 21. 2018 hemp variety trial, Central Ag Research Center, Moccasin, MT.

CULTIVAR	- - - - -COUNT- - - - -		CANOPY	1000	TEST		
	INITIAL	FINAL	HT	KERN WT	WT[1]	- - - - YIELD[2] - - - -	
	------------ft^2------------		(in)	(g)	(lb/bu)	(lb/ac)	(bu/ac)
CFX-1	**66.2**	**70.7**	19	**12.5**	36	286.3	6.5
CRS-1	49.1	**64**	21.2	**13.2**	35.7	**300.6**	**6.8**
Katani	51.5	**63.7**	17.8	11.5	34.5	288.9	6.6
Picolo	44.8	48.2	17.8	11.8	34.5	270.8	6.2
Grandi	**71**	**70.1**	20.2	11.8	34.8	**336.4**	**7.7**
Mean	56.5	63.4	19.2	12.2	35.1	296.6	6.7
CV%	21.8	14.8	8.9	5.5		8.9	9
LSD	19	14.4	NS[3]	1		40.8	0.9
P-Value	0.0435	0.0328	0.0509	0.0163		0.0418	0.0411

Bold = top performer(s)

Bold = statistically equivalent to top performer(s)

[1] Not enough seed to measure test weight for all plots

[2] Adjusted to 12% moisture

[3] Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

FORAGES

WINTER CEREAL FORAGE TRIAL

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Summary

There is interest among central Montana farmers and ranchers in growing annual crops for high-quality forage to supplement traditional sources (e.g., alfalfa). Winter triticale and wheat cultivars/lines were compared to identify those producing greatest amounts of dry matter (DM) under dryland management at the MSU Central Agricultural Research Center (CARC) during 2017-18. Grain yield of these entries also was determined. Differences in forage dry matter (DM) were not detected in 2018 ($P = 0.34$). Dry matter production across the 24 crop cultivars/lines was lower than expected, averaging 2.7 t/ac. By comparison, yield averaged 4 t/ac for entries included in the trial in 2017. Grain yield was greater for Ray (3425 lb/ac [57 bu/ac]) than for other cultivar/lines included in the trial in 2018. Results suggest that Ray is a better choice than Willow Creek for Montana farmers wanting to grow winter wheat for forage or grain under dryland management in central Montana, even though Ray is shorter.

Introduction

Annual forages can produce greater amounts of DM than traditional forage sources in central Montana, as well as high-quality hay when managed properly (Meccage et al., 2019). Over 40% of Montana farms have both crop and livestock enterprises represented (Chen, 2010), and it is on these farms that cereal forage crops may have the best fit. Winter wheat and triticale lines were evaluated for forage and grain yield at Bozeman, Conrad, Corvallis, Havre, and Moccasin, MT during 2018. Forage quality analyses are also underway but have not yet been completed. Here we summarize results of the trial at the Moccasin (CARC) location.

Methods

Seven winter wheat and seventeen winter triticale cultivars (i.e., varieties)/lines were direct planted on 11 October, 2017, in a field that was green-fallowed with a lentil/pea cover that was sprayed with glyphosate in mid-summer. Each entry was planted in four, 4.5 by 15 ft plots in an experimental design to determine cultivar differences. Entries were compared for plant height, moisture content at forage harvest, forage and grain yield, and quality. Forage plots were harvested targeting the milk growth stage of kernel development. This range of target growth stages allowed for sampling of all entries on two sampling dates (12 July June and 17 July). Grain plots were harvested on 14 August at physiological maturity.

Results and Discussion

Forage moisture content averaged 60% when samples were harvested during 2018, with a range of 55 to 62% (Table 22). This was slightly higher than forage moisture content of samples harvested the previous year (data not presented), and suggests improved targeting harvesting when plants were at the kernel milk growth stage of development.

Forage DM yield for winter triticale and wheat varieties and experimental lines averaged 2.7 t/ac (Table 22). This level of DM production was lower than anticipated, given the generally favorable growing conditions during the 2017-18 growing season. We were unable to detect a difference in DM production across the 24 entries. By comparison, forage DM production averaged 4 t/ac for winter triticale and wheat cultivars/lines evaluated during the 2016-17 growing season, with triticale cultivars/lines generally producing more DM than wheat lines/cultivars. Ray produced more DM than Willow Creek during the 2016-17 growing season (3.2 vs. 2.5 t/ac). Ray produced significantly more grain than Willow Creek in both the 2017-18 (3425 vs. 1980 lb/ac [57 vs. 33 bu/ac]) and 2016-17 (2022 vs. 1651 lb/ac [34 vs. 26 bu/ac]) growing seasons. Although shorter, these data indicate that Ray is a better choice than Willow Creek for Montana farmers wanting to maximize forage and grain yield.

Literature Cited

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Acknowledgments

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Table 22. 2018 winter cereal forage trial, Central Ag Research Center, Moccasin, MT.

CULTIVAR	CROP	CANOPY	FORAGE	- - - - -FORAGE YIELD- - - -			- - - - - - GRAIN YIELD- - - - - -			TEST	100
		HT	MOISTURE	2018	2017	AVG	2018	2017	AVG	WT	KERN WT
		(in)	(%)	---------------(t/ac) --------------			---------------(lb/ac) ---------------			(lb/bu)	(g)
Willow	Wheat	41	**59**	2.2	2.8	2.5	1980	1651	1816	60.8	3.5
MTF 1631	Wheat	36	**61**	2.6	3.5	3	2755	2120	2438	**63.7**	3.4
MT 1759	Wheat	38	**60**	2.6			2753			**64.4**	3.4
MTF 1435	Wheat	40	**62**	2.9	3.5	3.2	2156	2009	2083	62.6	3.5
MTF 1883	Wheat	38	**61**	2.8			2807			**64.9**	3.4
MTF 1884	Wheat	39	**61**	2.8			2434			62.8	3.5
Ray	Wheat	37	**63**	2.8	3.5	3.2	**3425**	2022	2724	62.2	3.4
Flex 719	Triticale	48	57	2.6	4	3.3	2349	1644	1997	52.2	4.3
T 14	Triticale	**51**	**59**	2.8			1984			56.5	3.8
T 6	Triticale	45	**60**	2.6			2509			54.6	4.6
T 107	Triticale	43	**61**	2.5			2022			53.3	4.3
T 109	Triticale	50	**59**	2.6			1965			58.1	3.6
T 1310-218	Triticale	**52**	**62**	2.4	4.4	3.4	2650	1065	1858	54.4	4.3
T 1310-219	Triticale	49	57	2.8	4.2	3.5	2231	1492	1862	55.7	4.3
T 1310-221	Triticale	50	58	2.6	4.1	3.4	2209	1487	1848	54.2	4.1
T1310-230	Triticale	**54**	55	3.3			2218			54.3	4.2
T16	Triticale	48	**62**	2.6			2760			52.6	3.7
Trical 102	Triticale	48	**59**	2.6	4.7	3.7	2171	1234	1703	51	3.7
WCF 0013	Triticale	**53**	57	3	4.2	3.6	2284	1198	1741	55.4	3.8
WCF 1020	Triticale	50	**60**	2.6	4.2	3.4	2573	1196	1885	55.1	4.1
WCF 1060	Triticale	**52**	56	3	4.1	3.6	2628	1411	2020	54.4	3.9
WCF 1078	Triticale	**54**	**61**	2.7	4.2	3.5	2403	1143	1773	53.7	4.3
WCF 1216	Triticale	50	**59**	2.6	4.1	3.4	2538	1569	2054	54.4	4.1
WCF 1440	Triticale	50	**59**	2.3	4	3.1	2574	1170	1872	54	4.1
Mean		47	60	2.7	4	3.3	2432	1494	1978	56.9	3.9
CV%		4.8	4.8	16.3	10		15	14.4		2	5.3
LSD (.050)		3	4	NS[1]	0.7		514	381		1.6	0.3
P-value		0.001	0.015	0.338	0.001		0.001	0.001		0.001	0.001

Bold = statistically equivalent to top performer(s); [1]Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

SPRING CEREAL FORAGE TRIAL

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Summary

There is interest among central Montana farmers and ranchers in growing annual crops for high-quality forage to supplement traditional sources (e.g., alfalfa). Both winter (e.g., wheat) and spring (e.g., barley) cereal crops have been grown for forage in the state. Barley and other cereals were evaluated for both forage and grain production at Bozeman, Conrad, Havre, and Moccasin in 2018. Here, we summarize results of growing 16 spring-seeded cereal cultivars/lines for forage and grain at the MSU Central Agricultural Research Center (CARC) near Moccasin. Forage dry matter (DM) yield averaged 2.8 t/ac across the crop treatments. Greatest amounts of forage DM were produced by two experimental barley lines along with Otana oat (3 t/ac; $P < 0.05$). The lowest forage DM yield was produced by Vida spring wheat (2.3 t/ac). One of the two experimental barley lines produced greatest amounts of forage DM also produced the most grain (2250 lb/ac [47 bu/ac]). These results suggest that experimental lines in the MSU barley breeding program show considerable promise compared with Lavina and other commercial cultivars/varieties presently grown for forage by Montana farmers.

