WADO

2023 WADO Annual Report

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Introduction

The Westman Agricultural Diversification Organization Inc. (WADO) manages a wide range of value-added and diversification agriculture research and demonstration projects that are summarized in this report. WADO operates in the southwest region of Manitoba and works in conjunction whenever possible with the other Diversification Centres in Roblin (PCDF), Arborg (PESAI) and Carberry (CMCDC). The non-profit organization owes its success to the excellent cooperation and participation it receives from its Board of Directors, cooperating landowners, local producers, industry partners and cooperating research institutes. WADO acts as a facilitator and sponsor for many of the Ag Extension events held across the province in conjunction with other Manitoba Agriculture staff and industry personnel. This is all part of WADO's goal of helping farmers and our rural communities embrace new challenges of agriculture cropping systems and better ways of improving profitability while being aware of the ever-changing needs of the industry.

WADO receives the majority of its operating funds from the Agricultural Sustainability Initiative (ASI) and other Sustainable Canadian Agriculture Partnership (SCAP) programs. Smaller amounts of additional funding come from the MCVET (Manitoba Crop Variety Evaluation Team) committee and other Industry Partners for the contract work that WADO is able to provide for these organizations.

2023 Industry Partners

Agriculture and Agri-Foods Canada
Assiniboine Community College
Alert Agronomy
Avondale Seeds
Barker's Agri-Centre
Barker Farms
BASF
Canada Malt Barley Technical Centre (CMBTC)
Manitoba Diversification Centres
Canadian Agricultural Partnership (CAP)
Covers and Co.
Crop Development Centre Saskatoon
Ducks Unlimited Canada
Fletcher Farms
General Mills
Greig Farms
Kirkup Farms
Manitoba Agriculture
Manitoba Cooperator
Manitoba Crop Alliance (MCA)
Manitoba Crop Variety Evaluation Team (MCVET)
Manitoba Pulse and Soybean Growers Association
Town of Melita

Mustard21
Lupin Platform Ltd.
Paterson Grain
Phillex
Pulse Genetics
Seed Manitoba
Sollio Agriculture
Southeast Research Farm
Tilbury Farms
Top Crop Manager
University of Alberta
University of Manitoba
University of Saskatchewan
Western Ag Professional Agronomy
Western Producer
Yield10 Biosciences

WADO Directors

WADO functions with a board of directors that assist in communications, activities, and project development. The directors are from all across southwest Manitoba, and they have a direct connection to farming and agriculture. The directors listed below are those that participated with WADO operations in 2023.

Board member	Location
Gary Barker - Chairman	Melita
Brooks White	Pierson
Darren Peters	Boissevain
Kevin Beernaert	Hartney
David Rourke	Minto
John Finnie	Kenton
Allan McKenzie	Nesbitt
Adam Gurr	Rapid City
Neil Galbraith	Minnedosa

Manitoba Agriculture staff members are also part of the WADO board:

Lionel Kaskiw – Souris
Amir Farooq - Hamiota
Scott Chalmers - Melita

Board Advisor: Elmer Kaskiw – Shoal Lake

Farmer Co-operators 2023 Trial Locations

Cooperator - Location	Kirkup Melita	Fred Greig Reston	Tilbury Melita	Barker Melita	Fletcher Melita
Legal Land Location	NW15-3-27W1 SE17-3-27W1	SE11-7-27W1	NW23-4-27W1	NE6-4-26W1 NW10-4-26W1	SE34-3-27W1
Soil type	Waskada Loam	Alexander Loam	Argue Loam	Margaret Loamy Sand Stanton Loamy Sand	Waskada Loam

WADO Staff

Scott Chalmers (P.Ag.) is the Applied Research Specialist for Manitoba Agriculture. Scott has a degree in Botany and minor in Chemistry from Brandon University. Scott is responsible for project development, staff management, data analysis and extension/communications. Scott has been working with WADO since 2007.

McKenzie Friesen joined WADO in May 2022 as a research technician after receiving a B.Sc. from the Brandon University in 2020 and a Diploma in Agribusiness from Assiniboine Community College in 2022. She has been responsible for report preparation and writing.

Leanne Mayes is the organization's full time Research Associate responsible for data collection, procurement of day-to-day supplies, equipment repairs and maintenance, and other administrative duties as assigned. **Chantal Elliott** is also a full time Research Associate who assists with sample analysis and equipment repairs and maintenance. Joy Mayes, Tylan Chalmers, Tom Burnett were students who helped the staff with daily tasks throughout the summer.

Clement David was our resident French summer student on an internship from his University in Angers, France. He helped with data collection and some harvest. He was responsible for the Corn-Soybean intercrop project as he was writing a report for this as part of his internship.

Top Left: (Left to right) Tylan Chalmers, Joy Mayes, and Tom Burnett.
Top Right: David Clement, our French summer student learning how to combine peas with the plot combine.

Right: David Clement enjoying a day golfing with the crew on WADO's summer student wind up day.

Got an idea or Proposal?

The Westman Agricultural Diversification Organization continually looks for new research project ideas, value-added ideas, partnerships, and producer production concerns to address current and future challenges in agriculture.

Please submit your contact information to Scott Chalmers to be put on an email notification list and check with the Manitoba Diversification Centres website for more information. If you have any ideas, please forward them to:

Westman Agricultural Diversification Organization (WADO)
c/o. Scott Chalmers, Manitoba Agriculture
139 Main Street, P.O. Box 519
Melita, MB R0M 1L0
204-522-5415
scott.chalmers@gov.mb.ca

2023 Weather Report and Data – Melita Area

Table 1. Melita 2023 Seasonal Report by Month (Normal is based on 30-year Average)

Month	Precipitation (mm)		Ave. Temperature (Celcius)		Corn Heat Units		Growing Degree Days	
	Actual	Normal	Actual	Normal	Actual	Normal	Actual	Normal
April	28	27.5	0.3	5.3	36	78	10	24
May	43	55.1	15.1	11.9	513	365	315	205
June	48	77.7	20.3	16.8	686	583	445	351
July	18	70.4	18.3	16.9	644	712	413	453
August	26	51.6	18.6	18.9	634	640	407	404
September	43	37.3	15.6	12.9	426	369	266	211
October	53	32.2	5.0	5.1	184	116	95	40
Totals	259	351.8	-	-	3123	2863	1951	1688

Table 2: Seasonal Summary (April 15 – October 31, 2023)

	Actual	Normal	% of Normal
Number of days	214		
Growing Degree Days	1969	1702	116
Corn Heat Units	3151	2884	109
Total Precipitation (mm)	265	399	66

Mean Monthly Air Temperature (normal and actual) at Melita (April 1 – October 31, 2023)

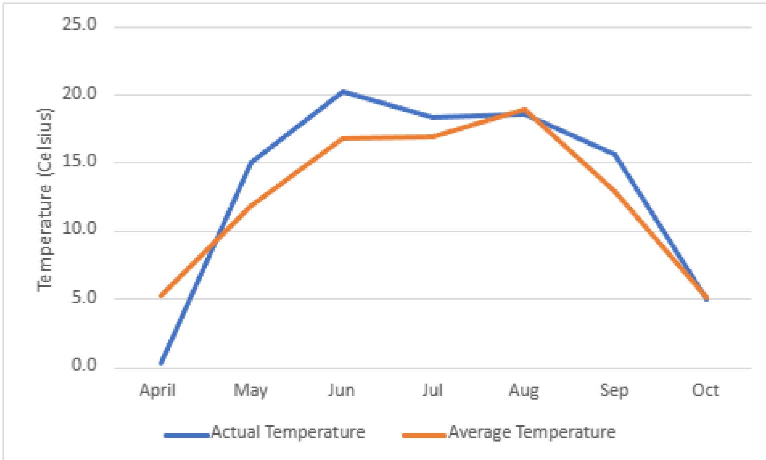

Figure 1a. The mean monthly air temperature (°C) recorded at Melita from April 1 to October 31, 2023, compared with the normal mean monthly temperatures at Melita.

In Melita, the average monthly temperature was below normal for April (0.3°C) then increased through the growing season eventually becoming above average for most of the growing season. The June average temperature was 3.5°C above average, and the average temperature peaked in August (18.6°C). The September average (15.6°C) exceeded normal temperatures for that time of year; in October the temperatures stayed around normal. These types of temperatures were ideal for creating heat accumulation that is required for crop development.

Precipitation (mm) (normal and actual) recorded at Melita (April 15 – October 31, 2023)

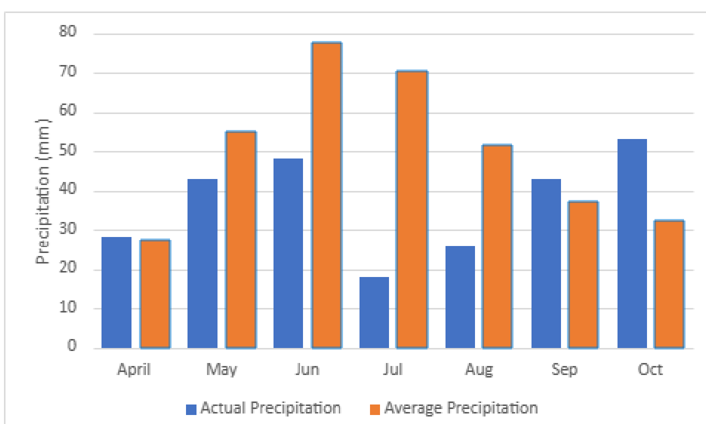

Figure 1b. Monthly precipitation (mm) recorded at Melita from April 15 to October 31, 2023, compared to the normal monthly precipitation for Melita from April to October

Once again, the 2023 growing season was drier than normal, with the total precipitation from April 15 to October 31 being only 66% of the normal precipitation for the area. With 28 mm of precipitation in April and 43 mm in May, the crops did have to depend on pre-existing soil moisture, which was abundant, to get established. After those early growing months, dry conditions began and persisted throughout the growing season. From June to August the amount of precipitation decreased per month, 48 mm in June, only 18 mm in July, and 26 mm in August. The dry trend turned around into September (43 mm) and October (53 mm); both amounts being above normal precipitation for this time of year. With most of the precipitation coming early in the growing season, some yield losses can be attributed to the dry conditions. The higher amounts of precipitation occurring in the fall may have caused some harvest delays, and possible harvest losses. The increase in fall soil moisture seemed to have a positive effect on fall seeded crops going into the winter months.

GDD (normal and actual) accumulated at Melita (April 15 – October 31, 2023)

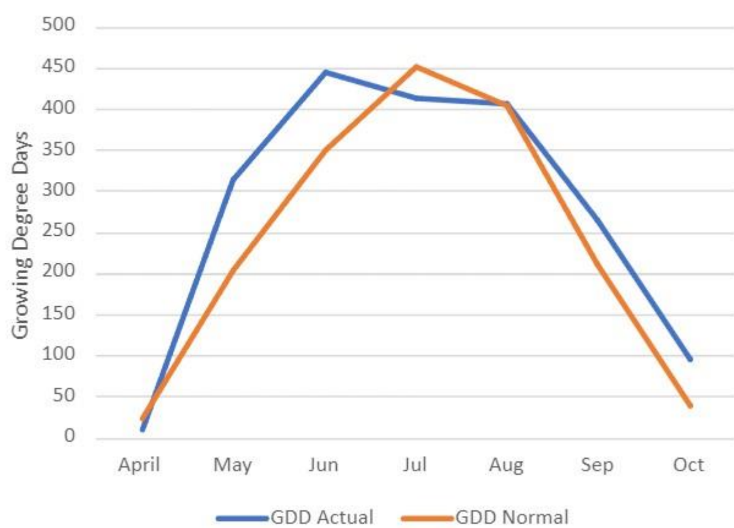

Figure 1c. Growing degree days in 2023 from Melita compared to the 30-year normal growing degree days for the region.

Growing degree days (GDD) are calculated as follows:

$$\text{Daily GDD} = \frac{[\text{maximum temperature} + \text{minimum temperature}]}{2} - \text{base temperature}$$

Base temperature varies from crop to crop, for example, 0°C for cereals, 5°C for alfalfa and canola, 6.7°C for sunflower and 10°C for corn and soybean. If the daily GDD calculates to a negative number, the value for that day is assumed to be zero. Each daily GDD is then accumulated over the growing season to come up with the seasonal value.

Corn heat units (CHU) are based on a similar principle to growing degree days. CHUs are calculated on a daily basis, using the maximum and minimum temperatures; however, the equation that is used is quite different. The CHU model uses separate calculations for maximum and minimum temperatures. The maximum or daytime relationship uses 10°C as the base temperature and 30°C as the ceiling, because warm-season crops do not develop at all when daytime temperatures fall below 10°C, and develop fastest at about 30°C. The minimum or nighttime relationship uses 4.4°C as the base temperature and does not specify an optimum temperature, because nighttime maximum temperatures very seldom exceed 25°C in Canada. The nighttime relationship is considered a linear relationship, while the daytime relationship is considered non-linear because crop development peaks at 30°C and reaches a plateau at temperatures above 30°C. Corn heat unit system is a more accurate and consistent crop prediction tool for warm season crops like corn and soybeans. The formula for CHU is illustrated below:

$$\text{Daily CHU} = \frac{1.8(T_{min}-4.4) + 3.3(T_{max}-10) - 0.082(T_{max}-10)^2}{2}$$

Where, T_{min} is the minimum daily temperature and T_{max} is the maximum daily temperature. When the daily CHU is negative, the value is assumed to be zero.

A good visual of our growing season is illustrated on the 2023 Precipitation Map and the 2023 Corn Heat Unit Map. These can be found at

https://www.gov.mb.ca/agriculture/weather/weather-conditions-and-reports.html

Sources

Government of Canada (2023) *Climate*. Available at: https://climate.weather.gc.ca/climate_data/daily_data_e.html?hlyRange=1994-02-01%7C2023-10-31&dlyRange=1992-12-01%7C2023-10-31&mlyRange=1996-01-01%7C2007-11-01&StationID=10185&Prov=MB&urlExtension=_e.html&searchType=stnProv&optLimit=yearRange&StartYear=2023&EndYear=2023&selRowPerPage=25&Line=46&lstProvince=MB&timeframe=2&Day=31&Year=2023&Month=4

Government of Canada (2023a) *Climate*. Available at: https://climate.weather.gc.ca/climate_normals/results_1981_2010_e.html?searchType=stnName&txtStationName=pierson&searchMethod=contains&txtCentralLatMin=0&txtCentralLatSec=0&txtCentralLongMin=0&txtCentralLongSec=0&stnID=3514&dispBack=1

Manitoba agriculture, Food and Rural Development (2023) *Seasonal Report - Manitoba Ag-Weather Program*. Available at: https://web43.gov.mb.ca/climate/SeasonalReport.aspx

WADO Tours and Special Events

WADO hosted their annual field day tour on July 19, 2023. There were 96 producers and industry members that attended to view the plots and listen to the invited speakers. WADO, along with the other three Manitoba Diversification Centers, attended Manitoba Ag Days in Brandon for the second time since Covid lockdowns. It was great to see many people attending the event; the Diversification Centers booth was visited by a steady stream of producers and industry members. The booth was also visited by numerous groups of kids as part of the Ag in the Classroom program. In February, WADO also attended the Crop Connect event in Winnipeg with a booth to spread more information about the research done here.

Throughout the year, Scott Chalmers participated in multiple social interactions with producers, industry members, and students including class lectures at the U of M in Winnipeg, a radio broadcast, and multiple online and in-person presentations.

WADO Plot Statistics

There are two types of plots at WADO. The first type is replicated research plots, and the other is demonstration plots. Demonstration plots are not used to determine statistical differences between data; they are typically used only for show-and-tell and observation.

Replicated plots are scientific experiments in which various treatments (ex. varieties, rates, seed treatments, herbicide efficacy, fertility rates etc.) are subject to a replicated assessment to determine if there are differences or similarities between them. Many designs of replicated trials include randomized complete block designs (most common), split plot design, multi-site and lattice designs. Since these types of trials are replicated, statistical differences can be derived from the data using statistical analysis tools.

The analysis of variance (ANOVA) is the most common of these calculations. From those calculations, we can determine several important numbers such as coefficient of variation (CV), least significant difference (LSD) and the probability value (P value). CV indicates how well we performed the trial in the field, which is a value of trial variation, variability of the treatment average as a whole of the trial. Typically, CV's greater than 15% are an indication of poor data in which a trial is usually rejected from further use. LSD is a measure of allowable significant differences between any two treatments. Ex: Consider two treatments; 1 and 2. The first treatment has a mean yield of 24 bu ac^{-1}. The second treatment has a yield of 39 bu ac^{-1}. The LSD was found to be 8 bu ac^{-1}. The difference between the treatments is 15. Since the difference was greater than the LSD value 8, these treatments are significantly different from each other. In other words, you can expect the one treatment (variety or fertilizer amount, etc.) to consistently produce yields higher than the other treatment in field conditions. If "means" (averages) do not fall within this minimal difference, they are considered not significantly different from each other. Sometimes letters of the alphabet are used to distinguish similarity (same letter in common) between varieties or differences between them (when letters are different representing them).

Probability value is the measure of the probability that observed differences between treatments could have happened randomly by chance. The assumption is that the lower the P value, the greater the significance of the observed differences. Coefficient of variation and least significant difference at the 0.05 level of significance is generally used to determine trial variation and mean differences respectively. At this level of significance, there is less than 5% chance that this data is a fluke when considered significant. For differences among treatments to be significant, the P-value must be less than 0.05. A P-value of 0.001 would be considered highly significant.

Grand mean is the average of the entire data set. Quite often, it helps gauge the overall yield of a site or trial location. Sometimes 'checks' are used to reference a familiar variety to new varieties and may be highlighted in grey or simply referred to as 'check' in the results table or summary for the readers' convenience.

Data in all replicated trials at WADO is analyzed by statistical software from either Agrobase Gen II version 16.2.1, or Minitab 18 software programs.

1.0 MCVET Variety Evaluations

The Westman Agricultural Diversification Organization is one of many sites that are part of the Manitoba Crop Variety Evaluation Team (MCVET) that facilitates variety evaluations of many different crop types in this province. The crops include grain corn, winter wheat, fall rye, sunflower, soybean, peas, barley, spring wheat, oats, annual forages, and dry bean.

The purpose the MCVET variety evaluations is to grow both familiar (checks or reference) and new varieties side by side in a replicated manner in order to compare and contrast various variety characteristics such as yield, maturity, protein content, disease tolerance and many others. From each MCVET site across the province, yearly data is collected, combined, and summarized in the "Seed Manitoba" guide. Hard copies can be found at most Manitoba Agriculture and Ag Industry Offices. The suite of Seed Manitoba products — the Seed Manitoba guide and the website www.seedmb.ca — provides valuable variety performance information for Manitoba farmers. Look for Seed Manitoba mailed out with the Manitoba Cooperator or on the web.

Table 3 below summarizes the WADO-grown MCVET trials agronomy for each crop type. The table provides extra insight; when combined with the weather summary, provides helpful insight into variety performance especially when compared year to year. Sunflower, annual forage, and grain corn variety evaluation results for 2023 are available in supplemental sections 2.0, 4.0, and 5.0 of this report.

Table 3: MCVET Variety Trial Agronomy Practices for 2022. All yield results are published in the 2022 Seed Guide.

Crop	Pre-Emergence Weed Application (rate/ac)	Soil Moisture at Seeding	Seeding Date	Seeding Depth	Fertilizer Applied (actual lb/ac) N-P-K-S-Zn	Post-Emergence Herbicides (Rate/ac)	Harvest date (2023)
Annual Forages	No burn off	Good	25-May	0.75"	110-35-25-15-1Zn	0.91L/ac Basagran on Millet/Sorghum / 0.2L/ac MCPA Amine 500 on other crops / 0.45L/ac Basagran for clean up	27-Jul all but Millet & Sorghum/01-Aug Millet/08-Aug Sorghum
Barley	No burn off	Excellent	5-May	1"	95-35-25-15-1Zn	275mL/ac Puma + 0.5L Mextrol	08-Aug
Corn	0.67L/ac + 15mL/ac Aim before seeding	Good	16-May	2"	100-40-25-15-1Zn Banded	@ 2-leaf stage - 0.67L/ac Round Up / 0.67L/ac Round Up for extra clean up	21-Sep
Herbicide Tolerant Soybeans	0.67L/ac Round Up before seeding	Excellent	15-May	1"	10-35-25-17-1Zn	150mL/ac Arrow + 0.5% X-Act / 0.67L/ac Round Up / 0.33L/ac Round Up (foxtail)	13-Sep
Convent. Soybeans	0.67L/ac Round Up before seeding	Excellent	15-May	1"	10-35-25-15-1Zn	150mL/ac Arrow + 0.5% X-Act / 0.4L/ac Viper + 0.81L/ac UAN	13-Sep
NR Dry Beans	0.67L/ac Round Up before seeding	Excellent	16-May	1"	95-35-25-15-1Zn	150mL/ac Arrow + 0.5% X-Act / 0.4L/ac Viper + 0.81L/ac UAN	30-Aug
Oats	0.67L/ac Round Up + 20mL/ac Aim before seeding	Excellent	10-May	0.75"	107-35-25-15-1Zn	0.5L/ac Mextrol	08-Aug
Flax	0.67L/ac Round Up + 85mL/ac Authority + 0.56L/ac Rival after seeding	Excellent	4-May	1"	110-35-25-15-1Zn	150mL/ac Arrow + 0.5% X-Act / 0.9L/ac Basagran	17-Aug

Peas	0.67L/ac Round Up before seeding	Excellent	3-May	1.25"	10-35-25-15-1Zn	17.3g Odyssey + 0.5% Merge	03-Aug
Sunflowers	0.67L/ac Round Up + 85mL/ac Authority + 0.56L/ac Rival after seeding	Excellent	18-May	1.25"	92-40-29-17-1Zn	Muster 12g/ac + 0.2L/ac Assure II + 0.5% LI700 / 0.54L/ac Assert + 25g/gal pH Adjuster	29-Sep
Spring Wheat	No burn off	Excellent	5-May	1"	134-35-25-15-1Zn	275mL/ac Puma + 0.5L Mextrol	08-Aug
Winter Wheat	0.67L/ac Round Up + 0.2L/ac Koril before seeding	Excellent but Shallow	16-Sep	0.5"	16-30-21-13-1Zn + 60lbs/ac of Agrotain in Spring	@ Boot Stage - 0.5L/ac Mextrol + 0.2L Achieve + 0.5% Turbocharge	14-Aug
Fall Rye	0.67L/ac Round Up + 0.2L/ac Koril before seeding	Excellent but Shallow	16-Sep	0.5"	16-30-21-13-1Zn + 60lbs/ac of Agrotain in Spring	@ Boot Stage - 0.5L/ac Mextrol + 0.2L Achieve + 0.5% Turbocharge	14-Aug

2.0 Confectionary & Oil Sunflower Variety Trial at Melita

Collaborators: Manitoba Crop Alliance
Project Duration: Ongoing

Objectives:

- To evaluate yield and quality of sunflower varieties under different growing conditions in Manitoba

Background

Sunflower varieties were tested, and data donated by the Manitoba Crop Alliance (MCA). These sunflower trials were grown in different areas across Manitoba in 2023 including Melita, Carberry, Elm Creek, Beausejour, and Rosendale. All confectionary sunflowers varieties used are susceptible to sclerotinia and sunflower rust strains present in Manitoba. Genetic resistance to verticillium wilt is rated as moderately susceptible to moderately resistant for all sunflower varieties used. Oil sunflower markets include bird food, oil crush and de-hull. Variety selection becomes more important when trying to capture de-hull markets. Producers should choose varieties with better de-hull ratios, larger sizes, and higher test weight. Plant population and environment will contribute greatly to the final product. All agronomy information for the sunflower variety trial is presented in Table 3 of this report. In 2023 the Melita site was found to have Black Medic growing as a weed; Assert (imazamethabenz; Group 2) was applied to control them. An unusually abundant amount of disformed sunflower heads caused by sunflower midge had occurred. Hand sprayers were used, and care was taken not to directly spray the sunflower plants. Unfortunately, the 2023 results from Melita were rejected due to severe bird damage. Results for the 2023 sunflower variety trials from all sites can be found in the 2023 Manitoba Seed Guide or on the MCA website.

