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WESTERN TRIANGLE AGRICULTURAL RESEARCH CENTER

Montana Agricultural Experiment Station

Conrad, MT

2013 Crop Year

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INTRODUCTION

The information and data reported are a compilation of ongoing or new research projects located at or near the Western Triangle Ag. Research Center (WTARC) of the Montana State University, Conrad, Montana. Many projects are conducted in cooperation with faculty members and research associates and Post-doctoral fellows from the Depts. of Plant Science and Plant Pathology (PSPP) and Land Resources and Environmental Science (LRES) located on the campus of Montana State University (MSU), and Agricultural Research Centers: Central (CARC), Northern (NARC), Eastern (EARC) and Western (WARC) of the Dept. of Research Centers.

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Summary of climatic data by month for the '12-'13 crop year (September thru August) at the Western Triangle Agricultural Research Center, Conrad, MT.

Month Year	Sep 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2013	Feb 2013	Mar 2013	Apr 2013	May 2013	Jun 2013	Jul 2013	Aug 2013	Crop Year
Precipitation, inches													
Current Year	0.00	1.3	0.11	0.00	0.25	0.1	0.29	0.56	2.64	3.09	0.46	1.36	10.16
28-year average	1.12	0.65	0.27	0.19	0.19	0.22	0.41	0.99	1.94	2.99	1.37	1.23	11.60
Mean Temperature, °F													Average
Current Year	59.9	38.5	32.7	21.3	24.4	31.4	30.4	37.1	51.6	58.4	66.1	67.4	44.0
28-year average	57.1	44.7	32.3	24.1	23.0	24.7	33.0	42.7	51.7	59.3	66.9	66.1	43.8

Last killing frost in Spring (32°F)
2013---------------------------------- May 2
Average 1986-2013-------------- May 18

First killing frost in Fall (32°F)
2013---------------------------------- Sept. 26
Average 1986-2013-------------- Sept. 26

Frost free period (days)
2013------------------------------ 148
Average-------------------------- 131

Maximum summer temperature------- 92°F (August 16, 2013)

Minimum winter temperature------- -17°F (December 25, 2012)

Summary of climatic data by month for the '12-13 crop year (September thru August) at the Western Triangle Agricultural Research Center, Conrad, MT.

Month	Precipitation (inches)		Mean Temperature (°F)	
	Current Year	Average (27-yr)	Current Year	Average (27-yr)
September, 2012	0.0	1.12	59.9	57.1
October, 2012	1.3	0.65	38.5	44.7
November, 2012	0.11	0.27	32.7	32.3
December, 2012	0.0	0.19	21.3	24.1
January, 2013	0.25	0.19	24.4	23.0
February, 2013	0.1	0.22	31.4	24.7
March, 2013	0.29	0.41	30.4	33.0
April, 2013	0.56	0.99	37.1	42.7
May, 2013	2.64	1.94	51.6	51.7
June, 2013	3.09	2.99	58.4	59.3
July, 2013	0.46	1.37	66.1	66.9
August, 2013	1.36	1.23	67.4	66.1
Total	10.16	--	--	--
Average	--	11.60	44.0	43.8

Last killing frost in Spring (32°F)
2013-------------------------------- May 2
Average 1986-2013-------------- May 18

First killing frost in Fall (32°F)
2013---------------------------------Sept. 26
Average 1986-2012-------------- Sept 26

Frost free period (days)
2013------------------------------ 148
Average-------------------------- 131

Maximum summer temperature------- 92°F (August 16, 2013)

Minimum winter temperature------- -17°F (December 25, 2012)

ENTOMOLOGY

&

INSECT

ECOLOGY

Title: Orange Wheat Blossom Midge (OWBM) Management (4W4102)

Principal Investigators: Bob Stougaard, Luther Talbert, Gadi Reddy and David Weaver

Project personnel: Brooke Bohannon, Dan Picard and Nancy Blake

Objective 1: Monitor midge populations in the Flathead and Triangle counties

Flathead

The midge life cycle was assessed at the Northwestern Agricultural Research Center, near Kalispell. Midge larvae were first observed on the soil surface on May 20, which is similar to the past three years. Soil surface sightings were May 28, May 27, and May 22 during 2010, 2011, and 2012 respectively. Although the calendar dates were similar among the three years, the accumulated growing degree days differed somewhat. The GDD requirements for soil surface sightings were 490, 363, 510, and 426 during 2010, 2011, 2012, and 2013, respectively. These results indicate that soil temperature is not the sole driving force affecting midge development. It seems probable that soil moisture also contributes to this behavior.

Adult emergence was monitored with the use of pheromone traps. These traps first captured adult males on June 18, which is 10 days earlier than the previous year. The first capture equates to 870 GDDs, which is less than the Canadian degree day model of 1300. This indicates that we may have a unique midge biotype with a lower temperature threshold. Overall midge numbers were low for this area. However, we did collect over 1000 adults over a two day period at the NWARC and at a field near Whitefish, MT.

Golden Triangle

We continued monitoring OWBM in the Golden Triangle area including Chouteau, Fergus, Glacier, Judith Basin, Liberty, Pondera, Teton, and Toole Counties. During 2012, only Pondera County had detectable OWBM populations, with one irrigated field having economically significant numbers. In 2013, over 12,000 acres in Pondera County were treated for this pest.

Midge adults were first detected in pheromone traps on June 29 in a field near Valier. Midge adults were also detected near Ledger and Conrad. It is noteworthy to report that owbm were captured at the Western Triangle Agricultural Research Center (WTARC). Toole County also reported significant numbers east of Oilmont and south of Shelby. Chouteau, Glacier, and Liberty Counties recorded the presence of midge, but the numbers were low. Midge adults were not observed in Fergus, Judith Basin, or Teton Counties. Although not included in our monitoring program, a producer near Scobey in Daniels County reported economic damaged due to midge in a field of durum wheat.

Objective 2: Screen Sm1 experimental lines for resistance to the OWBM

Results

The Sm1 gene is the only known form of antibiotic resistance against the orange wheat blossom midge (OWBM). A backcross and selection program has been on-going to incorporate the Sm1 gene into locally adapted spring wheats.

A head row nursery was established at the Northwestern Agricultural Research Center near Kalispell during 2013 to evaluate 220 early generation lines for resistance to the OWBM. Secondary consideration was given to stripe rust resistance. The most promising lines were selected and retained for further evaluation.

In a separate nursery, sixteen advanced experimental lines were screened for resistance to the midge as well as for agronomic performance (Table 1). The cultivars included nine experimental lines (CAP) containing the Sm1 gene, three commercially available varieties, Solano, Hank and Reeder, and four experimental lines derived from crosses between Hank and Reeder (MQTL).

Stripe rust (SR) was evident throughout the nursery with an average infection rating of 26 percent (Table 1). CAP400-1 demonstrated the lowest infection at 4% while Hank was the most susceptible variety with an infection rating of 83 percent. Hank also was the most susceptible/attractive to the midge, having 27 larvae per spike.

Overall, midge pressure was low this year in comparison to previous years. The average number of OWBM was only about 4 per spike. However, this number is slightly biased since OWBM were generally not found on lines with the Sm1 gene. To be sure, the Sm1 gene was very efficacious, resulting in almost complete mortality of the midge larvae. However, the low insect pressure limited differentiation among entries for yield.

Yields ranged from a low of 59 bu/A for Hank to a high of 90 bu/A for CAP400-1. Overall, the nonresistant lines had an average yield of 73 bu/A, while lines with the Sm1 gene averaged 81 bu/A. Protein averaged 15% and ranged from a low of 13.5% for CAP34-1 to a high of 16.9 for CAP400-1. Test weights averaged 60.6 lb/bu, with the seven nonresistant lines averaging 59.7 lb/bu, while the resistant lines averaged 60.5. Falling numbers averaged 340 seconds for the nursery. CAP400-1 produced the highest falling number (408) while Hank had the lowest (272). Overall, grain yield and quality improved as a result of the Sm1 gene.

Table 1. Effect of genetic resistance on OWBM control – 2013

Treatment	SR %	HT in	OWBM no/spk	YLD bu/A	PRO %	TWT lb/bu	TKW g	FN sec
CAP 34-1	40.0	33.0	0.0	81.7	13.5	60.5	32.4	335.9
CAP 84-1	40.0	36.2	0.0	73.3	14.8	60.1	32.2	347.9
CAP 84-2	30.0	36.1	0.3	71.4	14.8	60.5	32.5	347.6
CAP 108-3	25.0	35.0	0.0	86.4	14.9	60.6	34.0	357.2
CAP 151-3	23.3	32.3	0.0	77.4	15.4	61.5	31.2	362.2
CAP 197-3	20.0	38.1	0.0	87.8	13.7	60.0	30.6	328.7
CAP 201-2	26.7	36.9	0.0	83.3	14.9	60.4	31.9	321.5
CAP 219-3	35.0	35.6	0.0	76.7	14.0	60.3	31.7	318.8
CAP 400-1	4.3	37.3	0.0	90.8	16.9	60.8	33.8	408.0
MQTL 1075	21.0	35.3	13.0	66.7	16.6	58.9	39.1	294.5
MQTL 1076	16.0	38.9	7.7	78.5	16.3	59.2	34.9	365.5
MQTL 3042	33.3	37.5	11.0	74.3	15.3	60.5	38.9	347.7
MQTL 3043	26.7	37.4	9.7	69.9	16.3	60.5	38.4	317.8
REEDER	11.7	39.0	7.0	79.2	15.7	61.1	37.4	347.8
HANK	83.3	33.6	27.0	59.1	14.7	57.7	39.1	272.4
SOLANO	5.0	31.6	18.3	83.0	16.5	60.1	38.8	310.8
Mean	26.2	35.8	3.8	82.7	15.0	60.6	35.2	340.9
CV	33.2	3.9	74.4	5.7	1.4	0.6	1.9	3.6
LSD	14.2	2.3	4.6	7.7	0.3	0.6	1.1	20.0
Pr>F	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

SR: stripe rust, HD: heading HT: height, LOD: lodging, OWBM: orange wheat blossom midge, YLD: Yield, PRO: protein, TWT: test weight, TKW: thousand kernel weight, FN: falling number

Objective 3: Evaluation the concept of insect refuges using wheat varietal blends

Results

The purpose of the interspersed refuge system is to delay the selection of virulent, Sm1 resistant midge populations. The refuge, or susceptible variety, is blended with the midge resistant variety at a ratio of 1:10. The combination is then planted together in an effort to maintain the genetic diversity of the midge population.

In this study, CAP 34-1 and CAP 400-1 contain the Sm1 gene for OWBM resistance, while Solano and Choteau are midge susceptible varieties. These four cultivars were planted alone and as blends (Table 2), where the CAP lines comprise 90% of the blended mixtures. This study was established at The Northwestern Ag Research Center near Kalispell (NWARC), and at a producer field near Valier (WTARC).

Despite modest midge pressures at both locations, differences were detected among varieties. The non-resistant varieties, Solano and Choteau, had significantly higher number of larvae compared to the Sm1 resistant CAP lines. The CAP lines, alone or blended, resulted in 86% to 100% midge mortality at Kalispell and 100% to 80% mortality at Conrad. Yield difference were not observed at WTARC, but were detected at NWARC. The blend of CAP 400-1 & Choteau resulted in a 19.1 bu/A increase over Choteau. These results demonstrate that the interspersed refuge can allow a low number of owbm to reproduce without sacrificing grain yield.

Table 2. Evaluation of the interspersed refuge system for OWBM management.

	Yield (bu/A)		Protein (%)		OWBM (No./spike)	
Treatment	NWARC	WTARC	NWARC	WTARC	NWARC	WTARC
SOLANO	84.2	67.7	15.2	15.7	11.9	1.7
CHOTEAU	73.5	75.0	15.5	14.7	13.4	6.0
CAP 34	88.6	70.7	13.1	14.2	0.0	0.0
CAP 400	95.8	85.6	15.5	16.6	0.0	0.0
CAP 34 & SOLANO	90.0	70.3	13.4	14.5	0.0	0.0
CAP 34 & CHOTEAU	88.2	80.1	13.4	14.4	1.8	1.2
CAP 400 & SOLANO	91.5	83.2	15.6	16.5	0.0	0.0
CAP 400 & CHOTEAU	92.6	82.8	16.1	16.5	0.0	0.4
Mean	88.0	76.9	14.7	15.4	3.4	1.2
CV	5.6	12.4	4.4	1.5	94.8	71.3
LSD	8.7	16.7	1.1	0.4	5.6	1.5
Pr>F	0.0030	0.2297	0.0001	0.0001	0.0002	0.0001

Objective 4: Determining the interaction between Sm1 resistant varieties and insecticides.

Results

An experiment was conducted to evaluate the potential interaction between insecticide applications and host plant resistance to the OWBM. In the first study, sixteen spring wheat cultivars were screened for OWBM control (Table 3). Nine of the cultivars were experimental lines containing the Sm1 gene for resistance (CAP), four of the cultivars were experimental lines derived from crosses between Hank and Reeder (MQTL), and three entries were the commercial varieties Solano, Hank, and Reeder. The experiment was a split plot design where one set of sixteen cultivars were treated with Lorsban, and the second set was left untreated.

Stripe rust (SR) was evident throughout the nursery with an average infection rate of 26 percent. Solano and CAP400-1 demonstrated excellent resistance toward stripe rust. In contrast, Hank was very susceptible with an average infection rating of 65 percent. Hank also was the most susceptible to the orange wheat blossom midge, having 27 larvae per spike.

Overall midge pressure was low this year in comparison to previous years. The average number of owbm was only about 4 per spike. Nevertheless, the Sm1 gene was very efficacious and lines with this trait performed better than lines without it.

While the Sm1 gene resulted in almost complete insect mortality, the effect of the insecticide treatment was still apparent. Grain yields increased when plots were treated with Lorsban, regardless of the cultivar. The average yield increase for Reeder, Hank, and Solano was 12.8 bu/A. Likewise, the average yield increase for the MQTL lines was 17 bu/A.

This illustrates that low midge populations can have a negative impact on yield. However, even the CAP lines benefited from the insecticide application. For example, untreated CAP400-1 was devoid of midge larvae and produced 90 bu/A, but the same germplasm produced 99 bu/A when treated with Lorsban. Average over all of the CAP lines, yields increased by 6.6 bu/A when treated with the insecticide. This indicates that the young larvae manage to cause significant damage to the wheat seed before the Sm1 gene can elicit its lethal effect.

While the previous study evaluated the interaction between antibiosis and insecticide applications, the second experiment evaluated the interaction between antixenosis and insecticide application (Tables 4 – 6).

The factorial treatment arrangement consisted of three insecticide treatments and eight spring wheat varieties that varied in attractiveness/susceptibility to the orange wheat blossom midge. The spring wheat varieties consisted of Brennan, Hank, Kuntz, McNeal, Reeder, Treasure, MT0802 and MT1073. The insecticide treatments included Lorsban, Warrior, and a non- treated control. The study was planted on May 6, and individual plots consisted of seven, 6-inch rows, 15 feet in length, with each variety-insecticide combination replicated 3 times in a split plot design. Warrior and Lorsban were applied on July 2 at 1.9 oz/A, and 1 pt/A, respectively. Treatments were applied with a backpack sprayer in 20 GPA of water. The fungicide Headline was applied at 9 oz/A on June 21 to control stripe rust.

Table 3. Effect of genetic resistance and insecticide application on OWBM control.

Treatment	SR %	HT in	OWBM no/spk	YLD bu/A	PRO %	TWT lb/bu	TKW g	FN sec
				Treated				
CAP 34-1	36.7	33.7	0.0	88.4	13.4	61.4	32.9	324.8
CAP 84-1	35.0	37.0	0.0	80.4	14.6	60.9	33.2	353.0
CAP 84-2	31.7	34.5	0.0	82.3	14.3	61.0	34.4	347.3
CAP 108-3	20.0	34.1	0.0	94.8	14.4	61.4	35.9	349.3
CAP 151-3	18.3	31.6	0.0	87.3	15.0	62.2	32.5	380.0
CAP 197-3	25.0	38.3	0.0	88.7	13.6	60.1	31.6	333.7
CAP 201-2	26.7	36.6	0.0	84.6	14.6	61.2	33.1	317.1
CAP 219-3	40.0	35.3	0.3	82.9	13.8	61.3	33.1	337.3
CAP 400-1	5.0	37.5	0.0	99.2	17.0	61.4	34.6	420.5
MQTL 1075	21.7	36.5	4.0	86.4	16.0	60.1	39.4	332.0
MQTL 1076	16.7	37.7	4.3	88.2	16.1	59.8	36.4	365.5
MQTL 3042	28.3	38.1	3.0	94.2	14.3	61.6	38.5	353.9
MQTL 3043	30.0	37.3	4.7	89.9	15.2	61.7	37.9	355.0
REEDER	7.3	39.3	0.3	87.0	15.0	61.6	36.7	368.9
HANK	48.3	33.6	5.7	75.7	13.4	58.9	39.4	272.8
SOLANO	7.3	31.0	4.0	97.1	15.9	61.3	39.7	311.7
				Nontreated				
CAP 34-1	40.0	33.0	0.0	81.7	13.5	60.5	32.4	335.9
CAP 84-1	40.0	36.2	0.0	73.3	14.8	60.1	32.2	347.9
CAP 84-2	30.0	36.1	0.3	71.4	14.8	60.5	32.5	347.6
CAP 108-3	25.0	35.0	0.0	86.4	14.9	60.6	34.0	357.2
CAP 151-3	23.3	32.3	0.0	77.4	15.4	61.5	31.2	362.2
CAP 197-3	20.0	38.1	0.0	87.8	13.7	60.0	30.6	328.7
CAP 201-2	26.7	36.9	0.0	83.3	14.9	60.4	31.9	321.5
CAP 219-3	35.0	35.6	0.0	76.7	14.0	60.3	31.7	318.8
CAP 400-1	4.3	37.3	0.0	90.8	16.9	60.8	33.8	408.0
MQTL 1075	21.0	35.3	13.0	66.7	16.6	58.9	39.1	294.5
MQTL 1076	16.0	38.9	7.7	78.5	16.3	59.2	34.9	365.5
MQTL 3042	33.3	37.5	11.0	74.3	15.3	60.5	38.9	347.7
MQTL 3043	26.7	37.4	9.7	69.9	16.3	60.5	38.4	317.8
REEDER	11.7	39.0	7.0	79.2	15.7	61.1	37.4	347.8
HANK	83.3	33.6	27.0	59.1	14.7	57.7	39.1	272.4
SOLANO	5.0	31.6	18.3	83.0	16.5	60.1	38.8	310.8
Mean	26.2	35.8	3.8	82.7	15.0	60.6	35.2	340.9
CV	33.2	3.9	74.4	5.7	1.4	0.6	1.9	3.6
LSD	14.2	2.3	4.6	7.7	0.3	0.6	1.1	20.0
Pr>F	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

SR: stripe rust, HT: height, OWBM: orange wheat blossom midge, YLD: Yield, PRO: protein, TWT: test weight, TKW: thousand kernel weight, FN: falling number

Table 4. Main effect of insecticide treatment on management of OWBM

Treatment	SR %	OWBM no/spk	YLD bu/A	PRO %	TWT lb/bu	TKW g	FN sec
Check	17.2	10.9	85.9	14.6	60.6	37.8	358.3
Lorsban	11.8	3.4	98.1	14.3	61.1	37.7	376.1
Warrior	21.8	1.7	98.0	14.2	61.3	38.3	363.3
Mean	16.9	5.3	94.0	14.3	61.0	38.0	365.9
LSD	3.7	2.6	7.1	0.8	0.4	1.3	32.3
Pr>F	0.0045	0.0012	0.0138	0.4833	0.0198	0.4499	0.3802

Table 5. Performance of spring wheat cultivars on management of OWBM

Cultivar	SR %	OWBM no/spk	YLD bu/A	PRO %	TWT lb/bu	TKW g	FN sec
Brennan	6.0	4.3	77.7	15.6	61.4	35.5	297.7
Hank	46.4	10.7	88.4	14.0	59.1	42.8	295.5
Kuntz	6.6	6.9	95.0	14.0	62.3	33.7	412.8
McNeal	25.6	6.9	84.5	14.9	60.7	36.9	483.8
Reeder	7.8	2.3	97.9	15.1	61.6	38.1	400.2
Treasure	22.7	0.9	109.5	11.0	59.8	36.1	303.8
MT0802	18.3	8.6	95.8	15.3	60.6	42.4	358.1
MT1073	2.2	1.9	103.4	14.6	62.5	38.2	375.0
Mean	16.9	5.3	94.0	14.3	61.0	38.0	365.9
LSD	9.1	2.9	7.3	0.4	0.5	1.8	20.0
Pr>F	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

SR: stripe rust, OWBM: orange wheat blossom midge, YLD: Yield, PRO: protein, TWT: test weight, TKW: thousand kernel weight,FN: falling number.

Midge numbers were modest and averaged only 5.3 larvae per spike, yet significant yield differences were observed for the main effect of insecticide treatments (Table 4). Averaged over the eight varieties, yields for the non-treated check were 86 bu/A, whereas the average yield for the Lorsban and Warrior applications was 98 bu/A. This increase of 12 bu/A is impressive, if not disconcerting, considering the low midge population present and illustrates just how damaging this pest can be.

Differences in OWBM levels also were detected among varieties (Table 5). MT0802 and Hank had the highest infestations while MT1073 and Treasure had the lowest numbers. Nonetheless, cultivar attractiveness did not impact insecticide efficacy (Table 6). In summary, low midge pressures did not affect insecticide performance, but did impact yields.

Table 6. The effects of insecticide and variety on the management of OWBM

Cultivar	SR %	OWBM no/spk	YLD bu/A	PRO %	TWT lb/bu	TKW g	FN sec
				Check			
Brennan	6.3	8.3	66.4	15.8	60.6	34.2	272.1
Hank	46.0	26.3	73.2	14.6	58.5	43.9	291.1
Kuntz	8.0	11.9	90.5	14.4	62.2	34.3	404.9
McNeal	25.0	9.5	75.5	15.2	60.1	36.5	491.3
Reeder	10.7	5.2	93.0	15.3	61.3	37.7	396.2
Treasure	20.0	1.1	104.6	11.0	59.8	36.0	308.6
MT0802	18.3	20.3	85.9	15.6	60.1	41.7	338.4
MT1073	3.3	4.5	98.3	14.6	62.0	38.2	363.7
				Warrior			
Brennan	4.0	2.0	87.8	15.6	61.7	36.8	291.1
Hank	71.7	3.6	95.3	13.7	59.2	42.2	286.2
Kuntz	7.3	3.5	92.4	13.9	62.6	34.1	421.6
McNeal	30.0	2.7	90.1	14.7	61.4	38.0	459.6
Reeder	8.3	0.1	104.5	15.1	61.9	38.4	403.2
Treasure	31.7	0.0	107.6	11.1	59.7	35.6	288.8
MT0802	20.0	1.2	102.3	15.0	61.1	43.0	379.6
MT1073	1.3	0.3	104.3	14.6	62.8	38.6	376.0
				Lorsban			
Brennan	7.7	2.6	78.9	15.4	61.8	35.4	329.7
Hank	21.7	2.3	96.6	13.8	59.5	42.3	309.2
Kuntz	4.3	5.2	102.2	13.6	62.2	32.7	412.0
McNeal	21.7	8.5	88.0	15.0	60.7	36.0	500.6
Reeder	4.3	1.6	96.4	15.1	61.5	38.2	401.3
Treasure	16.3	1.7	116.3	11.1	59.9	36.8	313.9
MT0802	16.7	4.2	99.2	15.3	60.7	42.5	356.4
MT1073	2.0	0.9	107.6	14.7	62.6	37.9	385.3
Mean	16.9	5.3	94.0	14.3	61.0	38.0	365.9
LSD	15.8	5.1	12.7	0.6	0.8	3.1	34.7
Pr>F	0.0119	0.0001	0.3175	0.5139	0.4408	0.8662	0.1355

SR: stripe rust, OWBM: orange wheat blossom midge, YLD: Yield, PRO: protein, TWT: test weight, TKW: thousand kernel weight,FN: falling number

Objective 5: Determine the interaction between Sm1 resistant varieties and plant growth regulators

Results

This study was conducted to compare the treatment effects of Cerone and Lorsban when applied to CAP 400-1, an experimental cultivar with resistance to the OWBM, and Solano, a non-resistant cultivar. The study was planted as a split-plot design with three replications. Cerone treatments were applied at a rate of 0.75 pt/A, at early boot, on June 26. Lorsban treatments were applied at a rate of 1 pt/A, at heading, on July 2.

The main effect of PGR and insecticide treatments had a significant effect on heading date, yield and thousand kernel weights (Table 7). Cerone applied alone or in combination with Lorsban, delayed heading by two days and resulted in lower thousand kernel weights. The combination of Cerone with Lorsban produced the highest yields.

Table 7. Main effect of PGR and insecticide inputs on Spring Wheat. 2013

Input	HD Julian	HT in	OWBM no/spk	YLD bu/A	PRO %	TWT lb/bu	TKW g	FN sec
Check	184	35.5	12.2	84.1	15.0	61.6	37.3	376.0
Cerone	186	35.8	8.4	83.6	15.2	61.5	36.4	367.3
Lorsban	184	37.3	5.7	92.6	14.1	62.3	37.9	361.3
Cerone & Lorsban	186	34.9	4.8	100.9	14.9	62.3	36.8	387.5
LSD	0.9	1.9	6.1	13.3	1.7	0.8	0.5	54.1
Pr>F	0.0019	0.0881	0.0895	0.0555	0.4898	0.0837	0.0009	0.6792

HD: heading, HT: height, OWBM: orange wheat blossom midge, YLD: yield, PRO: protein, TWT: test weight, TKW: thousand kernel weight, FN: falling number,

Significant differences were observed with the main effect of cultivar (Table 8). CAP 400-1 afforded complete control of OWBM, and resulted in higher test weights and falling number values than Solano. Solano had higher thousand kernel weights. Although Solano had significantly greater owbm numbers, Solano and CAP 400-1 had similar yields when averaged over PGR and insecticide inputs. However, Interactions were observed for yield (Table 9).

Table 8. Main effect of variety on agronomic performance of spring wheat. 2013

Input	HD Julian	HT in	OWBM no/spk	YLD bu/A	PRO %	TWT lb/bu	TKW g	FN sec
CAP 400-1	185	34.9	0.0	89.8	14.8	62.4	34.6	413.7
Solano	185	36.8	15.5	90.8	14.8	61.5	39.6	332.4
LSD	1	2.2	4	4.2	0.6	0.4	0.4	27.3
Pr>F	0.7200	0.0799	0.0001	0.6260	0.9287	0.0011	0.0001	0.0001

HD: heading, HT: height, OWBM: orange wheat blossom midge, YLD: yield, PRO: protein, TWT: test weight, TKW: thousand kernel weight, FN: falling number, Overall, Cerone plus Lorsban afforded the greatest yield increase for both CAP 400-1 and Solano. However, Solano also benefitted from lorsban applied alone. These results indicate that there could be a synergistic effect to yield by applying lorsban plus cerone, regardless of the variety.

Table 9. Effect of PGR and insecticide on spring wheat agronomic performance. 2013

Input	HD Julian	HT in	OWBM no/spk	YLD bu/A	PRO %	TWT lb/bu	TKW g	FN sec
				CAP 400-1				
Check	184	35.1	0.0	83.0	15.0	62.1	34.5	429.7
Cerone	186	34.2	0.0	88.6	15.1	62.2	34.2	410.7
Lorsban	184	36.6	0.0	88.8	14.2	62.7	35.4	391.7
Cerone & Lorsban	186	33.7	0.0	99.0	15.0	62.6	34.4	422.7
				Solano				
Check	184	35.8	24.3	85.3	15.0	61.0	40.1	322.3
Cerone	186	37.4	16.8	78.7	15.2	60.8	38.5	324.0
Lorsban	184	38.1	11.4	96.4	14.1	62.0	40.4	331.0
Cerone & Lorsban	186	36.1	9.6	102.7	14.8	62.1	39.2	352.3
LSD	2.1	4.4	7.9	8.4	1.2	0.8	0.8	54.7
Pr>F	0.9860	0.8167	0.0618	0.0429	0.9799	0.3647	0.1474	0.5560

HD: heading, HT: height, OWBM: orange wheat blossom midge, YLD: yield, PRO: protein, TWT: test weight, TKW: thousand kernel weight, FN: falling number,

Objective 6: Evaluation of spring wheat cultivars for susceptibility to the OWBM

Results

Germplasm from the off-station spring wheat nursery was evaluated for susceptibility to the OWBM in order to determine if alternative resistance mechanisms might exist (Table 10). Midge densities were extremely low, averaging only 15 larvae per spike. The highest midge densities recorded were found on Hank (31), Jefferson (26.7) and Oneal (26.3). In contrast, the lowest larvae numbers were recorded for the CAP lines. Not surprisingly, the CAP lines afforded almost complete control of the larvae. In addition, Reeder and MT1172 both had low midge numbers, at 8.3 larvae per spike for both entries.

Yields generally declined as larvae numbers increase, but yield results were confounded by the effects of stripe rust, which averaged 36% for the nursery. Yields averaged 66 bu/A, ranging from a high of 94 bu/A for Volt to a low of 48 for AP604CL and Choteau. Several entries had falling number values less than 300, but this did not appear to be related to midge numbers.

Overall, the results of this nursery substantiate previous finding, where Hank is considered highly attractive/susceptible to the midge, and Reeder is unattractive. The most interesting observation is that MT1172 is similar to Reeder in attractiveness to midge egg-laying. This may provide another option in areas where Reeder is not well adapted.

Table 10. Agronomic performance of commercial spring wheat varieites.

Cultivar	HD Julian	HT in	SR %	OWBM no/spk	YLD bu/A	PRO %	TWT 13%	TKW 13%	FN sec
AP604CL	180	37.7	95.3	15.7	47.9	14.1	60.6	31.2	330.0
Brennan	181	30.2	34.7	17.0	74.4	15.6	60.7	35.4	248.2
BuckPronto	180	35.8	13.3	11.3	66.5	16.6	60.3	42.6	325.2
CAP 197-3	183	38.1	36.0	0.0	78.0	13.7	59.9	32.4	343.4
CAP 34-1	182	33.6	54.7	5.0	72.2	13.8	60.6	33.6	362.9
CAP 400-1	184	39.2	4.7	0.0	84.4	16.3	61.1	33.8	446.6
CAP219-3	181	36.3	44.0	0.0	73.7	14.1	60.3	32.7	354.2
Choteau	183	35.0	46.0	14.0	48.3	15.6	59.0	35.4	368.7
Corbin	181	35.5	28.3	21.3	60.8	15.7	60.7	42.5	344.7
Duclair	181	37.3	27.3	12.0	55.3	16.2	58.4	38.7	294.9
Fortuna	183	46.7	18.7	14.7	55.1	15.7	59.3	39.8	302.6
Hank	180	31.9	71.0	31.0	54.5	14.9	57.0	38.5	237.2
Jefferson	181	37.4	20.3	26.7	75.6	15.2	61.6	41.1	334.1
Kelby	180	30.8	39.0	18.3	54.6	16.0	59.7	33.2	203.0
McNeal	184	38.3	21.7	16.3	57.7	15.6	59.5	35.4	453.4
MT 1053	183	35.3	42.3	19.0	62.8	15.0	59.0	38.6	262.1
MT 1142	182	39.8	17.3	17.3	75.3	16.1	61.5	37.6	358.4
MT 1172	183	37.2	2.3	8.3	74.6	16.2	57.8	39.6	303.4
Oneal	184	36.3	64.3	26.3	44.0	15.2	57.8	31.6	388.5
Reeder	182	39.5	12.3	8.3	84.9	15.1	61.4	37.2	388.9
Solano	183	29.0	4.7	23.3	71.6	16.3	59.7	40.8	315.4
Vida	184	37.9	15.3	17.0	69.6	15.9	59.5	37.2	278.4
Volt	188	37.3	0.0	16.3	94.6	14.3	62.2	36.2	393.0
WB9879CLP	182	36.1	46.7	17.7	60.5	15.8	58.0	33.9	377.5
Mean	182	36.3	31.7	14.9	66.5	15.4	59.8	36.6	334.0
LSD	1.1	2.7	11.4	12.8	15.7	0.7	1.0	3.3	42.9

HD: heading, HT: height, SR: stripe rust, OWBM: orange wheat blossom midge, YLD: yield, PRO: protein, TWT: test weight, TKW: thousand kernel weight, FN: falling numbers.