Introduction

Spring-seeded cereals can be an alternative source of high-quality forage for Montana farmers and ranchers when traditional forage sources are in short supply. Much of the focus on annual spring-seeded forages centers on barley in the state, but there are other crops which can be grown (e.g., spring triticale). Similarly, within barley there are several cultivars/varieties that can be grown including Lavina, Hays, and several others. Five commercial barley cultivars/varieties along with six experimental lines were compared for forage DM yield and quality at the CARC during 2018, along with oat, triticale, rye, and wheat cultivars. The six experimental lines are part of a larger group being evaluated for possible release as new cereal forage options for farmers and ranchers in the state.

Methods

Plots were direct planted on 27 April into a field with a previous lentil/pea cover crop that was killed using a glyphosate plus 2,4-D burndown in 2017. Entries were compared for plant height, forage moisture content, forage DM and grain yield, and grain test weight. Forage also is being evaluated for quality but those data are not yet available.

Results and Discussion

Plant height ranged from 42 inches for Hays barley to over 70 inches for Gazelle spring rye at the time of forage harvest (Table 23). Other relatively tall crop treatments included Pronghorn triticale (62 inches) and Tritical 141-2 (68 inches). However, Pronghorn produced less forage DM (2.6 t/ac) than three entries (3 t/ac) that were several inches shorter. This demonstrates that plant height is not a guide indication of forage DM yield potential.

Two experimental barley lines were among the highest yielding crop treatments for forage DM (3 t/ac) during 2018 (Table 23). Conversely, lowest forage yield was produced by Vida spring wheat (2.3 t/ac). Other crop treatments producing relatively low forage DM yields included Pronghorn spring triticale (2.6 t/ac), an experimental barley line (2.5 t/ac), and Lavina barley (2.6 t/ac). In contrast, Lavina barley produced equal or greater amounts of forage DM compared with other entries in the trial during 2017. Although generally discouraged for forage production because of possible nitrate poisoning concerns, Otana oat was among the top DM producers (3 t/ac). For this reason, results of forage quality analyses are particularly important in 2018, since they will indicate whether or not nitrate concentration was a concern in oat forage at the CARC during 2018.

Three of the six experimental barley lines produced equal or greater amounts of grain compared with other crop treatments in 2018 (Table 23). Least amounts of grain were produced by Gazelle spring rye (1327 lb/ac [24 bu/ac]) and Trictical 141-2 triticale (1369 lb/ac [24.4 bu/ac]). Overall yield across all crop treatments in the study averaged 1852 lb/ac. By comparison, yield averaged only 0.7 t/ac for forage and 847 lb/ac for grain across spring-seeded, cereal crop treatments evaluated during 2017, when severe drought developed and persisted. Results of the field experiment during 2018 demonstrate the potential that spring-seeded annual cereals have as both forage and grain crops in central Montana under relatively good growing conditions.

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.

TABLE 23. 2018 spring cereal forage trial, Central Ag Research Center, Moccasin, MT.

CULTIVAR	CROP	CANOP	FORAGE	- - - - - -FORAGE YIELD- - - - - -			- - - - - - - - GRAIN YIELD - - - - - -			TEST
		HT	MOISTUR	2018	2017	AVG	2018	2017	AVG	WT
		(in)	(%)	----------------(t/ac)----------------			------------------(lb/ac)---------------			(lb/bu)
Gazelle	Spring rye	**72**	57	**2.8**	**0.7**	1.7	1327	976	1152	60.8
Haxby	Barley	40	59	**2.9**	**0.7**	1.8	1899	1203	1551	63.7
Haybet	Barley	51	57	**2.9**	**0.7**	1.8	1603	593	1098	64.4
Hays	Barley	42	56	**2.9**	0.6	1.8	**2150**	842	1496	62.6
Lavina	Barley	45	59	2.6	**0.9**	1.8	2018	574	1296	64.9
Lucille	Emmer	59	58	**2.8**	0.8	1.8	1649	853	1251	62.8
MT16F01601	Barley	43	61	**2.7**		2.7	**2136**			62.2
MT16F02401	Barley	47	61	**3**		3	**2250**			52.2
MT16F02410	Barley	45	58	**3**		3	**2091**			56.5
MT16F02901	Barley	47	61	**2.9**		2.9	1934			54.6
MT16F02903	Barley	50	61	**2.8**		2.8	1896			58.1
MT16F02910	Barley	49	61	2.5		2.5	1934			54.4
Otana	Oat	53	**63**	**3**	**0.8**	1.9	1922	971	1447	55.7
Pronghorn	Triticale	62	60	2.6	**0.6**	1.6	1656	586	1121	54.2
Tritical 141-2	Triticale	68	58	**2.8**	**0.7**	1.7	1369	761	1065	54.3
Vida	Spring wheat	46	61	2.3	0.4	1.4	1799	1112	1456	52.6
Mean		51	59	2.8	0.7	2.1	1852	847	1293	58.4
CV%		3.1	4.2	7.8	20.7		7.9	54.6		8.9
LSD (.050)		2	0.1	0.3	0.2		208	NS[1]		NS[1]
P-value		0.001	0.016	0.001	0.001		0.001	0.001		0.797

Bold = top performer(s)

Bold = statistically equivalent to top performer(s)

[1] Fisher's protected LSD not significant when CV% > 15 (YIELD only) and/or P-Value > 0.05

PRODUCTION

FERTILIZER MANAGEMENT AND MALT QUALITY IN LOW PROTEIN BARLEY

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Summary

Craft brewers are demanding low-protein malt barley varieties. Judicious applications of nitrogen (N) and sulfur (S) fertilizers can improve optimize grain yield and malt quality. Seven different combinations of N and P were applied to Hockett and three low-protein barley lines to determine impacts of cultivar (i.e., variety) selection and fertilizer management on grain yield, percentage of plump kernels, and grain protein in a small plot trial at the MSU Central Agricultural Research Center (CARC). Variety and fertilizer treatment had a significant impact on barley grain yield. Highest grain yield (55 bu/ac) resulted when Hockett was grown and the heaviest rate of N (41 lb/ac) along with S (20 lb/ac) were applied. Similarly, variety selection significantly affected plump kernel percentage, grain test weight, and kernel weight. Fertilizer failed to consistently affect plump kernel percentage ($P > 0.05$), but did affect grain test weight and kernel weight. Grain protein data are not yet available for analyses. Results of the field experiment during 2018 demonstrated the importance of variety selection in determining barley grain yield and quality, as in previous years. The importance of adequate N being available so grain yield can be optimized also was demonstrated. Less obvious was a consistent trend in N fertilizer additions on plump kernel percentage, grain test weight, and kernel weight, or in S fertilizer additions on any parameter.

Introduction

Montana ranked second in the country in barley production during 2017, behind only Idaho. Growth in the craft brewing industry is increasing demand for low-protein malt barley, but dryland production can be difficult because of uncertainties regarding growing season precipitation and temperature. While adequate N is needed for optimum grain yield, too much can result in grain protein concentrations that exceed malt-quality standards. Some evidence exists that S applications may be necessary for optimum production of malt-quality barley in central Montana because of soil chemical properties. The development of promising new malt barley lines justifies a reexamination of malt barley fertilizer recommendations in central Montana.

Methods

Nitrogen as urea at 0, 0.5, 1.0, and 1.5 times the recommended rate of 1.2 lb N/bu (0 to 41 lb N/ac), and S as gypsum at 0 and 20 lb/ac, were drilled directly in all eight possible combinations just prior to planting three experimental barley lines along with the variety Hockett in plots arranged in an experimental design so that data could be analyzed statistically. Entries were planted at a 1-inch depth in a no-till seedbed on 16 May. Plots were harvested on 22 August with a small plot harvester.

Results and Discussion

The study was located in a field with < 18 lb N/acre in the top two feet and growing conditions during 2018 generally favored barley plant growth, so there was a positive response between increasing rates of N fertilizer and barley grain yield (Table 24). Highest yield occurred when the maximum rate of N coupled with S at 20 lb/ac was applied. Likewise, grain test weight generally increased as greater amounts of N were applied. Fertilizer did not affect plump kernel percentage, nor did N and S applications have a consistent effect on barley kernel weight. Two of the three low-protein experimental lines (MT 124112 and MT 124128) had consistently higher percentages of plump kernels than Hockett. MT 124128 also produced heavier kernels than kernels produced by the three other varieties. It is too early to determine the impact of variety selection and fertilizer treatment on grain protein concentration since those data are not yet available. Still, results from 2018 demonstrate that barley grain yield and selected quality factors can be enhanced by judicious applications of N and S fertilizer under favorable growing conditions in central Montana, like those which occurred in 2018.