3.0 Oil Sunflower Row Spacing by Population Trial at Melita

Project Duration: 2023-2025
Collaborators: MCA (Darryl Rex), WADO, MCDC

Objectives

- To evaluate solid seeding versus mid- and wide row spacing in oil sunflower production
- To evaluate plant populations in solid seeded, mid- and wide row spacing

Background

This project is comparing various seeding rate of solid seeded oilseed sunflowers to row planted sunflowers over two field seasons. The experiment is designed similar to a small plot experiment; a randomized complete block design with four replicates. Row spacing was determined based on the existing capacity of seeding equipment at the diversification centers.

Different plant populations were also targeted since the theory is that an air seeder lacks the advantage of singulation and would be inefficient at low plant populations and would require a higher planting rate in order to match the yield of a planter. In this experiment, the oil-type sunflower hybrid P63ME80 was planted at 3 target plant populations (18,000 & 22,000 & 26,000 plants ac^{-1}) and in narrow (<12-inch, solid seeded), mid- (15-inch) and wide- (30-inch) rows. In Melita, the solid seeded plots had 9.5-inch row spacing, the mid-row plots had 15-inch, and wide-row plots were planted on 30-inch spacing. Each different spacing was planted at the three different populations mentioned above. There was a total of nine treatments in the trial, and those were replicated four times.

Materials and Methods

Sunflower row spacing by population trials were established in a single trial with four replicates at both the Melita and Carberry sites in 2023. In Melita, the trial was established into wheat stubble on May 18th at a 1.25-inch depth. The solid seeded plots were seeded with a Seedhawk Dual Knife Drill, while the mid- and wide row plots were planted using a Wintersteiger Dynamic Disc planter equipped with EasyPlant software. Fertility was banded before seeding at a rate of 92-40-29-17-1 actual lbs ac^{-1} (N-P-K-S-Zn). Burn off was applied as Round Up (0.67 L ac^{-1}), Rival (0.65 L ac^{-1}), and Authority (85 mL ac^{-1}) on May 19th. Additional post-emergence herbicide application was needed though the season as Muster (12 g ac^{-1}) tanked mixed with Assure II

(0.2 L ac^{-1}) on June 8th, followed by Assert (0.54 L ac^{-1}) on June 9th. The entire trial was desiccated on September 15th with Reglone (0.65 L ac^{-1}). All plots were harvested on September 29th. Data collected throughout the growing season included days to flowering, lodging, disease ratings, plant height, bird damage ratings, yield, and seed moisture.

Table 4a and 4b. Factors and Treatments of the 2023 Sunflower Row Spacing Trial at Melita.

Factor A		Factor B	
Row Spacing inches		Plant Population plants/acre	
1	9.5	1	18,000
2	15	2	22,000
3	30	3	26,000

Entry	Row Spacing	Plant Population
1,1	9.5	18,000
1,2	15	22,000
1,3	30	26,000
2,1	9.5	18,000
2,2	15	22,000
2,3	30	26,000
3,1	9.5	18,000
3,2	15	22,000
3,3	30	26,000

Results

When the data for this trial was analyzed, there was no significant effects found. The entire first replicate of this trial was removed from the data analysis because of severe losses due to birds feeding on the heads. Hopefully next year we will experience better growing conditions and can see some significant effects between the treatments.

Pictures

Figure 2: At seeding time. Solid seeded (9.5-inch row spacing) sunflowers being seeded right next to 30-inch spaced sunflowers.

Figure 3: Drone image of the second replication of treatments. Note differences in row spacing is quite visible. With 30” guards on left and right treatment order left to right is SS, 15”, 15”, 30”, 30”, 15”, SS, SS, 30” at the various populations.

4.0 Grain Corn Hybrid Variety Trial at Melita

Project duration: Ongoing
Collaborators: MCVET, Manitoba Crop Alliance

Objectives

- To evaluate performance of grain corn varieties for production in different regions in Manitoba

Background

The grain corn hybrid trials were established in 2021, though drought conditions experienced in Melita led to high variation in the collected data. This high variation resulted in a high coefficient of variation and therefore the data was rejected for the 2021 season. In 2022, the collected data turned out very good; the average yields were higher, and there was less variation across the trial. In 2023, the growing conditions were dry and there was high grasshopper pressure at the site, but the corn plots still produced respectable yields.

The Manitoba Corn Committee publishes the annual results with all the yearly data in their brochure, which is available by calling the MCA office. The agronomic and field information for this trial can be found in Table 3 of this report. A table of the 2023 Melita results presented by the MCA can be found below in Table 5. More information and the results from the other trial locations in Manitoba are available on the MCA website: https://mbcropalliance.ca/production/manitoba-corn-hybrid-performance-trials/. The Canadian Seed Trade Association (CSTA) website provides a database for corn hybrids available in Canada, available at https://seedinnovation.ca/corn-hybrids-database.

Table 5. 2023 MCA Hybrid Corn Trial Results from Melita, Manitoba.

CHU[1] Rating	Hybrid	Distributor	Technology/Genetic Trait (s)[2]	Melita 2023			
				50% Silk	Yield (bu/ac)	Moisture (%)	Bushel Wgt (lbs/bu)
1925	TH6370 VT2P	Thunder Seed	VT2P	61	91.3	12.4	55.6
1950	P6910AM	Corteva Agriscience (Pioneer)	YGCB/HX1/LL/RR2	62	94.9	11.2	55.3
2025	CX23072A/VT2P	WinField United (CROPLAN)	VT2P/RIB	63	95.9	11.2	56.2
2025	A3979G2 RIB	PRIDE Seeds	VT2P	63	88.9	13.4	56.3
2025	TH6072 VT2P	Thunder Seed	VT2P	62	101.1	13.9	51.8
2050	DKC20-23RIB	Bayer Crop Science (DEKALB)	VT2P	61	91.7	12.0	55.9
2050	MZ 1200DBR	Maizex Seeds Inc.	VT2P	61	91.4	13.4	54.6
2050	MZ 1231DBR	Maizex Seeds Inc.	VT2P	62	92.8	16.5	56.0
2050	P72068AM	Corteva Agriscience (Pioneer)	YGCB/HX1/LL/RR2	62	97.5	12.1	57.1
2050	P7211AM	Corteva Agriscience (Pioneer)	YGCB/HX1/LL/RR2	61	103.0	12.3	52.9
2075	NS 271	NorthStar Genetics	VT2PRO	59	102.4	13.8	56.2
2075	DLF 2158VT2P RIB	DLF Canada Inc.	GENVT2P	65	101.9	17.9	56.4
2075	TH6474 VT2P	Thunder Seed	VT2P	63	92.9	16.6	56.8
2075	DKC21-36RIB	Bayer Crop Science (DEKALB)	VT2P	64	102.7	14.0	57.1
2075	EXP072-23	Bayer Crop Science (DEKALB)	VT2P	62	108.0	15.9	56.4
2075	P7389AM	Corteva Agriscience (Pioneer)	YGCB/HX1/LL/RR2	64	101.2	15.3	55.8
2100	PV 60273RIB	Nutrien Ag Solutions (Proven Seed)	VT2PRO	63	103.4	17.9	55.1
2100	25-75	Fraser Seeds (Greenfield Genetics)	HAW	67	99.4	20.7	49.1
2100	CP1440VT2P/RIB	WinField United (CROPLAN)	VT2P/RIB	66	105.5	16.6	54.5
2100	DKC24-06RIB	Bayer Crop Science (DEKALB)	VT2P	65	98.9	16.9	55.4
2100	P7455R	Corteva Agriscience (Pioneer)	RR2	64	106.7	15.7	56.0
2125	NS EXP75	NorthStar Genetics	VT2PRO	62	95.3	17.1	56.9
2125	NS EXP75P	NorthStar Genetics	PowerCore Enlist	68	104.5	22.7	51.3
2125	DKC25-15RIB	Bayer Crop Science (DEKALB)	VT2P	66	103.9	17.1	55.8
2150	HZ 1265	Horizon Seeds	Agrisure GT	60	89.3	13.9	56.9
2150	P7527AM	Corteva Agriscience (Pioneer)	YGCB/HX1/LL/RR2	65	100.5	19.4	53.6
2175	PV 61276RIB	Nutrien Ag Solutions (Proven Seed)	VT2PRO	63	106.4	17.9	56.7
2175	TH6977 VT2P	Thunder Seed	VT2P	62	116.2	16.3	54.1
2200	A4494G2 RIB	PRIDE Seeds	VT2P	62	107.6	16.6	55.8
2225	TH6278 VT2P	Thunder Seed	VT2P	64	113.1	16.9	53.3
2250	DKC28-25RIB	Bayer Crop Science (DEKALB)	VT2P	65	105.1	17.6	55.0
2250	MZ 1544DBR	Maizex Seeds Inc.	VT2P	65	109.9	18.8	54.1
2250	P7822AM	Corteva Agriscience (Pioneer)	YGCB/HX1/LL/RR2	64	118.8	22.4	52.5
2350	NK7837-V	Syngenta Canada Inc.	Agrisure Viptera	66	107.3	23.1	53.3
			Site Average	63	101.2	15.9	54.9
			CV	2.08	7.80	6.02	2.17
			Sign. Diff.	Yes	Yes	Yes	Yes
			LSD	2	10.8	1.3	1.6
			Planting Date	May 16, 2023			
			Harvest Date	September 22, 2023			

5.0 Advanced Yield Tests for Malt Barley and Food Barley

Project duration: Ongoing
Collaborators: Agriculture and Agri-food Canada Brandon, Dr. Ana Badea

Objectives

- To evaluate grain yield potential, maturity, and lodging characteristics of different barley varieties under Prairie weather conditions

Background

Barley is one of the earliest domesticated and most important cereals widely used for food, feed and malting purposes. Canada is widely known for producing high quality malting barley that is highly valued by consumers. The quality profile of malting barley evolved as a result of many years of research and collaboration in understanding quality and setting objectives for quality in the development of new barley varieties and adapting improved ways of measuring quality (Edney et al., 2014). In order to continue to fulfill quality requirements of Canadian malting barley varieties, there is a need for breeders to continue breeding new varieties which can be highly competitive in local and global markets. While breeding work for improved varieties is necessary, barley management tools such as seeding rate, nitrogen fertilizer application rates and timing, and variety selection should not be ignored (Edney et al., 2012). These factors play a crucial role in determining kernel size, protein content and yield. This study seeks to evaluate new coop barley varieties under prairie weather conditions versus established varieties.

Materials and Methods

Advanced yield barley trials were established near Melita, Manitoba on Waskada Loam soil in 2023. The yield tests were arranged as randomized complete block design of 30 treatments (varieties) with 3 replicates for both AA (Malt) barley and AFOO (Food) barley. The AA barley was seeded into canola stubble at a 1-inch depth on May 8th. The AFOO barley trial was seeded on May 5th. Fertilizer was banded at seeding for AA at a rate of 95-35-25-15-1 actual lbs ac^{-1} (N-P-K-S-Zn), and for AFOO barley at a rate of 98-35-25-15-1 actual lbs ac^{-1} (N-P-K-S-Zn) as per soil test results and crop requirements. No pre-emergent herbicide was needed at the time of seeding. For additional post-emergent weed control, Puma (0.675 L ac^{-1}) and Mextrol (0.5 L ac^{-1}) were applied on May 31st. There was possible damage caused by the Puma application as the stage of the barley was at the later end of the acceptable spectrum. Matador (34 mL ac^{-1}) was applied for the control of grasshoppers on June 26th. Desiccation was not needed, and the plots and were harvested on August 3rd (Malt) and August 8th (Food).

Results and Discussion

Results from this study are for publication by Agriculture and Agri-Food Canada and may be available upon request by Dr. Ana Badea.

References

Edney, M. J., MacLeod, A. L. and LaBerge, D. E. 2014. Evolution of a quality testing program for improving malting barley in Canada. Can. J. Plant Sci. **94**: 535–544.

Edney, M. J., O'Donovan, J. T., Turkington, T. K., Clayton, G. W., McKenzie, R., Juskiw, P., Lafond, G. P., Brandt, S., Grant, A. C., Harker, K. N., Johnson, E. and May, W. 2012. Effects of seeding rate, nitrogen rate and cultivar on barley malt quality. Journal of the Science of Food and Agriculture **92 (13): 2672-2678**

6.0 Western Cooperative Hulless Barley Evaluation

Project duration: Ongoing
Collaborator: Dr. Ana Badea-AAFC Brandon

Objectives

- Evaluation of yield potential and agronomic characteristics of hulless barley

Background

Barley (Hordeum vulgare) is mainly used in the malting, brewing and feed industries, but has recently gained popularity in the food industry, primarily due to the beneficial health effects associated with consumption of barley-based foods. Such health benefits include lowering blood cholesterol and postprandial blood glucose in humans (Abdel-Aal and Choo, 2014). It is widely believed that hulless or free threshing barley has a great potential for food, feed, and industrial uses (Bhatty 1999), and is now available in various types such as normal, waxy or high-amylose starch, high or low β-glucan, and two- or six-row type. This diversity in characteristics and composition is significant to the development of hulless barley for various food and non-food applications. The current study seeks to evaluate new coop hulless barley varieties for their yield potential and other agronomic components such as lodging, maturity and disease pressure. Furthermore, the varieties will be characterized based on their protein content and malting quality. The expectation is that ideal varieties will be made available to barley producers so that producers can have a wide selection of suitable varieties for their areas of production.

Materials and Methods
The pre-registration coop variety trial was conducted on Waskada Loam soil under a no-till system at Melita in 2023. Experimental design used was a randomized complete block design with 11 treatments (varieties) replicated 3 times. Before seeding, no burn off was required. This hulless barley was seeded into canola stubble on May 8th at 1-inch depth. Fertilizer was applied at 95-35-25-15-1Zn (N-P-K-S-Zn) actual lbs ac^{-1}. Herbicide and insecticide applications were identical to that of the Barley advanced yield trials (section 6.0.) There was possible damage caused by the Puma application as the stage of the barley was at the later end of the acceptable stage spectrum. The trial was harvested on August 8th.

Results
Results from this study may be made available by contacting Dr. Ana Badea at Agriculture and Agri-Food Canada, in Brandon, MB.

References
Abdel-Aal, E. M. and Choo, T.-M. 2014. Differences in compositional properties of a hulless barley cultivar grown in 23 environments in eastern Canada. Canadian Journal of Plant Science **94**: 807-815.

Bhatty, R. S. 1999. The Potential of Hull-less Barley. Cereal Chemistry **76** (5): 589-599

7.0 Optimizing Nitrogen Fertility in Winter Wheat Varieties
Project Duration: 2023 – 2024. Reporting 2023.

Collaborators: Ducks Unlimited Canada (Ken Gross, Alex Griffiths, Elmer Kaskiw), Manitoba Agriculture (John Heard), Western Ag & Professional Agronomy (Edgar Hammermeister)

Objectives

- Update the winter wheat fertility recommendations in the Manitoba Soil Fertility Guide.
- To compare spring broadcast only application, to fall and spring split application of nitrogen for yield and protein.
- To see if there are varietal differences in nitrogen use efficiency between Wildfire and Vortex.

Background

Following decades of extensive work in winter wheat production in North America, many researchers and producers have begun to implement best management practices to obtain higher grain yield and improve profitability in the crop. Management practices presently being implemented to improve winter wheat production include increasing seeding rate, application of starter fertilizer by banding during seeding, variety selection, pest control and split application, during planting in fall and at tillering or stem elongation in spring (Anderson, 2008; Schulz et al., 2015). Fertility management, in particular nitrogen and phosphorus fertility, remains an integral part of the overall management package aimed at achieving higher yields in winter wheat (Halvorson et al. 1987). Recommended fertilizer management, particularly nitrogen management, differs widely in winter wheat production, but the crop's nitrogen demand is correlated to yield potential and availability of moisture in dryland production systems (Beres et al., 2018). Compared to spring wheat, winter wheat presents more challenges in development as a result of its higher nitrogen demand during the long vegetative phase, hence the reason why it requires 25 to 50% more N than spring wheat in the Prairies (Fowler et al., 1989). The ideal fertility management package would help counteract the escalating cost of winter wheat production per unit area, which is the main goal of winter wheat producers. There is still a knowledge gap on the rates and timing of nitrogen fertilizer application, particularly in Western Canada, that result in improved yield without compromising grain quality and economic returns. Morris et al. (2018) suggested the implementation of adaptive use of nitrogen to help augment and improve nitrogen application rate decision making by farmers. Therefore, there is a great need to continue with research on the best management practices which can be adopted by producers to improve economic returns in winter wheat production. This study aims to understand varietal demand to nitrogen as well as whether fall/spring split applications of nitrogen are more effective than single spring applications.

Methods and Materials

This study was established at Melita, Roblin, Carberry and Arborg, Manitoba. The trial design consisted of two varieties and 7 nitrogen treatments replicated three times, that were laid out factorially in a complete randomized block design.

Plot Treatments:

1. Wildfire – Highest yielding winter wheat on the market
2. Vortex – New Emerson replacement with great disease resistance and winter hardiness

Subplot Plot

1. Check – No fertility except starter phosphorus
2. 60 Kg ha^{-1} (53.5 lbs ac^{-1}) nitrogen, split 50:50
3. 90 Kg ha^{-1} (80.3 lbs ac^{-1}) nitrogen, split 50:50
4. 120 Kg ha^{-1} (107.1 lbs ac^{-1}) nitrogen, split 50:50
5. 150 Kg ha^{-1} (133.8 lbs ac^{-1}) nitrogen, split 50:50
6. 180 Kg ha^{-1} (160.6 lbs ac^{-1}) nitrogen, split 50:50
7. 120 Kg ha^{-1} (107.1 lbs ac^{-1}) nitrogen all applied in spring

The soil test results, and the applied fertilizer amounts are listed for each site in Table 6a. All 5 split applications had 50% of the rate being applied in the fall, and 50% of the rate being applied in the following spring. Specific treatment nitrogen rates using granular ESN/urea (50:50 blend) were placed at approximately 1.25-inch depth in a separate pass before seeding the wheat. Seeding target density was 325 plants m^{-2}. Germination was 95% for both varieties. Treatment-specific nitrogen rates were top-dressed in the early spring, as urea coated with Agrotain. The spring nitrogen application of 120 Kg ha^{-1} is the currently producer fertility practice when growing winter wheat representing treatment 7. Each site where this trial was grown used slightly different agronomic practices and had different field conditions which are outlined in the following Tables 6b and 6c.

Data collected throughout the growing season included soil tests at time of seeding, emergence counts, lodging scores, heights, yield, grain moisture, test weight, and protein. Data was analyzed with Minitab 18.1 statistical software using a GLM ANOVA with Fishers Least Significant Difference at a 0.05 level of significance. A test for equal variance was used to determine if data could be combined.

Table 6a. Fall soil test results by site and fertilizer treatments for winter wheat in the 2022/2023 season.

Fall Soil Test and Fertilizer Application (Actual lbs/ac)					
		Soil Supply	Applied*	Total	Product Type
Melita	N	31	120	151	Urea, 40 rock
	P	32	30	62	40rock
	K	72	20	92	Potash
	S	112	0	112	
	Zn	0.48	1	1.48	Zinc sulfate
Roblin	N	32	120	152	Urea, MAP
	P	61	15	76	MAP
	K	94	0	94	
	S	17	0	17	
	Zn	0.69	0	0.69	
Carberry	N	23	120	143	Urea, MAP
	P	17	35	52	MAP
	K	32	50	82	Potash
	S	21	0	21	
	Zn	0.78	0	0.78	
Arborg	N	23	120	143	Urea, MAP
	P	23	30	53	MAP
	K	41	30	71	Potash
	S	14	0	14	
	Zn	0.17	0	0.17	
*Note: Applied nitrogen value is the soil test recommended value for treatments 4 & 7 as a baseline and took into account nitrogen sources from phophorous products.					

Table 6b. Description of Site fields in the 2023 Ducks Unlimited Winter Wheat Fertility Trial in Melita, Roblin, Carberry, and Arborg.

Location	Melita	Roblin	Arborg	Carberry
Cooperator	WADO	PCDF	PESAI	CMDC
Legal	NW10-4-26W1	NE20-25-28W1	RL-37-22-02E	14W1
Rotation	Canola	Canola/Millet	Canola	Soybean/Canola
Soil Series	Sand	Loam	Heavy Clay	Loam
Soil Test	Yes	Yes	Yes	Yes
Field Prep	Harrowed	Direct Seed	Direct Seed	Direct Seed
Stubble	Canola	Millet	Canola	Canola
Burn off	Yes	Yes	No	Yes

Table 6c. Agronomic practices and Description of Sites in the 2023 Ducks Unlimited Winter Wheat Fertility Trial in Melita, Roblin, Carberry and Arborg.

Location	Melita	Roblin	Arborg	Carberry
(Date/Rate per acre/Products)	Glyphosate (0.67L/ac) + Koril (0.2L/ac) 16-Sep-22	Glyphosate (0.6 L/ac) + Heat LQ (37 ml/ac) + Merge (0.4 L/ac) 13-Sep-22	None	Round up (0.67 L/ac) + Heat (29 g/ac) Sep-14-22
Moisture at Seeding	Excellent	Very Dry	Excellent	Excellent
Seed Date	16-Sep-22	13-Sep-22	14-Sep-22	14-Sep-22
Seed depth (in)	0.5"	0.5"	0.5"	1"
Seeder	Air Drill	Disc Drill	Disc Drill	Disc Drill
Seeding Errors	None	None	None	None
Topdressing Date	11-May-23	end of May	06-May-23	27-Apr-23
Herbicides: (Date, Rate/ ac, Name)	Mextrol (0.5L/ac) + Achieve (0.2L/ac) + Turbocharge (0.5%) 29-May	None	Pardner @ 480 ml/acre (Sep 22)	Glyphosate (0.67L/ac) 08-Sep-22, Fitness (120mL/ac) 14-Jun, Buctril M (0.4L/ac) + Axial (0.5L/ac) 21-Jun
Fungicides	None	None	Prosaro (325 ml/ac) 30-Jun	Prosaro @ 325mL/ac Jun-29
Insecticides	None	None	Matador (34 mL/ac) 15-Jul	None
Desiccation	Reglone (0.5L/ac) 01-Aug	None	None	None
Harvest Date	14-Aug-23	15-Aug-23	17-Aug-23	30-Aug-23
Total Precip. (Seeding to Harvest)	370mm	226mm	253mm	271mm

Results and Discussion

In Arborg, the variety used was found to have a significant ($P < 0.001$) effect on winter wheat yield in 2023 (Table 6d). Wildfire winter wheat produced the highest yield at that site (3159 Kg ha^{-1}) and was significantly different from the yield of Vortex winter wheat (2701 Kg ha^{-1}) at Arborg. Protein content was also found to be significant ($P = 0.001$) between varieties at Arborg; Vortex had higher protein (15.0%) than Wildfire (14.3%). The variety used also had a significant ($P = 0.042$) effect on the test weight of the winter wheat. The variety Vortex had a higher test weight (67.0 Kg hL^{-1}) than Wildfire (65.6 Kg hL^{-1}) at Arborg. Plant population was also found to be significant ($P = 0.002$) between the two varieties grown. Fertility treatment was not found to have a significant effect on yield, protein, test weight, or plant population at the

Arborg site. The effects of both variety and fertility treatment together were found to have a significant (P = 0.040) effect on winter wheat yield at the Arborg site as well. Interestingly, the treatment that had the highest yield overall (3593 Kg ha^{-1}) was Wildfire grown with no extra fertility treatment (treatment 1,1). While the highest, the yield of that treatment was not significantly different from the yield of Wildfire grown with the fertility treatments of 120 and 180 Kg ha^{-1} of nitrogen split between spring and fall, and 120 Kg ha^{-1} of nitrogen applied in the spring. The treatment with the lowest yield (2245 Kg ha^{-1}) was shown to be Vortex grown with 120 Kg ha^{-1} of nitrogen with a split application; this yield was not significant from four other treatments in the trial. While significant (P = 0.036), the plant population did not vary as much between treatments; it is important to consider the plant population when evaluating yield differences between treatments.

