Department of Research Centers

37 th ANNUAL RESEARCH REPORT OF WESTERN TRIANGLE AGRICULTURAL RESEARCH CENTER

Montana Agricultural Experiment Station, Conrad, MT

2014 CROP YEAR

Submitted by

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Table of Contents

INTRODUCTION

The information and data reported are a collaboration of ongoing or new research projects located at or near Western Triangle Ag. Research Center (WTARC) of Montana State University, Conrad, Montana. Many projects are conducted in cooperation with faculty members, 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), Northwestern (NWARC) Southern (SARC) and Western (WARC) of the Dept. of Research Centers.

To simplify reading, trade or brand names of products, services, firms, or equipment are sometimes used. No endorsement of such names or firms is intended nor is criticism implied of those not mentioned.

ACKNOWLEDGEMENTS

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Summary of climatic data by month for the '13-'14 crop year (September thru August) at the Western Triangle Agricultural Research Center, Conrad, MT.

Month Year	Sep 2013	Oct 2013	Nov 2013	Dec 2013	Jan 2014	Feb 2014	Mar 2014	Apr 2014	May 2014	Jun 2014	Jul 2014	Aug 2014	Crop Year
Precipitation, inches													
Current Year	1.03	0.18	0.58	0.16	0.54	0.1	0.37	1.49	0.62	4.35	0.85	2.53	12.8
28-year average	1.17	0.62	0.28	0.20	0.19	0.22	0.42	1.01	1.91	2.98	1.41	1.23	11.6
Mean Temperature, °F													Average
Current Year	58.3	41.5	29.4	18.6	27.1	12.3	23.5	40.9	50.6	55.2	67.6	64.1	40.8
28-year average	57.1	44.6	32.2	23.9	23.2	24.3	32.6	42.6	51.6	59.2	66.9	66.1	44.5

Last killing frost in Spring (32°F)
2014--------------------------------- May 12
Average 1986-2014-------------- May 18

First killing frost in Fall (32°F)
2014--------------------------------- Sept. 10
Average 1986-2014-------------- Sept. 26

Frost free period (days)
2013------------------------------ 121
Average-------------------------- 131

Maximum summer temperature------- 91°F (August 12, 2014)

Minimum winter temperature--------- -29°F (December 7, 2013)

MONTANA STATE UNIVERSITY
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Entomology/Insect Ecology

Laboratory evaluation of five different species of entomopathogenic nematodes against wheat stem sawfly larvae *Cephus cinctus* (Hymenoptera: Cephidae)

Principle Investigator: Dr. Gadi. V.P. Reddy

Co-operators: Dr. Sindhu Krishnankutty, Dr. Brian Thompson and Debra A. Miller.

Western Triangle Agricultural Research Center, Montana State University, 9546 Old Shelby Road, P.O. Box 656, Conrad, MT 59425

Background.

Infectivity of different entomopathogenic nematodes (EPNs) have been proven against hundreds of species of insects in laboratory tests. No prior information is available on the dose-response relationship of different species of EPN against wheat stem sawfly (WSS). This study aims to compare the susceptibility of WSS to different nematode species.

Objective. To assess selected species of steinernematid and heterorhabditid nematodes against WSS larva in the laboratory.

Materials and Methods.

Overwintering WSS larvae were collected from wheat stubble. Wheat stubble was collected from Teton County, Montana (N47° 56' 52.1916 W112° 2' 35.5956"). Two pieces of moistened 55mm Whatman Grade 1 filter paper were placed in the lid of a plastic petri dish (55mm). Single larva of WSS were placed on the moist filter paper. EPNs were applied at the rate of 50, 100, 200 and 500 IJs/petri dish in 0.25 ml of water using a pipette. Petridish were then lined with parafilm and kept in incubator at 25 degree Celsius. Each treatment was replicated five times for each species and five replicates without nematodes for each species were served as control.

EPN species used. Heterorhabditis indica, H. bacteriophora, Steinernema kraussei, S. carpocapsae, and *S. feltiae* were used.

Evaluation method. Treatments were evaluated for one week following EPN application. Infection by EPN was confirmed by White Trap method. White trap method takes advantage of the natural tendency of nematodes to move to water. So if the dead larvae is infected with nematodes, nematodes will be moving away from the host cadaver to the water present in the petridish.

Statistical analysis. Mortality data was analyzed using Analysis of Variance on ranks (Kruskal-Wallis test, overall significance level = 0.05) in SigmaPlot v. 13.0 software (Systat Software Inc., San Jose, CA, USA).

Results and Discussion

Significant difference was found among the treatments (H= 15.667, d.f.= 4, *P*= 0.004). Among the five different EPN species, *H. indica* caused highest mortality (100%) within 48 hrs after the application (Fig. 1). This was followed by *S. feltiae* and *S.kraussei* that were effective with in 48 hrs of treatment application (fig 2 &3). The least effective EPN were *S. carpocapsae* and *H.*

bacteriophora . Both these species caused mortality 4 days after application even at highest dose of 500 IJS/larva. None of the control died during the same time period. This results suggests that *H. indica*, even at very low doses, kills WSS. *H. indica* should be further evaluated for efficacy in field trials.

Acknowledgements

This work was supported by Montana Wheat and Barley and United States Department of Agriculture- Cooperative Regional Project W3185 Biological Control in Pest Management Systems of Plants and Montana Wheat and Barley Committee.

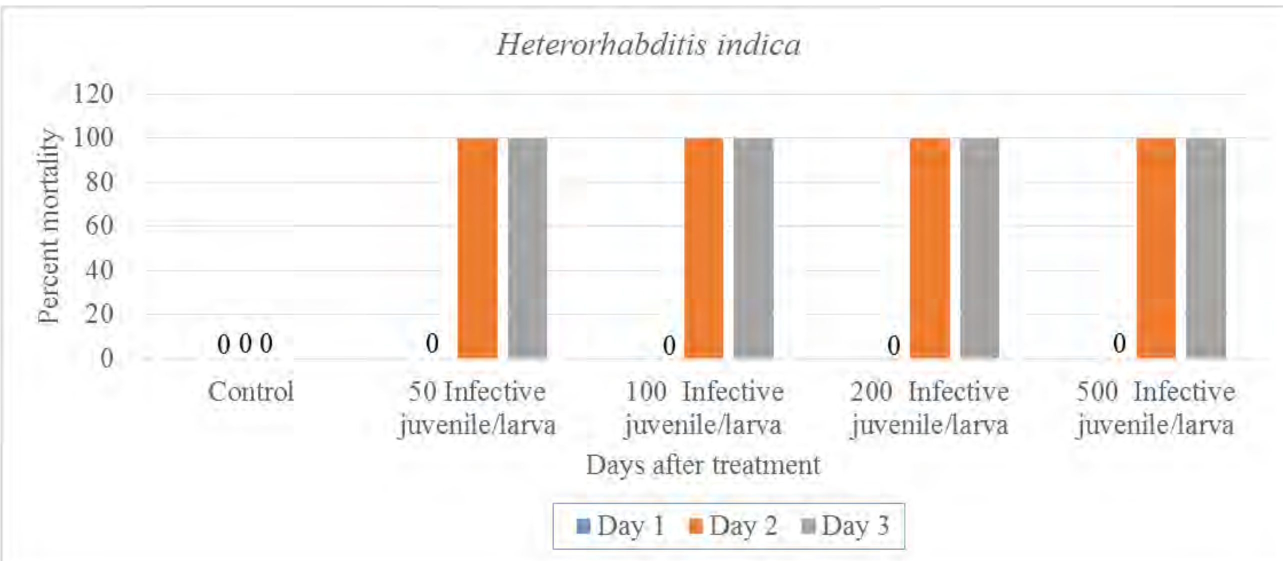

Figure 1. Effect of *Heterorhabditis indica* infective juvenile concentration on mortality of wheat stem sawfly larvae (mean ± SE).

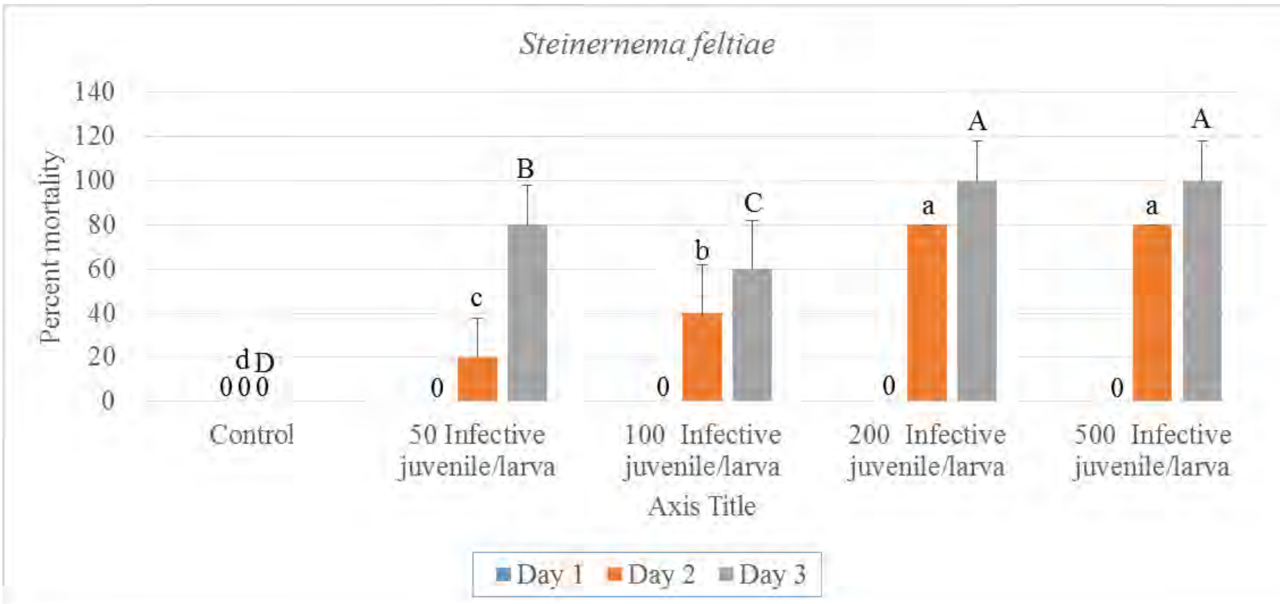

Figure 2. Effect of *Steinernema feltiae* infective juvenile concentration on mortality. Different letters above the bars indicate significant differences (One way ANOVA, Kruskal-Wallis test, P = 0.05).

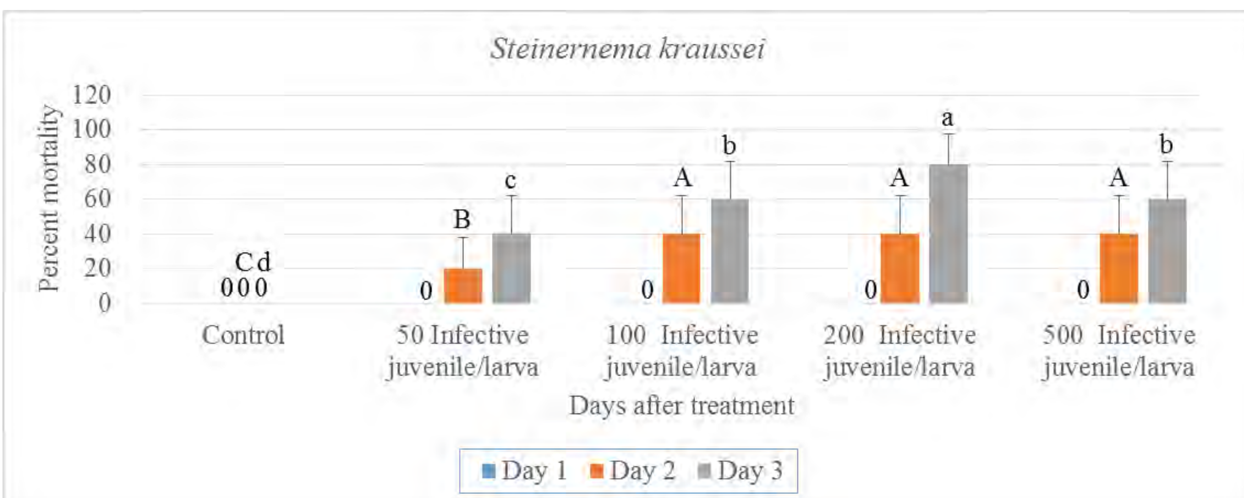

Figure 3. Effect of *Steinernema kraussei* infective juvenile concentration on mortality of wheat stem sawfly larvae (mean ± SE). Different letters above the bars indicate significant differences (One way ANOVA, Kruskal-Wallis test, P = 0.05).

Efficacy of entomopathogenic nematodes against wheat stem sawfly, *Cephus cinctus* (Hymenoptera: Cephidae)

Principle Investigator: Dr. Gadi. V.P. Reddy

Co-operators: Dr. Sindhu Krishnankutty, Dr. Brian Thompson, John Miller, Julie Prewitt and Debra A. Miller.

Western Triangle Agricultural Research Center, Montana State University, 9546 Old Shelby Road, P.O. Box 656, Conrad, MT 59425

Abstract

Despite considerable research efforts in the management of Wheat stem sawfly (*Cephus cinctus*), (WSS) this 'million dollar pest' continues to be a burden to wheat growers in Northern Great Plains. In the present study, we examined the effectiveness of different strains of entomopathogenic nematodes (EPNs) for controlling WSS larvae at their diapause stage. EPN strains mixed with water as well as Barricade® were applied on wheat stubble of eight different hollow-stem varieties. Results showed no significant difference in the number of dead sawfly larvae among the nematode treatments. However, we found there is significant difference in the number of dead sawflies among the wheat varieties.

Objective.

To evaluate the efficacy of different strains of entomopathogenic nematodes against diapausing larvae of WSS at two field locations in Montana.

To evaluate the level of infestation of WSS among different hollow-stem varieties.

Materials and Methods.

Field experiments were conducted in August 2014 at two locations in Montana, one at Devon (N48° 33' 14.94 W112° 23' 42.96") and the other in Choteau (N47° 56' 52.1916 W112° 2' 35.5956") (fig.1). Eight hollow-stem wheat varieties were planted in the field and the plots were arranged in a complete randomized block design (CRD) with three replicates. Each plot was 3.6 m x 1.2 m (48 Sq. Ft.) and consisted of four rows. Each row was equally divided into two (6 ft each) so that eight treatments (Table 1) could be applied in a single plot. Each treatment was replicated thrice within each variety. Entomopathogenic nematodes (EPNs) were sprayed over wheat stubbles containing diapausing WSS larvae. WSS larvae overwinter within the stem after plugging the stem with frass at it opening (Fig. 1). The plug protects the larva from excessive cold and dry conditions. The nematode concentrations were calculated based on recommendation rates for foliar application of pests by the manufacturer (Table 1). Nematodes were kept in a cooler at 10-15˚Celsius during transportation to the field.

Wheat varieties used. Accipiter, SY Clearstone 2, Colter, CDC Falcon, Decade, Yellowstone, Jagalene, and Jerry (all are hollow–stem wheat varieties)

EPN strains used. Three different strains, *Steinernema carpocapsae, Heterorhabditis bacteriophora* and *S. feltiae* were used. These strains were selected based on natural foraging strategies. *S. carpocapsae* has 'ambush' or 'sit- and-wait' foraging strategy. *H. bacteriophora* is a 'cruiser' meaning it actively seeks out its prey. *S. feltiae* has an 'intermediate' strategy between 'ambush' and 'cruise' strategies that helps them to infect both mobile and sedentary pests. The mix of foraging strategies provides a gradient to evaluate nematode habit in controlling sawfly.

Evaluation method. Infection of diapausing WSS larvae by nematodes was assessed by counting the dead larva in the stubble. Three wheat plants with multiple stubbles were randomly uprooted from each treatment area one week after spraying and were inspected later in the lab to check for the presence of dead larva.

Statistical analyses. The difference among treatments in wheat varieties and number of WSS larvae in the stubble were evaluated. All data were tested separately for normality using the Shapiro-Wilk test. As the data failed the normality test, ANOVA on ranks (Kruskal-Wallis test, overall significance level = 0.05) was used to determine statistical significance. All analyses were done using SigmaPlot v. 13.0 software (Systat Software Inc., San Jose, CA, USA).

Results.

There were no significant differences in the number of larvae found among treatments in both the locations (Location 1_Devon: P=0.103; Location 2_Choteau: F= P=0.844; Fig. 1). Slight significant difference in number of dead larvae was found among varieties (Location 1_Devon: P=0.014; Location 2_Choteau: F= P=0.010). Among wheat varieties, Accipiter and Yellowstone were found to be infested with more sawflies.

Discussion.

Results showed no significant difference among the treatments. The presence of a stem plug that does not retain water and the tendency of diapausing larvae to move towards the bottom of the stem when disturbed can be two main causal factors that affected survival and infectivity of nematodes in the wheat stubble. Future research efforts should be aimed at improving the survival capacity and penetration of nematodes in the stem lumen environment.

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 greatly appreciated local growers for allowing us to use their wheat fields to conduct the experiment in Devon, Montana.

Figure 1. Wheat stubble (cut open) with diapausing stem sawfly larvae inside

Table 1: Material, and rate of application in each treatment.

Treatment	Material	Trade name	Rate	Source
T1	Water spray (control)	-	-	-
T2	Barricade (control)	Barricade®	30 ml/1L	Barricade International Inc., FL
T3	*Steinernema carpocapsae* + Water	Millenium®	250 million/10000 sq ft.	BASF, Ames, Iowa
T4	*Heterorhabditis bacteriophora* + Water	Nemasys G®	50 million/ 1000 sq. ft	BASF, Iowa
T5	*Steinernema feltiae* + Water	Nemasys®	50 million/4300 sq. Ft	BASF, Iowa
T6	*S. carpocapsae* + Barricade®	Millenium®	Same as above	BASF, Ames, Iowa
T7	*H. bacteriophora* + Barricade®	Nemasys G®	Same as above	BASF, Ames, Iowa
T8	*S. feltiae* + Barricade®	Nemasys®	Same as above	BASF, Ames, Iowa

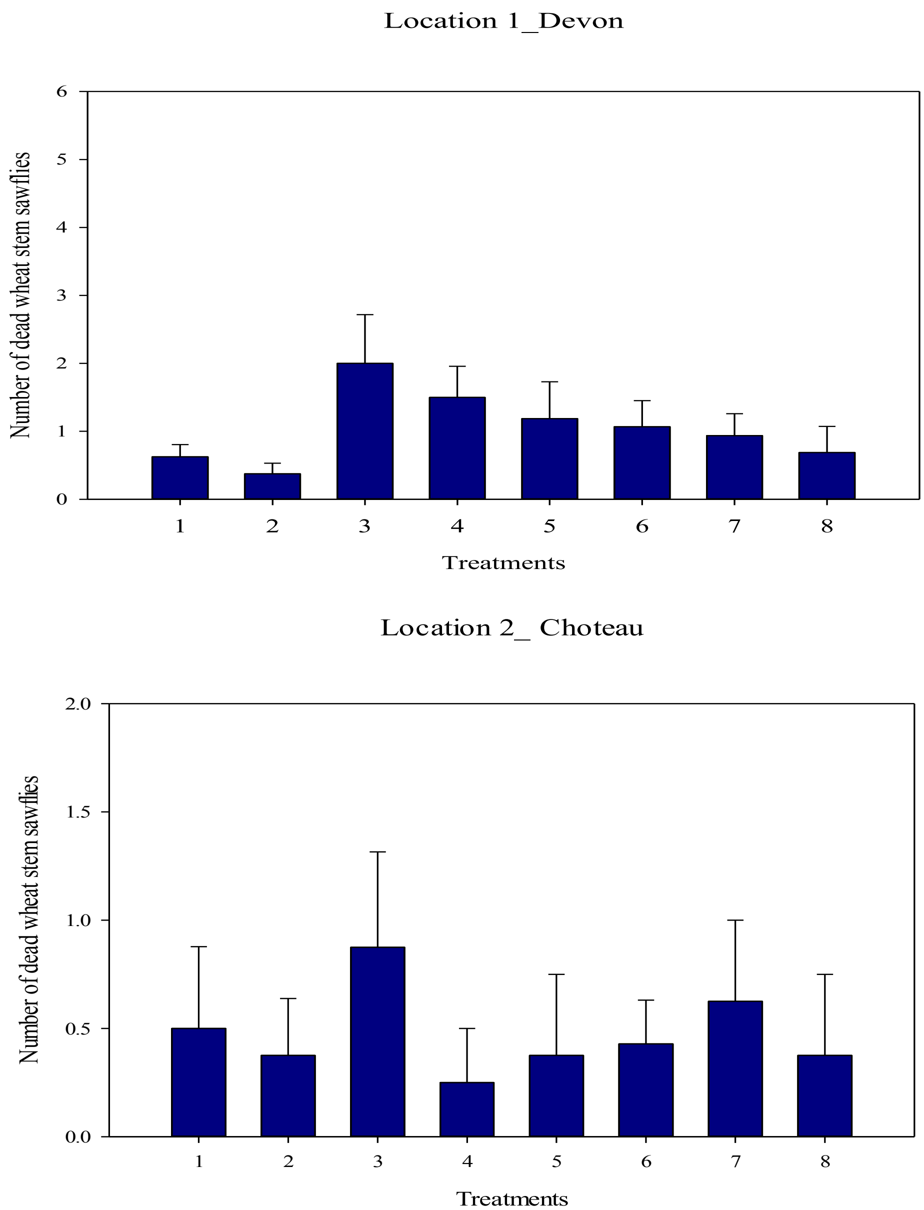

Figure 2. Number of dead sawfly larvae in treatments with different strains of entomopathogenic nematodes (mean ± SE). T1: Water spray; T2: Barricade; T3: *Steinernema carpocapsae* + Water; T4: *Heterorhabditis bacteriophora* + Water; T5: *S. feltiae* + Water; T6: *S. carpocapsae* + Barricade; T7: *Heterorhabditis bacteriophora* + Barricade; T8: *S. feltiae* + Barricade

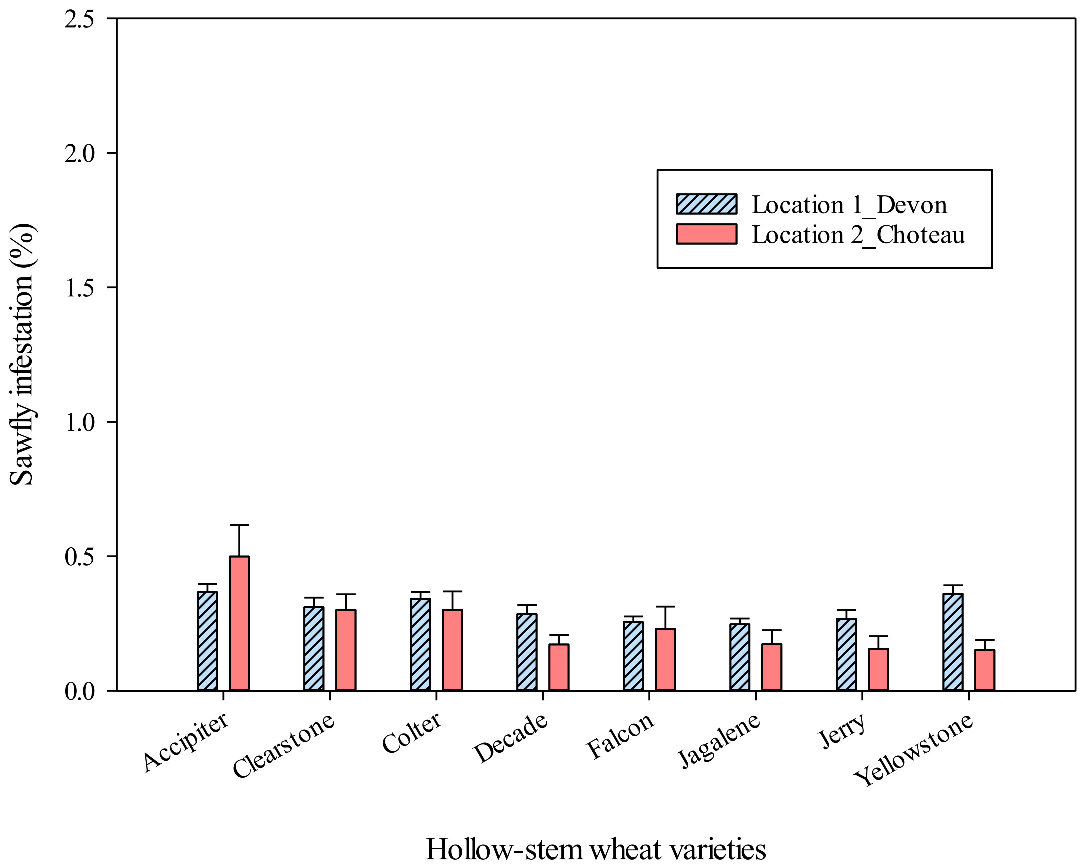

Figure 3. Number of dead sawfly larvae among different hollow stem wheat varieties (Mean ± SE).

Improved pheromone based trapping systems for wheat stem sawfly (*Cephus cinctus*) using color and pheromone lures.

Principle of Investigators: Dr. Gadi V.P. Reddy[1] and Dr. David K. Weaver[2]

Cooperators: Dr. Brian Thompson[1], Dr. Sindhu Krishnankutty[1]

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[2]Department of Land Resources & Environmental Sciences, Montana State University, 334 Leon Johnson Hall, Bozeman, MT 59717-3120

Background:

The wheat stem sawfly (*Cephus cinctus*) is one of the largest pests of wheat in Montana and the northern Great Plains in general. Sawfly cause damage to crops through yield reduction and yield loss due to interference with seed filling as a result of feeding on the plant and loss though direct cutting of the wheat stem during their pupation ritual. Cutting of wheat stems by sawfly (aka. lodging) results in wheat stem falling over where they may be missed by harvesting equipment (2012 approx. loss/ farmer = ~7 bushels/acre). In areas where sawfly are persistent many producers automatically implement procedures to reduce yield loss from lodging. This automatic practice is costly to the producers in time and materials. In recent, years this pest has expanded in range to areas south of it traditional range. In these new geographic regions and in its traditional range there is unpredictability in predicting the presence and magnitude of sawfly populations that hampers control measures.

C. cinctus distribution across the current geographic range is patchy. The density of populations varies from field to field and time to time. Uncertainty over where and when this pest occurs is expensive for land managers. Population controls, such as pesticides, rely on accurate information about when the pest is actively flying in the crop. The larvae of sawfly are not amenable to pesticide applications due to feeding internally concealed within the wheat stem. Therefore, accurate prediction of when the sawfly is actively flying in the crop is the best way to control this pest. A pheromone lure has been developed for *C. cinctus*, but optimal assessment of populations is not guaranteed with this lure alone.

Many herbivorous insects respond to colors. This type of phototaxis allows the herbivore to identify host plants for feeding or oviposition. In certain insects attraction toward a source of nectar, signified by the flower color, leads to a preferred food source. Sawfly adults are not known to feed. However adults may be preferentially attracted to particular colors due to innate characteristics of their biology. In this study we tested sawfly preference to pheromone baited colored traps to evaluate potential improvement to sawfly trapping systems.

Methods:

Sawfly traps consisted a combination of commercially produced insect traps and handmade colored panel traps. The three commercial traps were the white L P delta trap (Scentry), green and yellow bucket trap (Scentry) and the Bite Free Stable Fly trap (Starbar). There were eight colors for the sticky panel traps tested (white, yellow, red, blue, gray, black, purple and green). Panel traps consisted of laminated colored construction paper measuring approximately 8×8 inch squares. Two panels were laminated together for placement on the trap. PVC pipe held the two laminated sheets (4 panels) upright and separated. A hole in the middle of the sheets was affixed with the *C. cinctus* lure. Colored panels were coated with Tangle Trap prior to assembly. Assembled PVC traps were placed on staked or rebar driven into the ground in the field (Figure 1A). All commercial traps were fitted with pheromone bait and killing agent (bucket trap) prior to deployment in the field (Figure 1B). All traps were arranged 10m apart in a straight line at an equal height above the ground (Figure 2). Traps were placed in chemical fallow ten meters from the current crop of spring wheat. Trap lines were set up at three separate farms and at each farm 4 to 5 locations were trapped. Five locations were sample trapped at the Western Triangle Agricultural Research Center (48.306208, -111.925106), four locations were trapped at Kellog farm (48.042053, -111.978068) and 4 locations were trapped at the Meuli farm (48.261610, -111.557256). Traps were monitored weekly for insect catches and were replaced midway through the study to refresh sticky surfaces (Figure 3). All bees and sawflies were collected and catalogued from the 5th of June to the 16th July.

The mean trap catch between traps was analyzed using Sigma Plot v13. Mean comparisons were made via ANOVA with a post hoc Tukey HSD test for multiple mean comparisons.

Results:

Traps caught sufficient numbers of sawflies for statistical analysis in all but the WTARC location. The colored traps did not differ in their mean trap catches from each other both the Meuli and the Kellog locations. Colored traps caught more sawflies than the bucket trap and the delta trap at both locations (Figures 4 & 5). Bucket and delta traps caught next to no sawflies over the course of the study. All other traps were not significantly different. The traps located at WTARC caught less than five sawflies over the course of the summer and was not analyzed for statistical comparisons.

Discussion:

Pheromone baits are suspected to be loaded at a reduced concentration due to uncharacteristically low sawfly catch at typically consistent trapping sites. The WTARC site is typically very good for sawfly populations. The low number of sawflies observed at WTARC in this study may be due to the presence of parasitoids, which were in abundance this summer. That this typically good site was very depopulated and that the other sites also exhibited low counts are indicative of the seasonal variation in sawfly populations, possibly due to parasitoid populations. Even so, yellow and white traps seem to catch more sawflies than the other colors. These colors offer the advantage that sawflies are easier to see on these traps than on the darker colors. Commercial traps were not effective in monitoring sawfly populations.

Acknowledgments:

This work was supported by Montana Wheat and Barley Committee and U.S. Department of Agriculture-National Institute of Food and Agriculture (USDA-NIFA) Hatch (#MONB00859). We also like to thank Steve Kellog (Brady, MT and Dan Meuli (Ledger, MT) for providing fields for our experiments.

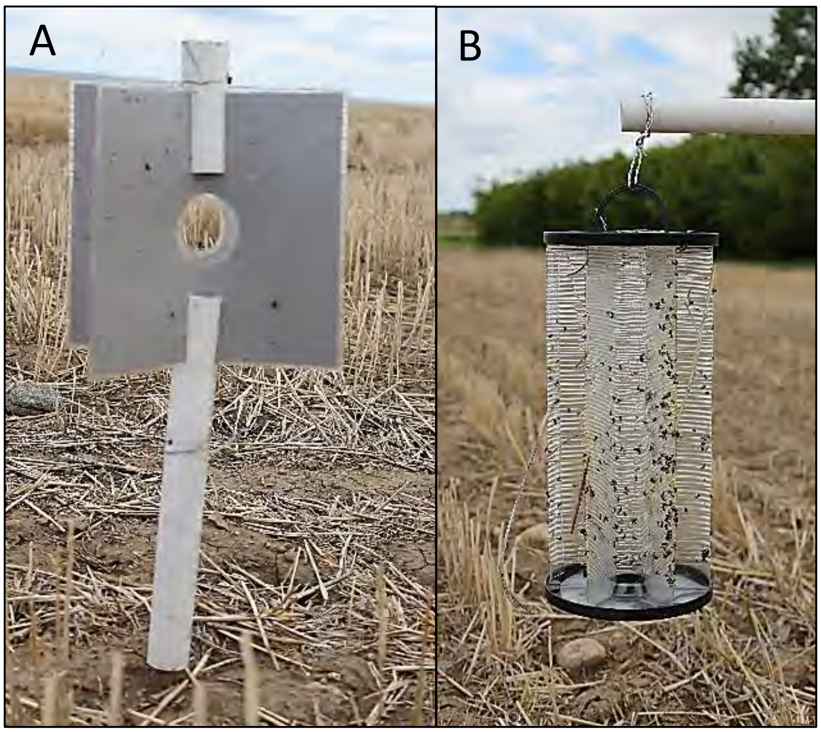


Figure 1: Trap designs for A) handmade sticky panel traps and B) commercial Stable Fly trap.

Figure 2: Traps were arranged in a random order in a straight line immediately adjacent to the crop of spring wheat but at a minimum of 10m inside the fallow field.

Figure 3: Insect catch on stable fly trap.

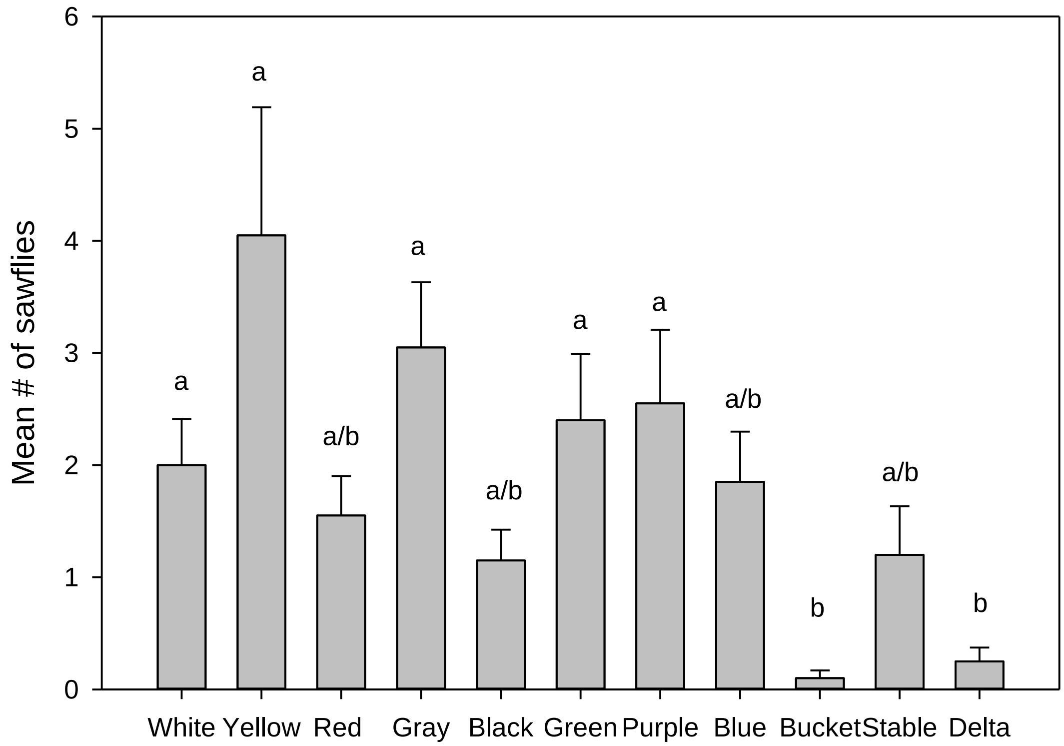


Figure 4: Mean ± SE sawfly catch by each trap type at Kellog Farm. Letters differentiate significantly different trap catches (One-way ANNOVA followed by Tukey < 0.05). Each treatment is replicated four times.