Acknowledgments

We are grateful to the Montana Fertilizer Tax Fund for providing funding for this research, along with the Montana Agricultural Experiment Station for providing through the USDA National Institute of Food and Agriculture, Hatch project 1012796.

TABLE 24. 2018 spring barley fertility study, Central Ag Research Center, Moccasin, MT.

N RATE	S RATE	TEST WT	PLUMPS	100 KERN WT	YIELD
-------------(lb/ac)	-------------	(lb/bu)	(%)	(g)	(bu/ac)
Hockett					
0	0	55.5	94	4.4	27
14	0	56.1	95	4.7	37
27	0	55.7	94	4.5	41
41	0	**56.6**	93	4.5	43
0	20	54.5	94	4.5	27
14	20	56.1	94	4.4	41
27	20	56	91	4.3	46
41	20	56	94	4.5	**55**
MT090190					
0	0	54.1	93	4.3	22
14	0	55.6	94	4.4	29
27	0	55.3	94	4.4	38
41	0	55.7	94	4.3	39
0	20	54.4	94	4.4	22
14	20	55.2	95	4.4	37
27	20	55.2	95	4.3	44
41	20	55.7	93	4.2	46
MT124112					
0	0	55.9	97	4.6	22
14	0	55.7	97	4.5	34
27	0	55.8	97	4.5	41
41	0	55	96	4.4	44
0	20	55.5	97	4.6	21
14	20	55.9	98	4.5	33
27	20	**56.5**	96	4.5	38
41	20	56	97	4.7	45
MT124128					
0	0	56	98	4.8	19
14	0	**56.9**	97	4.8	30
27	0	56.3	98	**5.1**	40
41	0	**56.5**	98	**5.1**	47
0	20	56.1	98	4.8	19
14	20	**57**	97	4.9	35
27	20	**56.6**	98	4.9	40
41	20	**56.9**	98	4.9	44
Mean (V x F)		55.8	95.6	4.6	35.8
CV%		5	1.6	2.8	14.5
LSD (Variety, V)		0.4	0.6	0.1	2.6
LSD (Fertilizer, F)		0.6	NS	0.1	3.6
P-Value V		0.0001	0.0001	0.0001	0.0002
P-Value F		0.0001	0.47	0.014	0.0001
P-Value V x F		0.61	0.04	0.004	0.42

Bold = statistically equivalent to top performer(s)

CANOLA SEQUENCE TRIAL

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Summary

Canola is becoming a popular choice among Montana dryland farmers looking to diversify their cropping systems. The impact canola has on subsequent crops in a rotation, and the effect of previous crops on canola performance, generally has been ignored in previous research in the state. Canola along with barley, lentil, pea, and spring wheat were established in plots at both the MSU Central Agricultural Research Center (CARC) near Moccasin during 2018, and at the MSU Western Triangle Agricultural Research Center (WTARC) near Conrad. In 2019, all possible 2-yr crop sequences (e.g., canola-barley and spring wheat-pea) will be established in a matrix by planting these same crops in a perpendicular direction to the planting direction used in 2018, for a total of 25, 2-yr crop sequences. Barley grain yield approached 2400 lb/ac (50 bu/ac) during 2018. Canola yield was less than a tenth that amount (144 lb/ac, $P < 0.05$). The low canola yields were the result of an herbicide mishap that resulted in plots being replanted on 13 June, well beyond the recommended seeding window for canola in central Montana. Nevertheless, plots of all five crops were established successfully in 2018, in preparation for the establishment of a crop matrix in 2019.

Introduction

Montana farmers are seeking broadleaf crops that can be used to diversify wheat-based cropping systems. Canola is a cool-season broadleaf crop which is being considered. This is reflected in the area dedicated to canola production, which has grown from 7500 acres during 2008 to 155,000 acres in 2017 (Sommer, 2018). Considerable research has been conducted on the rotational impact of canola on subsequent crops, and on the impact of previous crops on canola, in Canada (Harker et al., 2015, 2018) and North Dakota (Krupinsky et al., 2006). No comparable research has been done on canola in Montana. Our goal is to conduct research on how canola impacts wheat and other crops which follow the oilseed in Montana, and how previous crop affects canola performance.

Study Description

Canola was direct seeded in 4, 15- by 75-ft strips along with barley, lentil, pea, and spring wheat in a replicated and randomized experimental design at both the CARC and WTARC in 2018. Crop strips were planted in a north-south direction; the same five crops will be planted in strips of identical dimension (i.e., 15- by 75-ft) during 2019 in a perpendicular direction (i.e., east-west), creating a matrix consisting of 25 different, 2-yr crop sequences.

North-south crop strips were planted on 09 May, 2018, at the CARC. A post-emergence application of glyphosate was made to canola plots under the mistaken assumption that a roundup-ready hybrid had been planted; as a result, canola plots were replanted on 13 June. Grain or seed yield was determined for each crop strip.

Results and Discussion

Barley grain yield averaged 2371 lb/ac (49 bu/ac) and was significantly greater than that produced by the four other crops (P < 0.05; Fig 2). Canola yields were less than 10% the yield produced by barley (144 lb/ac). The low canola yields were expected given the late date of replanting plots. Still, strips of canola and other crops were established successfully in preparation for establishment of a crop matrix in 2019. ,

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Acknowledgments

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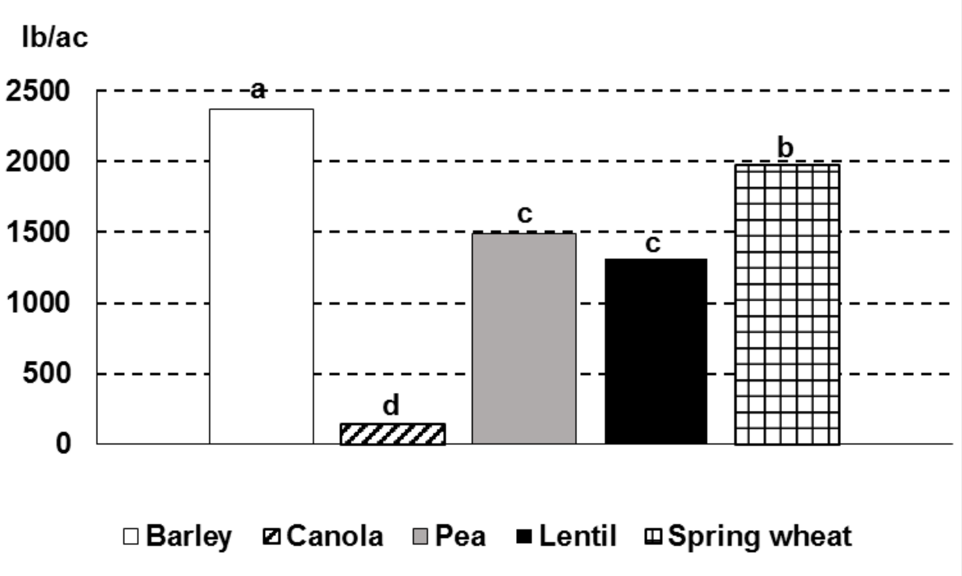

Figure 2. Grain or seed yield of five crops at the MSU Central Ag Research Center near Moccasin, MT, during 2018. Bars with different letters indicate differences at the $P < 0.05$ level of significance.

WARM SEASON CROP SEQUENCE STUDY

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Summary

Wheat-based cropping systems must be diversified to maintain economic profitability and environmental sustainability. Eighteen different warm-season crop species were screened as cover, forage, and grain/seed crops over a three-year period in four field experiments under dryland management at the MSU Central Agricultural Research Center (CARC), beginning in 2016. Wheat was grown following the warm-season crop treatments in three of four experiments during 2017 and 2018. Sunflower produced equal or greater amounts of above-ground dry matter (DM) compared with other warm-season species when grown as cover crops in each field experiment ($P < 0.05$). Sunflower DM production ranged from 2655 to 3646 lb/ac, depending on the environment. When grown for forage, corn or a corn + pinto bean mixture produced equal or more DM that amounts produced by other treatments. Forage DM production by corn or a corn + pinto bean mixture ranged from almost 3800 lb/ac to over 5000 lb/ac, depending on the environment. Grain or seed yields for corn, sunflower, and other warm-season crops were low (< 1500 lb/ac), suggesting greatest potential for warm-season species as cover and forage crops in Montana. Wheat grain yield was not depressed following warm-season crops compared with fallow, except when following grain sorghum, Hungarian and proso millet, and a sorghumXsudangrass cross in one environment. These results suggest that several warm-season species can be used to diversify wheat-based cropping systems when grown as cover and forage crops, and that wheat generally can be grown following warm-season crops without a yield penalty.