In Carberry, the winter wheat variety Wildfire produced higher yields (5803 Kg ha^{-1}) than Vortex winter wheat (5426 Kg ha^{-1}), though the difference was not significant (P = 0.196) (Table 6d). Vortex winter wheat also had a higher protein content (13.5%) than Wildfire (11.8%); these values were significant ($P < 0.001$). Plant population was found to be significant (P = 0.003) between the two varieties. Test weight of the grain was not found to be significantly different (P = 0.093) between the two varieties at Carberry in 2023. When evaluating fertility, yield and test weight again were not found to be significant. Protein content was found to be significant ($P < 0.001$) between fertility treatments. The split application of 180 Kg ha^{-1} of nitrogen was shown to have the highest protein content (13.7%), though it was not significantly different from the split applications of 120 and 150 Kg ha^{-1} nitrogen or the spring application of 120 Kg ha^{-1} nitrogen. The plots where only starter phosphorous was applied (checks), along with the low rate of split nitrogen (60 Kg ha^{-1}) both produced the lowest protein content (11.7%) of the trial at Carberry. The protein content of those treatments was not significantly different from the protein content of the split application of 90 Kg ha^{-1} nitrogen (12.1%). Plant population was found to be significant (P = 0.009) between fertility treatments in Carberry; this is important to consider when evaluating yield. At the Carberry site, none of the evaluated characteristics were found to be significant when looking at the effects of both variety and fertility. Though not significant, Wildfire with a split nitrogen application of 60 Kg ha^{-1} had the highest yield (6186 Kg ha^{-1}), while Wildfire with no nitrogen application (check) had the lowest yield (4573 Kg ha^{-1}) in the trial.

In Melita, the variety used was found to have a significant (P = 0.004) effect on winter wheat yield in 2023 (Table 6d). Wildfire winter wheat produced the highest yield at that site (4783 Kg ha^{-1}) and was significantly different from the yield of Vortex winter wheat (4370 Kg ha^{-1}). Protein content was also significantly (P = 0.001) affected by variety choice at Melita. Vortex winter wheat had a protein content of 12.7%, which was significantly higher than that of Wildfire winter wheat (12.3%). Variety choice did not influence test weight or plant population. The fertility treatment used was found to have a significant (P = 0.001) effect on yield of winter wheat and only at Melita in 2023 compared to all other sites. The treatment of a split nitrogen application of 120 Kg ha^{-1} was shown to have the highest yield (5086 Kg ha^{-1}), which was not significantly different from the split nitrogen applications of 90, 150, and 180 Kg ha^{-1}. The check fertility treatment had the lowest yield (3826 Kg ha^{-1}) which was not significantly different from the yields of split nitrogen applications of 60, 150, or 180 Kg ha^{-1} or 120 Kg ha^{-1} of nitrogen applied in the spring. Fertility had a significant (P < 0.001) effect on protein content at Melita. Winter wheat grown with 120 Kg ha^{-1} nitrogen applied in the spring had the highest protein content (13.3%) which was not significantly different from the protein content when 150 and 180 Kg ha^{-1} of nitrogen was split between the fall and spring. In Melita, fertility was also found to have a significant (P = 0.005) effect on test weight in 2023. The plots that had no nitrogen applied (checks) were found to have the highest grain test weight (80.9 Kg hL^{-1}) which was not significantly higher than the test weights of the treatments including split nitrogen applications of 60, 90, 120, and 150 Kg ha^{-1}. Together, variety choice and fertility treatment were not found to have any significant effects. While not significant, Wildfire grown with a split nitrogen application of 120 Kg ha^{-1} had the highest yield (5230 Kg ha^{-1}) while the Vortex grown with no additional nitrogen had the lowest yield (3539 Kg ha^{-1}). Interestingly, the higher protein contents were seen in the spring nitrogen application of 120 Kg ha^{-1} for both Vortex (13.5%) and Wildfire (13.1%) varieties at the Melita site in 2023.

In Roblin, the variety used was found to not have a significant effect on winter wheat yield in 2023 (Table 6d). Variety choice was found to have a significant ($P < 0.001$) effect on protein content. The protein content of Vortex winter wheat (12.9%) was significantly different from that of Wildfire (11.8%). The fertility treatment was also found to only have a significant ($P < 0.001$) effect on protein content. The application of 120 Kg ha^{-1} nitrogen was shown to produce the highest protein content (13.3%), though not significant from three other fertility treatments included in the trial. While not found to be significant, the split application of 150 Kg ha^{-1} of nitrogen produced the highest yield (5631 Kg ha^{-1}) at Roblin. When the effects of variety and fertility were evaluated together, no significance was found in any factor. While not significant, the variety Vortex grown with a split application of 120 Kg ha^{-1} of nitrogen had the highest yield (6166 Kg ha^{-1}) of the treatments grown at Roblin. The variety Wildfire grown with a split application of 180 Kg ha^{-1} of nitrogen produced the lowest yield (4786 Kg ha^{-1}) of the treatments grown at Roblin in 2023. Wildfire grown without additional nitrogen had the lowest protein content (10.1%), while Vortex with a spring application of 120 Kg ha^{-1} nitrogen produced the highest protein content (13.9%). The trend was similar for the grain test weight. At the Roblin site, the plant counts were more inconsistent than at the other sites; this could indicate issues with the plant stand and vigor, such as high weed pressure.

When the data from all four sites was combined, variety choice was shown to have significant ($P = 0.016$) effect on yield (Table 6e). Across all sites, the variety Wildfire had the highest yield (4772 Kg ha^{-1}). Variety choice was also found to have a significant ($P < 0.001$) effect on protein content across all trial sites. The variety Vortex produced the higher protein content (13.5%), while Wildfire produced the lower protein content (12.6%). Across all four sites, fertility treatment was only found to have a significant ($P < 0.001$) effect on protein content of the grain. Two treatments produced the highest protein content (13.7%); split application of 180 Kg ha^{-1} nitrogen and spring application of 120 Kg ha^{-1} nitrogen. Across all four sites, when variety and fertility were evaluated together, no factors were found to be significant. Though not significant, the variety Wildfire grown with a split application of 150 Kg ha^{-1} nitrogen produced the highest yield (4986 Kg ha^{-1}). The variety Vortex grown without additional nitrogen produced the lowest yield (4114 Kg ha^{-1}) over all trial sites.

When comparing the overall yield, protein, test weight, and plant population for each site to each other, all four factors were found to be significant (Table 6f). The Carberry trial site yielded the highest (5614 Kg ha^{-1}) overall, though it was not significantly different from the overall yield at Roblin (5379 Kg ha^{-1}) and Melita (4576 Kg ha^{-1}). Three of the four sites responded to nitrogen in terms of protein content, all three of which responded significantly and consistently to all fertilizer applied in spring (treatment 7) compared to split application treatments. The Arborg trial site had the highest overall protein content (14.7%), which was significantly ($P < 0.001$) higher than the other sites. The Melita trial site produced the highest overall test weight (80.1 Kg hL^{-1}) though not significantly different from the test weights at the Roblin site (76.8 Kg hL^{-1}). The Carberry trial site had significantly ($P = 0.003$) higher plant counts (334 ppms) from the rest of the sites and above target rates indicating that data collection was skewed. All four sites were seeded with the same target plant population at seeding time; there may have been some discrepancies in counting plants between the sites. The main reason for significant differences found between the four sites is the seasonal growing conditions in each site. The weather differed slightly at each site across the province. In the fall, Arborg received 125% of normal rainfall and Carberry received their normal average amount, while the Melita and Roblin sites only received around half of the normal rain fall for the area in that time frame (Table 6g). All four sites received significantly higher growing degree days than they normally get in that time frame. In the spring until harvest, all four sites received only 50-61% of normal rainfall (Table 6h). The four sites also received 111-114% of normal growing degree days for their area at that time of year. The crops at all sites may have been subjected to stressful conditions with low precipitation amounts, and higher than normal heat.

Table 6d. Results including yield, protein, and test weight from the 2023 in Arborg, Carberry, Melita, and Roblin.

Treatment		Factor	Location															
			Arborg				Carberry				Melita				Roblin			
			Yield (kg ha^{-1})	Protein (%)	Test Wt. (kg hL^{-1})	Plants (ppms)^	Yield (kg ha^{-1})	Protein (%)	Test Wt. (kg hL^{-1})	Plants (ppms)^	Yield (kg ha^{-1})	Protein (%)	Test Wt. (kg hL^{-1})	Plants (ppms)^	Yield (kg ha^{-1})	Protein (%)	Test Wt. (kg hL^{-1})	Plants (ppms)^
Variety	**Wildfire**	**1**	3159**a**	14.3**b**	65.6**b**	229**b**	5803	11.8**b**	70	323**b**	4783**a**	12.3**b**	79.9	205	5318	11.8**b**	76.8	132
	Vortex	**2**	2701**b**	15.0**a**	67.0**a**	292**a**	5426	13.5**a**	70.5	345**a**	4370**b**	12.7**a**	80.2	222	5440	12.9**a**	76.7	140
Fertility	**Check**	**1**	3184	14.3	66.4	235	4685	11.7**c**	70.3	325**bc**	3826**d**	11.6**c**	80.9**a**	226	5261	11.0**d**	76.4	108
	60	**2**	2870	14.2	66.5	678	6012	11.7**c**	69.7	321**c**	4524**bc**	11.7**c**	80.3**a**	214	5489	12.1**bc**	76.9	157
	90	**3**	2841	14.5	66.2	298	5776	12.1**bc**	69.7	326**bc**	4935**ab**	12.4**b**	80.6**a**	219	5308	11.8**c**	78.1	178
	120	**4**	2793	14.8	66.4	258	5923	13.0**ab**	70.8	349**ab**	5086**a**	12.4**b**	80.3**a**	235	5529	12.6**ab**	77.0	127
	150	**5**	2686	15.0	64.9	250	6101	13.0**ab**	70.7	366**a**	4687**abc**	13.0**a**	79.9**ab**	200	5631	12.9**ab**	75.7	139
	180	**6**	3157	14.9	66.8	251	5547	13.7**a**	69.9	323**bc**	4629**abc**	13.1**a**	79.2**b**	197	4921	12.9**a**	74.5	158
	Spring 120	**7**	2979	15.0	66.9	266	5256	13.3**a**	70.3	325**bc**	4347**c**	13.3**a**	79.2**b**	202	5515	13.3**a**	78.8	85
Variety x Fertility		**1,1**	3593**a**	13.7	66.4	213**cd**	4573	10.8	69.5	310	4113	11.4	80.6	222	5175	10.1	75.9	119
		1,2	2761**cde**	14.1	64.5	304**abc**	6186	11.0	69.1	304	4731	11.7	80.1	229	5795	11.7	79.4	148
		1,3	2994**bcd**	14.4	64.9	232**bcd**	6216	11.0	69.7	326	5195	12.1	80.1	199	4916	11	77.5	155
		1,4	3340**ab**	14.0	65.4	257**bcd**	6171	12.0	70.5	346	5230	12.2	80.3	202	4892	12.1	74.6	129
		1,5	2813**cd**	14.6	64.1	189**d**	6136	12.4	70.3	353	4869	12.8	79.8	183	6124	12.1	76.4	157
		1,6	3348**ab**	15.0	66.4	181**d**	6164	13.0	70.4	308	4982	12.8	79.2	190	4786	12.6	74.6	137
		1,7	3266**abc**	14.6	67.3	227**bcd**	5174	12.3	70.2	311	4360	13.1	79.0	209	5540	12.7	79.5	78
		2,1	2773**cd**	14.9	66.4	257**bcd**	4796	12.5	71	341	3539	11.8	81.2	231	5347	11.8	76.9	98
		2,2	2979**bcd**	14.3	68.4	232**bcd**	5838	12.5	70.3	338	4317	11.8	80.4	199	5182	12.5	74.4	166
		2,3	2689**de**	14.5	67.6	363**a**	5336	13.2	69.7	326	4675	12.6	81.2	239	5700	12.5	78.7	201
		2,4	2245**e**	15.5	67.4	259**bcd**	5674	14.0	71.1	351	4942	12.7	80.3	267	6166	13	79.4	125
		2,5	2559**de**	15.3	65.7	310**ab**	6066	13.6	71.1	379	4505	13.1	80.1	218	5138	13.6	75.0	121
		2,6	2966**bcd**	14.9	67.1	321**ab**	4931	14.4	69.5	338	4277	13.3	79.1	204	5056	13.2	74.4	178
		2,7	2696**de**	15.4	66.6	304**abc**	5338	14.3	70.4	339	4335	13.5	79.4	195	5490	13.9	78.1	92
P-Values	**Variety**		**<0.001**	**0.001**	**0.042**	**0.002**	0.196	**<0.001**	0.093	**0.003**	**0.004**	**0.001**	0.150	**0.045**	0.710	**<0.001**	0.881	0.615
	Fertility		0.072	0.088	0.783	0.663	0.142	**0.004**	0.287	**0.009**	**0.001**	**<0.001**	**0.005**	0.146	0.925	**<0.001**	0.389	0.082
	V x F		**0.040**	0.174	0.637	**0.036**	0.792	0.964	0.341	0.737	0.875	0.894	0.911	0.061	0.571	0.776	0.339	0.810
	CV %		10.4	3.9	3.4	22.3	16.4	7.5	1.3	6.6	9.4	2.7	1.0	12.3	19.6	5.3	4.4	39.3

Values followed by the same letter are not significantly different by Fisher's mean separation method at 95% confidence. ^Plants per meter squared.

Table 6e. Results including yield, protein, test weight, and plant counts from all the sites included combined for the 2023.

Treatment		Factor	Yield (kg ha^{-1})	Protein (%)	Test Wt. (kg hL^{-1})	Plants (ppms)^
Variety	Wildfire	1	4772**a**	12.6**b**	73.1	222**b**
	Vortex	2	4484**b**	13.5**a**	73.6	250**a**
Fertility	Check	1	4239	12.1**d**	73.5	224
	60	2	4744	12.4**cd**	73.4	240
	90	3	4715	12.7**c**	73.7	255
	120	4	4833	13.2**b**	73.6	242
	150	5	4776	13.5**ab**	72.8	239
	180	6	4564	13.7**a**	72.6	232
	Spring 120	7	4524	13.7**a**	73.8	219
Variety x Fertility		1,1	4364	11.5	73.1	216
		1,2	4909	12.1	73.4	246
		1,3	4830	12.1	73.0	228
		1,4	4909	12.6	72.7	234
		1,5	4986	13.0	72.7	221
		1,6	4820	13.4	72.6	204
		1,7	4584	13.2	74	206
		2,1	4114	12.8	73.9	232
		2,2	4579	12.7	73.4	234
		2,3	4600	13.2	74.3	282
		2,4	4757	13.8	74.6	251
		2,5	4567	13.9	73.0	257
		2,6	4307	14.0	72.5	260
		2,7	4465	14.3	73.6	233
P-Values	Variety		**0.016**	**<0.001**	0.114	**<0.001**
	Fertility		0.117	**<0.001**	0.342	0.155
	V x F		0.973	0.512	0.506	0.154

*Values followed by the same letter are not significantly different by Fisher's mean separation method at 95% confidence. ^Plants per meter squared.

Table 6f. Results including yield, protein, test weight, and plant counts over each site in 2023.

		Yield (kg ha^{-1})	Protein (%)	Test Wt. (kg hL^{-1})	Plants (ppms)^
Site	Arborg	2942**b**	14.7**a**	66.3**b**	261**ab**
	Carberry	5614**a**	12.7**b**	70.2**b**	334**a**
	Melita	4576**ab**	12.5**b**	80.1**a**	213**b**
	Roblin	5379**a**	12.4**b**	76.8**a**	136**b**
P-Value	Site	**<0.001**	**<0.001**	**<0.001**	**0.003**

*Values followed by the same letter are not significantly different by Fisher's mean separation method at 95% confidence. ^Plants per meter squared.

Table 6g. Seasonal precipitation and growing degree days from the fall seed date to November 15th, 2022, in Arborg, Carberry, Melita, and Roblin Sites.

		Normal Precipitation (mm)	Actual Precipitation (mm)	% of Normal Precipitation	Normal GDD	Actual GDD	% of Normal GDD
Site	Arborg	61	76	125	103	207	201
	Carberry	55	54	98	107	208	194
	Melita	59	31	53	119	208	175
	Roblin	67	37	55	83	157	188
Information obtained from: https://web43.gov.mb.ca/climate/SeasonalReport.aspx							

Table 6h. Seasonal precipitation and growing degree days from April 1st, 2023, to the harvest date in Arborg, Carberry, Melita, and Roblin.

		Normal Precipitation (mm)	Actual Precipitation (mm)	% of Normal Precipitation	Normal GDD	Actual GDD	% of Normal GDD
Site	Arborg	264	156	59	1216	1344	111
	Carberry	292	170	58	1336	1518	114
	Melita	299	148	50	1234	1379	112
	Roblin	243	147	61	1070	1219	114
Information obtained from: https://web43.gov.mb.ca/climate/SeasonalReport.aspx							

References

Anderson, R. L. 2008. Growth and Yield of Winter Wheat as Affected by the Preceding Crop and Crop Management. Agronomy Journal 100 (4) 977-980.

Beres, B. L., Graf, R. J., Irvine, R. B., O'Donovan, J. T., Harker, K.N., Johnson, E. N., Brandt, S., Hao, X., Thomas, B. W., Turkington, T. K., and Stevenson, F. C. 2018. Enhanced Nitrogen Management Strategies for Winter Wheat Production in the Canadian Prairies. Canadian Journal of Plant Science 98:3. https://doi.org/10.1139/cjps-2017-0319

Fowler, D. B., Brydon, J., and Baker, R. J. 1989. Nitrogen fertilization of no-till winter wheat and rye. I. Yield and agronomic responses. Agron. J. 81: 66–72.

Halvorson, A.D., Alley, M. M., and Murphy, L. S. 1987. Nutrient Requirements and Fertilizer Use: In Wheat and Wheat Improvement – Agronomy Monograph (13) 2nd Edition. Madison, WI 53711, USA.

Morris, T.F., Murrell, T. S., Beegle, D. B., Camberato, J., Ferguson, R., Ketterings, Q. 2018. Strengths and limitations of nitrogen recommendations, tests, and models for corn. Agron. J. 110:1–37. doi:10.2134/agronj2017.02.0112

Schulz, R., Makary, T., Hubert, S., Hartung, K., Gruber, S., Donath, S., Dohler, J., Weiss, K., Ehrhart, E., Claupein, W., Piepho, H. P., Pekrun, C., and Müller, T. 2015. Is it necessary to split nitrogen fertilization for winter wheat? On-farm research on Luvisols in South-West Germany. J. Agric. Sci. 153(4): 575–587.

8.0 General Mills Oat Variety Evaluation

Project duration: 2020 – 2024
Collaborators: General Mills, Brookings, SD

Objectives

- Evaluate agronomic traits of new oat varieties of interest to General Mills including yield and milling quality grown in the Melita region.

Background

Recently, oat production has shifted from a late-seeded fill crop to an economically viable crop, ushering premium markets and more options for producers in Western Canada (May et al. 2020). Canada produces 3 million tons of oats annually and is the largest producer of oats globally. Western Canada alone accounts for nearly 90% of Canada's oat production and this rise in oat production has transformed the crop from a domestic product to a major Canadian export (Statistics Canada, 2017).

Methods and Materials

An advanced oat variety trial has been conducted in Melita, Manitoba for General Mills for the past three years. The results from the 2023 growing season have been made available to report. In 2023, this oat variety trial was established on Waskada Loam soil. Entries were replicated 3 times. Varieties used for the advanced variety yield trial are listed in Table 7 below. Plots were established on canola stubble under a no-till system on May 10th. Plots were seeded at 0.75-inch depth using a Seedhawk Dual knife air seeder. Fertilizer was banded at seeding at a rate of 107-35-25-15-1 actual lbs ac^{-1} (N-P-K-S-Zn). Fertility application was based on soil test results and crop requirement estimates. Roundup Transorb (0.67 L ac^{-1}) and Aim (20 mL ac^{-1}) were applied as pre-emergence weed control on May 10th right before seeding. Mextrol 450 (0.5 L ac^{-1}) was applied on May 31st and Matador (34 mL ac^{-1}) was applied for the control of heavy grasshopper pressure on June 26th. Plots were harvested on August 8th. Possible causes of yield loss include the drought conditions encountered in July, and high grasshopper pressure that happened in August. Data collected included heading date, lodging assessment, maturity date, moisture content, test weight and grain yield. Additionally, the stems were scored for greenness at maturity.

Results

In this trial, plant height was found to be significant ($P < 0.001$) between the 20 varieties in the trial (Table 7). A newer variety named SD170935 was the tallest (32.33 inches). The variety CDC Anson was the shortest variety of the trial (22.67 inches). In oats, plant height can be an important factor considered by some producers; the height of oats can influence lodging and straw quality. The test weight of the different varieties was also found to be significant ($P < 0.001$). All varieties except for one, had test weights above the normal for oats (39.9 Kg hL^{-1}). The variety SD170935 also produced the highest test weight (50.40 Kg hL^{-1}) which is more than 10 Kg hL^{-1} higher than the standard for oats. 2018Y1315 had the lowest test weight (38.9 Kg hL^{-1}). High test weights are an indication of high-quality grain. Finally, the yield between the varieties in the trial were also found to be significant ($P = 0.010$). Two varieties, Kyron and CDC Endure, had yields significantly higher than the other in the trial (4349 and 4302 Kg ha^{-1}, respectively). The variety that had the lowest test weight, 2018Y1315, also had the lowest yield (3035 Kg ha^{-1}); but that yield was not significantly different from eight other varieties of the trial. Overall, the yield results of the trial were excellent. Grain samples were sent to General Mills in South Dakota for further grain testing.

Table 7. Fitted means table from the 2023 field results of the General Mills oat variety trial grown at Melita.

Variety Name	Height (inches)	Test Weight (Kg/hL)	Yield (Kg/ha @ 13.5% Moisture)
2018Y0689	27.00	47.27**B**	3759**ABCDE**
2018Y1315	23.00	38.9**E**	3035**F**
AAC Douglas	29.33	47.03**B**	4114**AB**
AAC Neville	23.67	46.43**B**	3788**ABCDE**
AAC Wesley	25.00	47.47**B**	3861**ABCD**
CDC Anson	**22.67**	42.77**CD**	3484**BCDEF**
CDC Arborg	27.67	45.43**B**	3772**ABCDE**
CDC Endure	29.00	45.77**B**	4302**A**
CS Camden	27.67	45.63**B**	3769**ABCDE**
Kalio	27.67	45.13**BC**	3371**DEF**
Kyron	28.00	45.00**BC**	4349**A**
ND Carson	27.67	46.13**B**	3489**BCDEF**
ND Spilde	28.00	41.567**D**	3357**DEF**
Orelevel48	28.33	46.37**B**	3928**ABCD**
Orelevel50	25.67	42.27**D**	3167**EF**
OT3115	25.33	45.03**BC**	3935**ABCD**
OT7104	26.67	41.90**D**	4082**ABC**
SD170935	**32.33**	50.40**A**	3418**CDEF**
SD201374	30.00	45.27**BC**	3289**DEF**
SD201470	26.00	46.83**B**	3701**ABCDEF**
P-Value	**<0.001**	**<0.001**	**0.010**

Yield is corrected to 13.5% moisture
Values followed by the same letter are not significantly different by Fisher's mean separation at 95% confidence

References

May, W. E., Brandt, S., Hutt-Taylor, K. 2020. Response of oat grain yield and quality to nitrogen fertilizer and fungicides. Agronomy Journal 112 (2): 1021-1034, https://doi.org/10.1002/agj2.20081.

Statistics Canada. 2017. Estimated areas, yield, production, average farm price and total farm value of principal field crops, in metric and imperial units, annual, 1908 to 2018. Ottawa: Statistics Canada. http://www5.statcan.gc.ca/cansim.