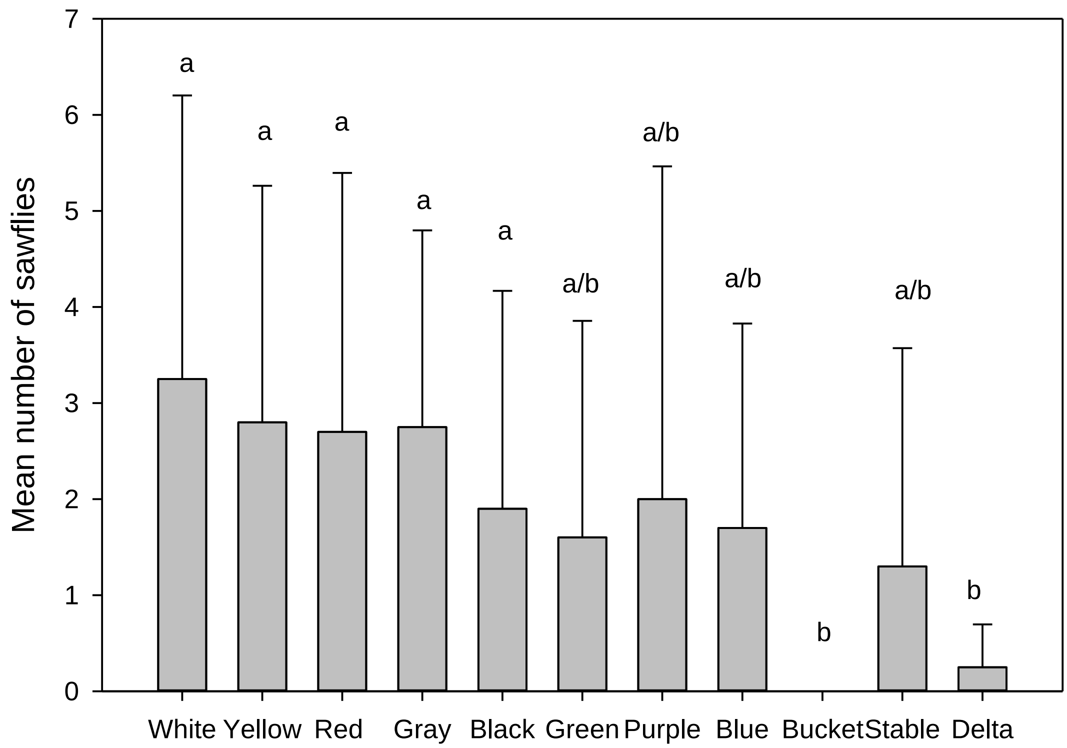


Figure 5: Mean ± SE number of sawflies trapped at Meuli farm. Letters differentiate significantly different trap catches (One-way ANNOVA followed Tukey < 0.05). Each treatment is replicated four times.

Survey of natural fungal pathogens of wheat stem sawfly (*Cephus cinctus*)

Principle Investigators: Dr. Gadi V.P. Reddy[1] and Dr. Stefan T. Jaronski[2]

Cooperators: Dr. Brian Thompson[1], Dr. Sindhu Krishnankutty[1]

[1]Western Triangle Agricultural Research Center, Montana State University, 9546 Old Shelby Rd., P.O. Box 656, Conrad, MT 59425, USA

[2]United States Department of Agriculture, Agricultural Research Service, Northern Plains Agricultural Research Laboratory, 1500 N. Central Avenue, Sidney, MT 59270

Background:

Fungal and bacterial pathogens of insects (entomopathogens) occur naturally in soil and water. Occasionally these entomopathogens cause widespread mortality among insect populations. These epizootics are rare in nature, but do occur. Biological control programs for agriculture attempt to initiate epizootics through the introduction of a critical mass of pathogens to the cropping system thereby reducing overall insect pest density. All pathogens are not equal in their ability to infect and kill insect hosts. Specialist pathogens exist much in the same way that insect specialists exist on different crops and plant parts. In this study, we sought out fungal pathogens of the wheat stem sawfly (*Cephus cinctus*) in wheat fields of the Golden Triangle wheat growing region.

Beauveria bassiana is one particular fungal pathogen that has been isolated in a previous pilot study from the Golden Triangle. The collection and isolation of fungal pathogens is the first step toward initiating a successful biocontrol program using native sawfly adapted fungal pathogens. *C. cinctus* overwinters as a larvae in a chamber constructed at the base of the wheat stem (stub) (Figure 1). Sawflies killed in the stub during overwintering, possibly by pathogens, are easy to overlook without the proper sampling materials. This study samples this life-stage of the sawfly in an attempt to locate new fungal pathogens for diapausing wheat stem sawfly.

Methods:

In the fall of 2014 the research scientists at WTARC participated in a collection of sawfly stubs from wheat fields around the Western wheat growing states. WTARC research team collected wheat stubbles from 20 different locations across five counties (Figure 2). These stubs were then sent to the USDA pathogen research lab of Dr. Stefan Jironski in Sydney, MT. There sawfly larvae are then removed from their stub (Figure 3). Larvae are then placed on selective media for isolation of *Beauvaria*. Fungal isolates are then transferred to separate culture dishes and catalogued for identification and long-term storage. Evaluation of pathogen efficacy in mortality studies will follow initial isolation.

Results:

Fungal isolation results are pending This ongoing study is funded through spring 2015. Fungal isolation and identification will take place in early 2015.

Discussion:

(Pending fungal ID)

Acknowledgments:

This work was supported by Montana Wheat and Barley Committee and U.S. Department of Agriculture-National Institute of Food and Agriculture (USDA-NIFA) Hatch (#MONB00859).

Figures

Figure 1: Wheat stubs created when sawfly larvae girdle the inside of the wheat stem and then plug the stem with frass to create a chamber in which to overwinter.

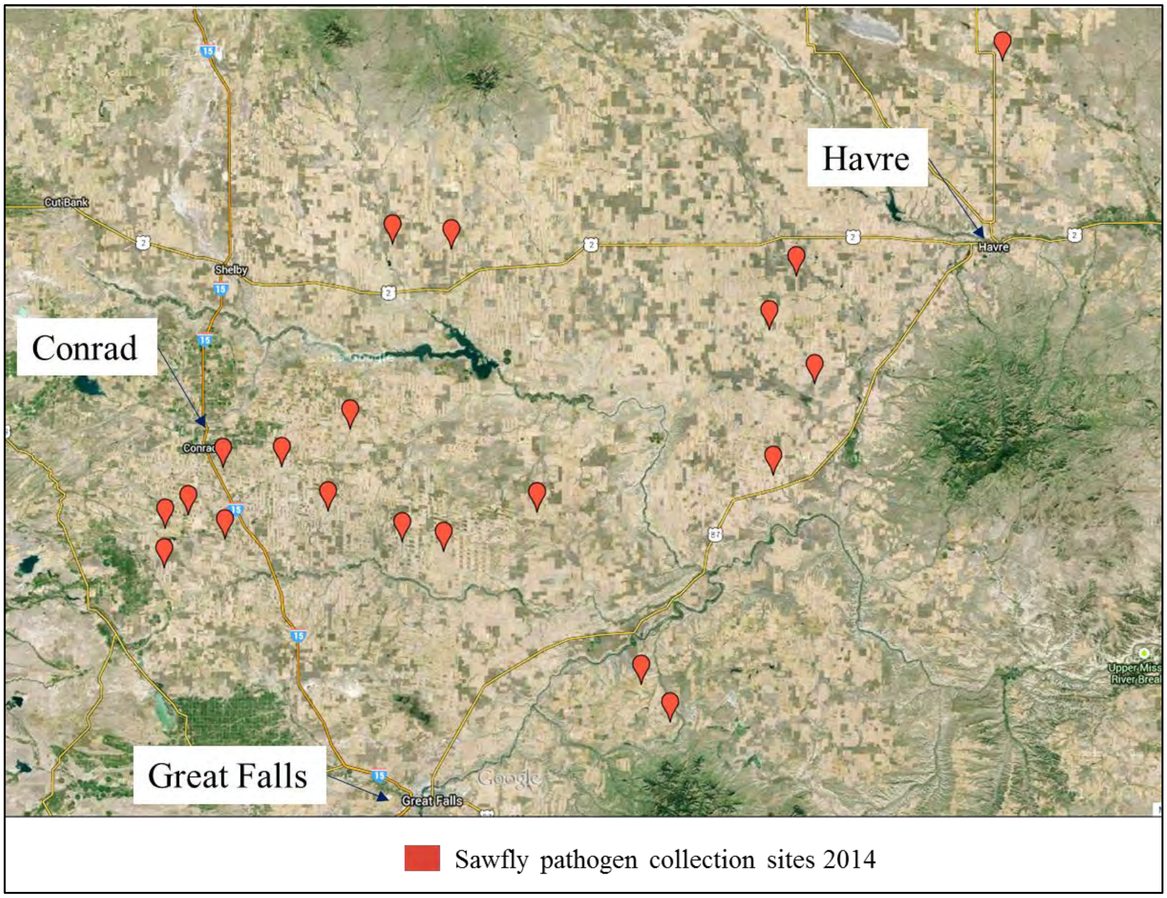


Figure 2: Sawfly collection sites (red balloons) for the Golden Triangle of Montana 2014.

Figure 3: Sawfly larvae (*C. cinctus*) removed from the stub and ready for transfer to fungal isolation media.

Field Efficacy of entomopathogenic fungi for the management of wireworms (Coleoptera: Elateridae) on spring wheat

Principle Investigator: Dr. Gadi. V.P. Reddy

Cooperators: Dr. Sindhu Krishnankutty, Dr. Brian Thompson, John Miller, and Julie Prewitt. Western Triangle Agricultural Research Center, Montana State University, 9546, Old Shelby Road, P.O. Box 656, Conrad, MT 59425

Dr. Stefan T. Jaronski, United States Department of Agriculture, Agricultural Research Service, Northern Plains Agricultural Research Laboratory, 1500 N. Central Avenue, Sidney, MT 59270

Abstract

Wireworms continue to be a major problem in north-central Montana. In the present study, different combinations of entomopathogenic fungi and low risk insecticides were tested for their efficacy against wireworms in spring wheat in two locations in Montana. The entomopathogenic fungi (*Metarhizium brunneum* F52, *Beauveria bassiana* GHA, *Metarhizium robertsii* DWR356 and *Metarhizium brunneum* MA1200) and the low risk insecticides (Spinosad (Conserve SC®), neem/Aza-Direct®) were applied as a soil drench, in addition to a seed treatment using imidacloprid (Gaucho®) and untreated control. Grain yield was analyzed to estimate the effect of these treatments. We found no significant difference in yield among the treatments in both the locations where this study was conducted.

Objective

To evaluate the efficacy of different combinations of entomopathogenic pathogens and low risk pesticides against wireworms in spring wheat at two field locations in Montana.

Materials and methods

Locations. Two locations were chosen for having persistent wireworm pressure in 2014, one at Conrad (N48° 15' 50.1546" W111° 53' 18.078") and the other at Valier (N48° 18' 52.3794" W112° 8' 30.9366"). Spring wheat (Duclair) was planted into the wireworm infested fields at a rate of 18 seeds/ft^2. Fertilizer N, P and K at 11-22-0 (actual lbs/a) applied with seed and 40-0-20 (actual lbs/a) was broadcast while seeding. The plot was top dressed 67 lbs N/a.

Fungal application. Soil moisture at the two locations was measured prior to the application of fungal isolates. Fungal isolates were applied as a soil drench using hand held sprayers according the rates described in Table 1. The application date was timed to approximately two weeks after planting date. The planting dates for Conrad and Valier are May 2nd, 2014 and May 14th, 2014, respectively. The plots were each sprayed twice on consecutive days. Conrad location was sprayed on the 13th and 14th of May, while Valier location was sprayed on the 27th and 28th of May. Each field was in a similar growth stage at the time of spraying (two-leaf). Each treatment at each location had three replicates arranged in a Randomized Complete Block design. All fungal solutions and controls were mixed immediately prior to their application to the field. Hand-held sprayers were not used for more than one fungal species.

Fungal assay. The soil from the study locations was sampled for each treatment plot at two week intervals starting with the final day of spraying and continuing up to six weeks (three sampling dates) for fungal density in the soil. Soil samples were aseptically collected using a sterile soil scoop that was sterilized between samplings to prevent cross contamination. Soil samples were held at temperatures below 40˚F and shipped to Sydney for quantification of fungal pathogen biomass using selective media.

Statistical analyses. All analyses were done using SigmaPlot v. 13.0 software (Systat Software Inc., San Jose, CA, USA). The grain yield data from the two locations were tested separately for normality using the Shapiro-Wilk test. Statistical significance was determined through one-way analysis of variance (ANOVA).

Results:

The wireworm population was not noticed either in control or treated plots. The yield data was normally distributed. There was no significant difference in the grain yield produced from different treatments at both the locations (F= 1.294, d.f.= 14, *P*=0.268; F= 1.390, d.f.= 14 , *P*=0.218) (Fig. 1). This experiment will be carried out again next year in a new location.

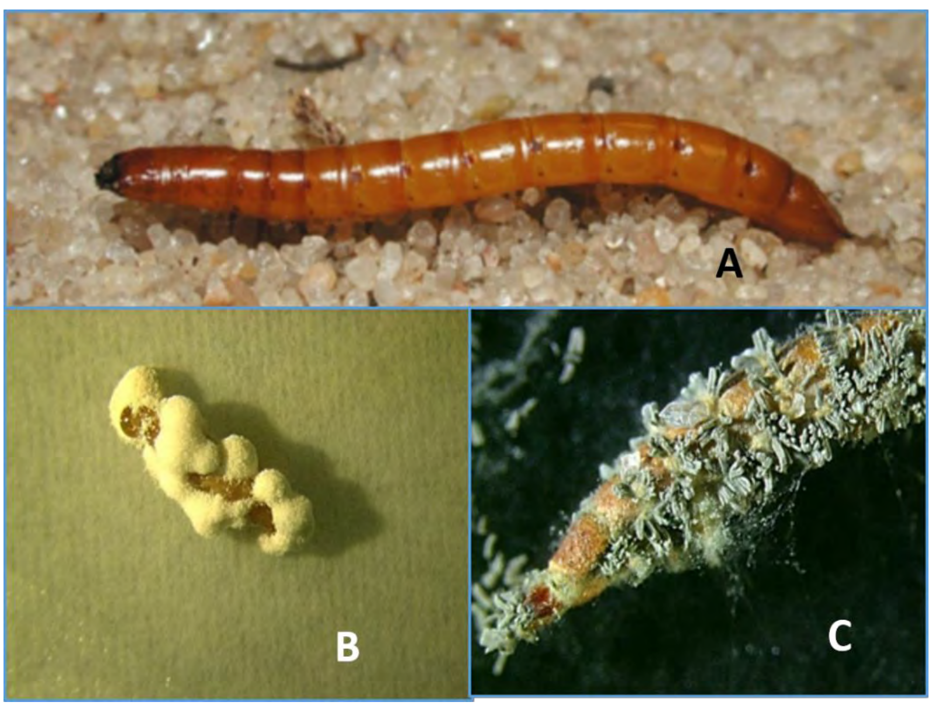


Figure-1: Healthy wireworm (A) and wireworms infected with entomopathogens (B, C).

Discussion.

Our data indicate that treatments with entomopathogenic fungi had no effect on the wireworm popultions in the test plots. This is unexpected as our previous data reported significant differences among the entomopathogenic fungi treatments in wireworm. In laboratory studies wireworms were proven to be infected with entomopathogenic fungi. However in this field trial all control treatments faired as well as fungal treated plots. Our trap catches for both wireworms as well as adult click beetles in this region during this year were low. This might have affected the results of the field experiments.We hope to continue this experiment for the next year.

Acknowledgments:

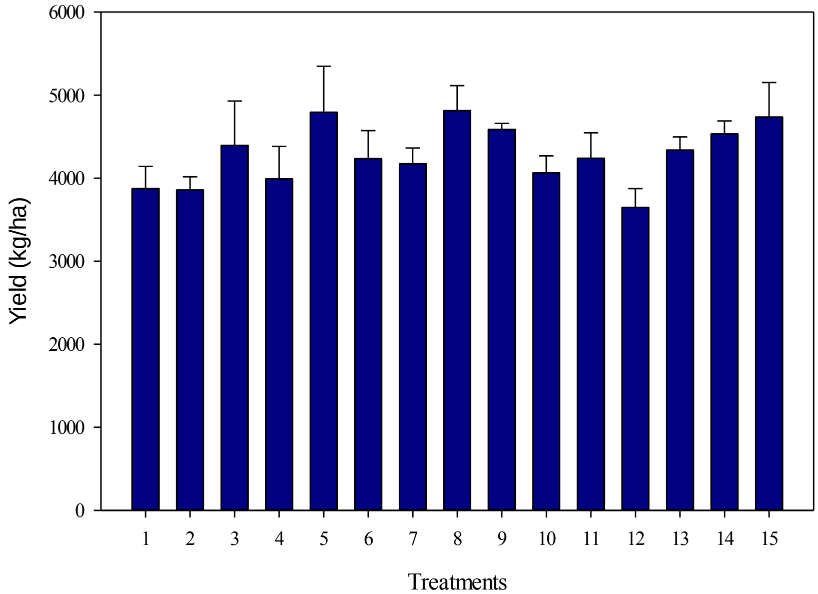
This work was supported by Montana Wheat and Barley Committee and USDA Multistate Project S-1052, The Working Group on Improving Microbial Control of Arthropod Pests Covering Research in Montana. We would also like to thank Mark Grubb and John Majurus for providing their fields to carry out the present work.

Table 1: Material, and rate of application in each treatment.

Treatment	Material	Rate	Source
T1	Untreated control		
T2	Imidacloprid (Gaucho)	1.77 ml/ha	Seed treatment
T3	Spinosad (Conserve SC®)	0.5 ml/liter of water (84g a.i.*/ha)*	Dow Agro Science LLC, Indianapolis, IN
T4	neem/Aza-Direct®	10 ml/liter of water (1484 ml/ha)	Gowan Company, Yuma, AZ
T5	*Metarhizium brunneum* F52 emulsifiable concentrate (Met52 EC)	80 ml/ha (4E11 sp/ha)	Novozymes Biologicals (Salem, VA)
T6	*Beauveria bassiana* GHA emulsifiable concentrate (BotaniGard ES)	20 ml/ha (4E11 sp/ha)	Laverlam International Corporation, Butte, MT
T7	*B. bassiana* + *M. brunneum*	10 ml/ha + 40 ml/ha (2E11 sp/ha each)	As mention above
T8	*B. bassiana* + Aza-Direct (neem)	10 ml/ha + 5ml/litter of water (2E11 sp/ha)	As mention above
T9	*B. bassiana* + spinosad	10 ml/ha + 0.25 ml/liter of water (2E11 sp/ha)	As mention above
T10	*B. bassiana* + imidacloprid	10 ml/ha + 0.885ml/ha	As mention above

		(2E11 sp/ha)	
T11	*M. brunneum* + Aza-Direct (neem)	40 ml/ha + 5ml/litter of water (2E11 sp/ha)	As mention above
T12	*M. brunneum* + spinosad	40 ml/ha + 0.25 ml/liter of water (2E11 sp/ha)	As mention above
T13	*M. brunneum* + imidacloprid	40 ml/ha +0.885ml/ha (2E11 sp/ha)	As mention above
T14	*M. robertsii* DWR356	80 ml/ha (4E11 sp/ha)	USDA-ARS, Sidney
T15	*M. brunneum* MA1200	80 ml/ha (4E11 sp/ha)	USDA-ARS, Sidney

Location 1



Location 2

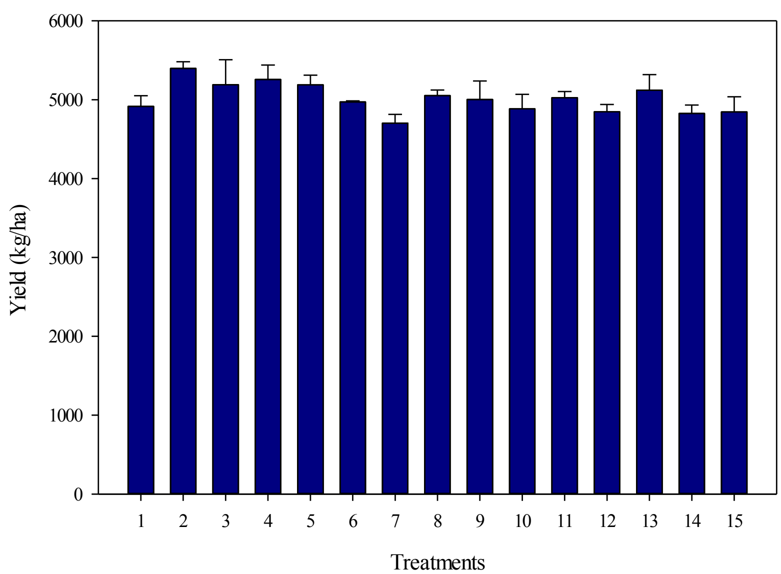


Figure 1. Wheat yield production in treatments with different combinations of entomopathogenic fungi and biopesticides (mean ± SE). T1: Untreated control; T2: Imidacloprid seed treatment; T3: Spinosad; T4: neem/Aza-Direct® ; T5: *Metarhizium brunneum* F52; T6: *Beauveria bassiana* ; T7: *B. bassiana* + *M. brunneum*; T8: *B. bassiana* + Aza-Direct (neem); T9: *B. bassiana* + spinosad ; T10: *B. bassiana* + imidacloprid; T11: *M. brunneum* + Aza-Direct (neem); T12: *M. brunneum* + imidacloprid ; T13: *M. brunneum* + imidacloprid; T14: *M. robertsii*; T15: *M. brunneum* MA1200.

Trapping click beetles with pheromone traps (Coleoptera: Elateridae)

Principal Investigator: Dr. Gadi V.P. Reddy

Cooperators: Dr. Brian Thompson, Dr. Sindhu Krishnankutty

Western Triangle Agricultural Research Center, Montana State University, 9546 Old Shelby Rd., P.O. Box 656, Conrad, MT 59425, USA

Background:

Wireworms are the soil dwelling larval stage of click beetles (Coleoptera: Elateridae). In this larval stage click beetles are a significant pest of a wide variety of crops grown in Montana. Wireworms have seen a recent reemergence due in large part to the loss of Lindane, a primary chemical control agent, due to toxicity concerns. The loss of Lindane and the reemergence of wireworms as a pest necessitates new ways of evaluating pest presence and control measures.

Pheromones are chemicals released by insects to communicate between members of a particular species. These highly specific compounds elicit attraction between sexes in click beetles and can be used to monitor population occurrence and density in agricultural fields. For the click beetles of the Northern Great Plains, pheromone based monitoring has not been developed. Development of this technology is crucial to monitoring and control programs. This ongoing research looks at the development of pheromone based trapping systems for *Limonius californicus* and *Hypnoidus bicolor*, two dominant wireworm species found in Montana.

Although no detailed work on the use of pheromone compounds has been done in the USA, there have been several reports available on related wireworms species found in Europe. Pheromone compounds appear to be similar in its related insect species. In this context, we attempted to lure in click beetles using chemical lures used to trap click beetles in Europe. In 2014, the work built on trapping data from the previous flight season of 2013 and will be continued again in the spring of 2015 ahead of the grant expiration deadline.

In 2013 sex pheromones from European *Agriotes* species of click beetle were tested for their ability to attract *Limonius* and *Hypnoidus* species in wheat fields around Conrad, MT. These studies showed that the local species exhibited no cross attraction with these sex pheromones. In 2014 we attempted plant volatile based attractants.

Methods:

In 2014, we set out traps in a circular array and baited them with plant oil extracts shown to have attractive properties in *Agriotes* species. Cis-3-hexene-1-ol, (Z)-3-Hexenyl acetate, Methyl benzoate, Methyl salicylate were tested alone and in combinations along with a control by filling 5 dram vials with a 0.5 Molar concentration of these plant oil extracts and capped them off with rubber septa. Odor release rates are highly dependent upon temperature and were not calculated, though a detectable smell was noticeable for each vial. Vials were wrapped in duct tape to keep UV light out and were individually wrapped in foil and placed in -20˚F freezer until needed (Figure 1A). There were three replicates of each volatile (n=30 trap total). Each trial consisted of the attractants randomly ordered on a circular array with the attractants hung from the exterior of the Yatlor trap (Figure 1C). Each trap was a minimum of 10m from the next trap. Each of the three arrays was a minimum of 25m from the next array. Traps were checked every two days for the presence of click beetles.

In addition to volatile traps pitfall traps were placed in an array of 10 traps placed 10 meters apart in a square grid pattern. Pitfall traps were deployed 30m from Yatlor traps in the same field and were checked every two days. Click beetles taken from pitfall traps (Figure 2A) were used to bait cages on Yatlor traps (Figure 2B). Beetles were held in captivity on a diet of honey water (1:10) soaked cotton balls (Figure 1B). Two types of pitfall traps were tested, bucket traps and funnel traps.

The location of traps in one large wheat field was determined by spring scouting for wireworms and a historical presence in that field. The land was owned by the Devries family and plots were approximately located at GPS coordinates 48.182867, -111.805412.

Results:

Catch data was highly skewed by catch results. The only traps to catch any click beetles were the bucket pitfall traps. These traps were unbaited by any scents or plant material. Bucket traps caught 979 *Hypnoidus* from May17th - June 23rd (Figure 3). *Hypnoidus* beetles placed in cages did not attract more beetles, neither did the plant compounds. The effectiveness of the Yatlor traps is questionable. This trap was proved to be effective in catching the click beetles in Europe. No statistics were performed on the data as the only trap to catch beetles was the pitfall trap.

Discussion:

Pitfall traps are passive traps that catch beetles that happen to fall into them. The beetles caught in the pitfall traps signify a large population of pestiferous species in the field, however the plant volatiles failed to catch any beetles. This failure may be due to the inadequacy of the Yatlor trap or of the plant volatiles. Pitfall traps will be used in combination with pheromones and plant volatiles in the coming spring in an attempt to test attractants with an effective trap. Adults collected in the spring of 2015 will be dissected and pheromone glands will be sent for analysis of chemical composition. These compounds will then be synthesized and analyzed in the following spring. The Western Triangle Agricultural Research Center (WTARC) will test the attractiveness of volatile chemicals such as pheromones in a more controlled environment using an olfactometer (Figure 4) that is currently being installed at the Center. Olfactometer confront insects in a special chamber in a controlled fashion where exact responses either positive or negative can be recorded and should eliminate much of the variability that currently confounds pheromone trapping of *Hypnoidus* and *Limonius* click beetles in this area.

WTARC is also in the process of understanding pheromone composition of local species of click beetles. This will eventually help us to develop synthetic pheromones that will be used in pest monitoring and mass trapping. Accurate identification of species is crucial as pheromones are species-specific. Poorly known click beetle taxonomy, variability in the presence of different species of beetles based on geography, crop, and soil type makes it difficult to identify the species accurately. WTARC has set up a DNA work room in 2014 (Figure 5). New genetic methods will be used as an efficient taxonomic tool to evaluate variability in species and subspecies in the area.

Acknowledgments:

This work was supported by Montana Wheat and Barley Committee and U.S. Department of Agriculture-National Institute of Food and Agriculture (USDA-NIFA) Hatch (#MONB00859).

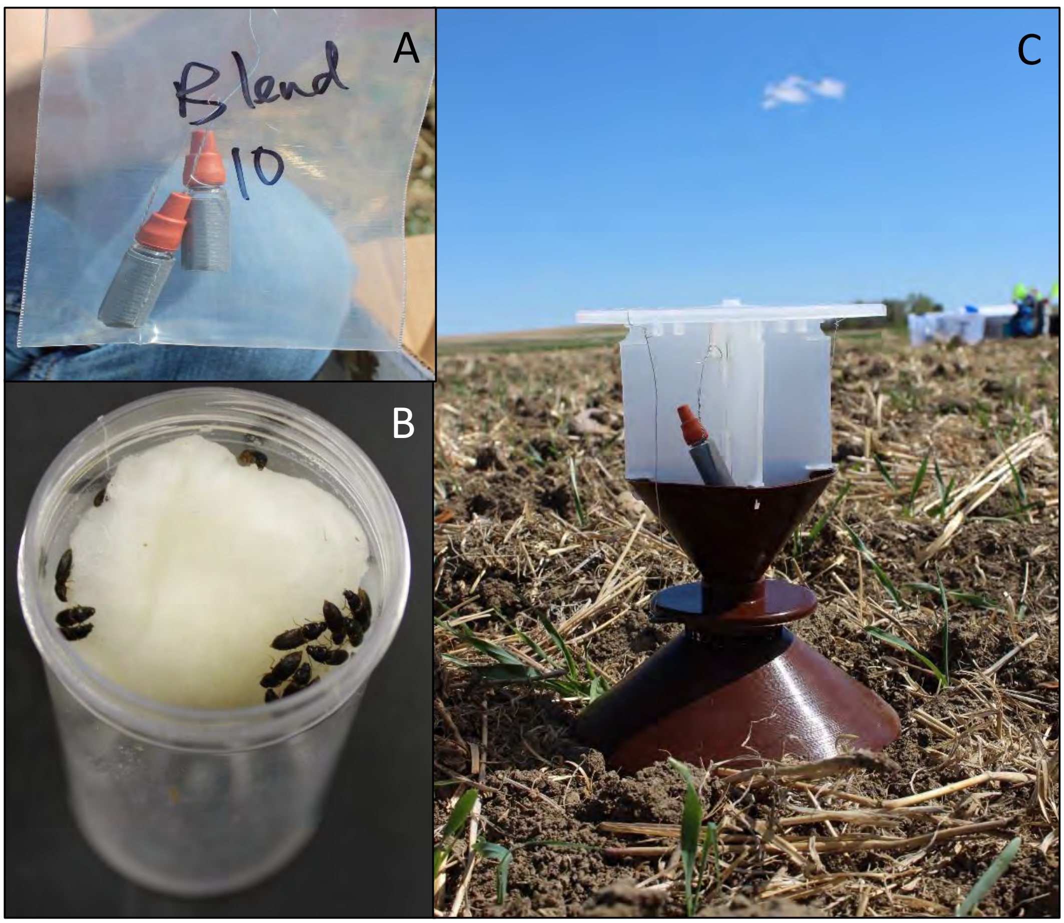


Figure 1. A) Plant volatile release vials, B) Click beetles feeding on honey water (1:10) soaked cotton ball in storage vial, C) Yatlor trap deployed in spring wheat field.

Figure 2. A) Pitfall trap, B) Yatlor trap with cage affixed to top to hold live insects.

Figure 3. The raw number of *Hypnoidus bicolor* click beetles caught in bucket pitfall traps daily.

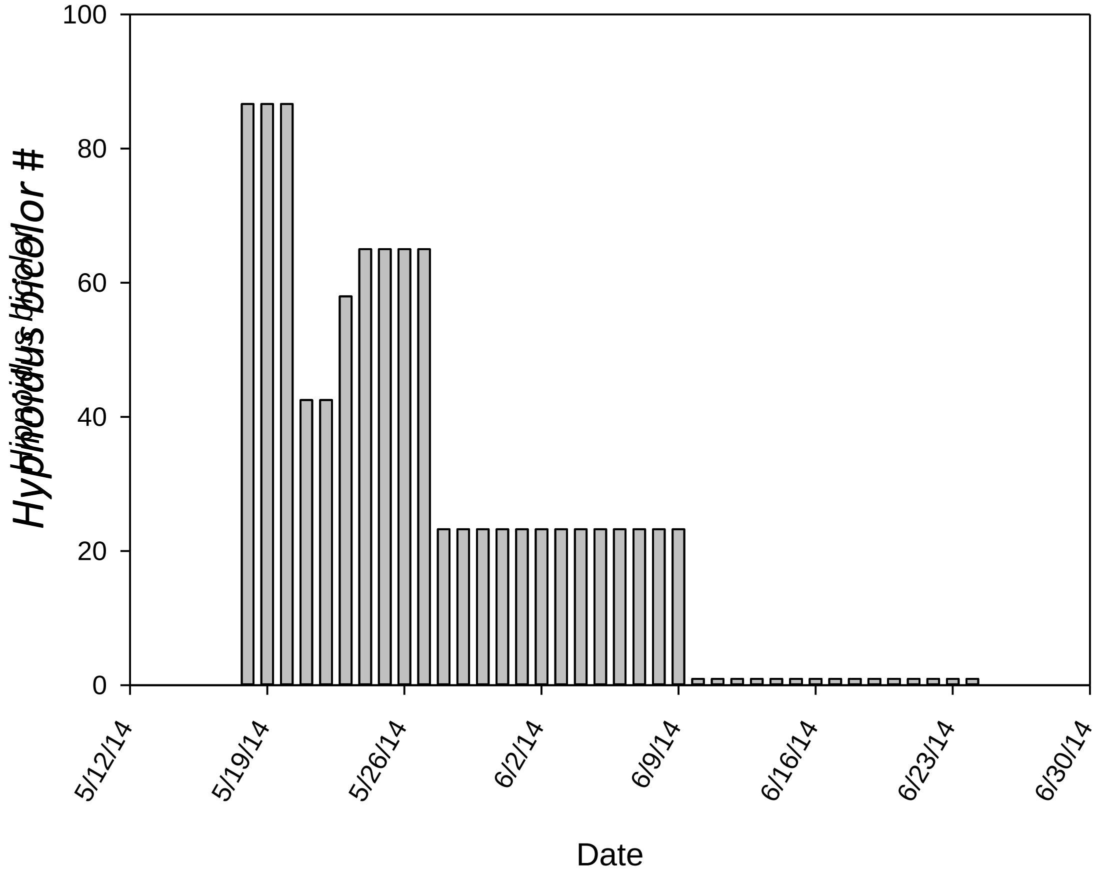


Figure 4. Olfactometer with decision chamber and collection ports installed. Air leaves through the hole in the center and is pumped in through the collection ports. The test insect follows attractants to their source and is collected in the glass collection chamber.

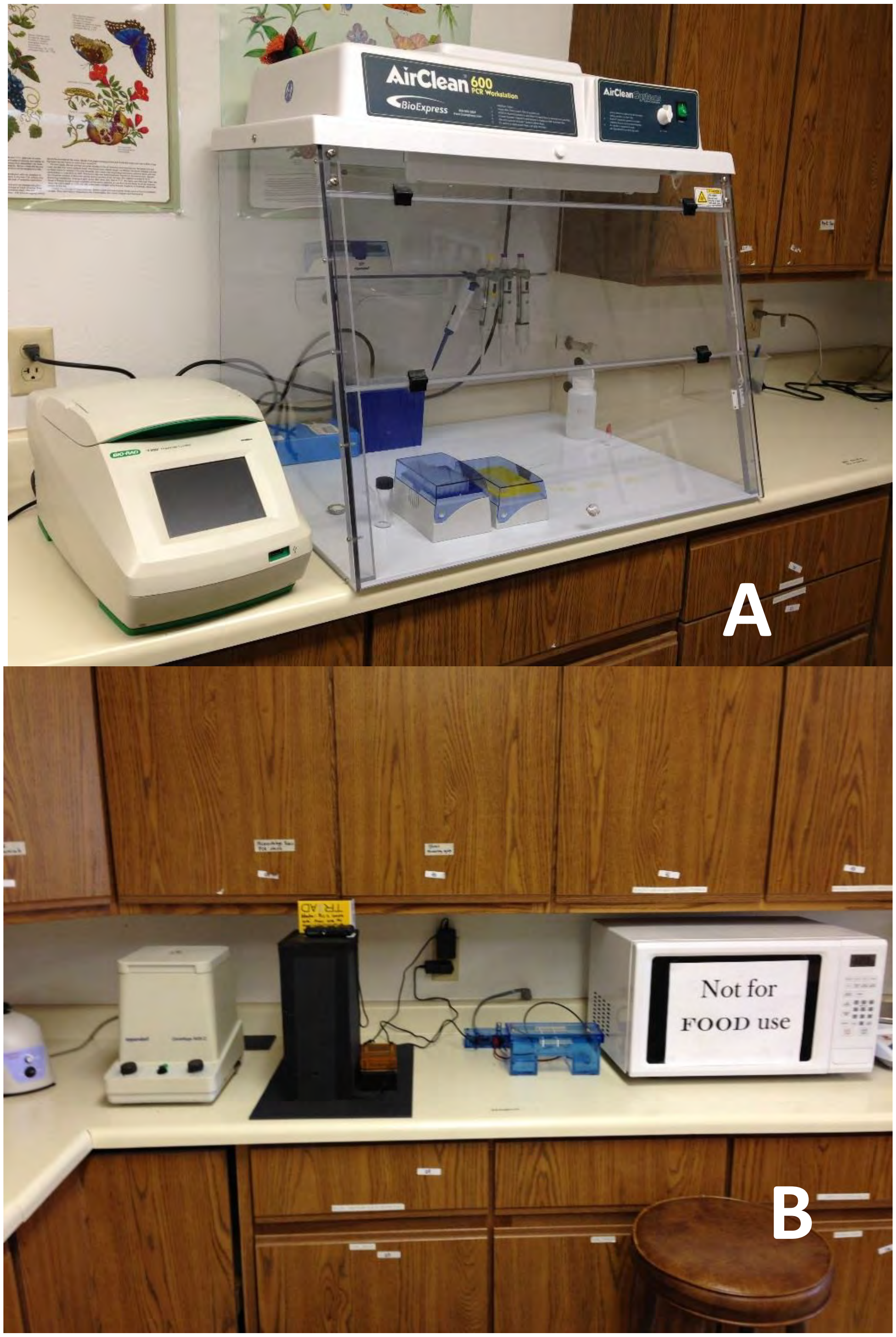


Figure 5. DNA work room at WTARC: A) PCR station; B) Gel electorphoresis area

Efficacy of Entomopathogenic Nematodes on Canola Flea Beetle, *Phyllotreta cruciferae* (Goeze) (Coleoptera: Chrysomelidae)

Principle Investigator: Dr. Gadi V.P. Reddy

Cooperators: Dr. Brian Thompson, Dr. Sindhu Krishnankutty, John Miller, Julie Prewitt

Western Triangle Agricultural Research Center, Montana State University, 9546 Old Shelby Rd., P.O. Box 656, Conrad, MT 59425, USA

Background

Entomopathogenic nematodes are an attractive alternative to chemical control measures for flea beetles *Phyllotreta cruciferae* (Figure 1). Flea beetles cause extensive damage in canola crops early in the growing season by chewing holes in leaves, stunting growth and even killing young plants (Figure 2). Entomopathogenic nematodes were tested for their ability to control flea beetle populations in three locations (Cut Bank, Sunburst, Western Triangle Ag Research Center) in the golden triangle area of Montana in 2014. The four species of nematode used were applied at ~230,000 nematodes/m^2 alone and in the presence of a bioprotectant (Barricade®) designed to prolong the survival of the nematode in the foliar environment. In Observed differences for canola yield in this study represent the impact of growing conditions, weather events and pest pressure. Differences between in field conditions were great enough ($p < 0.05$) that locations were analyzed separately. The application of nematodes did not significantly alter yield for study plots compared to the control in any field examined. These results suggest nematodes are not a reliable control measure for foliar pests of canola, such as flea beetles.