Introduction

There is a need to diversify wheat-based cropping systems in Montana to achieve economic and environment benefits. Miller and Holmes (2005) and others (e.g., Chen et al., 2012) have focused on cool-season broadleaf crops as a way to diversify dryland cropping systems. There are weed suppression benefits that can result when warm-season crops are included in diversification efforts (Anderson, 2008). Only limited research on crop sequences including wheat and warm-season crops has been conducted in Montana, particularly in dryland regions (Miller and Holmes, 2005). The purpose of this research project is to identify warm-season species that are adapted as cover, forage, and grain/seed crops in central Montana, and to determine how yield of a subsequent wheat crop is affected.

Study Description

Eighteen warm-season crops were grown along with two-crop combinations of corn + pinto beans and proso millet + pinto beans, as well as a four-crop combination (corn + sorghumXsudangrass + pinto bean + cowpea) in one field during 2016 two different fields during 2017, and one field in 2018 at the CARC. Multiple phenotypes of some crops species (e.g., bush-type and vining cowpea) were included. The warm-season crop treatments were compared with two cool-season crops (spring wheat and field pea) as well as a four-species, cool-season crop combination (barley

+ wheat + pea + lentil) when grown as cover, forage, and grain/seed crops. A fallow check treatment also was included. The crop treatments were arranged in an experimental design so that data could be analyzed statistically. Above-ground plant dry matter and grain/seed yield of warm- and cool-season crop treatments were determined. Wheat was planted during 2017 across plots in the experiment established in 2016, and in 2018 across plots in both experiments established in 2017.

Results and Discussion

Warm-Season Crops – Year 1

Sunflower produced equal or greater amounts of DM compared to other warm- as well as cool-season crop treatments when managed as cover crops in each field experiment (Table 25). Over 3000 lb DM/ac were produced by the oilseed crop, except in one environment (SW1). There, DM production totaled almost 2600 lb/ac. Other warm-season crop treatments produced >2000 lb DM/ac one environment included buckwheat, corn, German millet, and Hungarian millet, along with 2- and 4-crop species mixtures. By contrast, spring wheat produced >2000 lb DM/ac in only one environment, as did spring pea. Corn grown alone or in combination with pinto bean produced equal or greater amounts of DM compared to other warm- as well as cool-season crop treatments when grown for forage (Table 25). Corn forage yield averaged from almost 3000 lb DM/ac to over 5000 lb/ac, depending on the year. Other warm-season crop treatments producing over 3000 lb DM/ac in a majority of environments included the corn + pinto bean mixture along with sunflower. German and Hungarian millets both produced > 3000 lb DM/ac, but only in one environment. By comparison, neither pea nor spring wheat produced forage DM that exceeded 2800 lb/ac.

Grain or seed yields of warm-season crops was disappointing. Yields were < 1400 lb/ac in each environment (Table 25). However, grain yield of spring wheat exceeded 1400 lb/ac in only one environment, while pea yield generally was < 1000 lb/ac, so grain or seed yields of some warm-season crops were not particularly low relative to those of cool-season check treatments. Of the warm-season crops, corn and a corn + pinto bean mixture each had the highest grain yield in one environment.

Wheat Grain Yield – Year 2

No differences in wheat grain yield generally were detected following warm-season crops vs. fallow in any environment (Table 26). The only exception was in one environment where grain yield following grain sorghum (30 bu/ac), Hungarian millet (32 bu/ac), proso millet (28 bu/ac) and a sorghumXsudangrass cross (30 bu/ac) were lower than following fallow (39 bu/ac). Similarly, preceding wheat with a warm-season crop did not affect wheat grain test weight in any environment. This research suggests that a yield drag does not necessarily result when wheat is preceded by a warm-season crop compared with fallow in central Montana, and that there are warm-season crop options for farmers wanting to maximize DM production for cover or forage.

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Table 25. Dry matter yield (lb/ac), warm-season cover crop sequence study, Central Ag Research Center, Moccasin, MT.

	- - - - - COVER CROP- - - - -				- - - - - - FORAGE- - - - - -				- - - - - - - - -GRAIN- - - - - - - -			
TREATMENT	SW1	SW10	NT1	SW2	SW1	SW10	NT1	SW2	SW1	SW10	NT1	SW2
	--- (lb/ac) --											
Fallow												
Browntop	95	426	485	112	537	990	750	778				
Buckwheat	2328	1180	636	730	2368	885		1444	119			43
Bush cowpea	467	783	397	300	1167	918	833	678				
Corn	1661	1822	1592	**3616**	**2981**	**4490**	**4787**	**5170**	567		**992**	**1339**
Corn + pinto	1773	**2567**	1008	1074	**3797**	**3978**	3650	2042	621		**1061**	173
CS cocktail	1818	2061	1291	1074	2446	2204	1877	3366	**1322**	219	29	935
Forage	1699	1261	703	1318	2713	1631	1328	1856				
German millet	1193	1412	1119	2178	2315	1658	2234	3126		10	2	
Grain	1762	1578	1421	1268	1992	3022	2232	2508	170	35	53	
Hungarian	1980	1358	1427	2298	2520	2008	2290	3150	576	104	14	283
Mung bean	759	728	467	344	1606	1106	1041	1026	13			
Navy bean	1218	921	550	668	1290	1498	792	930	96	37		
Pearl millet	869	948	616	926	1733	1690	1871	1274				
Pinto bean	1296	1007	457	504	1736	1396	869	852	154	79	93	418
Proso millet	1324	1250	982	1534	1978	814	1321	2994	99		45	437
Proso + pinto	2488	1192	1363	1366	**3090**	1889	2366	2310	73	193		397
Sorghum x	1684	1153	777	1346	2450	1855	1296	1472				
Soybean	1419	717	340	570	2182	1119		982	168	46		217
Spring pea	1316	2027	1723	1456	1570	2367	1904	2406	1008	306	124	963
Spring wheat	1463	1381	1156	2064	1567	1800	1476	2736	**1492**	**580**	313	**1146**
Sudangrass	1728	1451	1125	1548	2840	1714	1382	2206		25	2	
Sunflower	**3114**	**2655**	**3068**	**3646**	2904	**4135**	3279	4292	755	**757**	265	326
Teff		474	194	1048		1651	280	2260				54
Viney cowpea	705	644	406	174	1237	1301	863	980				
WS cocktail	1925	1270	1284	1204	**3124**	2034	1746	1972				
Mean	1503	1291	983	1295	2173	1926	1759	2112	482	199	249	518
CV%	29.2	27.0	31.0	20.1	27.2	39.0	24.0	19.0	40.2	91.7	56.8	38
LSD (0.05)	620	497	424	393	830	1056	607	565	310	263	204	279
P-Value	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Bold = top performer(s); **Bold** = statistically equivalent to top performer(s)

Table 26. Post-treatment wheat yields, warm-season cover crop sequence study, Central Ag Research Center, Moccasin, MT.

	-TEST WT-			-WHEAT YIELD-		
TREATMENT	SW1	SW10	NT1	SW1	SW10	NT1
	(lb/bu)			(bu/ac)		
Fallow	64	62	61.5	**39**	36	20
Browntop millet	64.6	61.9	61.3	**39**	36	17
Buckwheat	65.2	62.1	61.8	38	32	19
Bush cowpea	64.6	61.4	61.4	38	32	20
Corn	65.2	62.1	62.4	37	29	19
Corn + pinto	65.2	61.5	62.3	36	31	22
CS cocktail	65.3	61.9	61.9	**39**	30	21
Forage sorghum	65.8	62.2	62.5	34	27	20
German millet	65.4	62	62.1	37	32	17
Grain sorghum	65.6	62.3	61.6	30	31	18
Hungarian millet	65.6	61.3	62	32	31	18
Mung bean	64.4	61.2	61.9	38	32	22
Navy bean	65.1	61.9	61.7	**43**	36	18
Pearl millet	65.7	61.3	61.7	**40**	34	21
Pinto bean	65	61.3	61.8	**40**	30	18
Proso millet	65.8	61.9	61.4	28	34	18
Proso + pinto	65.5	62	61.9	37	32	19
Sorghum x sudan	65.6	62.4	62.2	30	33	17
Soybean	65	61.8	61.8	**39**	31	22
Spring pea	64.8	61.9	61.8	**45**	34	21
Spring wheat	65.3	62.3	62.1	35	30	19
Sudangrass	65.5	62.2	62.1	33	33	18
Sunflower	64.8	62.4	62	37	34	16
Teff	63.6	62.1	62	**42**	33	20
Viney cowpea	65.1	61.3	61.3	**39**	31	19
WS cocktail	65.2	61.7	61.9	33	33	18
Mean	65.10	61.90	61.9	37.00	32.00	19.00
CV%	29.20	0.90	0.9	14.40	13.30	14.20
LSD (0.05)	NS	NS	NS	6.50	NS	NS
P-Value	<0.06	0.09	0.3	<0.001	0.19	0.81