Objective 7: Verify varietal preference behavior and trap performance using on-farm evaluations.

Results

Previous studies conducted at NWARC have demonstrated that certain spring wheat varieties attract the adult egg-laying midge, while other varieties deter egg-laying. To test this apparent preference trend under a field scale basis, Reeder (non-attractive) and Solano (attractive), were planted at five on-farm locations in Flathead County. Field size ranged from 5 to 16 acres per variety. The locations selected had a previous history of substantial OWBM pressure.

Fields were seeded at 100 lb/A (Reeder) and 135 lb/A (Solano) to achieve a target population of 35 plants per square foot. Planting was delayed until approximately May 1, to insure that heading coincided with peak oviposition (Table 1). Reeder, a taller variety and therefore prone to lodging, was treated with Palisade, a plant growth regulator, at the 2 node stage to all fields except the Passmore site. The insecticide, Warrior II, was applied at each location when OWBM populations reached economic threshold levels.

Table 11. Material and Methods

					OWBM	
Location	Seeding	Harvest	Palisade	Insecticide	#/ trap	Date
HCF	5/6	8/22	6/22	7/6	660	6/24-6/27
NWARC	5/9	9/12	6/21	7/9	1010	6/29-7/1
Passmore	5/1	8/25	–	7/5	161	6/27-7/1
Tutvedt	4/27	9/4	6/19	7/5	1115	7/2-7/4

Despite high OWBM numbers observed at all locations (Table 11), there were no significant differences in the number of larvae found per spike (Table 12). Significant differences were observed in plant height with Reeder being on average was 5 inches taller than Solano.

Table 12. Agronomic data from the on-farm comparison of varietal preference to egg-laying by OWBM

	Plant Density #/sqft		Height inches		OWBM no/spike		Yield bu/A	
Location	Reeder	Solano	Reeder	Solano	Reeder	Solano	Reeder	Solano
HCF	**25**	26	**28**	27	**4**	7	**42**	41
NWARC R13	**32**	23	**36**	33	**5**	1	**70**	100
NWARC Y7	**40**	30	**38**	33	**6**	12	**73**	85
Passmore	**26**	28	**38**	31	**1**	3	**69**	88
Tutvedt	**19**	34	**36**	28	**0**	0	**97**	107
Mean	**28**	28	**35**	30	**3**	5	**70**	84
LSD	12.6		3.6		4.6		14.2	
Pr>F	0.9669		0.0200		0.4466		0.0524	

OWBM: orange wheat blossom midge

On average, Solano produced 14 bu/A more grain than Reeder. However, yields were confounded by hail damage at three of the five locations, with Reeder being more susceptible to hail damage. Grain quality was similar between the two varieties (Table 13).

Table 13. Agronomic data from the on-farm comparison of varietal preference to egg-laying by OWBM

	Protein %		FNa seconds		FNb seconds		TWT lb/bu	
Location	Reeder	Solano	Reeder	Solano	Reeder	Solano	Reeder	Solano
HCF	17.4	16.7	386	375	451	387	56	54
NWARC R13	14.8	15.3	385	355	353	391	59	60
NWARC Y7	15.7	15.4	345	334	425	356	59	60
Passmore	14.6	15.3	331	401	394	460	62	61
Tutvedt	14.9	14.2	369	354	417	367	60	60
Mean	15.5	15.4	363.2	364	408	392	59	59
CV	3.0		7.6		11.1		1.7	
LSD	0.8		49.1		78.3		1.8	
Pr>F	0.7530		0.9746		0.6052		0.6051	

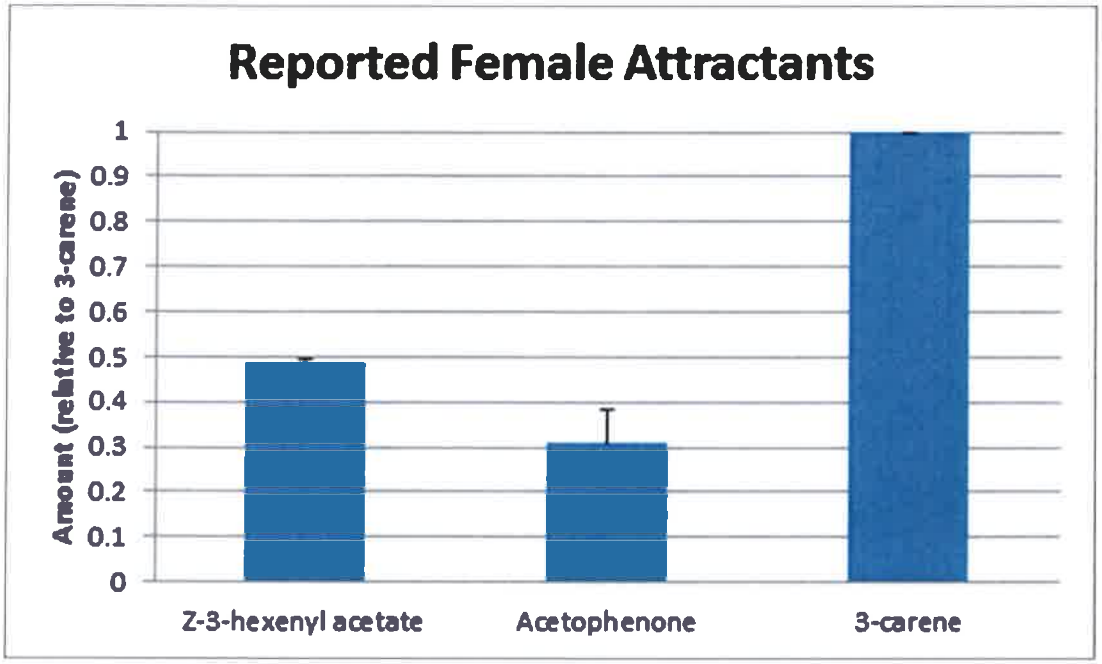
Fna: falling numbers tested at NWARC, FNb: falling numbers tested at the Nat'l Quality Inspection Lab, TWT: test weight

In small nursery plot situations, Reeder usually has far fewer midge larvae than Solano. This in turn translates to higher yields and better quality for Reeder. Either the application of an insecticide negated this advantage, or perhaps this ovipositioning dynamic does not hold when the varieties are grown on a large scale basis. Differential hail damage between varieties further complicates the results. It would be advantageous to repeat this exercise one more year. Overall, it seems beneficial to scale-up experiments in an attempt to substantiate preliminary findings.

Although attractiveness of midge to wheat varieties is of interest, we are also interested in attractiveness among midges. We conducted two sets of experiments with OWBM semiochemicals. The first was a simple comparison of pheromone lures from two suppliers. Given the importance of monitoring the spread of OWBM in the Triangle, we want to use the best one. This trial will be conducted again in the coming weeks because the initial comparison used lures that had been in the inventory for one supply for too long.

The second experiment was to test reported female OWBM attractants from a study conducted in England as lures for capturing females. In previous years, we collected volatiles from attractive and unattractive MT spring wheat varieties and found that these contradicted the published study. In 2013 we prepared lures in the compound ratios reported in the published paper. We targeted using approximately 100 wheat head equivalents of (*Z*)-3- hexenyl acetate, 3-carene and acetophenone in lures (Figure 1) and placed them in the same traps used for capturing male OWBM with pheromone. The lures did not catch a single female OWBM, which was not expected. The field location had a large OWBM infestation and we trapped during peak flight. An adjacent field baited with OWBM pheromone traps had average daily capture of male OWBM that were greater than 50. Therefore we can definitively conclude that these compounds are not suitable for lures for female OWBM in this MT population because MT spring wheat does not produce all of them and the females display no innate response to these.

Figure 1. Proportions of three reported female OWBM attractants.



Summary:

One of the most significant finding from this season is the fact that the orange wheat blossom midge has become well established in Pondera County, and to a lesser extent, can be found in other counties throughout the Golden Triangle. Further, reports indicate a resurgence of the midge in northeastern Montana as well.

Thanks to funding from the Montana Wheat and Barley Committee, our monitoring efforts have enabled us to alert affected growers, making them aware of the negative effects of this pest. This proactive strategy has helped to minimize the negative economic consequences of the midge. However, the insects' exact distribution is uncertain, and it may be established in other parts of Montana as well. It is for this reason that expanding our monitoring and education efforts throughout Montana would seem like a prudent response.

We are fortunate to have several management options available to combat this pest. One of the most economical and effective strategies is the use of resistant varieties. Efforts to incorporate the *Sm*1 gene into Montana adapted varieties have progressed well. Several lines have been identified that have resistance to the midge, while also possessing excellent agronomic and quality attributes. In particular, CAP400-1 has resistance to the midge and stripe rust. In addition, we anticipated that midge might become established in areas where the wheat stem saw fly is also present. As such, we have several experimental lines that contain the Sm1 gene and also possess the solid stem trait. These efforts will take on a greater urgency now that we have confirmed that the midge has expanded into saw fly country.

Efforts to conserve this resistance trait are very important. Our preliminary results indicate that blending resistant and susceptible wheat varieties is a viable strategy to delay the development of resistant midge populations. The use of an interspersed refuge can allow a low number of midges to reproduce without sacrificing yield or quality.

While the resistant gene is highly effective, this season efforts reconfirmed that midge larvae negatively impact grain yield even in materials that carry the Sm1 gene. The gene does cause mortality, which in turn reduces future midge densities and yield loss. However, yield reductions still occur as a result of the lag phase between the initial feeding, and the production of the toxic compound(s). The end result being that we observed a significant economic benefit to using insecticides in conjunction with the resistant spring wheats. In short, both tactics may be needed to maximize profits, depending on midge numbers. Towards that end, it would seem that separate economic thresholds should be used for susceptible and resistant spring wheat varieties.

We evaluated the use of plant growth regulators in an effort to shorten this lag phase between initial feeding damage and the production of the toxin. Low midge densities prevented a robust assessment of this strategy. However, preliminary results indicate a possible synergistic effect to applying a plant growth regulator plus an insecticide.

We continue to screen germplasm for new forms of plant resistance. Previous efforts have demonstrated that certain varieties seem to deter egg-laying (Reeder) while other varieties seem to encourage it (Solano). Five on-farm comparisons between Reeder and Solano were established to see if this differential egg-laying behavior transferred to large scale settings. There were no differences between varieties for owbm numbers, but this may have been due to the application of an insecticide treatment. Future comparisons should include non-treated areas as well.

Funding Summary:

Budget information to be provided by OSP. No other support for this project.

MWBC FY2011 Grant Submission Plans: Resubmittal is planned

Orange Wheat Blossom Midge

By Bob Stougaard and Brooke Bohannon, Northwestern Agricultural Research Center; Dan Picard and Gadi V.P. Reddy, Western Triangle Agricultural Research Center; Luther Talbert, Dept. Plant Science and Plant Pathology; Kevin Wanner, Dept. Animal and Range Science; and David Weaver, Dept. Land Resources and Environmental Sciences

Introduction

The Flathead Valley experienced an unprecedented insect outbreak during the 2006 growing season. This new pest, called the orange wheat blossom midge, proved to be devastating (Figure 1). Spring wheat fields that normally would have yielded 80 to 90 bushels per acre instead produced less than 2 bushels!

A conservative estimate put the economic loss at over 1.5 million dollars in Flathead County. The midge has since been a reoccurring problem in northwestern Montana and its distribution has expanded into other parts of the state.

The wheat midge is widely distributed throughout Europe and Asia and has long been recognized in many parts of North America. However, it has only recently developed into a serious insect pest of spring wheat. During the 1980's, the wheat midge became a key pest of spring wheat, with outbreaks occurring in the prairie provinces of Canada.

The outbreak spread throughout western Canada and the northern Great Plains of the United States by the early 1990s. Significant damage to spring wheat crops has been reported in Alberta, Saskatchewan, Manitoba, Minnesota, and North Dakota. The midge also has been reported in southern British Columbia, and the panhandle of Idaho.

Figure 1. Adult wheat midge.

The 1990's outbreak resulted in low numbers of the wheat midge being reported in northeastern Montana. However, the 2006 outbreak in northwestern Montana was the first report of any economic significance in the state.

Unfortunately, the distribution of the midge appears to be expanding. The midge has recently been reported in several counties in the Golden Triangle production area. In addition, there also appears to be a resurgence of the midge in the northeastern part of Montana.

The insects' exact distribution is uncertain, but it may be established in other parts of Montana as well. The midge can remain undetected and exist at low populations for several years before becoming a significant problem. However, as was the case in the Flathead Valley, populations have the potential to increase rapidly when given the proper set of climatic conditions.

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Damage

The wheat midge may be small, but its effects on wheat yields and local agricultural economies can be huge. Yield losses of more than 7 million bushels were reported in North Dakota during 1995, while economic losses in Canada can exceed $100 million when insecticide costs and dockage penalties are considered along with yield reductions.

Spring wheat is the primary host in North America, while winter wheat is the key host in Europe and Asia. That said, the midge can be found in winter wheat fields in Montana and may reproduce on late developing tillers. Durum wheat is another important host, with spring rye and triticale also being vulnerable. Barley can be an occasional host, but larvae development is rare.

Damage to the crop is not readily apparent since the insect feeds inside the wheat head. Damage can only be detected by threshing the heads and by inspecting the kernels. Upon inspection, orange-colored larvae can be found feeding on the developing seed (Figure 2). The larvae feed by exuding enzymes which break down cell walls and convert starch to sugar. Each larva is capable of reducing grain size by 30 to 50 percent, and it's not uncommon to find several larvae feeding on a single kernel.

Figure 2. Midge larvae feeding on wheat kernel.

The kernels may abort entirely, not fully develop, or only be slightly damaged. The extent to which the kernel is damaged largely depends on the number of larvae present as well as when feeding begins relative to the development of the kernel; smaller, immature seeds are most vulnerable to damage, while the larger more developed kernels are less affected (Figure 3). Concurrently, wheat plants are most susceptible when feeding occurs during early heading and declines once flowering is complete.

Figure 3. Midge-damaged wheat kernels.

The most obvious impact of this pest is a reduction in yield. However, more subtle effects also occur. Small, shriveled seed and low test weights are common occurrences and are often mistaken for the effects of frost damage or drought stress. Damage to the seed coat allows easier water entry, often resulting in sprout damage and low falling numbers.

In addition, damaged seeds are generally more susceptible to attack from pathogenic fungi, which can reduce germination and seedling vigor and result in dockage due to mold. Furthermore, the adults can act as a vector for diseases that infect wheat seeds (wheat scab and glume blotch).

The Enemy

The insect has one generation per year with four distinct life stages: egg, larval, pupal, and adult. The larvae over-winter within the top two to four inches of the soil surface inside a cocoon. As soil conditions improve in the spring, the larvae become active, emerge from the cocoon, and move closer to the soil surface to pupate.

Larvae can often be found on the soil surface during the last week of May if soil moisture is adequate (Figure 4). If soil conditions are dry, the larvae remain dormant (diapause). Dormancy periods of five years are not uncommon, and some reports indicate that these periods can last up to 13 years.

Northwestern Agricultural Research Center

Figure 4. Midge larvae on soil surface.

Once the midge has passed to the pupal stage, the adults will typically begin to emerge within two weeks. Pupation and adult emergence largely depends on soil temperatures. However, soil moisture also is critical, and June thunderstorms are often associated with major outbreaks. Adult emergence occurs over an extended period, with peak emergence occurring from mid-June to mid-July. However, the emergence period can extend into August.

The newly formed adult midge is a very small, orange-colored fly about half the size of a mosquito. Adults are relatively poor fliers, but they may be distributed over long distances by thermal updrafts and wind. During the day the adults stay within the crop canopy where humidity levels are high. In the evening the females become active, flying about and laying eggs on newly developing wheat spikes.

Due to the fragile nature of the midge, egg-laying generally takes place in the evenings from about 8:30 p.m. until 11:00 pm, which coincides with higher humidity levels. In addition, egg-laying rarely occurs if wind speeds are greater than 6 mph or if air temperatures are less than 59° F. In short, warm calm evenings are required for egg laying.

The female lays eggs either singly or in groups of 3 to 5 on individual florets of the wheat spike. Although the females only live for about seven days, they will lay an average of 80 eggs. The eggs hatch in about four to seven days, depending on environmental conditions.

Upon hatching, the small orange larvae move from the outer surface of the floret to feed on the developing wheat kernel. The larvae feed for two to three weeks before climbing up the awns and dropping to the soil surface in early August. This event requires either dew or rain to trigger the phenomenon (Figure 5). Upon reaching the ground, they immediately bury themselves into the soil and form a cocoon to over-winter and repeat the cycle.

Under dry conditions the larvae will stop development, will shrink back inside the outer skin and will remain within the wheat head until moisture conditions improve. If moisture conditions do not improve, the larvae will remain in the heads and get threshed out during harvest.

Figure 5. Larvae drop from wheat heads after rain or heavy dew.

Management Considerations

Rotations:

The first reaction is to plant anything other than spring wheat or durum wheat. Winter wheat would seem to be an option since grain filling is typically well underway by the time the adults emerge and start to lay eggs. However, late developing winter wheat tillers can still be vulnerable to egg-laying adults.

It should be noted that the midge is a major pest of winter wheat in Europe and Asia. Furthermore, insects have a habit of adapting to their environment. The wheat stem sawfly is an example of a pest that successfully made the transition from spring to winter wheat. Only time will tell, but for now winter wheat appears to be a viable option.

Other cereal crops are worth considering. However, the midge does attack other grasses, including barley, rye, triticale and intermediate wheat grass. Midge infestations on these plants are usually not serious enough to warrant control. While these grasses might allow the midge to complete its life cycle, the resulting population would be much smaller when compared to continuous spring wheat.

Peas, canola and other broadleaf crops are logical options to consider, but the overall effect of crop rotations on midge numbers is only a partial solution given the fact that the insect can remain dormant for periods ranging from five to 13 years. Nevertheless, there are many reasons to consider a diversified rotation.

Insecticides:

Insecticides are available for controlling the wheat midge, but there are two points to consider before applications are made:
1) Economic Thresholds - are adult populations sufficient to warrant an application and
2) Crop Stage - is the spring wheat crop vulnerable to damage from the midge.

<u>Economic Thresholds:</u> Fields should be monitored from late boot through flowering in order to determine if populations warrant an insecticide application. There are several methods available for detecting the presence of the midge, but pheromone traps are perhaps the easiest (Figure 6). The traps should be put in fields about five days before heading, and placed at the height of the crop canopy. Periodic adjustments in trap height are needed during the monitoring period as stem elongation occurs.

The traps should be placed about 75 feet in from the field edge and spaced about 300 feet apart. Three traps per 160 acres is the recommended density. Examine the traps every one to two days for the presence of midge. Traps can be purchased from Great Lakes IPM (www.greatlakesipm.com) [Mention of a product does not constitute an endorsement or recommendation by MSU].

Figure 6. Midge adults in pheromone trap.

While pheromone traps can indicate whether or not adult emergence has occurred, their use is generally considered as an early warning system. Scouting should be initiated as soon as midge adults are found in the pheromone traps. Scouting should be done after 8:30 pm to coincide with when the females are most active, and fields should be inspected in at least 3 to 4 different locations.

Insecticide treatments are recommended if 1 or more adults are observed for every 7 to 8 heads. If wheat prices decline, treatments may be justified if there is 1 adult per 4 to 5 wheat heads.

The midge is difficult to scout for. Densities might be high, but scouting efforts may fail to reveal their true numbers if evening temperatures are less than 59^0 F, humidity is low, or wind speeds are greater than 6 mph.

And because adults emerge over several weeks, late developing tillers, or areas in the field where heading is delayed, such as low spots where soil moisture is favorable, will continue to be vulnerable to attack.

Farming practices that promote greater crop uniformity during heading have been advocated as a means to reduce midge damage and to improve insecticide efficacy. Uniform planting depths and the use of high quality, certified seed can promote uniform crop emergence, while higher seeding rates can reduce tillering. Together, these practices will favor uniform crop maturity.

<u>Crop Stage:</u> Although chemical control measures are available, their efficacy is highly dependent on precise timing of spray applications. Because adult emergence and egg-laying occurs over a period of several weeks, insecticides rarely provide complete control. However, damage can be minimized if insecticide applications are timed to protect the crop when it is most vulnerable.

Wheat is most susceptible to midge damage when egg-laying occurs from early heading through pollination (Figure 7). As such, fields should be monitored daily from the time the heads begin to emerge from the boot until the anthers are visible.

Provided that economic threshold values are present, the optimum stage to apply an insecticide is when 70% of the crop is headed. Applications prior to this growth stage will result in reduced control. In fact, if only 30% of the crop is headed, you should wait up to four days before treating. Likewise, applications made after 70% heading may result in reduced control.

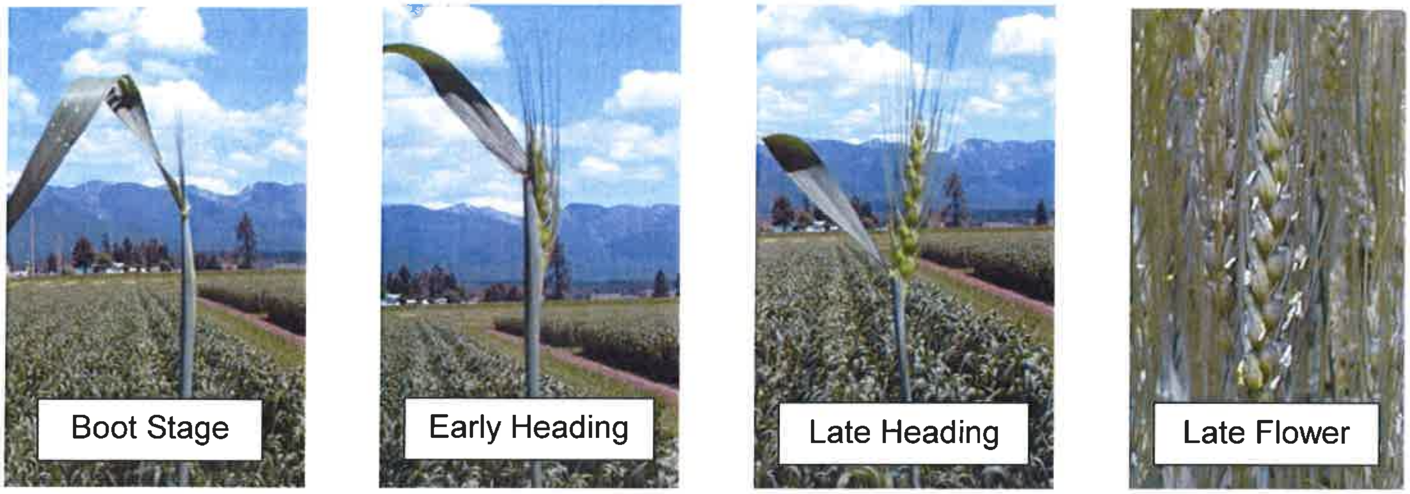

Figure 7. Highest risk of damage if egg-laying occurs from early heading to late heading.

Insecticides affect the adults as well as the emerging larvae as they eat through the outer integument of the egg. However, insecticides are not effective in controlling older larvae, which are protected within the floret of the wheat spike. As a result, insecticides applied when 75% of the plants have begun flowering do not provide adequate control. Further, late applications have the potential to kill beneficial parasitic wasps (see below).

Insecticide application is recommended at dusk because female adults are most active at this time of day. However, early morning applications may also produce acceptable results. Through spray coverage is essential, and application methods which improve the uniformity and amount of spray deposited on wheat heads provide better control.

Planting dates:

Since spring wheat is most vulnerable to attack from early heading through pollination, planting as early as possible may help the crop to develop beyond the susceptible stage before the adults begin laying eggs. Selecting early maturing varieties also would help the crop to develop sooner and avoid damage from the midge (Figure 8).

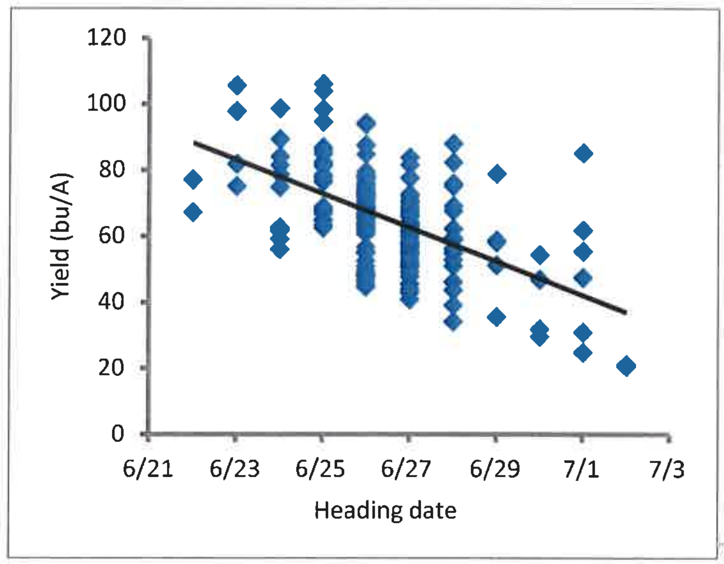

Figure 8. Effect of heading date on midge damage (symbols represent 64 different spring wheat varieties).

Canadian researchers have developed a model that estimates midge emergence and wheat growth based on accumulated degree-days. This information can then be used to estimate the last advisable planting date. The following is provided only as a rough guideline to assist in scouting efforts.

The hibernating midge larva doesn't become active until the threshold temperature of 40° F has been reached, and this is the temperature upon which the model is based.

Table 1. Midge degree day model.

DD	EVENT
450	the midge breaks the larval cocoon and moves close to soil surface and forms the pupal cocoon.
1300	10% of the females will have emerged
1475	about 50% of the females will have emerged
1600	about 90% of the females will have emerged.

Observations indicate that first 10% of the females will have emerged after 1300 degree days have accumulated (Table 1). When using 40°F as the base temperature, spring wheat heading usually occurs at around 1000 to 1100 degree days. As such, spring wheat planted before 200 degree days have accumulated will typically head before peak midge emergence.

While this provides a rough estimate of when or when not to plant spring wheat, these predictions are only estimates. The accuracy of the model is dependent on the temperatures used in calculating degree-days, and the temperatures should represent the environment where the insects are developing. Temperatures at one site only give a rough estimate of insect development at another site a few miles away.

Several factors impact the accuracy of the model. First, soil temperatures are affected by several variables including soil texture, tillage, residue cover, and topography. In addition to variable soil temperatures, crop development and maturity also varies with the spring wheat variety planted. Further, while temperatures generally drive the system, soil moisture is another critical aspect that impacts adult emergence.

All of these factors conspire together, making the use of degree-day models only rough estimates. Nevertheless, the model can be used to help eliminate unnecessary scouting and aid in making better management decisions.

Resistant Varieties:

A single resistant gene called *Sm1* has been identified that causes death of the larvae as they feed on the developing kernel. This is a highly effective gene, and several Canadian varieties have recently been released that contain this trait. Efforts are currently underway to incorporate this gene into Montana-adapted spring wheat varieties (Table 2).

Table 2. Effect of the Sm1 gene (CAP lines) on orange wheat blossom midge control, Kalispell, MT.

Cultivar	OWBM	Yield	Protein	Test wt.	FN
REEDER	46	34	16.7	59	180
HANK	102	15	16.1	52	193
CAP34-1	0	49	14.0	60	333
CAP84-1	1	41	15.5	59	320
CAP84-2	0	42	15.5	60	328
CAP108-3	0	51	15.1	59	338
CAP197-3	0	51	13.1	60	350
CAP201-2	0	46	14.1	60	303
CAP219-3	0	42	13.7	60	301
CAP400-1	0	52	17.8	56	326

OWBM: orange wheat blossom midge (no./spike).
FN: falling number (seconds).

The extreme efficacy of this gene has raised concerns about the midge population developing resistance to it. As a result, the Canadian varieties are being sold as an “interspersed refuge” where 10% of the seed is susceptible to the midge and 90% of the seed has the resistance trait. It is hoped that this strategy will prolong the utility of *Sm1* gene.

It will take a few more years to develop resistant wheats for Montana, but in the meantime, selecting early maturing spring wheat varieties is recommended to help the crop to develop out of sync with the midge.

Biological Control:

Fortunately the expression "fight fire with fire", applies to the wheat midge. A small parasitic wasp (*Macroglenes penetrans*) attacks wheat midge larvae, helping to regulate populations.

The adult parasitic wasp is about 1/10 inch long and metallic black. The adult female seeks out midge eggs in which to deposit their own eggs. The parasitized midge larva continues to feed on the developing wheat kernel, causing damage to the spring wheat crop during the current season. The mature midge larva drops to the soil, forms a cocoon and over-winters along with the dormant parasite inside its body. However, in the spring the wasp larva develops rapidly, consumes its host, and emerges as an adult in July.

Typically the wasp population lags behind the introduction of the midge by about one to three years, but once established the impact can be considerable. This parasitoid is credited with controlling about 25 to 40 percent of the midge population in parts of Canada and North Dakota. In some instances, parasitism rates of greater than 75% have been documented.

Efforts to introduce the parasitic wasp into Montana are on-going. However, proper use and timing of insecticide applications will be critical to encouraging the establishment of the wasp. Insecticides should only be used if current year populations of the wheat midge exceed the economic threshold. And insecticide use should be avoided if the crop has reached 75% flowering.

Summary:

Fortunately there are several tools available for managing the midge. Each individual management tactic has merit. But, as with most pest problems, an integrated approach that uses a combination of methods will be necessary in order to minimize damage from the orange wheat blossom midge.

Efficacy of Entomopathogenic Fungi and Nematodes and Low Risk Insecticides against Wheat Stem Sawfly, *Cephus cinctus* (Hymenoptera: Cephidae)

Principle Investigator: Dr. Gadi V.P. Reddy

Cooperators: Dr. Khanobporn Tangtrakulwanich, Dr. Shaohui Wu, John H. Miller, Victoria L. Ophus, Julie Prewitt.

Western Triangle Agricultural Research Center, Montana State University, 9546 Old Shelby Rd., Conrad, MT 59425, USA

Abstract

Entomopathogenic nematodes, fungi, and low risk insecticides were evaluated for the management of the wheat stem sawfly, *Cephus cinctus* Norton, in winter wheat at two locations (Devon and Western Triangle Ag Research center) in the Golden Triangle area of Montana (USA) in 2013. Two fungi (*Beauveria bassiana* and *Metarhizium brunneum*), four nematodes species (*Steinernema carpocapsae*, *Steinernema kraussei*, *Steinernema feltiae*, and *Heterorthabditis bacteriophora*), an insect growth regulator (diflubenzuron), and a botanical-based chemical (azadirachtin) were used as foliar pesticides. These control agents significantly reduced damage caused by *C. cinctus* larvae, compared to the untreated control or treatment with water alone. No yield differences were observed among entomopathogenic fungi, nematodes, and low risk insecticides. The effectiveness of botanical-based chemical (azadirachtin), insect growth regulator (diflubenzuron), the entomopathogenic fungi, and the nematodes persited at the 28th day post application, by which time the wheat had been harvested. Stubble collected after harvest showed significantly fewer sawfly larvae in the plots treated with entomopathogenic fungi, nematodes, diflubenzuron, and azadirachtin compared to the untreated and water spray plots, indicating that these biorational pesticides are alternatives to control the wheat stem sawfly larvae with conventional pesticides.

This study was aimed to investigate the potential use of these biorational control agents for the management of *C. cinctus*.

Materials and Methods

Trial design and location

Two trials were conducted, one at the Western Triangle Agricultural Research Center (WTARC) (N48°18′.24.88 W111°55′28.45) and the other in Devon, Montana (N48°33′14.94′W111°23′42.96). The experiments were carried out from May-September 2013. Winter wheat Yellowstone variety was used for these trials. The wheat was seeded at the rate of 194 live seeds per m^2. In both trials, the wheat was planted in 5 rows, with 30 cm between rows. Glyphosate (Roundup Powermax) was applied at the rate of 2.5 L/ ha (active ingredient of 540g/L of acid glyphosate) before the wheat was seeded to control weed growth. Fertilizer N, P,

and K ratio at 224.2, 0, and 22.4 kg/ha was broadcasted while planting, and an additional application of 12.3, 25.2, and 0 kg/ha of these three nutrients were placed through seed plot drill. The treatment plots were arranged in a complete randomized design (CRD) with four replicates. Treatment plots were 8 m × 4 m and separated from other plots by 2 m buffers to avoid spray drift. Each plot consisted of four rows. Standing plants were counted after seed germination. There were approximately 142 standing plants per m^2 in each plot. In each plot, control agents (Table 1) were sprayed after stem elongation had begun. Treatment materials were mixed in a Chapin Lawn & Garden Sprayer, tank capacity 7.6 L, pressure ranges 241 to 310 Kpa.
Stem damage was assessed weekly after treatment by counting the number of stems lodged in randomly selected $1m^2$ areas. The 1 m^2 quadrat was randomly thrown into each plot to determine the area to assess the stem damage. The wheat was harvested in late September 2013. A Hege 140 plot combine was used to thresh the wheat plots and the grain yield was recorded as grain weight in each plot divided by the plot area. To measure pest density after harvest, three pieces of wheat stubble were randomly uprooted from each plot at 1, 2, 3 and 4 weeks after harvest and the number of *C. cinctus* larvae inside stems recorded.