Materials and Methods

Three locations were selected for this trial, one at WTARC (N48˚18'.24.88 W111˚55'28.45), another north of Cutbank (N48˚83'39.08, W112˚29'40.25) and another east of Sunburst (N 48˚88'56.69, W111˚65'45.63). Canola was planted in May of 2014. Nematode treatments were applied using hand held sprayers held ~10cm above the seedling canola. Nematodes were mixed on site 15min prior to spraying to a concentration of ~230,000 nematodes/m^2. Nematode species used were *Steinernema carpocapsae*, *S. kraussei, S. feltiae*, *Heterorhabditis bacteriophora*. These species were used individually and in the case of *S. carpocapsae* there were additonal treatments in combination with *S. feltiae* and *H. bacteriophora*. In additon to pure nematode treatments mixed with water, nematodes were also applied individually in a tank mix with the fire retarded gel Barricade®. Barricade traps moisture and was used at a concentration of 2% when applied. Water control and Barricade control were applied at the same time as nematodes for comparison. Each of the 12 treatments was applied to 3 plots at each location for a total of n=108 plots. Nematodes were obtained from BASF, Ames, Iowa. Canola was planted at a rate of 12 seeds/ 30cm using a four row seed drill. At all locations, rows within the plots were spaced 0.3m 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.

Results

The three study locations showed statistically different yield (kg/ha) (Tukey HSD $p<0.001$; Figure 3). As such all subsequent analyses of yield were carried out separately for each location. Yield was highly variable among the study locations. Cutbank was the lowest yielding. This location received extensive hail damage during pod development. No statistical differences were observed between any of the treatments at this study location (Figure 4). There were no significant differences when all treatments were compared together nor when barricade and non-barricade treatments were compared separately. The same was true for both Sunburst and Western Triangle Research Center location (Figure 5&6 respectively). The number of flea beetles generally declined throughout the season, but no declines differed markedly from the control treatment (Figures 7,8&9).

Discussion

Flea beetles are a major pest of canola. In the seedling stage, heavy flea beetle feeding can cause stunting and even death of the plant. Flea beetles continue to feed on canola throughout the growing season and do damage seed pods, but are most destructive to seedling plants. Our previous studies indicated the effectiveness of nematodes against flea beetles on canola (Reddy et al. 2014. J. Econ. Entomol. 107: 661-666). However, the current study aimed to investigate the prolonged effectiveness of nematodes using a desiccation barrier (Barricade). There were no observed differences between treatments with and without Barricade in this study. A follow up study on the promising results from 2013 amended with information from 2014 will be carried out in 2015.

Acknowledgements

Funding for this research was provided by U.S. Department of Agriculture-National Institute of Food and Agriculture (USDA-NIFA) Hatch (#MONB00859). We also like to thank Phil Aschim, Bow & Arrow Ranch, Sunburst and Kevin Bradley, Cut Bank, for providing fields for our experiments.

Figures

Figure 1: Adult flea beetle *Phyllotreta cruciferae*

Figure 2: Flea beetles and their feeding damage on mature canola leaves

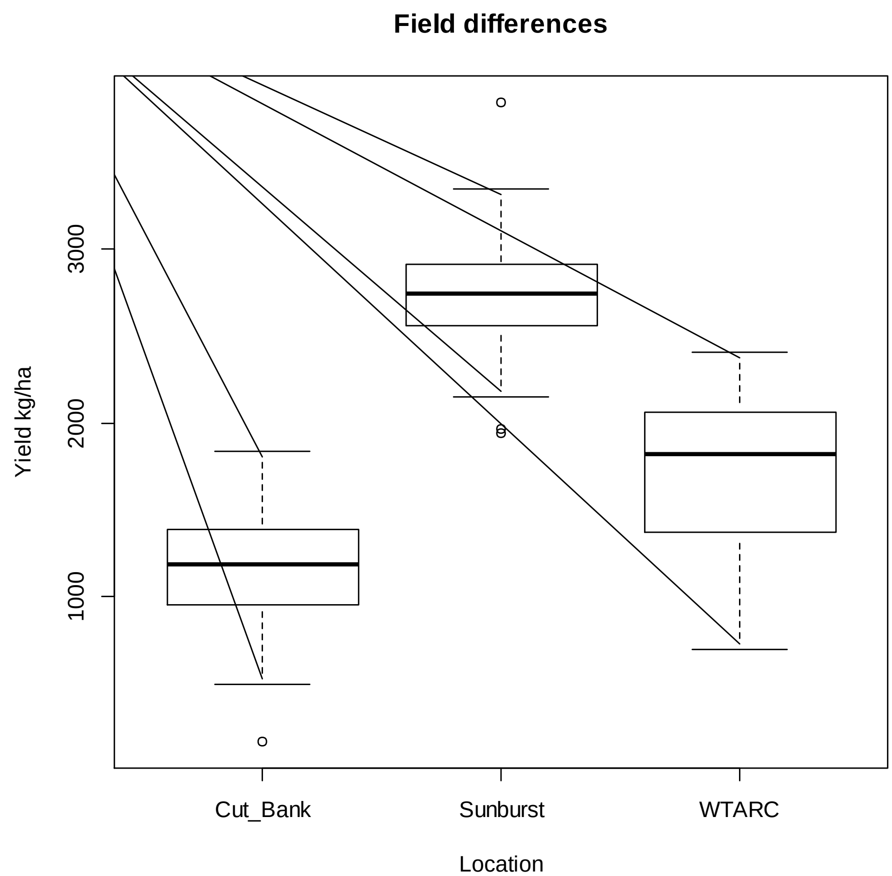


Figure 3: Yield (kg/ha) for canola fields at the various study locations were significantly different (Tukey HSD $p < 0.001$).

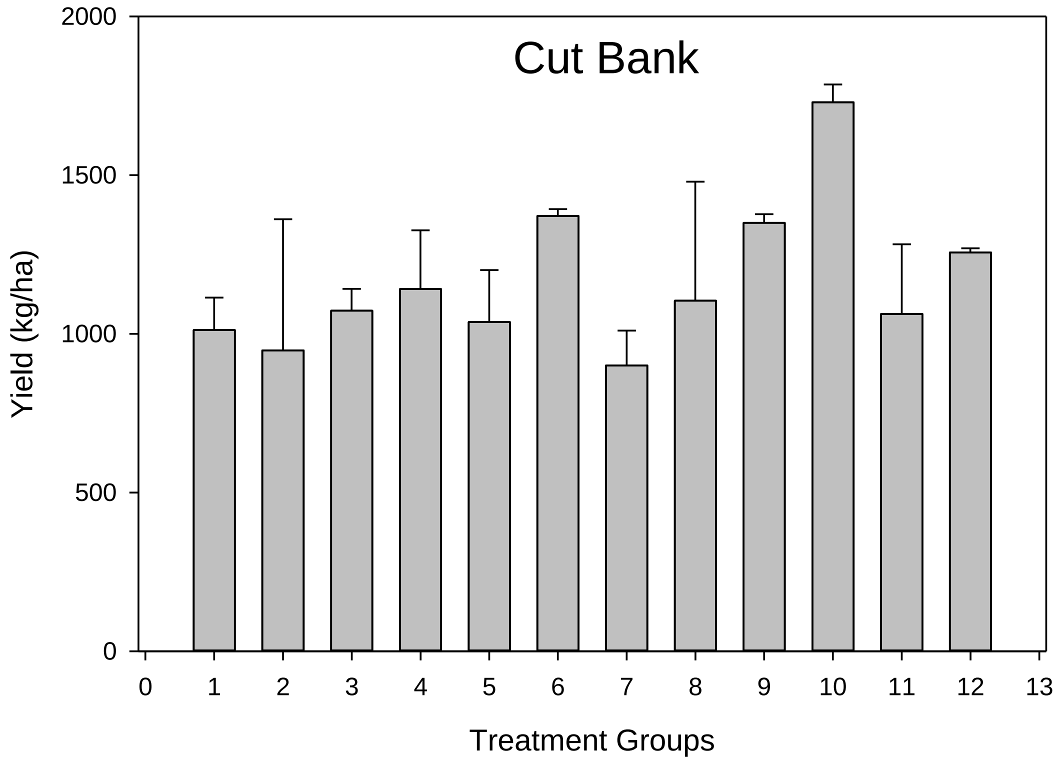


Figure 4: Yield (kg/ha) at Cut Bank location. 1) Barricade 2) Barricade + *H. bactiophora* 3) Barricade + *S. carpocapsae* 4) Barricase + *S. feltiae* 5) Barricade + *S. kraussei* 6) Control 7) *H. bacteriophora* 8) *S. carpocapsae* 9) *S. carpocapsae* + *H. bacteriophora* 10) *S. carpocapsae* 11) *S. feltiae* 12) *S. kraussei*, No difference observed between any barricade treatments (Tukey HSD >0.05).

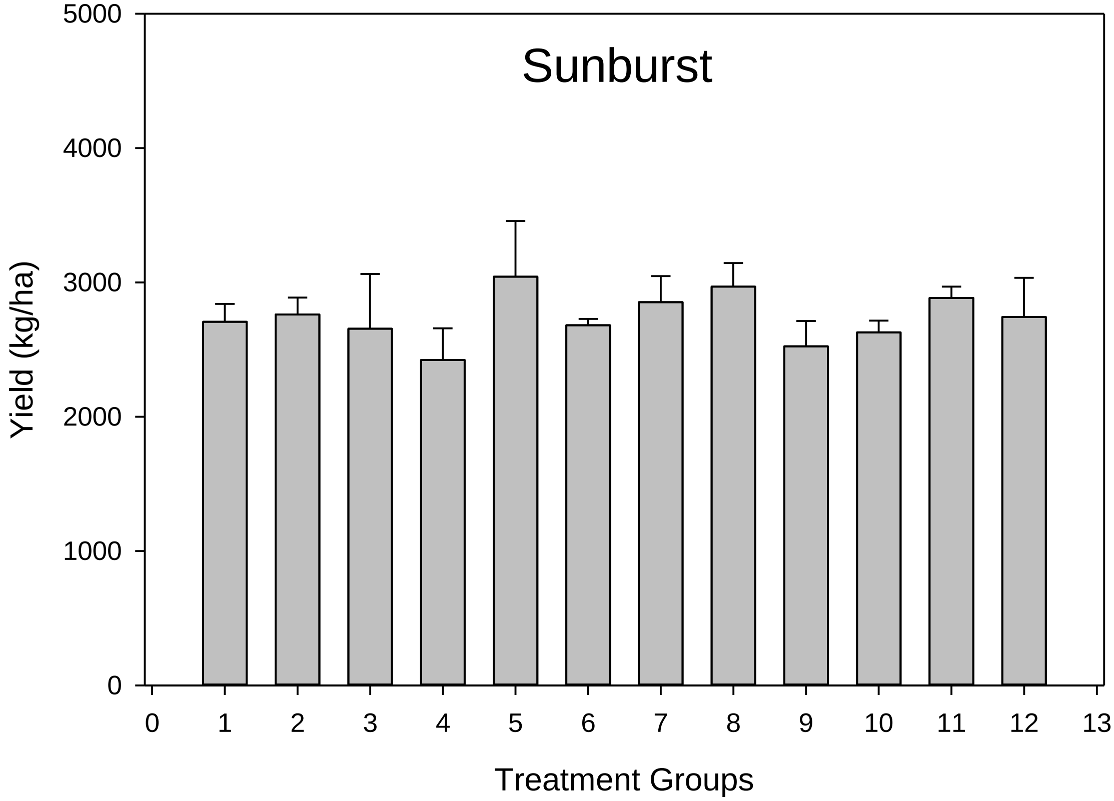


Figure 5: Yield at Sunburst (kg/ha); 1) Barricade 2) Barricade + *H. bactiophora* 3) Barricade + *S. carpocapsae* 4) Barricase + *S. feltiae* 5) Barricade + *S. kraussei* 6) Control 7) *H. bacteriophora* 8) *S. carpocapsae* 9) *S. carpocapsae* + *H. bacteriophora* 10) *S. carpocapsae* 11) *S. feltiae* 12) *S. kraussei*; No significance difference detected across all treatments. There is no difference in the treatments that do not include barricade. There is no significant difference in the treatments that do include barricade (Tukey HSD p>0.05).

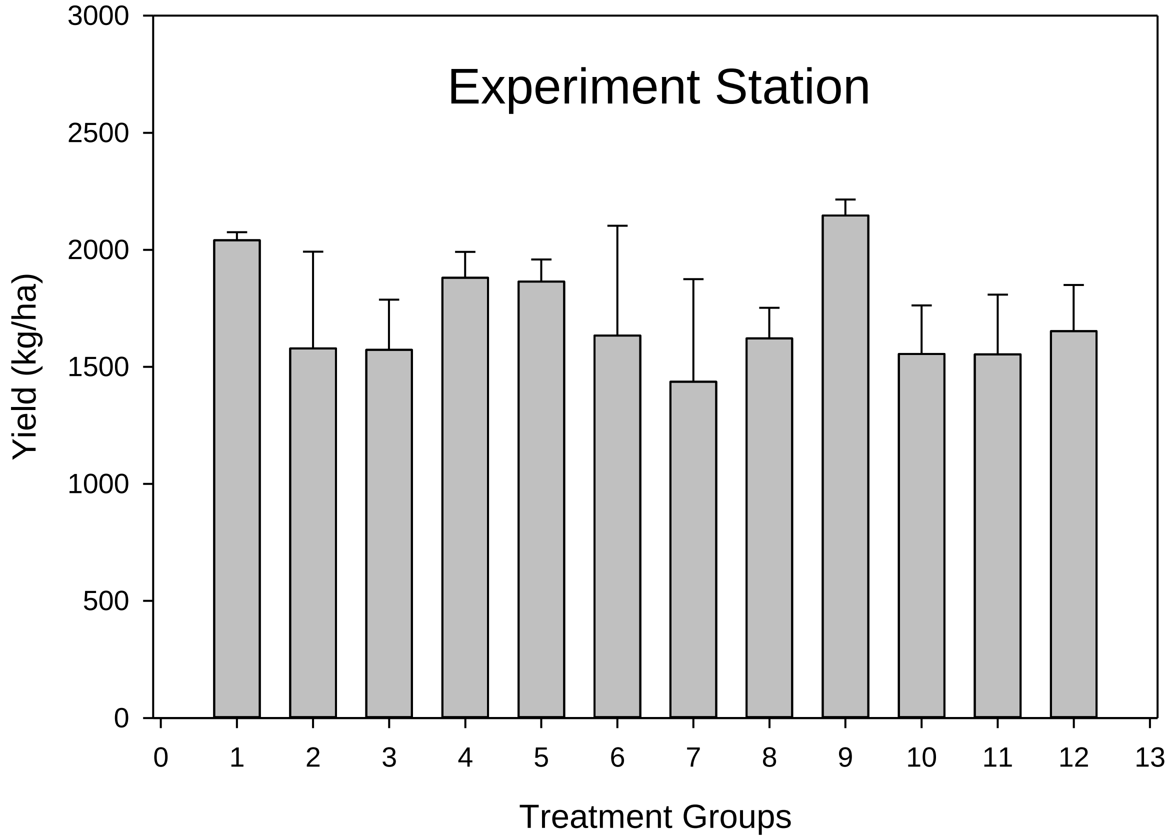


Figure 6: Yield WTARC (kg/ha); 1) Barricade 2) Barricade + *H. bactiophora* 3) Barricade + *S. carpocapsae* 4) Barricase + *S. feltiae* 5) Barricade + *S. kraussei* 6) Control 7) *H. bacte*riophora 8) *S. carpocapsae* 9) *S. carpocapsae* + *H. bacteriophora* 10) *S. carpocapsae* 11) *S. feltiae* 12) *S. kraussei*; No significance difference detected across all treatments. There is no difference in the treatments that do not include barricade. There is no significant difference in the treatments that do include barricade (Tukey HSD p>0.05).

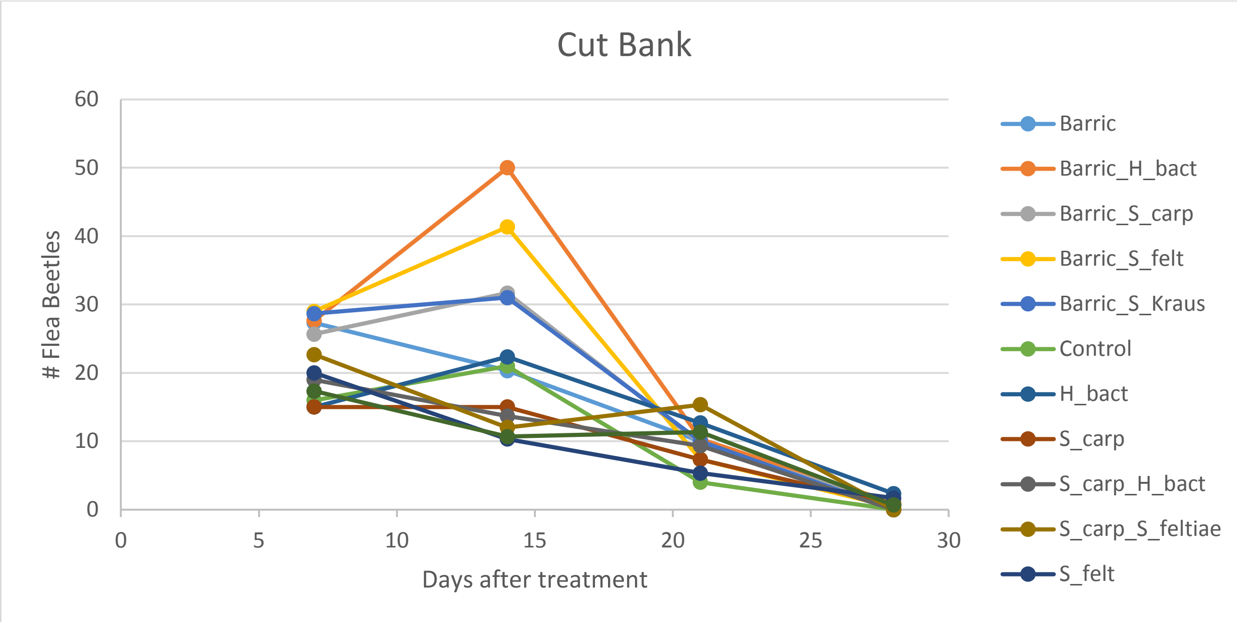


Figure 7: The mean number of flea beetles in each treatment over the course of the study at the Cut Bank location. No significant difference were found between treatments.

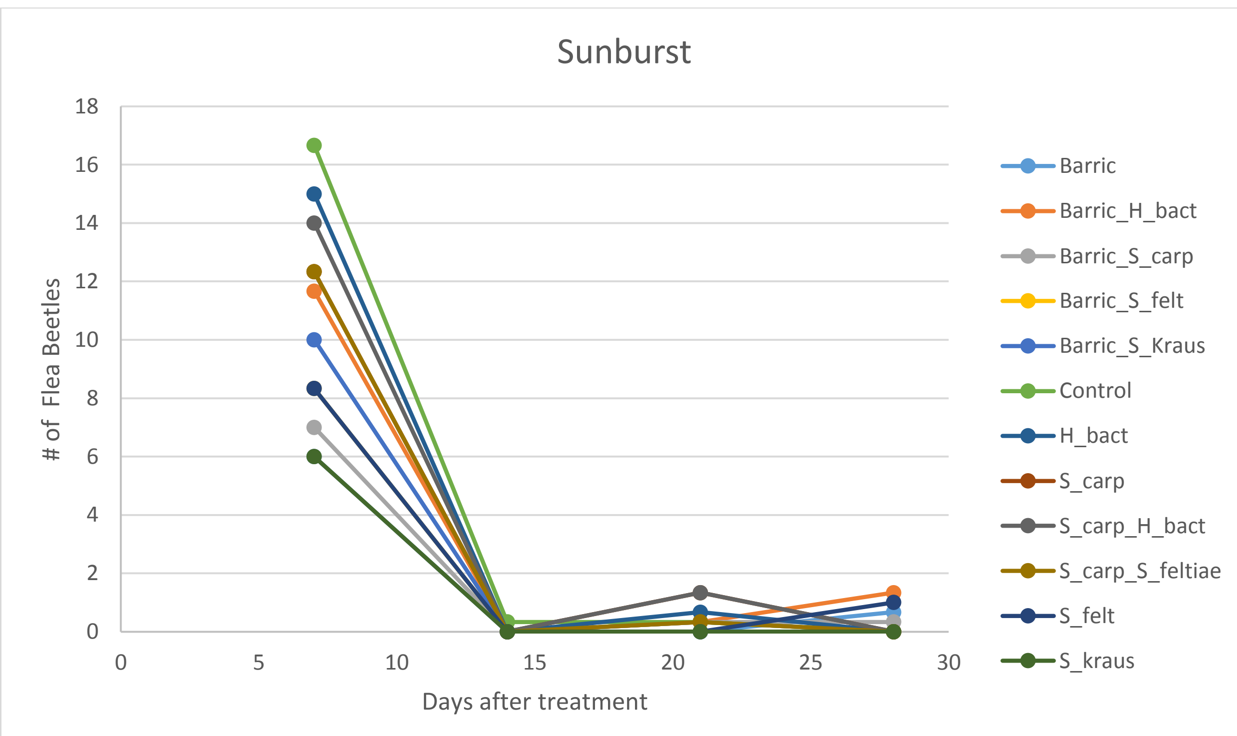


Figure 8: The mean number of flea beetles in each treatment over the course of the study at the Sunburst location. No significant difference were found between treatments.

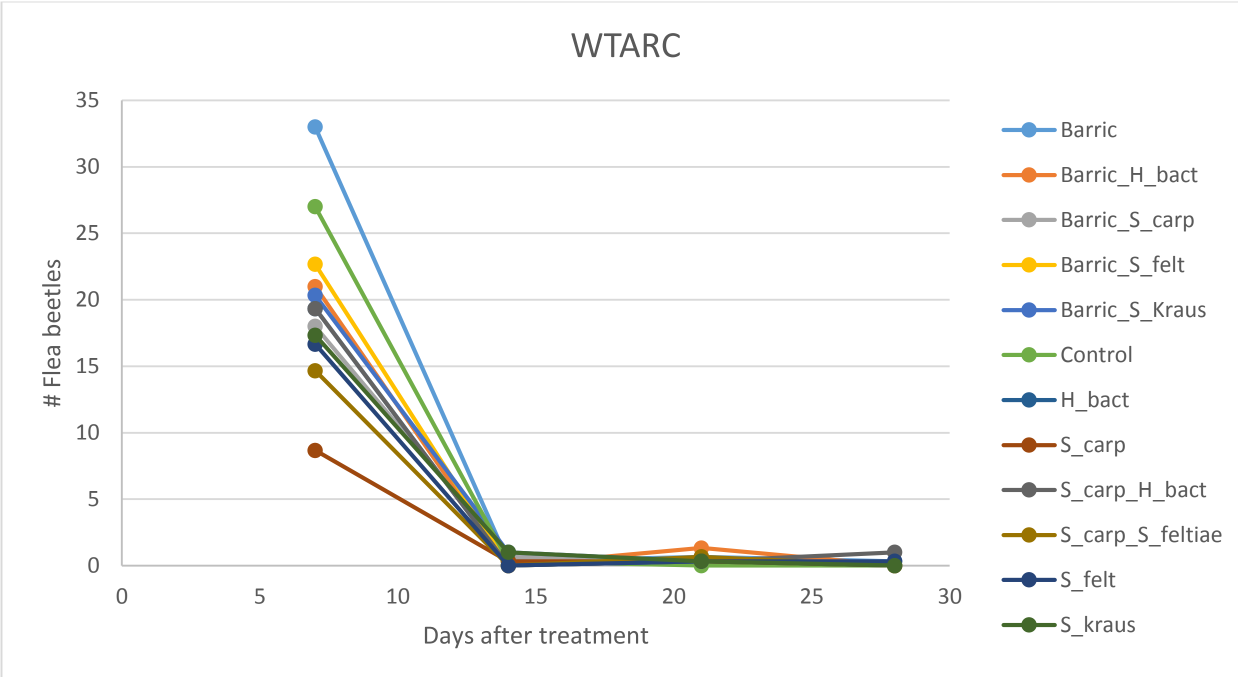


Figure 9: The mean number of flea beetles in each treatment over the course of the study at the experimental research station location (WTARC). No significant difference were found between treatments.

Pilot Study on the effects of induced plant resistance to canola flea beetle in canola with the addition of jasmonic acid.

Principle Investigator: Dr. Gadi V.P. Reddy

Cooperator: Dr. Brian Thompson

Western Triangle Agricultural Research Center, Montana State University, 9546 Old Shelby Rd., P.O. Box 656, Conrad, MT 59425, USA

Background:

Induction of plant resistance pathways may reduce insect damage by stimulating plant defense pathways prior to encounters with herbivores. Jasmonic acid is a plant hormone that induces plant defenses. In this pilot study, we looked at plant damage in induced and naïve plants exposed to canola flea beetle adults.

Methods:

- Canola seeds were planted in plastic pots and grown to 3-4 leaf stage.
- Seedlings on opposite sides of the pot (pairs) were treated with either a solution of 5 M jasmonic acid in 0.5% ethanol and water (JA) or treated with only 0.5% ethanol and water (Control).
- A total of six potted plants (pairs) were placed in a mesh enclosure in a growth chamber with 50 adult canola flea beetles.
- Beetles fed on plants over the course of one week (July 31st-August 6).
- Leaves were removed at the end of the study, scanned into a pdf and percent leaf damage as a function of total leaf area was calculated using Adobe measurement tools.
- Statistical analysis of paired samples was carried out using the software Sigma Plot V13.

Results:

- Flea beetle damage to plants was calculated from damage on leaves (Figure 1).
- Flea beetles damaged a higher proportion of leaves in the control treatment than in the jasmonic acid treated plants. (Figure 2)
- The difference was not significant between damage levels (paired t-test, One-tailed P-value = 0.114).
- Statistical power to reveal a difference between groups was low.
- The number of holes in the jasmonic acid treatment were fewer than for the control (Figure 3), but yet again statistical power was low and a statistically significant difference was not detected.

Discussion:

This simple experiment suggests jasmonic acid may be effective in reducing canola flea beetle damage in vulnerable canola seedlings. The amount of damage included total area of plant tissue removed and individual holes created in each leaf (Figure 3). These measures are correlated. Increasing the sample size will improve our ability to differentiate the true effects of this type of treatment. We plan to increase the sample size in the coming year and repeat the experiment in the lab and also in the field.

Acknowledgements

Funding for this research was provided by U.S. Department of Agriculture-National Institute of Food and Agriculture (USDA-NIFA) Hatch (#MONB00859).

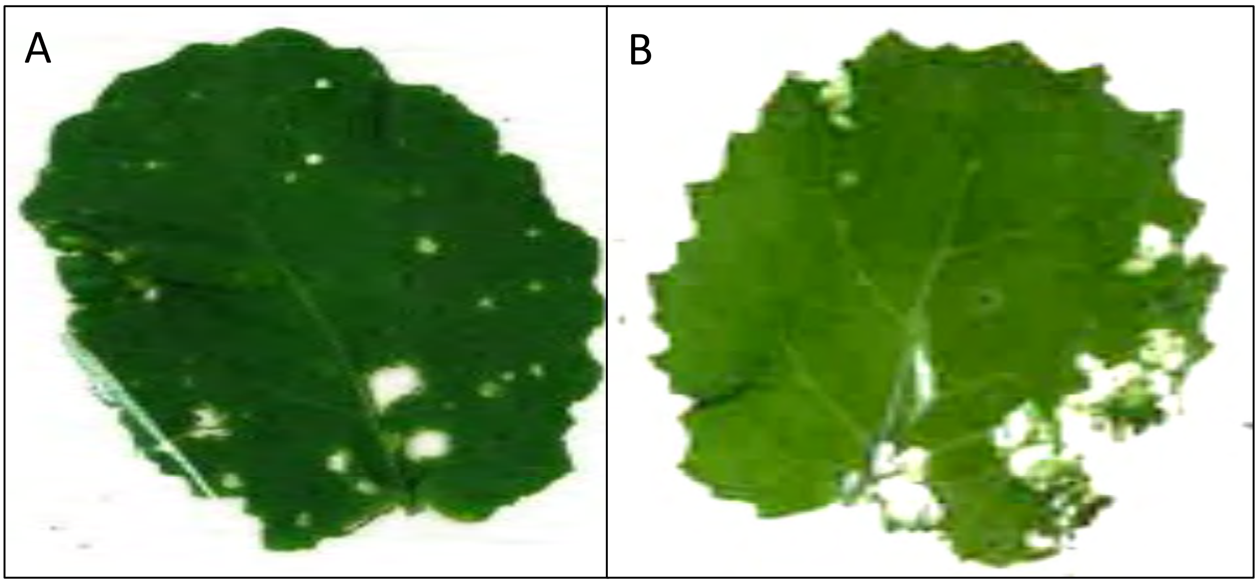


Figure 1: A) Jasmonic acid treated canola leaf and 2) the control untreated leaf collected from four leaf stage canola. Each exhibiting characteristic signs of canola flea beetle damage. The number of holes and their representative area were calculated as evidence of insect feeding damage.

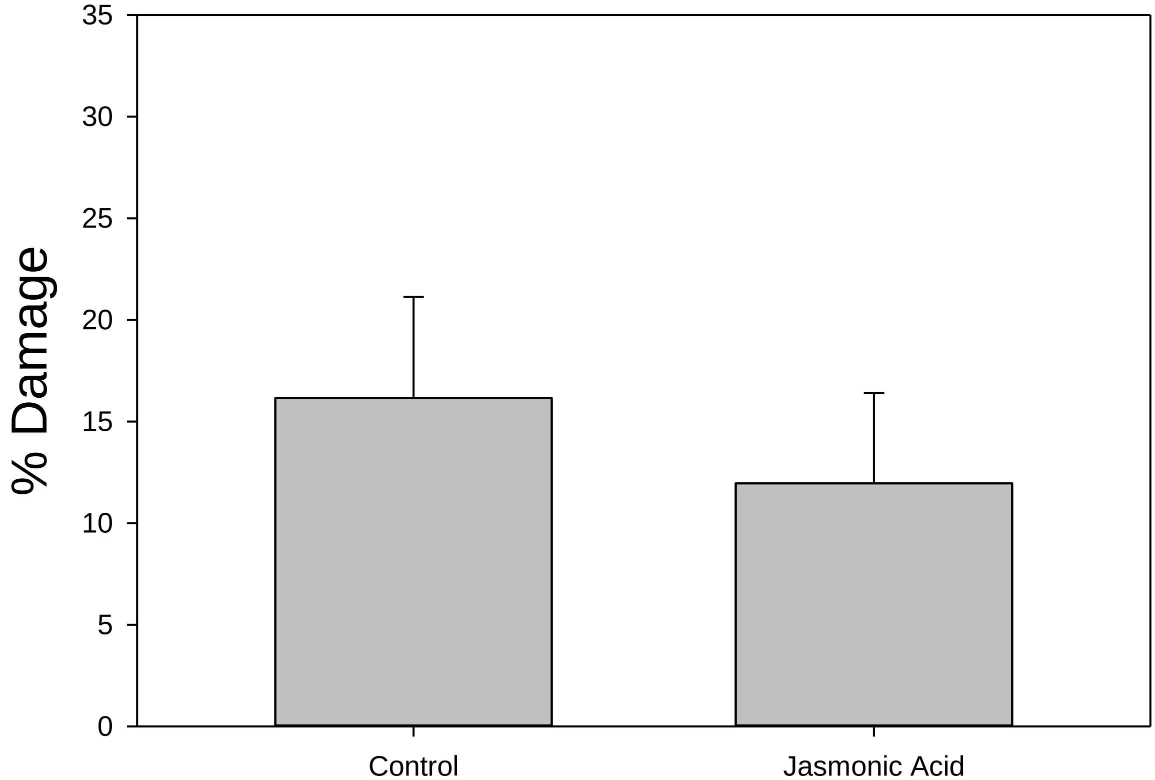


Figure 2: Percent damage to plants stimulated with jasmonic acid and controls that did not receive jasmonic acid.

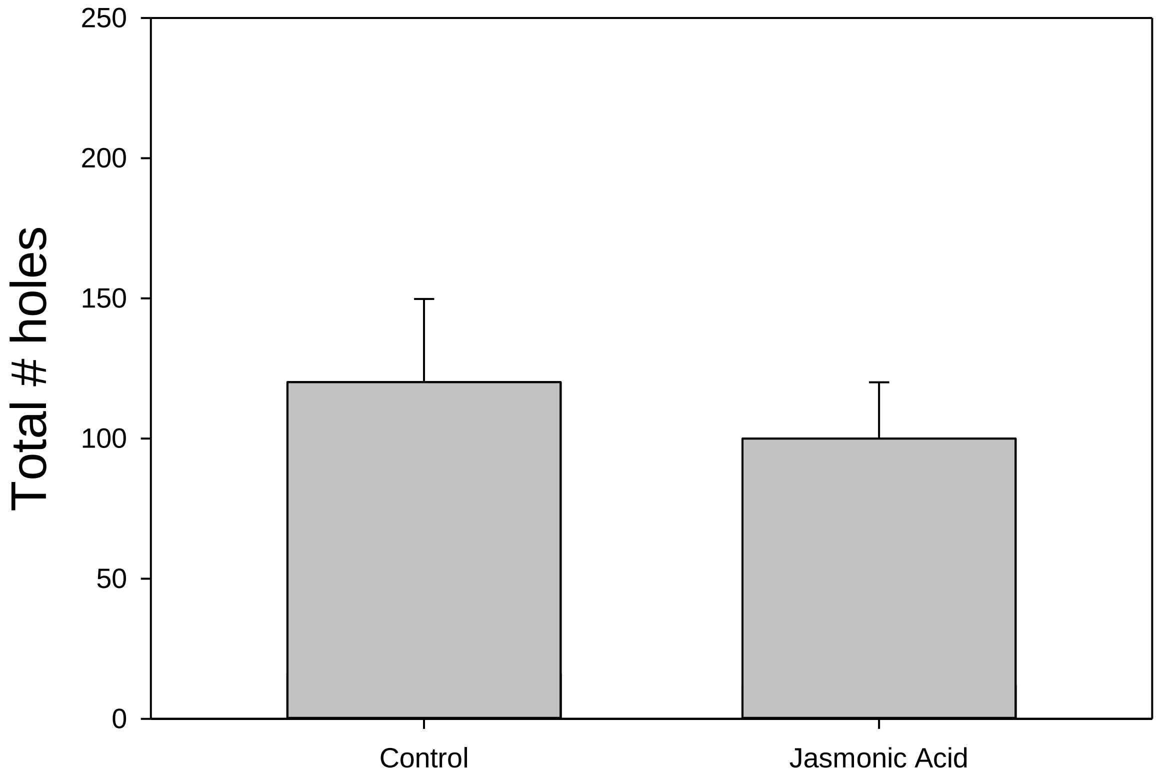


Figure 3: The number of individual holes in control and jasmonic acid treated plant leaves.