Bold = top performer(s)

Bold = statistically equivalent to top performer(s)

ROTATION AND TILLAGE SYSTEM TRIAL

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Summary

Dryland farmers need diversification options when growing grain and seed crops in central Montana. Three- and four-year rotations have been established at the MSU Central Agricultural Research Center (CARC) in both conventional-till and no-till environments to determine if agronomic and economic benefits result compared with wheat-fallow and continuous wheat systems. Growing conditions generally favored field crop production in 2018, although wet weather delayed planting beyond optimum window for seeding crops. There was a nonsignificant trend ($P < 0.06$) for winter wheat (WW) grain yield to be greater following lentil than pea in both no-till (27 vs. 16 bu/ac) and conventional-till (32 vs. 20 bu/ac) environments. Conversely, there was no yield advantage when winter wheat followed fallow vs. lentil. Spring wheat did yield more following fallow (30 bu/ac) than winter wheat (24 bu/ac) in a conventional-till environment, as well as in a no-till environment (29 vs. 20 bu/ac). Proso millet yields were low following pea under both conventional-till (293 lb/ac) and no-till (246 lb/ac) management, as were safflower (581 and 484 lb/ac). Legacy weed impacts continue to be a challenge in this large-plot study from previous research, though progress is being made in eliminating downy brome infestations. However, Canada thistle is becoming a greater problem in several plots, particularly those under no-till management.

Introduction

Winter wheat (*Triticum* spp.) dominates dryland grain farming in central Montana (Sommer, 2016). However, profit margins when growing wheat have shrunk or disappeared (Swenson and Haugen, 2017), supporting diversification strategies for wheat-based cropping systems. Rotating wheat with pulse and other crops in two-year rotations has been considered in Montana (Chen et al., 2012; Miller and Holmes, 2005). Three- and four-year rotations are being compared for their impact on wheat performance in central Montana.

Study Description

Five cropping systems were established in replicated and randomized plots in conventional-till and no-till environments in 2017: (1) WW-fallow; (2) WW-lentil-barley; (3) WW-pea-barley (4) spring wheat-pea-proso millet-safflower; and (5) WW-spring wheat. The fallow phase of the WW-fallow system is split into ‘green’ and ‘brown’ subplots, with a multi-species cover crop grown in the green subplot while nothing is planted in the brown subplot (i.e., chem-fallow). All phases of all systems are present each year so that comparisons between different systems having a common crop (e.g., WW in systems 1, 2, 3 and 5) can be made.

Results and Discussion

There was a nonsignificant trend ($P < 0.06$) for winter wheat yield to be greater following lentil than pea in both conventional-till and no-till environments, with wheat yield following fallow and spring wheat in between these two extremes (Fig 3). It is unclear why wheat yield tended to be higher following lentil than pea. We were unable to detect trends in winter wheat yield between other treatments. Challenges in establishing safflower in 2017 resulted in safflower plots essentially being fallowed that year. As a result, comparisons of spring wheat following safflower (cropping system 4) vs. WW (cropping system 5) essentially were spring wheat following fallow vs. WW in 2018. In this instance, there was yield benefit to spring wheat in both a conventional-till and a no-till environment following fallow compared with WW (30 vs. 24 bu/ac and 29 vs. 20 bu/ac) (Fig. 4). Growing pea following barley vs. spring wheat had no impact on pea yield in either tillage environment. Pea yield averaged 27 bu/ac under conventional-till management and 26 bu/ac under no-till management across both previous small-grain crops.

Proso millet (cropping system 4) yields were low and disappointing in 2018. Grain yields averaged 293 lb/ac in the conventional-till environment and 246 lb/ac in the no-till environment. Similarly, safflower yields were low (i.e., 581 lb/ac under conventional-till and 484 lb/ac under no-till management). In part, these low yields can be explained by legacy weed impacts in plots where previous research had been conducted. Downy brome infestations reportedly existed in several plots in previous research, and while suppression of this grassy weed has improved since the beginning of this study, consistent control across all plots has not yet been achieved. More recently, Canada thistle infestations have increased in a few plots, particularly during certain crop phases (e.g., lentil in cropping system 2) when in-crop herbicide options for suppression are non-existent.

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.

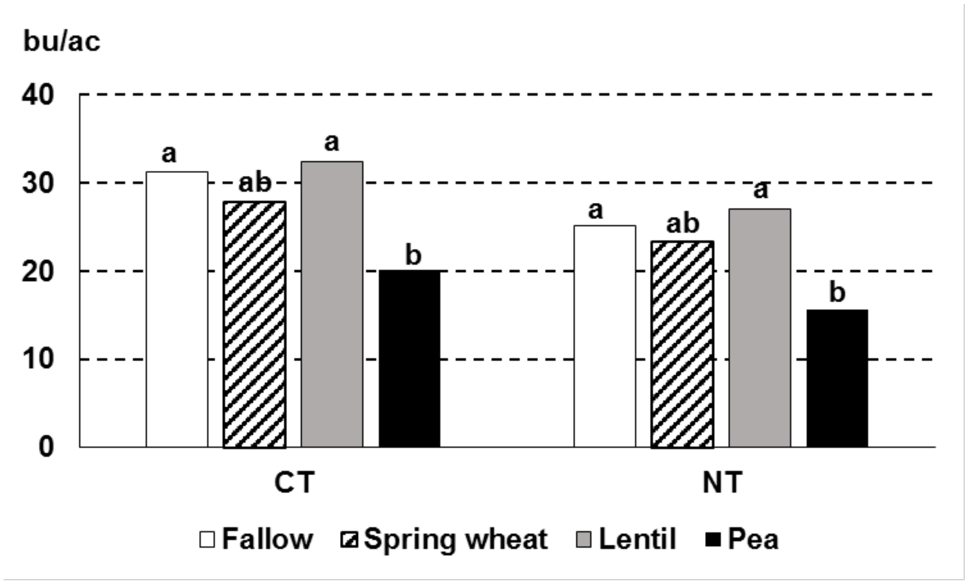

Figure 3. Winter wheat grain yield following fallow and three crops at the MSU Central Ag Research Center near Moccasin, MT, during 2018. Bars with different letters indicate differences at the *P* < *0.10* level of significance.

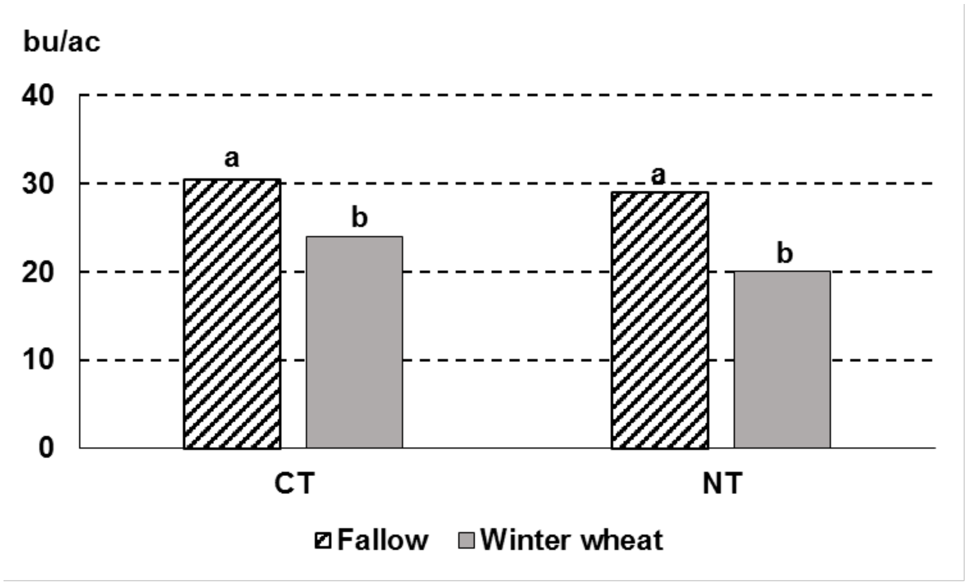

Figure 4. Spring wheat grain yield following fallow and winter wheat at the MSU Central Ag Research Center near Moccasin, MT, during 2018. Bars with different letters indicate differences at the P < 0.10 level of significance.

UNDERSTANDING ACIDIFICATION AND MANAGEMENT OF MONTANA SOILS

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Summary

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 twenty Montana counties. Here, we evaluated the performance of nine cultivars of spring pea, spring canola, spring wheat, and spring barley in response to sugar beet lime application in acidic soils. In addition, durum performance at five phosphorous (P) fertilizer rates was assessed in limed and unlimed conditions to determine whether seed-placed P in combination with sugar beet lime can mitigate aluminum toxicity.