9.0 Sollio Oat Variety Evaluation

Project duration: ongoing
Collaborators: Sollio Ltd. (Saint-Hyacinthe, QC)

Objectives

- To evaluate potential of 28 oat varieties interest for various agronomic characteristics including yield and milling quality grown in the Melita region.

Background

Oats are adapted to a wide range of environmental conditions such as low rainfall regions, infertile soils and somewhat saline soils (Liu et al. 2011). The crop is considered to be of high nutritional value and can be used as both food for human consumption and livestock feed in the form of grain or forage. Ideal oat varieties are expected to have high grain yield, groat percentage, β-glucan and protein content (Yan et al., 2016). The major component of oats is β-glucan, a soluble fiber, which plays a significant role in lowering cholesterol levels in humans (White, 2000). An increase in the world's populations means higher demand for food, feed and fiber, which in turn calls for the availability of higher yielding oat varieties to meet the rise in demand. Furthermore, the change in climate also requires availability of varieties that are well adapted to these conditions. Selection of oat varieties with high plasticity would help improve yield and adaptation to different environments, which can help producers meet increased oat demands (Sadras et al., 2017).

Methods and Materials

The trial was established near Melita on Waskada Loam soil under a no-till system. Plots were organized in a randomized complete block design with 28 treatments (varieties) that were replicated three times. Plots were seeded into canola stubble on May 10th at a 0.75-inch depth using a Seedhawk dual knife opener air seeder. Fertility was banded during seeding at a rate of 107-35-25-15-1 actual lbs ac^{-1} (N-P-K-S-Zn) according to soil test results. Fertility application was based on soil test results and crop requirement estimates. Roundup Transorb (0.67 L ac^{-1}) and Aim (20 mL ac^{-1}) were applied as pre-emergence weed control just before seeding on May 10th. Mextrol 450 (0.5 L ac^{-1}) was applied on May 31st. The plots were also sprayed with Matador (34 mL ac^{-1}) during high grasshopper pressure on June 26th. Plots were harvested on August 9th.

Data collected included emergence percentage, plant height, early and late lodging ratings, days to maturity, thousand kernel weight, grain yield, protein content and disease incidence for leaf spots, crown rust and stem rust.

Results

In 2023, the Sollio oat variety evaluation trial grown near Melita, Manitoba was very successful given the drought conditions and high insect pressure at the site. The average height of all the plots grown was 91.4 cm (Table 8). The tallest variety was 99 cm in height, while the shortest variety was 82.7 cm tall. The thousand kernel weight (TKWT) of all the entries ranged from 40.9 g/1000 seeds to 63.7 g/1000 seeds; the average being 45.6 g/1000 seeds. The test weight of the grain of each entry ranged from 32.4 Kg hL^{-1} to 39.9Kg hL^{-1}; the average test weight of all entries 35.8 Kg hL^{-1}. The days to maturity ranged from 206 to 212 days; the average days to maturity for all entries was 209.8 days. Lastly, the yield of the oats grown in this trial ranged from 4410 Kg ha^{-1} to 5923 Kg ha^{-1}, with the average yield being 5190 Kg ha^{-1} overall.

Currently, the variety names are not available to the public as they are confidential information. If you would like more information on the entries included in this trial, results may be made available from the collaborator upon request.

Table 8. Results from the 2023 Sollio Oat Variety Evaluation trial located at Melita, Manitoba.

Table of Fitted Means							
Entry	Height (cm)	TKWT (g)	Test Weight (Kg/hL)	Maturity Date	Disease Ratings		Yield (Kg/ha)
					Rust	Leaf Spot	
1	93.0	43.7	37.2**bc**	210**cdef**	1.0	1.3	4950
2	93.7	45.9	34.8**ghij**	211**abcd**	0.0	0.3	5195
3	89.3	41.3	39.9**a**	211.7**ab**	1.0	1.3	5526
4	85.0	41.2	35.4**defghij**	208.7**fgh**	0.7	1.3	**5923**
5	94.3	45.6	35.8**cdefghi**	210.3**bcde**	2.0	1.0	5246
6	93.7	49.8	37.7**b**	211**abcd**	1.0	2.0	5163
7	95.3	48.1	34.5**hij**	211.7**ab**	1.3	0.7	5177
8	91.0	47.2	36.8**bcde**	209**efgh**	1.0	1.0	**4410**
9	93.0	41.4	34.1**j**	212**a**	0.0	0.3	4663
10	95.3	46.6	35.9**cdefghi**	209.3**efgh**	2.0	2.0	5456
11	97.0	46.0	34.9**fghij**	210**cdef**	0.7	1.3	5450
12	**82.7**	41.9	35.8**cdefghi**	209.3**efgh**	0.7	1.0	5421
13	88.3	**40.9**	37.2**bc**	211.7**ab**	1.0	2.0	5019
14	88.0	42.4	35.7**cdefghij**	208**hij**	1.7	2.0	5430
15	94.7	**63.7**	34.1**j**	206**k**	1.7	1.0	5516
16	98.7	50.5	34.4**ij**	209**efgh**	1.7	1.3	5397
17	91.0	45.5	36.1**bcdefgh**	210.3**bcde**	1.3	1.0	5297
18	94.3	43.4	34.9**ghij**	209.7**defg**	1.0	1.3	4971
19	91.3	48.7	37.2**bc**	210**cdef**	0.7	1.3	5440
20	**99.0**	42.6	36.6**bcdef**	211.3**abc**	1.0	1.7	4808
21	86.3	44.8	35.1**fghij**	211**acbd**	2.0	1.3	5152
22	88.0	46.5	36.3**bcdefg**	210**cdef**	0.3	0.7	5152
23	83.7	44.0	35.2**efghij**	211**abcd**	2.0	1.0	4745
24	96.3	45.9	37.0**bcd**	208.3**ghi**	1.3	1.7	4909
25	87.3	44.8	32.4**k**	207**ijk**	0.3	1.7	5324
26	86.0	43.7	35.1**fghij**	211.7**ab**	0.3	1.3	5156
27	85.7	44.4	34.9**ghij**	206.7**jk**	0.0	0.7	5095
28	96.0	46.4	36.4**bcdefg**	208.3**ghi**	1.0	1.3	5353
P-Value	**0.017**	0.705	**<0.001**	**<0.001**	0.089	0.135	0.114
C.V.%	6.3	17.9	2.8	0.4	80.4	54.5	8.6
*Values with the same letters are not significantly different							

References

1. Liu, D., Wan, F., Guo, R., Li, F., Cao, H., and Sun, G. 2011. GIS-based modeling of potential yield distributions for different oat varieties in China. Mathematical and Computer Modelling **(54): 869-876**
2. Sadras, V. O., Mahadevan, M., and Zwer, P. K. 2017. Oat phenotypes for drought adaptation and yield potential. Field Crops **(212): 135-144**. https://doi.org/10.1016/j.fcr.2017.07.014.
3. White, P. J. 2000. Dietary Fiber. In: Designing Crops for Added Value. Agronomy Monograph **no. 40**.

4. Yan, W., Fregeau-Reid, J., Pageau, D., and Martin, R. 2016. Genotype-by-Environment Interaction and Trait Associations in Two Genetic Populations of Oat. Crop Science, 10.2135/cropsci2015.11.0678, **57**, 3, 1136-1145.

10.0 Linseed Coop Variety Evaluation

Project duration: 2023
Collaborators: CDC Saskatchewan, Dr. Bunyamin Tar'an (flax breeder), MCVET, Dane Froese (MB Ag Oilseed Specialist)

Objectives

- Flax variety testing of newly registered cultivars (SVPG entries) and experimental lines (FP entries) from the University of Saskatchewan, Crop Development Centre Flax Breeding Program as compared to relevant reference cultivars part of the MCVET program in Manitoba.

Methods and Materials

The coop trial was conducted at Melita, Roblin, Arborg and Carberry in Manitoba. The trial was also established at other sites across the Canadian Prairies in various soil zones but results from those trials will not be presented here. Twelve varieties laid out in a randomized complete block design were replicated three times. The Melita trial was seeded at one-inch depth on May 4th into wheat stubble on Waskada Loam soil. Roundup Tran (0.67 L ac^{-1}), Rival (0.65 L ac^{-1}) and Authority (85 mL ac^{-1}) were applied as burn-off at the time of seeding. Fertilizer was banded during seeding at a rate of 110-35-25-15-1 (N-P-K-S-Zn) actual lbs ac^{-1} following recommendations based on soil test results from AgVise Laboratories Inc. Arrow (150 mL ac^{-1}) plus X-act surfactant (0.5% v./v.) on May 31st and Basagran (0.91 L ac^{-1} at 20-gal H_2O ac^{-1}) June 1st were applied as extra weed control. Matador (34 mL ac^{-1}) was applied to the trial for control of heavy grasshopper pressure. Plots were desiccated August 2nd by application of 0.5 L ac^{-1} Reglone and LI-700 surfactant at 0.5% v./v. Plots were harvested on August 17th. Yield data was collected from the trial as well as emergence date, vigor, height, days to maturity, grain moisture, thousand seed weight, lodging, stem dry down, and determinate growth habit. Subsamples were sent to the Crop Development Centre in Saskatoon for fatty acid and protein analysis.

Results

In Melita, two entries produced the highest yield, the second-year experimental variety FP2609 and CDC Rowland (Table 9). Many of the entries in this trial that were grown at Melita produced higher yields than the average for Zone 1. Maturity for both entries FP2613 and FP2614 was 96 days, which is four days shorter than any other entry in the trial, including the checks. The experimental lines FP2607 and FP2612 were also notably high yielding in Melita, while they were average in the rest of Zone 1. The lowest yield for newly released varieties was 1460 kg ha^{-1} for FP2614 (Table 9). Overall, results show a potential of high yielding experimental lines to be considered for future registration if additional tests over varying environments are consistent.

Table 9. Predicted means for flax variety yield trial at Melita versus overall in Zone 1 in 2023.

	Yield ('00 kg/ha)			Prairie Wide	
Entry	**Melita**	**Zone Average**	**Zone Rank**	**Days to Maturity**	**Height (cm)**
Checks					
CDC Glas	29.0	22.6	8	99	59.2
AAC Bright	27.6	22.2	9	100	57.5
SVPT Entries					
CDC Rowland	32.1	24.6	2	103	57.4
CDC Kernen	27.7	22.0	10	101	60.4
CDC Esme	27.6	22.8	7	104	56.3
2nd Year Entries					
FP2607	28.6	23.8	5	102	59.5
FP2608	32.0	24.5	3	102	58.2
FP2609	32.1	25.0	1	102	58.2
1st Year Entries					
FP2611	27.9	23.3	6	101	62.8
FP2612	29.2	23.9	4	103	61.6
FP2613	25.4	20.4	11	96	44.7
FP2614	14.6	15.4	12	96	40.7
Mean	27.8	22.5	-	101	56.4
C.V. %	8.60	8.53	-	2.43	6.32
LSD 5%	1.74	1.80	-	1.14	1.74
P Value	**<0.001**	**<0.001**	-	**<0.001**	**<0.001**

11.0 MCA Flax Seed Treatment Evaluation

Project duration: 2023-2026
Collaborators: MCA (Daryl Rex), the Manitoba Diversification Centres (WADO, PCDF, CMDC, and PESAI)

Objectives

- To evaluate the efficacy of Manitoba-registered flax seed treatments against soil-borne diseases in two flax types (yellow and brown)
- To evaluate the relationship between the seed treatment and germination, emergence, and ultimately yield in brown and yellow flax types.

Background

There has been little testing done recently evaluating the commercially available seed treatments for flax in Manitoba. This project will evaluate commercially available seed treatments and respective label rates in brown and yellow flax for Manitoba farmers in 2023 and 2024 growing seasons, across the 4 Diversification Centre locations. The project will be set up as a small plot experiment, randomized complete block design with four replicates. Two flax varieties (one yellow, one brown) will be evaluated in this study. The available seed treatments for flax in Manitoba are Insure Pulse (300 mL to 600 mL/100 Kg of seed), INTEGO Solo Fungicide (13 mL to 19.6 mL/100 Kg of seed), and Vitaflo Brands (525 mL/100 Kg of seed). There will be 6 fungicide treatments applied to two flax types for a total of 12 treatments: 1) one untreated check, 2) Insure Pulse (300 mL/100 Kg of seed), 3) Insure Pulse (600 mL/100 Kg of seed), 4) INTEGO Solo Fungicide (13 mL/100 Kg of seed), 5) INTEGO Solo Fungicide (19.6 mL/100 Kg of seed), and 6) Vitaflo Brand product of choice (525 mL/100 Kg of seed). Each treatment was applied to yellow and brown flax types. The following data will be collected: observations on treatment application coverage and seed flow, seeding and harvest data, fertility data, crop emergence, disease presence and severity (Fusarium spp. and Rhizoctonia solani seed and root rots, plus seedling blight; Pythium spp. seed rot and pre-emergence damping off), late season disease development, crop yield, seed quality. Trial data collected by the Diversification Centre Specialists and Technicians is analyzed by the MCA. More information on this trial from other sites can be found by contacting Darryl Rex at the MCA.

Methods and Materials

This flax trial evaluated two different flax varieties, one brown variety and one yellow. CDC Rowland was the brown flax variety chosen, and AAC Bright was chosen for yellow flax. The available seed treatments for flax in Manitoba include Insure Pulse and Vitaflo brands. Four different fungicide treatments were applied to each type of flax for a total of eight treatments in the trial (Table 10a). These treatments were replicated four times and laid out in a randomized complete block design. The trial was established at all four of the Crop Diversification Centres located at Melita, Roblin, Carberry, and Arborg to help evaluate any differences that may be seen due to varying regional conditions.

Table 10a. The varieties and fungicide seed treatments used in Flax Seed Treatment Evaluation Trial at Melita in 2023.

Factor	Treatment	Name
Variety	1	AAC Bright
	2	CDC Rowland
Seed Treatment	1	Untreated
	2	Insure Pulse - Low
	3	Insure Pulse - High
	4	Vitaflo
Variety x Seed Treatment	1,1	AAC Bright x Untreated
	1,2	AAC Bright x Insure Pulse - Low
	1,3	AAC Bright x Insure Pulse - High
	1,4	AAC Bright x Vitaflo
	2,1	CDC Rowland x Untreated
	2,2	CDC Rowland x Insure Pulse - Low
	2,3	CDC Rowland x Insure Pulse - High
	2,4	CDC Rowland x Vitaflo

In Melita, the flax seed treatment trial was established on Waskada Loam soil into wheat stubble. The flax was seeded on May 4th using at Dual Knife Seedhawk Drill at 1-inch depth. Burn off was sprayed the same day after seeding as Round Up (0.67 L ac^{-1}) with Authority (85 mL ac^{-1}) and Rival (0.65 L ac^{-1}). Fertilizer was side banded during seeding as 110-35-25-15-1 actual lbs ac^{-1} (N-P-K-S-Zn). Table 10b below explains the in-crop pesticide applications.

Table 10b. The pesticide applications performed throughout the growing season for the Flax Seed Treatment Evaluation Trial at Melita in 2023.

	Date	Product/Rate
Herbicide	31-May	Arrow (150mL/ac) + X-Act (0.5%)
	01-Jun	Basagran (0.91L/ac)
	16-Jun	Arrow (120mL/ac) + X-Act (0.5%)
Insecticide	09-Jun	Matador (34mL/ac)
Desiccation	17-Aug	Reglone (0.65L/ac) + LI700 (0.25%)

In Melita, the plots were harvested on August 29th. Data Collected throughout the growing season included emergence counts, disease presence and severity ratings, flowering dates, heights, lodging rates, maturity dates, grain yield and moisture.

Results

When evaluating the differences between the two varieties grown in the trial (AAC Bright and CDC Rowland), plant stand 10 days after planting was found to be significant ($P < 0.001$) (Table 10c). AAC Bright had an average stand of 37.5% of the plot emerged 10 days after planting, while CDC Rowland had an average plant stand of 55.6% of the plot emerged 10 days after planting. The number of days from seeding to flowering was also found to be significant ($P = 0.014$) between varieties. On average, it took the variety CDC Rowland 48.9 days to flower, while it took AAC Bright slightly longer to flower at 50.3 days. The plot yield was also significantly different ($P < 0.001$) between the two varieties. CDC Rowland yield higher overall (52.7 bu ac^{-1}) than AAC Bright (45.9 bu ac^{-1}). No other factors were found to be significantly different between the two varieties grown in this trial.

The addition of a seed treatment was found to have a significant effect on two of the evaluated factors in this trial. The first being days to flower ($P = 0.033$); Insure Pulse at both the high and low rate seemed to shorten the number of days it took for the flax to flower compared to the untreated check and Vitaflo seed treatment. Secondly, yield was affected by the use of seed treatment as well ($P < 0.001$) (Table 10c). The untreated check yielded lower overall than all the other treatments in the trial, all of which included a seed treatment.

Lastly, when you evaluate the effects of variety and seed treatment together, there was a significant effect on days to flower ($P = 0.031$), days to maturity ($P = 0.028$), and yield ($P = 0.018$) (Table 10c). The number of days from seeding to flowering was decreased when a seed treatment was applied, regardless of the variety of flax, seed treatment product used, or the rate at which it was applied. The number of days from seeding to physiological maturity were highest when AAC Bright was grown without seed treatment (96.5 days) and when CDC Rowland was treated with Vitaflo seed treatment (92.0 days). The days to maturity were lower in all other treatments. The fewest days to maturity were seen when AAC Bright was grown with the high rate of Insure Pulse (88.3 days). In terms of yield, the highest was produced when CDC Rowland was treated with the low rate if Insure Pulse (54.3 bu ac^{-1}). The lowest yield was produced when AAC Bright was grown without seed treatment (37.9 bu ac^{-1}). Surprisingly, when CDC Rowland was grown without seed treatment, it still produced a higher yield than some of the treatments that did include applying a seed treatment. In conclusion, applying a seed treatment to the flax seemed to significantly improve the overall performance of the flax throughout the growing season.

Table 10c. Results for the 2023 MCA Flax Seed Treatment Trial at Melita, Manitoba.

Factor	Treatment	Plant Stand	Days to Flower	Height (cms)	Days to Maturity	Yield (bus/ac)	Moisture (%)	Test Weight
Variety	1	37.5**A**	50.3**B**	63.1	91.1	45.9**A**	8.5	54.4
	2	55.6**B**	48.9**A**	61.6	89.6	52.7**B**	8.3	56.9
Seed Treatment	1	38.8	50.9**B**	62.3	92.5	44.5**A**	8.5	56.2
	2	46.3	48.8**A**	61.9	89.3	51.9**B**	8.4	55.4
	3	53.1	49.0**A**	62.1	88.4	50.0**B**	8.4	55.6
	4	48.1	49.9**B**	63.3	91.3	49.7**B**	8.4	55.5
Variety x Seed Treatment	1,1	25.0	53.0**B**	63.0	96.5**B**	37.9**A**	8.6	55.1
	1,2	45.0	49.0**A**	63.0	89.0**A**	49.6**BCD**	9.3	53.9
	1,3	40.0	49.0**A**	63.0	88.3**A**	48.8**BC**	9.3	54.3
	1,4	40.0	50.3**B**	63.5	90.5**A**	47.4**B**	8.5	54.3
	2,1	52.5	48.8**A**	61.5	88.5**A**	51.2**BCDE**	8.3	57.2
	2,2	47.5	48.5**A**	60.8	89.5**A**	54.3**E**	8.4	56.8
	2,3	66.3	49.0**A**	61.3	88.5**A**	53.2**CDE**	8.4	56.8
	2,4	56.3	49.5**A**	63.0	92.0**AB**	51.0**CDE**	8.3	56.6
P-Value	Variety	**<0.001**	**0.014**	0.137	0.224	**<0.001**	0.099	--
	Seed Treatment	0.159	**0.033**	0.763	0.074	**<0.001**	0.743	--
	Variety x Seed Treatment	0.179	**0.031**	0.932	**0.028**	**0.018**	0.064	--
C.V.%		26.2	2.9	4.4	3.6	6.2	2.1	--

12.0 Yellow Mustard (Sinapis alba) Variety Evaluation

Project duration: 2018-2023
Collaborators: Mustard21 Canada, Agriculture & Agri-Food Canada

Objectives

- Evaluate agronomic performance and adaptation of yellow mustard (Sinapis alba) varieties on the Canadian Prairies

Background

Yellow mustard (Sinapis alba), which originated in the Middle east and the Mediterranean regions, is an important export crop and used as a condiment, vegetable oil or high protein meal in Canada (Hanelt, 2001). The crop is usually grown in the Brown and Dark Brown soil zones of the Canadian Prairies. More breeding work has been done to ensure that yellow mustard has good adaptation to heat and drought, and resistance or tolerance to a significant number of important diseases and insect pests (Brown et al., 1997; Katepa-Mupondwa et al., 2006). Compared to rapeseed or canola (Brassica napus or B. rapa), yellow mustard has superior heat and drought tolerance and can be grown in drier regions. Research has shown that yellow mustard has potential as an alternative crop in rotations with small grain cereals and has fewer limitations compared to other traditional alternative crops (Brown et al., 2005). On the Canadian Prairies, seed yield of yellow mustard is highly variable and impacted by the prevailing weather conditions in addition to seeding date, rate, and depth. When selecting yellow mustard varieties, most farmers are interested in yield potential and other parameters such as resistance to pod shattering in order to maximize profitability. As more new varieties of yellow mustard are being made available for the short growing season areas such as the Prairies, there is need to evaluate their early performance prior to registration and help producers select varieties which prevail in their areas of production.

Methods and Materials

Pre-registration co-op variety trials were conducted at Melita and Reston in 2023 and laid out in randomized complete block design with 5 treatments (varieties) replicated 4 times at each site. The Melita site (Waskada Loam soil) trials were established on wheat stubble and the Reston site (Alexander Loam soil) trials were also established on wheat stubble. Seeding was done on

May 15th at the Melita site and on May 25th at the Reston site. At both sites, the seeding depth was 0.5-inches. Fertilizer was side banded during seeding at the Melita site at 102-35-25-15-1 and 105-35-25-15-1 actual lbs ac^{-1} (N-P-K-S-Zn) at the Reston site. Trial agronomy at both sites can be found in Table 11 below.

Table 11. Agronomy for the yellow mustard at the Melita and Reston sites in 2023.

Mustard Variety Trials 2023 Agronomy				
Site	**Melita**		**Reston**	
Location	NW 15-3-27 W1		SE 11-7-27 W1	
Rotation	LL Canola, Spring Wheat		RR Soybean, Spring Wheat	
Stubble	Wheat		Wheat	
Burn-off	Glyphosate (0.67L/ac) + Rival (0.65L/ac)		Glyphosate (0.67L/ac) + Rival (0.65L/ac)	
Moisture At Seeding	Excellent		Good	
Seeding Date	15-May		25-May	
Seeding Depth	0.5"		0.5"	
Fertilizer Applied (lbs/ac)	102-35-25-15-1		105-35-25-15-1	
	Date	Product/Rate	Date	Product/Rate
Post-Emergence Herbicides	05-Jun	Arrow 120mL/ac + X-Act 0.5%	05-Jun	Arrow 60mL/ac
	07-Jun	Arrow 120mL/ac + X-Act 0.5%	07-Jun	Arrow 120mL/ac + X-Act 0.5%
	Date	Product/Rate	Date	Product/Rate
Insecticides	30-May	Pounce 50mL/ac	05-Jun	Pounce 74mL/ac
	31-May	Matador 34mL/ac	07-Jun	Pounce 74mL/ac
	02-Jun	Matador 34mL/ac		
	05-Jun	Pounce 74mL/ac		
	07-Jun	Matador 34mL/ac		
Desiccation Date & Product	02-Aug	Reglone 0.5L/ac + LI700 0.25%	09-Aug	Reglone 0.5L/ac + LI700 0.5%
Harvest Date		15-Aug		28-Aug

*This table displays the agronomy of the Yellow, Brown, and Oriental Mustard trials at both the Melita and Reston sites in 2023

Flea beetle pressure was very high in Melita; multiple applications of insecticide were needed to minimize damage to the trial. In Reston, the flea beetle pressure was not as high, and fewer applications were needed. The herbicide applications were similar at both sites. Prior to harvesting both sites were desiccated with Reglone (0.65 L ac^{-1}) and LI700; Melita on August 2nd and Reston on August 28th. Melita plots were harvested on August 15th, and Reston plots were harvested on August 28th. Data collected included maturity date, plant height at maturity, days to flowering and grain yield. Completed raw data and samples were sent to the collaborator for statistical analysis and publication.