Initiation of classical biocontrol in Montana for orange blossom wheat midge *Sitodiplosis mosellana* (Diptera: Cecidomyiidae) using *Macroglenes penetrans* (Hymenoptera: Pteromalidae)

Principle Investigator: Gadi V.P. Reddy

Cooperators: Brian Thompson, Dan Picard, Sindhu Krishnankutty, John Miller, Julie Prewitt, Western Triangle Ag Research Center, 9546 Old Shelby Rd., P. O. Box 656, Conrad, MT 59425

Bob Stougaard, Brooke Bohannon, Northwestern Agricultural Research Center, 4570 MT Hwy 35, Kalispell, MT 59901

Background:

The orange blossom wheat midge, *Sitodiplosis mosellana,* is one of the most significant pests of wheat to enter Montana in the last ten years. This pest damages wheat seeds during larval development and reduces crop value and yield. The population growth potential for this pest is very large. In a multi-pronged study aimed at monitoring pest populations and deriving solutions to reduce damage from this pest, the researchers at WTARC obtained permits to collect the natural enemy of OBWM (*Macroglenes penetrans;* Figure 1) from locations in Canada and release them into the state of Montana. This parasitoid lays its eggs inside the eggs of OBWM, where they develop and ultimately kill the midge larvae. The population growth potential of this natural enemy matches that of the midge and promises to be a powerful tool in mitigating midge damage in Montana wheat.

To begin with the biological control work, the federal permit (#P526P-14-01543) was obtained in April, 2014 to import *M. penetrans* from Canada to Montana.

Methods:

- Travel to locations in Canada where researchers have found populations of *M. penetrans*
- Collect *M. penetrans*
- Return to Montana
- Release *M. penetrans*
- Monitor *M. penetrans* and OBWM populations at release sites.

Results:

M. penetrans was collected from two wheat fields (Claresholm - N 49.61 W113.28) and Fort McLeod – N49.88 W 113.32) near Lethbridge, Canada Figure 2 (purple). Seven hundred individuals were collected in total. These individuals were sorted and identified in collaboration with Drs. Héctor Cárcamo and Scott Meers (Figure 3) at Agriculture and Agri-Food Canada. *M. penetrans* were transported to Conrad and Creston Montana for release (Figure 2 (lavender)).Each location released approximately 260 live adults. At release sites (Figure 4) and at various other locations in the state (Figure 2 (red)), wheat fields were sampled for the presence of *M. penetrans*. These samples revealed *M. penetrans* in low numbers in all of the Flathead valley samples and in the majority of the samples from east of the continental divide.

Discussion:

M. penetrans is present in Montana in certain locations. The introduction to fields east of the continental divide, where midge is just becoming a major pest, have the potential to mitigate the extensive damage this pest is capable of. To study the impact of these biocontrol agents, we plan on continually sampling for adult parasitoids and parasitized larvae. For this purpose, we successfully obtained an equipment grant for a machine that washes midge larvae from the soil. These diapausing larvae can then be tested for the presence of parasitoids. The researchers at WTARC are also pursuing genetic analysis techniques for streamlining the identification of *M. penetrans*. This study is ongoing.

Acknowledgments:

This work was supported by Montana Wheat and Barley Committee and United States Department of Agriculture- Cooperative Regional Project W3185 Biological Control in Pest Management Systems of Plants. We greatly appreciated Mr. Scott Meers and Dr. Héctor A. Cárcamo (Agriculture and Agri-Food Canada) for their help during the exploratory trip.

Figure 1: Parasitic wasp (*Macroglenes penetrans*)

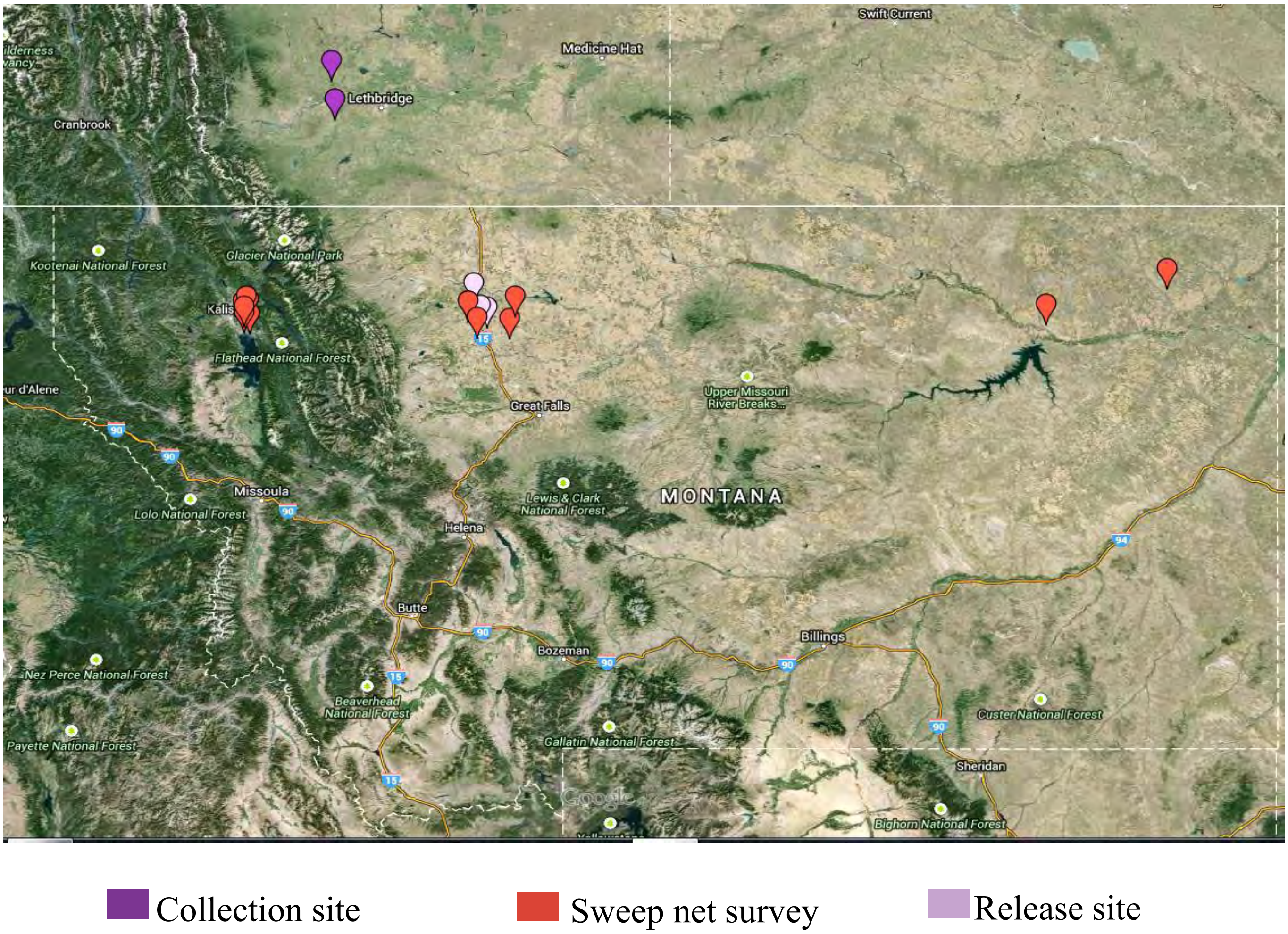


Figure 2: *M. penetrans* collection, survey and release sites in 2014.

Figure 3: Biological control team; L to R: Brooke Bohannon, Scott Meers, Dan Picard, Dr. Gadi V.P. Reddy, Dr. Brian Thompson in the Grower's field near Claresholm, Alberta (Canada)

Figure 4: Biological control team explaining to the growers about the establishment of parasitoid wasp and its sensitivity of insecticides.

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MONTANA STATE UNIVERSITY EXTENSION

MontGuide

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 and Kevin Wanner, *Dept. Plant Sciences & Plant Pathology;* and David Weaver, *Dept. Land Resources & Environmental Sciences*

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 in Montana.

MT201403AG New 5/14

DURING THE 1980S, 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.

The 1990s outbreak resulted in low numbers of the wheat midge being reported in northeastern Montana. However, the Flathead Valley experienced an unprecedented outbreak in 2006. This was the first report of any economic significance in the state.

Spring wheat fields that normally would have yielded 80-90 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.

FIGURE 1. Adult wheat midge.

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.

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 annual 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 also 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 larval development is rare.

FIGURE 2. Midge larvae feeding on wheat kernel.

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 30-50 percent, and it's not uncommon to find several larvae feeding on a single 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.

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.

FIGURE 3. Midge-damaged wheat kernels.

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

FIGURE 4. Midge larvae on soil surface.

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.

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 -11:00 p.m., which coincides with higher humidity levels. In addition, egg-laying rarely occurs if wind speeds are greater than six 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 three to five 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.

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

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 behavior (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.

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 can adapt 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, and recommendations can be found at the High Plains IPM guide, http://wiki.bugwood.org/HPIPM:SmallGrains.

However, 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.

Economic Thresholds 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 sex 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.

FIGURE 6. Midge adults in pheromone trap.

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.

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 start after 8:30pm to coincide with peak female activity, and fields should be inspected in at least three to four different locations. Insecticide treatments are recommended if one or more adults are observed for every six 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°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.

Crop Stage 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

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

late boot | early heading (25%) | late heading (75%) | late flowering (90%)

monitored daily from the time the heads begin to emerge from the boot until the anthers are visible.

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

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 percent 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.

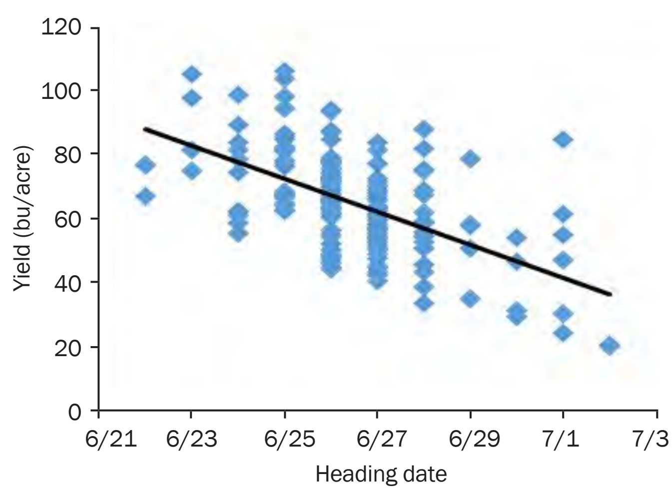
Planting dates

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).

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.

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



Observations indicate that first 10 percent 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. 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.

TABLE 1. Midge degree day model.

Degree Days	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

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

Cultivar	OWBM[1]	Yield	Protein	Test wt.	FN[2]
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

[1] OWBM - orange wheat blossom midge (no./spike). [2] FN - falling number (seconds).

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).

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 percent of the seed is susceptible to the midge and 90 percent 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 percent have been documented.

Efforts to introduce the parasitic wasp into Montana are ongoing. 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 percent 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.

For further information, contact the Northwestern Agricultural Research Center at 406-755-4303 or online, http://ag.montana.edu/nwarc/.

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File under: Agriculture and Natural Resources (Pest Management)
New May 2014 2000-514SA

Use of biocontrol fungi, bacteria and nematodes for control of *Tribolium confusum* and other stored grain pests.

Principle Investigator: Dr. Gadi V.P. Reddy

Co-investigators: Dr. Brian Thompson, Dr. Stefan Jironski, Daniel E. Picard, Debra A. Miller

Western Triangle Agricultural Research Center, Montana State University, 9546 Old Shelby Rd., P.O. Box 656, Conrad, MT 59425, USA

Objective:

Investigate the usefulness of entomopathogenic fungi (*Beauvaria bassiana* and *Metarhizium brunneum*), entomopathogenic bacteria (e.g. Spinosad) and entomogenous nematodes **(***Steinernema carpocapsae, Heterorhabditis bacteriophora Steinernema feltiae, H. bacteriophora* and *H. indica*) for the control of stored grain pests.

Background:

Stored grain pests are a significant post-harvest threat for grain producers. Insects that feed on small grains in storage decrease the value of the crop going to market and may delay shipment of grains. Hydrogen phosphide is the current preferred method for the control of stored grain pests, but is highly toxic to mammals, posing a significant risk to applicators and anyone or anything it contacts. Diatomaceous earth is a non-toxic alternative, but careful use is needed to prevent devaluing of the grain at time of sale as Diatomaceous earth wears on milling machinery and is not tolerated in high quantities in grain. Alternative tools for control of stored grain pests that are not dangerous and do not devalue grain are needed to address the stored grain pest issue without the negatives offered by current methods. This ongoing study looks at the use of entomopathogenic fungi (*Beauvaria bassiana* and *Metarhizium brunneum*), bacteria and entomogenous nematodes **(***Steinernema carpocapsae, Heterorhabditis bacteriophora Steinernema feltiae, H. bacteriophora* and *H. indica*) for the control of stored grain pests. The most prominent local stored grain pest is the confused flour beetle *Tribolium confusum*. This research will look at *T. confusum* and other stored grain pests under biological control paradigms. A body of literature suggests entomopathogenic fungi alone and in combination with diatomaceous earth are effective in controlling flour beetle populations and may even stimulate avoidance of recolonization. This research will expand on this previous literature and in the process develop another tool for controlling stored grain pests in Montana.

Methods:

Tribolium confusum was collected from local storage bins and purchased as intact colonies from Carolina Biological Supply Company, Burlington, NC. Flour beetle colonies will be set up in plastic Rubbermaid 6.15L containers (33.7 ×21.6×11.9cm). Each container will contain a combination of intact wheat seed and flour in an attempt to replicate conditions in storage bins. Fifty adult *T. confusum* will be placed in each storage container and allowed one week to establish prior to application of biocontrol fungi. The commercially available strain of *B. bassiana*, Botaniguard (Laverlam Inc) will be tested against a no-treatment control population for overall mortality and persistence in reducing flour beetle populations. Other biocontrol agents will be tested in a similar manner.

Colony members will be sorted and counted for larvae and adults in the colony prior to the application of biocontrol agents and every 24hrs after application for up to 30 days post application. Percent mortality will be tabulated and analyzed using sigma plot statistical software (Systat).

WTARC will test avoidance of fungal and nematode treated wheat seed using our recently acquired olfactometer (Figure 2).

Results:

This project is ongoing. No results to report at this time. Colonies were initated into the trial on December 22nd 2014. Earliest results will return in January of 2015.

Discussion:

Pending results.

Acknowledgements

Funding for this research was initially provided by U.S. Department of Agriculture-National Institute of Food and Agriculture (USDA-NIFA) Hatch (#MONB00859).

Figure 1. The confused flower beetle (*Tribolium confusum*) on wheat seed.

Figure 2. Olfactometer with decision chamber and collection ports installed. Air leaves through the hole in the center and is pumped in through the collection ports. The test insect follows attractants to their source and is collected in the glass collection chamber.

Wood-boring beetle diversity survey 2014

Principle of Investigator: Dr. Michael A. Ivie

Montana Entomology Collection, Marsh Labs, Room 50, 1911 West Lincoln Street, NW corner of Lincoln and S.19th, Montana State University, Bozeman, MT 59717

Cooperators: Dr. Brian Thompson, Dr. Gadi V.P. Reddy

Western Triangle Ag Research Center, 9546 Old Shelby Rd., P. O. Box 656, Conrad, MT 59425

Background:

Professor Mike Ivie is leading a project to survey wood-boring beetle diversity across Montana. Pondera County is underrepresented in this survey. Wood-boring beetles are attracted to ethane release by stressed trees. We surveyed wood-boring beetle communities using ethanol attractants that mimic ethane released by stressed trees.

Methods:

Lindgren funnel traps baited with ethanol attractants were placed in two locations along the Rocky Mtn. Front range in Western Pondera County, Montana. The first trap was placed in a deciduous birch forest at the Swift Current Dam campground (48.161193, -112.864566) (Figure 1A). The other trap was placed in pine scrub forest ~10 miles east of this location (48.209720, -112.746463) (Figure 1B). Traps were collected bi-weekly over the course of the summer and fall (June-October). Traps killed insects, which were then collected and held in a freezer before identification.

Results:

Numerous species of insect were attracted these ethanol baited traps. These insects were preserved and delivered to Mike Ivie for taxonomic identification. Some of the species identified were a Cerambycidae (*Stenocorus nubifer*), a ptinine Ptinidae, a *Rhysopertha dominica*, and a few bark beetles (Scolytinae). There were also a few salvageable click beetles, some scarabs, and a few miscellaneous things. This is the first year of a multi-year collection.

Discussion:

Wood-boring beetles are important as pests and part of woody debris decay in woodland environments. Cataloging their presence is vital to understanding their impact on our local forest ecosystems. This survey will be continued through 2015.

Figure 1: Lindgren funnel traps baited with ethanol lures in the A) pine scrub forest and B) deciduous birch forest.

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Soil Nutrient Management

POTASSIUM MANAGEMENT FOR IMPROVED DRYLAND SPRING WHEAT GRAIN YIELD AND QUALITY

Dr. Olga S. Walsh, Principle Investigator, Western Triangle Agricultural Research Center (WTARC), Conrad, MT 59425

Objectives:

- ✓ To evaluate root characteristics and distribution on N uptake, as influenced by K fertilization, and
- ✓ To determine optimum K fertilizer rate for improved grain yield and increased grain protein content in dryland hard red spring wheat.

Materials and Methods:

Two dryland experimental sites were established in Montana in the cooperating wheat producers' fields – Christiaens and Orcutt. Choteau red hard spring wheat variety was planted at 60 lb/ac pure live seed (PLS) - seeding rate recommended for spring wheat in Montana. The plot size was 5 ft by 25 ft, with 5 crop rows in each plot (12 in row spacing). At each location, a two-way factorial arrangement of treatments in a randomized complete block design with 4 replicates was utilized. Fertilizer N was applied as urea (46-0-0) with the seed at planting at 7 rates ranging from 0 to 270 lb/ac. The amount of residual N determined from the preplant soil test N was credited for calculation of the application rates. Previous studies in Montana showed that maximum K accumulation in wheat occurs just after flowering, or mid heading and, unlike N and P, very little (less than 20 percent) of the accumulated K is used for grain fill. However, K deficiency early in the growing season has been shown to limit N uptake and compromise grain yield and protein (Jones et al., 2011). Therefore, K was applied as KCl (0-0-60) at 3 rates – 10, 20, and 30 lb K2O per ac side-banded at planting to ensure K supply early in the growing season. Phosphorus and other plant nutrients were applied according to current Montana State University guidelines for spring wheat. Pest and weed control was carried out throughout the growing season as necessary to ensure high quality of collected data.

At 3 anthesis, plant height was determined by measuring 5 randomly selected plants per plot. Whole plant biomass samples were collected from each plot. The above ground biomass of the harvested plants was combined to produce a composite biomass sample. The above ground biomass weight was determined; the subsamples were analyzed for N and K concentration. At harvest, for each plot grain yield and grain test weight will be recorded, and grain samples will be collected and send for comprehensive quality analysis, including total N, and grain protein content. Statistical analyses were carried out to evaluate the effect of K application rate on grain yield, and grain quality characteristics such as test weight, protein content were evaluated. The proposed root analysis was not carried out due to numerous failed attempts to excavate plants from the plots utilizing the tree stump removed without damaging a significant portions of the plots. Analysis of variance were conducted using the PROC GLM procedure in SAS v9.4 (SAS Institute, Inc., Cary, N.C.). Mean separation was performed using the Orthogonal Contrasts method at a significance levels of 0.05.

Project Results and Relevancy to Montana

Several N rates used in the study enabled us to evaluate a wide range of nutrient levels and the top rate of 270 lb of N/ac represented the N rate recommended for yield potential of spring wheat in the region. In 2014, Christiaens was a low-yielding site, compared to Orcutt. Yields at Christiaens ranged from 14.8 to 38.4 bu/a, and at Orcutt – from 87.2 to 110.9 bu/a (Tables 1 and 2).

The amount of supplied N has significantly affected spring wheat grain yield at both locations (Figure 1, Table 3). At Christiaens, grain yields have increased from 19.0 to 31.9 to 35.2 bu/a with application of 45, 90, and 135 lb N/a; the yields reached plateau between 135 and 180 lb/a rate and then declined slightly to 30.3 and 31.2 bu/a at 225 and 270 lb N/a rates. At Orcutt, yields increased from 89.7 to 99.4 to 107.3 bu/a with 45, 90, and 135 lb N/a rates, the plateau of 104.7 bu/a was reached between 180 and 225 lb N/a rate, then declined slightly to 103.4 bu/a with 270 lb N/a. These findings illustrate the higher demand for N at a more responsive, higher yielding site. Grain yields responded to application of K at both sites. At Christiaens, the yields increased from 14.8 bu/a for no K trt (trt 1) to 15.4 bu/a for trt 2 (no N trt). Across N rates, application of 10 lb K_2O resulted in 29.2 bu/a yield; doubling K rate to 20 lb K_2O/a resulted in a slight yield decline to 28.8 bu/a; further increase to 30 lb K_2O/a resulted in a further slight yield decrease to 27.6 bu/a (Figure 2). These differences were not statistically significant ($p>0.05$) (Table 3). At Orcutt site, averaged across N rates, yields were significantly increased from 97.6 to 100.0 to 102.0 bu/a by increasing K rates from 10 to 20 to 30 lb K_2O/a (Figure 2). Trt 1 and trt 2 (unfertilized check plot and no N check) were not statistically significant at Orcutt site. At low-yielding Christiaens site, the best treatment combination of N and K was 180 lb N/a plus 10 lb K_2O/a (trt 6). At higher-yielding Orcutt site, trt 19 was the best yield-wise – 135 lb N/a plus 30 lb K_2O/a.

Test weights ranged from 57.3 to 58.3 lb/bu at Christiaens and from 52.1 to 57.0 at Orcutt (Tables 1 and 2). Test weights were and increased from 56.3 to 57.3 lb/bu at Christiaens and from 53.5 to 55.1 lb/bu by increasing K rate from 20 to 30 lb K_2O/a at Orcutt. These differences were not statistically significant (Table 3). Test weights were similar for all N rates at Christiaens; test weights were significantly ($p>0.05$) affected by N rate at
Orcutt (Table 3).

Grain protein values were varied from 9.2 to 13.0 % at Christiaens and from 10.1 to 14.9 % at Orcutt (tables 1 and 2). At Christiaens, grain protein content was not affected by supplied N amount (Figure 3; Table 3): protein values of 11.0, 10.8, 11.9, 12.0, 11.0, and 10.5 % were associated with the N rate incremental increase from 45 to 270 lb N/a. At Orcutt, grain protein values were significantly affected by the amount N: grain protein increased from 10.8 to 11.7 to 12.8 10 13.8 to 14.2 to 14.5 % when N rates increased in increments from 45 to 270 lb/N. Increasing K application rates from 0 to 10 to 20 lb K_2O/a resulted in higher grain protein content values at both sites (Figure 4; Table 3); these differences were substantial but not statistically significant ($p>0.05$).

1. Treatment structure, grain yield, test weight, protein content, plant height, Christiaens, 2014

Trt	Total N rate, lb/a	K_2O rate, lb/a	Grain yield, bu/a	Grain test weight, lb/bu	Grain protein content, %	Plant height, in	Bio-mass weight, g	Bio-mass total N, %	Bio-mass total K, %
1	0	0	14.8	57.7	9.9	26.5	51.1	0.92	0.81
2	0	10	15.4	56.0	11.2	33.0	74.8	0.89	0.83
3	45	10	16.0	56.6	10.4	24.7	40.9	1.08	0.74
4	90	10	33.5	56.6	10.1	27.0	48.0	0.72	1.01
5	135	10	35.6	56.3	11.6	28.8	57.9	1.24	0.80
6	180	10	38.4	55.6	11.3	31.9	65.8	1.22	0.99
7	225	10	32.2	57.1	11.2	28.1	65.7	1.23	0.86
8	270	10	33.0	56.0	11.4	27.9	48.0	1.34	1.12
9	0	20	20.4	56.6	11.1	27.5	57.5	0.95	0.80
10	45	20	25.3	57.3	11.6	33.6	83.4	0.83	0.78
11	90	20	28.2	57.3	10.7	27.7	48.8	0.82	0.92
12	135	20	35.1	56.4	13.0	27.1	47.2	1.09	0.87
13	180	20	36.7	58.0	12.6	27.7	54.5	1.21	0.98
14	225	20	26.7	57.2	9.9	26.7	44.3	1.48	1.02
15	270	20	29.5	58.3	10.9	32.2	72.0	1.55	1.07
16	0	30	15.3	57.0	12.7	30.1	62.4	0.85	0.70
17	45	30	15.7	57.0	11.0	28.8	55.1	0.87	0.72
18	90	30	34.0	56.7	11.7	28.7	55.8	1.01	0.77
19	135	30	35.0	55.2	11.1	28.6	50.4	1.02	0.92
20	180	30	30.4	55.8	12.0	33.0	74.1	1.57	1.16
21	225	30	32.1	56.6	12.0	32.3	72.2	1.24	1.12
22	270	30	31.0	57.3	9.2	30.8	65.2	1.51	0.88

Plant height and biomass weight in this study was not significantly affected by neither N nor K application rates (Tables 1, 2, and 3) at any of the two sites. Biomass total N content was significantly affected by N rate at both sites (Table 3). The rate of K had no statistically significant effect on biomass N content, although increasing K rate to 30 lb of K_2O has slightly increased the total biomass N content at Orcutt.

Biomass total K content was significantly affected by N rate at Christiaens, but not at Orcutt. Biomass total N content was increased by increasing N rate up to 180 lb N/a at Christiaens; further increase in N rate has resulted in lower biomass total K values. Similar trend was observed up to the 90 lb N/a rate at Orcutt, but the differences in biomass total K content were not statistically significant; further increase of N rate beyond the 90 lb N/a has resulted in a notable decline in biomass total K values.

Table 2. Treatment structure, grain yield, test weight, protein content, plant height, Orcutt, 2014

Trt	Total N rate, lb/a	K_2O rate, lb/a	Grain yield, bu/a	Grain test weight, lb/bu	Grain protein content, %	Plant height, in	Bio-mass weight, g	Bio-mass total N, %	Bio-mass total K, %
1	0	0	87.5	56.8	10.6	62.1	200.2	1.14	1.08
2	0	10	87.2	56.2	10.1	63.1	204.5	1.10	1.12
3	45	10	88.8	53.0	10.8	53.0	156.4	1.26	1.15
4	90	10	93.3	55.2	11.0	62.5	201.8	1.35	1.38
5	135	10	101.5	52.1	12.6	61.5	191.7	1.18	1.44
6	180	10	105.9	52.3	13.3	57.4	173.9	1.37	1.44
7	225	10	101.3	53.0	14.5	58.9	184.9	1.46	1.44
8	270	10	105.3	52.7	14.9	54.6	158.3	1.62	1.28
9	0	20	92.2	56.9	10.7	55.5	169.1	1.10	1.01
10	45	20	90.2	57.0	10.7	60.5	201.5	1.33	1.15
11	90	20	101.0	55.3	12.2	53.2	150.3	1.14	1.31
12	135	20	109.6	55.6	13.1	53.5	148.6	1.54	1.30
13	180	20	102.1	53.9	14.0	55.4	158.1	1.74	1.31
14	225	20	109.5	54.8	14.0	59.3	178.9	1.47	1.48
15	270	20	95.7	52.5	14.5	61.2	197.4	1.57	1.34
16	0	30	90.5	52.9	10.6	55.6	164.6	1.35	1.00
17	45	30	90.1	53.7	10.8	54.8	159.3	1.00	1.35
18	90	30	103.8	53.3	11.8	56.0	168.7	1.31	1.30
19	135	30	110.9	56.4	12.7	60.0	194.1	1.48	1.00
20	180	30	106.2	53.4	14.1	56.6	177.7	1.69	1.14
21	225	30	103.4	54.4	14.1	61.7	202.9	1.58	1.30
22	270	30	109.1	54.9	14.0	51.6	141.9	1.66	1.25

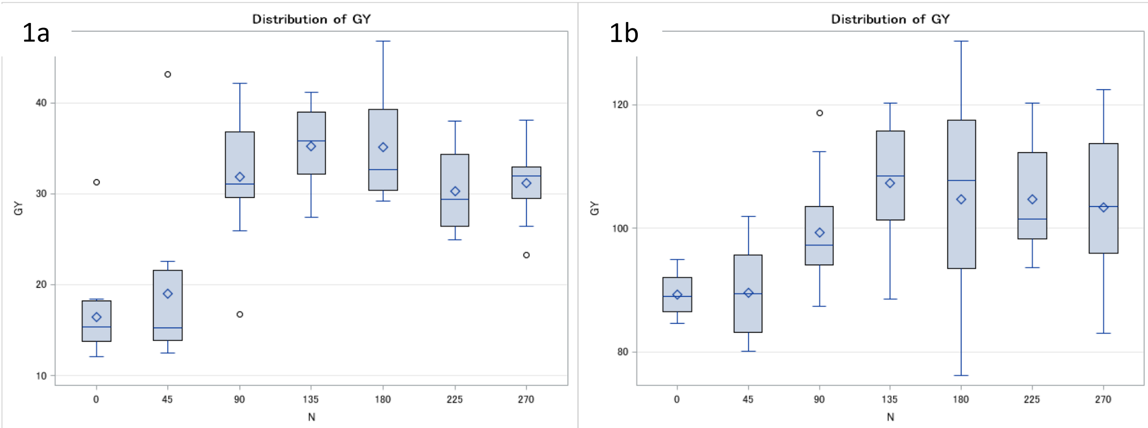


Figure 1. Effect of N rate (soil residual plus fertilizer) on spring wheat grain yield, Christiaens (1a), and Orcutt (1b), 2014.

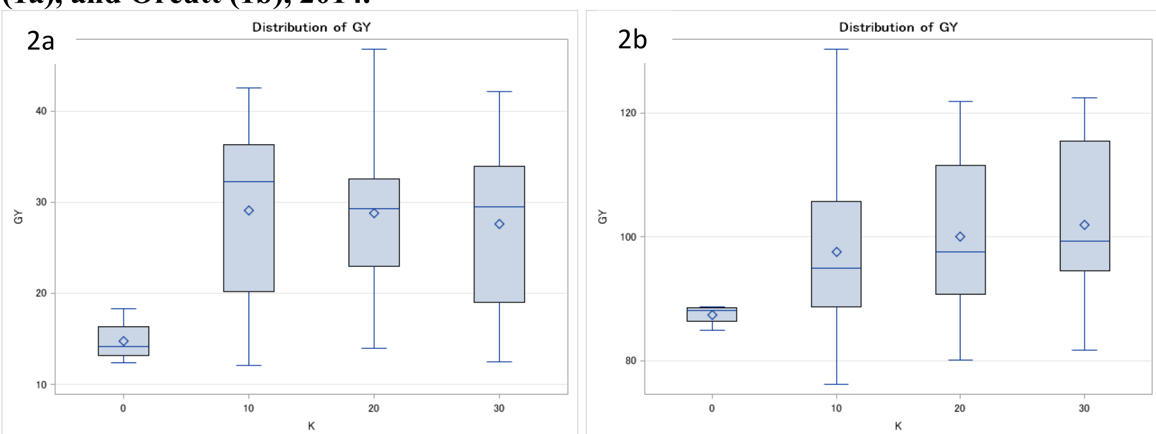


Figure 2. Effect of K_2O rate on spring wheat grain yield, Christiaens (2a), and Orcutt (2b), 2014.

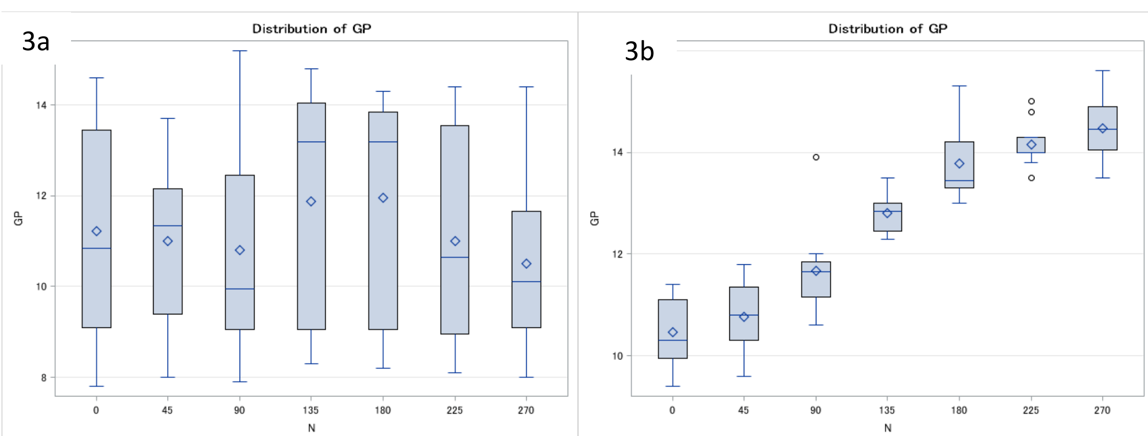


Figure 3. Effect of N rate (soil residual plus fertilizer) on grain protein content, Christiaens (3a), and Orcutt (3b), 2014.

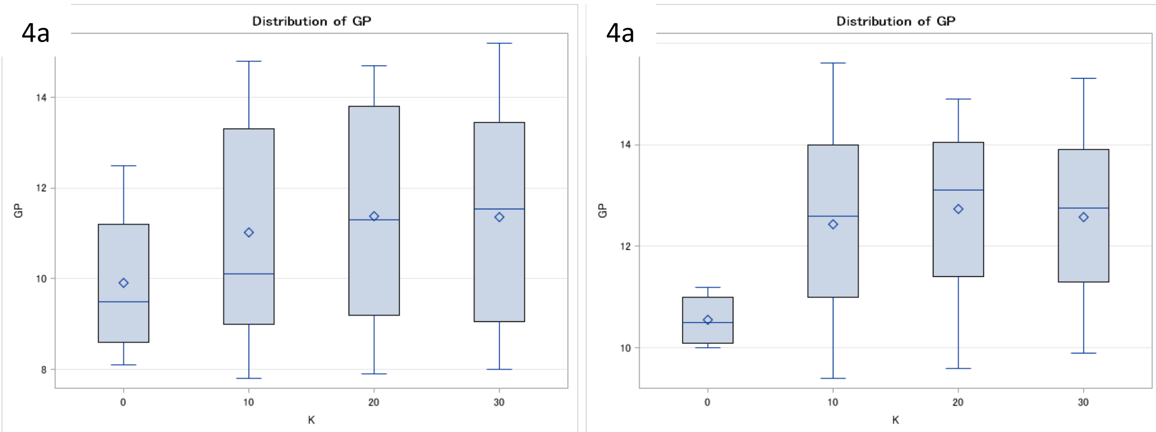


Figure 4. Effect of K_2O rate on grain protein content, Christiaens (4a), and Orcutt (4b), 2014.

Table 3. The summary of N rate, KCL application, fertilizer placement and residue management on spring wheat grain yield, test weight, rain protein content, plant height, biomass weight, biomass total n and K content, Fauque and Rouns, 2014.

Parameter	**N rate**	**K_2O rate**
	Christiaens	
Grain yield	***	ns
Test weight	ns	ns
Grain protein	ns	ns
Plant height	ns	ns
Biomass weight	ns	ns
Biomass total N	**	ns
Biomass total K	ns	ns
	Orcutt	
Grain yield	***	*
Test weight	*	ns
Grain protein	***	ns
Plant height	ns	ns
Biomass weight	ns	ns
Biomass total N	***	ns
Biomass total K	ns	ns

*, **, and *** designate significant, very significant, and highly significant effect; ns designates no significance at 95% confidence level.