Methods

Nine cultivars of spring canola, spring pea, spring barley, and spring wheat were established in acidic soils under limed (5 t/ac) and unlimed conditions in an experimental design to determine the efficacy of sugar beet lime for remediation of acidic soils. Cultivars were compared for kernel weight (not summarized here), test weight, and yield. A single cultivar of durum wheat was established under limed and unlimed conditions at five different rates of P fertilizer (0-45-0), and entries were compared for kernel weight, test weight, and yield. The studies were replicated at two locations in Chouteau County.

Results and Discussion

Results from the first year of this 2-yr study suggest good potential for lime applications to boost spring pea yields, spring canola yields, and spring canola test weights, though these responses were cultivar dependent ($P < 0.05$; Table 27). In other words, the ROI of lime application in spring pea and spring canola systems with soil pH < 4.5 may be increased with careful selection of cultivars. An assessment of cultivar specific tolerance to soil acidity is ongoing. The potential for lime application to boost test weights is also crop-dependent ($P < 0.1$). While test weights of canola benefited from lime applications, those of spring pea and spring were unaffected, and spring barley test weights were actually lower in limed areas, though more work is needed to determine the mechanisms behind this negative response. For example, early and mid-season differences in growth from lime applications were visually evident in barley, with greater biomass occurring in areas receiving lime. The greater top growth likely created more drought-stress at grain-fill, resulting in smaller mature kernel sizes (i.e., test weights) and a lower yields (8-31% reduction) dependent on cultivar. Mid-season biomass samples (planned for 2019) will provide evidence for or against this hypothesis. Finally, we observed a significant lime x P interaction (Table 27) on grain yield in durum, which indicated seed-placed fertilizer P could mitigate Al toxicity in acidic soils (Figure 5). This phenomenon has been reported previously in other Great

Plains states. The response is not associated with a phosphorus nutrition benefit as it occurs in soils that test very high in available P, which was the case at this location (i.e. soil P test = 50 ppm). Rather, the mechanism is believed to be in response to a reduction in Al availability as a result of Al-P precipitation. Also, this mitigation strategy does not impact or remediate soil pH, but has an application where a grower is seeking a short-term benefit, e.g. where the land is rented under a short-term lease agreement.

Acknowledgements

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

FIGURE 5. Phosphorous fertilizer mitigates Al toxicity in durum wheat (Credit: Dr. Rick Engel).

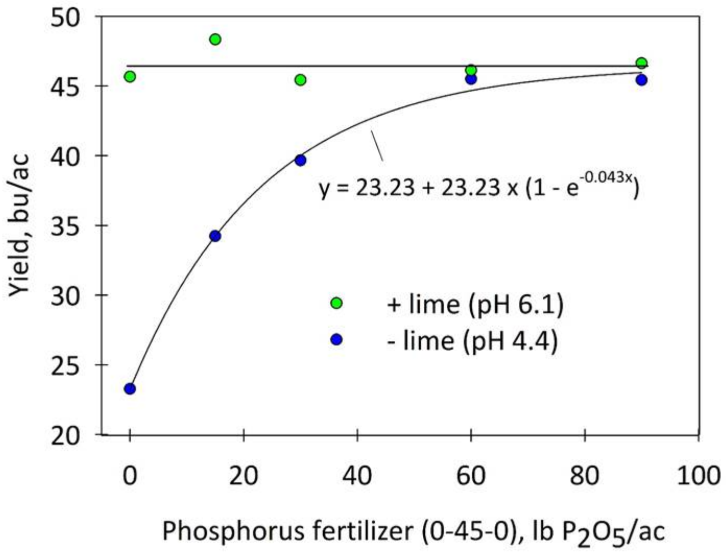

Table 27. Response to sugar beet lime in cultivars of spring pea, spring canola, spring wheat, and spring barley grown in acidic soils, Highwood, MT.

- - - - - - - - -SPRING PEA- - - - - - -			- - - - - - -SPRING CANOLA- - - - -			- - - - - - - -SPRING WHEAT- - - - - -			- - - - - - -SPRING BARLEY- - - - - -		
CULTIVAR	YIELD (lb/ac)	TEST WT (lb/bu)	CULTIVAR	YIELD (lb/ac)	TEST WT (lb/bu)	CULTIVAR	YIELD (lb/ac)	TEST WT (lb/bu)	CULTIVAR	YIELD (lb/ac)	TEST WT (lb/bu)
Unlimed											
Agassiz	1416	61.9	Gen Hybrid	1176.1	50.8	Alum	1677	54.4	10WA.106.18	3499.1	47.7
Aragorn	949.6	62.8	4187 RR	649.9	50.8	Brennan	2346.3	57.5	10WA.107.43	3375	48.4
Carousel	1221	63.5	6074 RR	727.6	51.3	Duclair	1997.1	54.5	10WA.117.17	3297.9	48.2
CDC Mozart	1486.1	64	6090 RR	666.4	50.5	Lanning	2049	52.2	11WA.107.58	3651.9	50.1
Cruiser	1094.5	62.5	DKL 35-23	899.4	50.9	MT 1621	2146.2	57.6	12WA.120.14	3461.9	47.1
Delta	1545.6	64.3	DKL 70-10	1053.9	51.5	MT 1673	2424.7	55.5	Hockett	3265	49
DS Admiral	428.9	61.3	HyCLASS 730	1075.8	51.1	SY Soren	2130.7	57.3	Lavina[2]	3466.1	45.1
Lifter	1099	62.3	HyCLASS 930	960	51	Vida	2122.2	56.3	MT124027	3010.8	45.7
Majoret	785.9	62.5	HyCLASS 955	1026.2	51.1	WB Gunnison	2011.1	58	MT124112	3379.9	49.3
Limed											
Agassiz	1197.8	61.5	Gen Hybrid	1349.2	51.3	Alum	2376.8	53.3	10WA.106.18	2841.2	45.3
Aragorn	1573.4	62.4	4187 RR	678.5	51.3	Brennan	2488.6	55.9	10WA.107.43	3444.9	45.9
Carousel	1432.3	63.3	6074 RR	849.6	52.5	Duclair	2717.6	54.5	10WA.117.17	2272.5	45
CDC Mozart	1568.4	64	6090 RR	677.2	50.8	Lanning	2249.4	50.7	11WA.107.58	2993.1	46.6
Cruiser	1209.5	62.2	DKL 35-23	1484.1	51.4	MT 1621	2435.5	54.9	12WA.120.14	2964.8	43.8
Delta	1740.9	64.3	DKL 70-10	1292.7	52.3	MT 1673	2503.5	54.2	Hockett	2584.3	45.6
DS Admiral	608.4	61.4	HyCLASS 730	1115.1	52.2	SY Soren	2454.8	54.8	Lavina[2]	2731.6	41.2
Lifter	1009.6	61.9	HyCLASS 930	1646.8	51.9	Vida	2269.6	52.7	MT124027	2731.4	43.5
Majoret	981.9	63	HyCLASS 955	1110.2	52	WB Gunnison	2381.4	56.1	MT124112	3120.8	47.2
Overall Mean	1186	62.7		1024.4	51.3		2265.6	55		3116.2	46.4
Unlimed Mean	1114.1	62.8		915	51		2100.5	55.9		3378.6	47.8
Limed Mean	1258	62.7		1133.7	51.7		2430.8	54.1		2853.8	44.9
CV%	29.1	1.5		27.9	1.1		10.5	3.5		11.7	4.7
p(Rep)	0.611	0.783		0.057	0.629		0.639	0.872		0.022	0.100
p(Lime)	0.514	0.672		0.066	0.038		0.410	0.213		0.060	0.045
p(Cultivar)	<0.001	<0.001		<0.001	<0.001		0.668	<0.001		0.118	<0.001
p(Lime:Cultivar)	0.0456	0.785		0.049	0.016		0.832	0.290		0.458	0.802

[1]Identifier omitted at the request of the breeder; [2]Seed contaminated with an unknown cultivar of bearded barley prior to seeding.

MICROBIAL TRIALS

EVALUATING MICROBIAL INOCULANT PERFORMANCE IN SMALL GRAINS AND PULSES

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Summary

Inoculant trials were established with winter wheat and spring wheat to evaluate the effectiveness of several biological treatments on the agronomic performance of wheat. The results of this year's trials showed no significant difference between biological treatments and the control.

Introduction

Several microbial inoculant trials were performed at CARC to evaluate inoculants with putative plant beneficial characteristics. Winter and spring wheat studies were established to evaluate the effectiveness of several microbial inoculants in conjunction with Vibrance® Extreme, a seed treatment fungicide. Inoculant formulations contained species of the genera *Bradyrhizobium* and chitosan, which functions as a biostimulant. Many members of the genera *Bradyrhizobium* are capable of nitrogen fixation in legumes and may have additional plant beneficial properties[1]. The purpose of this work was to evaluate the effectiveness of these inoculants on the agronomic performance of winter wheat and spring wheat.