Statistical analyses
Analyses of variance (ANOVA) was used to analyze differences among treatments in yield, percentage of stems damaged, and number of sawfly larvae per stubble. Means were compared using the least square difference (LSD) test. Values of $P < 0.05$ were considered significantly. All analyses were conducted using SAS version 9.3.

Results

Stem damage
In the first week after treatment, there were no significant differences among the untreated control, water spray, *B. bassina, S. carpocapsae, S. kraussei. S. feltiae, H. bacteriophora,* Dimilin, and Aza-Direct plots ($F_{8, 63} = 0.50$, $P > 0.05$; Figure 1). Plots treated with *M. brunneum* had significantly lower stem damage compared to other treatments ($F_{9, 70} = 2.24$, $P < 0.05$). In the second weeks, we found no significant differences among the untreated, *B. bassiana, S. carpocapsae, S. kraussei* plots ($F_{3, 28} = 0.77$, $P > 0.05$). There were no significant differences among plots treated with *M. brunneum, S. carpocapsae, S. kraussei, S. feltiae, H. bacteriophora,* Dimilin, and Aza-Direct ($F_{6,49} = 0.61$, $P > 0.05$). The plots treated with *B. bassiana* had significant lower stem damage compared to other treatments except for plots treated with *S. feltiae* and Aza-Direct ($F_{9, 70} = 2.24$, $P < 0.05$). Stem damage in the third week was not significantly different among the untreated control, water spray, and treatment with *B. bassiana, S. kraussei, H. bacteriophora,* or Dimilin ($F_{5, 42} = 0.59$, $P > 0.05$). No significant differences were found among treatment with *M. brunneum, S. carpocapsae,* and *S. feltiae* ($F_{2, 21} = 0.12$, $P > 0.05$). These three treatments differed significantly to the untreated, water spray, and *B. bassiana* plots ($F_{5, 42} = 2.35$, $P < 0.05$) but did not differ significantly from treatments with *S. kraussei, H. bacteriophora,* and Dimilin ($F_{5, 42} = 0.24$, $P > 0.05$). Plots treated with *B. bassiana* had significant lower stem damage compared to other treatments ($F_{9, 70} = 2.34$, $P < 0.05$) in the third week after spray. In the fourth week, there were no significant differences between the untreated and water spray plots ($F_{1, 14} = 0.58$, $P > 0.05$). Both the untreated control and water spray treatment had significant higher stem damage than treatments with *B. bassiana, M.*

brunneum, S. carpocapsae, S. kraussei, and *S. feltiae* ($F_{6, 49} = 3.46$, $P < 0.05$). No significant differences were found among water spray, *B. bassiana, M. brunneum, S. carpocapsae, S. kraussei,* and *S. feltiae* ($F_{5, 42} = 1.15$, $P > 0.05$). No stem damage was found in treatments with *H. bacteriophora,* Dimilin and Aza-Direct (Figure 1).

Number of larvae

In the first week after treatment, all other treatments had significantly more larvae than plots treated with *S. carpocapsae* ($F_{9, 70} = 2.05$, $P < 0.05$) (Figure 2). No significant differences were found among the untreated control, water spray, *B. bassiana, M. brunneum, S. kraussei, S. feltiae, H. bacteriophora,* Dimilin, and Aza-Direct plots ($F_{8, 63} = 1.11$, $P > 0.05$). In the second week, the untreated plots showed significantly higher number of larvae than other treatments, except for water spray control plots ($F_{9, 70} = 3.04$, $P < 0.05$). There was no significant differences between the untreated and water spray plots ($F_{1, 14} = 0.77$, $P > 0.05$). Plots treated with *B. bassiana, M. brunneum, S. kraussei, H. bacteriophora,* Dimilin, and Aza-Direct did not differ significantly in number of larvae ($F_{5, 42} = 1.68$, $P > 0.05$). Plots treated with *S. carpocapsae* and *S. feltiae* had significantly fewer larvae than other treatments ($F_{9, 70} = 2.45$, $P < 0.05$) (Figure 2). For week 3, the untreated and water spray plots had significantly more larvae than other treatments ($F_{9, 70} = 2.34$, $P < 0.05$). There were no significant differences in the number of larvae found among treatments with *S. carpocapsae, S. kraussei, H. bacteriophora,* Dimilin and Aza-Direct ($F_{4, 35} = 0.94$, $P > 0.05$). Plots treated with *B. bassiana, M. brunneum,* or *S. feltiae* had significantly fewer larvae than other treatments ($F_{9, 70} = 2.23$, $P < 0.05$). For the fourth week, only the untreated and water spray plots had significantly more larvae than other treatments ($F_{9, 70} = 4.39$, $P < 0.05$). In the fourth week, the water spray treatment did not have a significantly different effect from the untreated control ($F_{1, 14} = 0.00$, $P > 0.05$), and no larvae were found in plots treated with *B. bassiana, M. brunneum, S. carpocapsae, S. kraussei, S. feltiae, H. bacteriophora,* Dimilin and Aza-Direct.

Effect on yield

There were no significant differences in wheat yield between the control plots and plots treated with water ($F_{1, 14} = 0.15$, $P > 0.05$). There were no significant difference in yield among plots treated with *B. bassiana, M. brunneum, S. carpocapsae, S. kraussei, S. feltiae, H. bacteriophora,* Dimilin, and Aza-Direct. However, plots treated with these agents produced significantly higher yield than either the untreated control or the water spray plots ($F_{9, 70} = 2.27$, $P < 0.05$) (Figure 3).

Acknowledgements

This work was supported by United States Department of Agriculture- Cooperative Regional Project W3185 Biological Control in Pest Management Systems of Plants and Montana Wheat and Barley Committee. We would like to thank Julie Prewitt for assistance with field work.

Table 1. Materials and rates applied in each treatment

Treatment	Active Ingredient	Dose	Source
T1: Control (no spray)	No treatment	-	-
T2: Water spray	-	-	-
T3: Mycotrol® 22WP)	*Beauveria bassiana Strain*	2.4 grams/L of water	Laverlam International Corporation, Butte, MT
T4: Met 52G	*Metarhizium brunneum* Strain F52	5 grams/liter	Novozymes, Davis, CA
T5: Millenium®	*Steinernema carpocapsae*	1 mil/13 liters	Becker Underwood Ames, Iowa 50010
T6: Nemasys® L	*Steinernema kraussei*	1 mil/13 liters	Becker Underwood Ames, Iowa 50010
T7: Nemasys®	*Steinernema feltiae*	1 mil/13 liters	Becker Underwood Ames, Iowa 50010
T8: Nemasys® G	*Heterorhabditis bacteriophora*	1 mil/13 liters	Becker Underwood Ames, Iowa 50010
T9: Growth Hormone (Dimilin)	Benzoylurea-type insecticide of the benzamide class	0.5grams/liter	Chemtura company, Middlebury, CT
T10: Neem (Aza-Direct)	Azadirachtin 1.2%	5 mil/liter	Gowan Company, Yuma, AZ

Figure 1

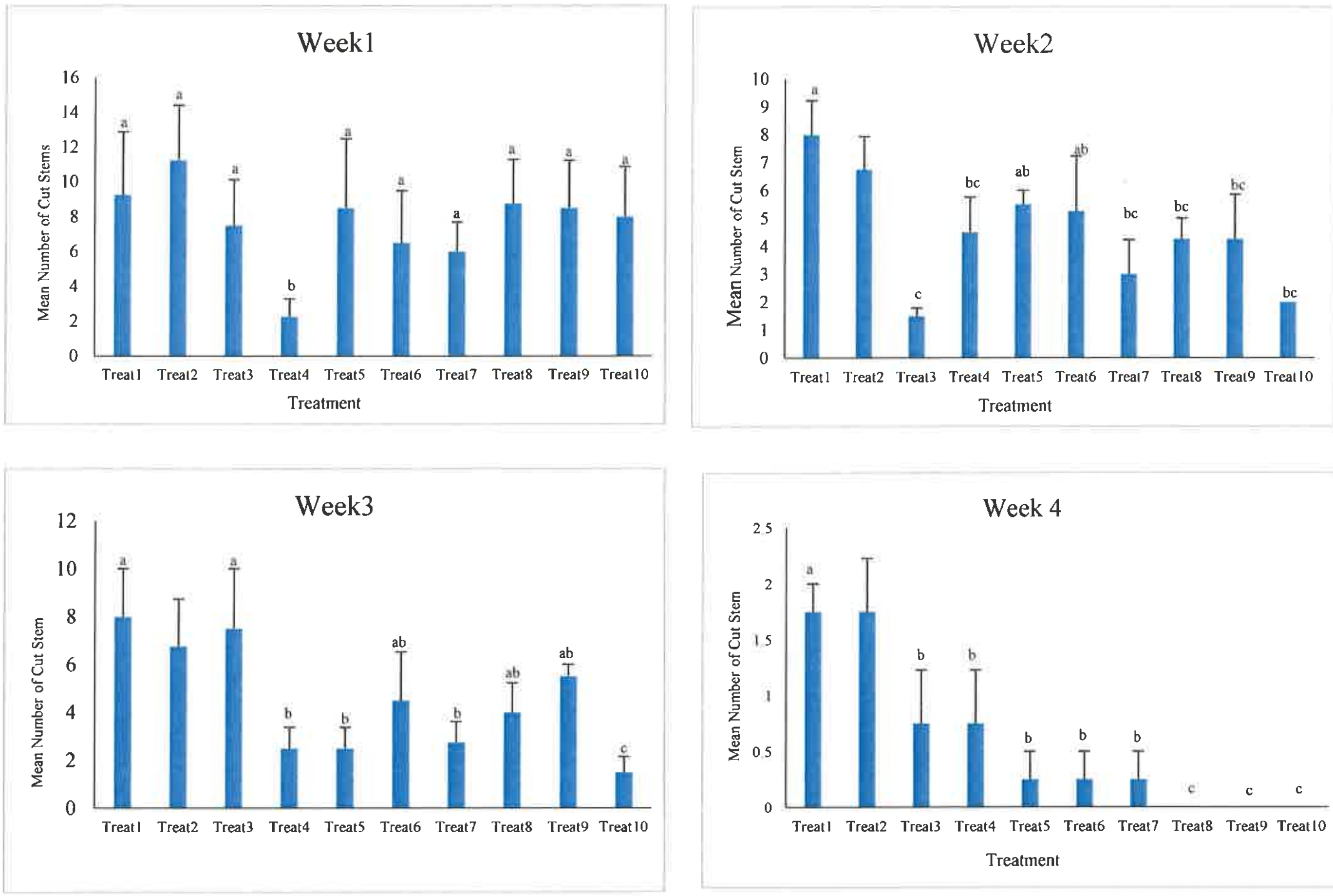

Figure 1. Percentage of cut stem in plots treated with control materials for *Cephus cinctus* (mean ± SEM). Different letters indicate significant differences (Two-way ANOVA, LSD test, α=0.05). T1= control (no treatment); T2= control (water spray); T3= *Beauveria bassiana*; T4= *Metarhizium brunneum*; T5= *Steinernema carpocapsae*; T6= *Steinernema kraussei*; T7= *Steinermema feltiae*; T8= *Heterorhabditis bacteriophora*; T9= Dimilin; T10= Neem (Aza-Direct).

Figure 2

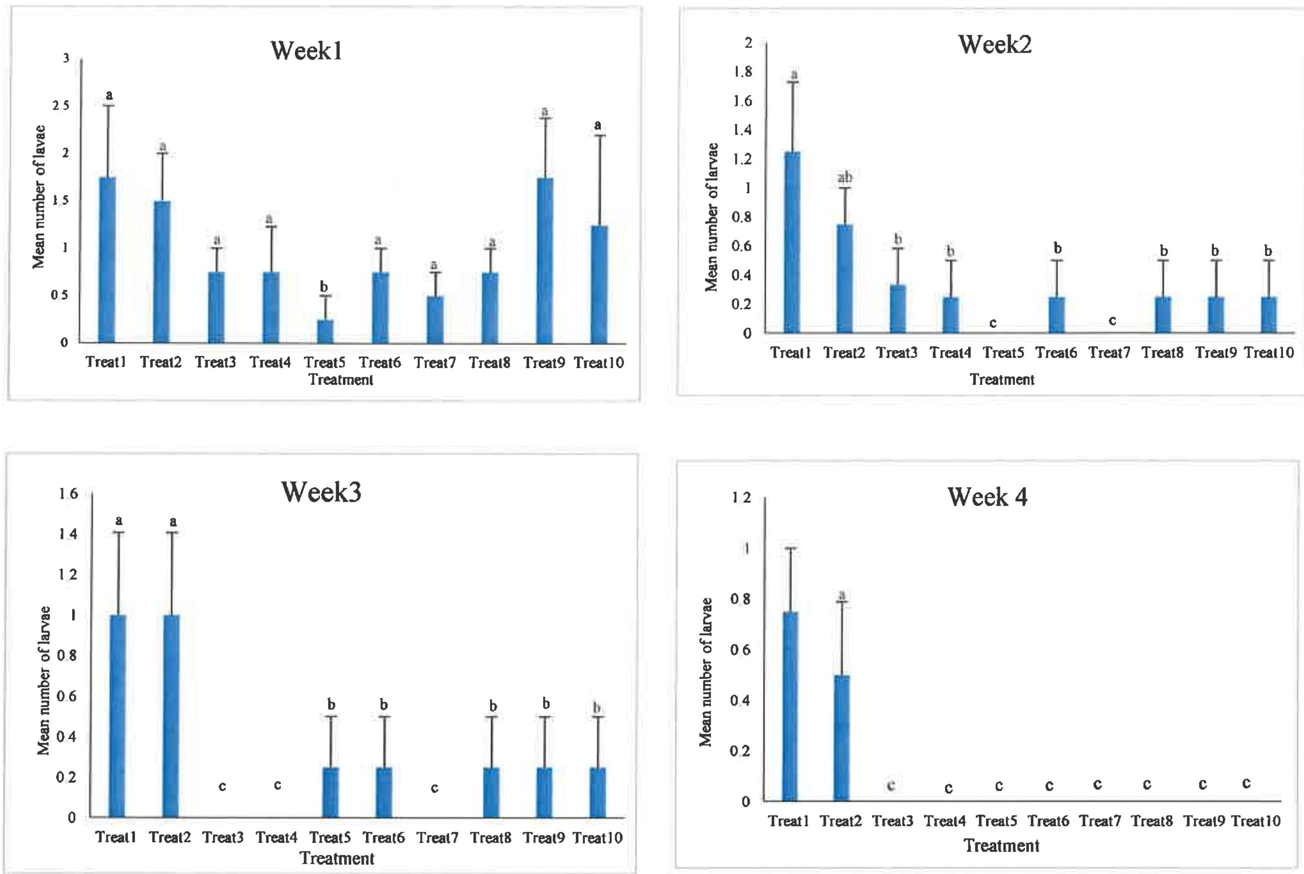

Figure 2. Number of *Cephus cinctus* larvae per stem at different times after treatment with different agents (mean ± SEM). Different letters indicate significant differences (Two-way ANOVA, LSD test, α=0.05). T1= control (no treatment); T2= control (water spray); T3= *Beauveria bassiana*; T4= *Metarhizium brunneum*; T5= *Steinernema carpocapsae*; T6= *Steinernema kraussei*; T7= *Steinermema feltiae*; T8= *Heterorhabditis bacteriophora*; T9= Dimilin; T10=Neem (Aza-Direct).

Figure 3

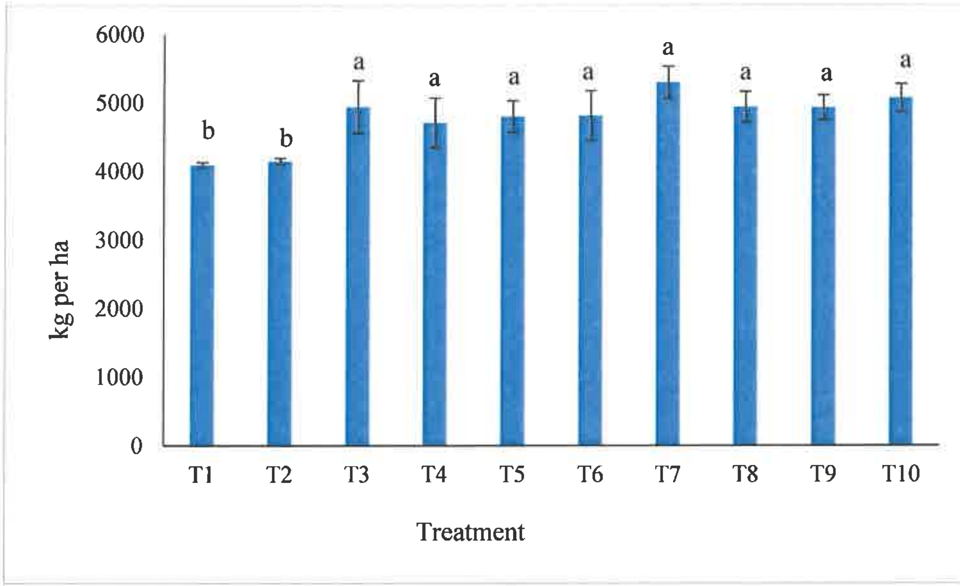

Figure 3. Wheat yield production in treatments with different agents (mean ± SEM). Different letters indicate significant differences (Two-way ANOVA, LSD test, α=0.05). T1= control (no treatment); T2= control (water spray); T3= *Beauveria bassiana*; T4=*Metarhizium brunneum*; T5= *Steinernema carpocapsae*; T6= *Steinernema kraussei*; T7= *Steinermema feltiae*; T8= *Heterorhabditis bacteriophora*; T9= Dimilin; T10=Neem (Aza-Direct)

Evaluation of the effectiveness of the entomopathogens for the management of wireworms (Coleoptera: Elateridae) on spring wheat

Principle Investigator: Dr. Gadi V.P. Reddy

Cooperators: Dr. Khanobporn Tangtrakulwanich, Dr. Shaohui Wu, John H. Miller, Victoria L. Ophus, Julie Prewitt, Western Triangle Agricultural Research Center, Montana State University, 9546 Old Shelby Rd., Conrad, MT 59425, USA

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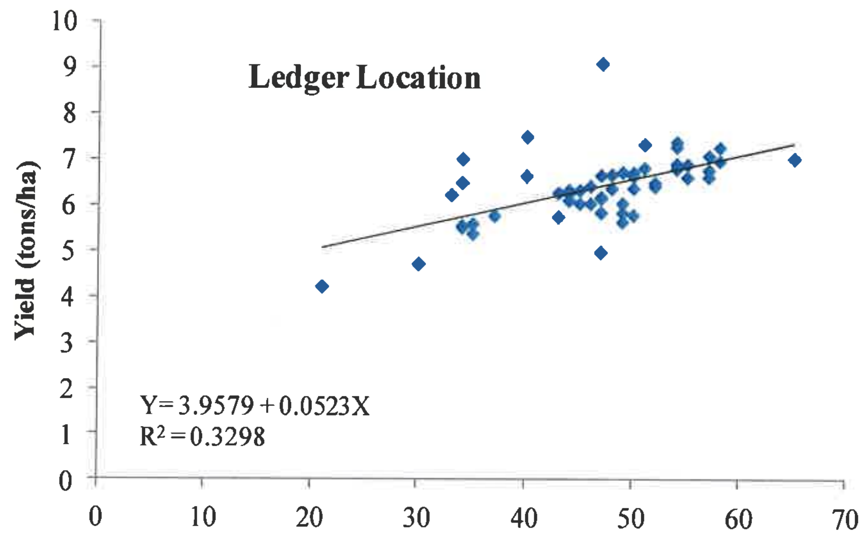
Abstract

Wireworms, the larval stage of click beetles (Coleoptera: Elateridae), are serious soil dwelling pests of small grain, corn, sugar beet and potato crops. *Limonius californicus* (Mannerheim) and *Hypnoidus bicolor* (Eschscholtz) are the predominant wireworm species infesting wheat in Montana, particularly in the 'Golden Triangle' area of north-central Montana. Wireworm populations in field crops are increasing, but currently available insecticides provide only partial control, and no alternative management tools exist. In the current study, three entomopathogenic fungi were tested for efficacy against wireworms in spring wheat at two field locations (Ledger and Conrad, Montana, USA) in 2013. The fungi (*Metarhizium brunneum* F52, *Beauveria bassiana* GHA, and *Metarhizium robertsii* DWR 346) were evaluated in seed coat, in furrow granular and soil drench applications, in addition to imidacloprid (Gaucho®) in seed treatment, which is currently being used by growers. Wireworm damage in various treatments was evaluated as standing plant counts, wireworm population survey, and grain yield production. Three Fungi applied as formulated granules or as soil drenches, and imidacloprid seed treatment resulted in significantly higher plant stand counts and yields at both locations, than fungus-coated seed treatments and the untreated control. Significant difference was detected among the application methods instead of species of the fungi. All three fungi applied as granules in furrow and in soil drench were paramount to seed-coating treatments in wireworm control, and provided an efficacy comparable or superior to imidacloprid. The fungi used in the current study provided significant plant and yield protection under moderate wireworm pressure, indicating their potential utility in the integrate management of this pest.

Materials and methods

Fungi

Conidia of *B. bassiana* strain GHA were supplied as unformulated technical grade powder by Laverlam International, Butte MT, Conidial titer was 1.6×10^{11} conidia/g and viability was 98%, based on conidial germination on potato dextrose yeast extract agar after incubation for 18 hr at 27° C. Cultures of *M. brunneum* F52 and *M. robertsii* DWR346 were obtained from Novozymes Biologicals Inc., Salem VA and Don W. Roberts, Utah State University, resp. The two *Metarhizium* isolates were passaged through grasshoppers and the resulting conidia stored in 30% glycerol at -80° C. Conidia of these two fungi were produced using biphasic liquid-solid fermentation methods as described in Jaronski and Jackson (2012) and the resulting spores used



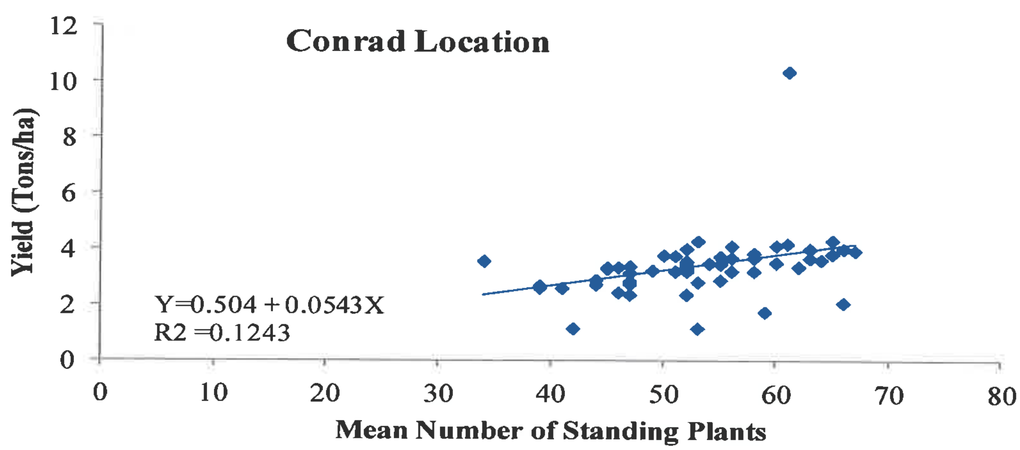


Fig 5. Regression analysis between wheat grain yield and mean number of standing plants from wireworm damage.

Trapping click beetles with pheromone traps (Coleoptera: Elateridae)

Principal Investigator: Dr. Gadi V.P. Reddy

Cooperators: Dr. Khanobporn Tangtrakulwanich, Dr. Shaohui Wu, John H. Miller, Victoria L. Ophus, Julie Prewitt, Western Triangle Agricultural Research Center, Montana State University, 9546 Old Shelby Rd., Conrad, MT 59425, USA

Miklós Tóth, Plant Protection Institute, MTA ATK, Budapest, Hungary, H-1525

Kevin Wanner, Assistant Professor, Department of Plant Sciences and Plant Pathology, Montana State University

Abstract:

1. Screen European based pheromone lures (Hungary) in the Golden Triangle areas using Yatlor Funnel trap (Italy) which is specifically designed for catching click beetles.

None of European-based pheromone lures were highly effective in catching the wireworms species recorded in Montana, although lures with *A. sputator* tended to be more effective than others. According to the recent survey, *Limonius californicus* and *Hypnoidus bicolor*, are the two common wireworm species damaging the spring wheat in the Golden Triangle areas of Montana. However, *L. californicus* is the predominant species found in Montana.

2. Develop the appropriate pheromone traps suitable for use under Montana weather conditions.

The same experiment will be repeated again for summer 2014 with more lure types. Once we know the effective lure, several types will be evaluated for this summer with the available grant.

3. Isolate the chemicals, investigate the active components, and identify them from the pheromones of the predominant species found in the Western Triangle.

Dr. Tóth Miklós will be sending his Postdoctoral Research Associate Dr. Jozsef Vuts to Conrad in May to help us with isolation and identification of pheromone compounds from the wireworm species. Meanwhile, we have obtained all the necessary supplies for identification of the compounds.

4. Develop laboratory rearing technique for the wireworms/click beetles based on the pheromone trap catches.

We have already developed a laboratory wireworm rearing method in incubators. Since they have very long lifecycles (2-7 years), it is taking time. Anyway, we will be developing mass rearing will be developed in order to conduct some laboratory experiments.

Objectives:

1. Screen European based pheromone lures (Hungary) in the Golden Triangle areas using Yatlor Funnel trap (Italy) which is specifically designed for catching click beetles.

2. Develop the appropriate pheromone traps suitable for use under Montana weather conditions.

3. Isolate the chemicals, investigate the active components, and identify them from the pheromones of the predominant species found in the Golden Triangle.

4. Develop laboratory rearing technique for the wireworms/click beetles based on the pheromone trap catches.

The pheromone lures was obtained from Dr. Tóth Miklós, MTA lev. tagja - corr. member of HAS tud. tan. - Scientific advisor, Plant Protection Institute, MTA ATK, Budapest, Pf 102, Hungary, H-1525, and was stored in the laboratory until use.

The Yatlor Funnel traps with the European based lures were installed in the growers' field in Kalispell, Ledger, Conrad, Rock city and Valier in May 2013. Traps with different lures and control (without lures) were tested independently (12 pheromone lures × 3 replications × 4 sites) at the above mentioned locations. The experiment was carried out from May to August 2013. The trap catches were recorded every two weeks. The trapped adults were brought to the laboratory to be reared.

Results:

The Yatlor traps baited with European based lures (Figure 1) installed at Kalispell, Ledger, Conrad, Rock city and Valier collected different species of wireworms. None of the tested lures collected significantly high number of adults (Figures 2). The trap with the lures of *Agriotes sputator* appeared to be more effective than other lures. However, no major difference was found.

A laboratory rearing of wireworms is being maintained at the Western Triangle Agricultural Research Center in Conrad. These adults will be used for the identification of pheromone compounds for the wireworm species in Montana.

Figure 1: Yatlor Funnel trap designed specifically for pheromone trapping of click beetles (Photo credit: L. Furlan, Italy; *Inform. Fitopatol.* 10: 49–54, 2004).

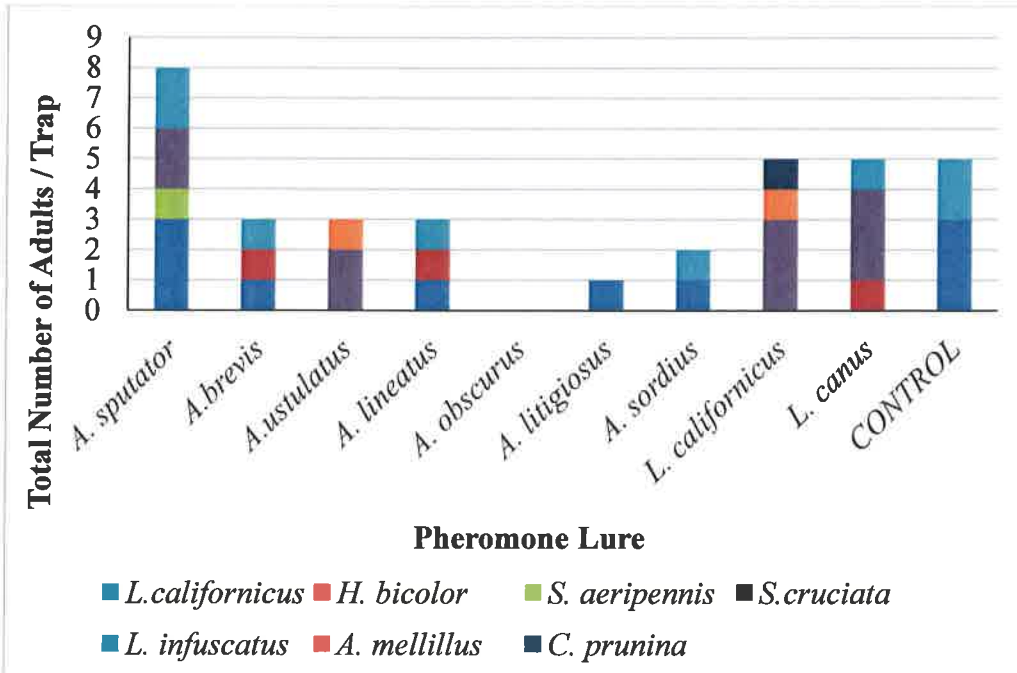


Figure 2: Total number of adults caught in Yatlor traps baited with European-based lures.

Developing Threshold Levels for the Flea Beetle *Phyllotreta cruciferae* on Canola in Montana

Principle Investigator: Dr. Gadi V.P. Reddy

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ABSTRACT

The flea beetles *Phyllotreta cruciferae* (Goeze) and *Phyllotreta striolata* (F.) (Coleoptera: Chrysomelidae) are pests of canola (*Brassica napus* L.) in the northern Great Plains of the United States. In Montana, *P. cruciferae* is the only species attacks canola during the crop growing stage. Management of *P. cruciferae* is usually focused on adults in canola seedings, which is the stage most vulnerable to flea beetle damage. In the Golden Triangle area in Montana, canola growers traditionally use calendar based spraying to control *P. cruciferae*. Here, we compared the calendar based spray schedule with seed treatment and damage- level treatment spraying schedules. Of eight treatments, in treatments 1, 2, and 3 were plots were sprayed when 15-20, 25, and 45% of leaf damage occurred. Treatments 4, 5, and 6 were sprayed at 15, 30, and 45 day intervals after the sowing dates. Treatment 7 was the conventional seed treatment and treatment 8 was the control plot. We found that the calendar based spray schedule at the 15 days interval gave the highest yield, and the treatment in which the spraying was initiated at 15-20% leaf damage gave the second highest yield. However, there were no significant differences in yield between these two treatments. Meanwhile, the seed treatment did not give a higher yield compared to calendar based sprays. We also found a negative correlation between the leaf damage and the yield in every treatment. Because we found no significant difference between the two highest yielding spray schedules, while it is beneficial to spray canola every 15 days, it is better to spray when damage reaches 15-20% in order to reduce the number of chemical applications.

Materials and Methods

Experimental Design and Treatments

Field trials were established in May 2013 at two locations in Montana: the Western Triangle Agricultural Research Center in Conrad, MT (N48°18.627′W111°55.402′) and at a grower's field in Conrad, Montana (N48°11.633′W111°48.290′). These trails were conducted on the Nexera 1012 canola variety, which is extensively grown in the region. Treatment plots were 8m × 4m and separated from other plots by a 1 m buffer to avoid spray drift. Each plot was comprised of 12 rows spaced 15.24 cm apart. Canola seeds were drilled into the soil of plots measuring 8 m by 4 m. The plant density was 72 plants/m^2, or approximately 576 plants per plot. To control weeds, Roundup Powermax (glyphosate) was applied before seeding at of 2.5 kg/ ha.