Summary of preliminary conclusions:

The result of the evaluated two site years suggest that application of K fertilizer at the rate of 10 to 20 lb K_2O/a may have the potential to improve grain yield and increase grain protein content in dryland hard red spring wheat in Montana. In this study, grain yield was increased by approximately 5 bu/a with K fertilization at a higher yielding site. The positive results from K application are likely to be more pronounced in higher yield potential areas. It is recommended to repeat this study for one more growing season at three locations to verify the first year's results. The root sampling method must be refined in order to obtain good quality root data. It is suggested that a soil auger is used to extract the root samples within the rows and between the rows to get a comprehensive picture of root biomass and root characteristics.

Termination Date: September 2014.

EVALUATION OF UREA-POTASSIUM CHLORIDE BLEND AND RESIDUE MANAGEMENT IN SPRING WHEAT.

Dr. Olga Walsh, Principal Investigator, Western Triangle Agricultural Research Center (WTARC)

Objectives:

- ✓ To compare N use efficiency of urea and KCL-amended urea
- ✓ To evaluate the effect of residue removal on N loss, and
- ✓ To assess the effect of side-banding vs soil-applied N, for spring wheat grown under dryland no-till conditions in Montana

Materials and Methods:

Two dryland experimental sites were established in Montana in the cooperating wheat producers' fields (Fauque and Rouns). Choteau, red hard spring wheat was planted at 60 lb/ac pure live seed (PLS) - seeding rate recommended for spring wheat in Montana. The plot size was 5 by 25 feet, with 5 crop rows in each plot (12 in row spacing). The treatment structure is summarized in Table 1.

Table 1. Treatment structure.

Treatment	Target N rate: N ha^{-1}	Fertilizer sources	Fertilizer placement	Residue management
1	0	-	-	undisturbed
2	0	-	-	removed
3	120	urea	broadcasted	undisturbed
4	120	urea	side-banded	undisturbed
5	120	urea	broadcasted	removed
6	120	urea	side-banded	removed
7	240	urea	broadcasted	undisturbed
8	240	urea	side-banded	undisturbed
9	240	urea	broadcasted	removed
10	240	urea	side-banded	removed
11	120	urea + KCl	broadcasted	undisturbed
12	120	urea + KCl	side-banded	undisturbed
13	120	urea + KCl	broadcasted	removed
14	120	urea + KCl	side-banded	removed
15	240	urea + KCl	broadcasted	undisturbed
16	240	urea + KCl	side-banded	undisturbed
17	240	urea + KCl	broadcasted	removed
18	240	urea + KCl	side-banded	removed

Treatments were arranged in a Randomized Complete Block Design with 4 replications. The study was established in the fields under dryland no-till conditions with very low to low residual soil N. Treatments 2, 5, 6, 9,10, 13, 14, 17 and 18 were mowed using a grass mower and the residue will be removed from the plots using a hay rake. Residue was left to remain undisturbed in the rest of the plots. Treatments 1 and 2 were established as unfertilized check plots. According to treatment structure, fertilizer N was applied as urea (46-0-0) or as a urea/KCL 50%-50% blend at planting to achieve 2 target N rates – 120 and 240 lb N/ac. The urea and urea-KCl blend were applied either in a side-band with the seed or broadcasted. The amount of residual N determined from the soil test N was credited for calculation of the application N rates. Phosphorus and other plant nutrients were applied according to current Montana State University guidelines for spring wheat. Pest and weed control was carried out throughout the growing season as necessary to ensure high quality of collected data. At tillering (Feekes 5) whole plant biomass samples were collected, weight to determine biomass weight and analyzed for total N content. Additionally, the Normalized Difference Vegetative Index (NDVI) readings from each experimental plot were collected at Feekes 5 growth stage. Feekes 5 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 effects of N rate, KCL application, fertilizer placement, and residue management on spring wheat grain yield, test weight, grain protein, biomass production (weight), and biomass content were assessed. The analysis of variance was conducted using the PROC GLM procedure in SAS v9.4 (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

This report summarizes results from 2 locations from 1 growing season. Grain yields ranged between 59.5 and 87.2 bu/a at Fauque and between 63.4 and 75.3 bu/a at Rouns in 2014 (Tables 2 and 3). The best treatment at Fauque was trt 14 – urea applied at 120 lb N/a rate with KCl in a side-band, with residue removed. Supplying N at the rate of 240 lb/a in a sideband, with undisturbed residue (trt 8), and application of urea+KCl side-banded with removed residue (trt 18) were also superior yield-wise, at Fauque. At Rounds, trt 10 (240 lb N/a rate of urea side-banded, with residue removed) was top-yielding, followed by trt 14 - urea applied at 120 lb N/a rate with KCl in a side-band, with residue removed. A much more apparent response to N fertilizer was noted at Fauque compared to Rouns (Figure 1).The rate of N has significantly ($p>0.05$) affected spring wheat grain yields at Fauque, but not at Rouns (Table 4).

Similarly, application of KCl with urea (compared to urea alone) has produced superior yields at Fauque, but not at Rouns (Figure 2; Table 4). No statistically significant differences in grain yield associated with KCl application were observed at Rouns. At Fauque, application of KCl has resulted in the average yield of 80.4 bu/a, compared to 77.5 bu/a with urea alone.

Fertilizer placement has significantly affected grain yields at both sites: side-banging fertilizer has resulted in superior yields compared to broadcasting (Figure 3; Table 4). Specifically, at Fauque, on average, broadcasting yielded 76.6 bu/a and side-banding – 81.3 bu/a. Similarly, at Rouns, broadcasting yielded 66.1 bu/a, and side-banding – 70.1 bu/a.

Although the differences in yield associated with the residue management were not statistically significant ($p>0.05$), removing residue produced higher yields at both locations (Figure 4; Table 4). At Fauque, the undisturbed plots yielded 74.9 bu/a, on average, compared to 79.5 bu/a yielded by plots with removed residue. Similarly, at Rouns, the plots with undisturbed residue yielded 67.4 bu/a compared to 68.9 bu/a – by plots with removed residue.

Test weights ranged from 53.2 to 55.1 lb/bu at Rouns, which was lower compared to 54.5 to 58.5 lb/bu at Fauque (Tables 2 and 3). Test weights were significantly ($p>0.05$) affected by the amount of supplied N at both sites (Table 4). Other treatments (application of KCl, fertilizer placement, residue management) did not significantly affect test weights at any of the two locations (Table 4). Grain

protein values ranged from 9.2 to 14.6% at Fauque and 13.5 to 15.3% at Rouns (Tables 2 and 3). Total amount of supplied N has significantly (p>0.05) affected grain protein content at both sites (Figure 5; Table 4). Specifically, at Fauque, the plots receiving 120 lb N/a averaged 11.9% protein compared to 14.0% with 240 lb N/a. At Rouns, 14.6% was noted for 120 lb N/a rate vs 14.9 – for 240 lb N/a.
Grain protein values were also significantly affected by application of KCl, but only at Fauque site (12.9% without KCl vs 13.0% with KCl).

Fertilizer placement had a significant (p>0.05) effect on grain protein content at both locations (Table 4) - side-banding produced superior grain protein values compared to broadcasting. Side-banding averaged 13.1% vs 12.8% for broadcasting at Fauque; at Rouns, side-banding produced 14.9% protein compared to 14.6% noted for broadcasting. Virtually the same grain protein contents were observed for the two residue management treatments – no significant differences in protein values were associated with undisturbed vs removed residue treatments (Table 4).

Biomass weight and biomass total N content is reported in Tables 2 and 3 for both sites. At both sites, biomass weight has been significantly affected by KCL application and fertilizer placement. Increasing N rate from 120 to 240 lb N/a has not resulted in higher biomass production (Table 4 Side-banding resulted in higher biomass weights compared to broadcasting at both sites. Residue management had no significant effect on biomass production at any of the two sites (Table 4).
At both sites, biomass total N content was statistically significantly higher with higher N application rate, and addition of KCL. Also, side-banding resulted in higher biomass total N values at both sites (Table 4). Similar trends were observed for NDVI at both sites: NDVI was higher with side-banding compared to broadcasting. Other treatments had no significant effect on HDVI values at any of the two sites (Table 4).

The NDVI values ranged from 0.32 to 0.42 at Fauque and from 0.52 to 0.73 at Rouns, corresponding with higher biomass weights and grain yields at Rouns locations (Tables 2 and 3). The correlation between NDVI as grain yield at Rouns (more responsive to N site) was much more pronounced compared to Fauque (Figure 6).

From the two site-years evaluated in this report, it appears that N amount and fertilizer placement have the strongest overall effect on spring wheat grain yield and protein content (Table 4). There was no consistent trend associated with application of KCl in this study, as positive effects of KCL addition were much more apparent at Fauque, compared to Rouns site. At Fauque, KCl application has affected yield, protein content, biomass production and its' N content, while at Rouns, the KCl effects were concentrated on the biomass side (biomass weight and its' total N). At both locations, removing residue from the plots has provided a slight advantage in grain yield, but not in grain protein content. Further research is necessary to verify these preliminary findings and to make conclusions in regards to the effects of KCl application, fertilizer placement and residue management in spring wheat. Also, further evaluation of NDVI usefulness as plant health assessment parameter needs to continue. It is recommended to repeat the experiment next growing season at three locations.

Table 2. Grain yield, test weight, protein content, biomass weight, biomass total N content, and NDVI, Fauque, 2014.

Trt	Grain yield, bu/a	Grain test weight, lb/bu	Grain protein content, %	Biomass weight, g	Biomass total N, %	NDVI
1	59.5	57.8	10.2	9.1	4.2	0.36
2	67.4	58.5	9.2	12.3	4.2	0.38
3	67.4	57.1	11.5	6.5	4.5	0.34
4	78.6	56.8	12.3	12.0	4.6	0.42
5	80.9	58.2	11.4	7.0	4.6	0.37
6	77.9	56.9	12.4	8.5	4.6	0.42
7	77.0	56.1	13.8	6.8	4.7	0.32
8	86.5	55.8	13.9	6.4	4.8	0.39
9	70.5	54.5	14.4	6.2	4.4	0.37
10	81.4	56.7	13.7	8.4	5.0	0.34
11	72.1	58.2	11.7	11.7	4.5	0.32
12	77.7	57.0	12.3	10.8	4.7	0.40
13	81.6	57.8	12.0	23.1	4.2	0.39
14	87.2	57.7	12.0	9.4	4.8	0.37
15	80.9	56.4	13.8	18.5	4.7	0.35
16	75.0	55.5	14.6	15.1	4.7	0.33
17	82.3	56.6	14.0	15.4	4.8	0.33
18	86.5	56.7	13.9	14.7	5.0	0.35

Table 3. Grain yield, test weight, protein content, biomass weight, biomass total n content, and NDVI, Rouns, 2014.

Trt	Grain yield, bu/a	Grain test weight, lb/bu	Grain protein content, %	Biomass weight, g	Biomass total N, %	NDVI
1	66.7	54.5	13.9	23.7	4.3	0.67
2	70.2	54.9	13.5	28.4	3.8	0.66
3	66.6	54.9	14.1	23.2	4.4	0.57
4	67.7	53.4	15.3	30.4	4.6	0.73
5	68.9	54.7	14.2	29.0	4.3	0.57
6	71.2	54.2	15.0	31.1	4.6	0.67
7	66.1	53.7	14.6	23.3	4.8	0.57
8	67.0	54.0	15.2	20.5	4.7	0.67
9	63.4	53.2	15.2	23.7	4.8	0.62
10	75.3	54.3	15.3	20.4	4.7	0.72
11	65.6	54.5	14.2	24.1	4.6	0.53
12	70.9	54.5	14.8	30.2	4.3	0.69
13	65.4	53.7	14.6	24.1	4.5	0.61
14	72.5	55.1	14.4	28.7	4.5	0.66
15	66.4	53.3	14.9	30.1	5.0	0.64
16	70.1	54.5	14.8	38.2	4.6	0.69
17	66.7	53.7	14.7	35.5	4.3	0.58
18	66.4	55.1	14.4	39.7	4.6	0.52

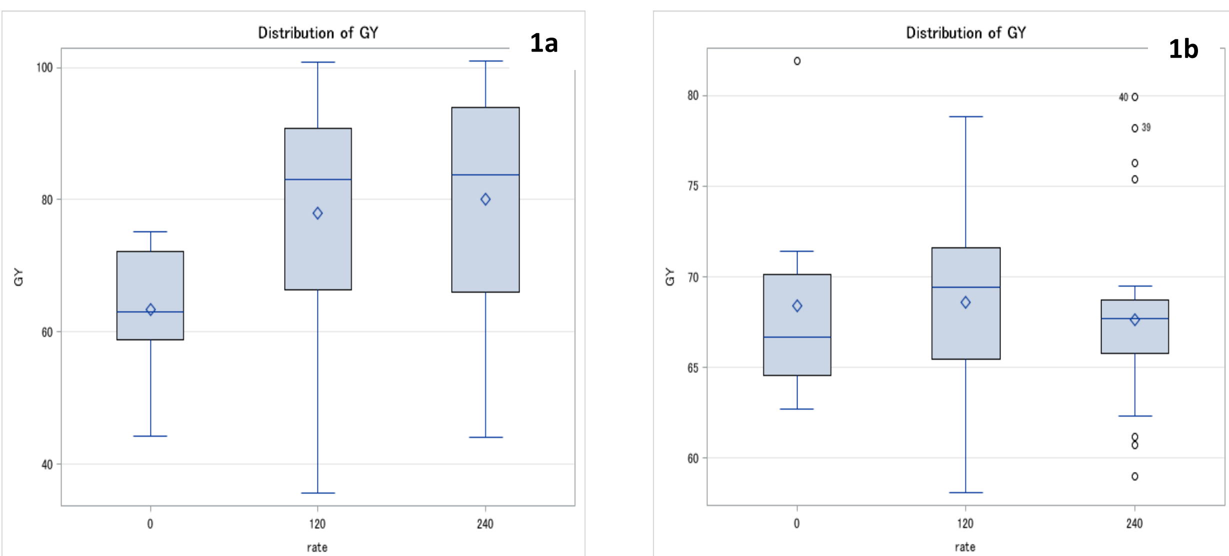


Figure 1. Effect of N rate (soil residual plus fertilizer) on spring wheat grain yield, Fauque (1a), and Rouns (1b), 2014.

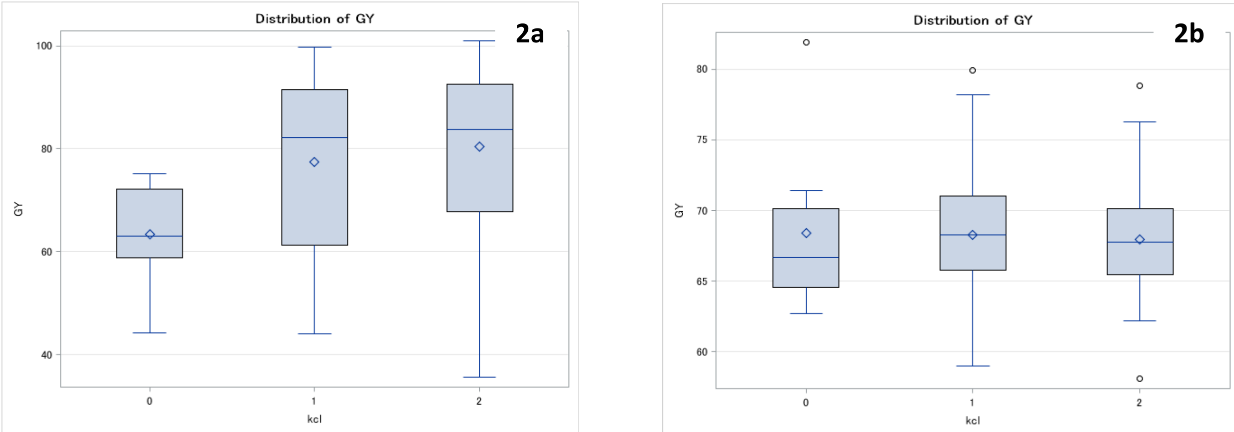


Figure 2. Effect of KCL application on spring wheat grain yield, Fauque (2a), and Rouns (2b), 2014. On the X axis, 0 = no fertilizer; 1 = urea, no KCL; 2 = urea plus KCL.

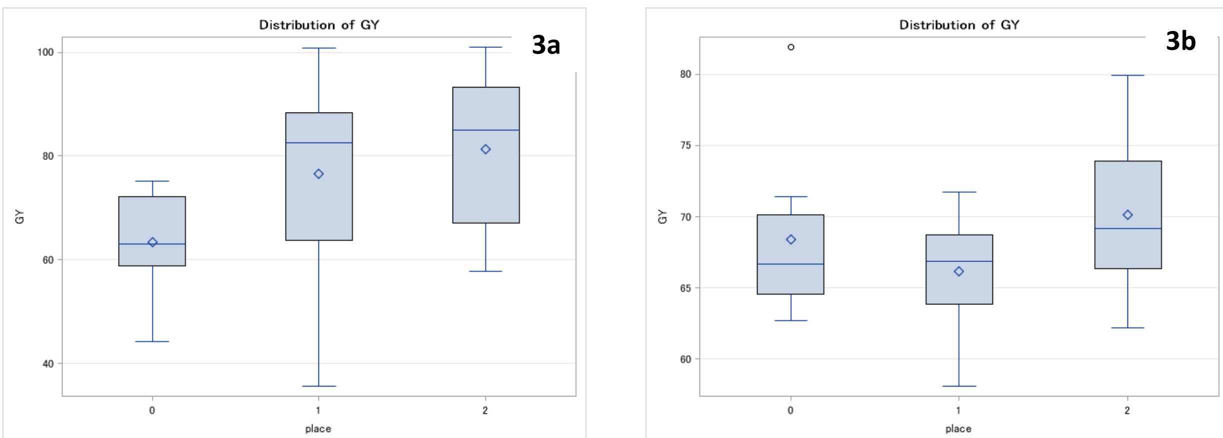


Figure 3. Effect of fertilizer placement on spring wheat grain yield, Fauque (3a), and Rouns (3b), 2014. On the X axis, 0 = no fertilizer; 1 = broadcasted; 2 = side-banded.

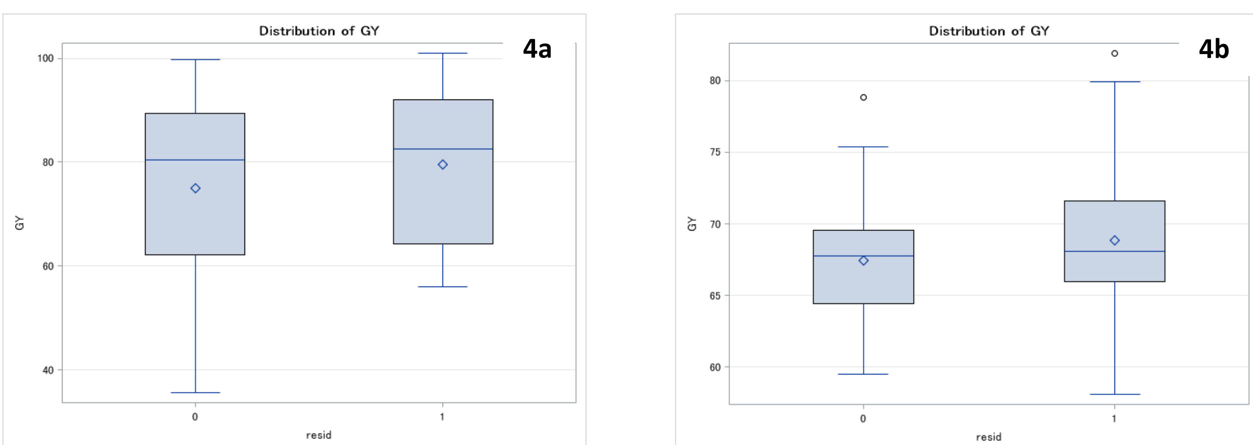


Figure 4. Effect of residue management spring wheat grain yield, Fauque (4a), and Rouns (4b), 2014. On the X axis, 0 = undisturbed; 1 = removed.

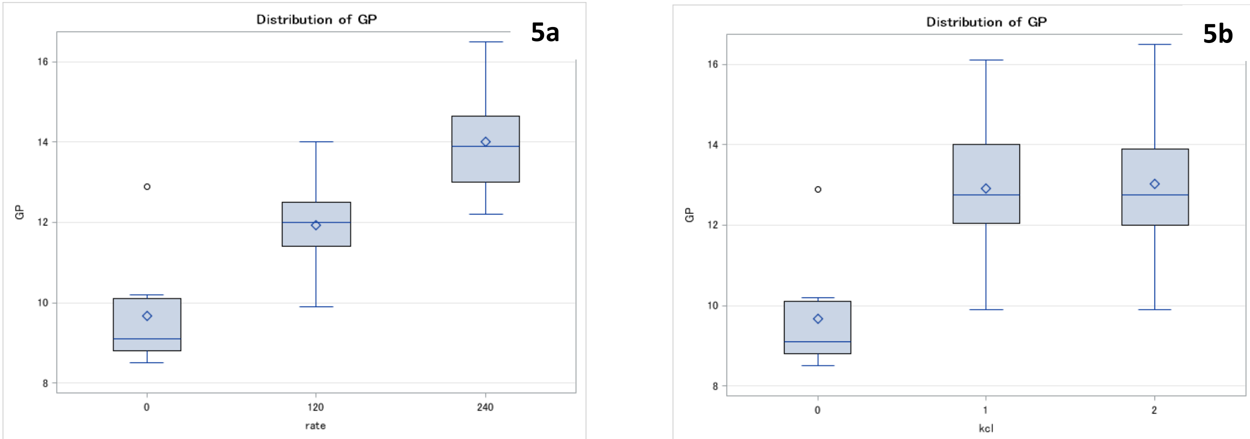


Figure 5. Effect of N rate (soil residual plus fertilizer) on spring wheat grain protein content, Fauque (1a), and Rouns (1b), 2014.

Table 4. The summary of N rate, KCL application, fertilizer placement and residue management on spring wheat grain yield, test weight and grain protein content at Fauque and Rouns, 2014.

Parameter	**N rate**	**KCL**	**Fertilizer Placement**	**Residue management**
Fauque				
Grain yield	*	*	**	ns
Test weight	*	ns	ns	ns
Grain protein	***	**	***	ns
Biomass weight	ns	***	ns	ns
Biomass total N	**	**	***	ns
NDVI	ns	ns	*	ns
Rouns				
Grain yield	ns	ns	*	ns
Test weight	*	ns	ns	ns
Grain protein	***	ns	***	ns
Biomass weight	ns	*	ns	ns
Biomass total N	***	***	***	ns
NDVI	ns	ns	**	ns

*, **, and *** - significant, very significant, and highly significant effect; ns - no significance at 95% confidence level.

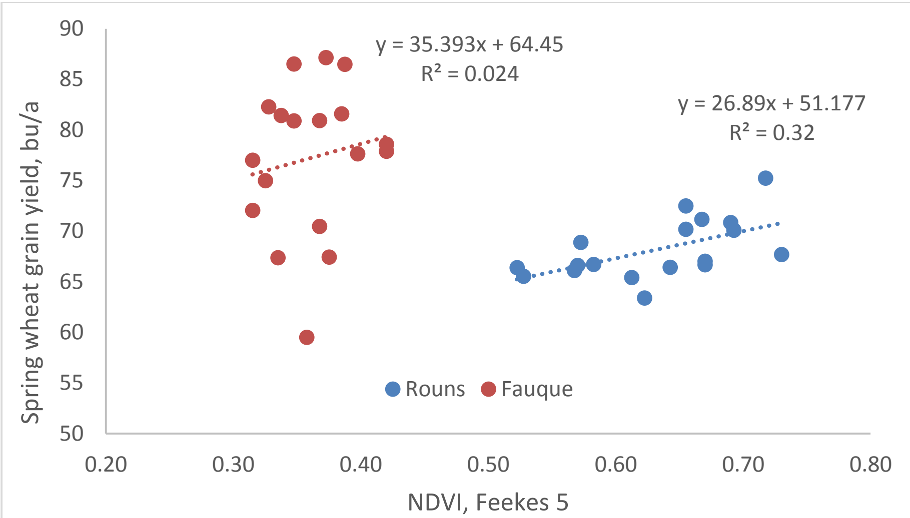


Figure 6. Relationship between NDVI (Feekes 5) and spring wheat grain yield, Fauque and Rouns, 2014.

Termination Date: September 2014.

PLANT POPULATION AND N APPLICATION TIME FOR IMPROVED SPRING WHEAT PRODUCTION

Dr. Olga Walsh, Principal Investigator, Western Triangle Agricultural Research Center (WTARC)

Objectives:

- To determine how late can N be applied to spring wheat without reducing grain yield and quality
- To determine the most effective combination of seeding rate and N rate and application time for spring wheat dryland production system

Materials and Methods:

Two dryland experimental sites were established in Montana in the cooperating wheat producers' fields (Martin and Orcutt). Choteau, red hard spring wheat was planted at 60 and 120 lb/ac pure live seed (PLS) - the recommended seeding rate for spring wheat in Montana (x1) and double the recommended rate (x2). The plot size was 5 by 25 feet, with 5 crop rows in each plot (12 in row spacing). At each location, a two-way factorial arrangement of treatments in a randomized complete block design with 3 replicates was utilized. The treatment structure is summarized in Table 1. Fertilizer N was applied as urea (46-0-0) at 4 rates ranging from 0 to 125 lb/ac. Four N fertilizer application times were evaluated: at seeding, or in-season - early tillering (Feekes 2-3), late tillering-beginning of jointing (Feekes 5-6), and flag leaf emergence (Feekes 8). The amount of phosphorus and other plant nutrients was applied according to current Montana State University guidelines for spring wheat. Pest and weed control was carried out throughout the growing season as necessary to ensure high quality of collected data. At grain maturity, within each plot, a subsample will be collected from two middle rows, by cutting the plants within 1 foot of row. At harvest, for each plot, grain yield and grain test weight were recorded, and grain samples were collected and analyzed for protein content. The effects of seeding rate, N rate, and N application time on spring wheat grain yield, test weight and protein content were assessed. The analysis of variance was conducted using the PROC GLM procedure in SAS v9.4 (SAS Institute, Inc., Cary, N.C.). Mean separation was performed using the Orthogonal Contrasts method at a significance level of 0.05.

Project Results and Relevancy to Montana

This report summarizes results from 2 locations from 1 growing season.

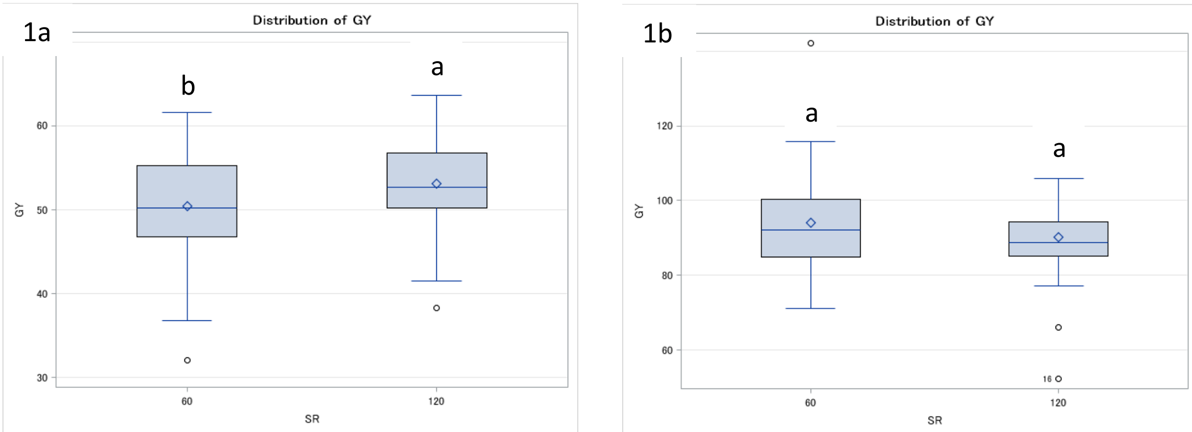


Figure 1. Effect of seeding rate on spring wheat grain yield, Martin (1a) and Orcutt (1b), 2014.

Spring wheat grain yields varied from 45.7 to 63.0 bu/a at Martin and from 77.0 to 103.7 bu/a at Orcutt (Table 1). Seeding rate of 120 lb/a PLS produced statistically significantly higher grain yield at Martin compared to 60 lb/a PLS. At Orcutt, similar yields were obtained with the two seeding rates (Figure 1).

Table 1. Treatment structure, spring wheat grain yield (GY), test weight (TW), and grain protein content (GP), Martin and Orcutt, 2014.

Trt	Seeding rate, lb/ac (PLS)	Fertilizer N rate, lb N/ac	Fertilizer N application time	Martin			Orcutt		
				GY, bu/a	TW, lb/bu	GP, %	GY, bu/a	TW, lb/bu	GP, %
1	60	0	n/a	45.7	58.1	11.7	87.2	58.4	11.1
2	120	0	n/a	45.9	56.7	12.6	81.6	59.7	10.6
3	60	25	at seeding	48.2	55.1	13.0	92.7	59.4	11.3
4	120	25	at seeding	55.7	56.2	12.6	77.0	58.5	10.8
5	60	75	at seeding	49.6	55.1	13.9	88.1	59.0	11.5
6	120	75	at seeding	52.8	55.1	13.8	89.0	57.8	12.6
7	60	125	at seeding	49.4	55.6	14.2	98.1	57.6	13.2
8	120	125	at seeding	53.6	54.9	14.4	96.5	56.9	13.7
9	60	25	early tillering	49.7	57.3	12.3	99.5	59.0	11.5
10	120	25	early tillering	51.8	58.1	11.4	90.1	59.2	10.7
11	60	75	early tillering	53.1	57.6	12.3	98.8	59.0	12.5
12	120	75	early tillering	52.6	55.9	13.5	98.4	59.0	12.5
13	60	125	early tillering	52.9	57.0	13.8	103.7	59.4	13.3
14	120	125	early	53.9	58.4	12.1	99.6	57.3	13.5

			tillering						
15	60	25	late tillering	53.8	57.7	12.1	97.0	59.1	11.2
16	120	25	late tillering	54.3	57.6	12.1	91.7	59.3	10.9
17	60	75	late tillering	53.6	56.9	13.2	88.5	58.8	11.9
18	120	75	late tillering	54.6	55.5	13.5	93.8	59.1	12.1
19	60	125	late tillering	55.0	57.6	12.8	97.6	59.2	13.0
20	120	125	late tillering	63.0	54.8	14.8	94.9	59.2	12.8
21	60	25	flag leaf	48.1	56.9	12.4	88.4	59.3	11.0
22	120	25	flag leaf	48.3	58.3	11.4	83.8	59.3	10.6
23	60	75	flag leaf	48.3	58.2	11.3	89.8	59.7	12.0
24	120	75	flag leaf	53.1	56.9	13.1	88.0	58.7	11.5
25	60	125	flag leaf	49.0	58.8	12.2	90.4	59.2	12.6
26	120	125	flag leaf	51.3	59.7	12.5	87.2	58.6	11.8

Grain yield was significantly affected by N application rates at both sites (Figure 2). At Martin, the lower yielding site, grain yield was increased from 45.8 for unfertilized check plot to 51.2 to 52.2 to 53.5 bu/a with application of 25, 75 and 125 lb N/a. The yields beyond the 25 lb N/a rate were not statistically different. At the high-yielding site, Orcutt, grain yields responded to N application up to 125 lb N/a (Figure 1); the response resulted in a 11.6 bu/a difference between the unfertilized check plot and the highest fertilized treatment.

At both sites, application of N at seeding has produced the lowest grain yields, which were statistically significantly superior to other treatments (Figure 3). At both sites, fertilization at tillering resulted in best yields. At Orcutt, yield was increased by 8.9 bu/a by application at early tillering compared to at-seeding (from 90.2 to 98.4 bu/a); late tillering application reduced yields by 4.9 bu/a (to 93.9 bu/a), and N application at flag leaf emergence resulted in further yield decline of 6.0 bu/a (to 87.9 bu/a) (Figure 3). At Martin, best yield of 55.7 bu/a was achieved when N fertilization was delayed until late tillering, compared to 52.3 bu/a obtained with early tillering N fertilization, 51.6 bu/a – with at-seeding application, and 49.7 bu/a – with fertilization at flag leaf emergence (Figure 3).

Test weight values ranged from 54.8 to 59.7 lb/bu at Martin and from 56.9 to 59.7 lb/bu at Orcutt (Table 1). No statistically significant differences in test weights associated with the seeding rate were observed at any of the two sites. At Martin, comparable test weights were obtained independent of N rate applied. At Orcutt, as N application rate increased, the test weight values decreased, as a side effect of increasing grain yields (Figure 4). At both sites, grain test weight values were higher for unfertilized check plots and for treatments fertilized at flag leaf emergence, associated with the lower yields for those treatments and production of fewer larger seeds (Figure 5).

Grain protein values varied from 11.3 to14.8 % at Martin and from 10.6 and 13.7 % at Orcutt (Table

1).

The seeding rate did not significantly affect the grain protein content at any of the two sites. Highest grain protein values were achieved with the highest N rate of 125 lb N/a at both sites. The protein values increased from 12.1 to 12.2 to 13.1 to 13.3 % at Martin and from 10.8 to 11.0 to 12.1 to 13.0 % at Orcutt with increase in N rate from 0 to 25 to 75 to 125 lb N/a (Figure 6).

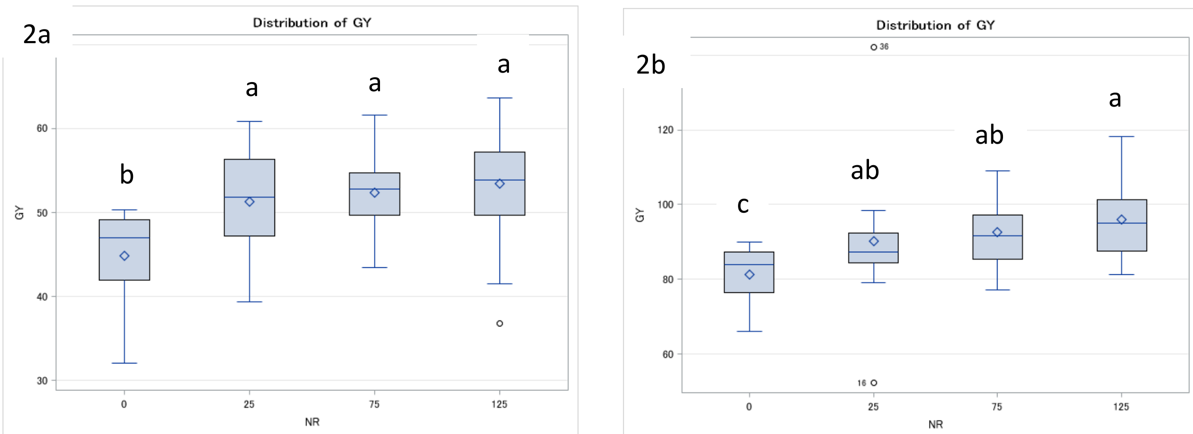


Figure 2. Effect of N rate on spring wheat grain yield, Martin (2a) and Orcutt (2b), 2014.