Results and Discussion

This is ongoing research which started in 2018/2019 under the Diverse Field Crop Cluster with funding support from the Canadian Agricultural Partnership (CAP). Executive summaries can be obtained at https://www.mustard21.com/research-summaries/condiment-mustard-development/.

References

Brown, J., Brown, A. P., Davis, J. P., Erickson, D. 1997. Intergeneric Hybridization Between Sinapis alba and Brassica napus. Euphytica **93: 163-168.**

Brown, J., Davis, B., and Esser, A. 2005. Pacific Northwest Condiment Yellow Mustard (Sinapis alba L.) Grower Guide. University of Idaho, Subcontract Report Nrel SR-510-3607. http://www.osti.gov/bridge.

Hanelt, P. (**ed**.). 2001. Manfeld's encyclopedia of agricultural and horticultural crops. 6 vols. Springer-Verlag, Berlin, Germany **3: 1465-1469**.

13.0 Brown Mustard/Oriental Mustard (Brassica Juncea) Variety Evaluation

Project duration: 2017-2023
Collaborators: Mustard21 Canada, Agriculture Agri-Food Canada

Objectives

- Evaluation of agronomic performance and adaptation of Juncea Mustard varieties on the Canadian Prairies

Background

Brassica juncea is an important oil crop that has been grown in the semiarid ecological regions of the Canadian prairies for use in the condiment industry. Newly developed juncea varieties have the potential to increase juncea production area because they have better drought and heat tolerance than hybrid varieties of canola (May et al., 2010). Recent genetic improvements in Brassica juncea varieties suggest the need to re-evaluate them for adaptation and agronomic performance in various regions on the Canadian prairies. Knowledge of juncea variety performance under different environmental conditions could help oilseed producers make informed decisions on the appropriate varieties to select for their areas of production (Gan et al., 2007).

Materials and Methods

The trials were conducted at Melita and Reston under the same environment as the yellow mustard trial in 2023; this information can be found in Section 13.0 (Table 11) of this report. 15 varieties of Oriental Mustard and 6 of Brown Mustard were laid out in randomized complete block design and replicated four times. The soil type and seeding dates were the same as for the yellow mustard trial at Melita and Reston. Fertilizer application rates, dates, and methods were the same as the yellow mustard trial for both locations (Section 13.0). Herbicide use and desiccation methods also mirrored that of the yellow mustard trial for each site. Mustard at the Melita site was harvested on August 15th, and mustard at the Reston site was harvested on August 28th. Data collection objectives were similar to that of the yellow mustard trial. Data and samples were sent to cooperators for statistical analysis and publication.

Results and Discussion

This is ongoing research which started in 2018/2019 under the Diverse Field Crop Cluster with funding support from the Canadian Agricultural Partnership (CAP). Executive summaries can be obtained at https://www.mustard21.com/research-summaries/condiment-mustard-development/.

References

Gan, Y., Malhi, S. S., Brandt, S., Katepa-Mupondwa, F. and Kutcher, H. R. 2007. Brassica juncea canola in the Northern Great Plains: Responses to diverse environments and nitrogen fertilization. Agronomy Journal **99: 1208-1218**.

May, W. E., Brandt, S. A. Gan, Y., Kutcher, H. R., Holzapfel, C. B., and Lafond, G. P. 2010. Adaptation of oilseed crops across Saskatchewan. Canadian Journal of Plant Science **90: 667-677**

14.0 Dry Bean Evaluation – Agriculture and Agri-Food Canada

Project duration: 2019 - 2023
Collaborator: Anfu Hou Ph.D., Agriculture and Agrifood Canada, Morden MB

Objectives

- Evaluation of yield potential and agronomic characteristics of different dry bean varieties and lines in Southwest Manitoba

Background

Dry beans are grown in regions of the world that typically experience soil moisture deficits during the growing season, such as the Canadian Prairies (Nleya et al., 2001). Development and release of new varieties requires extensive screening and testing at different locations over many years in order to find appropriate varieties to grow in specific ecological regions (Saindon and Schaalje, 1993). Well-proven positive performance of these varieties enables dry bean producers to select varieties which suit their production goals. Therefore, there is need to evaluate different varieties in different environments for potential yield and agronomic characteristics before they can be recommended for different production areas on the Prairies. Among other parameters, dry bean producers are also interested in pod height, disease resistance, days to maturity, and nitrogen fixation capacity (Wilker et al., 2019).

Methods and Materials

This dry bean trial was established near Melita, on Waskada Loam soil NW15-3-27 W1. The treatments were seeded into wheat stubble at a depth of 1 inch on the 16th of May. Granular fertilizer was banded at seeding at a rate of 95-35-25-15-1 (N-P-K-S-Zn) actual lbs ac^{-1}. Chemical weed control included a burn-off application of Roundup Transorb (0.67 L ac^{-1}) and Rival (0.65 L ac^{-1}) on the day of seeding. Arrow (120 mL ac^{-1}) plus X-act (0.5% v./v.) was applied on May 31st and Viper (0.4 L ac^{-1}) plus UAN (0.81 L ac^{-1}) was applied on June 7th for additional in-crop weed control. On June 30th and Aug 9th, Matador (15 mL ac^{-1}) was applied targeting corn seed maggots, cutworms, and grasshoppers. The beans were desiccated on August 25th with Reglone (0.65 L ac^{-1}) with LI700 (0.25% v./v.) surfactant. The plots were harvested on August 30th. Data collection included emergence date, pod clearance, lodging ratings, flowering date, maturity date, and grain yield. Data and samples were sent to AAFC Morden for analysis.

Results

Results from these trials can be obtained by contacting Dr. Anfu Hou at the Morden AAFC station.

References

Nleya, T. M., Slinkard, A. E. and Vandenberg, A. 2001. Differential performance of pinto bean under varying levels of soil moisture. Canadian Journal of Plant Science **81:233-239.**

Saindon, G. and Schaalje, G. B. 1993. Evaluation of locations for testing dry bean cultivars in western Canada using statistical procedures, biological interpretation and multiple traits. Canadian Journal of Plant Science **73: 985-994.**

Wilker, J., Navabi, A., Rajcan, I., Marsolais, F., Hill, B., Torkamaneh, D., and Pauls, K. P. 2019. Agronomic Performance and Nitrogen Fixation of Heirloom and Conventional Dry Bean Varieties Under Low-Nitrogen Field Conditions. Frontiers in Plant Science **10: 952**. doi: 10.3389/fpls.2019.0

15.0 Measuring Biological Nitrogen Fixation (BNF) in Modern Dry Bean Cultivars

Project Duration: 2023-2025
Collaborators: University of Manitoba, MPGA, Kristen MacMillan

Objectives

- To quantify biological nitrogen fixation in modern pinto, navy, and black bean cultivars

Background and Protocol

Dry beans are poor nitrogen (N) fixers compared to soybean and field pea, producing <45% of their N requirements through biological N fixation (BNF) and their efficiency can be variable depending on cultivar and environment (Walley et al. 2007; Hossain et al. 2016; Hossain et al. 2017). Inoculation with compatible rhizobia often improves N fixation of legumes. However, there have been few and variable responses to dry bean inoculant (McAndrew et al. 2000; Buetow et al. 2017). Additionally, with limited acreage and several market classes, there is typically none or few inoculant products available specifically for use in dry bean. For these reasons, application of N fertilizer is common practice in bean production systems in Canada and the United States. This practice is a significant cost of production and can volatilize potent greenhouse gases such as nitrous oxide.

Current nitrogen recommendations in Manitoba are to reach 70-120 lbs N ac^{-1} total N supply (soil + fertilizer N) for a yield goal of 2,400 lbs ac^{-1}, depending on production system (wide- vs. narrow-row), to account for nitrogen mineralization associated with inter-row cultivation (MB Soil Fertility Guide 2007). This is based on work by Dr. David McAndrew in the late 1990s (John Heard, pers. communication). A survey of 116 MB bean farmers in 2016 confirmed that ~90% of farmers apply N fertilizer at a rate of 60-90 lbs N ac^{-1} (Heard 2016). An earlier survey by Manitoba Pulse & Soybean Growers showed similar results (MPSG, 2014). Comparatively, Manitoba has the highest N fertilizer recommendation for dry beans. North Dakota, for example, recommends a total N (soil + fertilizer N) rate of 70 lbs ac^{-1} for non-inoculated beans and 40 lbs ac^{-1} for inoculated beans (Franzen 2017). From the 2021 Dry Bean Grower Survey of the Northarvest region (ND and MN), 95% of respondents applied N fertilizer and 23% used rhizobia inoculant (NDSU, 2021).

The need to re-visit nitrogen recommendations for Manitoba beans was first identified in 2016. Results of a previous study indicated small, incremental yield increases in response to N rates from 35-140 lbs ac^{-1}, which were non-economical (MacMillan 2021). Nodulation was also observed, which was reduced as N rate increased. Recently, newly available inoculant products were evaluated, which have also been inconsistent, and nodulation is continued to be observed at multiple MB sites (MacMillan 2023). The hypothesis is that biological nitrogen fixation is contributing to the N requirements of MB dry beans. The last step to update nitrogen recommendations for MB dry beans is to account for the crop's nitrogen requirements and test the hypothesis by measuring BNF. Additionally, a separate study will directly compare fertilization and inoculation strategies with non-inoculated, non-fertilized beans.

The trial will be non-inoculated, relying on native rhizobia to infect dry bean roots and develop nitrogen-fixing nodules. The reason for this being two-fold; the rhizobia species that infect dry beans occurs naturally and inoculant products are not widely available nor consistently effective. Nitrogen derived from the atmosphere (%NDFA) will be estimated through the natural 15N abundance method for pinto, navy, and black bean cultivars. The bean cultivars used in the trial can be found below in Figure 3e.

Figure 3. Dry bean cultivars used in the 2023 BNF trial. The cultivar description and seed source are also listed.

Bean type	Cultivar	Description	Source	MB	ND
1. Navy bean	R99	Non-nodulating mutant	Peter Pauls, U of Guelph		
2. Pinto bean	AC Pintoba	Old cultivar (top market share 2000-2003)	AAFC Morden		
3. Pinto bean	Maverick	Old cultivar (top market share 2004-2008)	AAFC Morden		
4. Pinto bean	Vibrant	Modern cultivar: highest market share (2019-)	Western Harvest	58	8
5. Pinto bean	Windbreaker	Modern cultivar: highest market share	Western Harvest	32	4
6. Pinto bean	Monterrey	Modern ND cultivar: 3 days > Windbreaker	Dennis Lange	<1	9
7. Navy bean	T9905	Modern cultivar: highest market share MB (2013-)	Western Harvest	72	5
8. Navy bean	Indi	Modern cultivar: second highest market share MB	Western Harvest	9	
9. Navy bean	Envoy	Modern cultivar: top market share (2000-2012)	Viterra/Brett Takvam	5	
10. Navy bean	AAC Argosy	Modern cultivar: third highest market share MB	Hensall/Calem Alexander	6	
11. Black bean	Eclipse	Modern cultivar: highest market share MB (2008-)	Western Harvest	52	8
12. Black bean	CDC Blackstrap	Modern cultivar: third highest market share MB	Martens Seed	24	
13. Black bean	Black tails	Modern cultivar: second highest market share	Western Harvest	22	6

Methods and Materials

The trial in Melita was established near NW15-3-27 W1 on Waskada Loam soil into wheat stubble. The beans were seeded into good moisture on May 16th at a depth of 1-inch using a Dual Knife Seedhawk Drill. Chemical burn off was applied before seeding as Round Up Transorb (0.67 L ac^{-1}) plus Aim (20 mL ac^{-1}); Rival (0.65 L ac^{-1}) was applied for additional weed control after the plots were seeded and rolled. Granular fertilizer was applied as 10-35-25-15-1 actual lbs ac^{-1} (N-P-K-S-Zn). An in-crop herbicide application was needed; Viper (0.4 L ac^{-1}) and UAN (0.81 L ac^{-1}) were used on June 16th. On August 9th, Matador (34 mL ac^{-1}) was applied for control of grasshoppers. On August 25th, the plots were desiccated with Reglone (0.5 L ac^{-1}) with LI-700 (0.25% v./v.). The plots were harvested on September 8th. Data collected throughout the growing season included emergence counts, flowering dates, nodule ratings, biomass samples and weights, maturity date, and grain yield. Biomass samples were dried and sent away for analysis, and well as grain samples for analysis of grain quality, nitrogen content, and %NDFA (nitrogen derived from the atmosphere).

Results and Discussion

This is ongoing research and preliminary results and discussion for this study are combined for Melita and other sites; questions can be directed to Kristen MacMillan (University of Manitoba – Soybean Pulse Agronomy Lab).

16.0 Comparison of Nitrogen Management Strategies in Dry Beans

Project Duration: 2023-2025
Collaborators: University of Manitoba, MPGA, Kristen MacMillan

Objectives

- Directly compare nitrogen management strategies and determine the effect on dry bean nitrogen fixation, nitrogen uptake, seed yield and economics.

Background and Protocol

Building upon previous research evaluating N fertilizer rates and inoculant products, this study will directly compare N management strategies at two locations in MB from 2023-2025. Current research shows that nitrogen response (fertilizer or inoculant) is consistent among market classes (MacMillan 2023). Therefore, this study will focus on pinto beans (cv. Vibrant), the market class with predominant market share in Manitoba. The current research also demonstrates that Primo GX2/N-Charge inoculant has been the most consistent product to increase nodulation and yield in dry beans. This study will also measure soil nitrogen and nutrient uptake to calculate the nitrogen budget of dry beans under various nitrogen management strategies.

The pinto beans were grown under the following treatments:

1. Non-inoculated, non-fertilized cv. R99 (non-nodulating mutant)
   Pinto bean cv. Vibrant will be used for all remaining treatments.
2. Non inoculated, non-fertilized cv. Vibrant
3. Inoculated with N-Charge peat inoculant
4. Low N fertilizer – 35 lbs ac^{-1} (to meet ~40% N requirements)
5. Medium N fertilizer – 70 lbs ac^{-1}
6. High N fertilizer – 105 lbs ac^{-1} (to meet total N requirements)
7. Excess N fertilizer – 140 lbs ac^{-1}
8. Low N + Inoculant
9. Medium N + Inoculant
10. High N + Inoculant
11. Excess N + Inoculant

Methods and Materials

The dry bean management trial at Melita was established near NW15-3-27 W1 on Waskada Loam soil into wheat stubble. The trial included 11 treatments that were laid out in a randomized complete block design. The beans were seeded into good moisture on June 2nd at a depth of 1.25-inches using a Dual Knife Seedhawk Drill. Chemical burn off was applied before seeding on May 30th as Round Up Transorb (0.67 L ac^{-1}) plus Aim (20 mL ac^{-1}). Nitrogen was applied as per plot treatments, as well as 10-35-25-15-1 actual lbs ac^{-1} (N-P-K-S-Zn) of granular fertilizer at the time of seeding. On June 16th, when the first trifoliate was opening, the plots were sprayed with Viper (0.4 L ac^{-1}) and UAN (0.81 L ac^{-1}) for additional in-crop weed control. The plots were also sprayed with Matador (34 mL ac^{-1}) on August 9th to control grasshoppers. The trial was desiccated on August 29th with Reglone (0.5 L ac^{-1}) with LI-700 (0.25% v./v.), then harvested on September 13th. Data collected throughout the growing season included emergence counts, flowering dates, nodule ratings, biomass samples and weights, maturity date, and grain yield. Biomass samples were dried and sent away for analysis, and well as grain samples for analysis of grain quality, nitrogen content, and %NDFA (nitrogen derived from the atmosphere).

Results and Discussion

This is ongoing research and preliminary results and discussion for this study are combined for Melita and other sites; questions can be directed to Kristen MacMillan (University of Manitoba – Soybean Pulse Agronomy Lab).

17.0 Phillex: Quinoa Variety Performance Trial

Project duration: 2023
Collaborators: Phillex Ltd. - Percy Phillips, WADO

Objectives

- To test the performance and gather information about agronomic characteristics of seven quinoa varieties across different locations in Manitoba
- To determine cultivars of quinoa that can perform well in the prairies

Background

Bolivia and Peru are the world's top producers of quinoa, followed by Ecuador, U.S.A., China, Chile, Argentina, France, and Canada, which together produce 15 – 20% of the world's total quinoa supply (Bazile et al., 2016). Quinoa has a vast genetic diversity resulting from its fragmented and localized production over the centuries in many different regions around the world. The crop can withstand sub-zero temperatures, but temperatures below -2.2 °C during the mid-bloom stage can cause more than 70% yield loss due to flower abortion. Significant yield losses also occur when quinoa is exposed to temperatures below -6.7°C before the dough stage (AAFRD, 2005). On the other hand, exposure to temperatures elevated above 35°C for lengthened periods during the reproductive stage can cause dormancy and pollen sterility in quinoa (OMAFRA, 2012). A major setback when growing quinoa in Canada is the short growing season, as the crop requires up to 150 days between planting and seed harvest (Jacobsen, 2003). In this regard, early maturity becomes the most important characteristic when selecting varieties to grow in Canada, especially in the Prairies which experience a relatively cool and short growing season. Due to its adaptation to cool, dry environments, the crop is tolerant to early planting. In Manitoba, where quinoa is threatened by a host of insects that are not present in its native environments, early planting can also help the crop to reach key developmental stages before it is damaged by pests. Key insect pests include the diamondback moth, goosefoot groundling moth, lygus bugs, bertha armyworm, a stem-boring fly (Amauromyza karli), and various grasshoppers.

Quinoa is one of the few crops which can maintain productivity on rather poor soils, in areas with high salinity, and under conditions of erratic rainfall. As a result, it becomes an alternative crop which could play a significant role in sustainable agriculture. Apart from its usefulness on marginal agricultural lands, quinoa is an exceptionally nutritious food source which has high protein, calcium, magnesium, and iron content, contains all essential amino acids, and contains health promoting compounds such as flavonoids (Ruiz et al., 2014). Quinoa also contains saponins in the seed hull and is a gluten free grain, making it a popular heath food.

Methods and Materials

In 2023, Melita's quinoa plots were established on Waskada Loam soil near SE15-3-27 W1 into wheat stubble. The trial was arranged in a randomized complete block design with seven varieties replicated three times. Varieties seeded were PHX22-01, PHX22-02, PHX22-03, PHX22-04, PHX22-05, and PHX22-06. In Melita, plots were seeded with a Seedhawk Dual Knife air seeder on May 3rd into excellent soil moisture at 0.5-inch depth. Fertility was side banded during seeding with granular fertilizer at 114-35-25-15-1 (N-P-K-S-Zn) actual lbs ac^{-1} based on the soil tests taken in the spring. Pre-emergence weed control was applied as Round Up (0.67 L ac^{-1}) before seeding; post-emergence weed control was done using Arrow herbicide (0.15 L ac^{-1}) tank mixed with X-Act adjuvant (0.5% v./v.) applied to all plots on May 31st. On June 9th, August 1st, and August 9th, Matador was applied (34 mL ac^{-1}) for control of lygus bugs and grasshoppers. Plots were straight cut harvested on September 5th. Data collected included emergence date, lodging rating, plant vigor rating, days to maturity, and grain yield and moisture content at harvest. The data were subjected to two-way analysis of variance using Minitab 18.1 software and mean separation was done using Fisher's LSD method at 95% confidence.

Results and Discussion

Table 12a. Means and analysis of variance for plant height, plant lodging (1-9, 9 = flat), days to maturity, and yield of six quinoa varieties grown in Melita, Manitoba in 2023.

Phillex Quinoa Varieties 2023 Table of Fitted Means				
Variety	**Height**	**Lodging^**	**Days to Maturity**	**Yield (Kg/ha)**
PHX23-01	104.7**c**	3.0	121.3	1526
PHX23-02	121.0**b**	2.3	117.3	1179
PHX23-03	139.7**a**	3.0	155.0	995
PHX23-04	126.7**b**	4.3	122.3	1316
PHX23-05	124.3**b**	4.7	122.3	1385
PHX23-06	120.7**b**	4.0	120.3	1269
P-Value (Variety)	**0.001**	0.485	0.779	0.521
P-Value (Rep)	0.130	**0.015**	0.070	**0.001**
C.V.%	5.1	45.3	5.9	24.8

*Values that do not share a letter are significantly different
^Evaluated on a scale of 1-9 (9 = flat)

In this trial, only the height of the plants was found to be significant (P = 0.001) between the six quinoa varieties evaluated (Table 12a). The variety PHX23-03 was the tallest variety (139.7 cm) and was significantly taller than the other varieties evaluated. PHX23-01 was the shortest variety (104.7 cm) in the trial. Lodging was not significant (P = 0.485) between varieties; PHX23-05 had the highest lodging rating (4.7 out of 9). Days to maturity were also not found to be significant (P = 0.779) between varieties. Though not significantly different, PHX23-02 was the fastest to mature (117.3 days), and PHX23-03 took the longest to mature (155.0 days). Interestingly, grain yield was also not found to be significantly different (P = 0.521) between varieties. Though not found to be significantly different from the other varieties, PHX23-01 was the highest yielding (1526 Kg ha^{-1}) and PHX23-03 was the lowest yielding (995 Kg ha^{-1}) entry.

Table 12b. The fitted means and P-values for lodging, days to maturity, height, and yield calculated by rep.

Phillex Quinoa Replicate Fitted Means				
Rep	Height (cm)	Days to Maturity	Lodging^	Yield (Kg/ha)
1	120.5	126.3	5.5**a**	1850**a**
2	127.5	116.7	2.5**b**	1254**b**
3	120.5	116.3	2.7**b**	731**c**
P-value	0.130	0.070	**0.015**	**0.001**

*Values that do not share a letter are significantly different
^Evaluated on a scale of 1-9 (9 = flat)

In this trial, while not found to be significant when comparing varieties, lodging and grain yield were significant when comparing fitted means by the replicate. Rep 1 was found to have significantly (P = 0.015) higher lodging (5.5 out of 9) compared to Rep 2 (2.5 out of 9), and Rep 3 (2.7 out of 9). Rep 1 also had significantly (P = 0.001) higher yields (1850 Kg ha^{-1}) than Rep 2 (1254 Kg ha^{-1}) and Rep 3 (731 Kg ha^{-1}) (Table 12b).

There are multiple possible reasons why significant differences are seen between the replicates in a trial. These can include conditions such as one replicate being on a headland or compacted area, large nutrient differences in the areas, or salinity. Another issue this trial faced during the growing season was high insect pressure from both grasshoppers and lygus bugs. One replicate may have been closer to where the insects had emerged in the spring for eating. In addition to high insect pressure, the trial also faced drought conditions; only receiving 164 mm of precipitation from the seeding date to the harvest date, where the normal amount received in that period for this area is 314 mm. A small hail event during the growing season may be one last possible conclusion for reduced yields that were observed in this trial.

Pictures

Figure 4a & 4b. Quinoa plots throughout the growing season.

18.0 MCVET Blue and White Lupin Evaluation

Project Duration: 2023
Collaborators: MCVET, MB Ag (Dennis Lange), Lupin Platform Inc.

Objectives

- To evaluate agronomic characteristics of blue lupin compared to white lupin
- To evaluation agronomic characteristics of blue and white lupin compared to field peas

Background

Lupins are a legume crop that originally came from Europe, which we are now growing in Canada. They are most commonly used for food products and as livestock feed. There are many species of lupin that are native to Europe; here the focus will be put on two different species with multiple varieties. The species Lupinus albus refers to a white, narrow-leaved lupin, while Lupinus angustifolius refers to a blue, broad-leaved lupin. While these are both species of lupin, it can be thought of as comparing wheat and oats; both are cereals but are managed differently.