Fertilizer was applied at 134.5 kg/ ha of nitrogen, 2.47 kg/ha of phosphorus, 61.64 kg/ha of potassium and 22.4 kg/ha of sulfur. For treatments T1 to T3, an application of Warrior-II (lambda cyhalothrin, Syngenta) at the rate of 83g/ha was sprayed within 12 h after the plot reached mean threshold levels of 15-20, 25 and 45%, respectively, of leaf damage by *P. cruciferae.* For treatments T4-T6, an application of the same chemical insecticide was applied at 15, 30, and 45 day intervals after plant emergence, respectively. Lambda-cyhalothrin was used in this study because it is one of the most commonly used insecticides used by growers in the Golden Triangle area. For treatment T7, and application of Guacho (Imidacloprid, Bayer Crop Science) at a concentration of 4 g/1 kg of seed was used for the seed treatment. Treatment 8 was the control, and was therefore never sprayed and did not use treated seed. Leaf damage in each plot was determined weekly. We estimated the damage by counting the number of holes caused by *P. cruciferae*. In each plot, the area of 1 m^2 was randomly selected (72 plants in 1m^2) and the number of holes per plant in that 1m^2 area was counted. The total number of holes per plant within a given treatment was used to compare the treatment effectiveness. Then we calculated the percentage of leaf damage. For treatments 1, 2, 3, 4, 5 and 6, the Hudson Never Pump Bak-Pak DC Pump sprayer- 4 Gallon, 60 PSI, Model # 13854 was used to apply Lambda-cyhalothrin. The crop was harvested in late September 2013, when 50% of the canola seeds in the pods looked very dark in color. The cut canola was left to air dry for 7 to 10 days to allow the seeds to finish ripening. Windrows were threshed using a Hege 140 plot combine. Yield was calculated using the plot weight divided by plot area.

Data Analysis

Analysis of variance (ANOVA) was used to analyze differences among treatments in yield and percentage of leaf damage. Means were compared using the least square difference (LSD) test. Values of $P<0.05$ were considered significant. Linear regression was used to analyze the correlation between yield loss and percentage of leaf damage. All analyses were conducted using SAS version 9.3 (SAS Institute 2011).

Result

Percentage of Leaf Damage

The most leaf damage occurred in the control (T8) (Figure 2). T1 had the least leaf damage. We found no significant differences between T2 and T6 ($F_{1,4} = 0.52$, $P>0.05$) and no significant differences in percentage of leaf damage among T3, T4, T5, T6, T7, and T8 ($F_{5,12} = 0.69$, $P>0.05$).

Correlation between Yield and Percentage of Leaf Damage

Regression analyses found a negative correlation ($R^2 = 0.5482$) between yield and percentage of leaf damage ($P<0.05$) (Figure 3).

Yield Per Treatment

Every treatment had a significantly higher yield than the control plot (T8) ($F_{7,40} = 11.13$, $P<0.05$). Treatment 4, calendar-based applications at 15 day intervals after sowing, showed the highest yield (Figure 1). Treatment 1, application at 15-20% leaf damage, gave the second highest yield (Figure 1). However, the difference between treatments 1 and 4 was not significant ($F_{1,4} = 0.67$, *P*>0.05). In addition, we found no significant differences among treatments T2, T3, T5, T6, and T7 ($F_{4,10}$ = 9.95, $P>0.05$)

Acknowledgements
We appreciate the field work contribution of John H. Miller, Julie Prewitt and Vickie Ophus, Western Triangle Agricultural Research Center. Funding for this research was provided by USDA Hatch (#MONB00859).

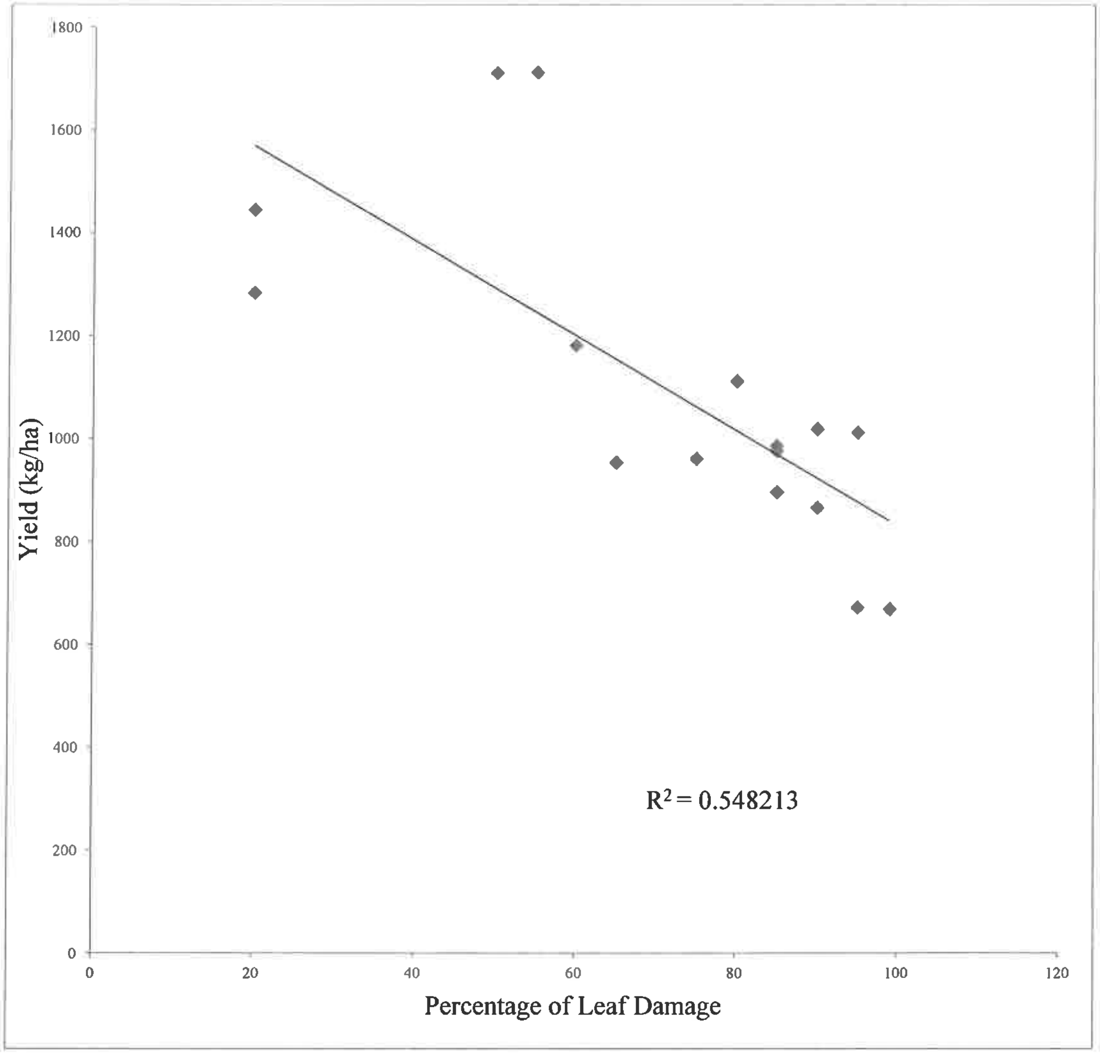

Figure 3. Regression between canola yield and percentage of leaf damage from flea beetles in Montana in 2013 where treatments were as follows.
Treat 1: Initiate chemical spray when 15-20% leaf damage occurs in the plot; Treat 2: Initiate chemical spray when 25% leaf damage occurs in the plot; Treat 3: Initiate chemical spray when 45% leaf damage occurs in the plot; Treat 4: Calendar-based spray schedule (CSS) (15 day intervals after sowing): 15, 30, 45, 60, 75, 90, 105 and 120; Treat 5: Calendar-based spray schedule (CSS) (30 day intervals after sowing): 30, 60, 90, and 120; Treat 6: Calendar-based spray schedule (CSS) (45 day intervals after sowing): 45, 90, and 135; Treat 7: Seed treatment (no spray); Treat 8: Untreated control (no spray).

Sustainable Management Tactics for Control of Flea Beetle *Phyllotreta cruciferae* (Coleoptera: Chrysomelidae) on Canola in Montana

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Abstract

The crucifer flea beetle, *Phyllotreta cruciferae* (Goeze) (Coleoptera: Chrysomelidae), has recently emerged as serious pest of canola (*Brassica napus* L.) in Montana. The adult beetles feed on canola leaves, causing many small holes that stunt growth and reduce yield. In 2013, damage to canola seedlings was high (ca. 80%) in many parts of Montana, evidence that when flea beetles emerge in large numbers, they can quickly destroy a young canola crop. Some reports have estimated flea beetle damage to oilseed brassica crops in North America to be >$300 million annually, and this damage is exacerbated by the fact that flea beetles are one of the most difficult-to-manage pests of canola. In this study, field trials were conducted during the summer of 2013 at two locations in Montana to compare the effectiveness of different control strategies. The performance of two commonly used insecticides, deltamethrin and bifenthrin, were compared with entomopathogenic nematodes and fungi, neem oil, and petroleum spray oils (PSO) against *P. cruciferae*. *Beauveria bassiana* + two applications of *Metarhizium brunneum* at 15, 30 + 45, 60 DAS (days after sowing), and five applications of bifenthrin (at 10, 20, 30, 40 and 50 days after sowing) were found to be the most consistent at reducing damage in comparison with untreated controls in both the trials. The plots treated with these two chemicals gave the highest yield compared to the control treatments. The plant-derived compound neem (azadirachtin), horticultural oilS (PSO), and fatty acids (M-pede) also significantly reduced the damage and gave higher canola yield than the control. Our study therefore indicates that entomopathogenic fungi combine well with other strategies to effectively manage *P. cruciferae* populations, and may serve as alternatives to conventional insecticides or seed treatments.

Materials and Methods

Trial Location

Trials were conducted at two field locations: Cut Bank (N48° 50.292' W112° 17.746') and Sweet Grass (N48° 57.831' W111° 40.801') in the Golden Triangle area of Montana. Experiments were carried out from May-September 2013 at Cut Bank and from June-September 2013 at Sweet Grass. HyClass 955 canola seeds were used for both locations and the crop was seeded at a rate of 12 seeds per 30 cm using a four row plot drill. At both locations, rows within the plots were spaced 0.3 m apart, and the herbicide Roundup Powermax (Glyphosate) at the rate of 2.5 L/ha was applied before planting for weed control. Fertilizer N, P,K and S ratio was applied at 134.5, 25.2, 61.6, and 22.4 kg/ha at actual time of planting and an additional application of 12.3, 25.2, and 0 kg/ha was broadcast through the seed plot drill. For each experiment, the treatment plots were arranged in a completely randomized block design with three replicates. No irrigation was used as the trials were conducted under dry conditions.

Experiments and Treatments
The Summary of treatments tested for flea beetle management is given below.

T1: Control (no spray);
T2: Standard seed treatment (no spray);
T3: Release of nematodes (*Steinernema carpocapsae*) at 15 and 30 days after sowing;
T4: Release of nematodes *S. carpocapsae* at 15, 30, 45 and 65 DAS;
T5: An application of petroleum spray oil (PSO) + an application of neem at 15 + 30 DAS;
T6: Two application of PSO + two applications of neem at 15, 30 + 45, 60;
T7: An application of *Beauveria bassiana* + an application of *Metarhizium brunneum* at 15 + 30 DAS;
T8: Two applications of *B. bassiana* + two applications of *M. brunneum* at 15, 30 + 45, 60 DAS;
T9: Application of M-pede + an application of neem at 15 + 30 DAS;
T10: Two applications of M-pede + two applications of neem at 15, 30 + 45, 60 DAS;
T11: Five applications of deltamethrin at 10, 20, 30, 40 and 50 DAS (the growers' practice); and
T12: Five applications of bifenthrin at 10, 20, 30, 40 and 50 DAS (the growers' practice).

Plot Design and Data Collected
Treatment plots measured 8 × 4 m, and were separated from other plots by 1 m buffer zones to prevent spray drift. Each plot consisted of 12 rows of 80 canola plants, for a total of 960 plants per plot. The source, number, and timing of biological treatments carried out on canola fields against *P. cruciferae* are shown in Tables 1.

To compare effectiveness the total number of feeding holes per plant within a given treatment was used. The number of *P. cruciferae* per plant could not be measured as beetles are highly mobile.

The plots were swathed when approximately 50% of the seed in the pods about half way up the main stem have turned to a very dark color. Plots were allowed to air dry and the seed to ripen completely about 7 to 10 days. A Hege 140 plot combine was used to thrash the canola plots.

Statistical Analyses
Data on plant damage were pooled within the treatments and analyzed using two-way ANOVA, and differences among the treatments were tested using Fisher's Least Significant Difference (LSD) Test. Data were analyzed using PROC GLIMMIX in SAS version for Windows.

Results

In both trials, all treatments (entomopathogenic nematodes and fungi, botanical insecticide, and insecticides) significantly reduced the number of holes per plant compared to theuntreated controls. ($F_{11, 46} = 21.33$, $P < 0.05$) (Figs. 1 and 2). The plots treated with two applications of *B. bassiana* + two applications of *M. brunneum* at 15, 30 + 45, and 60 DAS and plots treated with five applications of bifenthrin at 10, 20, 30, 40 and 50 DAS had significantly fewer holes compared to the control treatments at both the locations ($F_{11, 14} = 36.8$, $P < 0.05$) (Fig. 1) Control plots suffered the greatest damage from *P. cruciferae*, while all other treatments had an intermediate effect. The canola yield was significantly greater in plots treated with two applications of *B. bassiana* + two applications of *M. brunneum* and plots treated with five applications of bifenthrin (the standard growers practice) compared to the other treatments ($F_{11,56} = 9.11$, $P < 0.05$) (Fig. 2). The combination of biological treatments and neem oil were only moderately effective, but were significantly ($F_{11, 22} = 13.8$, $P < 0.05$) better than the control.

Acknowledgements

We would like to thank Vickie Ophus, John H. Miller, and Julie Prewitt for assistance with field work. Funding for this research was provided by USDA Hatch (#MONB00859). We would also like to thank Dr. Shaohui Wu for help with the literature.

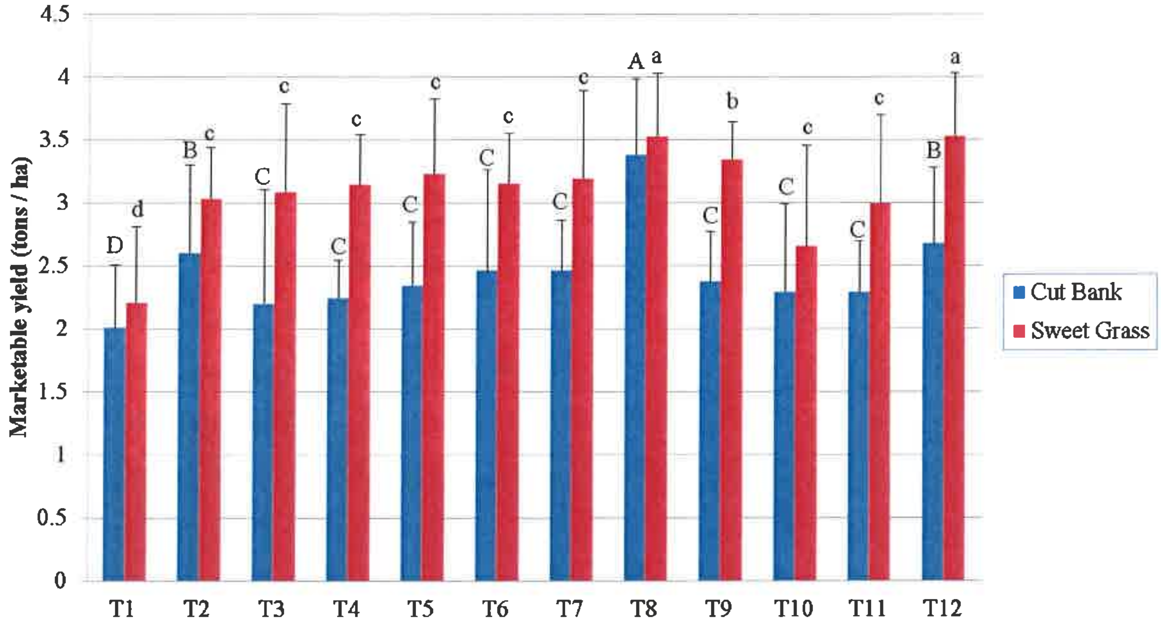

Fig. 2. Yield of canola in various treatments against *Phyllotreta cruciferae* at two field locations in Montana. Different letters above the bars indicate significant differences $P > 0.05$ (Two-way ANOVA, LSD test). Each value represents the mean (± SE) of 3 replications.
T1: Control (no spray); T2: Standard seed treatment (no spray); T3: Release of nematodes (*Steinernema carpocapsae*) at 15 and 30 days after sowing; T4: Release of nematodes *S. carpocapsae* at 15, 30, 45 and 65 DAS; T5: An application of petroleum spray oil (PSO) + an application of neem at 15 + 30 DAS; T6: Two application of PSO + two applications of neem at 15, 30 + 45, 60; T7: An application of *Beauveria bassiana* + an application of *Metarhizium brunneum* at 15 + 30 DAS; T8: Two applications of *B. bassiana* + two applications of *M. brunneum* at 15, 30 + 45, 60 DAS; T9: Application of M-pede + an application of neem at 15 + 30 DAS; T10: Two applications of M-pede + two applications of neem at 15, 30 + 45, 60 DAS; T11: Five applications of deltamethrin at 10, 20, 30, 40 and 50 DAS (the growers' practice); T12: Five applications of bifenthrin at 10, 20, 30, 40 and 50 DAS (the growers' practice).

SOIL
FERTILITY

Evaluation of product effect on protein yield and NUE allow us to assess how efficiently N products were taken up, assimilated and utilized to produce both grain yield and quality (protein). Protein yield is a valuable characteristic, especially for spring wheat in Montana. Protein yield was clearly higher with HNRGN at both dryland sites in 2012 and in 2013 (Figures 5 and 6). Even where the differences were not statistically significant (WARC, 2012 and Patton, 2013), over 30 lb ac^{-1} advantage in protein yield accumulation was observed with HNRGN compared to UAN (Figure 6).

The effect of N source on NUE was very pronounces in favor of HNRGN at dryland locations in both growing seasons (Figures 7 and 8). The lowest NUE values were observed with UAN and LU produced intermediate results. The irrigated WARC location had similar NUEs for all products, except for 2012, when LU resulted in lower (not statistically significant) NUE (Figure 7).

The cost per unit of N of HNRGN at the time of application was approximately 25% higher than cost of LU and UAN. Many growers chose to produce their own LU on-site; they prefer non-corrosive LU to readily available for purchase UAN. Results showed that the N source choice may be more important in a dryland situation compared to irrigated. Considering both agronomic and economic benefits, LU can be recommended as most appropriate liquid fertilizer N source for spring wheat production in Montana. Encouraging results obtained in both growing seasons at WTARC (prime dryland spring wheat growing area) utilizing LU emphasizes this recommendation.

In regards to product dilution (since dilution ratios had no effect of grain yield, grain protein content and other variables), data indicated that it is possible to apply undiluted liquid N products to spring wheat utilizing the stream bar sprayer without damaging the crop. This is especially true with non-corrosive LU. We caution growers in applying undiluted N products at a rate higher than 40 lb N ac^{-1} used in this study. Grower recommendations and a Fertilizer Fact sheet will be produced based on the results of this two-year study.

Table 1. Treatment structure, Patton, WTARC, and WARC, 2012 and 2013.

Trt	Preplant N Fertilizer (urea) Rate, lb N ac^{-1}	Topdress N Fertilizer Source	Topdress N Fertilizer Rate, lb N ac^{-1}	Topdress N Fertilizer/Water Ratio, %
1	0	-	-	-
2	80	UAN	40	100/0
3	80	UAN	40	66/33
4	80	UAN	40	33/66
5	80	LU	40	100/0
6	80	LU	40	66/33
7	80	LU	40	33/66
8	80	HNRGN	40	100/0
9	80	HNRGN	40	66/33
10	80	HNRGN	40	33/66

Table 2. Treatment structure, Patton, WTARC, and WARC, 2012 and 2013.

Trt	Mean spring wheat grain yield, bu ac^{-1}					
	2012			2013		
	PATTON	WTARC	WARC	PATTON	WTARC	WARC
1	37.6 (bcd)	79.9 (c)	83.7 (abc)	53.0 (ab)	55.0 (c)	27.6 (b)
2	31.5 (ed)	88.9 (ab)	89.4 (abc)	51.7 (ab)	59.5 (bc)	31.6 (ab)
3	33.2 (cde)	86.4 (bc)	84.9 (abc)	50.6 (b)	60.4 (bc)	32.5 (ab)
4	31.1 (e)	86.8 (bc)	94.4 (ab)	51.9 (ab)	58.8 (c)	31.7 (ab)
5	38.3 (bc)	89.9 (ab)	80.4 (c)	52.6 (ab)	68.3 (ab)	35.1 (a)
6	38.4 (bc)	92.1 (ab)	80.6 (bc)	52.7 (ab)	72.0 (a)	31.8 (ab)
7	40.0 (ab)	92.3 (ab)	82.5 (abc)	57.7 (a)	70.3 (a)	29.1 (ab)
8	41.8 (ab)	94.9 (ab)	95.5 (a)	55.7 (ab)	70.9 (a)	29.1 (ab)
9	38.9 (bc)	94.7 (ab)	93.5 (abc)	49.9 (b)	75.9 (a)	33.4 (ab)
10	45.1 (a)	96.0 (a)	91.4 (abc)	57.5 (a)	75.2 (a)	34.7 (ab)

Table 3. Mean spring wheat grain protein content, and protein yield, Patton, WTARC, and WARC, 2012.

Trt	Mean spring wheat grain protein content, %			Mean spring wheat protein yield, lb ac^{-1}		
	PATTON	WTARC	WARC	PATTON	WTARC	WARC
1	13.8 (c)	10.8 (c)	13.4 (f)	349 (d)	579 (b)	754 (b)
2	17.2 (a)	12.8 (b)	14.4 (bcde)	365 (d)	764 (a)	862 (ab)
3	16.8 (ab)	13.2 (ab)	13.9 (def)	376 (cd)	769 (a)	792 (ab)
4	17.0 (ab)	13.1 (ab)	14.2 (cde)	355 (d)	766 (a)	901 (ab)
5	16.7 (ab)	13.2 (ab)	15.1 (a)	430 (bc)	800 (a)	817 (ab)
6	16.8 (ab)	13.7 (a)	15.0 (ab)	433 (bc)	845 (a)	809 (ab)
7	16.5 (b)	13.1 (ab)	14.9 (abc)	442 (b)	810 (a)	823 (ab)
8	16.9 (ab)	13.1 (ab)	13.8 (ef)	475 (ab)	833 (a)	882 (ab)
9	17.1 (a)	13.2 (ab)	14.6 (abcd)	447 (b)	841 (a)	916 (a)
10	16.8 (ab)	12.9 (b)	14.0 (def)	510 (a)	829 (a)	859 (ab)

Table 4. Mean spring wheat grain protein content, and protein yield, Patton, WTARC, and WARC, 2013.

Trt	Mean spring wheat grain protein content, %			Mean spring wheat protein yield, lb ac^{-1}		
	PATTON	WTARC	WARC	PATTON	WTARC	WARC
1	12.5 (c)	10.6 (d)	16.0 (a)	398 (c)	351 (e)	264 (a)
2	14.9 (ab)	13.4 (ab)	15.2 (ab)	462 (b)	480 (d)	287 (a)
3	15.0 (ab)	13.5 (a)	14.5 (bc)	455 (b)	489 (cd)	283 (a)
4	15.3 (a)	13.3 (abc)	14.8 (bc)	477 (ab)	470 (d)	281 (a)
5	15.2 (ab)	13.1 (bc)	13.3 (c)	478 (ab)	538 (bcd)	280 (a)
6	14.7 (b)	13.3 (abc)	14.7 (bc)	465 (b)	572 (ab)	280 (a)
7	15.0 (ab)	13.1 (c)	14.4 (c)	521 (a)	550 (abc)	251 (a)
8	15.0 (ab)	13.4 (ab)	14.4 (bc)	503 (ab)	571 (ab)	251 (a)
9	15.4 (a)	13.4 (ab)	14.1 (bc)	461 (b)	610 (a)	282 (a)
10	15.2 (ab)	13.5 (ab)	14.8 (bc)	524 (a)	607 (a)	308 (a)

Table 5. Mean spring wheat N uptake and NUE, Patton, WTARC, and WARC, 2012.

Trt	N Uptake, lb N ac^{-1}			NUE, %		
	PATTON	WTARC	WARC	PATTON	WTARC	WARC
1	60 (d)	99 (b)	129 (b)	-	-	-
2	63 (d)	131 (a)	148 (ab)	1.9 (d)	23.5 (a)	13.8 (a)
3	65 (cd)	132 (a)	136 (ab)	10.4 (cd)	24.1 (a)	4.8 (a)
4	61 (d)	131 (a)	155 (ab)	16.0 (d)	23.8 (a)	18.7 (a)
5	74 (bc)	137 (a)	140 (ab)	23.7 (bc)	28.1 (a)	8.1 (a)
6	74 (bc)	145 (a)	139 (ab)	30.1 (bc)	33.8 (a)	7.1 (a)
7	76 (b)	139 (a)	141 (ab)	32.4 (b)	29.4 (a)	8.8 (a)
8	81 (ab)	143 (a)	151 (ab)	12.0 (ab)	32.2 (a)	16.3 (a)
9	77 (b)	144 (a)	157 (a)	7.5 (b)	33.3 (a)	20.6 (a)
10	88 (a)	142 (a)	147 (ab)	16.4 (a)	31.8 (a)	13.3 (a)

Table 6. Mean spring wheat N uptake and NUE, Patton, WTARC, and WARC, 2013.

Trt	N Uptake, lb N ac^{-1}			NUE, %		
	PATTON	WTARC	WARC	PATTON	WTARC	WARC
1	68 (c)	60 (e)	45 (a)	n/a	n/a	n/a
2	79 (b)	82 (d)	49 (a)	28.6 (b)	37.7 (bc)	15.9 (a)
3	78 (b)	84 (cd)	48 (a)	27.4 (b)	38.9 (bc)	15.0 (a)
4	82 (ab)	80 (d)	48 (a)	31.2 (ab)	36.0 (c)	14.3 (a)
5	82 (ab)	92 (bcd)	48 (a)	31.3 (ab)	47.7 (abc)	22.4 (a)
6	79 (b)	98 (ab)	48 (a)	28.6 (b)	53.6 (a)	14.5 (a)
7	89 (a)	94 (abc)	43 (a)	38.6 (a)	49.8 (ab)	12.0 (a)
8	86 (ab)	98 (ab)	43 (a)	35.8 (ab)	53.5 (a)	9.9 (a)
9	79 (b)	104 (a)	48 (a)	28.7 (b)	60.0 (a)	14.6 (a)
10	90 (a)	104 (a)	53 (a)	39.4 (a)	59.5 (a)	19.1 (a)

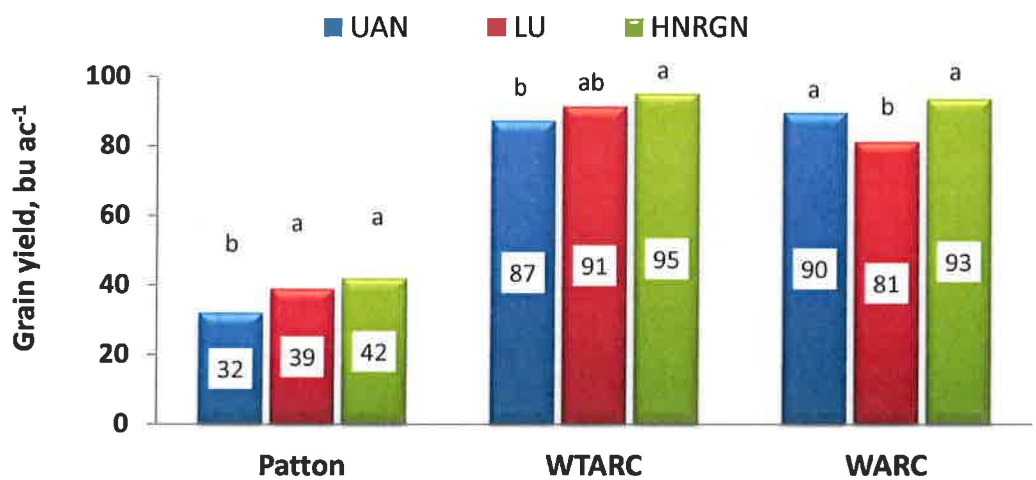

Figure 1. Fertilizer N source effect on spring wheat grain yield, Patton, WTARC, and WARC, 2012.

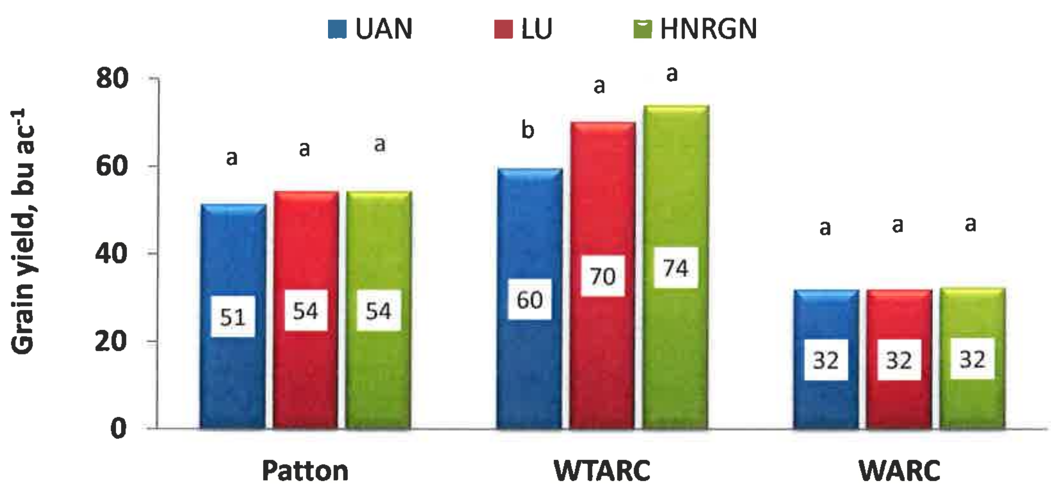

Figure 2. Fertilizer N source effect on spring wheat grain yield, Patton, WTARC, and WARC, 2013.

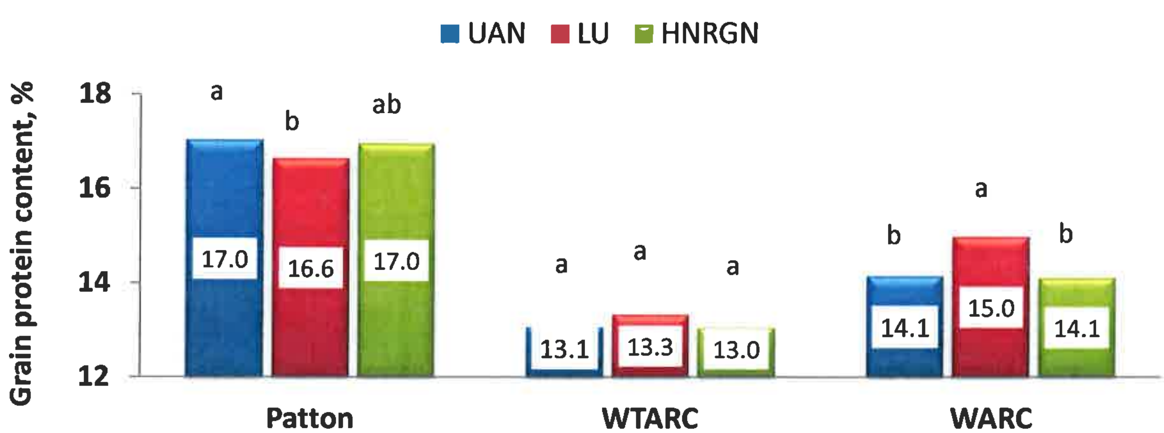

Figure 3. Fertilizer N source effect on spring wheat grain protein content, Patton, WTARC, and WARC, 2012.