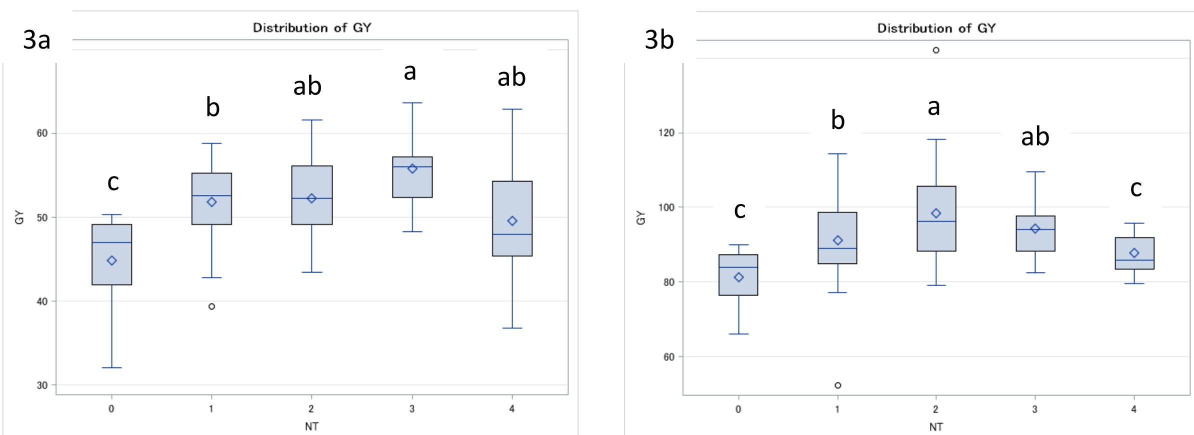


Figure 3. Effect of N application time on spring wheat grain yield, Martin (3a) and Orcutt (3b), 2014.

On the X axis: 0 = no N; 1 = at seeding; 2 = early tillering; 3 = late tillering; 4 = flag leaf.

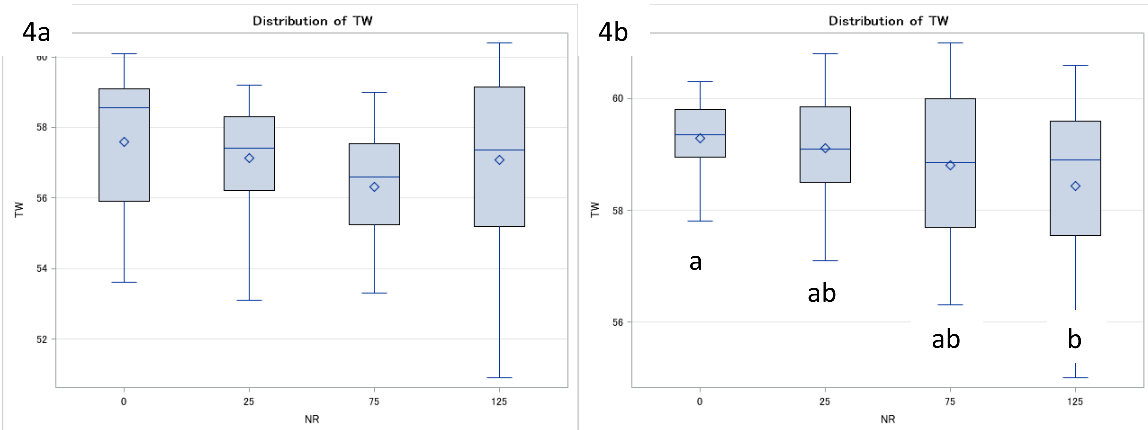


Figure 4. Effect of N rate on spring wheat grain test weight, Martin (4a) and Orcutt (4b), 2014.

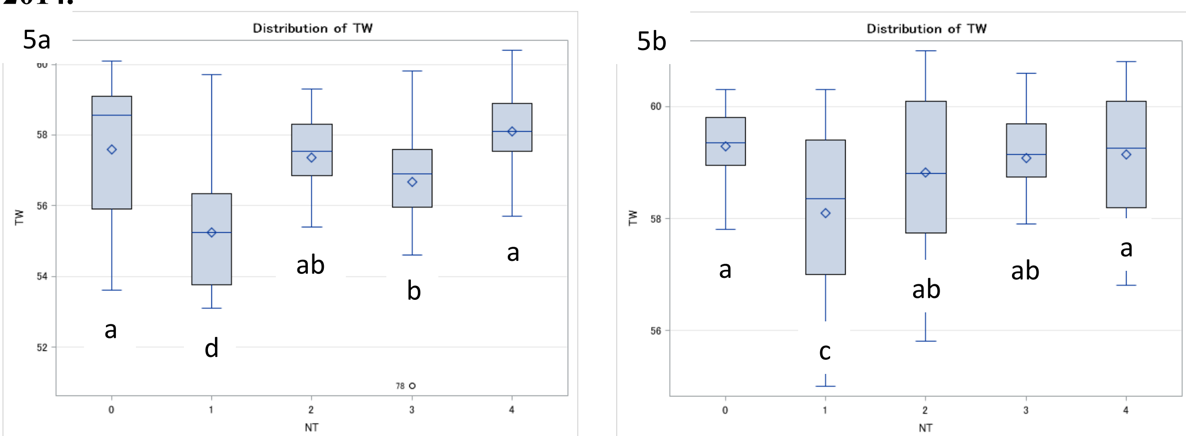


Figure 5. Effect of N application time on spring wheat grain test weight, Martin (5a) and Orcutt (5b), 2014.

On the X axis: 0 = no N; 1 = at seeding; 2 = early tillering; 3 = late tillering; 4 = flag leaf.

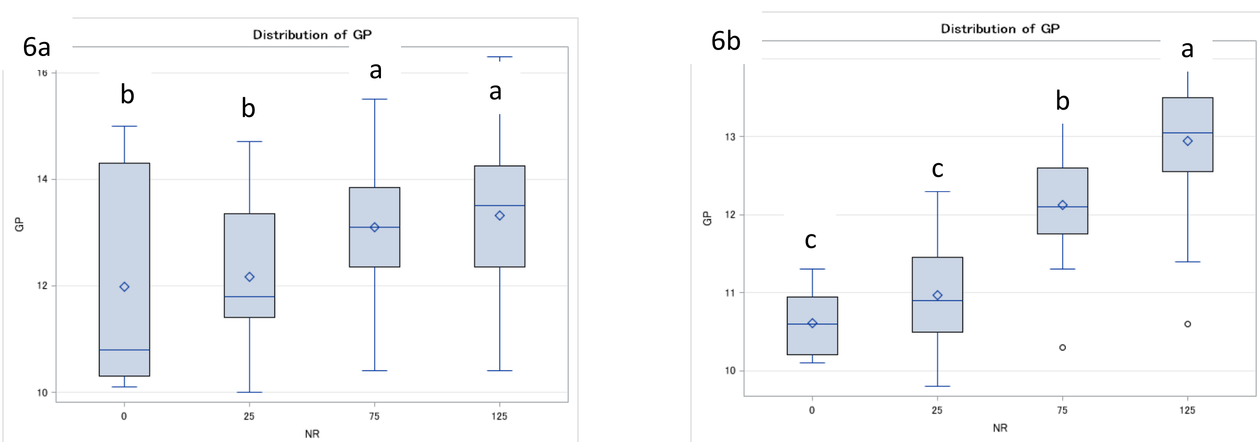
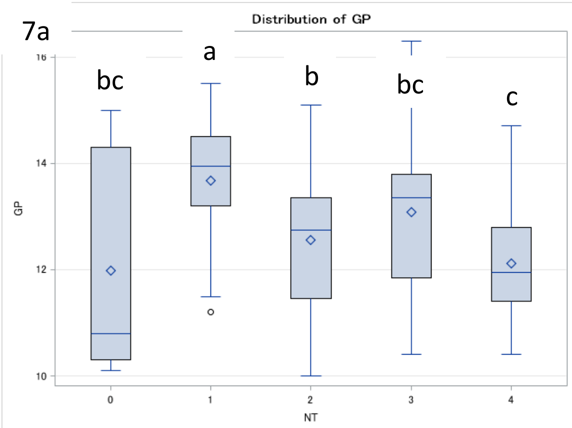


Figure 6. Effect of N rate on spring wheat grain protein content, Martin (6a) and Orcutt (6b), 2014.



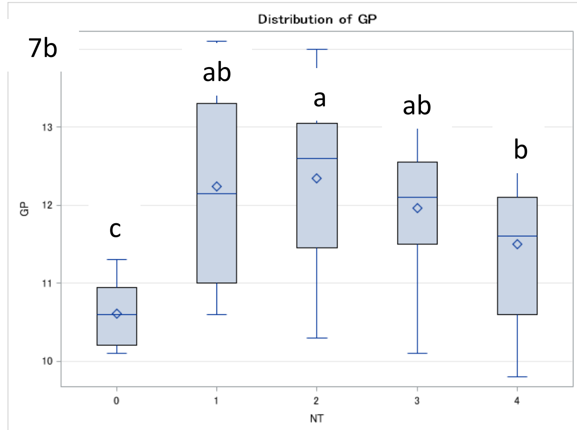


Figure 7. Effect of N application time on spring wheat grain protein content, Martin (7a) and Orcutt (7b), 2014.
On the X axis: 0 = no N; 1 = at seeding; 2 = early tillering; 3 = late tillering; 4 = flag leaf.

Overall, at a high yielding site, Orcutt, the best grain yield/protein combination was achieved with trt 13: seeding rate of 60 lb/a PLS, with N applied at 125 lb N/a at early tillering growth stage. At lower yielding site, Martin, trt 20 was the best treatment when considering both grain yield and quality – seeding rate of 120 lb/a PLS, with N applied at 125 lb N/a at late tillering/beginning stem elongation growth stage. These preliminary results indicate that early tillering to beginning of stem elongation (Feekes 2 through 6) is the optimum N fertilizer application time. Delaying fertilizer N applications in spring wheat is not recommended beyond Feekes 6 growth stage due to increased risk of yield and quality loss. Results strongly indicate that application of N at seeding is not advisable. It is recommended to repeat this study one more growing season at three locations to make more informed conclusions in regards to best seeding rate/N rate/N application time combinations in terms of both spring wheat grain yield and quality (test weigh and protein).

Termination Date: September 2014.

UNMANNED AERIAL SYSTEMS FOR PRECISION CROP SENSING

Dr. Olga Walsh, Principal Investigator, Western Triangle Agricultural Research Center (WTARC)

Objectives:

- To evaluate the Multirotor Ready to Fly Kit X4 unmanned aerial system for precision crop sensing, and
- To compare the unmanned aerial system with ground-based handheld sensor – GreenSeeker 505 – for collection of spectral reflectance data

PROPOSED Materials and Methods:

The following materials and methods were proposed for this project:

"In order to initiate this project, 2 members of precision nutrient management team at MSU will be thoroughly trained and will obtain the UAV-related pilot license mandated by the Federal Aviation Administration (FAA) for everyone involved in operation of drones for research purposes. This ensures the proper use of the equipment, high quality data to be collected, as well as safety of the personnel.

The crop reflectance measurements will be collected from currently established soil nutrient management studies near Conrad, MT utilizing the UAV - Multirotor Ready to Fly Kit X4 (Aerial Precision Ag., Phoenix, AZ) equipped with a multi-spectral camera - and ground-based optical sensor – GreenSeeker 505 (Trimble Navigation Ltd, Ukiah, CA). The spectral measurements will be taken three times during the growing season: at early tillering (Feekes 2-3), late tillering (Feekes 5-6), and flowering (Feekes 10.5). The GreenSeeker sensor enables collecting NDVI data at 200 readings per second while the sensor is scanning the crop. The GreenSeeker will be mounted on an all terrain vehicle (ATV) equipped with speed control. The drone's GoPro multi-spectral camera allows capturing multispectral image data at specific frequencies across the electromagnetic spectrum. The wavelengths (red and near-infrared) will be separated by provided filters.

To make the collected data as comparable as possible, the following methodology will be utilized:

- The data will be collected by flying the drone at the set height of 2 feet from the crop canopy. The GreenSeeker sensor height of 2 feet from crop canopy will be maintained while scanning the crop.
- The ATV's and the drone's speed will be set at 5 miles per hour.
- The readings using the drone and the GreenSeeker will be collected simultaneously to minimize variability in NDVI associated with environmental factors such as leaf curling due to heat.
- The readings will be collected in the presence of sufficient light (early morning, clear skies) to accommodate the multi-spectral

The NDVI-based maps of field experiments will be created using the GreenSeeker and drone-derived reflectance data. The collected NDVI will be incorporated in the database of crop reflectance measurements and utilized for building a sensor-based N optimization algorithm for

Montana conditions and wheat varieties. In addition, the collected spectral reflectance data and aerial images will be used for extensive outreach activities, such as creating educational materials, blog posts, grower seminars and workshops and field demonstrations and field days."

Project Results and Relevancy to Montana

The project was not initiated due to uncertainty in the FAA the regulations and guidelines for UAV systems use, especially in the area of agriculture. Several legal cases have been brought against ag producers flying drones over their fields. Several growers have been fined over $10,000 for simply surveying and taking the pictures of their fields using a drone. Prior to 2014, the FAA had especially restricted the use of drones for profit; for example, crop consultants could not legally fly drones over their clients fields and charge for this service, however the growers themselves were allowed to use drones within the boundaries of their own land. At a 2013 international meeting on UAVs, the official representatives for the Unmanned Vehicle Aerial Systems International has presented the new more restrictive regulations. These regulations included banning ag producers from legally flying drones even within their land boundaries, since their farming operations fall under enterprise use. They also stated that the initial legalization of drone use for agricultural purposes anticipated in 2015 most likely be postponed. This was due to several serious accidents that enhanced the safety concerns and prompted the need for further more thorough review of the standards. A decision has been made not to establish the UAV project due to these uncertainties.

2014 has brought new developments in this area, including the statements that the FAA is back on track of probably approving the general use of drones for agriculture, as well as allowing several commercial companies to fly the drones within the United States. We anticipate that in a year or two, once these guidelines are firmly in place, the proposed project may be successfully implemented.

Termination Date: September 2014.

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Varietal Trials

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Winter wheat

2014 Winter Wheat Variety Evaluations in the Western Triangle Area.

Location: Western Triangle Agricultural Research Center (WTARC), Conrad, MT.

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 nursery and four off station locations were grown 2014. 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.

Results: Winter wheat intrastate data are shown in Tables 1 and 2. The preliminary A data are shown in Table 3 and the advanced nursery data is presented in Table 4. Off station plots were harvested at Choteau, Cut Bank, Devon, and the 'Knees'. The data are presented in Tables 5 thru 11, with soil test results presented in Table 1 of the soil test results section.

The 2014 growing season at WTARC was a little cooler than average with a wetter than normal June. The June rain was very timely with respect to the small grain plots.

Intrastate trial average yield was about16 bu/a higher than the six year average. With test weight one half pound lighter and protein one half percent higher.

Grain yields and test weights at the 'Knees' were 2.9 bu/a and 0.7 lb/bu higher than the four year average. Protein at the 'Knees' were equal to the four year average (Table 10 and 11). Grain yields at Devon were much higher than the four year average. Test weights at the Devon location were three and a half pounds per bushel higher than the four year average, whereas the protein was one percent lower than the four year average (Tables 8 and 9). The data for Choteau are presented in Tables 5 and 6. Yields at Choteau were 10 bu/a higher than the three year average. The test weight was the same as the three year average, with protein being slightly lower. Plots at Cut Bank received hail as is reflected in the yield and test weight data (Table 7). There is no long term table for Cut Bank.

Top yielding varieties at the Choteau location were Yellowstone, Jagalene, and Bearpaw. MT1286, MT1090, and Accipiter were the high yielding varieties at Devon. Top yielders at the 'Knees' include Yellowstone, Decade, and Colter. At Cut Bank, the top yielding wheats were MT1138, MTW08168, and MTS0826-63.

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, MT

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. Additional observations concerning the varieties are presented in the following pages. MWBC FY2015 Grant Submission Plans: A similar project will be proposed for FY 2016.

Table 1. 2014 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 %
MT1113	-	-	123.2	62.1	176.5	32.6	12.1
LCS Mint	-	-	122.7	63.7	166.7	30.4	11.9
MT1138	-	-	120.3	60.5	172.5	32.9	12.1
MT1265	-	-	119.5	60.9	175.7	31.7	12.0
MT1257	-	-	118.7	60.5	173.1	32.0	12.0
WB3768	Montana/Westbred, 2013	-	117.6	60.6	176.8	36.0	12.4
Yellowstone	Montana, 2005	-	117.2	59.9	175.5	32.7	12.1
Keldin	-	-	115.6	61.5	172.8	29.8	12.2
MT1117	-	-	115.0	61.6	171.6	33.3	12.6
MT0978	-	-	114.9	60.1	173.5	30.5	12.3
Cowboy	Wyoming/Colorado, 2012	-	114.5	61.2	171.6	31.3	11.4
MTCL1131	-	-	113.8	61.4	175.9	33.7	12.0
MT1286	-	-	112.9	61.4	173.7	31.9	12.2
LCS Colonia	-	-	112.7	56.5	177.6	27.0	11.9
MT1246	-	-	112.3	60.3	172.6	32.2	12.3
SY Wolf	Syngenta (Agripro), 2010	-	111.7	61.6	168.8	27.3	12.4
MT1262	-	-	111.3	61.5	173.8	30.8	12.4
Jagalene	AgriPro, 2002	-	110.4	63.2	169.6	32.5	12.4
Broadview	Alberta, 2009	-	109.6	60.6	170.5	31.5	12.0
Decade	Montana/North Dakota, 2010	-	109.6	60.5	167.7	30.7	12.5
LCS Wizard	-	-	109.2	61.9	169.4	26.6	12.3
MT1078	-	-	108.6	59.4	173.2	29.8	11.9
SY Clearstone 2CL	Montana/Syngenta, 2012	-	108.6	60.6	173.8	33.7	11.8
MTS1224	-	-	107.8	60.0	176.1	27.9	12.4
Colter	Montana, 2013	-	107.2	60.2	174.6	32.9	12.9
Emerson	-	-	106.9	61.4	175.5	33.5	12.8
McGill	Nebraska, 2010	-	106.7	60.9	168.5	33.4	12.1
Freeman	-	-	106.6	58.7	166.7	27.3	12.4
Promontory	Utah, 1990	-	105.7	63.0	171.7	32.7	11.1
CDC Falcon	Sask/WestBred, 1999	7.1	104.4	60.7	171.5	28.7	12.0
Carter	WestBred, 2006	14.3	104.2	60.1	169.1	28.5	12.6
MTS1228	-	-	103.5	60.4	173.8	29.7	12.4
MTS1024	-	-	103.2	59.0	176.1	28.7	12.4
Genou	Montana, 2004	21.5	103.0	61.3	172.8	34.4	12.4
MTCS1204	-	-	102.4	61.6	174.7	31.8	12.3

Table 1 continued on next page

Table 1 continued								
Variety and Class	Source	Solid Stem score*	Yield bu/ac	Test weight lb/bu	Heading Date Julian	Plant height In	Protein %
Radiant	Alberta, 2002	-	101.4	60.9	173.4	35.4	12.6
T158	-	-	100.5	63.2	166.0	25.9	12.1
WB4614	Westbred,2013	-	100.2	60.9	172.0	30.1	12.2
Rampart	Montana, 1996	23.5	99.7	61.0	171.3	33.7	13.4
Bearpaw	Montana, 2011	22.8	98.5	60.1	170.7	29.7	12.8
MTF1232	-	-	98.3	60.2	176.4	42.0	13.6
Jerry	North Dakota, 2001	-	97.5	59.9	173.4	34.0	12.2
Judee	Montana, 2011	22.3	97.5	62.1	169.4	30.2	12.6
WB-Quake	WestBred, 2011	21.1	97.2	60.2	174.2	31.5	12.7
MTS0826-63	-	-	95.3	59.5	175.3	35.6	13.1
Ledger	WestBred, 2004	10	94.4	61.4	170.0	30.2	11.8
MT1090	-	-	94.4	59.2	173.1	31.6	12.5
Warhorse	Montana, 2013	22.6	91.9	60.1	171.8	29.0	13.0
WB4059CLP	Westbred2013	-	67.3	60.0	166.5	25.3	12.8
Mean			106.6	60.8	172.3	31.3	12.3
LSD (0.05)			16.5	1.4	3.0	1.9	
C. V. (%)			8.8	1.3	1.0	3.4	
P-value (Varieties)			<0.0001	<0.0001	<0.0001	<0.0001	

Planted: 9/19/2013 on chemical fallow and harvested on 8/19/2014.
Fertilizer, actual pounds/ac of N-P-K: 11-22-0 applied with seed and 40-0-20 broadcast at planting. 130 lbs/ac N as urea was broadcast on 4/14/2014.
Herbicide, Huskie at 11.0 oz/ac and Axial XL at 16.4 oz/ac applied on 5/28/2014.
* Solid stem score of 19 or higher is generally required for reliable sawfly resistance.
CL = Clearfield System

Table 2. Six-year means, 2008 – 2014, 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
Yellowstone	MSU	-	-	100.3	60.7	34.3	172.9	11.2	4
SY Wolf	Syngenta	-	-	98.5	62.2	30.0	169.0	11.6	-
Colter	MSU	-	-	95.1	0.1	34.7	172.7	11.6	-
SY Clearstone 2CL	SY/MSU	-	-	95.1	60.1	34.7	172.7	11.6	-
Jagalene	AgriPro	-	-	94.1	63.0	32.6	169.6	11.9	2
CDC Falcon	CDC/WestBred	-	7.1	93.6	61.2	31.0	170.9	11.4	4
Decade	MSU/ND	-	-	91.6	61.2	32.7	169.1	12.0	-
Judee	MSU	-	22.7	89.8	62.4	32.8	170.1	11.6	-
Warhorse	MSU	-	23.9	89.1	60.9	32.4	172.2	12.0	-
Carter	WestBred	-	14.5	87.8	61.2	29.9	170.1	11.9	3
WB-Quake	WestBred	-	22.9	87.5	61.4	32.9	172.4	11.7	-
Bearpaw	MSU	-	22.5	86.8	61.1	31.5	170.6	11.9	-
Ledger	WestBred	-	9.5	86.0	61.6	31.8	170.7	11.2	2
Genou	MSU	-	23.0	85.4	61.6	36.0	172.0	12.0	2
Jerry	N. Dakota	-	-	83.6	60.5	37.3	172.0	11.9	5
Rampart	MSU	-	24.5	80.1	61.3	35.8	171.6	12.6	2
Mean				90.4	61.3	33.1	171.2	11.7	

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

Table 3. 2014 Preliminary A Variety Nursery, Western Triangle Ag. Research Center, Conrad, MT.

Variety or ID	Yield bu/ac	Test weight lb/bu	Heading date Julian	Protein %
MT1486	119.6	61.5	174.7	11.6
MT1467	119.3	64.0	167.3	13.0
CDC Falcon	118.9	61.7	170.4	12.3
MT1481	118.5	60.9	171.5	12.0
MT1471	117.8	62.0	174.2	13.0
MTCL1437	117.5	61.2	170.1	12.6
MT1460	116.9	61.1	174.8	12.1
MT1469	116.8	63.9	167.6	13.1
MT1487	116.8	60.4	170.6	12.6
MT1488	116.2	61.5	174.9	12.5
MT1489	114.7	62.1	175.6	11.9
MT1440	114.4	61.9	175.6	11.3
MT1473	114.0	61.6	172.9	12.5
MT1480	113.9	60.1	172.8	12.2
MT1458	113.8	60.2	166.2	12.3
MT1475	112.9	59.4	166.9	12.3
MT1483	112.7	61.3	175.7	12.2
MT1472	112.6	62.0	172.0	13.3
MT1447	110.8	61.1	171.9	11.9
MT1482	109.5	61.5	171.8	11.8
MT1465	109.3	61.6	172.3	12.2
MT1462	109.2	60.8	172.3	12.2
MT1478	108.9	61.2	170.0	11.9
Yellowstone	108.6	61.6	175.6	11.7
MTW1477	108.0	61.3	168.0	12.9
MT1444	107.0	61.1	174.4	12.2
MT1453	105.9	62.5	168.4	11.8
MT1485	105.3	61.4	176.4	12.6
MT1461	105.0	60.6	170.5	11.3
MTW1491	104.8	62.8	174.8	11.0
MT1470	104.5	61.8	168.5	12.9
MT1443	104.4	60.9	173.3	12.1
Jagalene	103.5	63.2	167.9	12.5
MTF1435	103.5	61.6	176.0	11.9

Table 3 continued on next page

Table 3 continued

Variety or ID	Yield (bu/a)	Test Weight (lbs/bu)	Heading Date Julian	Protein (%)
Decade	103.4	60.9	167.5	12.3
MT1445	103.2	61.5	174.2	11.9
MT1449	102.1	61.5	172.2	12.3
MT1448	101.9	61.3	173.6	11.5
MTW1490	101.5	61.4	176.1	11.5
MTCL1436	101.0	60.1	174.4	11.1
MT1459	99.4	61.7	173.2	12.3
MTF1432	99.0	60.4	178.0	11.7
MT1450	98.3	60.9	172.5	12.5
MTF1433	96.6	62.4	177.3	13.6
MTW1479	95.7	61.3	173.2	11.5
MT1446	95.3	61.2	171.4	12.0
MT1468	94.5	63.7	167.5	12.5
MT1451	94.1	61.2	174.5	11.7
MT1439	93.0	60.8	171.0	12.4
MTW1463	92.2	62.1	172.0	11.9
MT1452	88.3	60.3	173.9	12.0
MT1484	88.1	60.3	174.1	12.1
MT1474	87.6	59.6	168.4	12.5
MTW1466	86.3	64.0	169.3	12.8
MT1455	82.2	61.8	175.2	12.4
MT1464	81.9	61.6	167.9	11.7
MT1441	81.4	60.9	173.8	12.4
MT1456	79.9	61.6	171.7	13.1
MT1476	78.6	61.9	169.7	13.7
MT1454	78.0	60.2	175.8	12.6
MTF1434	76.9	62.8	179.3	14.1
MT1438	59.9	61.8	170.1	12.0
MT1457	53.9	62.4	170.5	12.7
Mean	101.1	61.5	172.3	12.3
LSD (0.05)	31.4	1.1	2.9	
C. V. (%)	15.6	0.8	0.8	
P-value (Varieties)	0.0263	<0.0001	<0.0001	

Planted: 9/19/13 on chemical fallow and harvested on 8/20/14.
Fertilizer, actual pounds/ac of N-P-K: 11-22-0 applied with seed and 30-0-20 broadcast at planting. 97.5 lbs/ac N as urea was broadcast on 4/11/14.
Herbicide, Huskie at 11.0 oz/a and Axial XL at 16.4 oz/a applied on 5/28/14

Table 4. 2014 Advanced Yield 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 %
MT1356	127.3	61.4	173.7	32.0	11.9
MT1361	120.5	61.7	175.3	31.0	12.0
Yellowstone	117.5	61.4	174.3	33.0	11.9
MT1352	113.8	60.9	173.0	33.3	11.9
MT1358	112.9	61.3	177.3	32.3	12.0
MT1332	112.8	61.6	175.0	32.0	11.8
MT1351	112.7	60.2	174.7	32.0	12.3
MT1369	111.6	62.4	169.0	31.3	13.6
MTCL1329	111.0	62.9	173.0	30.7	11.5
Jagalene	109.0	63.9	169.7	31.0	12.7
MT1348	108.2	61.3	170.7	29.3	11.8
MT1378	108.1	61.6	174.0	31.7	12.1
MT1331	105.1	61.9	169.7	32.3	12.4
MT1380	105.0	60.9	177.0	31.7	12.4
MT1383	104.1	62.9	174.7	31.3	11.4
MT1360	103.7	61.6	176.3	29.3	12.1
MT1381	102.1	62.4	176.7	32.3	11.6
MT1350	101.5	62.2	172.0	27.0	11.7
MT1336	101.1	60.7	167.3	31.0	12.5
MTS1326	100.8	61.5	174.7	31.0	12.6
MT1354	100.6	61.6	177.0	32.0	11.9
MTW1374	100.6	62.1	174.3	31.0	11.7
MTCS1301	99.9	62.2	170.7	29.0	12.3
MT1376	98.7	60.6	174.3	31.7	12.6
MT1385	98.5	61.7	177.3	36.0	12.9
MT1346	94.8	61.7	170.0	26.7	12.2
MT1334	93.6	60.4	174.7	32.3	12.1
Decade	92.4	60.1	169.0	31.7	12.2
Genou	91.9	61.4	170.7	36.0	12.8
MTS1308	91.7	61.6	169.0	27.0	12.0
MT1373	89.9	60.7	177.7	32.3	12.3
MTS1307	86.0	62.4	168.7	29.3	11.3
MTS1305	85.5	62.0	171.0	26.3	12.2

Table 4 continued on next page

Table 4 continued

ID or Variety	Yield bu/ac	Test weight lb/bu	Heading Date Julian	Plant height In	Protein %
MTCL1328	84.7	61.1	169.7	27.3	12.5
Judee	83.0	61.7	172.3	28.3	12.1
MT1355	82.6	61.3	176.3	31.3	12.1
Mean	101.8	61.6	173.1	30.9	12.2
LSD (0.05)	21.3	1.2	3.5	3.1	
C.V. (%)	12.9	1.2	1.2	6.2	
P-value (Varieties)	0.0043	<0.0001	<0.0001	<0.0001	

Planted: 9/19/13 on conventional fallow and harvested on 8/13/14.
Fertilizer, actual pounds/ac of N-P-K: 11-22-0 applied with seed and 40-0-20 broadcast at planting. 115 lbs/ac N as urea was broadcast on 4/11/14.
Herbicide, Huskie at 11 oz/ac and Axial XL at 16.4 oz/a. applied on 5/28/14.

Table 5. Off-station Winter Wheat variety trial (Exp. 3866) located east of Choteau, MT. Teton County. Western Triangle Ag. Research Center. 2014.

Variety or ID	Yield bu/ac	Test weight lb/bu	Plant height in	Protein %	Lodging %
Jagalene	80.0	63.2	35.0	14.4	12
MT1138	75.9	57.4	34.7	15.1	13
MTCS1204	75.8	61.0	36.0	14.4	8
SY Clearstone 2CL	75.5	57.8	35.3	14.6	30
Yellowstone	75.2	57.4	35.0	15.3	42
MT0978	74.3	57.6	34.3	15.3	9
Decade	73.2	60.6	33.3	14.7	2
WB3768	72.7	58.7	36.7	14.9	20
MT1078	72.6	57.7	33.7	14.3	27
MT1117	70.8	57.9	33.7	15.5	37
Colter	70.4	58.0	35.0	15.3	30
Accipiter	67.7	57.0	34.0	15.1	4
CDC Falcon	67.5	58.4	31.7	14.8	3
MT1090	67.5	56.8	35.3	15.1	22
Jerry	67.3	57.8	38.7	14.8	22
MTS1024	67.3	56.3	32.3	14.3	10
Judee	67.2	58.7	33.3	15.5	4
WB-Quake	67.1	59.2	33.7	14.9	2
Bearpaw	65.6	60.3	34.3	14.9	1
Genou	65.2	58.5	38.0	15.4	4
MT1286	64.5	58.1	30.7	14.7	60
Warhorse	64.1	58.1	32.7	14.4	1
Rampart	62.7	59.6	37.3	15.3	3
MTS0826-63	62.7	59.2	37.3	15.6	1
Mean	69.7	58.6	34.7	14.9	15.2
LSD (0.05)	8.5	1.3	1.5		15.3
C.V. (%)	7.5	1.3	2.6		61
P-value (Varieties)	0.0034	<0.0001	<0.0001		<0.0001

Cooperator and Location: Inbody Farms, Teton County.
Planted: September 20, 2013 on chem-fallow Harvested: 8/13/14
Fertilizer, actual lbs/ac: 11-22-0 applied with seed and 40-0-20 urea blended with potash were broadcast at seeding. Spring topdressing took place on 5/6/2014 with 29-0-0. For fertilizer rates a yield goal of 70 bu/ac.
Herbicide: None Precipitation: No data.
Conducted by MSU Western Triangle Ag. Research Center.

Table 6. Three-year means, Winter Wheat varieties, Choteau Area, Teton County. 2012-2014.

Variety	**	3-Year Mean Yield bu/a	Test weight	Height in.	Protein %
Yellowstone	-	57.5	57.9	31.4	15.1
Jagalene	-	57.1	61.3	29.5	14.8
Bearpaw (MTS0721)	**	53.6	59.3	29.4	15.0
CDC Falcon	-	53.0	57.7	28.7	15.0
Colter (MT08172)	-	53.0	57.7	28.7	15.0
SY Clearstone 2CL	-	52.8	58.0	31.9	15.2
Genou	**	52.4	58.9	29.0	15.2
Judee (MTS0713)	**	52.1	58.9	29.0	15.2
Decade	-	51.9	59.1	29.3	15.4
Warhorse (MTS0808)	**	49.2	57.9	28.7	15.0
Jerry	-	48.8	58.0	32.9	15.6
Accipiter	-	48.7	57.3	29.0	15.7
WB-Quake	**	48.0	58.1	28.7	15.4
Rampart	**	45.3	59.0	32.5	15.8
Mean		51.7	58.5	30.4	15.3

** = 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 7. Off-station Winter Wheat variety trial located north of Cut Bank, MT. Glacier County. Western Triangle Ag. Research Center. 2014.

Variety or ID	Yield bu/a	Test Wt. lb/bu	Height in.	Protein %
MT1138	80.4	56.5	34.3	13.6
MTW08168	75.4	56.0	35.0	13.6
MTS0826-63	73.4	56.1	35.3	14.4
Jagalene	71.9	57.2	33.3	13.4
Judee	71.1	55.6	32.0	13.5
MTS1024	70.5	52.6	30.0	13.4
Bearpaw	70.2	54.0	32.3	13.8
Yellowstone	67.6	53.9	34.3	13.7
MT1078	67.6	53.0	30.7	13.1
Accipiter	66.2	54.7	33.0	13.9
MT1090	66.1	54.8	34.3	13.6
MTCS1204	65.3	55.5	33.5	13.2
CDC Falcon	64.3	52.5	30.0	14.0
Warhorse	64.3	54.6	30.7	14.4
SY Clearstone 2CL	64.3	53.8	34.3	13.7
Decade	64.2	54.2	32.3	13.6
MT1117	64.1	55.8	34.3	13.7
Rampart	64.0	55.4	35.3	14.8
Colter	63.1	55.4	34.0	13.7
MT0978	61.4	54.6	33.3	14.1
Jerry	59.9	52.7	36.7	14.1
MT1286	57.8	54.4	33.3	13.6
WB-Quake	54.6	55.3	32.3	13.8
Genou	50.8	55.0	37.0	14.5
Mean	65.8	54.7	33.4	13.8
LSD (.05)	NS	2.0	2.2	
C.V. (%)	17.1	2.2	4.0	
P-Value	0.4910	0.0004	<0.0001	

Cooperator and Location: Bradley Farms, northern Glacier County.
Planted 9/24/13 on chem-fallow. Harvested 9/18/14.
Fertilizer, actual lbs/a: 11-22.5-0 with seed at planting, top dressed with 99-0-00 on 5/22/14. For fertilizer rates a yield goal of 70 bu/ac.
Sprayed with Huskie at 11 oz/ac and Axial XL at 16.4 oz/ac on 6/21/13.
Conducted by MSU Western Triangle Ag. Research Center.

Table 8. Off-station Winter Wheat Variety Trial located in the Devon area.
Western Triangle Ag. Research Center. 2014.

Variety or ID	Yield bu/ac	Test Wt lb/bu	Plant Ht (in)	Protein %
MT1286	67.9	62.6	27.7	10.4
MT1090	65.2	62.8	30.3	11.2
Accipiter	62.7	63.9	28.3	10.7
Yellowstone	62.1	62.1	30.0	11.1
Colter	62.1	63.2	30.0	11.4
MT0978	61.5	62.5	25.0	11.9
WB-Quake	61.0	63.1	27.3	11.2
Decade	60.9	63.9	28.3	12.0
MT1138	60.9	62.7	29.0	11.4
MTW08168	60.5	62.8	32.0	11.4
MTS1024	59.8	60.9	25.0	10.6
MTS0826-63	58.3	62.2	29.3	11.8
MT1117	57.1	62.8	28.3	10.9
CDC Falcon	55.9	62.8	25.0	11.5
SY Clearstone 2CL	55.9	62.3	29.0	11.5
Rampart	54.7	63.3	29.3	12.4
Warhorse	53.1	62.9	26.3	11.5
MT1078	53.1	61.5	24.3	10.4
Genou	52.8	63.0	26.0	11.5
Jerry	52.7	61.8	28.0	11.8
MTCS1204	52.6	63.0	29.0	13.1
Bearpaw	51.7	63.2	23.7	12.9
Jagalene	51.3	65.0	26.0	12.5
Judee	50.1	63.5	23.7	11.9
Average	57.7	62.8	27.5	11.5
LSD (.05)	ns	1.3	2.6	
C.V.	13.5	1.3	5.8	
P-Value (0.05)	0.3159	0.0003	<0.0001	

Cooperator and Location: Aklestad Farms, Toole County.
Planted9/20/14 chem-fallow. Harvested 8/6/14
Fertilizer, actual lbs/ac: 22-22-20. 11-52-0 Placed with seed while planting. Top dressed with 10-0-20 while planting. Spring topdressing took place on 5/22/14 with 29-0-0. For fertilizer rates a yield goal of 50 bu/ac.
Herbicide: None
Precipitation: 3.8 inches

Table 9. Four-year means, Winter Wheat varieties, Devon area, Eastern Toole County. 2010 2014.