Both the white and blue species of lupin require high moisture (>225 mm) during the growing season, but they also have many differences. White lupins can handle slightly higher soil pH and are more susceptible to anthracnose than blue lupins. White lupins have a lower target plant population (4.5-6 plants/ft^2) than blue lupins (10-11 plants/ft^2). White lupins also have a larger seed size and grow taller than blue lupins (70-80 cm and 50-60 cm, respectively). Both types have good standability and are not prone to lodging, but at harvest time blue lupins are more susceptible to pod shattering under certain field conditions.

There are initiatives in Manitoba and across Canada seeking to increase the efficiency of protein production. It is thought the lupins are more sustainable than field peas since they have been shown to have higher seed protein. There are other important interests in lupins as well. In addition to the high seed protein content, they also come with all the conventional benefits that legumes bring to the producer's rotation, additional resistance and a longer rotation from Aphanomyces root rot (Boström 2005). Lupins are classified as nitrogen-fixing legumes and can be treated similarly as the other pulse crops that provide the advantage of nitrogen fixation.

This trial focuses on comparing white and blue lupins to each other as well as to field peas, which farmers are more familiar with.

Methods and Materials

In Melita, the Lupin variety trial was established on Waskada Loam soil in excellent moisture on May 16th at a depth of 1-inch. Chemical burn-off was needed and was applied as Round Up Transorb (0.67 L ac^{-1}), Rival (0.65 L ac^{-1}), and Authority (85 mL ac^{-1}). Granular fertilizer was side-banded during seeding as 10-35-25-15-1 actual lbs ac^{-1} (N-P-K-S-Zn); the lupins were also inoculated with a peat-based lupin specific Rhizobia species. Different post-emergence herbicides were used on the peas and the lupins. The peas were sprayed with Viper (0.4 L ac^{-1}) and UAN (0.81 L ac^{-1}); the lupins were sprayed with Arrow (150 mL ac^{-1}) and 0.5% v./v. X-Act. The plots were harvested on different days; the blue lupins and peas were harvested on August 17th, and the white lupins were harvested later on September 8th.

Results and Discussion

In terms of height, the white lupin variety Dieta was the tallest (73.8 cm) but was not significantly taller than any of the other white lupin varieties (Table 13). The variety Lunabor was the tallest of the blue lupins (41.0 cm) but was not significantly taller than any of the other blue lupin varieties. All the white and blue lupin varieties were significantly different ($P < 0.001$), in terms of height, compared to the field peas. Of the field peas, the variety CDC Lewochko was the tallest (76.0 cm) and was also the tallest entry of the trial. The white lupins, blue lupins, and field peas all had a significantly different ($P < 0.001$) number of days to maturity. Blue lupins were the first to mature (69-71 days), field peas were second (75-76 days), and white lupins matured last (92-95 days). Yield was also found to be significantly different ($P < 0.001$) between the white and blue lupins and field peas. AAC Carver peas had the highest yield of the entire trial (4621 Kg ha^{-1}) but was not significantly different from the yield of AAC Chrome peas (4443 Kg ha^{-1}). The lowest yielding entry of the trial was the blue lupin variety Probor (1666 Kg ha^{-1}). The blue lupin variety with the highest yield was Lunabor (2323 Kg ha^{-1}) but was not significantly higher than the yield of the blue lupin variety Boregine (2056 Kg ha^{-1}). The white lupin variety with the highest yield was found to be Bonus (2911 Kg ha^{-1}) but its yield was not significantly higher than any of the other white lupin varieties.

Crude protein content for pea and white lupin are approximately 24% and 38%, respectively. Since lupin is significantly higher in crude protein content it is important to take this in consideration when protein is the goal in yield and profitability. For example, in this trial Chrome peas would have yielded 1066 Kg ha^{-1} crude protein whereas white lupin Bonus would have yielded 1047.96 Kg ha^{-1} crude protein, which are likely not significantly different in this perspective of crude protein.

Table 13. Fitted means for lodging (1-5, 5 = flat), height (cm), nodule rating, days to maturity, and grain yield of white lupin, blue lupin, and field pea varieties grown near Melita, Manitoba in 2023.

Blue and White Lupin Evaluation - Melita 2023					
Table of Fitted Means					
Variety Name	**Lodging**	**Height (cm)**	**Nodule Rating**	**Days to Maturity**	**Yield (Kg/ha)**
Blue Lupin					
Lunabor	1.00	41.0**C**	2.0	69**H**	2323**DE**
Boregine	2.00	39.7**C**	1.7	71**G**	2056**E**
Probor	2.00	37.3**C**	2.0	71**G**	1666**F**
White Lupin					
Dieta	1.00	73.8**AB**	2.4	94.3**AB**	2543**CD**
Snowbird	1.00	72.3**AB**	2.8	94**BC**	2638**CD**
Periwinkle	1.00	69.0**AB**	1.9	95**A**	2855**C**
Volos	1.00	68.0**B**	2.0	93.3**CD**	2579**CD**
Bonus	1.00	72.0**AB**	2.7	92.7**D**	2911**C**
Field Peas					
AAC Carver	1.00	66.0**B**	2.8	75**F**	4621**A**
AAC Chrome	1.00	66.0**B**	2.9	75.7**EF**	4443**A**
CDC Lewochko	1.00	76.0**A**	3.0	76**E**	3973**B**
P-value	-	**<0.001**	0.149	**<0.001**	**<0.001**
CV%	0.0	7.2	30.9	0.7	7.7

*Means that do no share a letter are significantly different

References

Boström 2005. Weed management in organically-grown narrow-leafed lupin. IN, pp.4-9.

Manitoba Agriculture (2023) *Agriculture: Province of Manitoba*, *Province of Manitoba - Agriculture*. Available at: https://www.gov.mb.ca/agriculture/protein/index.html

Manitoba Agriculture (2023) *Agriculture: Province of Manitoba*, *Province of Manitoba - Agriculture*. Available at: https://www.gov.mb.ca/agriculture/protein/sustainability/index.html

Lupin 101 - Lupin Platform Inc. (2022) *Lupin Platform*. Available at: https://lupinplatform.com/lupin-101/

Pictures

Figure 5a: white and blue lupins flowering. **Figure 5b:** white lupins podding.

19.0 Comparative Fungicide Efficacy Testing for Managing Mycosphaerella Blight and White Mould in Peas in Manitoba

Project Duration: 2023

Collaborators: Assiniboine Community College (ACC), Manitoba Pulse and Soybean Growers (MPSG)

Objectives

- Compare the relative performance (fungicide efficacy and impact on yield) of five different registered foliar fungicide products at three testing sites in controlling Mycosphaerella blight in peas in Manitoba.

Background

Ascochyta/Mycosphaerella blight complex is among the most widespread and economically damaging foliar diseases of pea crop (Pisum sativum) in Manitoba. Ascochyta infections are caused by the fungi Ascochyta pinodes (leaf infection), Ascochyta pinodella (foot rot infection), and Ascochyta pisi (pod infection) on peas. The Mycosphaerella pinodes is the sexual stage of A. pinodes causing Mycosphaerella blight in peas. Mycosphaerella infection begins at the bottom third of the plant and progresses upward during the early flowering stage of pea growth. Where, white mould (Sclerotinia sclerotium) affects the stems, leaves, pods, and seeds of peas. The symptoms start with brown, water-soaked lesions that enlarge rapidly under cool and moist conditions. These lesions become water soaked, rotted sections on plant tissue eventually expanding in size. Under humid conditions, such lesions may become covered with white, cottony growth. Within a week, black sclerotia are formed in the infected tissue. The lesions eventually become dry, bleached, and shredded, causing wilting and subsequent death of entire branches, and girdling the plant's main stem.

In all 14 fields surveyed in 2020 by Manitoba Pulse and Soybean Growers (MPSG), Mycosphaerella blight was present (100% prevalence and severity scale of 3.4 (0-9 scale), whereas white mould was noted in only 14% of the fields with a severity scale of 0.4%. In 2021, in 41 pea fields surveyed by MPSG, Mycosphaerella blight prevalence was 100% and the average severity was 3.5 (0-9 scale). White mould was not found in any fields in 2021, most likely due to extremely dry conditions in the province. In 2022, MPSG conducted a foliar and stem disease survey in 48 pea fields at R4 stage in Manitoba. Mycosphaerella blight was the most common foliar disease, found in 100% of fields. Mycosphaerella blight severity was on average 2.2 (range: 1.0-5.1) on a scale of 0-9. Bacterial blight was present in 83% of fields. White mould was found at trace levels in 4% of pea fields The ACC/MPSG field trials conducted under this program in 2022 at Roblin, Manitoba, and Portage La Prairie, Manitoba, showed Mycosphaerella blight was present in all test plots at both sites at severity levels of 2.5 and 3.0 (0-7 scale), at each site respectively, seven days after the fungicide application. White mould infections were not found at any of the trial sites regardless of the fungicide applications, which may be again due to prolonged dry conditions in the province.

With the arrival of different pea protein processing facilities in Manitoba, the acreages under pea production are steadily increasing, especially in the southwest part of the province. In response to this increase in pea acres, it is important to maximize the yield potential by effectively managing disease inoculum buildup over time. One method of suppressing disease development is to apply commercially available foliar fungicide products that not only effectively control the disease but also pose little threat to the environment. In Manitoba, many registered fungicide products are available for the management of Mycosphaerella blight and white mould infections, however, studies show the maximum effectiveness of fungicides occurs if they are applied at the early flowering stage combined with weather conditions observations conducive to infection. Field trials provide an opportunity to assess the relative performance of different registered fungicide products in order to guide pea producers in Manitoba to make crop application decisions. The proposed field trial is a continuation of the 2022 study to compare the relative performance of fungicide efficacy and impact on pea yield of five commercially registered fungicide products in controlling Mycosphaerella blight and white mould diseases in peas in Manitoba.

Methods and Materials

In 2023, this trial was established near Melita, Manitoba (NW15-3-27 W1) on Waskada Loam soil with excellent moisture on May 3rd. The peas were seeded at a depth of 1.25-inches and granular fertility was applied at 10-35-25-15-1 actual lbs ac^{-1} of N-P-K-S-Zn. Chemical burn off was applied at Round Up Transorb (0.67 L ac^{-1}) before seeding; the plots were rolled after seeding, then sprayed with Authority (85 mL ac^{-1}) and Rival (0.65 L ac^{-1}) after rolling. In crop herbicide was required when the peas were 4-inches tall; Odyssey (17.3 g ac^{-1}) with Merge (0.5% v./v.) was used. All fungicide treatments (Table 14) were applied on June 19th after a small rainfall event. The plots were desiccated on August 1st with Reglone (0.5 L ac^{-1}) with LI-700 (0.25% v./v.), and here harvested on August 9th.

Table 14. Fungicides used in the pea fungicide evaluation trial.

Fungicide Product	Fungicide Name	Group	Rate	Application Timing According to the Label
Delaro 325 SC	Prothioconazole, Trifloxystrobin	3, 11	356 mL/acre	Apply at the first sign of disease. When disease pressure is high or when agronomic or weather conditions are conducive to disease development, make a second application 10 to 14 days later. Use shorter intervals for best protection.
Miravis Neo 300 SE	Pydiflumetofen, Azoxystrobin, Propiconazole	3, 7, 11	505 mL/acre	The application must occur before the disease is established and no later than the onset of flowering.
Dyax	Fluxapyroxad, Pyraclostrobin	7, 11	160 mL/acre	Apply at the onset of symptoms and prior to row closure at the beginning of flowering.
RevyPro	Mefentrifluconazole, Prothioconazole	3	400 mL/acre	Apply RevyPro at the beginning of flowering or at the onset of symptoms. Apply a second time 10–14 days later if the disease persists or if weather conditions are favourable for disease development.
Acapela	Picoxystrobin	11	240 mL/acre	Begin applications prior to disease development and continue on a 7- to 14-day interval. Use higher rate and shorter interval when disease pressure is high.

Results and Discussion

A multi-site multi-year final report will be made available in the 2024 Annual Report by ACC (March 2024).

20.0 Fusarium Head Blight Project

Project Duration: 2023
Collaborators: Dr. Mkhabela (University of Manitoba)

Background and Protocol

In 2023, WADO teamed up with the University of Manitoba for a second year to assist in improving the current Fusarium Head Blight Model by evaluating spikes of plants from the MCVET winter wheat, spring wheat, and barley trials. The seeding, harvest, and agronomic information about these trials can be found in Table 3 (Section 1.0) of this report. The varieties used for the collection can be found in Table 13b, below. 50 heads per plot, three plots per variety were inspected for evidence of fusarium head blight (FHB) in the 2023 growing season. The inspections took place when the crops had reached 18-21 days after 50% anthesis stage

(BBCH 85). For each spike observed, the number of infected and non-infected spikelets were recorded. Using the values collected, a rating scale is used to determine disease severity. Collection dates and field information can be found below in Table 13a.

Last year, the heads collected were frozen to preserve spore samples and sent away for sampling. This year, spikelet counts and ratings had been done to evaluate the presence of FHB. After combining, harvest grain samples were also sent away for a grading evaluation as well as analysis on FDK (Fusarium Damaged Kernels) and DON ("Deoxynivalenol" also known as Vomitoxin). In the last 5 years (including 2023), it has been difficult to find and collect FBH-damaged heads since the environmental conditions have not been conducive to disease development. The collaborators have been hoping for higher disease incidences to collect good samples for evaluating the model.

Table 13a. Site, crop, and collection information for the Fusarium Head Blight Analysis at Melita in 2023.

Fusarium Head Blight - Field & Crop Information				
Crop	**Winter Wheat**	**Spring Wheat**	**Barley**	**Durum**
Seeding Date	Sep-19-22	May-05-23	May-05-23	May-31-23
Depth	0.5"	1"	1"	1"
Fertilizer (N-P-K-S-Zn)	16-30-21-13-1Zn	134-35-25-15-1Zn	95-35-25-15-1Zn	95-35-25-15-1Zn
Herbicide	Mextrol and Achieve	Puma and Mextrol	Puma and Mextrol	Mextrol, hand weeded
Dessication	01-Aug Reglone	02-Aug Round Up + Heat	None	05-Sep Reglone
Mid-Anthesis	15-Jun	26-Jun	07-Jul	03-Aug
Date of FHB Observations	10-Jul	17-Jul	12-Jul	17-Aug
Harvest Date	14-Aug	08-Aug	08-Aug	08-Sep
All plots involved were top dressed with 60lbs of N as Agrotain coated urea in spring				

Table 13b. Varieties used for Fusarium Head Blight Analysis from Melita in 2023.

Crop	Variety
Winter Wheat	Emerson AAC Goldrush AAC Vortex
Spring Wheat	AAC Brandon SY Cast AAC Hassler
Barley	AB Hague CDC Austenson Torbellion
Durum	AAC Donlow

21.0 Protein Evaluation in Irrigation versus Dryland Soybeans

Project Duration: 2023-2025
Collaborators: Dr. Elroy Cober (AAFC)

Objectives

- To evaluate the agronomics of drought stress on soybean seed yield and seed protein. A series of low to high protein lines will be grown in dryland and irrigated conditions to determine the role of drought stress on seed yield and seed protein.

Background

Canadian climate models predict that soybean growing areas will be hotter, with increased precipitation irregularity resulting in a greater likelihood of periodic moisture stress occurring during critical periods of crop growth such as flowering and seed development. While not as devastating as season-long drought, periodic moisture stress occurs when there is an interval of two or more weeks without precipitation. While no crop plant can be productive without water, there are adaptive mechanisms that ensure that plants can survive periodic moisture stress well enough to recover and achieve seed yields that are not significantly reduced. Moisture stress tolerance mechanisms that are beneficial in dry years but, result in a yield penalty in normal years are not useful for farmers. Soybean derives 50% or more of its nitrogen from symbiotic N_2-fixation, which is more susceptible to moisture stress than either photosynthesis or growth.

Soybean derives 50% or more of its nitrogen from symbiotic N_2-fixation, which is one of the economic advantages of legumes, however N_2-fixation is more susceptible to moisture stress than either photosynthesis or growth. As the amount of available soil water decreases, plant processes such as photosynthesis, and N_2-fixation slow and stop reducing growth and protein accumulation (Sinclair et al. 2010). Protein is a product of the amount of inorganic nitrogen removed from the soil and the biologically fixed N_2. Nitrogen, stored in protein bodies in leaves and stems, is translocated to the seed during maturation requiring energy, and moisture. Prolonging biological N_2 fixation under periodic moisture stress increases the capacity to accumulate protein in stems, leaves, and seed. Greater than 99 % of the nitrogen in the atmosphere is composed of ^{14}N non-radioactive N_2. Only 0.4% of the atoms are ^{15}N and soil contains very little. Therefore, the ratio of $^{14}N/^{15}N$ in vegetative material and seed is a good method of determining where the N_2 originated and the effectiveness of the plant in obtaining N from N_2-fixation under moisture stress (Unkovich et al. 1997).

This research proposal will address priorities expressed in the Guelph statement. In the focus area of Climate Change and Environment with the priority to prepare for and respond to a changing climate by accelerating technological adoption, the proposed work addresses soybean drought tolerance for resilience in the face of variable precipitation. In this proposal, both seed yield and seed protein content will be evaluated in regard to drought tolerance. Tools will be developed to allow for introgression of drought tolerance into other germplasms.

This project tests 10 different varieties of conventional soybeans as part of a broader project examining protein differences between irrigated and dryland conditions in Western Canada. Each location where the trial is grown will conduct the project in partnership with Elroy Cober of AAFC, Ottawa. The data collected for the project will include flowering date, days to maturity, plant height, lodging, yield, and seed composition.

Methods and Materials

In 2023, this trial was established near Melita, Manitoba (NE6-4-26 W1) in Margaret Loamy Sand (Terence Association). The soybeans were seeded into canola stubble which had good moisture, at a depth of 1-inch on May 19th. Fertility was side banded as 10-35-25-15-1 actual lbs ac^{-1} (N-P-K-S-Zn). Chemical burn off was applied as Round Up Transorb (0.67 L ac^{-1}) before seeding and Authority (85 mL ac^{-1}) and Rival (0.65 L ac^{-1}) after seeding and rolling. On June 12th, Viper (0.4 L ac^{-1}) with UAN (0.81 L ac^{-1}) was applied for in crop herbicide. Two varieties were harvested early on September 27th due to shatter; the rest of the plots were harvested on October 10th. A shatter rating and seed counts were done on the plots that had a lot of seed shatter. Table 14 below lists the irrigation dates and amounts that were applied to the irrigated portion of the trial. This weather data was collected using at weather station positioned at the non-irrigated site of soybeans. Any precipitation amount that was collected and recorded that was less than 2mm precipitation per day was excluded from the table. The irrigated soybeans received 68% more precipitation than the dryland soybeans.

Table 14a. Precipitation and irrigation dates with amounts and season totals for the 2023 Protein Evaluation in Irrigated versus Dryland Soybeans. All precipitation amounts are given in mm.

Date		Natural Precipitation	Irrigation Water
June	8	29.0	
	20	2.6	7.6
	22	11.6	
	27	2.3	
July	7		33.0
	12	2.9	
	13	7.4	
	21	4.5	15.2
	23		7.6
	26		15.2
	31		7.6
August	5		15.4
	9		7.6
	13	18.3	
	16		15.4
	21	28.4	
	31	20.0	
Septemeber	4	22.7	
	11	58.4	
	23	14.6	
	24	6.5	
October	3	25.2	
	4	3.7	
	5	3.3	
Total Natural Precipitation		**261.4**	
Total Irrigation Precipitation		124.6	
Total Received by Irrigated Plots		**386.0**	

Results and Discussion

Not surprisingly, irrigation of the soybeans throughout the season resulted in higher yields in every entry included in the trial (Table 14b). The average days to maturity and plant heights were also increase as a result of irrigation. Seed weights of the soybeans were slightly decreased on average under irrigated conditions, while protein content of the seed was slightly increased from an average of 39.2% to 41.6% across varieties. The overall protein yield of the soybeans was significantly increased when irrigation was used during the growing season. When comparing the differences in grain yield between the dryland and irrigated soybeans, the dryland soybeans only produced half the yield (1668 kg ha^{-1}) of that produced by the irrigated (3510 kg ha^{-1}). There are varieties included in this trial, including a non-nodulating variety, that are being used to evaluated how the soil-available and atmospheric nitrogen is being utilized in the plant to produce the protein content of the seed at maturity. The non-nodulating variety OT07-20 had the lowest crude protein value of 33.5% according to WADO's analysis. Currently, the project coordinators are waiting on more nitrogen tests to be performed on the soybean samples provided from multiple sites across Western Canada. Additional years of research and testing are needed to make conclusions on the protein evaluations between dryland and irrigated production of soybeans.

Table 14b. Results and means of grain yield, days to maturity, plant height, seed weight, protein content, oil content, protein yield, and fixed protein yield from the irrigated versus dryland soybean trial near Melita in 2023.

	Variety	Yield (Kg/ha)	Days to Maturity	Plant Height	Seed Weight	Protein %	Oil Content	Protein Yield	Fixed Protein Yield
Irrigated	AC Proteus	2100	125	83	15.7	46.8	16.6	983	109
	AAC Springfield	3565	119	69	15.1	44.2	18.1	1576	702
	Jari	4845	125	81	17.6	43.6	18.7	2113	1239
	OT14-03	3505	122	63	16.6	42.9	18.9	1504	630
	90A01	3366	120	57	15.7	40.5	20.6	1363	489
	AAC Edward	3577	116	56	15.5	39.7	20.6	1420	546
	OAC Prudence	4406	117	81	19	40	20	1763	889
	AC Harmony	3790	122	63	15.1	38.1	22.2	1444	570
	OT07-20	2608	130	78	14.8	33.5	22.7	874	0
	OT94-47	3337	125	61	18.1	39.6	20.9	1322	448
	Mean	3510	122	69	16	41	20	1436	562
Dryland	AC Proteus	1270	125	59	17.9	44.6	18.5	566	103
	AAC Springfield	1350	125	41	16.5	41	20.6	553	89
	Jari	2445	125	57	18.3	41	20.9	1003	539
	OT14-03	1471	126	37	15.6	40.5	21.2	596	132
	90A01	1718	113	42	16.4	38.6	22.5	663	199
	AAC Edward	1326	107	36	15.1	36.1	23.6	479	15
	OAC Prudence	2364	114	59	18.5	36.7	22.7	868	404
	AC Harmony	2108	125	53	15.5	36	23.9	759	295
	OT07-20	1385	129	52	16	33.5	23.6	464	0
	OT94-47	1249	107	44	18.4	37	23.8	462	-2
	Mean	1669	120	48	17	39	22	641	197
Difference	AC Proteus	830	0	24	-2.2	2.2	-1.9	416	6
	AAC Springfield	2216	-6	28	-1.4	3.2	-2.5	1022	613
	Jari	2400	0	24	-0.7	2.6	-2.2	1110	700
	OT14-03	2034	-4	26	1	2.4	-2.3	908	498
	90A01	1648	7	15	-0.7	1.9	-1.9	700	290
	AAC Edward	2250	9	20	0.4	3.6	-3	941	531
	OAC Prudence	2042	3	22	0.5	3.3	-2.7	895	485
	AC Harmony	1682	-3	10	-0.4	2.1	-1.7	685	275
	OT07-20	1224	1	26	-1.2	0	-0.9	410	0
	OT94-47	2088	18	17	-0.3	2.6	-2.9	859	449
	Mean	1841	3	21	0	2	-2	795	428
	% Loss	52	2	31	-3	6	-11	55	76

Pictures

Figures 6a & 6b. Left: soybean grown without irrigation. Right: soybeans grown with irrigation. Both pictures were taken on the same day.

References

Sinclair TR. et al. 2010. Assessment across the United States of the benefits of altered soybean drought traits. Agron. J. 102:475-482.

Unkovich MJ. et al. 1997. Nitrogen fixation by annual legumes in Australian Mediterranean agriculture. Crop and Pasture Sci. 48 267-293

22.0 Green House Gas Emissions Long-term Evaluation

Project Duration: 2023 – Ongoing
Collaborators: University of Manitoba, Manitoba Agriculture & Resource Development, and Agriculture & Agrifoods Canada, Manitoba Diversification Centres

Objectives

- To find a balance between lowering nitrogen rates and maintaining high yields of major crops with the goal of reaching the government mandated reduction in GHG emissions by 2030.
- To determine if a sustained reduction in nitrogen application will decrease the yield of crops in different areas of Manitoba over the long-term.
- To determine if reducing nitrogen losses using the 4Rs will allow for sustained decreased rates of nitrogen fertilizer.