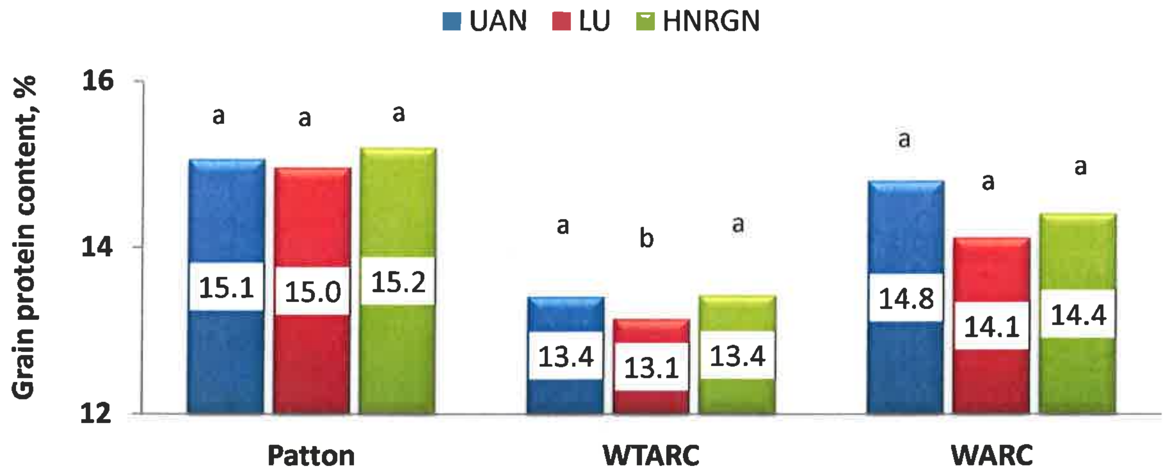

Figure 4. Fertilizer N source effect on spring wheat grain protein content, Patton, WTARC, and WARC, 2013.

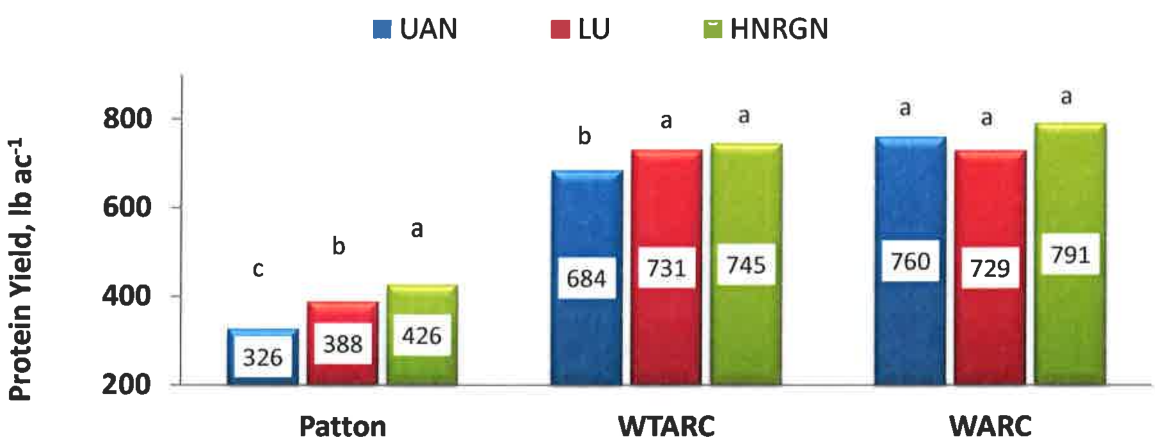

Figure 5. Fertilizer N source effect on spring wheat protein yield, Patton, WTARC, and WARC, 2012.

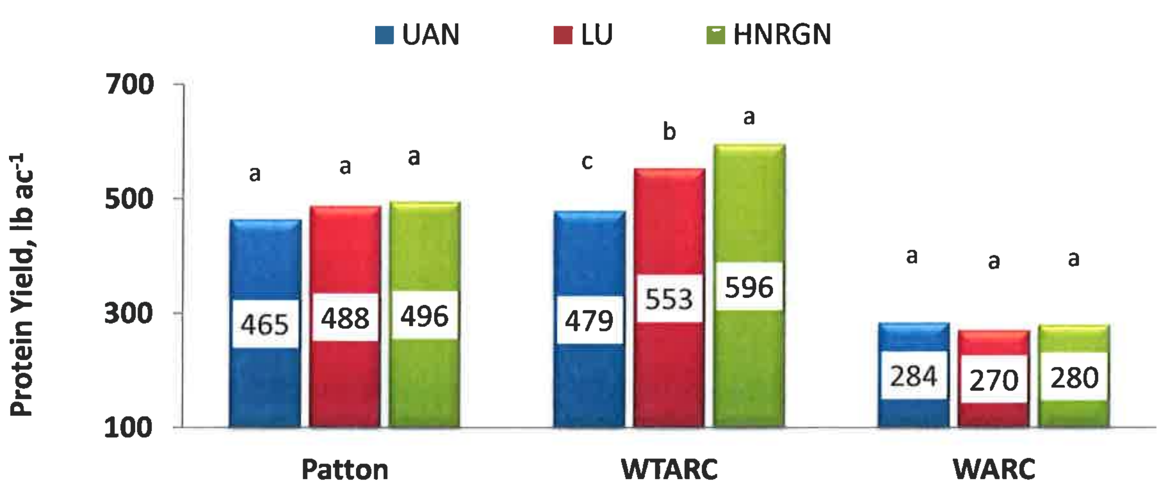

Figure 6. Fertilizer N source effect on spring wheat protein yield, Patton, WTARC, and WARC, 2013.

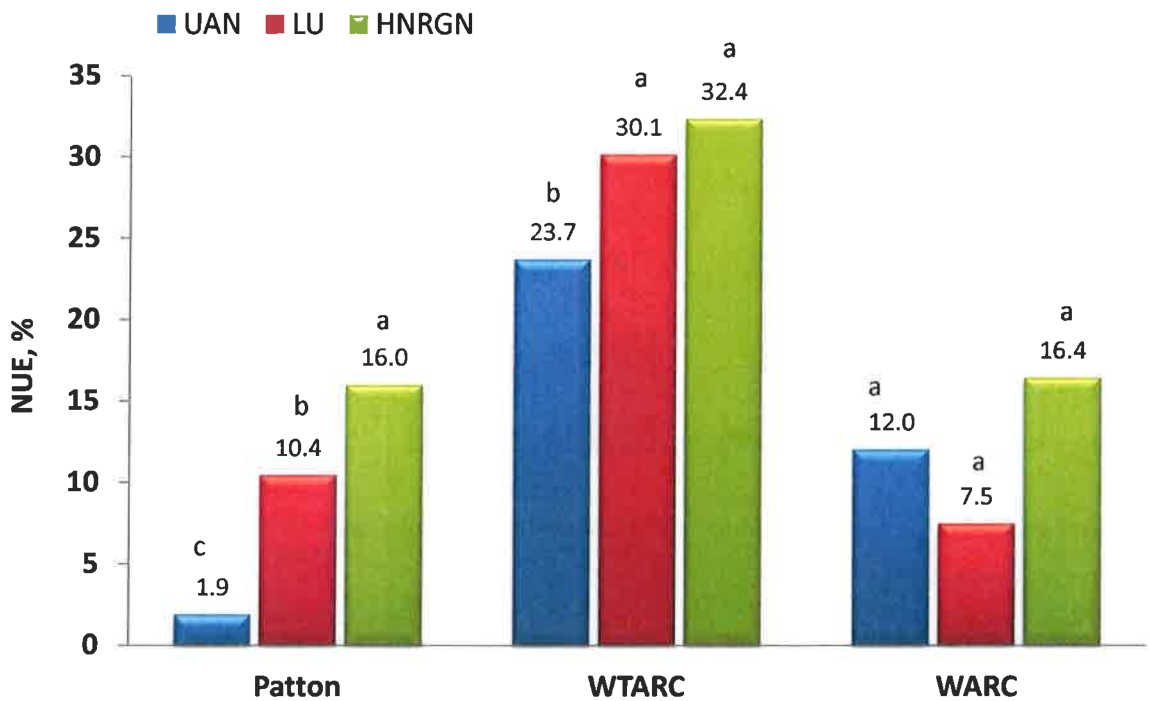

Figure 7. Fertilizer N source effect on NUE, Patton, WTARC, and WARC, 2012.

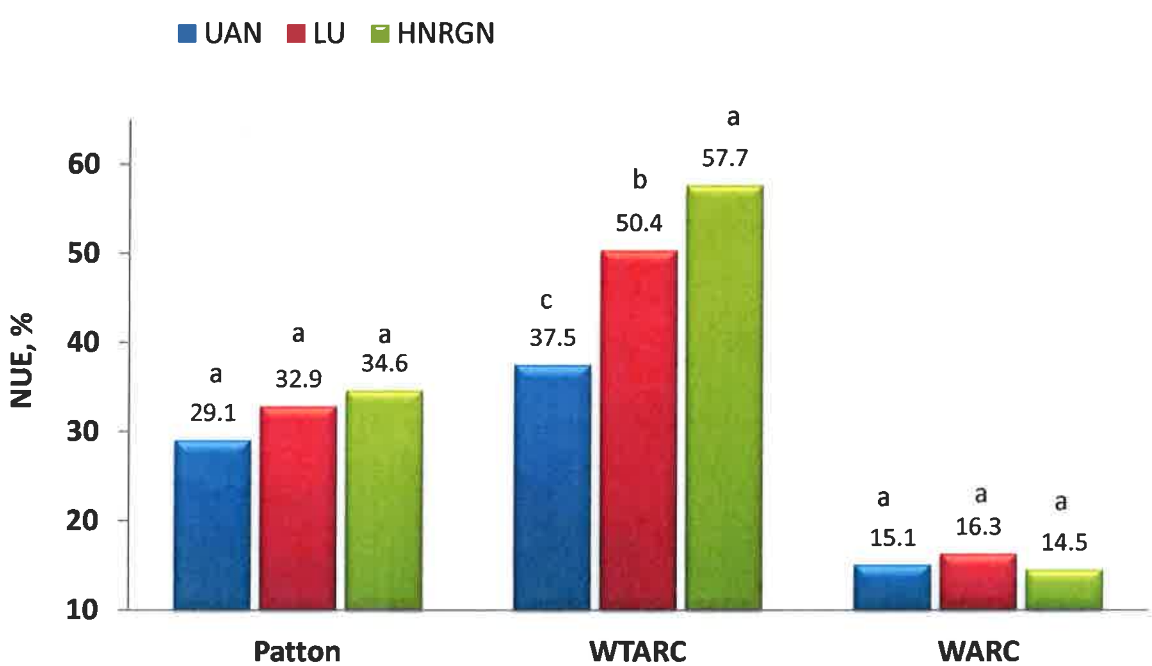

Figure 8. Fertilizer N source effect on NUE, Patton, WTARC, and WARC, 2013.

6. Termination Date: Termination Date: September 2013.

FINAL REPORT

1. Project Name:
Evaluation of Sensor-Based Technologies and Nitrogen Sources for Improved Recommendations for Dryland and Irrigated Spring Wheat Production in Montana

2. Principal Investigators and Cooperators:
Olga Walsh, Assistant Professor, Western Triangle Ag. Research Center (WTARC), Conrad
Mal Westcott, Professor and Supt., Western Ag. Research Center (WARC), Corvallis
Lindsey Martin, Producer, Pendroy, Teton County

3. Objectives:
   1. To evaluate two sensors (GreenSeeker, and Pocket Sensor) for developing normalized difference vegetative index (NDVI)-based topdress fertilizer nitrogen (N) recommendations in spring wheat in Montana.
   2. To determine whether sensor-based recommendations have to be adjusted depending on what N fertilizer source (liquid urea ammonium nitrate (UAN), or granular urea) is used.

4. Materials and Methods:

This project was originally established in the spring of 2011. In 2012 and 2013, this study was repeated at three experimental locations: two dryland sites - at WTARC near Conrad, MT and in cooperating producer's field (Lindsey Martin, Pendroy, Teton County) and one irrigated site at WARC, near Corvallis, MT, using the spring wheat variety Choteau. Sites where N is known to have been liberally applied over the years were avoided. Appropriate weed and pest management control were employed when necessary. Treatment structure is reported in Table 1. Four preplant N rates - 20, 40, 60, and 80 lb N ac^{-1} were applied as broadcasted urea. Treatment 1 was established as an unfertilized check plot. Treatment 2 received 220 lb N ac^{-1} preplant as urea and served as a non-limiting N-rich reference. Each treatment was replicated 4 times. The plot size was 5'x 25'. Wheat crop reflectance measurements (NDVI) from each plot were collected at Feekes 5 growth stage. Feekes 5 - early jointing (beginning of stem elongation, prior to first visible node) - has been identified in a course of multiple field studies as the most appropriate sensing time for wheat because it provides reliable prediction of both N uptake and biomass. The GreenSeeker (model 505) and Pocket Sensor were used to collect the NDVI measurements. According to treatment structure, topdress N fertilizer was applied as urea (as dry prills, manually broadcasted) or as UAN (as a foliar spray, using a battery operated backpack sprayer with a fan nozzle). Topdress N recommendations for Treatments 2-10 were made using algorithms experimentally developed specifically for spring wheat: 1. Spring Wheat (Canada), 2. Spring Wheat (US, Canada, Mexico), and 3. Generalized Algorithm. (available at: http://www.soiltesting.okstate.edu/SBNRC/SBNRC.php). The effects of preplant N rate, topdress N source, on spring wheat grain yield, grain protein content, protein yield, and N use efficiency (NUE), were assessed. Grain N uptake was calculated by multiplying yield by total N concentration. N use efficiency was determined using the difference method (Varvel and Peterson, 1990) by deducting the total N uptake in wheat from the N-unfertilized treatment (check plot) from total N uptake in wheat from fertilized plots and then divided by the rate of N fertilizer applied. The analysis of variance was conducted using the PROC GLM procedure in SAS v9.3 (SAS Institute, Inc., Cary, N.C.). Mean separation was performed using the Orthogonal Contrasts method at a significance level of 0.05.

5. Project Results and Relevancy to Montana:

Spring wheat grain yield data for each site-year is reported in Table 1. A wide variety of grain yields was observed among treatments at different site-years ranging from 14 bu ac^{-1} to 114 bu ac^{-1}.

A strong linear relationship was observed between NDVI values obtained with GreenSeeker and with Pocket Sensor (R^2=0.70) (Figures 1 and 2).

Table 2 helps to examine how the algorithm were tested. The algorithm's data inputs were: 1) NDVI from trt 2 (non-limiting N reference) or the highest NDVI value, 2) NDVI from all other treatments, 3) Seeding date, 4) Date of sensing, and 5) Yield goal (determined based on the average yield goal for the area). Based on the provided input data, the algorithm software has generated the following outputs: 1) Yield potential without added topdress N, 2) Yield potential with added topdress N, and 3) Recommended

N fertilizer topdress rate. The Spring Wheat (Canada) and the Generalized algorithm did not prescribe any topdress N rate to be applied at any of 8 site-years, even when the differences in crop stand and nutrient level (substantiated by the obtained NDVI sensor readings) were clearly apparent. The US-Canada-Mexico Algorithm has prescribed topdress N rates ranging from 0 to 122 lb N ac^{-1} depending on the yield goal for the location and the obtained NDVI values (Tables 2, 3 and 4).

It's clear from Table 5 that in some cases (WTARC, 2012 [Case1], and MARTIN, 2012 [Case 2]), the prescribed N rates were excessive. A 24 lb N ac^{-1} rate prescribed for trt 6 resulted in a total of 104 lb N ac^{-1} applied to that trt (compared to 62 lb N ac^{-1} topdress N, and a total N rate of 282 lb N ac^{-1} for trt 2) has resulted in a significantly higher grain yield (88 bu ac^{-1} vs only 74 bu ac^{-1} for trt 2 (Table 5). In some instances, the prescribed N rates did not make sense (WTARC, 2011 [Case 3]), and in some instances – the rates seemed appropriate (WTARC, 2012 [Case 4]) (Table 5).

At all site-years, N fertilizer rates recommended by the USA/Canada/Mexico Algorithm were not appropriate for grain yield optimization. For example, much higher top-dress N rates were prescribed for WARC (the irrigated site) compared to those for the dryland sites WTARC and Martin (Tables 2, 3, and 4). This makes sense since the expected yield potential at the irrigated site was much greater. On the other hand, grain yields obtained at WTARC were just as high as at WARC, indicating that the yield potential was either overestimated at WARC or underestimated at WTARC. This puts forward a question of whether there is a need for two separate algorithms, one developed for dryland spring wheat, and another for irrigated spring wheat production systems.

Spring what grain yield responded significantly to application of N fertilizer (5 out of 8 site-years), and grain protein content – in 6 out of 8 site-years (Table 6). In 7 of evaluated 8 site-years, protein yield has significantly responded to N fertilizer application rate (Table 7).

In 6 out of 8 site-years, there were no significant differences in grain yields and grain protein content values associated with topdress fertilizer N source (urea vs. UAN) (Table 6). No significant differences in protein yield or NUE associated with N fertilizer source were observed at any of the site-years (Table 7). This shows that topdress N fertilizer rates do not need to be adjusted based of fertilizer sources used, i.e. the same N rates should be prescribed whether urea or UAN is applied.

In conclusion, results indicated that both sensors performed well and were useful in predicting mid-season spring wheat grain yield potential. In addition, algorithms developed in other regions did not provide the appropriate top-dress N rates for Montana spring wheat varieties and growing conditions. These findings emphasize the importance of a state-wide collaborative research currently being conducted in Montana to develop improved sensor-based N optimization algorithms for Montana spring wheat and winter wheat varieties and growing conditions. The findings from this study will be summarized in publications, including a Fertilizer Fact sheet.

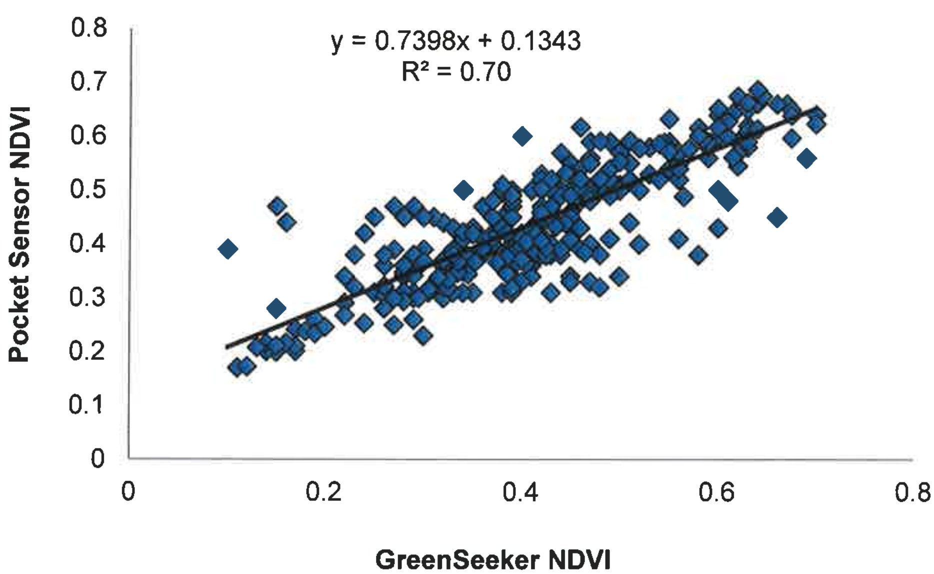

Figure 1. Relationship between GreenSeeker NDVI and Pocket Sensor NDVI, for 8 site-years in Montana.

Table 1. Treatment structure and spring wheat grain yields for 8 site-years in Montana.

Trt	*Preplant N Fertilizer Rate, lb N ac^{-1}	**Topdress N Fertilizer Source	Spring wheat grain yield, bu ac^{-1}							
			2011		2012			2013		
			WTARC	WARC	WTARC	WARC	MARTIN	WTARC	WARC	MARTIN
1	0	-	14 (f)	30 (f)	87 (d)	58 (f)	34 (ab)	64 (ab)	51 (a)	50 (a)
2	200	urea	40 (a)	55 (abc)	92 (d)	96 (d)	33 (ab)	61 (b)	59 (a)	50 (a)
3	20	urea	23 (e)	41 (d)	99 (c)	100 (cd)	35 (a)	63 (ab)	59 (a)	53 (a)
4	40	urea	23 (e)	51 (bc)	104 (abc)	103 (bcd)	31 (ab)	64 (ab)	60 (a)	51 (a)
5	60	urea	28 (cd)	57 (abc)	105 (abc)	111 (ab)	34 (ab)	68 (ab)	59 (a)	52 (a)
6	80	urea	32 (b)	59 (a)	108 (a)	102 (bcd)	30 (b)	70 (ab)	60 (a)	53 (a)
7	20	UAN	22 (e)	48 (cd)	99 (c)	107 (abcd)	31 (ab)	66(ab)	51 (a)	49 (a)
8	40	UAN	24 (de)	52 (abc)	100 (bc)	110 (abcd)	33 (ab)	67 (ab)	51 (a)	50 (a)
9	60	UAN	29 (bc)	50 (bc)	103 (abc)	113 (a)	34 (ab)	72 (a)	51 (a)	50 (a)
10	80	UAN	32 (b)	53 (abc)	106 (ab)	114 (a)	33 (ab)	68 (ab)	51 (a)	52 (a)

* Preplant fertilizer N will be applied as urea. ** Todress fertilizer N rates were determined based on the NDVI values obtained using GreenSeeker and Pocket Sensor.

Table 2. Normalized Difference Vegetative Index (NDVI) obtained with GreenSeeker and Pocket Sensor, and N rate prescribed by USA, Canada, Mexico Algorithm, WTARC and WARC, 2011.

Trt	2011					
	WTARC			WARC		
	GS NDVI	PS NDVI	N rate	GS NDVI	PS NDV	N rate
1	0.3	0.3	-	0.4	0.4	-
2	0.5	0.5	20	0.5	0.5	21
3	0.3	0.3	20	0.5	0.5	29
4	0.4	0.4	20	0.6	0.6	7
5	0.4	0.4	20	0.6	0.5	15
6	0.4	0.4	10	0.6	0.6	21
7	0.3	0.3	30	0.5	0.5	29
8	0.4	0.4	20	0.6	0.6	7
9	0.4	0.5	10	0.6	0.6	7
10	0.4	0.5	10	0.6	0.6	15

Table 3. Normalized Difference Vegetative Index (NDVI) obtained with GreenSeeker and Pocket Sensor, and N rate prescribed by USA, Canada, Mexico Algorithm, WTARC, WARC and MARTIN, 2012.

Trt	2012								
	WTARC			WARC			MARTIN		
	GS NDVI	PS NDVI	N rate	GS NDVI	PS NDVI	N rate	GS NDVI	PS NDVI	N rate
1	0.5	0.4	-	0.5	0.4	-	0.3	0.2	-
2	0.3	0.3	70	0.5	0.4	98	0.3	0.3	0
3	0.5	0.4	14	0.5	0.4	111	0.4	0.3	18
4	0.5	0.4	14	0.5	0.4	111	0.4	0.3	18
5	0.5	0.5	14	0.5	0.5	111	0.4	0.3	0
6	0.5	0.4	27	0.5	0.4	111	0.4	0.4	19
7	0.5	0.5	22	0.5	0.5	111	0.4	0.3	16
8	0.5	0.5	14	0.5	0.5	98	0.4	0.4	16
9	0.5	0.4	19	0.5	0.4	111	0.4	0.3	21
10	0.5	0.4	19	0.5	0.5	98	0.4	0.3	6

Table 4. Normalized Difference Vegetative Index (NDVI) obtained with GreenSeeker and Pocket Sensor, and N rate prescribed by USA, Canada, Mexico Algorithm, WTARC, WARC and MARTIN 2013.

Trt	2013								
	WTARC			WARC			MARTIN		
	GS NDVI	PS NDVI	N rate	GS NDVI	PS NDVI	N rate	GS NDVI	PS NDVI	N rate
1	0.6	0.6	-	0.3	0.2	-	0.4	0.4	-
2	0.4	0.4	81	0.4	0.3	80	0.4	0.4	0
3	0.6	0.6	48	0.3	0.3	80	0.4	0.4	0
4	0.6	0.6	48	0.3	0.3	80	0.4	0.4	0
5	0.6	0.6	48	0.3	0.2	122	0.3	0.3	50
6	0.6	0.6	48	0.4	0.3	80	0.3	0.3	50
7	0.6	0.6	48	0.3	0.2	122	0.4	0.4	0
8	0.6	0.6	48	0.4	0.3	80	0.4	0.4	0
9	0.6	0.5	48	0.3	0.3	80	0.4	0.4	0
10	0.5	0.6	93	0.3	0.2	122	0.4	0.3	0

Table 5. Four cases illustrating the recommendations developed by US-Canada-Mexico algorithm and grain yield results obtained following the application of prescribed topdress N rates.

Case	Site-year	Trt	Preplant N rate, lb N ac^{-1}	GS NDVI	Recommended topdress N rate, lb N ac^{-1}	Total N rate, lb N ac^{-1}	N rate difference, lb N ac^{-1}	Grain yield, bu ac^{-1}	Yield gain, bu ac^{-1}
1	WTARC, 2012	2	220	0.3	62	282	- 178	74 (d)	+ 14
		6	80	0.5	24	104		88 (a)	
2	Martin, 2012	5	60	0.3	0	60	+37	35	± 0
		6	80	0.4	17	97		35	
3	WTARC, 2011	6	80	0.4	9	89	- 42	32 (b)	+10
		7	20	0.3	27	47		22 (e)	
4	WTARC, 2012	3	20	0.5	13	33	+91	80 (c)	+ 8
		6	80	0.5	24	124		88 (a)	

Table 6. Effect of preplant N rate and topdress N source on spring wheat grain yield and protein content for 8 site-years in Montana.

Effects	Growing Season 2011				Growing Season 2012						Growing Season 2013					
	Grain Yield	Protein	Grain Yield	Protein	Grain Yield	Protein	Grain Yield	Protein	Grain Yield	Protein	Grain Yield	Protein	Grain Yield	Protein	Grain Yield	Protein
	bu/a	%	bu/a	%	bu/a	%	bu/a	%	bu/a	%	bu/a	%	bu/a	%	bu/a	%
	Preplant N Rate															
0	30	14	14	9.5	58	11	87	9.6	34	14.3	51	14.3	64	12.4	50	15.4
20	45	15	22	9.5	104	13	99	10.5	33	15.5	55	17.3	64	14.0	51	15.7
40	51	13	24	9.6	106	14	102	11.1	32	15.7	55	16.6	65	14.6	51	16.1
60	54	15	29	9.5	112	14	104	11.8	34	15.9	55	17.1	70	15.2	51	16.2
80	56	15	32	9.6	108	14	107	14.3	32	16.3	55	17.2	69	15.7	52	16.3
220	55	16	40	9.7	96	15	92	15.4	33	16.7	59	17.4	61	17.2	50	16.9
F test	***	**	**	ns	***	***	***	ns	**	**	ns	***	ns	***	ns	***
	Topdress N Source															
Urea	52	14.5	26	9.6	89	14.1	85	11.5	34	15.8	59	17.2	66	15.2	52	15.9
UAN	51	14.4	27	9.5	96	13.6	83	11.6	34	16.0	51	16.9	68	14.6	51	16.3
F test	ns	ns	ns	ns	***	***	ns	ns	ns	ns	***	ns	ns	***	ns	ns

Table 7. Effect of preplant N rate and topdress N source on spring wheat protein yield and NUE for 8 site-years in Montana.

Effects	Growing Season 2011				Growing Season 2012						Growing Season 2013					
	Protein yield	NUE	Protein yield	NUE	Protein yield	NUE	Protein yield	NUE	Protein yield	NUE	Protein yield	NUE	Protein yield	NUE	Protein yield	NUE
	lb/a	%	lb/a	%	lb/a	%	lb/a	%	lb/a	%	lb/a	%	lb/a	%	lb/a	%
	Preplant N Rate															
0	25889	n/a	7878	n/a	40602	n/a	40792	n/a	23853	n/a	15008	n/a	47816	n/a	46582	n/a
20	39370	35	12713	12	71931	72	50855	35	30805	30	29372	18	50855	35	48223	1
40	41253	38	13694	13	75306	78	56146	44	31921	32	26665	15	57007	12	49232	2
60	47643	49	16275	18	81064	87	58830	49	32267	33	28089	17	63305	20	49963	3
80	51078	55	18460	22	79690	85	67221	63	33809	35	31125	20	64230	21	51485	5
220	54516	61	22984	29	74355	76	68043	36	30631	30	31804	21	62324	18	50500	3
F test	***	**	***	***	**	ns	*	ns	***	ns	*	ns	**	*	ns	ns
	Topdress N Source															
Urea	45663	48.4	15169	18.7	75564	77.6	58761	46.3	32250	32	29786	19.3	59564	15.6	50126	3
UAN	44009	42.6	15402	16.4	78431	82.9	58073	47.8	32151	32.4	27840	16.3	59747	15.2	49494	2
F test	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Figure 2. Robin Christiaens, Research Associate, and Jeff Jerome, Research Assistant, obtaining spring wheat reflectance measurements using GreenSeeker Sensor (1 A) and Pocket Sensor (1 B), Western Triangle Agricultural Research Center, Conrad, MT, Spring 2012.

6. Termination Date: September 2013.

PROGRESS REPORT

1. Project Name:

Effect of Nitrogen Sources, Rates, and Application Time on Spring Wheat Yield and Grain Protein

2. Principal Investigators and Cooperators:

Olga Walsh, Assistant Professor, Western Triangle Ag. Research Center (WTARC)
Robin Christiaens, Research Associate, Western Triangle Ag. Research Center (WTARC)
Jack Patton, Producer, Knees, Chouteau County
Lindsey Martin, Producer, Pendroy, Teton County

3. Objective:

   1. To determine the most efficient nitrogen (N) fertilizer source, rate, and application time combination for optimizing Montana spring wheat yield while maximizing grain protein.

4. Materials and Methods:

Three dryland experiments were established: one at WTARC and two in cooperating producers' fields (Jack Patton, Knees, Chouteau County, and Lindsey Martin, Teton County) using Choteau spring wheat variety. Sites where N is known to have been liberally applied over the years were avoided. Appropriate weed and pest management control were employed when necessary. The plot size was 5'x 25' at each site. The treatment structure is reported in Table 1.

Table 1. Treatment structure.

Treatment	Fertilizer N Application					
	Preplant rate, lb N ac^{-1}	Preplant source	Todress rate, lb N ac^{-1}	Todress source	Topdress application time	Total N applied, lb N ac^{-1}
1	0	n/a	0	n/a	n/a	0
2	80	urea	0	n/a	n/a	80
3	120	urea	0	n/a	n/a	120
4	40	urea	40	urea	Before flowering	80
5	40	urea	40	urea	After flowering	80
6	40	urea	80	urea	Before flowering	120
7	40	urea	80	urea	After flowering	120
8	40	urea	40	UAN	Before flowering	80
9	40	urea	40	UAN	After flowering	80
10	40	urea	80	UAN	Before flowering	120
11	40	urea	80	UAN	After flowering	120

A combination of 4 preplant N rates (0, 40, 80, and 120 lb N ac^{-1}), 3 topdress N rates (0, 40, and 80 lb N ac^{-1}), 2 topdress N fertilizer sources (granual – urea, 46-0-0, and liquid – urea ammonium nitrate (UAN) , 28-0-0), and 2 topdress application times (before flowering and after

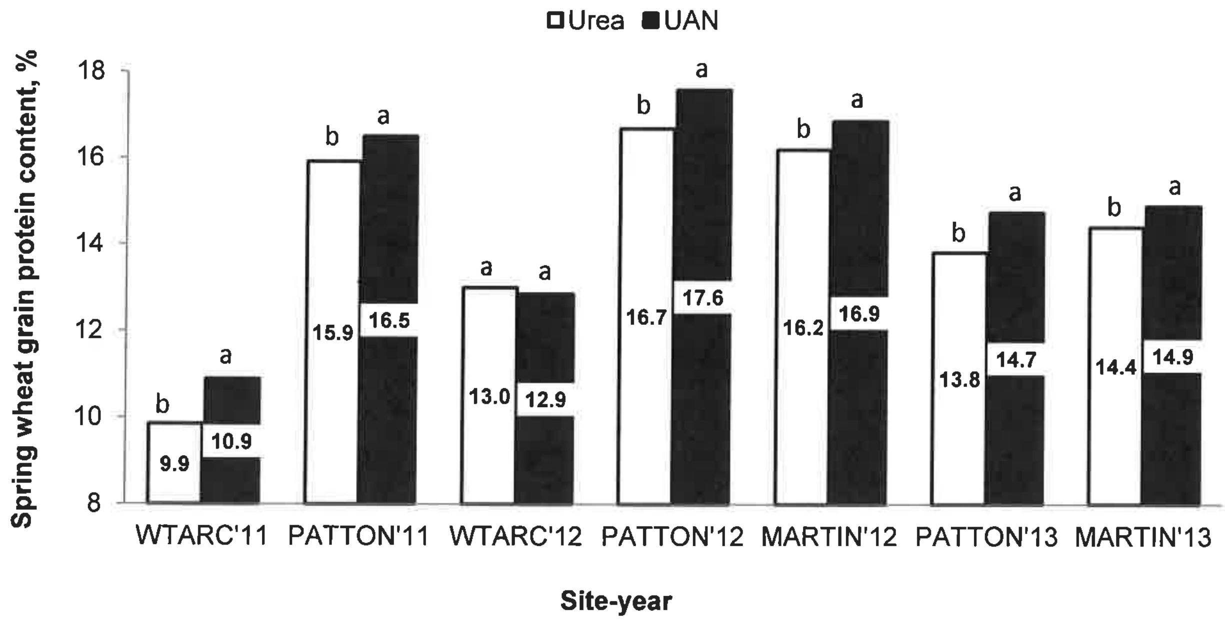

Figure 3. Effect of topdress N source on spring wheat grain protein content at 7 site-years in Montana.