Variety	**	4-Year Mean Yield bu/a	Test weight	Height in.	Protein %
Yellowstone	-	50.7	58.4	27.2	12.5
Decade	-	50.6	60.0	27.1	12.7
WB-Quake	**	49.2	59.3	26.5	13.0
Colter (MT08172)	-	49.1	59.4	28.1	13.1
Accipiter	-	49.0	59.1	26.7	12.4
CDC Falcon	-	47.2	58.8	24.9	12.7
SY Clearstone 2CL	-	47.0	58.6	27.7	12.8
Jerry	-	46.8	58.7	27.4	12.7
Judee (MTS0713)	**	46.4	59.8	25.3	13.2
Bearpaw (MTS0712)	**	46.2	59.6	24.9	13.2
Warhorse (MTS0808)	**	45.3	59.1	26.5	13.1
Jagalene	-	44.7	60.5	26.4	12.8
Genou	**	44.7	59.6	28.0	12.9
Rampart	**	39.7	59.2	27.7	13.4
Mean		46.9	59.3	26.8	12.9

** = 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 10. Off-station Winter Wheat variety trial located near the Knees.
Chouteau County. Western Triangle Ag. Research Center. 2014.

Variety or ID	Yield bu/a	Test Wt. lb/bu	Height in.	Protein %
Yellowstone	74.1	60.6	29.0	12.9
Decade	70.9	62.6	29.7	14.1
Colter	69.2	60.5	29.3	13.4
MTS1024	69.0	59.0	28.0	12.6
MT1117	67.0	61.1	31.3	13.6
MT1138	66.4	60.3	29.7	13.5
WB-Quake	63.1	61.6	27.5	13.0
Accipiter	63.0	61.8	28.5	13.1
MT0978	62.9	60.6	27.0	13.2
MTCS1204	62.0	61.6	28.0	13.3
Warhorse	61.3	61.5	27.0	12.9
Judee	60.9	61.5	29.0	13.7
SY Clearstone 2CL	59.5	59.2	30.0	13.7
MT1286	59.5	59.2	29.3	13.0
MTW08168	59.3	60.9	31.3	13.1
MTS0826-63	59.0	61.3	30.3	13.9
CDC Falcon	58.2	61.4	25.0	14.0
Jerry	58.0	59.7	31.0	13.5
MT1078	58.0	59.2	26.7	13.0
Bearpaw	57.6	62.0	26.7	13.7
Rampart	57.1	60.6	28.3	13.6
MT1090	52.2	59.8	31.3	12.8
Genou	51.9	61.0	28.3	13.3
Jagalene	48.9	63.6	26.0	13.8
Mean	61.2	60.9	28.7	13.4
LSD (.05)	ns	1.8	2.1	
C.V. (%)	18.4	1.8	4.5	
P-Value	0.6361	0.0002	<0.0001	

Cooperator and Location: Aaron Killion, western Chouteau County.
Planted 9/30/ 2013 on chem-fallow. Harvested 8/12/14.
Fertilizer, actual lbs/ac: 11-22-0 with seed at planting, 105-0-20 broadcast while planting. Spring topdressing took place on 5/21/14 with 65-0-0. For fertilizer rates a yield goal of 70 bu/a.
Pre-plant sprayed with Olimpus @ 0.6 oz/ac on May 10/23/13
Conducted by MSU Western Triangle Ag. Research Center.

Table 11. Four-year means, Winter Wheat varieties, Knees area, western Chouteau County. 2010-2014.

Variety or ID	**	4-Year Mean Yield (bu/a)	Test weight (lbs/bu)	Height (in)	Protein (%)
Yellowstone	-	65.9	59.5	31.5	13.2
SY Clearstone 2CL	-	64.2	58.6	33.7	13.4
Colter (MT08172)	-	63.9	59.6	31.3	13.0
Warhorse (MTS0808)	**	62.9	60.3	29.7	12.8
Decade	-	61.3	60.9	30.3	13.6
WB-Quake	**	59.1	60.1	30.0	13.1
Judee (MTS0713)	-	58.8	61.1	28.8	13.6
Accipiter	-	58.2	60.5	29.6	13.3
CDC Falcon	-	58.1	60.4	28.3	13.6
Jagalene	-	54.4	62.2	29.3	13.1
Bearpaw (MTS0721)	**	53.5	60.1	28.9	13.5
Jerry	**	53.2	59.3	32.1	13.4
Genou	**	51.3	60.4	32.0	13.4
Rampart	**	51.3	60.4	31.2	13.7
Mean		58.3	60.2	30.4	13.3

** = 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.

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.

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Spring wheat

2014 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 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 2014. 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.

Results: Results are tabulated in Tables 1 thru 15. Results for the Advance 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 is for the Choteau location, with multi-year data presented in Table 6. Tables 9 and 10 are for the Devon location, with Table 11 and 12 representing the 'Knees' location. The durum nursery data are shown in Tables 13 and 14. The Cut Bank location sustained a hailstorm affecting the yield data (Tables 7 and 8). Soil test results presented in Table 1 of the soil test results section.

The 2014 growing season at WTARC was a little cooler than average with a wetter than normal June. The June rain was very timely with respect to the small grain plots.

Top yielding varieties at Choteau were MT1172, MT1203, and WB Gunnison with protein averaging 14.7% across all varieties. MT1172, Vida, and Reeder were the high yielding varieties at Devon while averaging 14.6% protein across all varieties. The 'Knees' high yielders were Mott, MT1172, and WB Gunnison with 15.4% protein across all varieties. The best yielding varieties, after the hail storm at the Cut Bank location were Duclair, WB Gunnison, and Vida with 15.9% protein across all varieties. The top yielders in the irrigated trial were Volt, MT1103, and Duclair with protein averaging 13.2 percent. The top yielding varieties in the advanced nursery were LIMAGR142, Reeder, and SY Rowyn . Average grain protein for the advanced nursery was 12.2%.

Yields in the advanced nursery ranged from 64.5 to 106.4 bu/acre. Yields were much higher when compared to the six year average. Test weight for the advanced nursery was half pound per bushel higher, with higher grain protein when compared to the six year average (Tables 1 and 2).

Yields in the irrigated off-station spring wheat trial ranged from 78.9 to 117.8 bu/acre. When compared to the five year averages, the irrigated off-station spring wheat nursery had much higher yields, with average test weight, and with similar grain protein (Tables 3 and 4). Yields ranged from 39.0 to 50.1 bu/acre at Choteau, 32.9 to 47.6 bu/acre north of Devon, and 31.1 to 58.7 bu/acre at the 'Knees'. At Devon the 2014 yield was up 3.8 bu/acre from the four year average; with similar grain protein and slightly higher test weight (Tables 9 and 10). The 'Knees' location had lower yields, higher grain protein and lower test weight when compared to the four year mean (Tables 11 and 12). Yields at Cut Bank ranged from 26.1 to 44.3 bu/acre, with 15.9% seed protein across all varieties, with low test weights.

Durum yields ranged from 74.1 to 87.9 bu/acre (Table 7). With Strongfield, MT06584, and Alzada being the top three yielding varieties. The 2014 yields were about 7.7 bu/acre higher than the six year average (Table 8). Test weights were about a pound per bushel lighter 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, MT

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.

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.

Table 1. 2014 Spring Wheat Advanced Yield 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 %
LIMAGR142	106.4	61.5	181.0	32.3	11.4
Reeder	104.7	61.5	182.3	35.0	11.4
SY Rowyn	104.3	61.0	181.3	30.7	12.1
MT1219	101.5	60.6	181.7	29.7	11.8
MT1205	101.3	61.2	181.0	31.3	12.0
LIMAGR143	100.8	61.2	182.3	36.3	11.6
MT1304	100.5	61.6	180.0	30.7	11.3
LIMAGR141	99.8	58.8	183.3	29.3	11.7
MT1319	99.7	61.7	180.7	33.7	11.9
Corbin	98.0	61.9	181.7	32.3	12.1
Volt	97.6	63.3	183.7	30.0	11.6
WB 96688	95.8	60.6	181.0	27.0	12.7
MT 1348	95.5	61.2	181.3	32.7	12.6
MT 1273	95.3	61.6	183.0	32.7	10.6
Duclair	94.7	60.9	181.0	32.0	11.6
Buckpronto	94.4	59.7	180.7	29.3	13.2
MT 1264	94.1	59.3	181.7	32.3	12.2
MT 1320	94.1	61.4	181.3	35.3	12.7
Vida	94.0	61.3	182.7	34.0	10.7
MT 1316	93.7	61.1	180.7	31.0	12.0
MT 1337	93.7	60.9	181.3	33.7	13.1
MT 1203	93.6	61.1	180.3	30.3	13.2
WB9879CL	93.6	61.0	183.0	32.0	12.6
MT 1225	93.1	59.3	182.0	32.0	12.2
McNeal	92.7	60.8	182.7	33.0	12.8
SY Soren	92.5	61.1	182.3	29.3	12.4
MT 1118	91.7	58.5	181.3	29.7	12.8
MT 1276	91.4	60.7	181.3	32.3	11.7
MT 1315	91.2	62.1	180.3	32.3	12.2
SY Tyra	91.2	59.9	181.7	28.7	10.8
WB 9518	91.2	59.9	181.7	28.7	10.8
SY605 CL	89.6	61.9	180.0	34.7	14.1
WB Gunnison	89.3	62.4	182.7	33.3	11.9

Table 1 continued on next page

Table 1 Continued

ID or Variety	Yield bu/ac	Test weight lb/bu	Heading Date Julian	Plant height In	Protein %
MT 1224	88.8	59.0	182.3	32.0	11.9
MT1341	88.8	60.6	180.7	30.7	12.5
MT1331	88.5	56.0	181.7	31.7	11.4
WB 9507	88.4	57.6	182.3	34.3	12.4
MT 1336	87.7	59.9	181.0	31.3	12.1
MT 1222	87.7	59.9	181.0	31.3	12.1
ONeal	86.5	61.0	183.7	33.3	11.0
MT 1206	86.2	60.5	181.7	30.7	11.7
MT 1228	85.2	58.2	183.0	31.7	11.6
MT 1346	84.8	60.5	181.0	31.3	13.1
MT 1230	84.5	58.8	183.0	31.3	12.3
MT 1343	83.4	60.4	182.3	33.0	12.6
MT 1227	83.2	56.4	183.7	31.7	11.6
MT 1007	83.0	60.9	182.0	30.3	11.2
MT 1360	82.3	58.2	180.7	32.3	12.8
MT 1340	82.1	59.4	181.0	28.7	12.6
MT 1231	81.9	58.5	182.7	31.0	12.8
MT 1349	81.8	58.4	181.3	29.7	12.8
BZ 903-473	81.4	61.7	183.0	27.3	11.7
SY Ingmar	81.3	60.9	182.7	30.7	11.9
MT 1333	80.9	61.9	182.7	32.7	13.4
Fortuna	80.6	60.3	183.3	41.0	12.8
Brennan	79.3	61.1	180.7	28.7	13.1
MT 1236	78.7	59.0	181.7	30.7	12.7
Egan	77.6	60.4	183.7	32.7	13.5
Jedd	75.8	59.6	182.7	27.0	12.3
Mott	75.4	59.3	183.0	37.3	12.3
Choteau	73.9	58.5	182.3	29.7	12.3
Thatcher	64.5	58.3	185.0	43.0	13.0
Mean	89.3	60.3	181.9	31.9	12.2
LSD (0.05)	15.2	1.7	1.1	2.0	
C.V. (%)	10.8	1.7	0.4	4.0	
P-value (Varieties)	<0.001	<0.001	<0.001	<0.001	

Planted: 4/21/2014 on conventional fallow and harvested on 9/7/14.
Fertilizer: actual pounds/ac. of N-P-K: 11-22-0 applied with seed and a 180-0-20 blend of urea and potash was broadcast at planting. Fertilizer rates are based on a yield goal of 60 bu/ac.
Herbicide: The plot area was pre-plant sprayed with 20 oz/ac RT3 on 4/24/2014. The plots were sprayed with Huskie at 11 oz/ac and Axial XL at 16.4 oz/ac on 5/30/2014.
Precipitation for growing season: 7.2 in.

Table 2. Five Year averages, advanced dry land Spring Wheat varieties, Conrad area, Pondera, County MT. 2010 - 2014.

Variety	Source	Class	5-Year Average Yield bu/a	Test Weight	Height in.	Head date	Protein %
Duclair	MSU	**	80.2	59.8	32.5	181.8	13.0
SY Soren	Syngenta/AgPro	-	79.3	61.5	30.9	183.9	13.5
SY605CL	Syngenta/AgPro	CL	78.8	62.0	35.1	182.6	14.1
Corbin	WestBred	*	77.7	60.6	32.0	183.2	13.3
Volt	WestBred	-	77.1	62.9	30.1	185.8	12.5
Reeder	N.Dak	-	76.6	61.1	33.9	183.5	13.2
Vida	MSU	*	76.1	60.3	33.8	185.0	12.4
Choteau	MSU	**	76.1	59.5	30.8	183.7	13.0
WB9879CL	Westbred/CL	CL	76.1	60.6	32.1	184.7	13.4
McNeal	MSU	-	75.1	60.4	33.7	184.7	13.0
SY Tyra	Sygenta	*	74.6	60.9	28.8	184.6	12.0
WB Gunnison	WestBred	*	73.2	61.4	31.2	183.9	12.8
Buck Pronto	Limagr	-	71.7	59.9	30.3	182.4	13.7
ONeal	Westbred	*	70.9	61.1	33.1	185.1	12.7
Egan		-	69.1	60.0	32.5	184.9	13.9
Fortuna	ND	**	67.1	61.1	39.0	185.3	13.5
Jedd	Westbred	CL	65.8	59.9	27.3	183.5	12.7
Mean			74.4	60.8	32.2	184.0	13.1

** = Solid stem sawfly-resistant (solid stem score of 19 or higher).
* = Less preferred by sawfly (behavioral preference) in small plots.
CL = Clearfield System
Location: MSU Western Triangle Ag. Research Center, Conrad, MT.

Table 3. Off-station Irrigated Spring Wheat variety trial located, WTARC MT.
Pondera County. Western Triangle Ag. Research Center. 2014.

Variety	Class	Yield bu/ac	Test Wt lb/bu	Height in.	Head Date	Protein %
Volt	-	117.8	63.6	32.3	184.7	13.1
MT1103	-	114.0	63.2	32.3	187.0	12.5
Duclair	**	111.4	61.4	31.7	186.0	13.0
SY Tyra	*	107.8	62.5	31.0	185.0	12.1
MT1172	-	107.6	61.5	31.3	187.7	13.0
Vida	*	107.0	62.0	34.0	186.3	13.3
MT1236	-	104.3	61.2	33.0	186.3	13.7
WB9879CL	CL	103.5	62.0	35.0	185.0	13.5
WB Gunnison	*	103.2	63.0	32.0	187.3	12.8
McNeal	-	100.9	62.1	33.7	184.0	13.2
Corbin	*	99.5	62.3	32.0	186.0	13.3
MT1203	-	98.1	61.7	33.0	185.3	13.7
Choteau	**	97.6	61.5	30.3	185.0	13.1
Brennan	-	97.5	62.6	29.7	185.7	13.9
Reeder	-	96.8	62.7	34.3	185.3	13.1
Egan	-	95.7	61.7	32.7	186.3	14.5
ONeal	*	91.5	62.1	32.7	186.7	12.6
Mott	-	86.6	61.2	36.0	184.0	12.9
Fortuna	**	85.4	62.4	39.7	184.0	14.2
Jedd	CL	78.9	60.9	28.0	185.3	12.3
Mean		100.2	62.1	32.7	185.7	13.2
LSD (.05)		10.1	1.0	5.1	2.6	
C.V. 1 (%) (S/mean)*100		6.1	0.9	9.4	0.8	
P-Value		<0.0001	<0.0001	<0.0477	0.1697	

Cooperator and Location: WTARC, Pondera County.
Planted May 1, 2014 on chemical fallow barley stubble. Harvested September 6, 2011.
Fertilizer: actual pounds/ac of N-P-K: 11-22-0 applied with seed and a 240-0-20 blend of urea and potash was broad cast at planting. Fertilizer rates are based on a yield goal of 80 bu/ac.
Herbicide: The plot area was pre-plant sprayed with 20 oz/ac RT3 5/1/2014. The plots were sprayed with Huskie at 11 oz/ac and Axial XL at 16.4 oz/ac on 6/10/2014.
Irrigation: 4.0 inches
** = Solid stem sawfly-resistant (solid stem score of 19 or higher).
* = Less preferred by sawfly (behavioral preference) in small plots.
CL= Clearfield
Precipitation during growing season: 8.35 in.
Conducted by MSU Western Triangle Ag. Research Center.

Table 4. Five year means, Irrigated Spring Wheat Varieties, Conrad, MT. 2009 – 2014.

Variety	Class	Yield bu/ac	Test Wt lb/bu	Head date	Height in.	Protein %
Duclair	**	96.6	61.5	186.7	32.1	13.6
SY Tyra	*	90.1	62.4	188.5	30.6	12.7
Volt	-	90.0	63.6	189.4	32.1	13.1
WB Gunnison	*	88.7	62.4	188.7	32.1	13.4
Choteau	**	85.9	61.6	188.1	31.1	13.9
Corbin	*	82.0	62.5	187.6	33.4	13.5
O Neal	*	82.0	62.4	188.5	34.4	12.8
Vida	*	79.7	61.5	188.4	33.5	13.4
McNeal	-	78.8	61.8	188.3	33.7	13.3
Jedd	CL	76.6	61.5	187.4	27.6	12.7
Reeder	-	75.4	62.5	188.3	33.6	13.6
Fortuna	**	69.7	62.0	187.9	39.6	14.1
Means		83.0	62.1	188.1	32.8	13.3

** = Solid stem sawfly-resistant (solid stem score of 19 or higher).
* = Less preferred by sawfly (behavioral preference) in small plots.
CL= Clearfield
Conducted by MSU Western Triangle Ag. Research Center.

Table 5. Off-station Spring Wheat variety trial located northeast of Choteau, MT. Teton County. Western Triangle Ag. Research Center. 2014.

Variety	Source	Class	Yield bu/ac	Test Wt lb/bu	Height in.	Protein %
MT1172		-	50.1	54.4	30.0	14.2
MT1203		-	49.7	55.2	29.7	15.0
WB Gunnison	WestBred	*	49.7	57.1	32.0	13.1
Brennan		-	49.0	57.5	27.0	14.5
Vida	MSU	*	47.9	55.1	30.0	14.3
Duclair	MSU	**	47.6	54.0	30.3	14.2
Volt	WestBred	-	46.6	58.7	28.0	14.1
McNeal	MSU	-	45.5	55.4	31.3	15.1
MT1103		-	44.9	53.5	29.0	13.8
Egan		-	44.9	54.7	27.7	16.4
WB9879CL		CL	44.1	54.3	29.0	14.7
Corbin	WestBred	*	43.9	55.5	30.3	15.0
Mott	N.Dak	-	43.5	55.6	32.7	14.8
SY Tyra	Syngenta	*	42.5	56.0	26.0	13.2
Reeder	N.Dak	-	42.5	55.8	30.7	15.1
ONeal	WestBred	*	41.7	56.9	29.7	15.3
Fortuna	N.Dak	**	40.8	57.4	37.0	14.2
Choteau	MSU	**	40.1	53.5	28.0	15.1
Jedd	WestBred	CL2	39.6	54.1	24.7	15.1
MT1236		-	39.0	50.3	28.7	16.0
Mean			44.7	55.3	29.6	14.7
LSD (.05)			6.5	2.1	3.1	
C.V. (%)			8.9	2.3	6.3	
P-Value			0.0121	<0.0001	<0.0001	

Cooperator and Location: Inbody Farms, Teton County.
Planted May 6, 2014 on chemical fallow. Harvested September 6, 2014.
Fertilizer: actual pounds/ac of N-P-K: 11-22-0 applied with seed and a 100-0-20 blend of urea and potash was broadcast at planting. Fertilizer rates are based on a yield goal of 50 bu/ac.
Sprayed: none
Precipitation: N/A
** = Solid stem sawfly-resistant (solid stem score of 19 or higher).
* = Less preferred by sawfly (behavioral preference) in small plots.
CL = Clearfield
Conducted by MSU Western Triangle Ag. Research Center.

Table 6. Three-year means, Spring Wheat varieties, Choteau area, Teton County. 2012-2014.

Variety	Class	3-Year Mean Yield bu/ac	Test weight	Height in.	Protein %
WB Gunnison	*	43.1	58.0	28.1	14.8
Volt	-	42.9	60.2	27.7	15.0
McNeal	-	42.2	56.5	30.6	15.9
ONeal	*	40.6	57.3	28.8	16.2
Duclair	**	40.2	56.0	29.7	15.5
Vida	*	40.1	57.0	27.5	15.3
Corbin	*	38.8	58.1	28.1	15.9
Choteau	**	38.2	56.5	26.8	15.7
Reeder	-	37.9	58.3	28.3	15.9
SY Tyra	*	37.3	57.1	24.7	14.7
Jedd	CL	36.7	56.8	24.1	15.7
Fortuna	**	36.6	59.2	35.1	15.2
Mean		39.5	57.6	28.3	15.5

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

Table 7. Off-station spring wheat variety trial located north of Cut Bank, MT.
Glacier county. Western Triangle Ag. Research Center. 2014.

Variety	Class	Yield bu/ac	Test Wt lb/bu	Height in.	Protein %
Duclair	**	44.3	56.1	30.3	15.5
WB Gunnison	*	43.7	55.3	26.7	14.6
Vida	*	39.8	55.2	27.0	15.4
Choteau	**	39.5	55.3	28.0	15.8
Volt	-	38.0	56.3	29.3	15.5
Corbin	*	37.4	56.7	28.3	14.9
MT1172	-	37.2	54.3	27.7	15.7
Brennan	-	37.1	57.3	25.3	15.8
MT1103	-	37.0	56.9	29.3	15.3
McNeal	-	35.2	55.7	28.0	16.8
WB9879CL	CL	35.2	55.2	28.7	16.0
ONeal	*	33.7	55.5	28.7	16.1
MT1203	-	33.2	54.9	27.7	17.4
Jedd	CL	33.1	54.4	24.0	14.5
SY Tyra	*	32.2	56.0	24.5	15.1
Egan	-	31.5	55.4	26.7	17.9
MT1236	-	30.3	54.8	28.0	16.5
Reeder	-	30.2	54.4	28.7	16.5
Fortuna	**	28.5	55.7	35.7	15.5
Mott	-	26.1	56.1	32.0	16.9
Mean		35.1	55.6	28.3	15.9
LSD (.05)		ns	1.8	3.1	
C.V. 1 (%) (S/mean)*100		17.4	1.6	5.4	
P-Value		0.0691	0.0058	0.0000	

Cooperator and Location: Bradley Farms, northern Glacier County.
Planted May 22, 2014 on chemical fallow. Harvested September 18, 2014.
Fertilizer: actual pounds/ac of N-P-K: 11-22-0 applied with seed and a 75-0-20 blend of urea and potash was broadcast at planting. Fertilizer rates are based on a yield goal of 50 bu/ac.
Herbicide: The plots were sprayed with Huskie at 11 oz/ac and Axial XL at 16.4 oz/ac on 6/23/2014.
** = Solid stem sawfly-resistant (solid stem score of 19 or higher).
* = Less preferred by sawfly (behavioral preference) in small plots.
CL = Clearfield
Conducted by MSU Western Triangle Ag. Research Center.

Table 8. Five-year averages, dryland Spring Wheat varieties, Cut Bank, MT. Glacier County 2010-2014.

Variety	Class	5-Year Average Yield bu/ac	Test Weight	Height in.	Protein %
Choteau	**	64.1	58.1	30.6	14.0
Volt	-	63.9	61.9	31.2	13.4
Corbin	*	60.7	60.1	31.2	13.4
Vida	*	59.3	58.4	31.4	13.8
Duclair	**	57.4	57.2	31.9	14.0
WB Gunnison	*	57.4	60.5	31.0	12.8
Reeder	-	56.1	59.0	33.0	14.2
ONeal	*	55.9	56.1	32.0	14.4
McNeal	-	53.4	57.4	31.6	13.6
SY Tyra	*	48.0	57.6	28.3	13.0
Fortuna	**	48.0	60.7	38.4	13.8
Jedd	CL	47.8	55.4	26.9	13.5
Mean		56.0	58.5	31.5	13.6

** = Solid stem sawfly-resistant (solid stem score of 19 or higher).
* = Less preferred by sawfly (behavioral preference) in small plots.
CL = Clearfield System (2-gene).
MSU Western Triangle Ag. Research Center, Conrad, MT.

Table 9. Off-station spring wheat variety trial located Devon, MT.
Toole county. Western Triangle Ag. Research Center. 2014.

Variety	Class	Yield bu/a	Test Wt lb/bu	Height in.	Protein %
MT1172	-	47.6	59.7	25.0	14.0
Vida	*	45.7	59.8	25.0	14.0
Reeder	-	44.2	60.9	25.3	14.5
MT1103	-	43.1	58.7	23.3	14.6
Duclair	**	43.0	58.6	23.3	14.3
WB9879CL	CL	42.7	59.1	23.3	14.7
Mott	-	42.5	60.0	25.3	14.8
MT1203	-	42.5	59.1	23.7	15.8
SY Tyra	*	42.1	61.3	22.0	13.9
Volt	-	41.9	61.5	24.3	13.6
Brennan	-	40.0	60.4	21.0	15.2
Corbin	*	39.8	59.9	24.3	14.3
McNeal	-	39.4	59.7	24.7	14.4
Choteau	**	39.4	59.1	22.7	14.6
WB Gunnison	*	39.3	60.4	20.7	13.9
MT1236	-	39.3	56.9	23.0	15.3
Egan	-	39.2	57.9	24.7	15.8
Oneal	*	37.4	60.9	22.3	14.0
Fortuna	**	34.1	59.5	28.3	15.4
Jedd	CL	32.9	60.4	20.3	14.0
Mean		40.8	59.7	23.6	14.6
LSD (.05)		4.5	1.2	2.5	
C.V.		6.7	1.2	6.4	
P-Value		<0.0001	<0.0001	<0.0001	

Cooperator and Location: Brian Aklestad
Planted May 21, 2014 on chemical fallow barley stubble. Harvested September 7, 2014.
Fertilizer: actual pounds/ac of N-P-K: 11-22-0 applied with seed and a 90-0-20 blend of urea and potash was broadcast at planting. Fertilizer rates are based on a yield goal of 35 bu/ac.
Herbicide: The plot area was pre-plant sprayed with 20 oz/ac RT3 on 5/21/2014. The plots were sprayed with Huskie at 11 oz/ac and Axial XL at 16.4 oz/ac on 6/16/2014.
Growing season precipitation: 3.8 inches
** = Solid stem sawfly-resistant (solid stem score of 19 or higher).
* = Less preferred by sawfly (behavioral preference) in small plots.
CL = Clearfield
Conducted by MSU Western Triangle Ag. Research Center.

Table 10. Four-year means, Spring Wheat varieties, Devon area, Eastern Toole County. 2010-2012, 2014.

Variety	Class	4-Year Mean Yield bu/ac	Test weight	Height in.	Protein %
Vida	*	41.2	58.4	26.3	13.6
WB Gunnison	*	39.6	58.6	24.9	14.6
Volt	-	39.3	61.0	25.5	14.0
Duclair	**	39.0	56.0	26.3	14.4
Reeder	-	37.6	58.5	26.9	14.7
ONeal	*	37.1	59.8	26.1	14.7
Fortuna	**	37.0	58.6	30.6	14.7
Corbin	*	36.4	58.6	26.2	14.7
Choteau	**	36.0	57.3	24.3	14.7
McNeal	-	35.8	57.9	26.9	15.0
SY Tyra	*	33.4	58.7	23.2	13.8
Jedd	CL	32.2	58.7	23.3	14.5
Mean		37.0	58.5	25.8	14.4

** = Solid stem sawfly-resistant (solid stem score of 19 or higher).
* = Less preferred by sawfly (behavioral preference) in small plots.
CL = Clearfield System (2-gene). HW = Hard White
Location: MSU Western Triangle Ag. Research Center, Conrad, MT.

Table 11. Off-station spring wheat variety trial located near the Knees. Chouteau County. Western Triangle Ag. Research Center. 2014.

Variety	Class	Yield bu/a	Test Wt lb/bu	Height in.	Protein %
Mott	-	58.7	58.4	30.7	16.3
MT1172	-	53.7	58.0	27.7	14.3
WB Gunnison	*	52.3	58.6	27.7	14.8
Duclair	**	47.4	55.8	28.3	15.5
Volt	-	46.7	58.8	27.7	14.9
McNeal	-	46.5	57.6	29.7	15.3
MT1103	-	46.5	58.3	26.0	15.0
Vida	*	46.2	56.8	29.3	15.3
MT1203	-	46.1	57.5	27.7	15.9
Choteau	**	45.3	56.8	26.0	15.4
Brennan	-	44.5	58.0	25.0	15.8
MT1236	-	43.6	56.3	24.3	15.4
Egan	-	42.7	57.2	26.3	16.7
Fortuna	**	42.6	58.8	32.0	15.5
Jedd	CL2	41.2	57.3	23.3	14.9
Reeder	-	40.3	59.6	26.3	15.5
WB9879CL	CL	39.3	57.4	26.0	15.3
ONeal	*	38.9	58.4	28.0	15.3
SY Tyra	*	38.0	55.9	23.7	15.1
Corbin	*	31.1	57.5	26.3	15.2
Mean		44.2	57.6	27.1	15.4
LSD (.05)		ns	3.6	2.8	
C.V. 1 (%) (S/mean)*100		16.7	2.1	6.3	
P-Value		0.0965	0.0511	<0.0000	

Cooperator and Location: Aaron Killion, western Chouteau County.
Planted May 21, 2014 on chemical fallow. Harvested September 7/ 2014.
Fertilizer: actual pounds/ac of N-P-K: 11-22-0 applied with seed and a 100-0-20 blend of urea and potash was broadcast at planting. Fertilizer rates are based on a yield goal of 45 bu/ac.
Herbicide: The plot area was pre-plant sprayed with 20 oz/ac RT3 on 5/21/2014. The plots were sprayed with Huskie at 11 oz/ac and Axial XL at 16.4 oz/ac on 6/16/2014.
** = Solid stem sawfly-resistant (solid stem score of 19 or higher).
* = Less preferred by sawfly (behavioral preference) in small plots.
CL = Clearfield System
Conducted by MSU Western Triangle Ag. Research Center.

Table 12. Five-year averages, dryland Spring Wheat varieties, Knees, MT. Chouteau County 2010-2014.

Variety	Class	5-Year Average Yield bu/a	Test Weight	Height in.	Protein %
Duclair	**	52.6	58.6	27.6	14.2
WB Gunnison	*	51.0	60.4	27.5	14.0
Vida	*	49.3	59.4	28.4	13.9
Choteau	**	48.5	59.2	26.1	14.5
Corbin	*	46.5	59.7	26.7	14.2
Volt	*	45.7	61.0	26.3	13.6
ONeal	*	45.4	59.8	28.1	13.8
McNeal	-	45.3	58.5	28.9	14.4
Reeder	-	45.0	60.0	27.3	14.6
Jedd	CL	41.7	58.9	22.5	14.2
SY Tyra	*	41.1	58.2	24.0	13.8
Fortuna	**	40.0	60.2	32.4	14.9
Mean		46.0	59.5	27.2	14.2

** = Solid stem sawfly-resistant (solid stem score of 19 or higher).
* = Less preferred by sawfly (behavioral preference) in small plots.
CL = Clearfield System
Conducted by MSU Western Triangle Ag. Research Center, Conrad, MT.

Table 13. Durum Variety Trial located WTARC. Pondera County. Western Triangle Ag. Research Center. 2014.

Variety	Yield bu/a	Test Wt lb/bu	Height in.	Head Date
Strongfield	87.9	60.9	38.3	184.3
MT06584	85.6	60.0	26.3	184.0
Alzada	84.9	60.2	28.3	181.0
Grenora	84.2	60.1	35.0	182.3
Joppa	83.4	61.4	37.7	182.0
Carpio	82.2	60.8	39.0	184.7
Divide	81.3	59.8	37.3	181.7
Silver	80.5	60.2	26.3	180.0
MT101395	79.9	57.4	39.0	185.0
Tioga	79.8	60.8	40.0	183.0
Alkabo	78.3	60.0	36.0	182.0
MT101730	77.3	60.5	47.3	184.3
MT101427	76.9	59.0	26.7	182.0
Mountrail	74.1	59.7	39.3	184.0
Mean	81.2	60.1	35.5	182.9
LSD (.05)	14.2	1.4	3.0	1.3
C.V.	10.5	1.4	5.1	0.4
P-Value	0.8234	0.0019	<0.0001	<0.0001

Planted: 4/21/2014 on conventional fallow and harvested on 8/28/2014.
Fertilizer: actual pounds/ac. of N-P-K: 11-22-0 applied with seed and a 180-0-20 blend of urea and potash was broadcast at planting. Fertilizer rates are based on a yield goal of 60 bu/ac.
Herbicide: The plot area was pre-plant sprayed with 20 oz/ac RT3 on 4/24/2014. The plots were sprayed with Huskie at 11 oz/ac and Axial XL at 16.4 oz/ac on 5/30/2014.
Precipitation for growing season: 9.47 inches.

Table 14. Six-year means, dryland Durum varieties. Western Triangle Ag. Research Center Conrad, MT, Pondera County, 2009 – 2014.

		6 year mean			
	Source	Yield	Test	Height	Head
Variety		bu/a	weight	in.	date
Alkabo	N. Dak.	76.3	61.8	36.7	75.5
Grenora	N. Dak.	76.3	61.4	34.5	75.2
Alzada	WestBred	74.2	60.5	28.6	73.0
Silver (MT03012)	MSU	73.9	61.2	27.8	72.6
Mountrail	N. Dak.	70.3	60.2	37.4	77.0
Divide	N. Dak.	70.1	61.2	37.4	76.0
Nursery Mean		73.5	61.0	33.7	74.9

Table 15. Orange Blossom Wheat Midge blend nursery, Valier, MT. 2014.

Variety	Yield bu/a	Test Wt lb/bu	Height in.	Protein %
Egan (Cap 400)	81.0	58.0	33.0	17.8
90% CAP 400/10%Choteau	77.0	58.7	30.7	17.2
CAP 34	75.8	58.3	28.3	14.6
90% CAP 34/10%Choteau	74.7	58.2	28.3	15.3
Choteau	72.5	56.9	28.3	15.9
90% CAP 400/10% Solano	71.3	58.1	31.3	17.0
90% CAP 34/10% Solano	71.0	59.5	29.0	14.7
Solano	48.9	57.4	22.3	16.3
Mean	71.5	58.2	28.9	16.1
LSD (.05)	10.5	2.0	2.3	
C.V. (s/mean)*100	8.4	1.9	4.6	
P-Value	<0.0006	<0.2127	<0.0000	

Planted April 22, 2014 Harvested: 8/28/2014
Pre-plant spray and Fertilizer where applied by Crawford farms
Conducted by MSU Western Triangle Ag Research Center, Conrad, MT.

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.

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Barley

2014 Barley Variety Evaluations In The Western Triangle Area.

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Dryland off-station barley variety trials were grown in Teton County near Choteau, Glacier County near Cut Bank, Toole County near Devon, and Choteau County near the Knees. The on-station trials at Conrad were grown on dryland and irrigated in 2014. All trials were no-till planted on chemical fallow.

The 2014 growing season at WTARC was a little cooler than average with a wetter than normal June. The June rain was very timely with respect to the small grain plots.