Methods

Winter wheat was tested with one microbial inoculant formulation and spring wheat was tested with 2 different microbial inoculant formulations along with Vibrance® Extreme, a commercial seed treatment fungicide used as a control. Four replicate plots were arranged in a randomized complete block experimental design so that differences from the treatments could be separated from other effects. Seeding dates were 9 October for winter wheat and 26 April for spring wheat. Planting depth was 1 inch at a rate of 20 kernels/ft^2. Starter fertilizer, 20-30-20-10 NPKS, was applied at seeding at a rate of 50 lb/ac. An additional 180 lb/ac of urea was broadcast applied on 16 May. Broadleaf and grass weeds were controlled with a burndown of glyphosate at 1.25 pt/ac prior to planting. Trials were also sprayed 15 May with Vendetta at a rate of 24 oz/ac to control field pennycress, flixweed, kochia, and prickly lettuce. Power Flex HL was applied at a rate of 2 oz/ac for the control of cheat grass. Winter wheat plots were harvested with a small-plot harvester on 9 August and spring wheat plots were harvested 30 August.

Results and Discussion

No significant differences were observed between treatments and the control in either the winter wheat or spring wheat inoculant trials for any of the reported agronomic traits (Tables 28 and 29).

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 1015780.

Table 28. Winter wheat inoculant trial.

Treatment	Heading Date		Height	Grain Yield	Test Weight	Protein
	cal	jul	(in)	(bu/ac)	(lb/bu)	(%)
Exceed SAR	18-Jun	170	33.5	72.3	61.6	11.9
Vibrance Extreme	**20-Jun**	**171**	**33.3**	**70.5**	**61.7**	**12.1**
Average	19-Jun	170	33.4	71.4	61.6	12.0
CV%	0.0	1.0	3.0	11.7	2.9	7.1
LSD (0.05)	2.9	2.9	1.8	15.2	3.2	1.6
P-value	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

N.S. = Not Significant

Table 29. Spring wheat inoculant trial.

Treatment	Heading Date		Height	Grain Yield	Test Weight	Protein
	cal	jul	(in)	(bu/ac)	(lb/bu)	(%)
Exceed HSD	1-Jul	183	27.5	51.7	60.8	10.6
Exceed SAR	30-Jun	182	26.8	51.7	61	10.8
Vibrance Extreme	**1-Jul**	**183**	**28.5**	**58.7**	**60.6**	**11.4**
Average	1-Jul	182	27.6	54.1	60.8	10.9
CV%	0.0	0.7	5.5	12.5	1.1	6.4
LSD (0.05)	2.0	2.0	2.4	10.8	1.1	1.1
P-value	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

N.S. = Not Significant

References

1. Jones, F.P., et al., *Novel European free-living, non-diazotrophic Bradyrhizobium isolates from contrasting soils that lack nodulation and nitrogen fixation genes - a genome comparison.* Sci Rep, 2016. **6**: p. 1-10.

IMPROVING NITROGEN MANAGEMENT IN MONTANA DRYLAND SOILS BY DETERMINING THE CONTRIBUTION OF MICROBIAL MINERALIZATION TO NITROGEN AVAILABILITY

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Summary

A study was initiated to compare nitrogen (N) mineralization rates under two different cropping systems consisting of spring wheat-winter wheat and spring pea-proso millet-safflower-SW. Initial results indicate higher ($p = 0.0026$) total nitrogen concentrations in spring 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.

Introduction

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.

Methods

This study is part of an existing crop rotation study that was started in 2004 and modified as a crop Rotation And Tillage Systems (RATS) study 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-winter lentil; (3) WW-winter pea (4) spring wheat-spring pea; (5) spring pea-proso millet-safflower-SW; and (6) WW-spring wheat. All crop phases are currently in place for a total of 14 plots arranged in an RCB design with 4 replicates.

Soil respiration data is currently being collected with a soil gas flux system. This will monitor 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. Initially a single respiration chamber was deployed in July and preliminary respiration data was collected from July – November while remaining chambers were being assembled. Additional chambers were deployed in October for data collection from 3 replicate plots for each treatment (SW-WW and spring pea-proso millet-safflower-SW rotations). All chambers were located in the spring wheat plots of both rotations in order to minimize variability between the two cropping systems. The respiration systems were in place and fully functional by November 1 and data were collected over a 9-day period.

Comparisons of respiration rates, N availability, and N mineralization rates will be performed in the SW-WW and spring pea-proso millet-safflower-SW rotations to determine the effect of increased cropping system diversity on N mineralization. Soil samples were collected from SW plots in each of these treatments in the fall of 2018 to establish baseline levels of total N and Nitrate-N prior to initiating mineralization studies.

Results and Discussion

Total N was 1986 ppm in spring wheat plots in the spring pea-proso millet-safflower-SW rotation compared to 1778 ppm in the SW-WW rotation (Figure 6). Differences were significant (p = 0.0026) based on a parametric unpaired t-test. Differences in Nitrate-N were not significant.

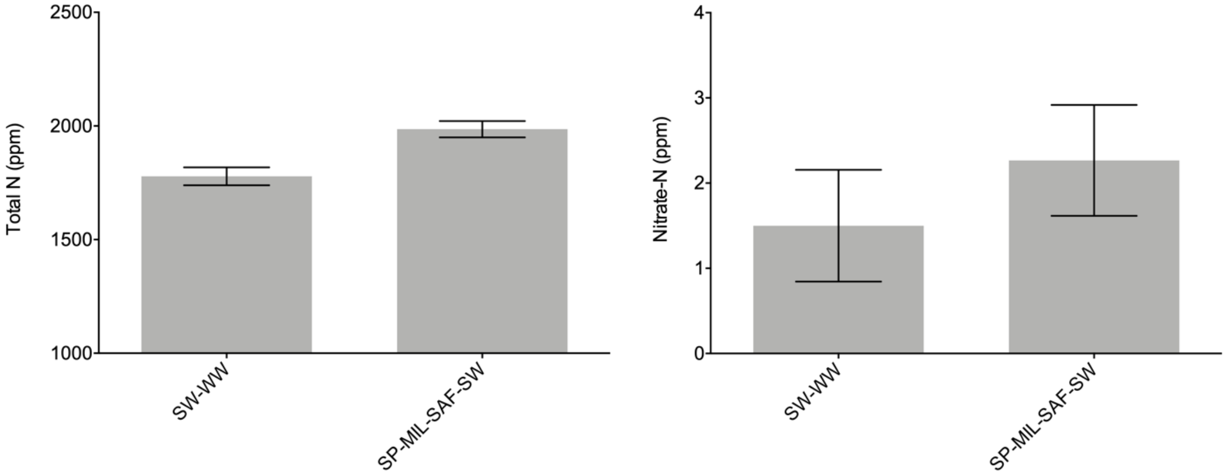

Figure 6. Comparison of total N and Nitrate-N in SW-WW and spring pea-proso millet-safflower-SW rotations.

A single respiration chamber was deployed in July and preliminary respiration data were collected from July – November while remaining chambers were being assembled. Respiration rates declined from 1.32 – 0.48 μmol CO_2 m^{-2} s^{-1} with decreasing soil moisture levels throughout late summer (Figure 7). A half inch rain event August 21 resulted in a rapid increase in soil respiration to 1.77 μmol CO_2 m^{-2} s^{-1}, however respiration returned to 0.2-0.4 μmol CO_2 m^{-2} s^{-1} over the subsequent weeks. These preliminary results indicate that additional sampling will be needed following rain events to capture the rapid response in microbial activity that occurs.