Background

The Federal Government has proposed a national target to reduce greenhouse gas emissions, particularly N2O from fertilizer use, by 30% below 2020 levels by 2030. For the agriculture sector in Manitoba, achieving the 30% reduction in GHG emissions from fertilizer use by 2030 will require a shift in farming practices. Research conducted by the 4R IRC Program at the University of Manitoba shows reductions possible from most to least being growing nitrogen fixing legumes, split nitrogen application, use of nitrification inhibitors, use of polymer coated urea and deep banding. Lowering nitrogen rates is very effective in cutting emissions, however, yields and production economics can be compromised. Farmers are aware of the above means to reduce emissions. What they are unsure of is the practicality and impact on their bottom line. They also are skeptical of research not done in their region. The approach of collaborating with the Crop Diversification Centers and taking field research to four regions of Manitoba allows the University research to explore areas it usually doesn't get the chance to.

Currently, the Federal Government tallies N_2O emissions based on a Tier II protocol that mainly uses the rate of nitrogen fertilizer application and fertilizer emission factors by eco-district. Thus, some provincial governments, farmer advocates and many farmers are concerned that eventually reductions in N use will be imposed to achieve emission reductions. The argument against rate reductions is yields will be reduced resulting in loss of profit to farmers and loss of GDP. However, the counter argument is reducing nitrogen rates by 10 or even 20% doesn't result in a yield decrease from many short-term research trials. Adam Gurr, a farmer/consultant near Brandon, has challenged whether continuous nitrogen rate reductions for field crop production is sustainable in the long-term. Adam found yields with field crops at 30% reduction of recommended nitrogen rates faired just as well as full rate fertilization in the short-term. However, after five years of the continuous rate reduction crop yields plummeted.

Extensive research by the 4R IRC has shown nitrification inhibitors to reliably reduce N2O emissions from field crop production in Manitoba by about 40%. However, the inhibitors haven't been proven to increase yields. Thus, farmers are not recouping the cost of the nitrification inhibitors.

The four Crop Diversification Centers in Manitoba will be used to examine two approaches to reduce emissions, reduce nitrogen (N) rates and include nitrification inhibitors with fertilizer nitrogen. Over three years, trials will compare the agronomics of sustained additions of 100, 90 and 70% of recommended nitrogen, and emissions at 100% nitrogen rate without and with nitrification inhibition.

Methods and Materials

In 2023, this trial was established at the four Crop Diversification Centers, in Melita, Roblin, Carberry, and Arborg. This is the first year of a multi-year study focusing on crop rotation, fertilizer rates, yield potential, nitrogen loss with or without the use of nitrification inhibitors, and greenhouse gas emissions. Melita's trial was seeded near (NE6-4-26 W1) into Margaret Loamy Sand on May 30th in two different passes with a Seedhawk dual knife drill. Chemical burn off was applied as Round Up Transorb (0.67 L ac^{-1}) and Aim (20 mL ac^{-1}) on May 29th, the day before seeding. In the first pass, variable treatments of nitrogen were applied at a depth of 1.5-inches with or without a nitrification inhibitor (NI) . Table 15 below displays the different fertilizer amounts that were included in the trial.

The fertilizer treatments that did not require a nitrification inhibitor were applied using pure urea (46-0-0). The fertilizer treatments that did require a NI were applied using the fertilizer product SuperU (46-0-0). There are two types of inhibitors that are commonly talked about in agriculture: inhibitors that either work on urease or nitrification (UNL, 2019). What nitrification inhibitors usually do is inhibit the ability of nitrifying bacteria that are responsible for converting ammonium into nitrate to do so (UNL, 2019). These compounds work to reduce denitrification because the fertilizer will stay in the ammonium form (UNL, 2019). Three products that are known to have good efficacy for nitrification inhibition include dicyandiamide (DCD), nitrapyrin, and pronitradine (UNL, 2019). DCD is the key component of the fertilizer product SuperU. SuperU is intended to reduce volatilization, denitrification, and leaching of urea (nitrogen) fertilizer (Koch Agronomic Services, 2023). There was also a granular fertilizer blend applied at the time of seeding; 10-35-25-15-1 actual lbs ac^{-1} (N-P-K-S-Zn) to balance with the spring soil tests.

In the second pass of the seeder, the canola variety DKB82SC Liberty Link was seeded over top of the fertilizer bands to replicate side-banded fertilizer. The canola was seeded at 0.5-inch depth, into good moisture. Due to restrictions of the equipment available, all fertilizer and seed were not able to be seeded in the same pass. The goal of seeding was to have the canola seeded 1-inch above the fertilizer with enough room to avoid burning the seed. Unfortunately, considerable GPS accuracy was lost during seeding and in some areas of the trial the fertilizer was not placed deep enough. Some plots required rows of canola to be reseeded on June 16th due to fertilizer burn of the plants. For 2024 and the future years of this trial at Melita, a one-pass seeding method is being adopted in order to eliminate any seed burn issues encountered in 2023.

The gas chambers were placed in the plots the day of seeding, and first gas samples were collected on June 1st. For the first week, gas samples were collected three times a week, then samples were collected twice a week until the middle of August. From then, gas samples were collected once a week until freeze up. Regular gas sampling was scheduled to try and establish how much nitrogen fertilizer is gassed off to the atmosphere during a regular growing season with and without the use of nitrification inhibitors.

On June 16th, Interline (Liberty) was applied at a rate of 1.5 L ac^{-1} as in crop weed control. The plots were desiccated on September 5th with Reglone (0.65 L ac^{-1}) + LI700 at 0.25% v./v.; all plots were harvested on September 18th.

Results and Discussion

The results of the first year in the multi-year trial of a long-term green house gas emissions evaluation showed no significant (P = 0.463) yield differences between the different treatments involved (Table 15). The treatment including 100% of recommended nitrogen with a nitrification inhibitor added produced the highest yield, but there was not enough variation in the yield data across the trial in order for the treatment to be considered significantly different from the others. This suggests that yields in Year 1, when growing canola, were not affected by decreasing the applied nitrogen rates with or without the use of a nitrification inhibitor. In the reduced rate plots, it is suspected that mineralization of organic forms of nitrogen found naturally in the soil, such as organic matter or other plant residues was taking place. This process provides inorganic forms of nitrogen to the plants that they are able to uptake and utilize, which helped the plants reach normal acceptable yields. Because it was a dry year, the lowest rate of nitrogen performed better than it would have under wet conditions. In wet years, more gassing off and leaching of nitrogen fertilizers takes place within the soil and on the soil surface.

Table 15. The yield results from the 2023 green house gas emissions collection trial performed near Melita.

	Normal Recommended N for Canola	Plot Yield (Kg/ha)
Without Nitrogen Inhibitor Applied	0	3167
	70	3286
	90	3085
	100	3034
With Nitrogen Inhibitor Applied	70	3208
	90	3397
	100	**3489**
	P-Value	0.463
	C.V.%	9.5%

Pictures

Figure 7a: seeding the canola over top of the fertilizer bands.

Figure 7b: Visual of the gas chambers in the flowering canola.

Figure 7c: the WADO staff on Day 1 of sampling; learning sampling the protocol.

References

FlipperSiteDeveloper® (2023) *Superu® Premium fertilizer, SUPERU® Fertilizer for Nitrogen Preservation | Koch Agronomic Services*. Available at: https://kochagronomicservices.com/solutions/nutrient-protection/superu/

Nitrogen inhibitors for improved fertilizer use efficiency (2021) *CropWatch*. Available at: https://cropwatch.unl.edu/2019/nitrogen-inhibitors-improved-fertilizer-use-efficiency

23.0 Teferi Variety Evaluation

Project Duration: May – October 2023
Collaborators: Dawit Teferi, PCDF, MCDC, WADO

Objectives:

- To evaluate seeding rates of teff for grain and forage production

Background

Teff *(Eragrostis tef)* is a warm-season annual grass that originates in northeast Africa, where it is grown for grain and forage production. The grain is very small, about the size of a poppy seed, with approximately 1.2 million seeds per pound (2.6 million seeds per kilogram). The flour is used to produce a traditional flatbread called *injera*, which is naturally gluten-free. As a forage, the crop is notable for its high protein content and palatability, as well as its potential for high yields.

This report presents the results for teff grain and forage trials, grown in partnership with Dawit Teferi, a businessperson who provided one red and one white variety for testing. The trials were grown at Carberry (MCDC), Melita (WADO) and Roblin (PCDF). The trial was also established at Arborg (Prairies East Agricultural Sustainability Initiative) but was terminated due to poor emergence. The trial builds on small-plot trials that were conducted in Roblin in 2021-2022, and in Arborg in 2022.

The current report builds upon tests in 2021 in Roblin and in 2022 at Arborg and Roblin. In brief, total forage yields for those trials did not differ significantly by seeding rate. Grain yields (at Roblin only) did not differ by seeding rate, but yielded significantly less if the teff was cut for hay in mid-season than if the grain was allowed to reach full maturity without being cut. In

2021, barley greenfeed at Roblin yielded less than the combined yield for two cuts of teff. In 2022, barley greenfeed yields were higher than combined teff yields at both Roblin and Arborg.

Figure 8: (a) "Teferi Red" variety, Aug 17, Roblin (b) "Teferi White" variety, Aug 29, Roblin (c) "Control Red" at grain harvest (Sept 22) (d) "Teferi Red"

Figure 9 (clockwise from top-left):
a. “Teferi White”
b. Close-up of teff seeds (with 10-cent piece for size reference).

Table 16a: Materials and methods of the 2023 Teferi Variety trial at the different sites across Manitoba.

Overview	
Design	RCBD
Entries	3 (grain) at Carberry and Melita
	6 (3 grain, 3 forage) at Roblin
	“Control Red”
	“Teferi Red”
	“Teferi White”
Reps	4
Harvest area	8.0 m2
Seeding rate	5 lbs/ac
Target N	110 lbs/ac

Seeding Date	
Carberry	May 23
Melita	May 31
Roblin	May 26
Number of cuts (Roblin forage only)	
Teff	2
Harvest Dates	
Carberry	Sept 13 (grain and straw)
Melita	Sept 28 (straw; no grain harvest)
Roblin	Jul 14 (1st forage cut)
	Sept 22 (2nd forage cut; grain, straw)

Results

Grain Yield

Teff grain was harvested at Carberry and Roblin. Melita had exceptionally high numbers of grasshoppers, which fed on the seedheads of the maturing teff plants. As a result, grain was not harvested at that location. The grain yields for Carberry and Roblin are shown in Figure 10. Yields marked with the same letter do not differ significantly.

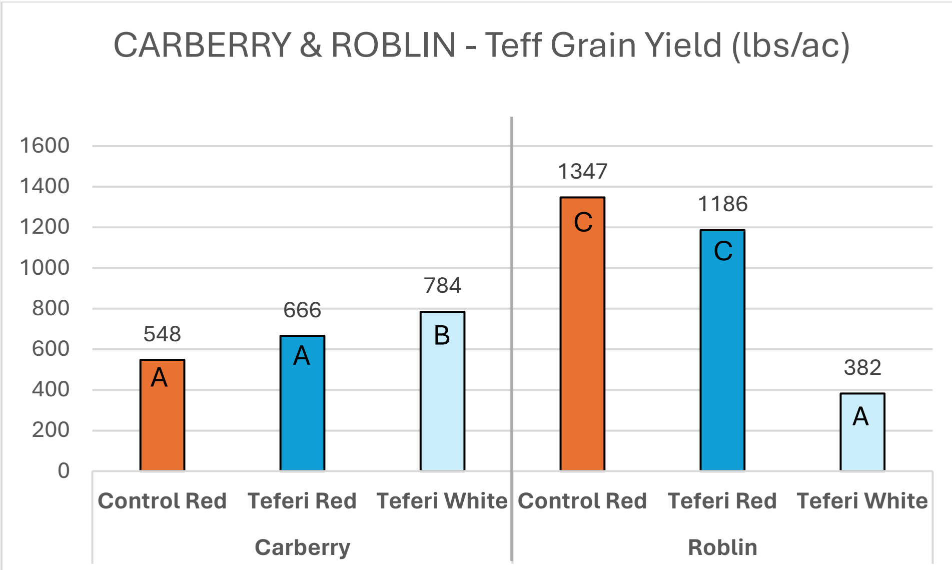

Figure 10: Grain yield (lbs ac^{-1}) by location for teff varieties.

Hay Yield

The varieties were tested for hay yield at Roblin only. Yields for both cuts are shown in Figure 11.

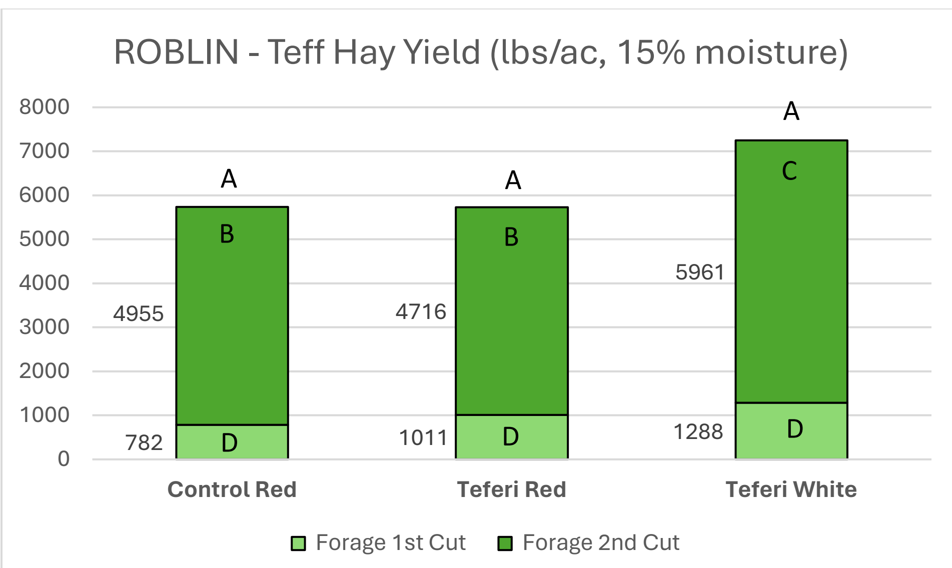

Figure 11: Hay yields (lbs ac^{-1}, 15% moisture) at Roblin for 1st cut and 2nd cut by variety.

Straw Yield

In regions where teff is cultivated for grain, the straw plays an important role in livestock production. For the grain plots, straw was collected after harvest with the plot combine. The results are included in Figure 12.

Note that the teff grain was not harvested in Melita. The higher straw yields at that site compared to the other sites may be due to the weight of unharvested grain on the plants. This dynamic is inferred from observations in Roblin, where much higher forage yields were observed in 2021 (when no grain was harvested) than in 2022 (when plots were combined before measuring straw yield). The difference in straw yield between Melita and the other sites is roughly comparable to the grain yield for the other sites (Figure 10).

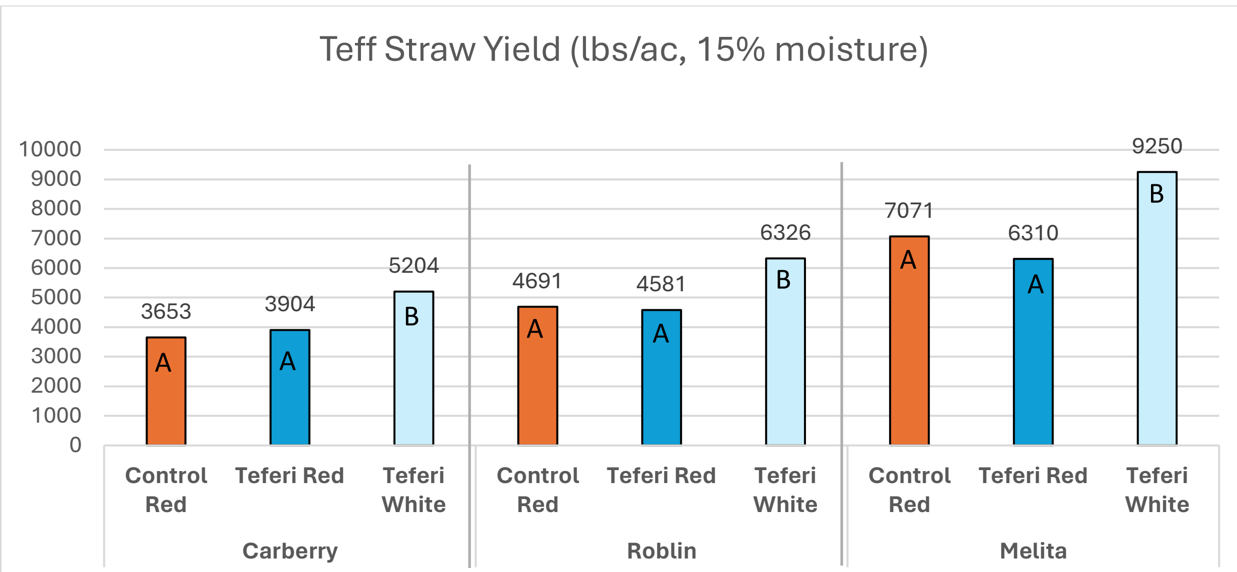

Figure 12: Straw yield for all sites (lbs ac^{-1}, 15% moisture) for teff varieties.

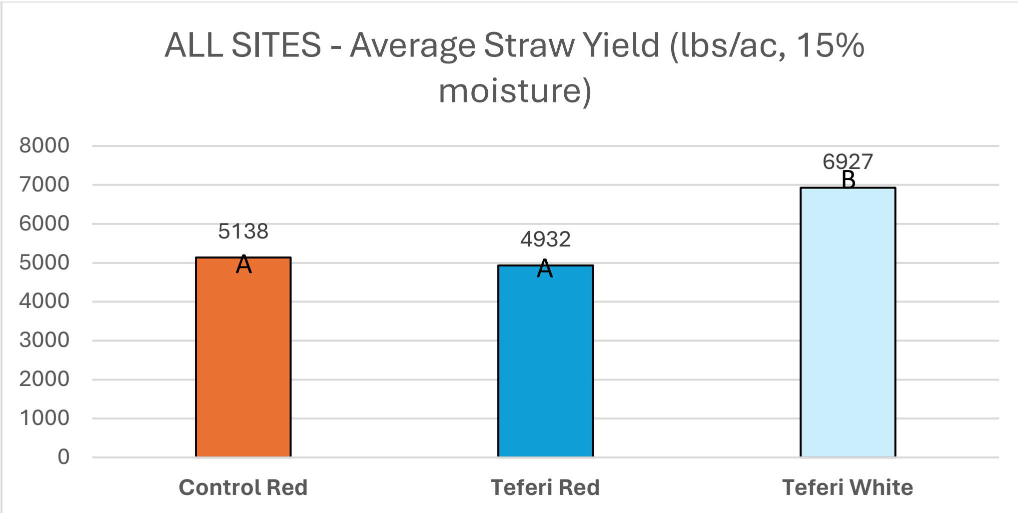

Figure 13: Average straw yield for all sites (lbs ac^{-1}, 15% moisture) for teff varieties.

<u>Plant Height</u>

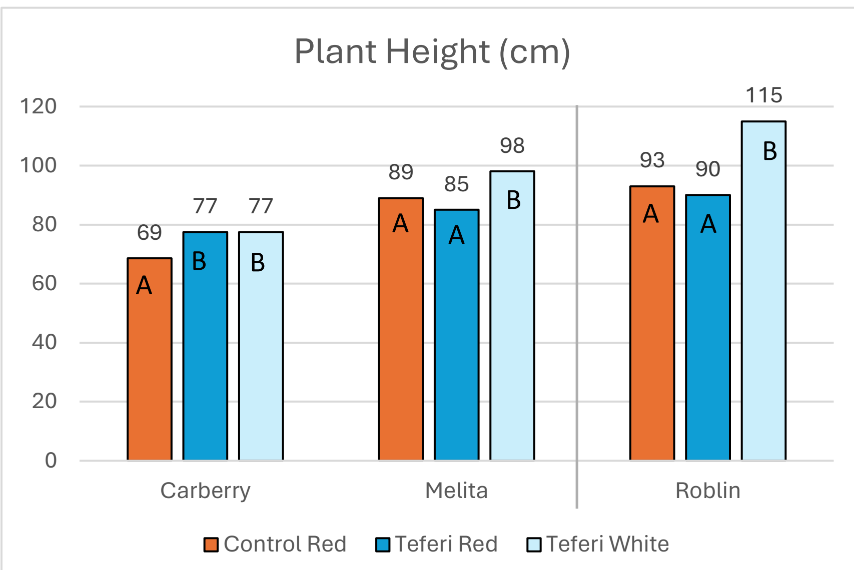

Figure 14 (above): Plant height (cm) by variety for all locations.

Figure 15 (side): Comparison of Teferi White (left) and Teferi Red (right). Note the branching form and thinner stems of Teferi Red.

Lodging

Due to the relatively weak stem strength of teff compared to other common field crops, lodging can be a problem in teff production. The lodging ratings by variety are shown for all sites in Figure 16.

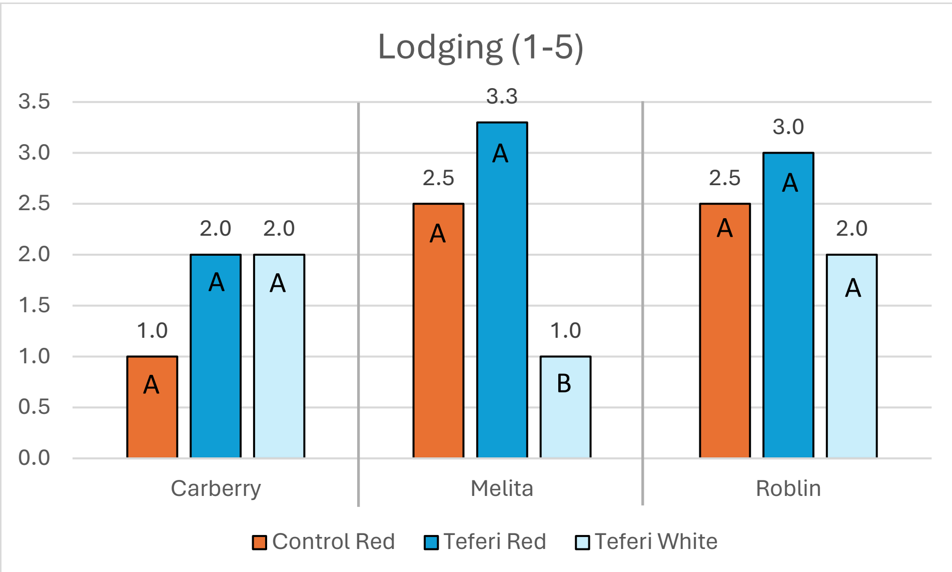

Figure 16: Lodging ratings for teff varieties at all sites (1-5; 1 = upright, 5 = flat)

Discussion

Varietal differences

The Teferi Red variety performed well for grain, straw, and hay production when compared to the Control Red variety. Hay yields (Roblin only) did not differ from the control.

The Teferi White variety yielded significantly more grain at Carberry than the other entries, but significantly less in Roblin. The difference in grain yields is likely connected to the difference in plant height, where Teferi White remained vegetative and actively growing for longer at Roblin. This plant response might be attributed to more favorable heat conditions in Carberry, triggering seed formation.

Although the Teferi White variety yielded statistically more hay for both 1st and 2nd cut (Roblin only), there was no statistical difference in yield for both cuts combined (p-value = 0.066). Based on the observation that seed was only beginning to develop in early October, the variety appears to be a long-season variety that is not well-suited to Manitoba growing conditions.

Crop height was greater for Teferi White than for the control at all sites, but higher for Teferi Red at Carberry only. Lodging differed only at Melita, where Teferi White showed better standability. This is likely due to the low seed production for that variety at that location.