Results: Data for the dryland Intrastate trials at Conrad are listed in Table 1, with multi-year data shown in Table 2. Table 3 is the irrigated intrastate trial, with Table 4 containing the multi-year summary. Table 5 are data from the off station irrigated barley trial. Tables 6 thru 10 are for off station barley nurseries. The Cut Bank nursery was lost to hail.

The 2014 dryland intrastate and irrigated intrastate barley nurseries contained hooded and hulless barleys along with the normal spring barley. The test weights to the hulless and hooded barleys tend to be much higher than the test weight of feed and malt barley. The dryland intrastate barley was harvested just before the wet period in August. Yields for the dryland intrastate nursery were quite high, averaging 112.7 bu/acre, with an average kernel plumpness of 89.4%, a mean protein of 10.5%, and a average test weight of 53.6 lb/bu. (Table 1) Four year means from the dryland intrastate nursery are from traditional barleys. (Table 2)

The irrigated intrastate barley was harvested just after the wet period in August. There was sprout and mold damage in the irrigated intrastate nursery. Yields for the irrigated intrastate nursery were not as high as the dryland intrastate nursery, averaging 94.1 bu/acre, with an average kernel plumpness of 92.7%, a mean protein of 10.2%, and a average test weight of 50.7 lb/bu (Table 3). Four year means from the dryland intrastate nursery are from traditional barleys (Table 4).

Grain yields averaged 73.4 bu/acre at the Knees, 57.8 bu/acre north of Devon, and 78.2 bu/acre at the Choteau site. Kernel plumpness averaged 90.9% and test weight averaged 46.4 lbs/bu at the Devon site while kernel plumpness averaged 88.4% and test weight averaged 46.9 lbs/bu at the Knees. Choteau kernel plumpness was 66.1% and test weight averaged 49.2 lbs/bu. Top yielding varieties at the Knees were Haxby, Champion, and MT100120, whereas the top yielding barleys north of Devon were Tradition, MT100120, and MT090180. Yielding highest at the Choteau site were Champion, Craft, and MT100120. The Cut Bank site was not harvested due to severe hail damage.

All malt varieties in the dryland intrastate nursery met or exceeded market requirements for test weight, protein, and plump in 2014.

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, MT

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.

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.

Table 1. Intrastate Barley variety trial, Conrad 2014.

Variety	Yield bu/a	Test Wt lb/bu	Plump %	Thin %	Protein %	Head Date	Height in.
MT100125	143.4	52.4	95.8	1.4	10.2	183.7	34.0
MT124688	140.6	54.4	97.8	0.7	10.2	181.7	33.0
MT100120	138.7	53.4	96.4	1.2	9.6	182.7	33.3
MT090182	137.1	53.1	93.4	2.1	9.4	182.0	33.7
MT124243	133.4	52.6	96.2	1.1	10.	182.7	31.3
MT100126	132.8	52.7	96.2	1.8	9.5	183.3	33.0
MT124026	132.0	52.9	97.1	0.7	10.4	180.7	32.7
MT090193	131.8	52.4	96.1	0.8	9.3	182.7	32.7
MT100136	130.9	52.6	94.5	1.4	9.7	182.3	33.0
MT090190	128.3	52.5	94.1	2.3	9.5	182.0	30.7
MT100132	127.5	52.2	93.9	1.7	9.1	183.0	31.7
MT090181	126.9	53.1	97.6	0.8	9.1	183.0	33.3
07005-007	125.8	52.6	96.8	1.1	11.2	180.7	31.7
MT124240	125.4	52.6	94.8	1.8	9.0	183.0	32.7
Pinnacle	125.3	52.5	97.3	1.0	10.6	181.0	33.0
MT124728	125.2	52.1	96.6	1.0	11.4	180.3	30.7
MT090184	125.2	54.1	97.2	0.8	9.6	183.0	29.7
Hockett	124.9	53.9	95.1	1.4	10.4	179.3	29.7
Champion	123.1	53.2	92.4	1.8	9.0	180.7	30.3
MT090186	122.5	53.3	95.6	1.3	9.1	183.0	31.3
Conrad	121.6	52.6	96.6	1.0	10.6	181.7	29.3
Eslick	121.5	51.9	86.3	4.6	9.0	182.3	27.3
MT124093	121.3	53.9	97.6	0.6	12.6	180.7	34.7
05032-068	121.2	52.1	95.1	1.2	8.6	180.3	30.7
MT090180	120.8	51.8	89.4	2.9	8.7	181.3	32.0
Craft	120.0	54.5	96.6	0.9	10.6	178.6	31.3
MT100130	119.5	51.4	89.6	3.3	8.8	181.0	33.0
MT124338	118.2	51.6	94.6	1.5	9.7	179.7	31.7
MT124933	117.6	52.1	88.2	3.5	9.9	178.0	30.3
MT124025	117.0	52.7	97.4	0.8	10.0	180.7	30.3
MT100124	116.7	52.3	93.8	1.4	8.4	183.0	32.0
Haxby	116.6	54.0	92.8	1.8	9.1	181.3	30.0
07034-005	116.6	52.1	96.2	1.4	10.9	179.7	31.3
MT124027	116.2	51.1	94.1	1.6	9.7	180.7	30.3
MT124367	116.2	52.8	95.4	1.4	8.7	181.7	31.3
MT100060	115.3	53.6	94.4	1.9	9.6	180.3	31.7
07030-034	115.6	50.9	97.8	0.7	10.5	182.0	29.0
MT124945	115.2	52.7	91.5	2.7	9.7	182.0	31.0

Table 1 continued on next page

Table 1. continued

Variety	Yield bu/a	Test Wt lb/bu	Plump %	Thin %	Protein %	Head Date	Height in.
MT124411	115.2	54.0	96.2	0.9	10.9	177.7	32.3
MT100128	114.9	53.3	94.6	1.7	9.1	183.0	31.3
MT124582	114.0	53.6	94.2	1.7	9.8	177.3	31.0
07034-012	111.7	52.5	98.9	0.4	11.0	180.0	33.3
MT100051	110.2	53.7	92.8	2.3	8.4	179.0	28.3
Tradition	109.5	52.0	94.4	0.7	9.9	179.0	35.0
Harrington	107.9	49.9	87.5	3.9	10.1	180.7	28.7
Hays	107.5	49.0	75.6	10.0	10.9	182.3	28.0
Metcalfe	105.7	51.6	92.0	2.3	10.0	181.0	29.3
MT110065	105.1	56.5	57.2	9.3	11.6	184.7	33.3
MT110008	101.7	56.8	73.6	8.5	11.7	181.3	30.7
MT110066	100.1	57.1	53.5	10.8	13.2	183.7	29.3
MT110130	99.7	52.4	87.8	4.1	13.7	181.0	29.3
MT110061	99.4	58.9	57.5	9.1	11.8	180.7	31.0
MT110016	98.5	53.0	69.9	10.3	11.6	181.7	31.3
MT110009	89.9	57.3	77.3	5.0	10.4	183.0	32.7
MT110043	84.3	54.8	69.9	8.5	12.5	184.0	22.0
MT110139	84.1	59.2	80.5	6.3	9.5	179.3	32.0
MT110113	83.9	60.4	93.9	2.0	14.2	178.6	33.0
MT110109	83.9	54.1	49.5	25.0	13.3	180.3	27.3
MT110092	80.6	59.2	93.9	2.7	12.0	177.0	31.3
MT110031	80.5	54.8	84.9	3.9	13.0	179.0	23.7
MT110097	80.3	57.8	94.9	1.9	13.0	177.0	28.3
PI596299	77.9	46.6	70.6	20.5	13.6	179.3	27.3
MT110141	74.0	59.5	91.4	1.7	12.9	181.7	32.3
MT110095	65.6	58.4	87.7	2.0	12.9	177.0	32.3
Mean	112.7	53.6	89.4	3.4	10.5	181.0	31.0
LSD	19.4	2.4	7.8	2.6		1.8	4.5
CV	10.7	2.8	5.4	47.9		0.6	9.0
P-value (0.05)	<0.0000	<0.0000	<0.0000	<0.0000		<0.0000	<0.0002

Planted April 22, 2014 on chemical fallow barley stubble. Harvest August 19, 2014.
Fertilizer, actual (lbs/a): 11-22-0 place with seed at planting, 12-0-20 broadcast while seeding. Fertilizer rates are based on achieving malt grade barley. Growing season ppt: 6.54 inches. Preplant sprayed with RT3 at 20oz per acre on 4/24/14. Sprayed on 5/30/2014 on Huskie at 11 oz/a and Axial XL at 16.4 oz/a
Location: MSU Western Triangle Ag Research Center, Conrad, MT.

Table 2. 4-year Means, Intrastate Dryland Barley varieties, Conrad, MT, 2011-2014

Variety [1]	Yield bu/a	Test Wt lb/bu	Plump %	Thin %	Protein %	Head date	Height in.
Tradition	110.9	51.2	95.7	0.9	10.8	185.1	25.5
Champion	108.7	53.7	94.0	1.8	10.4	182.4	33.1
Pinnacle	101.7	52.7	97.3	0.9	10.0	181.8	29.3
Conrad	100.5	52.0	96.9	1.2	10.9	185.7	30.4
Haxby	97.7	54.4	94.0	1.8	10.3	183.0	28.0
Craft	97.2	53.9	95.7	1.5	10.7	181.7	29.4
Eslick	96.9	52.5	90.5	2.8	9.7	184.5	28.3
Harrington	93.2	51.4	91.9	2.3	10.4	183.3	29.8
Metcalfe	92.4	51.9	94.0	1.8	10.7	181.8	28.4
Hockett	92.2	53.4	96.2	1.4	10.7	183.2	26.9
Mean	99.1	52.7	94.6	1.6	10.4	183.2	28.9

[1] Tradition is 6-row; all others are 2-row.
Location: MSU Western Triangle Ag. Research Center, Conrad, MT.

Table 3. Irrigated Intrastate Barley variety trial, Conrad 2014.

Variety	Yield bu/a	Test Wt lb/bu	Plump %	Thin %	Protein %	Head Date	Height in.
MT100126	130.7	50.6	97.3	0.8	8.6	187.3	31.7
MT090186	120.7	50.9	98.2	0.5	9.9	187.3	31.3
MT124945	119.9	50.0	98.6	0.5	8.5	186.7	30.3
MT124240	119.8	49.9	99.0	0.4	8.9	185.0	30.7
MT124688	119.5	50.8	98.9	0.5	9.4	186.0	31.3
MT090181	116.9	49.8	98.7	.03	8.9	187.0	31.0
MT124027	116.6	48.0	97.4	0.6	9.4	184.7	30.0
MT124582	116.5	51.1	98.3	0.6	11.2	185.0	33.0
MT100125	115.2	48.5	98.9	0.3	9.4	186.7	31.3
MT124243	114.2	49.6	98.5	0.5	8.7	187.3	32.7
Eslick	113.7	48.3	95.2	1.4	9.0	187.7	24.7
MT100124	113.6	49.6	98.5	0.4	9.3	185.3	29.0
MT090190	112.1	50.0	98.7	0.4	8.5	185.0	30.0
Pinnacle	110.0	49.0	98.4	0.4	8.9	187.7	29.0
Conrad	109.8	48.7	96.9	1.1	9.9	185.7	28.3
MT124025	109.8	48.7	99.3	0.4	8.9	187.7	29.0
07005-007	108.9	49.2	98.6	0.3	10.3	185.0	30.0
Champion	108.3	50.3	96.9	0.6	9.7	186.7	28.7
Hockett	106.9	50.6	98.5	0.5	11.6	184.7	30.3
MT124933	106.1	48.4	95.6	1.0	9.1	184.3	27.0
Harrington	105.5	47.9	96.8	1.0	10.1	187.0	29.3
MT100128	105.1	50.8	98.3	1.4	8.8	187.3	31.0
07030-034	104.6	47.5	99.1	1.7	9.7	185.7	30.7
MT090184	103.8	50.8	98.6	0.5	8.9	186.0	31.3
MT100136	103.7	49.3	98.2	0.5	8.9	187.0	29.0
Metcalfe	103.2	48.2	98.4	1.3	10.4	185.7	30.3
MT100120	102.8	50.3	98.9	0.5	8.9	182.7	30.0
MT124367	102.7	47.9	98.3	0.7	8.5	188.3	28.0
MT090193	102.7	48.9	97.8	0.7	8.8	186.0	31.7
MT090182	101.0	50.1	98.2	0.4	8.5	187.7	28.7
Craft	99.7	51.1	98.4	0.4	9.9	185.7	28.7
MT124026	99.2	48.2	98.7	0.4	10.1	185.0	30.0
05032-068	97.4	46.9	98.8	0.9	8.8	185.7	27.7
MT100130	97.4	49.6	98.4	1.0	8.6	186.7	29.3
Haxby	95.8	50.3	97.3	0.6	9.6	186.0	30.7
MT100132	95.8	48.5	98.2	0.5	8.4	187.3	31.0
07034-005	95.3	45.4	98.8	0.9	9.4	187.0	30.0
MT124093	95.2	50.9	98.5	0.4	9.8	186.0	32.3

Table 3 continued on next page

Table 3.
continued

Variety	Yield bu/a	Test Wt lb/bu	Plump %	Thin %	Protein %	Head Date	Height in.
Tradition	94.9	47.3	97.0	0.6	9.8	184.3	33.0
MT124411	93.2	49.3	97.8	1.7	9.9	185.3	31.0
07034-012	92.4	47.4	99.1	0.8	9.5	184.7	29.7
MT124338	92.2	47.1	98.0	0.8	9.0	185.0	29.7
MT110009	91.0	57.1	83.2	2.5	13.0	186.0	33.7
MT110008	90.3	56.7	77.3	4.2	11.7	187.3	28.7
MT100051	88.3	50.4	98.2	0.8	8.8	186.0	29.7
MT124728	85.3	47.8	97.7	0.6	11.0	187.3	27.7
MT110066	83.4	57.3	49.6	6.6	12.1	184.0	29.7
MT090180	81.7	49.5	98.3	0.3	9.3	184.3	34.3
MT110016	78.0	56.5	76.7	4.7	10.6	188.7	29.3
MT100060	75.8	50.2	97.3	0.8	8.8	186.3	28.7
MT110061	73.5	56.0	61.7	6.0	11.5	186.7	30.3
MT110043	72.5	56.6	82.0	2.0	11.9	186.0	30.0
Hays	71.3	47.3	92.4	3.0	9.3	186.7	27.0
MT110065	70.5	57.8	59.0	7.4	10.8	187.0	28.7
MT110031	70.0	55.5	85.6	2.4	13.3	187.0	25.7
MT110130	66.3	49.5	84.4	3.4	12.0	186.7	28.3
MT110113	61.2	57.5	90.3	2.0	13.4	186.0	27.3
MT110141	59.5	56.1	92.1	1.0	14.0	185.0	31.0
MT110097	58.8	53.6	94.4	1.6	12.0	185.3	27.3
MT110139	58.4	55.0	85.5	3.8	10.9	183.7	30.3
PI596299	58.1	46.0	68.6	21.3	13.8	188.0	27.7
MT110109	57.6	55.0	59.0	14.4	12.8	185.7	28.0
MT110092	53.0	57.1	93.3	1.8	13.1	183.3	27.0
MT110095	44.5	53.8	85.3	2.0	14.2	183.3	30.7
Mean	94.1	50.7	92.7	1.9	10.2	186.0	29.7
LSD	28.7	2.1	7.6	1.9		3.1	4.2
CV	18	2.5	4.1	51.8		1.0	8.7
P-value (0.05)	<0.000	<0.000	<0.0000	<0.0000		<0.0632	<0.0252

Planted May 1, 2014 on fallow. Harvest September 5, 2014.
Fertilizer, actual (lbs/a): 11-22-0 place with seed at planting, 60-0-20 broadcast while seeding.
Fertilizer rates are based on a yield goal of 90 bu/a.
Growing season ppt: 8.35 inches. Irrigation = 4.0 inches
Preplant sprayed with RT3 at 20 oz/a on 5/1/2014. Sprayed with Huskie at 11 oz/a and Axial XL at 16.4 oz/a on 6/10/2014. Location: MSU Western Triangle Ag Research Center, Conrad, MT.

Table 4. Five year Means, Intrastate Irrigated Barley varieties, Conrad, MT, 2009, 2011-2014

Variety [1]	Yield bu/a	Test Wt lb/bu	Plump %	Thin %	Plant Height	Protein %	Head date
Champion	105.4	53.0	96.7	0.8	28.6	9.4	188.4
Eslick	105.2	51.3	94.0	2.4	24.9	9.3	191.0
Conrad	101.2	52.5	96.7	1.2	26.8	9.7	189.7
Metcalfe	99.6	51.0	96.4	2.0	28.9	10.2	187.8
Haxby	99.0	51.9	96.2	1.5	27.3	9.9	187.4
Craft	97.9	51.2	96.8	1.2	30.5	10.3	187.7
Harrington	97.3	49.6	95.7	1.8	28.3	9.8	189.6
Hockett	96.5	51.7	96.7	1.2	28.2	10.3	188.5
Pinnacle	96.2	51.7	97.9	1.0	28.8	8.7	188.9
Tradition	87.6	51.9	97.3	0.6	31.5	9.7	186.3
Mean	98.6	51.6	96.5	1.4	28.4	9.7	188.5

[1] Tradition is 6-row; all others are 2-row.
Location: MSU Western Triangle Ag. Research Center, Conrad, MT.

Table 5. 2014 Irrigated Barley variety trial, Conrad, MT.

Variety	Yield bu/a	Test Wt lb/bu	Height in.	Plump %	Thin %	Heading Date	Protein %
MT100120	125.9	51.9	31.7	99.2	0.2	187.0	9.5
Geraldine	121.0	51.8	34.7	98.0	1.6	183.7	11.6
Champion	119.9	50.8	32.0	98.0	0.8	186.0	10.8
Conrad	118.8	49.7	32.0	98.6	0.5	185.0	10.8
MT090180	117.7	50.9	32.0	99.4	0.1	185.0	9.2
Metcalfe	117.1	49.0	32.0	96.5	1.2	185.3	10.9
Eslick	117.0	49.4	28.7	97.7	0.6	185.0	9.7
Craft	116.9	51.6	33.0	98.5	0.5	186.3	10.9
MT100126	114.1	51.2	31.7	98.4	0.2	186.3	9.3
Harrington	110.0	47.9	30.7	96.4	1.0	185.3	10.8
Gallatin	118.2	51.8	33.7	98.0	0.6	185.7	10.8
Haxby	105.7	51.0	31.7	98.0	0.6	184.0	10.2
Hockett	100.4	50.3	28.7	98.4	0.6	185.0	9.6
MT090190	100.3	48.9	30.6	99.0	0.3	184.0	11.1
Cowboy	94.8	50.8	38.7	98.3	0.5	185.3	11.1
Tradition	88.7	48.6	35.3	97.5	0.5	185.3	10.4
Mean	111.0	50.3	32.3	98.1	0.6	185.3	10.4
LSD (.05)	14.6	0.6	3.4	0.9	0.4	ns	
C.V. (s/mean)*100	7.9	0.7	6.3	0.6	37.5	0.8	
P-Value	<0.0003	<0.0000	<0.0003	<0.0000	<0.0001	0.4140	

Planted May 1, 2014 on chemical fallow barley stubble. Harvest September 6, 2014.
Fertilizer, actual (lbs/a): 11-22-0 place with seed at planting, 60-0-20 broadcast while seeding.
Fertilizer rates are based on achieving malt grade barley.
Growing season ppt: 8.35 inches. Irrigation = 4.0 inches
Preplant sprayed with RT3 at 20 oz/a on 5/1/2014. Sprayed with Huskie at 11 oz/a and Axial XL at 16.4 oz/a on 6/10/2014.
Location: MSU Western Triangle Ag Research Center, Conrad, MT.

Table 6. Off-station spring barley variety trial located in the Choteau area.
Western Triangle Ag. Research Center. 2014.

Variety	Spike	Yield bu/a	Test Wt lb/bu	Plump %	Thin %	Protein %	Plant Ht (in)
Champion	2	91.5	51.7	74.6	5.9	11.0	29.3
Craft	2	86.2	51.8	80.4	6.3	11.3	32.3
MT100120	2	82.4	52.0	83.3	5.7	11.0	31.3
Tradition	6	81.5	49.0	76.3	5.6	11.5	35.3
Haxby	2	80.2	50.9	59.5	16.6	12.4	30.3
Gallatin	2	80.0	49.1	61.6	15.6	13.8	30.0
Hockett	2	79.3	47.7	63.5	16.9	12.8	28.3
Geraldine	2	77.7	48.1	53.7	22.7	13.5	30.0
Metcalfe	2	76.7	47.1	66.7	13.0	12.7	30.3
MT100126	2	76.5	50.3	74.1	9.6	11.5	31.7
Conrad	2	75.3	47.9	67.9	14.0	12.2	28.7
MT090180	2	74.5	49.3	70.6	12.2	11.5	31.0
Harrington	2	73.6	46.3	63.6	15.5	12.6	29.0
Eslick	2	73.0	47.5	27.3	38.0	13.8	27.3
Cowboy	2	72.3	48.6	75.3	9.1	13.4	36.3
MT090190	2	70.8	50.0	62.5	15.3	15.2	27.0
Average		78.2	49.2	66.1	13.9	12.5	30.5
LSD (.05)		7.5	2.4	17.4	12.0		2.1
C.V.		4.7	2.9	15.7	52.0		4.1
P-Value (0.05)		0.0003	0.0002	0.0002	0.0009		<0.0001

Planted May 6, 2014 on chemical fallow. Harvest August 13, 2014.
Fertilizer, actual (lbs/a): 11-22-0 place with seed at planting, 15-0-20 broadcast while seeding. Fertilizer rates are based on achieving malt grade barley.
Growing season ppt: Forgot to read at harvest.
Herbicide: None
Conducted by MSU Western Triangle Ag Research Center, Conrad, MT.

Table 7. 3-year means, dry land Barley varieties, Choteau. 2012-2014.

Variety	Yield	Test Wt	Plump	Thin	Protein	Height
			3-Year means			
	bu/a	lb/bu	%	%	%	in.
Champion	63.1	50.5	70.4	8.9	13.5	27.8
Eslick	60.8	47.7	61.1	22.2	15.6	24.7
Geraldine	60.6	48.7	66.7	16.3	15.21	25.8
Metcalfe	58.1	48.5	81.3	7.9	14.8	26.4
Tradition	57.3	48.3	71.2	8.1	14.4	30.2
Conrad	56.2	48.9	77.3	10.6	15.2	24.9
Haxby	56.1	51.1	78.7	11.2	14.1	26.3
Gallation	55.4	49.2	80.7	10.6	15.4	26.7
Harrington	52.9	47.6	47.7	14.3	15.2	25.4
Cowboy	51.4	48.9	78.1	6.8	15.1	31.3
Mean	57.2	48.9	72.2	11.6	14.8	26.8

Table 8. 2014 Barley variety trial, Devon, MT.

Variety	Yield bu/a	Test Wt lb/bu	Height in.	Plump %	Thin %	Protein %
Tradition	64.9	45.8	22.3	93.1	1.4	12.4
MT100120	63.7	48.2	23.0	95.7	1.1	11.2
MT090180	62.6	47.3	22.7	94.1	1.4	11.3
Conrad	62.3	46.0	20.0	93.0	2.1	12.9
Champion	61.5	48.5	20.0	94.4	1.4	11.6
Harrington	60.7	44.1	21.0	88.3	3.5	12.6
Hockett	59.6	46.5	21.0	90.9	2.9	11.5
Craft	58.0	47.0	24.7	92.8	2.0	12.6
Haxby	57.3	47.6	22.3	91.2	2.2	12.0
MT090190	56.0	47.2	20.3	94.9	1.4	13.6
Geraldine	55.2	46.0	22.7	89.4	3.1	12.0
MT100126	54.6	46.8	23.0	91.6	2.4	11.3
Eslick	54.3	44.6	20.0	75.9	7.1	12.1
Gallatin	53.0	45.2	22.3	83.9	5.6	12.3
Cowboy	51.6	46.8	27.7	94.3	1.9	13.3
Metcalfe	49.9	44.5	20.0	90.5	2.2	12.6
Mean	57.8	46.4	22.1	90.9	2.6	12.2
LSD (0.05)	6.4	1.3	2.4	6.7	2.2	
C.V. (s/mean)*100	6.6	1.7	6.6	4.4	51.3	
P-Value	0.0004	<0.0001	<0.0001	0.0002	0.0002	

Cooperator and Location: Brian Aklestad farm, north east of Devon.
Planted May 21, 2014 on chemical fallow. Harvest September 7, 2014.
Fertilizer, actual (lbs/a): 11-22-0 place with seed at planting, 30-0-20 broadcast while seeding.
Fertilizer rates are based on achieving malt grade barley.
Growing season ppt: 3.8 inches.
Herbicide: The plot area was pre-plant sprayed with 20 oz/a RT3 on 5/21/2014. The plots were sprayed with Huskie at 11 oz/a and Axial XL at 16.4 oz/a on 6/16/2014.
Conducted by MSU Western Triangle Ag Research Center, Conrad, MT.

Table 9. Four-year means, Barley varieties, Devon area, Eastern Toole County. 2011-2014.

Variety	4-Year Mean					
	Yield bu/a	Test weight	Plump %	Thin %	Protein %	Plant Height
Haxby	61.6	50.6	86.5	10.8	10.1	26.3
Tradition	60.2	48.2	86.1	4.2	10.6	23.1
Gallatin	58.9	48.5	89.4	6.1	10.7	24.1
Champion	58.6	51.3	84.8	4.0	10.0	23.4
Hockett	58.4	48.6	83.8	4.7	10.5	23.1
Geraldine	56.5	48.6	87.0	7.3	10.4	25.2
Harrington	55.0	47.5	74.1	3.4	10.4	23.2
Conrad	54.6	48.7	83.2	4.1	10.3	24.0
Eslick	52.5	50.3	76.2	8.1	9.9	21.5
Cowboy	46.7	49.6	92.6	3.0	11.3	31.2
Mean	56.4	49.1	84.0	5.5	10.4	24.5

Table 10. Off-station spring barley variety trial located in the Knees area. Western Chouteau County. Western Triangle Ag. Research Center. 2014.

Variety	Spike	Yield bu/a	Test Wt lb/bu	Plump %	Thin %	Plant Height (in)	Protein %
Haxby		84.0	49.0	88.0	2.4	29.7	13.5
Champion		80.7	48.9	93.2	1.8	26.7	13.0
MT100120		79.2	48.5	94.0	1.5	31.3	12.9
Hockett		78.1	47.4	89.4	3.4	29.0	13.6
MT100126		77.6	47.6	92.9	2.0	31.3	12.0
Eslick		76.9	45.7	70.7	9.4	24.3	14.1
Craft		76.1	47.2	91.7	2.5	32.0	14.2
Tradition		75.6	44.2	76.6	6.3	30.3	13.8
MT090180		74.5	47.7	93.7	1.6	29.3	12.7
Conrad		73.4	47.5	93.6	2.4	26.3	13.9
Geraldine		73.0	47.3	91.8	3.4	30.0	14.3
Harrington		70.4	44.5	86.2	3.6	28.3	14.0
Gallatin		69.8	47.4	85.4	4.6	30.7	13.4
Metcalfe		69.7	44.5	85.5	4.1	29.0	14.5
MT090190		63.6	46.3	91.0	2.5	25.0	15.8
Cowboy		51.9	46.2	89.8	3.8	35.0	15.2
Average		73.4	46.9	88.4	3.5	29.3	13.8
LSD (.05) =		11.9	1.5	13.2	5.0	2.7	
C.V. =		9.7	2.0	8.9	70.3	5.5	
P-Value (0.05)		0.0021	<0.0001	0.0460	0.0428	<0.0001	

Cooperator and Location: Aaron Killion, western Chouteau County.
Planted May 21, 2014 on chemical fallow. Harvest September 6, 2014.
Fertilizer, actual (lbs/a): 11-22-0 place with seed at planting, 0-0-20 broadcast while seeding.
Fertilizer rates are based on achieving malt grade barley.
Growing season ppt: 3.8 inches.
Herbicide: The plot area was pre-plant sprayed with 20 oz/a RT3 on 5/21/2014.
Conducted by MSU Western Triangle Ag Research Center, Conrad, MT.

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.

Pulses

Spring Lentil, Pea and Chickpea Variety Evaluation.

Project Coordinators: Chengci Chen and Yesuf Mohammed, MSU/MAES, Central Ag. Research Center, Moccasin, MT.

Personnel: John Miller, Julie Prewett, and Gadi V.P. Reddy, MSU/MAES, Western Triangle Ag. Research Center, Conrad, MT.

Spring pea, lentil, and chickpea were grown on no-till chemical fallow at Western Triangle Ag. Research Center. Data are summarized in Tables 1 and 2. Chickpea data were not collected due to antelope eating the pods while they were green.

The 2014 growing season at WTARC was a little cooler than average with a wetter than normal June. The June rain was very timely with respect to the pulse crop plots.

Results: Lentil data are summarized in Table 3. The lentil nursery grown at WTARC yielded between 1174 and 2056 lbs/acre. With the small green Viceroy lentil yielding the best followed by the small green Eston lentil. The lentils grew to an average mature canopy height of 19.8 cm (7.8 inches), with an average yield of 1682 lbs/acre.

Yellow pea data are summarized in Table 1. Yellow pea varieties grown at WTARC yielded between 1796 lbs/acre for Earlystar and 3625 lbs/acre for CDC Leroy. Yellow pea averaged 2723 lbs/acre with an average test weight of 63.9 lbs/bu and an average plant height at maturity of 75.7 cm (29.8 inches).

Green pea data are summarized in Table 2. Green pea varieties grown at WTARC yielded from 2017 lbs/acre for CDC Striker to 3674 lbs/acre for Ginny. Green pea averaged 2723 lbs/acre with an average test weight of 63.5 lbs/bu and an average plant height at maturity of 69.4 cm (27.3 inches).

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

Table 1. Statewide Dry Pea Variety Evaluation. Yellow pea. Western Triangle Ag. Research Center. 2014.

Variety	Pea Color	Yield (lbs/a)	Test Weight (lbs/bu)	Plant Height (cm)	1000 Kernel Weight (g)	Days to Flower
CDC Leroy	Yellow	3625	64.9	68	162.7	61
Spider	Yellow	3492	64.1	84	242.8	60
Montech 4152	Yellow	3459	65.1	80	247.0	58
Abarth	Yellow	3228	63.7	78	272.3	58
Jetset	Yellow	3225	63.9	83	237.3	60
SW Midas	Yellow	3216	64.1	74	219.3	59
Korando	Yellow	3182	63.2	67	238.0	55
Pro 793	Yellow	3138	64.0	55	275.0	57
Pro127-2	Yellow	2992	64.1	76	263.8	59
Agassiz	Yellow	2876	63.7	76	229.0	60
CDC Treasure	Yellow	2876	64.4	87	224.7	59
Nette	Yellow	2867	63.9	77	215.0	58
DS Admiral	Yellow	2795	63.4	74	244.0	58
Navarro	Yellow	2492	62.7	72	270.3	54
Mystique	Yellow	2281	63.0	84	235.0	59
Bridger (LL7020)	Yellow	2212	64.3	70	217.5	58
Montech 4193	Yellow	2209	63.4	74	250.8	58
Salamanca	Yellow	2157	63.7	80	239.0	60
Earlystar	Yellow	1796	63.9	81	219.8	58
Yellow pea means		2723	63.9	75.7	238.2	58.2
P-Value		0.2898	<0.0001	<0.0001	<0.0001	<0.0001
LSD (0.05)		ns	0.57	9.5	22.1	0.7
CV (%)		32.53	0.63	8.89	0.56	0.27

Seeding Date: April 30, 2014.
Harvest Date: August 8, 2014.
Precipitation: 5.92 inches.
Fertilizer (actual): 11-22-20. 11-22-0 was applied with the seed with 0-0-20 being broadcast while planting.
Pre-plant sprayed with Prowl H_2O at 30 oz/a and RT3 at 10 oz/a on April 25, 2014.
Located at Western Triangle Ag. Research Center, Conrad, MT.

Table 2. Statewide Dry Pea Variety Evaluation. Green pea. Western Triangle Ag. Research Center. 2014.

Variety	Pea Color	Yield (lbs/a)	Test Weight (lbs/bu)	Plant Height (cm)	1000 Kernel Weight (g)	Days to Flower
Aragorn	Green	2597	62.4	67	218.8	58
Arcadia	Green	3346	63.7	55	208.0	60
Banner	Green	2651	64.1	74	219.3	56
Bluemoon	Green	2827	62.9	70	236.0	60
CDC Striker	Green	2017	63.9	69	241.8	60
Cruiser	Green	2995	62.2	62	205.8	58
Daytona	Green	2148	63.9	73	253.3	60
Ginny	Green	3674	63.8	71	206.5	58
Greenwood	Green	2473	64.9	70	216.5	59
K2	Green	2619	63.2	69	209.5	59
Majoret	Green	2469	64.0	77	234.3	60
Viper	Green	2707	62.7	78	232.5	59
Green Pea Means		2723	63.5	69.4	222.9	58.7
P-Value		0.3342	<0.0001	0.0224	0.0224	<0.0001
LSD0.05 (by t)		ns	0.83	11.1	20.6	1.1
CV% (s/means)		30.7	0.92	11.38	11.38	0.43

Seeding Date: April 30, 2014.
Harvest Date: August 8, 2014.
Precipitation: 5.92 inches.
Fertilizer (actual): 11-22-20. 11-22-0 was applied with the seed with 0-0-20 being broadcast while planting.
Pre-plant sprayed with Prowl H_2O at 30 oz/a and RT3 at 10 oz/a on April 25, 2014.
Located at Western Triangle Ag. Research Center, Conrad, MT.

Table 3. Statewide Lentil Variety Evaluation. Western Triangle Ag. Research Center. 2014.

Variety	Lentil Color and size	Yield (lbs/a)	Mature Canopy Height (in)	Test Weight (lbs/bu)	1000 Kernel Weight (g)	Vine Length (in)
CDC Greenland	lg	1768	6.5	55.9	65.8	17.3
Merrit	lg	1744	7.8	55.4	67.0	15.8
Riveland	lg	1616	9.0	47.1	109.3	18.0
CDC Richlea	mg	1752	6.8	54.2	68.0	15.5
Impress CL	mg	1799	7.0	54.9	59.0	14.3
Imi-Green	mg	1174	9.8	53.2	104.3	19.3
Viceroy	sg	2056	6.5	59.5	44.0	17.0
Eston	sg	2020	8.5	58.3	63.8	14.8
Essex	sg	1865	6.0	58.2	46.3	14.8
CDC Redberry	sr	1869	14.3	57.8	45.0	19.5
Red Coats	sr	1630	8.5	57.9	58.0	16.5
Crimson	sr	1590	5.0	61.2	33.3	13.8
CDC Impact	sr	1514	7.5	59.5	47.0	13.5
Morena	sb	1633	8.8	57.8	64.8	15.8
Pardina	sb	1259	4.5	59.2	67.5	12.8
Avondale	tr	1597	9.0	52.7	60.5	15.0
Means		1682	7.8	56.4	62.7	15.8
$LSD_{0.05}$ (by t)		ns	2.3	4.8	29.7	2.3
CV% (s/means)		23.6	21.0	6.0	33.4	10.1
P-Value		0.1820	<0.0000	<0.0001	0.0003	<0.0001

Seeding Date: May 19, 2014.
Harvest Date: September 23 2014.
Fertilizer (actual lbs/a): 11-22-20. 11-22-0 was applied with the seed with 0-0-20 being broadcast while planting.
Precipitation: 8.68 inches.
Sprayed with pre-plant spray with Roundup RT3 at 10oz/a. Prowl H2O at 30 oz/a.
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.

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Soil test values

Table 1. Soil test values for off-station and on-station plots, 2014.

Location	N (lbs/a)[1]	Olsen-P (ppm)	K (ppm)	pH	OM (%)	EC (mmhos/cm)
Cut Bank	54.6	18	394	7.9	2.4	0.44
Devon	11.9	18	408	6.6	1.0	0.18
Choteau	26.5	11	550	8.0	2.7	0.62
WTARC	17.6	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