Clearly, more applied research is needed to pinpoint the most productive and efficient way to managing N in wheat, especially in dryland production systems. Spring wheat is one of the major cereal crops grown in Montana. Wheat production represents almost 25% of Montana's agricultural revenue. There is a need to develop more efficient soil fertility and nutrient management strategies in order to maximize wheat grain yields and increase grain protein levels. The results of this study, in combination with findings from other experiments carried out in Montana, have significantly contributed to the volume of science. Results of this study will be summarized in scientific and outreach publications; a Fertilizer Fact sheet will be developed based on this study's findings.

6. Termination Date: 2013.

SPRING WHEAT VARIETIES

2013 Spring Wheat Evaluations in the Western Triangle Area

Personnel: John H. Miller, Julie Prewett, and Gadi V.P. Reddy, Western Triangle Ag. Research Center, Conrad, MT and Luther Talbert, Susan Lanning, and Hwa-Young Heo PSPP, Bozeman.

The advanced spring wheat and durum nurseries were planted on barley stubble chemical fallow and grown under dryland conditions in 2013. Off-station spring wheat variety nurseries were planted on chemical fallow. Off station trials were grown north of Cut Bank, MT, north of Devon, MT, near the 'Knees' east of Brady, MT, and northeast of Choteau, MT in Teton county. For the 2014 growing season, all nurseries will be grown on no-till chemical fallow.

Results: Results are tabulated in Tables 1 thru 12. Results for the advanced nursery are presented in Tables 1 and 2. Results are tabulated in Table 3 for the irrigated off-station spring wheat nursery and Table 4 is six year averages for selected varieties in the irrigated off-station spring wheat nursery. Table 5 contains the 2013 data and Table 6 showing a two year average for the Choteau location. Tables 7 and 8 are for the Cut Bank location, with Tables 9 and 10 representing the 'Knees' location. The durum nursery data are shown in Tables 11 and 12. The Devon location was lost due to soil crusting after seeding, causing a very poor stand. Soil test results may be viewed in Table 24 at the end of this section.

The 2013 growing season at WTARC began with temperatures a bit cooler than normal, there was a less precipitation than the 27 year average until May, then it warmed up and we received a bit more rain than usual until July. July was cooler than the 27-year average while being drier than the average.

Top yielding varieties at Choteau were WB Gunnison, McNeal, and Jedd with protein averaging 15.4% across all varieties. Vida, WB Gunnison and Duclair were the high yielding varieties at Devon while averaging 15.1% protein across all varieties. The 'Knees' high yielders were WB Gunnison, IMICHT79, and Duclair with 13.7% protein across all varieties. The top yielders in the irrigated trial were SY Tyra, Duclair, and IMICHT79, with protein averaging 13.3 percent.

Yields in the advanced nursery ranged from 59.0 to 87.1 bu/acre. The top yielding varieties were MT 1203, MT 1173, and Brennan. Yields were about 8 bu/a more in 2013 than the 6-year average and test weight was about 1.5 pounds lighter for the advanced nursery when compared to the longer term data. Grain protein was quite close to the 6-year average.

Yields in the irrigated off-station spring wheat trial ranged from 49.1 to 72.8 bu/acre. When compared to the six year averages, the irrigated off-station spring wheat nursery had much lower yields, with similar test weight, and lower grain protein (Tables 3 and 4). Yields ranged from 22.5 to 45.7 bu/acre at Choteau, 44.2 to 76.8 bu/acre north of Cut Bank, and 36.7 to 61.0 bu/acre at the 'Knees'. The multiyear means for the 'Knees' contain data from the last four years. The 'Knees' location had higher yields, with grain protein about equal when compared to the four year mean (Tables 9 and 10).

Durum yields ranged from 66.7 to 80.1 bu/acre (Table 11). With MT06578, Aldabo, and Alzada being the top three yielding varieties. The 2013 yields were about equal to the six year average (Table 12). Test weights were slightly lower than the long term average.

Off station cooperators: Bradley Farms, North of Cut Bank, MT
Brian Aklestad, North of Devon, MT
Aaron Killion, East of Brady, MT
Inbody Farms, Northeast of Choteau

These data should be used for comparative purposes rather than using absolute numbers. Statistics are used to indicate that treatment or variety differences are really different and are not different due to chance or error. The least significant difference (LSD) and coefficient of variability (CV) values are useful in comparing treatment or variety differences. The LSD value represents the smallest difference between two treatments at a given probably level. The LSD at p=0.05 or 5 % probability level is usually the statistic reported, and it means that the odds are 19 to 1 that treatment differences by the amount of the LSD are truly different. The CV value measures the variability of the experiment or variety trial, and a CV is greater than 15 % indicates a high degree of variability and less accuracy.

Funding Summary: The Office of Special Projects will provide expenditure information. No other grants support this project.

MWBC FY2015 Grant Submission Plans: A similar project will be proposed for FY 2015. The continuation of on and off-station variety trials help to elucidate researchers and farmers which varieties are better suited for that particular region in Montana.

Spring Wheat Variety Notes & Comments

Western Triangle Agricultural Research Center, Conrad MT

Sawfly Tolerant & Semi-tolerant Hard Red Spring Wheat Varieties:

Resistance (stem-solidness) among varieties ranges from low to high and varies with yearly climate differences; none have total resistance. Stem-solidness scores range from 5 (hollow) to 25 (completely solid). Solidness should be at least 19 to provide a reliable level of sawfly tolerance. However, some partially-solid stem varieties, such as Conan and Corbin, are less attractive to sawflies and show higher tolerance than expected for their level of stem solidness.

Agawam: See Hard White Spring Wheat. (Solid stem score = 23).

Choteau (MSU, 2004): Semidwarf with good straw strength. Height is 2" shorter than McNeal and 4" shorter than Fortuna. Stems very solid with good sawfly resistance (more solid than Fortuna). Sawfly resistance comparisons (max rating = 25): Choteau = 21, Fortuna = 19, Ernest = 16. Medium-early, 2 days later than Hank, 0.5 day later than Ernest & Fortuna, 2 days earlier than McNeal. High yield, similar to McNeal on both dryland and irrigated. Yields substantially higher than Ernest and Fortuna. Above average test wt (similar to Fortuna, and higher than McNeal). Moderate resistance to Septoria, and good resistance to most stem rust races. Protein above average. Normal gluten strength and good milling and baking quality. Fair Hessian fly tolerance. Some tolerance to root-lesion nematode.

Conan (WPB, 1998): Semidwarf. Solid stem score is low (10), but has low levels of sawfly-attractant cis-3-hexenylacetate, which increases sawfly resistance to medium. Medium maturity. Average yield and test weight. Some tolerance to Wheat Streak M V. Protein 0.5-0.9% higher than Rambo, and better protein quality than Rambo.

Corbin (WPB, 2006). Semidwarf height, 1" taller than Conan. Stem-solidness score = 10, medium sawfly resistance. Medium maturity, 1 day earlier than Conan. Average yield. Above-average test weight. Higher yield and test weight than Conan. Moderate resistance to stripe rust. Average protein.

Duclair (MSU, 2011): Solid stemmed hard red spring wheat, with stem solidness score of 20, slightly less than Choteau and slightly more than Fortuna. Yields were comparable to Choteau, Reeder, and Vida. Maturiety is day earlier than Choteau. Plant heights average about 31 inches. Yields (66 bu/a) tend to be similar to Choteau (65 bu/a), Reeder (66 bu/a) and Vida (68 bu/a). The average test weight is 60 lbs/bu, with grain protein averaging 13.7%. Duclair showed good resistance to stripe rust at Kalispell in 2010.

Ernest (ND, 1995): Tall, weak straw. Medium sawfly resistance (solid stem score = 16). High level of sawfly-attractant cis-3-hexenylacetate. Moderately late maturing, slightly earlier than McNeal. Poor threshability. Tolerant to Far-go. Resistant to prevalent races of leaf & stem rust. Below average yield. High protein and test weight. Good quality.

Lillian (Sask.): Tall weak straw. Late heading. Partial stem solidness. Sawfly cutting for Lillian was 30% at Conrad 2008, compared to 65% for susceptible varieties. Below average test weight. Above average protein.

Fortuna (ND): Beardless, tall straw. Too tall for irrigated conditions, vulnerable to lodging. Good sawfly resistance (solid stem score = 19). Early maturity. Tolerant to Fargo. Very susceptible to Septoria. Medium to low yield except under severe sawfly conditions, where Fortuna often ranks high for yield. Susceptible to shattering, especially in conditions favoring development of large kernels. Average test weight and protein. Fair Hessian fly tolerance.

Triangle II (WestBred, bz9m1024, 2008): Clearfield version of Conan, 2-gene resistance. Stem solidness less than Conan. Yield 1 bu higher than Conan, otherwise similar to Conan.

WB Gunnison (WestBred): Gunnison is intended to replace Conan and Corbin acres. Gunnison is hollow stemmed, but shows good tolerance to cutting by the wheat stem sawfly. The yield (55) is similar to Corbin and slightly higher than Conan. Average test weight is 60 lbs/bu, with grain protein levels of 13.8%, a bit lower than both Conan and Corbin. Average plant height is 30 inches with similar maturity to Conan and Corbin. Gunnison has moderate resistance to stripe rust.

Hollow-Stem, Sawfly Intolerant Hard Red Spring Wheat Varieties:

Alsen (ND, 2004). Moderate Fusarium scab resistance (MR). Semidwarf height. Medium maturity. Average yield. High test weight. High protein. Very poor Hessian fly tolerance.

AP604CL (AgriPro-8): Medium height, med-early maturity. Avg yield. Above avg test weight & protein.

AP603CL (AgriPro): Two-gene IMI resistance for Clearfield System. Med-tall, med-late maturity. Below average yield. Above average test weight & protein. Medium scab tolerance.

Freyr (AgriPro-3, 2004): Semidwarf height. Good lodging resistance, but less than Norpro. Medium maturity, 2 days earlier than McNeal. Average yield. Above average test weight. Average protein. Fusarium Scab resistance slightly lower than for Alsen (MR). Stripe rust MR. Acceptable quality.

Hank (WestBred): Semidwarf height. Medium lodging resistance. Early heading, 3 days earlier than McNeal. Above average yield. Better shatter resistance than 926. Below average test weight. Good tolerance to dryland root rot, tolerant to Far-go. Protein above average. Good quality. Hessian fly tolerant (similar to Choteau).

Hanna (AgriPro): Fusarium Scab tolerant.

Jedd (WestBred, 2007): Clearfield System hard red with 2-gene resistance. BC-derived from Hank. Short semidwarf height, 3" shorter than Hank or Choteau. Medium heading. Above average yield and test weight, dryland or irrigated. Higher dryland yield than Hank. Average protein. High quality. Moderately susceptible to stripe rust. Tolerance to Hessian fly biotypes of Washington, but unknown for biotypes in Montana.

Kelby (AgriPro, 2006, AP06): Good scab tolerance. Semidwarf height, stiff straw. Early heading. Below average yield. Above average test weight and protein. Good foliar disease resistance.

Kuntz (AgriPro-7, 2006): Medium height and maturity. Average yield. Above avg test weight. Average protein.

McNeal (MSU, 1994): Red chaffed. Semidwarf. Good lodging resistance, but straw is less resilient, and is prone to breaking over in strong wind. Medium-late maturity. Fair tolerance to wheat streak mv (2.5 on scale of 1-3). Some tolerance to dryland root rot. Above average yield, similar to Reeder and Choteau. Average test weight. Very good quality with high protein and loaf volume. Medium-low Hessian fly tolerance. Some tolerance to root lesion nematode.

Norpro (AgriPro-1): Semidwarf, very strong straw. Medium-late maturity. Below avg yield and test weight. Average protein. Low flour yield and high ash. Not well-adapted for dryland in District 5 (Triangle), but **suitable for irrigated.**

ONeal (WestBred, bz999592, 2008): A McNeal/906R cross. Semidwarf height similar to McNeal. Head date similar to McNeal and one day later than Choteau. Above-average yield, 3-5 bu higher than McNeal and similar to Choteau. Average test weight, above-average protein. A high quality wheat for areas where McNeal is adapted. Hollow stemmed, but shows less sawfly damage than McNeal.

Outlook (MSU, 2002): Russian Wheat Aphid resistant, but susceptible to new biotype in 2004. Stiff straw, semidwarf, height equal to McNeal & Reeder. Med-late maturity = McNeal. Above average yield, similar to McNeal and Reeder. Below average test weight. Average protein. Quality acceptable, and superior to Reeder.

Reeder (ND, 1999): Semidwarf height. Medium head date, slightly earlier than McNeal, but maturity slightly later than McNeal. The "stay-green" trait provides a longer grain-fill period and higher yield, as long as moisture is available.

Similar to McNeal for agronomics. Above average yield. Average test weight and protein. Quality is below average. Susceptible to Everest W.O. herbicide. Very poor Hessian fly tolerance.

Vida (MT 0245): Semidwarf height, medium straw strength. Med-late maturity, heading = McNeal, but stays green 3 to 4 days later than McNeal. High yield, 4 bu over McNeal. Average test weight and protein, acceptable quality. Possible replacement for Outlook and Reeder (except Outlook would remain in use for RWA resistance). MR stripe rust and Septoria. Partially-solid stem (stem score = 11), slightly less than Conan & Ernest for sawfly tolerance.

Volt (WestBred, 2007): Semidwarf height. Late heading. Average yield on dryland, above-average yield on irrigated. Above avg test wt. Average protein. Good tolerance to stripe rust and Fusarium head blight. Sawfly cutting similar to McNeal. A high yield, disease resistant variety **for irrigated conditions**.

WestBred - See also Agawam, Conan, Corbin, Hank, Jedd, ONeal, Triangle II, Volt.

Hard White Spring Wheat

Protein of hard white wheat for bread baking needs to be higher than wheat required for noodle markets. Some varieties are dual-purpose and can be used for both bread and noodles. Although not a concern for bread baking quality, varieties with low levels of polyphenol oxidase (PPO) are desirable for noodles, since high PPO levels are associated with noodle discoloration. At present, all Montana hard white spring varieties are high PPO, and thus better suited for bread baking. Many hard white varieties sprout more readily than hard reds, especially those developed from Australian germ plasm. The pure white trait is difficult to maintain, as pollen from red wheats may pollinate a white variety, causing a mixture of red kernels. It is very important to clean the combine, storage bins and other grain handling equipment prior to harvest to avoid mixing white wheat with other wheats. Seeding equipment and seedbed must also be free of red wheats. Seeding rate should be 10% higher than for red wheat to reduce late tillers and thereby reduce green kernels.

Agawam (WestBred, 2005): Hard White. Semidwarf height. Sawfly resistant: solid stem score = 22, similar to that of Choteau, and has a low level of sawfly-attractant cis-3-hexenylacetate . Early heading, similar to Explorer. Very high yield and test weight. Protein 1.4% lower than Explorer. Fair Hessian fly tolerance.

Blanca Grande (Gen Mills): Hard white. Short stiff straw. Early maturity. Medium high yield. High test weight and low protein.

Clarine (WestBred): Hard white. Clearfield system, 2-gene resistance. Very high milling/baking quality. A Clearfield version of Pristine. Available in 2009.

Explorer (MSU, 2002): Hard white, bread-baking type. Semidwarf, 2 inches shorter than McNeal. Slightly solid-stem, but not sufficient for sawfly resistance. Early maturing. Average yield and test weight. Very susceptible to Septoria, thus not recommended for far eastern Montana. High protein, and probably too high for noodles. Excellent bread baking quality.

Golden 86 (GP Seed & Research Inc, 1986): Hard white. Used by a commercial milling and baking firm north of Three Forks, Montana. High quality.

MTHW 9420 (MSU, 1999): Experimental for exclusive release. Medium height and maturity. Below average yield. Average test weight. Very susceptible to wheat streak mosaic virus. Excellent bread quality, but too high in protein for noodles.

Plata (Gen Mills): Hard white. Short stiff straw. Medium maturity. Medium yield & test wt. Med-low protein.

Pristine (WPB): Hard white. Semidwarf. 3 days earlier than McNeal. Yield = McNeal. Protein 0.5% < McNeal. Very high quality, and used for bread baking by industry in Mid-west. See also Clarine.

Durum

Durum is generally much more susceptible to wheat streak mv and Fusarium crown rot than spring wheat.

Quality durum has strong gluten. Growers who plan to grow weak-gluten varieties need to have a marketing organization identified that will purchase those varieties. Kernel color is a very important quality trait. Rainfall or irrigation after heading causes color loss (bleaching), but some varieties are less prone to color loss. Canadian varieties are screened for bleaching resistance. Such varieties are the preferred choice in areas of late-season rainfall. Varieties that lose color more readily may be okay for drier areas of Montana. Seeding rate for durum should be 30% higher than for spring wheat due to the larger durum kernel (fewer kernels per bushel). An additional seed-rate increase may be desirable to suppress late tillers and thereby decrease green kernels. Color score is important, and green kernels contribute to poor color and dockage. 23 to 29 seeds per square foot (approx 1.0 to 1.26 million seeds per acre) has normally been a good seeding rate for durum.

Alkabo (ND, 2006): Medium-tall height, very stiff straw. Medium maturity. Above average yield and test wt. Good quality.

Alzada (WestBred, 2005): Semidwarf height, short stiff straw. Early maturing. High yield, average test weight. Medium protein. Very good quality and gluten strength, and very good semolina color.

Avonlea (Can, 1997): Medium tall. Medium straw strength and lodging resistance. Early maturity. High yield and average test weight. Good quality and protein.

Dilse (ND): Medium height, late maturity. Below average yield. Average weight. High protein, excellent quality.

Divide: (ND, 2006): Medium-tall height, stiff straw. Medium maturity. Average yield. Above average test wt. Excellent quality.

Grenora (ND, 2006): Medium-tall height, stiff straw. Medium maturity. Average yield and test wt. Good quality.

Kyle (Canada, 1984): Very tall weak straw, poor lodging resistance. Very late maturing. Average yield and test weight, large kernel size. Kyle has the highest tolerance to color-loss (rain-bleaching). Above average protein. Strong gluten; good quality.

Lebsock (ND, 1999): Medium height, stiff straw. Late maturity. Below average yield. High test weight and excellent quality.

Levante (AllStar Seeds, 2007): Short semidwarf height. Early heading. Above average yield & test weight on dryland in 2007; and average performance on irrigated.

Maier (ND, 1998): Medium height, stiff straw, good lodging resistance. Medium maturity. Above-average yield. Medium large kernels, very high test weight. Average protein. Good milling quality.

Mountrail (ND,1998): Medium-tall, but stiff straw and fair lodging resistance. Medium-late maturity. Average yield and test weight. Medium large kernel and average protein. Medium quality, but kernel color more sensitive to late rain than some other varieties. (All durums are sensitive to late rain/irrigation relative to color loss).

Navigator (Can): Med short, but weak straw. Med late maturity. Medium test weight & protein, good quality.

Normanno (AllStar Seeds, 2007): Semidwarf height. Medium maturity. Average yield and below average test weight in 2007.

Pathfinder (Can): Med tall, weak straw. Med late maturity. Med test weight. Med low protein, good quality.

Pierce (ND): Medium-tall height and lodging resistance. Below average yield. High test weight. Average protein, good quality.

Plaza (ND): Med-short straw, med lodging resistance. Late maturity. Below-average yield on dryland; above-average yield on irrigated. Below average test weight. Low protein, medium quality.

Silver (MSU, 2011): Medium-short, with good lodging resistance, with maturity comparable to Alzada. Above average yield on dryland with slightly above average test weight on dryland and irrigated plots. Silver has average protein.

Strongfield (WestBred/Canada, 2005): Medium tall, med-late maturity. Above average yield. Average test weight. Above-average protein. Good color and quality. Low grain cadmium concentration.

Table 1. 2013 Advanced Spring Wheat variety nursery, Conrad Dryland.

Variety or ID	Class	Yield (bu/a)	Test Wt. (lb/bu)	Head Date	Protein (%)
MT 1203	-	87.1	59.4	180.0	13.9
MT 1173	-	87.0	58.3	182.0	12.8
Brennan	-	86.6	63.2	182.7	13.9
MT 1264	-	86.6	61.3	183.0	12.8
SY605 CL	CL	84.4	62.5	182.0	14.2
MT 1231	-	84.1	61.0	182.0	13.7
SY Soren	-	83.8	62.3	182.0	13.6
MT 1172	-	83.7	59.9	181.0	13.2
McNeal	*	83.3	60.4	182.0	13.0
MT 1273	-	82.7	61.4	182.3	12.2
MT 1276	-	82.5	61.1	183.0	13.0
MT 1053	-	81.0	60.3	182.3	12.9
CAP197-3	-	80.6	59.3	182.0	12.5
MT 1228	-	80.0	59.9	182.0	13.2
LCS Powerplay	-	79.8	60.8	182.0	12.8
Vida	*	79.6	58.9	182.7	12.7
WB Rockland	-	79.0	61.0	181.7	13.8
Volt	-	78.0	62.8	181.0	12.2
MT 1118	-	77.8	55.9	182.0	14.6
MT 1007	-	77.5	60.9	182.0	13.6
MT 1224	-	77.5	59.6	182.3	13.6
Reeder	-	77.1	60.9	182.0	13.7
Vantage	-	77.1	60.4	182.0	13.8
MT 1222	-	77.0	59.4	181.0	14.4
MT 1255	-	76.8	58.8	182.0	13.0
MTHW1150	-	75.7	59.7	181.0	13.0
SY Rowyn	-	74.9	61.1	181.7	12.6
MT 1002	-	74.6	57.8	183.0	13.0
MT 1142	-	74.5	59.2	183.0	14.2
Fortuna	**	74.5	62.1	182.0	13.6

Table 1 continued on next page

Table 1 continued

Variety		Yield	Test Wt	Head date	Protein
MT 1225	-	74.5	59.5	182.0	13.7
Choteau	**	74.4	57.8	182.0	13.2
Duclair	**	74.4	58.5	180.0	13.6
MT 1252	-	73.8	60.2	182.3	12.8
Corbin	*	73.8	60.3	182.0	13.7
WB9879CL	CL	73.7	59.9	182.3	13.8
CAP 34-1	-	73.6	60.8	181.0	13.6
WB Mayville	-	73.6	63.5	182.3	14.6
MT 1219	-	73.3	58.5	180.0	13.4
CAP400-1	-	72.3	59.9	182.3	14.6
MT 1206	-	71.2	59.9	181.7	13.4
MT 1205	-	70.7	59.9	181.0	13.8
MT 1103	-	70.1	59.6	182.0	13.1
MT 1235	-	70.1	59.4	182.0	14.3
Mott	-	70.1	60.9	181.0	13.5
LNR0551	-	70.1	62.1	181.0	12.5
CAP219-3	-	69.8	60.0	182.0	13.1
MT 1213	-	69.6	58.2	182.7	14.2
MT 1211	-	69.5	58.5	182.0	13.9
Buckpronto	-	69.1	60.3	181.0	13.6
MT 1233	-	69.0	59.3	181.0	14.0
LCS Breakaway	-	68.0	61.8	181.0	13.7
SY Tyra	-	67.2	61.9	182.0	12.4
MT 1227	-	67.1	55.8	182.3	14.0
Conan	*	67.1	59.7	180.7	14.0
Thatcher	-	66.5	60.1	182.7	13.2
WB Gunnison	*	66.3	62.0	181.0	13.3
MT 1236	-	66.0	56.8	181.0	14.1

Table 1 continued on next page

Table 9. Off-station spring wheat variety trial located near the Knees.
Chouteau county. Western Triangle Ag. Research Center. 2013.

Variety	Class	Yield bu/a	Test Wt lb/bu	Height in.	Protein %
MT 1053	-	61.0	62.8	26.0	12.2
Duclair	**	59.3	62.1	25.7	13.1
Vida	*	59.2	62.1	25.7	13.2
MT 1172		58.7	62.3	25.3	12.3
Reeder	-	58.1	62.9	26.3	13.2
Corbin	*	57.2	62.9	23.0	13.4
WB9879CL	-	55.5	62.9	24.3	13.3
Choteau	**	55.2	62.9	24.3	13.5
Mott	-	53.7	63.0	28.6	13.5
Volt	-	51.7	63.5	24.7	12.2
SY Tyra	-	50.4	64.6	23.3	12.0
ONeal	*	50.1	61.8	26.6	12.3
MT 1142	-	48.7	62.9	25.7	13.8
WB Gunnison	*	48.6	63.4	26.0	13.8
AP604 CL	CL	46.7	64.4	24.7	13.2
McNeal	-	44.9	61.6	26.0	13.6
Jedd	CL2	42.8	63.1	20.0	12.8
Hank	-	42.8	61.4	22.3	13.4
Fortuna	**	40.9	62.5	29.0	14.9
Kelby	-	36.7	62.8	20.7	15.3
Mean		51.3	62.8	24.8	13.3
LSD (.05)		10.0	1.3	1.6	
C.V. 1 (%) (S/mean)*100		9.6	1.1	3.2	

Cooperator and Location: Aaron Killion, western Chouteau county.
Planted: May 9, 2013 on chem-fallow. Harvested: August 23, 2013.
Fertilizer, actual lbs/a: 11-22.5-0 with seed at planting and 58-0-20 broadcast while planting.
Fertilizer rates are based on soil testing and a yield goal of 50 bu/a.
Preplant sprayed with Roundup Max™ @ 20 oz/a on May 9, 2013. Sprayed with Huskie at 11 oz/a and Axial XL at 16.4 oz/a on 6/17/2013.
Precipitation: Not Available.
** = Solid stem sawfly-resistant (solid stem score of 19 or higher). * = Less preferred by sawfly (behavioral preference) in small plots.
Conducted by MSU Western Triangle Ag. Research Center.

Table 10. Five-year means, Spring Wheat varieties, Knees area, western Chouteau County. 2009-2013.

Variety	Class	5-Year Means Yield bu/a	Test weight	Height in.	Protein %
Duclair	**	53.0	59.7	27.0	13.7
Corbin	*	49.8	60.5	26.6	13.7
Vida	*	49.5	60.4	27.7	13.5
WB Gunnison	*	48.6	61.1	27.2	13.7
Choteau	**	48.2	60.2	25.9	14.1
ONeal	*	47.0	60.7	27.7	13.5
Reeder	-	44.8	60.4	27.3	14.3
Volt	-	44.6	62.0	25.7	13.2
McNeal	-	44.4	59.0	28.6	13.9
Jedd	CL2	41.3	60.1	22.0	13.8
SY Tyra	*	40.7	59.2	23.9	13.3
AP604 CL	CL	39.6	61.0	26.7	13.9
Fortuna	**	38.6	60.8	32.2	14.5
Kelby	-	38.1	61.2	23.3	14.9
Hank	-	36.9	58.5	25.1	14.0
Mean		44.3	60.3	26.5	13.9

** = Solid stem sawfly-resistant (solid stem score of 19 or higher).
* = Less preferred by sawfly (behavioral preference) in small plots.
CL= Clearfield technology
Cooperator and Location: Aaron Killion, western Chouteau county.
Conducted by MSU Western Triangle Ag. Research Center.

Table 11. 2013 Dryland Durum variety nursery, WTARC, Conrad, MT.

Variety	Yield (bu/a)	Test Wt (lb/bu)	Height (in.)	Heading, days from planting	Grain Protein (%)
MT06578	80.1	60.9	26.3	64.0	11.97
Alkabo	79.7	61.2	36.3	63.7	12.65
Alzada	78.5	59.8	28.0	63.0	13.89
Silver	75.7	60.1	27.3	63.7	13.61
MT07707	70.4	56.5	26.3	64.3	13.02
Grenora	70.1	60.2	34.0	63.7	13.99
Tioga	68.5	60.7	38.3	64.3	13.93
APB D6-419	67.5	58.3	30.0	63.7	13.89
MT05157	65.1	62.1	26.3	63.7	13.39
APB D7-12	64.7	57.0	28.0	63.0	12.63
Kronos	63.6	57.0	25.7	61.0	13.31
Normanno	63.1	57.8	24.0	63.3	13.61
DG Max	61.7	59.7	36.0	64.0	13.32
Divide	60.4	61.1	37.3	64.0	13.73
MT06584	60.2	58.0	24.7	64.0	13.76
VT Peak	58.7	60.2	35.7	64.0	14.31
Mountrail	56.3	57.2	34.7	63.7	14.93
Carpio	56.3	58.6	37.7	64.7	14.83
Means	66.7	59.3	30.9	63.7	13.60
LSD (.05)	14.0	2.2	2.2	1.7	
CV (%), S/mean	15.9	2.2	4.3	1.6	

Planted April 29, 2013. Harvested August 20, 2013.
Fertilizer, actual: 145-22-20, 11-52-0 place with seed, Urea and potash broadcast on April 17, 2013. A yield goal of 60 bu/a and soil tests were used to calculate the fertilizer rate on Durum. Soil test results may be found in Table 24.
Herbicide: Preplant sprayed with RoundupMax at 18 oz/a on 4/23/2013. Then sprayed with Huskie at 11 oz/a and Axial XL at 16.4 oz/a on 6/7/2013.
Total precipitation from planting to harvest: 8.03 inches.
Location: Western Triangle Ag. Research Center, Conrad, MT.

Table 12. Six-year means, dryland Durum varieties. Western Triangle Ag. Research Center Conrad, MT, Pondera County, 2008 – 2013.

		6 year mean				
Variety	Source	Yield (bu/a)	Test weight	Height (in)	Head date	Protein
Alkabo	N. Dak.	70.0	62.0	36.1	74.6	12.5
Grenora	N. Dak.	69.2	61.5	33.7	74.3	12.9
Alzada	WestBred	67.7	60.8	28.0	71.8	12.6
Silver (MT03012)	MSU	67.1	61.1	27.9	71.5	12.8
APB D6-419	APB	64.4	59.9	29.4	72.9	12.9
Mountrail	N. Dak.	64.1	60.2	36.0	76.1	13.0
Divide	N. Dak.	63.5	61.4	36.7	75.5	12.9
Normanno	AllStar	59.7	59.6	25.0	73.4	12.4
Nursery Mean		65.7	60.8	32.0	74.0	12.7

Table 24. Soil test values for off-station and on-station plots, 2013.

Location	N (lbs/a)[1]	Olsen-P (ppm)	K (ppm)	pH	OM (%)	EC (mmhos/cm)
Cut Bank	44.7	14	495	7.4	2.8	0.41
Devon	33.0	7	170	8.9	0.9	0.86
Knees	59.5	25	414	7.3	2.6	0.57
Choteau	71.5	13	580	8.0	3.0	0.51
WTARC	52.5	18	346	7.5	2.7	0.38

[1]Nitrogen soil samples were to a depth of four feet in one foot increments. All other soil tests were for zero to six inches in depth.
WTARC- Western Triangle Ag. Research Center

BARLEY VARIETIES

2013 Spring Barley Evaluations in the Western Triangle Area

Personnel: John Miller, Julie Prewett, and Gadi V.P. Reddy, Western Triangle Ag. Research Center, Conrad, MT, and Tom Blake, PSPP, Bozeman.