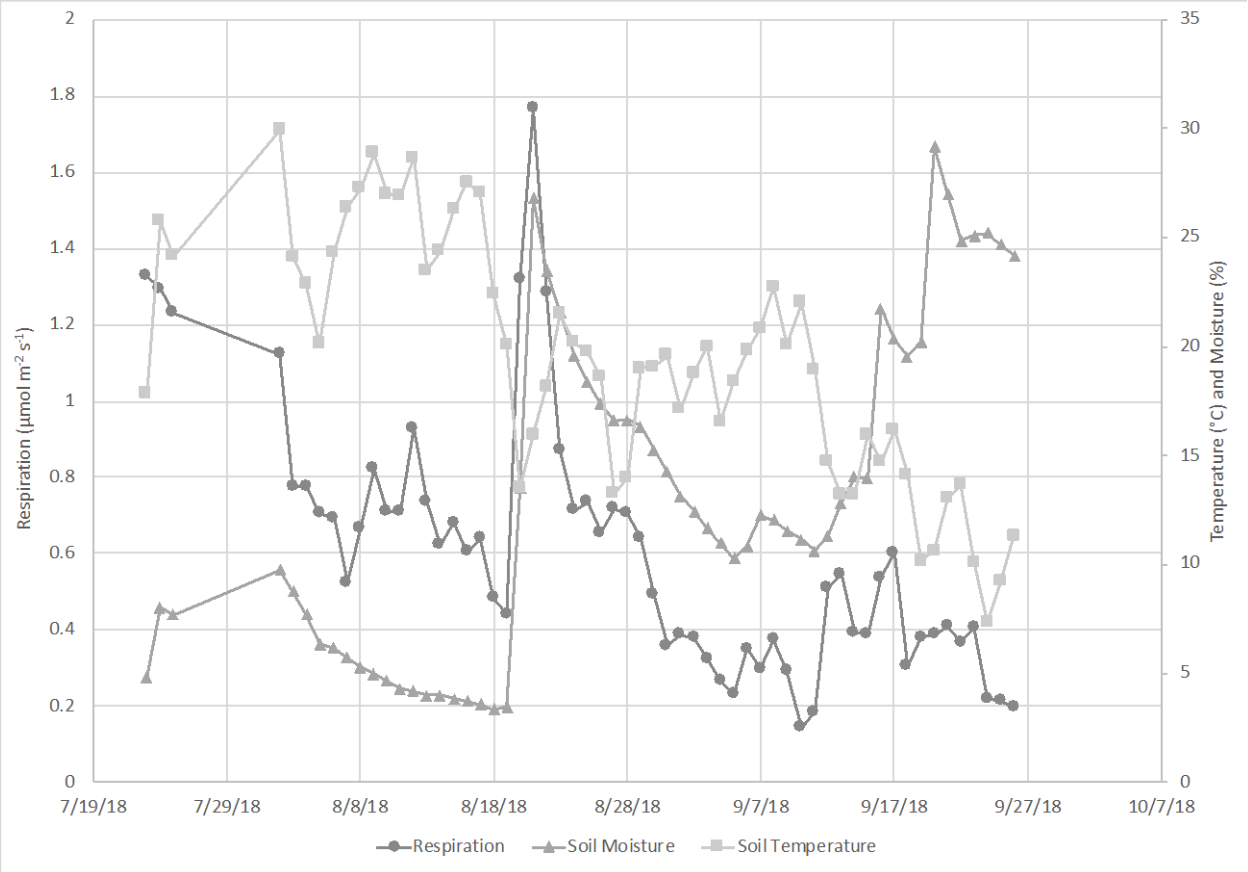

Figure 7. Changes in soil respiration, moisture, and temperature over time.

The remaining respiration systems were in place and fully functional by November 1 and data was collected over a 9-day period. About a ¼ inch of rain was recorded on November 2 which led to respiration rates almost doubling in both SW-WW and spring pea-proso millet-safflower-SW rotations the following day (Figure 8). Following this rain event, respiration remained relatively constant in the SW-WW rotation but began declining in the spring pea-proso millet-safflower-SW. The average respiration rate over the 9-day period was 1.58 and 0.99 μmol m^{-2} s^{-1} for SW-WW and spring pea-proso millet-safflower-SW, respectively. Differences were statistically significant (p = 0.0002) based on a parametric unpaired t-test.

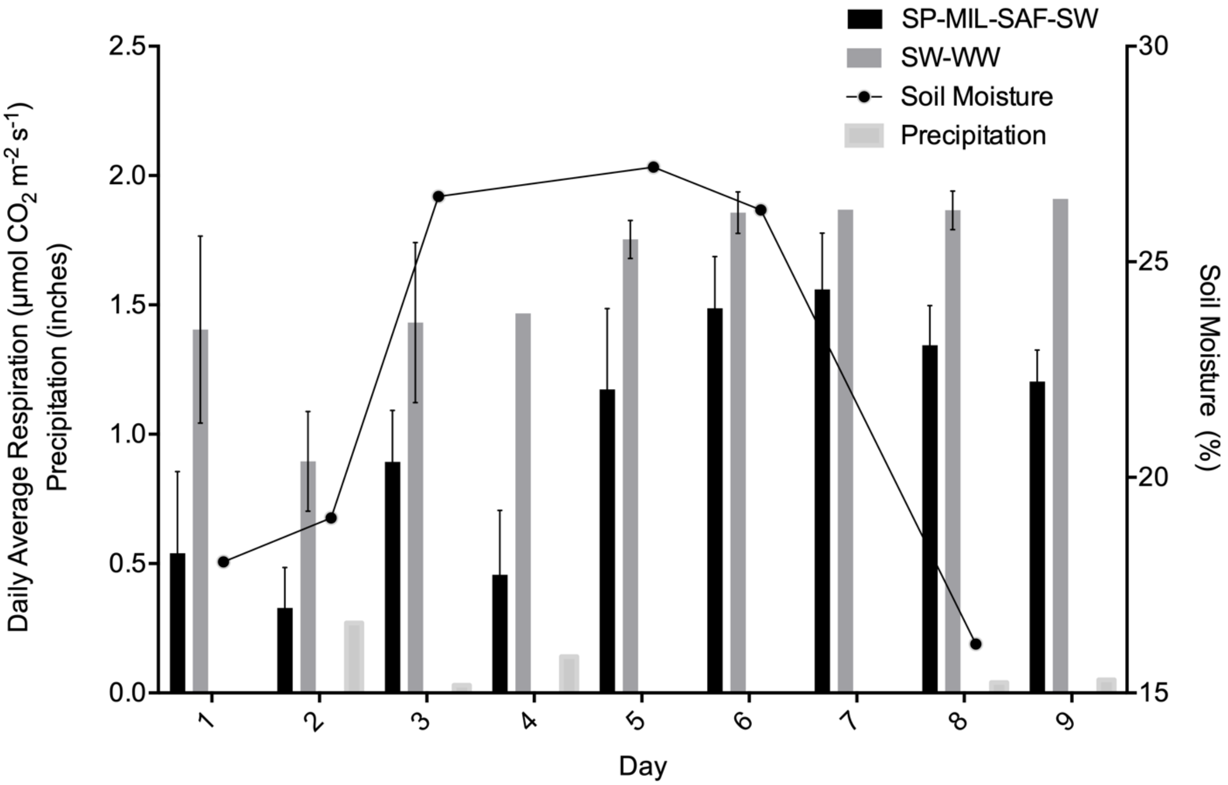

Figure 8. Daily average respiration rates, soil moisture, and precipitation November 1-9.

Future work will focus on measuring mineralization rates and the anticipated outcome of this work is a better understanding of N mineralization under different crops which will provide a more complete N budget. Collectively, the results from this effort will provide insights into N mineralization under a variety of crops that are important to central Montana dryland agriculture. It will also improve understanding of N availability and risks of N leaching throughout the year with different types of crops, which will be useful for helping farmers choose crops to incorporate into their existing rotations. This work will also be used to guide producers both in timing and N application rates to maximize uptake by the crop while minimizing leaching.

Acknowledgements

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OUTREACH

COMMUNICATING THROUGH SOCIAL MEDIA

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Summary

The Central Agricultural Research Center (CARC) is one of seven remote research centers in the Department of Research Centers in Montana State University's College of Agriculture and the Montana Agricultural Experiment Station (MAES). The CARC addresses production challenges, supports research and outreach programs, explores grain varieties and alternative crops and conducts soil microbiology research. All of the research centers have individual website pages housed at agresearch.montana.edu. Since 2016, the CARC has been striving to enhance outreach through social media by creating Facebook and Twitter accounts. The goal is to educate the public about our research, and social media provides opportunities to share our work with an audience in ways that were not available prior to 2006.

Introduction

Faculty and staff at MSU agricultural research centers, including CARC, serve farmers and ranchers in the local area as well as the broader needs of Montana agriculture through research and outreach programs. Social media tools can be used effectively to disseminate knowledge to agriculturalists and others interested in farming and ranching. The CARC is located on the plains of central Montana and is fairly remote. Therefore, we need use outreach tools effectively to provide timely messages, disseminate important research results and stay in touch with Montanans and the agriculture community.

Methods

Our methods of communication include a website page, Facebook and Twitter account. We feel these tools are used by a growing number of scientists, farmers, and local community members. The CARC website, http://agresearch.montana.edu/carc/, was revamped by organizing and updating all of its pages in 2016. The CARC created a Facebook and Twitter account under the same user name during that same year: Central Ag Research @CentralAgCenter.

Results and Discussion

To date, our Facebook page has 318 followers and our Twitter account has 362 followers. We are hopeful that these numbers will continue to grow and, to that end, are dedicated to improving content with timely and up-to-date information for followers.

Acknowledgements

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