The uniform, intrastate barley nursery was grown on dryland and irrigated conditions at the Research Center. Four off station locations were planted during 2013. Off station trials were grown north of Cut Bank, MT, north of Devon, MT, near the 'Knees' east of Brady, MT, and northeast of Choteau, MT in Teton county. All nurseries were grown on no-till chemical fallow. For the 2014 growing season, all nurseries will be grown on no-till chemical fallow.

Results: Tables 12 and 13 contain the results for the 2013 intrastate irrigated nursery and the five year averages. Devon location was lost due to soil crusting after seeding, thereby causing a very poor stand. Soil test results may be viewed in Table 24.

The 2013 growing season at WTARC began with temperatures a bit cooler than normal, there was a less precipitation than the 27 year average until May, then it warmed up and we received a bit more rain than usual until July. July was cooler than the 27-year average while being drier than the average.

Grain yields averaged 75.0 bu/a for the irrigated intrastate barley nursery (Table 12), multiyear yields for the irrigated intrastate barley trial are much higher (Table 13), the low yields of the irrigated intrastate nursery were probably due to a much later than usual planting date. Although, quality factors, such as, plump and protein were very similar in 2013 when compared to the 5 year averages. The average test weight of the 2013 intrastate variety trial was influenced by the larger than usual number of entries of hullless barley.

The results of the other off-station locations are being processed.

<u>Off station cooperators</u>: Bradley Farms, North of Cut Bank, MT
Brian Aklestad, North of Devon, MT
Aaron Killion, East of Brady, MT
Inbody Farms, Northeast of Choteau

These data should be used for comparative purposes rather than using absolute numbers. Statistics are used to indicate that treatment or variety differences are really different and are not different due to chance or error. The least significant difference (LSD) and coefficient of variability (CV) values are useful in comparing treatment or variety differences. The LSD value represents the smallest difference between two treatments at a given probably level. The LSD at p=0.05 or 5 % probability level is usually the statistic reported, and it means that the odds are 19 to 1 that treatment differences by the amount of the LSD are truly different. The CV value measures the variability of the experiment or variety trial, and a CV of greater than 15 % indicates a high degree of variability and less accuracy.

Funding Summary: Office of Special Projects will provide expenditure information. No other grants support this project.

MWBC FY2015 Grant Submission Plans: A similar project will be proposed for FY 2015. The continuation of on and off-station variety trials help to elucidate researchers and farmers which varieties are better suited for that particular region in Montana.

Barley Variety Notes & Comments

Western Triangle Agricultural Research Center, Conrad, MT

Baroness (WestBred): 2-row feed. Short straw and good lodging resistance; 2.5" shorter than Harrington. Equal or slightly later maturity than Harrington. High yield when tested in favorable moisture conditions. Average test weight. Stripe rust resistant.

Boulder (WestBred, 2005): 2-row feed. Composite-cross, non-Baroness derived. Height similar to Haxby. Heading 1 day later than Haxby, and 1 day earlier than Baroness. High yield, similar to Haxby. High test weight, 0.5 lb less than Haxby. Replacement for Baroness and Xena.

Challenger (WestBred, 2008): 2-row feed. Above average yield and test weight. Average height and maturity.

Champion (WestBred, 2007): 2-row feed. Medium stiff straw. Heading one day later than Haxby and Boulder. Very high yield, greater than for Boulder & Baroness. High test weight, 1 lb less than Haxby.

Charles: 2-row malt. Grown as a winter barley in Idaho, but has very low winter hardiness. Winter survival on tillage-fallow at Conrad was 40% in 2007, and 10% in 2008.

Conlon (ND, 1996): 2-row malt. Medium height, weak straw. Early maturity, 1-2 days earlier and higher test weight than Bowman. Developed for areas of heat & drought stress. High resistance to net blotch; susceptible to spot blotch & Fusarium head blight.

Conrad (Busch Ag): 2-row malt, Busch Agr Resources. About 2 inches shorter than Harrington. Medium maturity, similar maturity as Harrington. Higher yield than Harrington. Slightly higher test weight and plump than Harrington.

Copeland (Sask. Canada, 1999): 2-row malt. Better straw strength and earlier maturity than Harrington. Similar yield, test weight, and plump than Harrington. Net blotch resistant. Scald & Septoria susceptible.

Craft (MT970116; MSU, 2006): 2-row malt. Taller than Harrington & Merit. 2 days earlier heading than Harrington, but later heading than Hockett. High yield, test weight, & plump. Moderate stripe rust resistance. Susceptible to net blotch. European style of malt enzyme activity for microbrew market. AMBA approved for organic malt production.

Drummond (ND 15477): 6-row malt. Stronger straw than other 6-row malt types. Improved yield over Morex, Robust and Foster. Plump higher than Morex.

Eslick (MSU, 2005): 2-row feed. Height 1" taller than Baroness, 1" shorter than Haxby. Heading date similar to Harrington, and 1-2 days later than Haxby. Yield similar to Baroness and Haxby. Test wt = Baroness, greater than Harrington, and 2# less than Haxby. Eslick has superior performance in areas of ample moisture, while Haxby is preferred where lower moisture conditions are expected.

Geraldine (MT960101; MSU, Miller Brewing): 2-row malt for Miller Brewing Co. One day later heading than Harrington. Good performance on irrigated conditions; below average performance on dryland. Moderate stripe rust resistance.

Harrington (Sask. Can): 2-row malt. Medium height; medium weak straw. Medium-late maturity. Sensitive to hot dry areas; yields good in moist areas. Can sprout or germinate (internal falling number) at a lower moisture content than other varieties.

Haxby (MSU, 2002): 2-row feed. 3 inches taller and two days earlier than Baroness. Among highest yielders in Triangle Area. Highest test weight of all varieties. High feed quality. Non-Baroness derived, providing good diversity. Haxby has superior yield performance in lower moisture conditions, while Eslick has a yield advantage in high moisture conditions.

Hays (MSU, 2004): Hooded 2-row forage. Shorter than Haybet and more resistant to lodging. Higher grain yield than Haybet. Low test weight. Higher forage yield than Haybet and Westford (8%). Harvest between heading stage and 5 days post-heading for highest protein. Caution: any cereal grain grown for hay should be tested for nitrate level prior to cutting. Nitrates decrease during grain filling, but in drought conditions, nitrates may be high all season, unless irrigation is available.

Hockett (MSU, MT910189): 2-row malt for dryland. 4 days earlier than Harrington, and retains plump on dryland much better than Harrington. 5 bu/a higher yield than Harrington. Very susceptible to stripe rust.

Kendall (Can): 2-row malt. High irrigated yield.

Lacey (M98, MN 1999): 6-row malt. Intended to replace Robust. Height intermediate between Robust & Stander. Lodging resistance greater than Robust, but less than Stander.

Legacy (Busch Ag): 6-row malt. 2 to 4 inches taller than Harrington. Higher yield than Morex and Robust, but lower than Harrington. Has 30% resistance to vomatoxin. Very susceptible to stripe rust.

Merit (Busch Ag): 2-row malt. Late maturing, too late for dryland. Lodges easier than Harrington, but yields higher. Very high diastatic power for excellent malting ability. Net blotch resistance, and moderate Scald resistance.

Metcalfe (Manitoba Canada, 1994): 2-row malt. Replacement for Harrington in Canada. Medium straw strength. Latitude sensitive - higher yield, test weight and plump than Harrington in Canada, but similar to Harrington in Montana. Similar protein as Harrington. Medium-late, slightly earlier to head than Harrington. Moderate resistance to spot-form net blotch. Susceptible to scald and Septoria.

Stellar (ND16301, 2005): 6-row malt. Medium-short. Good straw strength and widely adapted across North Dakota. Medium maturity. High plump and low protein. Excellent malt quality. Moderate spot-blotch resistance. Net-blotch susceptible.

Stockford (WestBred, 2005). 2-row hooded hay barley. Height is 2" taller than Hays. Heading is 2 days earlier than Hays. Forage yield is similar to Hays and Haybet. Harvest between heading stage and 5 days post-heading for highest protein. Caution: any cereal grain grown for hay should be tested for nitrate level prior to cutting (see note for Hays).

Tradition (Busch Ag,): 6-row malt. Stiffer straw than Legacy, good lodging resistance. Higher yield, test weight and plump than Legacy and other 6-row varieties. Very susceptible to stripe rust.

Xena (WPB bz594-19): baroness/stark cross. 2-row feed. Two inches taller and better boot emergence than Baroness. Lodging resistance equal to Baroness. Late maturity, similar to Baroness. Better adapted to dryland than Baroness, (higher test wt and plump than Baroness on dryland). Equal or better yield than Baroness on dryland.

"BG Barley": A food barley classification, and includes waxy hulless and waxy covered varieties. Beta glucan levels of BG varieties are 50% higher than for oats or pearled barley. Grain yields are generally lower than other barley varieties. End-use includes various foods, including rice-extender, 'Heart Balance Cereal' etc.

Table 13. Irrigated Intrastate Barley variety trial, Western Triangle Ag Research Center Conrad 2013.

Variety	Yield (bu/a)	Test Wt (lb/bu)	Plump (%)	Thin (%)	Protein (%)	Head Date	Height (in)
MT100132	103.2	51.8	95.0	1.8	8.9	195.7	29.0
MT100130	96.9	52.7	95.3	1.8	8.9	194.7	28.0
MT090181	96.2	53.3	97.3	0.7	9.2	196.7	28.3
Overture	94.3	49.2	95.2	2.0	13.7	198.7	23.3
MT100120	93.2	52.2	97.2	0.9	13.3	195.7	27.3
Vespa	91.0	51.2	93.0	3.9	8.5	197.0	21.7
MT100125	89.4	51.7	96.7	1.3	10.1	198.0	29.7
MT090182	89.2	52.8	96.3	1.4	11.2	196.3	28.0
MT100136	86.8	51.6	95.7	1.7	8.7	195.0	28.0
Harrington	86.6	50.6	93.6	3.6	10.1	195.3	25.3
18-20	86.5	50.6	94.5	2.5	8.7	197.3	22.3
MT090193	85.9	51.9	96.1	1.2	9.0	197.0	28.0
MT100051	85.8	53.6	96.0	1.3	8.9	192.3	23.0
Champion	85.8	53.2	95.2	0.9	9.3	194.0	25.0
Craft	85.7	53.1	94.5	2.3	11.2	193.3	27.7
Eslick	84.8	51.7	92.2	3.3	9.3	194.7	21.7
ME 07005-007	84.5	51.7	94.8	2.8	11.8	193.3	24.0
Pinnacle	84.4	52.1	97.5	0.8	8.1	194.3	26.0
Genie	83.9	51.0	92.4	4.0	10.1	197.7	22.0
MT070125	83.9	53.0	95.2	2.0	10.3	197.3	27.0
MT070158	82.9	51.4	95.0	2.7	10.5	195.7	22.0
MT110008	82.4	56.8	86.0	5.6	12.3	196.3	26.3
MT090186	82.4	53.1	95.5	2.0	7.9	197.7	29.7
Haxby	82.1	53.7	95.7	1.6	8.6	192.6	23.0
MT090190	81.6	52.9	97.0	0.9	9.5	196.3	27.0
MT100124	81.4	51.3	96.6	0.9	9.1	198.0	29.0
ME 07005-026	81.2	53.4	98.8	0.4	11.8	196.7	24.3
MT090180	80.4	51.5	96.6	0.8	8.2	197.3	28.0
MT100126	80.0	53.2	97.2	0.7	11.0	198.0	27.7
MT100060	79.8	53.0	96.6	1.1	9.4	192.7	23.0
Odessey	79.7	48.2	94.4	2.8	9.6	198.7	21.3
Conrad	79.5	51.7	95.0	2.2	8.5	195.0	22.7
MT103022	78.7	51.3	96.8	1.5	10.0	195.7	24.3
MT010160	77.1	51.5	94.3	2.6	10.6	195.3	25.3
MT020155	76.6	51.1	94.2	2.5	12.5	192.0	21.7
MT110065	76.3	57.1	73.6	7.6	14.2	196.3	27.7
MT100128	76.2	52.7	97.0	0.9	9.1	197.7	27.7
MT110009	75.4	56.5	85.3	4.0	9.8	198.3	29.0

Table 13 continued on next page

Table 13 Continued

Variety	Yield (bu/a)	Test Wt (lb/bu)	Plump (%)	Thin (%)	Protein (%)	Head Date	Height (in)
MT080281	74.8	50.7	96.0	1.8	8.8	194.3	21.3
Hockett	74.8	51.9	96.3	1.8	8.7	194.0	22.3
MT090184	74.1	52.9	97.3	0.8	8.8	196.7	27.7
MT070175	73.5	51.9	96.2	0.9	10.1	194.7	26.3
ME05065-147	73.2	51.8	94.1	2.8	10.3	194.3	24.0
ME 05064-005	72.7	53.2	95.0	1.9	8.7	192.7	22.3
ME05050-045	72.4	53.3	94.9	2.5	8.0	193.3	22.7
MT080243	72.0	52.8	95.8	1.2	8.3	196.3	24.0
MT070161	70.9	51.0	63.2	1.4	9.9	195.0	21.0
MT110061	68.8	56.4	96.2	9.5	8.5	197.0	23.3
Scarlett	68.5	51.3	97.6	1.1	8.0	197.0	20.7
Tradition	66.3	51.0	97.7	0.6	8.2	191.0	26.0
MT110066	64.3	57.7	70.3	6.9	9.3	195.7	23.0
MT110113	62.1	59.6	93.7	2.0	9.8	193.0	25.0
MT103005	59.4	60.8	79.6	6.2	8.5	198.7	25.0
MT110043	59.2	59.8	90.7	3.2	11.8	198.3	25.0
MT110016	58.8	57.4	80.5	8.4	9.7	197.3	24.3
MT110130	57.3	50.3	83.0	6.8	12.9	193.7	22.7
MT110141	52.1	60.8	96.6	0.7	13.7	194.3	26.3
MT110097	50.2	59.2	93.8	2.1	8.7	192.3	22.7
MT110092	49.9	60.7	94.4	2.0	12.5	192.7	22.3
MT110139	48.0	61.8	93.1	2.2	10.4	196.7	26.7
MT110109	47.8	58.7	59.9	19.7	9.8	193.0	23.0
MT110031	42.6	58.6	89.2	3.3	9.2	197.7	19.3
MT110095	41.2	55.9	91.6	1.7	17.6	191.7	27.0
PI596299	31.8	46.9	61.8	30.7	8.4	193.0	20.0
Mean	75.0	53.5	92.0	3.2	10.0	195.5	24.8
LSD	19.5	1.3	2.9	2.1		2.0	2.5
CV	16.1	1.5	2.0	41.8		0.6	6.3

Planted May 22, 2013 on fallow. Harvest September 12, 2013.
Fertilizer, actual (lbs/a): 11-22-0 place with seed at planting, 30-0-20 broadcast while seeding. Fertilizer rate was determined through soil test data and a yield goal of 75 bu/a.
Growing season ppt: 6.93 inches. Irrigation = 8.55 inches
Sprayed with Roundup Power Max @20oz per acre on 5/21/13.
Location: MSU Western Triangle Ag Research Center, Conrad, MT.

WINTER WHEAT VARIETIES

2013 Winter Wheat Variety Evaluations in the Western Triangle Area.

Personnel: John H. Miller, Julie Prewett, and Gadi V.P. Reddy, WTARC, Conrad, MT, and Phil Bruckner and Jim Berg, MSU Plant Science Dept., Bozeman, MT.

The uniform, winter wheat intrastate and advanced variety nurseries, along with four off station locations were grown during 2013. Intrastate and advanced nurseries were grown on no-till, chemical fallow barley stubble, while all off-station plots were grown on no-till chemical fallow. Off station trials were grown north of Cut Bank, MT, north of Devon, MT, near the 'Knees' east of Brady, MT, and northeast of Choteau, MT in Teton county. For the 2014 growing season, all nurseries will be grown on to-till chemical fallow.

Results: Winter wheat variety data are shown in Tables 15 thru 23. Soil test results may be viewed in Table 24.

Winter wheat intrastate and advanced data are shown in Tables 15 thru 17. Off station plots were harvested at Choteau, Devon, and the 'Knees'. The Cut Bank location was lost due to a sprayer boom hanging over the plot. The data for the off-station plots are presented in Tables 18 thru 23.

The 2013 growing season at WTARC began with temperatures a bit cooler than normal, there was a less precipitation than the 27 year average until May, then it warmed up and we received a bit more rain than usual until July. July was cooler than the 27-year average while being drier than the average.

Yields in the intrastate nursery were about 10 bu/acre higher than the multiyear average, with test weight about a pound and a half greater, with grain protein of 1.3 percent higher, and plant height about two inches shorter than the long term mean (Tables 15 and 16).

Grain yields, test weights, and protein at the 'Knees' were slightly below the four year average (Table 22 and 23). Grain yields at Devon were much higher than the four year average due to a greater amount on precipitation than is usually received in that area. Test weights at the Devon location were a pound per bushel higher than the three year average, whereas the protein was one percent lower than the four year average (Tables 20 and 21). The Choteau location was quite dry this past growing season. The data for Choteau are presented in Tables 18 and 19. Due to dry conditions yields were lower than expected and the protein percentages were quite high.

Top yielding varieties at the Choteau location were Jagalene, Overland, and Bearpaw. MTW08168, MT0978, and Overland were the high yielding varieties at Devon. Top yielders at the 'Knees' include MT0978, SY Clearstone 2CL, and MT1078.

Off station cooperators: Bradley Farms, North of Cut Bank, MT
Brian Aklestad, North of Devon, MT

Aaron Killion, East of Brady, MT
Inbody Farms, Northeast of Choteau

These data should be used for comparative purposes rather than using absolute numbers. Statistics are used to indicate that treatment or variety differences are really different and are not different due to chance or error. The least significant difference (LSD) and coefficient of variability (CV) values are useful in comparing treatment or variety differences. The LSD value represents the smallest difference between two treatments at a given probably level. The LSD at p=0.05 or 5 % probability level is usually the statistic reported, and it means that the odds are 19 to 1 that treatment differences by the amount of the LSD are truly different. The CV value measures the variability of the experiment or variety trial, and a CV greater than 15 % indicates a high degree of variability and less accuracy.

Detailed descriptions of most of the varieties tested are included in Extension Bulletin 1098 "Performance Summary of Winter Wheat Varieties in Montana", available at County Agent Offices.

MWBC FY2015 Grant Submission Plans: A similar project will be proposed for FY 2015. The continuation of on and off-station variety trials help to elucidate researchers and farmers which varieties are better suited for that particular region in Montana.

Winter Wheat Variety Notes & Comments

Western Triangle Agricultural Research Center, Conrad, MT

Winterhardiness ratings: 5 = very good; 1 = poor.
Coleoptile length: Long = 3.4" or more; Short = 3" or less.
Stem solidness scores of 19 or higher are generally required for reliable sawfly resistance.

Accipiter (Sask. DH0018196): First tested in 2008. High yield in 2008. 4" taller than Falcon. Similar to Falcon for test weight, head date and protein. Parentage = Raptor x Falcon.

Bauermeister (WA7939, 2005): Winterhardiness = 2. Medium height, med-strong straw. Medium coleoptile. Very late maturity. Very low test weight.

Bearpaw (MSU, 2011): Awned, white-glumed, solid-stem (stem solidness score = 21.8), semi-dwarf hard red winter wheat. Maturiety similar to CDC Falcon, and a day earlier than Genou and Rampart. About 3.5 inches shorter than Genou and Rampart, with yields similar to CDC Falcon and higher than Genou and Rampart. Susceptible to strip and leaf rust. Resistant to prevalent races of stem rust and UG99.

Big Sky (MT9432, 2001): Nuwest/Tiber cross, hard red kernels, white chaff. Good winterhardiness (4). Strong, stiff straw, very good lodging resistance, height equal to Tiber. Medium coleoptile. Medium maturity, heading 1-2 days later than Rocky, but 2 days earlier than Tiber and Morgan. Yield about equal to Rocky, and 2-3 bu higher than Tiber. High test weight and protein. Post-harvest seed dormancy is high, like Tiber. Septoria and tan spot resistance is good. A good alternative to Tiber.

Bond (CO 2004): Winterhardiness = 2. Clearfield system IMI resistant. Stiff straw, medium height & coleoptile, early maturity. Above average yield. Average test weight. Resistant to biotype 1 Russian wheat aphid. Low protein and poor quality.

Buteo (CDC, WPB, Sask., 2006): Winterhardiness = 4. Standard height, medium coleoptile. Medium-late maturity. Below average yield. Above average test wt. Average protein.

Bynum (MSU & WPB, 2005): Clearfield system single-gene resistance to imazamox or 'Beyond' herbicide. Winterhardiness = 2. Medium strong straw, medium height, long coleoptile. Stem solidness = 20 (compared to 22 for Rampart), which typically provides a reliable level of sawfly tolerance. Similar in yield and other characteristics to Rampart. Sawfly resistant, low yield, high protein, and excellent baking quality.

Carter (WestBred, 2007): Winterhardiness = 3. Semidwarf height, stiff straw, short coleoptile. Stem solidness score = 15. Medium early heading. Average yield. Above average test weight. Average protein. Moderate resistance to stripe rust.

Colter (MSU, 2013): White chaffed, hard red winter wheat. A high yielding winter wheat, similar to Yellowstone. Colter has a test weight of 0.5 lb higher than Yellowstone, heading two days later than Yellowstone. Colter has good stem rust resistance when related to Yellowstone. It is resistant to prevalent races of stripe rust, but susceptible to leaf rust.

Darrell (S. Dak., 2006): Medium height and coleoptile. Medium-early heading. High yield. Average test weight and protein.

Decade (MSU/NDSU, 2009): White chaffed, hard red winter wheat, with winter hardiness almost equal to Jerry. High yield potential, medium to high test weight, early maturity, and medium to high grain protein.

Falcon (CDC, WPB, Sask. 1999): Good winter-hardiness (4). Semi-dwarf, stiff straw, 4" shorter than Rocky. Short coleoptile. The first true winter hardy semi-dwarf available for irrigated conditions in Montana. Heading 1 day later than Rocky, 2 days earlier than Neeley & Tiber. Above average yield and test weight on dryland, good performance for irrigated or high rainfall conditions. Protein similar to Rocky. Not for stripe rust areas.

Genou (MSU, 2004): Sawfly resistant. Stem solidness not quite as solid as Rampart; and may be more sensitive to environmental factors than that of Rampart. Solid stem comparison: (max rating = 25): Rampart = 22, Genou = 19. Winterhardiness higher than Vanguard and Rampart, equal to Rocky. Medium stiff straw. Height similar to Vanguard, and 2" shorter than Rocky. Medium coleoptile. Maturity 1-2 days later than Rocky. Yield 7% higher than Vanguard & Rampart, 5% less than Rocky. Average test weight and protein.

Hawken (AgriPro, 2007): Semidwarf height, short coleoptile. Early maturity. Yield is below average. Above average test weight and protein.

Hatcher (CO 2004): Winterhardiness = 2. Strong straw, semidwarf height, medium coleoptile. Early maturity. Low protein. Resistant to biotype 1 Russian wheat aphid and Great Plains biotype Hessian fly. Very low quality.
Jagalene (AgriPro, 2002): Winterhardiness = 2. Semidwarf, stiff straw, medium coleoptile. Early maturity, 1 day earlier than Rocky. Shatter resistant. Average yield. Very high test weight. Avg protein, but higher than Rocky. Good milling quality. Good disease resistance package (stem & stripe rust, tan spot and Septoria).

Jerry (ND, 2001): Winterhardiness high (5). Medium-stiff, med-tall straw, medium coleoptile. Medium-late maturity. Yield is below average, except in winterkill areas where it's above average. Below-average test weight. Average protein. Has one of the worst sawfly stem-cutting ratings. Shatter susceptible.

Judee (MSU, 2011): Awned, white-glumed, solid-stem (stem solidness score = 20.1), semi-dwarf hard red winter wheat with good straw strength. Maturiety similar to CDC Falcon, and a half day earlier than Genou and Rampart. About 2.5 inches shorter than Genou and Rampart, with yields similar to CDC Falcon and higher than Genou and Rampart. Winter hardiness is medium to low. Susceptible to prevalent races stem and leaf rust, but is resistant to stripe rust.

Ledger (WestBred, 2005): Winterhardiness = 2. Semidwarf height & stiff straw, 4" less than Rocky. Medium coleoptile. Stem solidness = 10, variable & sensitive to cloudy conditions; not a reliable level of sawfly tolerance. Early heading. Above avg yield & test wt. Avg protein and acceptable quality. Moderate stripe rust resistance.

Morgan (Sask & WPB, 1996): High winterhardiness (5). Standard height. Medium stiff straw. Very short coleoptile. Three days later to head and slightly later maturity than Rocky; heading similar to Neeley. Below average yield. Test wt 1-lb less than Rocky or Tiber. Protein slightly higher than Rocky, similar to Neeley. Milling and baking acceptable. Recommended for areas needing high levels of winterhardiness.

MT08172 (MSU): Awned, white-glumed, high-yielding hard red winter wheat. Similar to Yellowstone for most agronomic traits with the exception of test weight, MT08172 is about 0.5 lb/bu higher. Better stem rust resistant than Yellowstone, moderately resistant to prevalent races of stem rust including UG99. Also, moderately resistant to stripe rust, but susceptible to leaf rust. Medium to late maturity, 2.5 days later than CDC Falcon and 4 days later than Jagalene. Similar in height to Yellowstone.

MTS0808 (MSU): Awned, white-glumed, solid-stem, semi-dwarf hard red winter wheat. With medium maturiety, similar to Genou and Rampart. Medium-short, similar to Judee and Bearpaw. Resistant to prevalent races of stem rust including UG99 and stripe rust. Suseptable to leaf rust. Solid-stem score averages 21.4, similar to Rampart and Bearpaw.

Neeley (Idaho, 1980): Winterhardiness medium (3). Medium short straw. Medium coleoptile. Medium-late maturity. Susceptible to stem rust. High yielder in good years, but does poor if stressed for moisture. Below average test weight. Good shatter resistance. Protein & quality are erratic, ranging from low to high. Not for stripe rust areas.

Norris (MSU & WPB, 2005): Clearfield system single-gene resistance to imazamox or 'Beyond' herbicide (which controls cheatgrass, goatgrass and wild oats). Winterhardiness = 3. Stiff straw, medium height, medium coleoptile. Early maturity. Above average yield and test weight. Average protein, good quality. Replaces MT1159CL.

Promontory (Utah, 1990): Red head. Winter hardiness poor (2 or less). Medium-short, medium-strong straw. Short coleoptile. Medium maturity. Excellent stripe rust & dwarf smut resistance; Stem rust susceptible. Average yield and above average test weight. Protein medium low. Has severe sawfly stem cutting ratings.

Pryor (WPB, 2002): Winterhardiness 3 = Neeley. Short stiff straw, 4" shorter than Neeley. Short coleoptile. Medium late maturity similar to Neeley & Tiber, 2 days later than Rocky. Above average yield. Average test weight and protein, good quality. Intended mainly for Central Montana as a replacement for Neeley. Not for stripe rust areas.

Rampart (MSU, 1996): Sawfly resistant (sister line to Vanguard). Solid stem rating = 22. Red chaff, upright head. Winterhardiness is marginal (2-). Should not be grown in areas where high levels of winterhardiness are needed, unless protected by stubble. Height 1 inch shorter than Neeley, med-stiff straw. Very long coleoptile. Matures 1 day later than Rocky, 2 days earlier than Neeley. Some resistance to stem rust, and some tolerance to wheat streak mv. Medium shatter resistance. Yield is below average, but is above average under heavy sawfly conditions. Does not seem as prone to shatter as Vanguard. Good test weight, protein and quality. See Genou.

Ripper (Colorado, 2006): Semidwarf height, medium coleoptile. Early maturity. Above average yield and test weight. Average protein.

Rocky (Agripro, 1978): A selection from Centurk for soil borne mosaic resistance. Winterhardiness = 2. Medium weak straw, medium height. Medium coleoptile. Early maturity. High yield. Very susceptible to yellow berry expression under low nitrogen conditions. Medium protein. See Jagalene and Ledger for shorter-straw alternatives.

SY Clearstone 2CL (MSU/Syngenta): SY Clearstone is a 2-gene Clearfield hard red winter wheat. SY Clearstone 2CL has yields similar to Yellowstone, and about 10 bu/a more than AP 503 CL2. SY Clearstone 2CL has average test weight and protein. SY Clearstone 2CL is resistant to stripe rust and moderate resistance to stem rust.

Tiber (MSU, 1988): Dark Red head, (blackish-red in years of favorable moisture). Winterhardiness = 3. Medium height with good lodging resistance. Stiff straw, which may cause it to thresh a little harder than weaker-strawed varieties. Med-long coleoptile. Very resistant to sprouting, causing some dormancy. Medium maturity. Susceptible to stem rust. Very resistant to shatter. Below average yield. Protein above average. Good milling and baking quality. Fdn seed being discontinued. See Big Sky for alternative.

Vanguard (MSU, 1995): Sawfly resistant. Good stem solidness. White chaff, nodding head. Winterhardiness marginal (2-). Straw slightly stiffer and 1 inch shorter than Rocky, but moderately susceptible to lodging under high-yield conditions. Long coleoptile. Medium head date, 1 day later than Rocky, 3 days earlier than Neeley. Good wheat streak mv tolerance. Susceptible to stem & stripe rust. Below average yield; but under heavy sawfly infestation, yield is above average. Medium shatter resistance. Good test weight. Protein high; quality adequate. Not a satisfactory variety for non-sawfly areas, and should not be grown where high levels of winterhardiness are needed unless protected by stubble. See Genou.

Wahoo (Nebr & Wyo, 2000): Winterhardiness = 3. Semidwarf, 2" shorter than Rocky, stiff straw. Short coleoptile. Very early maturity. High yield. Average test weight & protein, marginally poor quality.

Warhorse (MSU, 2013): Solid-stemmed hard red winter wheat with improved yield potential over Genou and Rampart. Warhorse is a white-glumed, semi-dwarf winter wheat with medium maturity. Warhorse does well where sawfly is a problem, it has stem solidness score similar to Rampart and Bearpaw. Warhorse has average test weight, and protein, but below average winter hardiness. Warhorse is resistant to prevalent races of stripe and stem rust. It is susceptible to leaf rust.

WB Quake (WestBred/Monsanto): WB Quake has a stem solidness score similar to Judee and Genou, but less than Warhorse and Rampart. WB Quake is equal to Genou for seed protein percent and test weight. Winter hardiness of WB Quake is similar to Yellowstone, and slightly more hardy than Genou. WB Quake has good resistance to local races of stripe rust.

Willow Creek (MSU 2005): Beardless forage winter wheat for hay. HRW class. Winterhardiness = 5. Very tall straw, lodging susceptible. Long coleoptile. Very late maturity. High forage yield. Tends to be safer than barley for nitrates, because earlier seasonal development escapes heat stress better. Low grain yield and test weight. High protein.

Yellowstone (MSU, 2005): Winterhardiness = 4. Medium height similar to Neeley, and taller than Falcon, and Pryor. Straw strength is excellent. Medium-short coleoptile length. Medium maturity. Broadly adapted state-wide, but is stem-rust susceptible (thus, not for District 6, eastern Montana). Moderate resistance to stripe rust. Very high-yielding, and 3% higher than Falcon. Below average test weight. Protein is medium. Excellent baking quality and good Asian noodle quality.

Hard White Winter Wheat

Protein of hard white wheat for bread baking needs to be higher than required for noodle markets. Some varieties are dual-purpose and can be used for both bread and noodles. Although not a concern for bread baking quality, varieties with low levels of polyphenol oxidase (PPO) are desirable for Chinese noodles, since high PPO levels are associated with noodle discoloration. Low PPO provides good noodle brightness and color stability. Some hard white varieties sprout more readily than hard reds, especially those developed from Australian germ-plasm. The pure white trait is difficult to maintain, as pollen from red wheats may pollinate a white variety, causing a mixture of red kernels. It is very important to clean the combine, storage bins and other grain handling equipment prior to harvest to avoid mixing hard white wheat with other wheat. Seeding equipment and seedbed must also be free of red wheat. It is important to have a market strategy in place before growing a hard white variety.

Alice (S. Dak., 2006): Hard white. Short straw, short coleoptile. Early heading. Above average yield, test weight and protein.

Golden Spike (UT, Gen Mills, 1998): Hard white, low PPO. Winterhardiness 3. Height similar to Rocky, med-stiff straw. Medium coleoptile. Medium maturity. Below average yield. Low test weight & protein.

Hyalite (MSU & WPB, 2005): Hard White, low PPO with good noodle brightness and color stability. Clearfield system single-gene resistance to imazamox or 'Beyond' herbicide. Winterhardiness = 3. Standard height, but stiff straw. Short coleoptile. Early maturity. Average yield and test weight. Red kernel occurrence is 0.7% (high, but still acceptable). Dual-purpose quality similar to NuWest & NuSky. Above average protein, good milling & baking quality. Stem rust resistant. Stripe rust susceptible.

MDM WA7936 (Wash., 2006): Hard white. Winterhardiness = 2. Medium stiff straw. Medium coleoptile. Very late maturity. Yield similar to NuWest. Low test weight.

NuDakota (AgriPro, 2005): Hard white. Winterhardiness = 2. Semidwarf height, stiff straw. Early heading. Average yield, test weight and protein. Medium PPO.

Nuwest (MSU, 1994): Hard white, low PPO. Dual purpose, noodle and bread. Winterhardiness = 4. One inch shorter than Rocky. Stiff straw. Very short coleoptile. Two days later than Rocky. Resistant to stem rust but susceptible to stripe rust, dwarf bunt, and WSMV. Susceptible to sawfly, RWA, and Hessian fly. Average yield and well adapted to Montana. Medium test weight and protein. Good resistance to preharvest sprouting – (In 1993, everything sprouted - red or white). Contains 1 red kernal/1000. Protein medium to high. Good quality.

NuSky (MSU, 2001): Hard white, low PPO. (Sister line to the hard red var BigSky). Good dual purpose quality for noodles & bread. Winterhardiness 4. Height and straw strength similar to Nuwest & Rocky, med-stiff. Short coleoptile. Heading similar to Nuwest, Tiber & Neeley; and 3 days later than Rocky. Shatter resistant. Average yield. Test weight similar to Nuwest. Medium to high protein. Quality similar to Nuwest. High level of post-harvest dormancy (similar to Tiber), and thus does not have the sprouting problems common to some of the other hard white wheats. NuSky is a public release.

WB3768 (MSU/WestBred/Monsanto): WB3768 is a white chaffed hard white winter wheat that is a low PPO wheat that has favorable Asian noodle color stability and noodle score. WB3768 is similar to Yellowstone with the exception of higher test weight and a later heading date and maturity. It is slightly taller than Yellowstone.

Wendy (SD, 2004): Hard white. Winterhardiness = 3. Semidwarf height, Short coleoptile. Early heading. Average yield. Above-average test weight and protein. Medium PPO.

Table 15. 2013 Intrastate Winter Wheat Variety Nursery, Western Triangle Ag. Research Center, Conrad, MT.

Variety and Class	Source	Solid Stem score*	Yield bu/ac	Test weight lb/bu	Heading date Julian	Plant height in	Protein %
MT1078	-	-	104.2	59.6	166.9	34.5	12.4
12.4MTCL1131	-	-	103.2	59.7	168.3	37.4	12.4
Art	AgriPro, 2007	-	101.9	60.9	162.1	34.1	13.0
MT1138	-	-	99.6	60.3	167.9	35.9	13.0
MTW08168	-	-	98.4	60.4	170.6	37.7	12.9
MT1102	-	-	98.1	59.6	169.5	33.2	13.5
Overland	Nebraska, 2007	-	98.0	61.8	162.8	35.3	11.8
Cowboy	Wyoming/Colorado, 2012	-	97.8	59.7	165.4	35.7	12.7
MT1091	-	-	97.7	57.3	167.6	35.6	13.2
MT1105	-	-	96.7	59.8	166.7	33.7	13.2
MT1092	-	-	96.6	59.6	167.5	35.8	12.2
MT1143	-	-	95.9	59.9	164.9	32.5	13.0
Yellowstone	Montana, 2005	-	95.8	60.7	168.2	34.5	12.7
MT10116	-	-	95.5	59.5	169.0	35.1	13.8
SY Clearstone 2CL	Montana/Syngenta, 2012	-	95.2	57.8	167.5	35.9	13.1
MT1117	-	-	94.9	60.7	169.1	35.9	12.7
Jagalene	AgriPro, 2002	-	94.9	62.5	164.2	34.4	13.0
MT1108	-	-	94.6	60.2	168.4	34.5	12.6
MT1137	-	-	94.5	62.7	166.8	34.5	13.1
Colter	Montana, 2013	-	94.5	60.7	169.3	35.1	12.7
MT0978	-	-	94.1	60.7	169.1	35.0	13.2
Promontory	Utah, 1990	-	92.1	60.9	165.7	35.2	12.3
SY Wolf	Syngenta (Agripro), 2010	-	91.2	61.4	163.4	30.6	12.6
MT1156	-	-	90.9	60.4	168.6	34.8	13.5
MT1090	-	-	90.8	59.0	168.9	33.4	13.5
MTS1024	-	18.9	90.1	58.2	168.9	33.4	13.5
Curlew	Utah, 2009	-	89.8	58.2	166.6	39.3	13.8
Broadview	Alberta, 2009	-	89.8	59.7	167.6	34.4	13.3
Carter	WestBred, 2006	14.3	89.8	60.7	167.2	31.1	13.4
MT1113	-	-	89.7	60.8	168.8	35.4	14.0
Decade	Montana/North Dakota, 2010	-	89.4	60.8	162.7	33.4	12.6
Robidoux	Nebraska, 2010	-	89.1	59.2	162.1	34.0	12.4
WB Matlock	WestBred, 2010	-	88.9	61.6	166.9	37.4	13.0
McGill	Nebraska, 2010	-	88.3	58.7	161.6	34.3	12.4
MTS0826-63	-	24.2	84.6	60.3	170.7	38.2	13.8

Table 15 continued on next page

Table 15 continued

Variety and Class	Source	Solid Stem score*	Yield bu/ac	Test weight lb/bu	Heading Date Julian	Plant height In	Protein %
Accipiter	Saskatchewan, 2008	-	84.3	60.0	168.1	35.3	12.8
CDC Falcon	Sask/WestBred, 1999	7.1	83.8	59.0	165.2	32.3	12.9
Ledger	WestBred, 2004	10	82.7	60.7	166.7	32.7	11.9
Bearpaw	Montana, 2011	22.8	82.5	60.9	165.3	33.8	13.4
Radiant	Alberta, 2002	-	81.4	60.6	167.3	36.6	12.5
Jerry	North Dakota, 2001	-	80.8	59.2	167.4	39.3	12.8
Norris CL	Montana/WestBred, 2005	-	79.8	59.3	163.4	36.6	12.9
Warhorse	Montana, 2013	22.6	79.6	58.9	168.9	34.2	13.4
Judee	Montana, 2011	22.3	78.8	60.4	166.1	34.6	12.9
WB-Quake	WestBred, 2011	21.1	77.7	60.7	168.9	34.7	13.2
Bynum (CL)	Montana/WestBred, 2005	20.1	75.6	60.5	163.8	37.2	13.2
Rampart	Montana, 1996	23.5	75.6	60.7	166.4	37.7	13.9
MTS0832	-	24.7	74.9	60.0	168.8	37.3	13.2
Genou	Montana, 2004	21.5	74.7	60.1	167.4	37.2	13.9
Mean		19.5	90.0	60.1	166.8	35.1	13.0
LSD (0.05)		1.7	10.7	1.7	1.7	1.4	
C. V. (%)		5.0	6.7	1.7	0.6	2.3	
P-value (Varieties)		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	

Planted: 9/15/2012 on chemical fallow and harvested on 8/12/2013.
Fertilizer, actual pounds/a of N-P-K: 11-22-0 applied with seed and 30-0-20 broadcast at planting. 97.5 lbs/a N as urea was broadcast on 4/7/2013. Fertilizer rate was determined through soil test data and a yield goal of 75 bu/a.
Herbicide, Huskie at 11.0 oz/a and Axial XL at 16.4 oz/a applied on 5/12/2013.
* Solid stem score of 19 or higher is generally required for reliable sawfly resistance.
CL = Clearfield System

Table 16. Six-year means, 2008 – 2013, Winter Wheat varieties, Western Triangle Ag. Research Center, Conrad, MT.

Variety	Source	Class	Solid stem* score	6-Year Means Yield bu/a	Test wt	Height in.	Head date	Protein %	Winter survival class
Colter	MSU			88.3	60.7	33.5	173.7	11.5	
Yellowstone	MSU	-	-	86.1	60.9	34.2	172.8	11.0	4
Jagalene	AgriPro	-	-	84.1	63.1	31.8	170.0	11.7	2
Judee	MSU	-	22.7	83.0	62.6	32.2	170.6	11.4	-
Decade	MSU/ND	-	-	82.7	61.5	31.9	169.5	11.9	-
Warhorse	MSU	-	23.9	81.7	61.3	32.6	172.7	11.8	-
Falcon	CDC/WestBred	-	7.1	80.3	61.4	30.7	171.3	11.3	4
Carter	WestBred	-	14.5	80.0	61.7	29.4	170.4	11.8	3
Norris	WestBred	CL	-	79.2	61.5	35.4	169.4	11.7	3
Promontory	Utah	-	-	79.2	62.5	33.9	171.6	11.0	2
Bearpaw	MSU	-	22.5	78.8	61.6	31.1	171.1	11.7	-
WB-Quake	WestBred	-	22.9	78.6	62.0	32.6	172.4	11.5	-
Ledger	WestBred	-	9.5	77.9	61.9	31.3	171.2	11.0	2
Genou	MSU	-	23.0	76.8	61.7	35.8	172.0	11.9	2
Jerry	N. Dakota	-	-	75.3	60.8	37.0	172.1	11.8	5
Rampart	MSU	-	24.5	71.2	61.4	34.8	172.0	12.5	2
Bynum	WestBred	CL	22.4	68.8	61.5	34.5	170.1	12.9	2
Mean				79.5	61.6	33.1	171.4	11.7	

* Solid stem score of 19 or higher is generally required for reliable sawfly resistance.
HW = Hard White; CL = Clearfield herbicide system.
Winterhardiness: 5 = high, 1 = low.

Table 17. 2013 Advanced Yield Winter Wheat Nursery, Western Triangle Ag. Research Center, Conrad, MT.

ID or Variety	Yield (bu/ac)	Test weight (lb/bu)	Heading Date Julian	Plant height (in)	Protein %
Genou	72.5	60.4	167.3	38.5	13.3
Yellowstone	95.7	60.5	168.3	36.3	13.0
Jagalene	94.9	62.5	164.3	33.6	13.1
Decade	85.3	60.1	164.8	34.2	13.4
Judee	81.2	60.7	167.7	34.7	13.5
MTCS1201	81.9	60.1	164.4	32.1	13.4
MTCS1202	79.8	60.8	164.8	29.4	13.0
MTCS1203	72.6	61.2	166.4	33.6	13.1
MTCS1204	91.7	62.0	166.7	35.0	12.4
MTS1209	80.3	59.8	168.3	35.0	13.6
MTS1211	84.6	59.9	169.3	33.9	12.0
MTS1214	78.4	59.3	168.5	35.8	12.8
MTS1222	76.5	60.3	169.8	36.5	13.2
MTS1224	87.5	59.7	170.4	33.0	13.9
MTS1226	84.5	60.5	166.2	33.7	13.6
MTS1228	94.2	59.2	168.6	33.9	13.3
MTF1229	91.2	58.2	171.0	39.0	12.4
MTF1232	86.7	60.5	172.5	45.8	13.5
MT1233	83.6	61.8	168.7	36.1	12.8
MT1241	94.8	58.5	164.1	33.9	12.9
MT1245	84.5	61.1	169.2	34.6	12.3
MT1246	84.1	60.1	168.6	35.7	12.5
MT1247	90.1	60.5	169.6	35.2	13.4
MTW1250	90.6	60.4	168.9	32.3	12.6
MTW1251	91.1	61.7	169.6	34.6	11.7
MT1257	102.3	60.3	167.9	36.5	11.7
MTCL1261	93.2	60.9	167.4	37.3	11.5
MT1262	91.8	60.4	168.2	36.5	13.2

Table 17 to continue on next page

Table 17 continued

ID or Variety	Yield bu/ac	Test weight lb/bu	Heading Date Julian	Plant height In	Protein %
MT1265	92.4	59.4	169.2	35.6	13.3
MT1266	90.4	59.4	169.9	37.0	13.1
MT1272	80.0	58.9	169.2	36.5	14.2
MT1273	85.8	58.4	168.5	36.3	14.5
MT1275	80.4	57.5	168.4	35.1	13.4
MT1280	85.6	59.8	167.6	35.9	12.8
MT1286	102.2	62.7	167.6	36.9	12.3
MT1287	93.0	60.8	163.8	35.6	13.1
Mean	87.1	60.2	167.9	35.4	12.9
LSD (0.05)	12.5	1.5	1.7	1.6	
C.V. (%)	8.0	1.4	0.6	2.5	

Planted: 9/15/2012 on conventional fallow and harvested on 8/13/2013.
Fertilizer, actual pounds/a of N-P-K: 11-22-0 applied with seed and 30-0-20 broadcast at planting. 97.5 lbs/a N as urea was broadcast on 4/7/2013. Fertilizer rate was determined through soil test data and a yield goal of 75 bu/a.
Herbicide, Huskie at 11.0 oz/a and Axial XL at 16.4 oz/a applied on 5/12/2013.

Table 18. Off-station Winter Wheat variety trial (Exp. 3866) located east of Choteau, MT. Teton county. Western Triangle Ag. Research Center. 2013.

Variety Or ID	Stem Solidness Score*		Yield bu/ac	Test weight lb/bu	Plant height in	Protei n %	Lodging %
Jagalene	-		58.2	59.8	29.3	15.5	19
Overland	-		57.6	59.1	32.0	15.2	11
Bearpaw	22.8		55.7	28.5	30.0	15.8	3
MT1078	-	+	52.5	57.1	28.7	16.1	22
MTS1024	18.9	+	51.3	56.8	29.3	16.0	11
Genou	21.5		51.2	59.3	34.4	16.3	8
MT1090	-	+	50.9	57.7	32.3	16.0	8
Yellowstone	-		50.3	57.9	31.0	15.6	8
CDC Falcon	7.1		49.0	56.4	29.0	15.7	8
Norris (CL)	-		48.0	57.7	33.7	15.9	14
Judee	22.3		46.4	58.0	28.7	16.3	0
MTS0832	24.7		45.9	58.6	28.3	16.4	3
MTW08168	-	+	44.2	58.5	29.3	16.9	14
Colter	-		43.2	56.6	30.3	17.4	8
Decade	-		41.6	57.0	28.0	17.3	14
Warhorse	22.6		41.6	56.8	29.0	16.0	0
Jerry	-		41.1	57.2	32.0	16.9	11
SY Clearstone 2CL	-		41.1	57.8	31.3	17.2	11
MT0978	-	+	37.3	56.4	28.0	18.1	8
Ledger	10.0		36.9	57.0	28.0	16.8	3
Rampart	23.5		35.6	58.5	32.3	17.7	3
MTCS1202	-	+	35.5	54.4	27.0	17.1	8
Accipiter	-		33.8	56.6	27.3	17.4	0
WB-Quake	21.1		33.4	56.9	25.7	17.1	0
Mean			45.1	57.5	29.8	16.5	8.2
LSD (0.05)			ns	1.8	2.8		10.0
C.V. (%)			21.9	1.9	5.7		73
P-value (Varieties)			0.0576	0.0003	<.0001		0.0007

Cooperator and Location: Inbody Farms, Teton county.
Planted: September 12, 2012 on chem-fallow Harvested: August 17, 2013
Fertilizer, actual lbs/a: 11-22-0 applied with seed and 30-0-20 urea blended with potash were broadcast at seeding. Spring topdressing took place on 5/12/2013 with 91-0-0.
Herbicide: None Precipitation: No data
* = Solid stem sawfly-resistant (solid stem score of 19 or higher) and were determined at the on station intrastate winter wheat nursery. + = New to off station trial for 2012.

Conducted by MSU Western Triangle Ag. Research Center.

Table 19. Two-year means, Winter Wheat varieties, Choteau area, Teton County. 2011-2013.

Variety	**	2-Year Mean Yield bu/a	Test weight	Height in.	Protein %
Yellowstone		48.7	58.2	29.7	15.0
Bearpaw		47.6	58.8	28.0	15.0
Genou	**	46.0	59.1	30.4	15.3
CDC Falcon	*	45.8	57.3	27.2	15.1
Jagalene		45.6	60.4	26.8	15.0
MTS0832	**	44.8	59.7	28.7	15.0
Judee	**	44.6	59.0	26.9	15.1
Colter		44.3	57.4	29.5	15.7
Warhorse		41.8	57.8	26.7	15.3
SY Clearstone 2CL		41.4	58.3	30.2	15.5
Ledger	*	41.4	58.3	25.9	15.4
Decade		41.3	58.3	27.4	15.8
Norris CL		40.1	59.2	29.9	14.4
Jerry		39.6	58.1	30.0	16.0
Accipiter		39.2	57.4	26.5	16.0
WB-Quake		38.5	57.6	26.2	15.7
Rampart	**	36.6	58.7	30.2	16.1
Mean		42.8	58.4	28.2	15.4

** = Solid stem sawfly-resistant (solid stem score of 19 or higher).
* = Less preferred by sawfly (behavioral preference) in small plots.
Cooperator and Location: Inbody Farm, Teton County.
Conducted by MSU Western Triangle Ag. Research Center.

Table 20. Off-station winter wheat variety trial (Exp. 3865) located north of Devon, MT. Toole county. Western Triangle Ag. Research Center. 2013.

Variety Or ID	Stem Solidness Score*		Yield bu/ac	Test weight lb/bu	Plant height in	Protein %	Lodging %
MTW08168	-	+	88.7	60.7	33.3	11.6	26
MT0978	-	+	88.2	60.3	29.3	11.6	19
Overland	-		86.9	60.8	30.3	11.2	11
Yellowstone	-		86.1	58.9	30.3	12.2	33
Decade	-		85.2	60.1	29.3	11.4	22
Bearpaw	22.8		85.1	60.3	30.0	12.2	8
MT1078	-	+	85.1	57.9	29.3	12.0	8
Jerry	-		82.8	59.4	33.7	11.8	11
MTS1024	18.9	+	82.4	59.0	28.7	12.2	26
Jagalene	-		82.0	61.4	29.3	11.9	37
MTCS1202	-	+	80.2	59.3	27.7	12.5	22
Judee	22.3		79.9	59.6	29.3	13.2	11
CDC Falcon	7.1		79.5	59.1	29.0	12.4	33
Ledger	10.0		79.5	60.3	28.3	12.2	22
SY Clearstone 2CL	-		78.9	58.8	30.3	11.8	48
Colter	-		78.3	59.9	31.7	12.1	26
Accipiter	-		77.8	60.0	31.0	11.8	11
WB-Quake	21.1		77.6	59.8	30.0	11.8	8
MT1090	-	+	76.8	58.5	31.0	12.2	41
Warhorse	22.6		75.7	58.5	29.3	12.9	22
Genou	21.5		74.0	60.0	33.7	12.2	48
Norris (CL)	-		72.0	60.4	32.0	12.1	59
MTS0832	24.7		70.6	59.2	33.0	11.4	14
Rampart	23.5		69.6	60.4	33.0	11.9	14
Mean			80.2	59.7	30.5	24.2	12.0
LSD (0.05)			12	1.3	2.2	ns	
C.V. (%)			9.1	1.3	4.5	97	
P-value (Varieties)			0.0485	0.0002	<.0001	0.3604	

Cooperator and Location: Brian Aklestad Farm, Toole county.
Planted: September 17, 2012 on chem-fallow. Harvested: August 14, 2013
Fertilizer, actual lbs/a: 11-22-0 applied with seed and 30-0-20 urea blended with potash were broadcast at seeding. Spring topdressing took place on 6/8/2013 with 13-0-0. Fertilizer rate was determined through soil test data and a yield goal of 50 bu/a.
Herbicide: None
Precipitation: 7.5 inches
* = Solid stem sawfly-resistant (solid stem score of 19 or higher) and were determined at the on station intrastate winter wheat nursery. + = New to off station trial for 2011.
Conducted by MSU Western Triangle Ag. Research Center.

Table 21. Four-year means, Winter Wheat varieties, Devon area, Eastern Toole County. 2010-2013.

Variety	**	4-Year Mean Yield bu/a	Test weight	Height in.	Protein %
Decade	-	48.1	59.0	25.9	12.9
Yellowstone	-	47.8	57.5	25.3	12.8
Accipiter	-	45.6	57.9	24.7	12.9
Jerry	-	45.4	58.0	25.1	12.9
Judee	**	45.4	58.8	24.4	13.6
CDC Falcon	-	45.1	57.9	23.6	13.0
Bearpaw	**	44.8	58.7	23.7	13.3
Jagalene	-	43.0	59.4	25.6	12.9
Genou	**	42.6	58.8	26.8	13.3
MTS0832	**	41.0	58.1	25.8	12.5
Ledger	*	40.2	59.7	25.0	12.5
Norris CL	-	37.3	58.3	26.1	12.9
Rampart	**	35.9	58.2	25.3	13.6
Mean		43.4	58.5	25.3	13.0

** = Solid stem sawfly-resistant (solid stem score of 19 or higher).
* = Less preferred by sawfly (behavioral preference) in small plots.
Cooperator and Location: Brian Aklestad, Eastern Toole County.
Conducted by MSU Western Triangle Ag. Research Center.

Table 22. Off-station winter wheat variety trial (Exp. 3862) located at the Knees, Chouteau county. Western Triangle Ag. Research Center, 2013.

Variety Or ID	Stem Solidness Score*		Yield bu/ac	Test weight lb/bu	Plant height in	Protein %	Lodging %
MT0978	-	+	78.3	62.8	27.7	13.6	9
SY Clearstone 2CL	-		68.1	62.0	31.3	13.5	28
MT1078	-	+	62.4	61.8	25.7	13.0	17
Yellowstone	-		61.8	62.0	28.0	13.5	15
Colter	-		59.5	62.5	26.7	13.3	12
MTW08168	-	+	59.5	62.2	29.7	13.6	15
Judee	22.3		59.0	63.7	24.3	14.0	16
MTS1024	18.9	+	56.7	62.5	24.3	13.3	15
Decade	-		56.2	62.9	25.3	14.3	4
MTCS1202	-	+	55.6	61.8	24.0	14.1	3
Jerry	-		55.1	62.1	28.7	13.6	18
Accipiter	-		55.0	63.8	23.7	13.6	3
Warhorse	22.6		54.0	62.8	25.0	13.5	5
Ledger	10.0		53.8	63.1	24.0	12.6	15
MT1090	-	+	53.7	62.1	27.7	13.4	17
MTS0832	24.7		53.0	62.6	27.7	13.2	6
CDC Falcon	7.1		52.0	62.5	23.7	13.7	6
Norris (CL)	-		49.3	63.3	28.0	13.7	8
WB-Quake	21.1		47.1	62.9	23.3	13.7	8
Jagalene	-		47.0	64.3	25.7	14.2	16
Overland	-		47.0	62.0	24.3	13.7	16
Genou	21.5		43.5	63.6	24.7	14.2	37
Rampart	23.5		41.6	62.6	26.3	14.4	22
Bearpaw	22.8		38.9	62.4	22.7	13.9	12
Mean			54.5	62.7	25.9	13.7	13.4
LSD (0.05)			13	0.6	2.4		15.2
C.V. (%)			14.5	0.6	5.7		69

Cooperator and Location: Aaron Killion, eastern Chouteau county.
Planted: September 13, 2012 on chem-fallow Harvested: August 15, 2013.
Fertilizer, actual lbs/a: 96-22.5-20; 11-52-0 applied with seed and urea blended with potash (30-0-20) were broadcast while seeding. The balance of the N was applied topdress on 4/6/2013. The plot was fertilized to a yield goal of 60 bu/a.
Sprayed with Olympus at 0.6 oz/a and Roundup WeatherMax at 6 oz/a on 9/13/2012.
Precipitation, rain gauge cracked.
* = Solid stem sawfly-resistant (solid stem score of 19 or higher) and were determined at the on station intrastate winter wheat nursery. + = New to off station trial for 2013.

Table 23. Four-year means, Winter Wheat varieties, Knees area, western Chouteau County.
2010-2013.

Variety Or ID	**	4-Year Mean Yield (bu/a)	Test weight (lbs/bu)	Height (in)	Protein (%)
Yellowstone	-	63.8	59.2	32.2	13.3
Warhorse (MTS0808)	**	63.7	60.4	29.7	12.8
MTS0832	**	60.1	59.9	33.1	12.8
Decade	-	58.9	60.4	30.5	13.4
Judee (MTS0713)	**	58.3	61.0	28.7	13.6
CDC Falcon	-	58.1	60.1	27.9	13.5
WB-Quake	-	57.9	60.1	30.0	13.1
Ledger	-	57.2	60.6	28.3	12.5
Accipiter	-	57.1	60.2	29.9	13.3
Jagalene	-	55.7	61.8	30.2	13.0
Norris (CL)	-	53.6	60.6	33.5	13.1
Bearpaw (MTS0721)	**	52.5	59.6	29.4	13.4
Jerry	-	52.0	59.3	32.4	13.3
Genou	**	51.2	60.3	32.9	13.5
Rampart	**	49.9	60.4	31.9	13.7
Mean		57.6	60.3	30.7	13.2

** = Solid stem sawfly-resistant (solid stem score of 19 or higher).
* = Less preferred by sawfly (behavioral preference) in small plots.
Cooperator and Location: Aaron Killion, western Chouteau County.
Conducted by MSU Western Triangle Ag. Research Center.

Table 24. Soil test values for off-station and on-station plots, 2013.

Location	N (lbs/a)[1]	Olsen-P (ppm)	K (ppm)	pH	OM (%)	EC (mmhos/cm)
Cut Bank	44.7	14	495	7.4	2.8	0.41
Devon	33.0	7	170	8.9	0.9	0.86
Knees	59.5	25	414	7.3	2.6	0.57
Choteau	71.5	13	580	8.0	3.0	0.51
WTARC	52.5	18	346	7.5	2.7	0.38

[1]Nitrogen soil samples were to a depth of four feet in one foot increments. All other soil tests were for zero to six inches in depth.
WTARC- Western Triangle Ag. Research Center

PULSE
&
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VARIETIES

Table 25. Statewide Dry Pea Variety Evaluation. Western Triangle Ag. Research Center, 2013.

Variety	Pea Color	Yield (lbs/a)	Test Weight (lbs/bu)	Plant Height (cm)	1000 Kernel Weight (g)	Flower Date (Julian)
DS Admiral	Yellow	1638.3	63.1	20.5	230.1	191.0
Delta	Yellow	1640.6	63.8	17.0	221.5	191.5
Bridger (LL7020)	Yellow	1740.5	63.9	19.5	218.1	190.5
SW Midas	Yellow	1845.8	63.5	20.3	210.0	193.0
CDC Meadow	Yellow	1853.7	64.7	22.5	197.4	192.8
Montech 4152	Yellow	1862.2	64.0	20.3	242.2	191.0
Spider	Yellow	1748.1	63.5	22.0	246.9	192.8
Montech 4193	Yellow	1371.3	63.0	16.3	236.9	192.3
Pro 793	Yellow	1628.2	64.6	18.5	264.2	189.8
Pro 127-2	Yellow	2139.3	63.7	22.3	233.4	192.3
Jetset	Yellow	2001.8	63.5	22.8	246.1	193.2
Vegas	Yellow	1315.9	64.1	21.5	227.5	193.0
Navarro	Yellow	1987.6	63.3	20.3	263.8	189.7
Mystique	Yellow	1580.6	62.2	22.7	242.1	193.0
Korando	Yellow	1718.2	63.4	21.0	251.5	188.8
CDC Treasure	Yellow	1926.9	64.5	23.0	210.1	193.3
Nette	Yellow	1820.5	63.7	22.0	222.1	190.3
Agassiz	Yellow	1518.4	63.1	20.3	224.4	193.0
Arcadia	Green	1717.6	62.9	16.3	199.1	192.5
Cruiser	Green	1488.3	62.5	19.7	199.1	191.3
K2	Green	1713.0	62.4	18.8	218.2	192.0
Majoret	Green	1606.8	63.9	19.3	228.4	193.3

Table 25 continued on next page

Table 25 continued

Variety	Pea Color	Yield (lbs/a)	Test Weight (lbs/bu)	Plant Height (cm)	1000 Kernel Weight (g)	Flower Date (Julian)
CDC Striker	Green	1812.5	64.2	22.3	231.3	194.0
Montech 1103	Green	1771.7	63.2	21.7	266.7	193.7
PRO 091-7137	Green	1632.0	63.3	17.3	203.9	190.8
Banner	Green	1346.4	62.8	17.7	184.5	187.3
Greenwood	Green	1867.5	64.0	20.5	202.4	192.3
Aragorn	Green	1993.6	62.4	21.0	208.8	191.0
Daytona	Green	1815.4	63.3	23.3	264.7	192.3
Bluemoon	Green	1422.1	63.1	16.0	231.5	193.0
Viper	Green	2068.0	62.6	23.5	236.1	192.0
CDC Raezer	Green	1605.5	62.9	22.3	236.0	193.7
Trial Means		1734.5	63.4	20.5	227.1	191.8
$LSD_{0.05}$ (by t)		684.2	1.2	4.8	20.0	1.7
CV% (s/means)		19.8	0.9	11.8	4.4	0.4

Seeding Date: May 22, 2013
Harvest Date: August 29, 2013
Precipitation: 6.16 inches.
Fertilizer (actual): 11-22-20 lbs/a. 11-22-0 was applied with the seed with 0-0-52 being broadcast while planting.
Sprayed with Prowl H_2O @ 28 oz/a and Roundup Max @ 18 oz/a on April 28, 2013.
Western Triangle Ag. Research Center, Conrad, MT.

Table 26. Statewide Lentil Variety Evaluation. Western Triangle Ag. Research Center, 2013.

Variety	Lentil Color and size	Yield (lbs/a)	Mature Canopy Height (cm)	Test Weight (lbs/bu)	1000 Kernel Weight (g)	Flower Date (Julian)
CDC Greenland	lg	1571.0	13.5	62.2	715.0	193
Imi-Green	mg	1465.3	14.5	63.1	617.5	192.3
CDC Richlea	mg	1697.8	12.0	62.9	562.5	192.0
Impress CL	mg	1497.6	12.8	65.1	570.0	192.3
Avondale	tr	1501.5	11.8	63.2	525.0	191.3
Viceroy	sg	1570.6	12.5	64.5	345.0	192.8
Crimson	sr	1036.2	9.5	63.5	370.0	191.8
CDC Redberry	sr	1350.6	12.0	63.3	455.0	192.8
Means		1460.6	12.3	63.5	520	192.3
$LSD_{0.05}$ (by t)		236.9	1.1	1.4	33.4	1.2
CV% (s/means)		11.0	5.8	1.6	4.4	0.4

Seeding Date: May 22, 2013.
Harvest Date: September 5, 2013.
Fertilizer (actual): 11-22-20 lbs/a. 11-22-0 was applied with the seed with 0-0-52 being broadcast while planting.
Precipitation (planting to harvest): 6.16 inches.
Sprayed with Prowl H_2O @ 28 oz/a and Roundup Max @ 18 oz/a on April 28, 2013.
Lentil color: Small Green = sg; Medium Green = mg; Large Green = lg; Small Red = sr; Spanish Brown (Pardina) = sb
Western Triangle Ag. Research Center, Conrad, MT.

Table 27. Statewide Chickpea Variety Evaluation. Western Triangle Ag. Research Center, Conrad, MT. 2013.

Variety	Yield (lbs/a)	Test Weight (lb/bu)	1000 Kernel Weight (g)	Flower date (Julian)
Myles	2360.1	63.3	352.8	189.5
CDC Orion	2210.9	63.5	344.0	188.5
CDC Alma	2159.9	62.5	324.3	190.8
CDC Frontier	1588.7	62.0	333.3	190.5
Means	2079.9	62.8	338.6	189.8
$LSD_{0.05}$ (by t)	401.4	2.0	47.0	1.2
CV% (s/means)	12.06	2.0	8.7	0.4

Seeding Date: May 22,2013
Harvest Date: September 17, 2013
Fertilizer (actual): 11-22-20. 11-22-0 was applied with the seed with 0-0-52 being broadcast while planting.
Precipitation: 7.04 inches.
Sprayed with Prowl H_2O @ 28 oz/a and Roundup Max @ 18 oz/a on April 28, 2013.