General observations

Teff seeds are 1 mm long, roughly the same size as a poppy seed. The ideal seeding depth is no more than 1/8 of an inch. Although germination usually occurs in 2-3 days, when surface soil conditions are dry, the small roots can easily dry out, resulting in poor establishment. The spring season was dry across all sites, and especially Arborg, which received only 12% of the normal precipitation from May 15 to June 15. Poor establishment resulted in the cancellation of the trial at that location.

The relatively low grain yields at both sites may be attributed to a shortage of early season moisture (Table 16b). The 2023 values are expressed as percent normal as compared to the 30-year average for the location. Note that the amount of precipitation for each site was low (55-58% of the 30-year average), while heat units and growing degree days were higher than normal for all sites.

Table 16b. Precipitation, crop heat units and growing degree days for trial locations (% normal) for April 15 to September 30.

	% Normal		
	MCDC	**PCDF**	**WADO**
Precipitation	58	58	55
Crop Heat Units	112	115	108
Growing Degree Days	120	120	113

The timing of the first cut for the teff is important. At Roblin, the first cut for teff occurred before the plants had headed out (July 14). This resulted in smaller plants that were very smooth and not easily cut by the plot swather. Consequently, plot yields were highly variable, and the dried harvest material was difficult to collect due to its small size. On a field scale, cutting at this stage would likely result in very low yields. Waiting until the plants have headed out is critical to achieving a good cut with a swather and will result in a better capacity to pick up the dried material with a baler.

Grain production

Teff grain production in Manitoba presents a promising opportunity. As the community of migrants from northeast Africa in North America grows, so does the demand for teff flour, which is used to produce *injera*, a staple fermented flatbread. Although milling capacity for teff exists in Manitoba, the grain is currently imported from Ethiopia. Producing teff grain in Manitoba may provide a unique opportunity to tap into pre-existing markets and infrastructure.

The results from teff seeding rate trials at the Diversification Centers suggest that a seeding rate of 5 lbs ac^{-1} is ideal. Lower rates tend to produce lower grain yields, and higher rates increase seeding costs without significantly increasing grain yields.

Nevertheless, more work is needed to identify ideal fertility rates for grain production. Excessive nitrogen applications are to be avoided due to the plant's tendency to lodge, which can result harvest difficulties, yield losses, and spoilage. However, the relatively low yields for the control variety, relative to the yield for other test years, suggests that the crop was limited for nitrogen. Testing in 2024 will explore grain yield response at fertility rates ranging from 60 to 140 lbs N ac^{-1}, with 100 lbs N ac^{-1} assumed to be optimal target. Herbicide tolerance is another area for more study and is slated for 2024 in Roblin.

24.0 Teferi Seeding Rate Evaluation

Project Duration: May – October 2023
Collaborators: PCDF, MCDC, WADO

Objectives:

- To evaluate seeding rates of teff for grain and forage production

Background

Teff *(Eragrostis tef)* is a warm-season annual grass that originates in northeast Africa, where it is grown for grain and forage production. The grain is very small, about the size of a poppy seed, with approximately 1.2 million seeds per pound (2.6 million seeds per kilogram). The flour is used to produce a traditional flatbread called *injera*, which is naturally gluten-free.

As a forage, the crop is notable for its high protein content and palatability, as well as its potential for high yields. The crop is relatively new to Manitoba. For a detailed examination of teff forage nitrogen and irrigation requirements, see this Pacific Northwest Extension Publication.

This report presents the results for teff grain and forage trials grown at Carberry (MCDC), Melita (WADO) and Roblin (PCDF). The trial was also established at Arborg (Prairies East Agricultural Sustainability Initiative) but was terminated due to poor emergence. The trial builds on small-plot trials that were conducted in Roblin in 2021-2022, and in Arborg in 2022.

The current report builds upon tests in 2021 in Roblin and in 2022 at Arborg and Roblin. In brief, total forage yields for those trials did not differ significantly by seeding rate. Grain yields (at Roblin only) did not differ by seeding rate, but yielded significantly less if the teff was cut for hay in mid-season than if the grain was allowed to reach full maturity without being cut. In 2021, barley greenfeed at Roblin yielded less than the combined yield for two cuts of teff. In 2022, barley greenfeed yields were higher than combined teff yields at both Roblin and Arborg.

Figure 17a: Left: 1st cut teff hay. Right: 2nd cut teff hay.

Figure 17b: Left: mature teff plants prior to grain harvest (Oct 6, 2022). Right: close-up of teff seeds (with 10-cent piece for size reference.

Table 17a: 2023 materials and methods for the Teff Seeding Rate trial at Roblin, Carberry, and Melita.

Overview	
Design	RCBD
Entries	10 (5 forage, 5 grain)
Reps	4
Harvest area	8.0 m2
Seeding Rate (lbs ac^{-1})	
Barley	108
Teff	4, 5, 6, 7
Target N	110
Replications	4
Seeding Date	
Carberry	May 23
Melita	May 31
Roblin	May 26
Number of cuts (forage plots only)	
Barley	1
Teff	2
Harvest Dates	
Carberry	Aug 1 (teff 1st cut, barley) Sept 13 (teff 2nd cut; grain)
Melita	Jul 31 (teff 1st cut) Aug 1 (barley) Sept 28 (teff 2nd cut; no grain harvest)
Roblin	Jul 14 (teff 1st cut) Aug 3 (barley) Sept 22 (teff 2nd cut; grain)

Results

Hay Yield

Total hay yields (two cuts) and barley greenfeed yields (one cut) are shown for Carberry (Figure 18a), Melita (Figure 18b) and Roblin (Figure 18c). Yields marked with the same letter do not differ significantly.

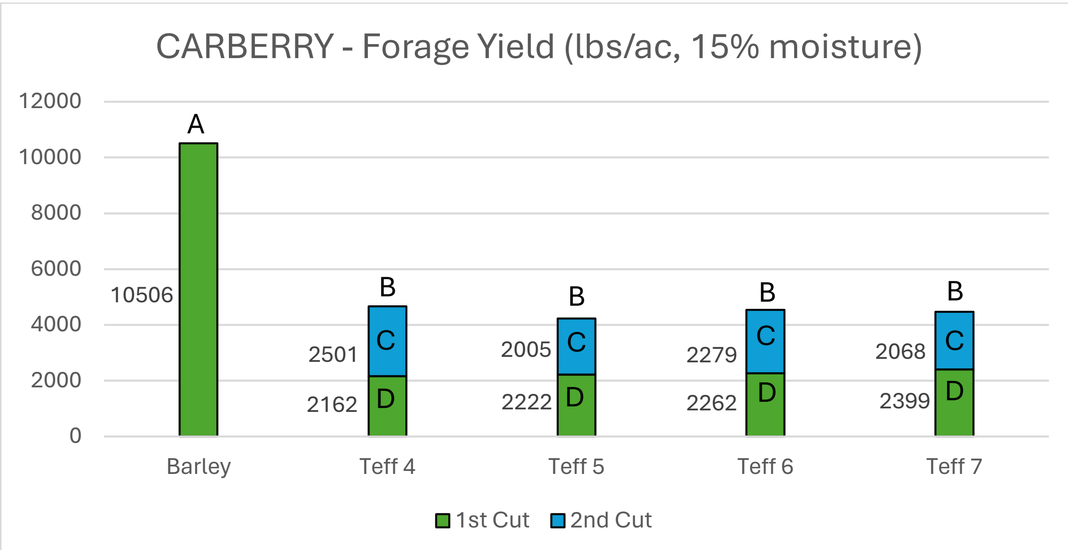

Figure 18a: Carberry teff forage yields (lbs ac^{-1}, 15% moisture) for 1st cut and 2nd cut by seeding rate (lbs ac^{-1}), plus yield for barley greenfeed comparison.

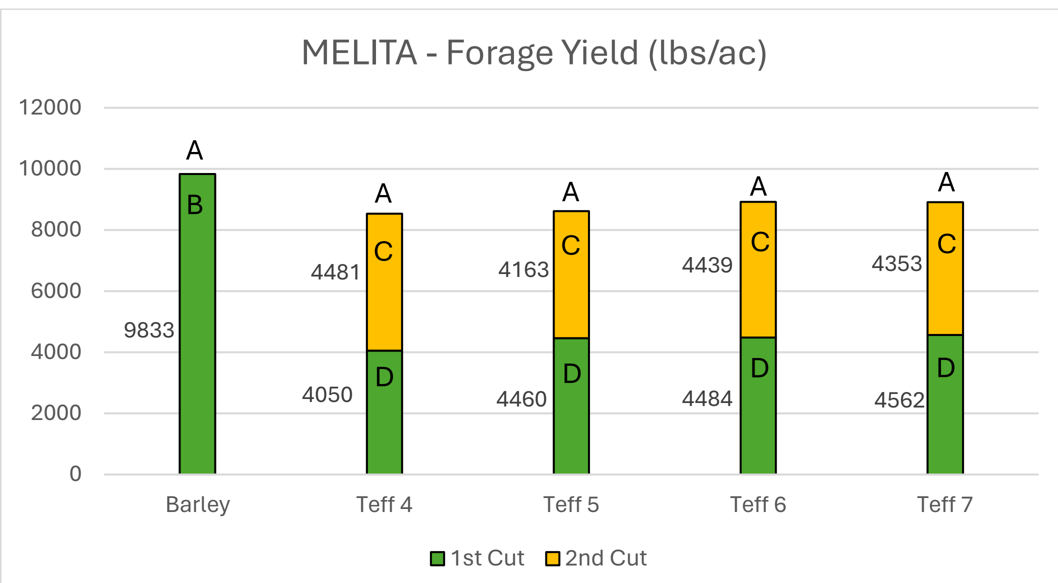

Figure 18b: Melita forage yields (lbs ac^{-1}, 15% moisture) for 1st cut and 2nd cut by seeding rate (lbs ac^{-1}), plus yield for barley greenfeed comparison.

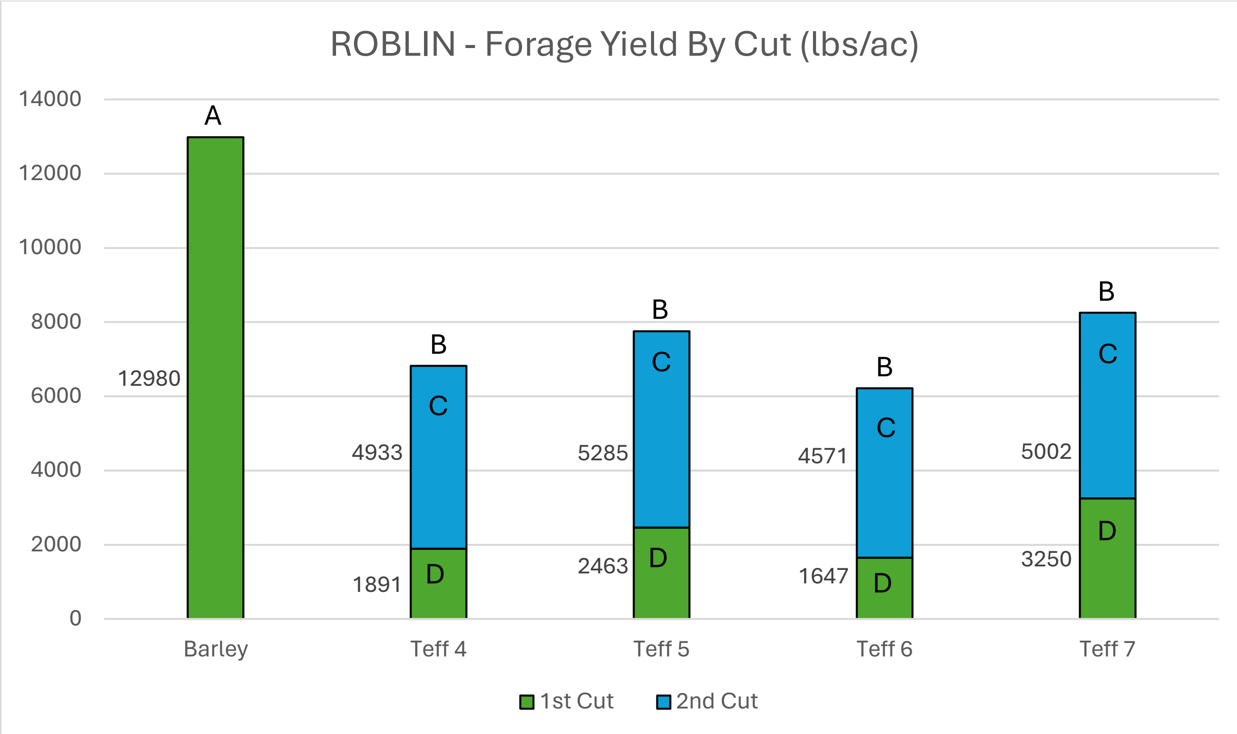

Figure 18c: Roblin forage yields (lbs ac^{-1}, 15% moisture) for 1st cut and 2nd cut by seeding rate (lbs ac^{-1}), plus yield for barley greenfeed comparison.

Barley greenfeed yields were higher than teff yields for all sites. Melita showed the most robust teff yields and the lowest barley yields, such that the total teff yield for all treatments did not differ statistically from the yield for barley. However, total teff yields were significantly lower than barley yields at Carberry and Roblin. A more detailed comparison of the effect of yields on cost of production for hay is provided later in this report.

The timing of the first cut for the teff is important. At Roblin, the first cut for teff occurred before the plants had headed out (July 14). This resulted in smaller plants that were very smooth and not easily cut by the plot swather. Consequently, plot yields were highly variable, and the dried harvest material was difficult to collect due to its small size. On a field scale, attempting to cut at this stage would likely result in very low yields. Waiting until the plants have headed out is critical to achieving a good cut with a swather and will result in a better ability pick up the dried material with a baler.

Straw Yield

In regions where teff is cultivated for grain, the straw plays an important role in livestock production. For the grain plots, straw was collected after harvest with the plot combine. The results are included in Figure 19. Yields marked with the same letter do not differ significantly.

Note that the teff grain was not harvested in Melita. The higher straw yields at that site compared to the other sites may be due to the weight of unharvested grain on the plants. This dynamic is inferred from observations in Roblin, where much higher forage yields were observed in 2021 (when no grain was harvested) than in 2022 (when plots were combined before measuring straw yield). The difference in straw yield between Melita and the other sites is roughly comparable to the grain yield for the other sites (Figure 20).

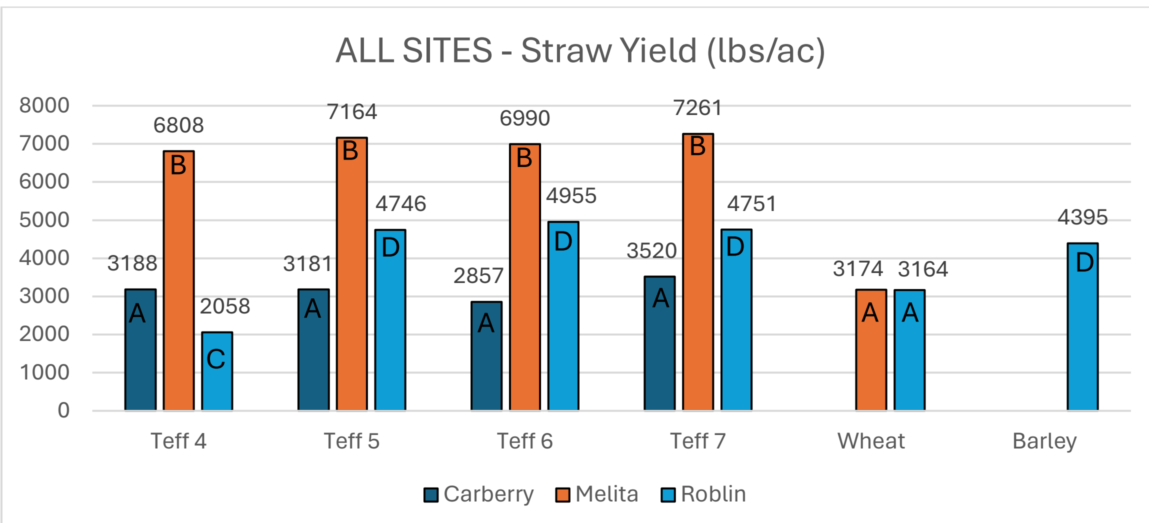

Figure 19: Straw yield for all sites (lbs ac^{-1}, 15% moisture) for teff (by seeding rate, lbs ac^{-1}), plus wheat and barley for comparison.

<u>Feed quality</u>

The results for feed quality at Roblin are shown in Table 17b. Note that the values are for samples collected in 2022. The general feed requirements for cattle are provided for comparison. Mineral content for feed by treatment is shown in Table 17c.

Table 17b: Feed values for teff and barley compared to animal feed requirements*

Entry	% Crude Protein	% TDN
Teff 1st cut	20.9	69.2
Teff 2nd cut	11.4	59.9
Teff straw	8.4	51.6
Barley greenfeed	10.0	58.4
Teff screenings (chaff and light seed)	18.5	66.7
Animal feed requirements**		
Mature cows		
Mid gestation	7	50-53
Late gestation	9	58
Lactating	11-12	60-65
Replacement heifers	8-10	60-65
Breeding bulls	7-8	48-50
Yearling bulls	7-8	55-60

* *Dry matter feed values from Central Testing Laboratory, Winnipeg, 2022*
** *Animal feed requirements developed by Elizabeth Nernberg (Manitoba Agriculture).*

Table 17c: Mineral content for feed by treatment*

Treatment	Mineral									
	(%)					(ppm)				
	Ca	P	Mg	Na	K	Mo	Cu	Zn	Mn	Fe
Teff (1st cut)	0.77	0.22	0.16	0.04	2.25	2.41	9.00	21.36	26.10	138.15
Teff (2nd cut)	0.51	0.23	0.24	0.02	1.62	1.20	4.72	20.05	22.82	110.44
Teff straw	0.34	0.14	0.18	0.04	1.57	-	-	-	-	-
Barley greenfeed	0.33	0.21	0.14	0.26	1.49	1.17	3.60	17.27	23.80	90.55
Teff screenings (chaff and light seed)	0.58	0.44	0.28	0.03	1.00	2.35	7.54	56.51	91.41	956.60

* *Dry matter values from Central Testing Laboratory, Winnipeg, 2022*

Grain Yield

Teff grain was harvested at Carberry and Roblin. Additionally, wheat and barley grain were harvested at Roblin to provide comparative yields for more typical crops. Melita had exceptionally high numbers of grasshoppers, which fed on the seedheads of the maturing teff plants. As a result, grain was not harvested at that location. The grain yields for Carberry and Roblin are shown in Figure 20.

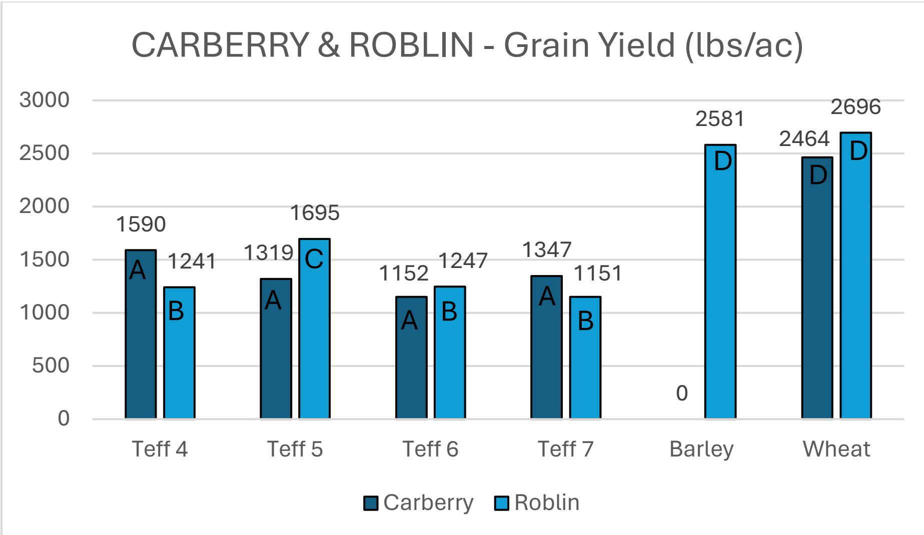

Figure 20: Grain yield (lbs ac^{-1}) by location for teff (by seeding rate, lbs ac^{-1}), plus wheat and barley for comparison.

Discussion

Teff seeds are 1 mm long, roughly the same size as a poppy seed. The ideal seeding depth is no more than 1/8 of an inch. Although germination usually occurs in 2-3 days, when surface soil conditions are dry, the small roots can easily dry out, resulting in poor establishment. The spring season was dry across all sites, and especially Arborg, which received only 12% of the normal precipitation from May 15 to June 15. Poor establishment resulted in the cancellation of the trial at that location.

A summary of climate factors at the growing sites is provided in Table 17d. The 2023 values are expressed as percent normal as compared to the 30-year average for the location. Note that the amount of precipitation for each site was low (55-58% of the 30-year average), while heat units and growing degree days were higher than normal for all sites.

Table 17d. Precipitation, crop heat units and growing degree days for trial locations (% normal) for April 15 to September 30.

	% Normal		
	MCDC	**PCDF**	**WADO**
Precipitation	58	58	55
Crop Heat Units	112	115	108
Growing Degree Days	120	120	113

Hay cost of production

An estimate of the cost of production is provided in Table 17e. The cost includes the seed and the cost of cutting the hay. Other factors, such as land rental and baling costs, are not included.

Table 17e: Cost of production by treatment for teff and barley by seeding rate and cut

Treatment	Seeding cost ($ lbs^{-1})	Seeding rate (lbs ac^{-1})	Cutting cost ($ ac^{-1})*	Seeding plus cutting cost ($ ac^{-1})
Barley (single cut)	0.29	108	20.00	51.50
Teff (Two cuts)	5.39	4	20.00	61.56
		5		66.95
		6		72.34
		7		77.73

**Based on an average of costs for disc bine and sickle mower cuts from the Manitoba Agriculture Cost of Production for Farm Machinery.*

The relative cost of production (Figure 21a) compares the cost by treatment (from Table 17e) to produce one unit of teff hay, protein, and total digestible nutrients (TDN), relative to the cost for barley greenfeed. The values are averaged for all sites. A more detailed breakdown of relative costs for all sites is presented in Figure 21b.

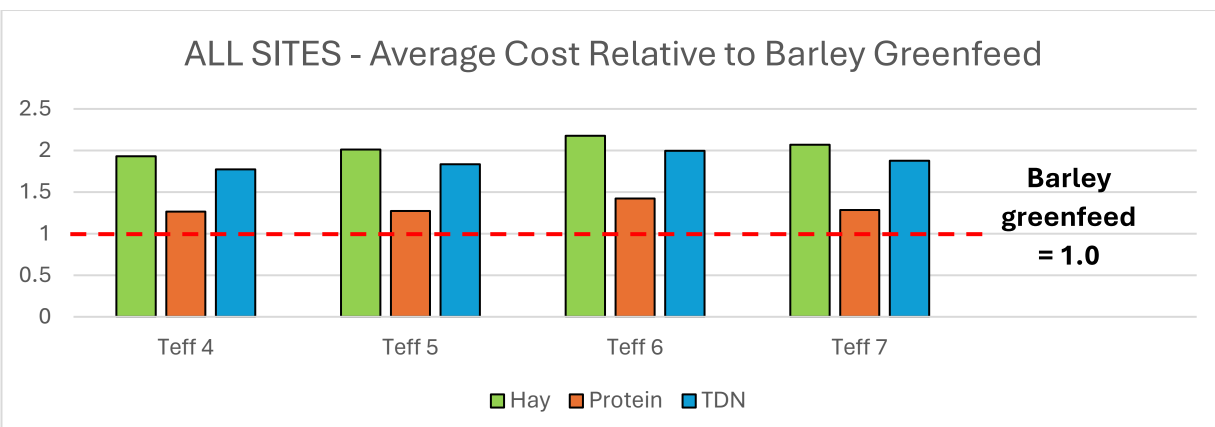

Figure 21a: Average cost of production for all sites, relative to barley greenfeed.

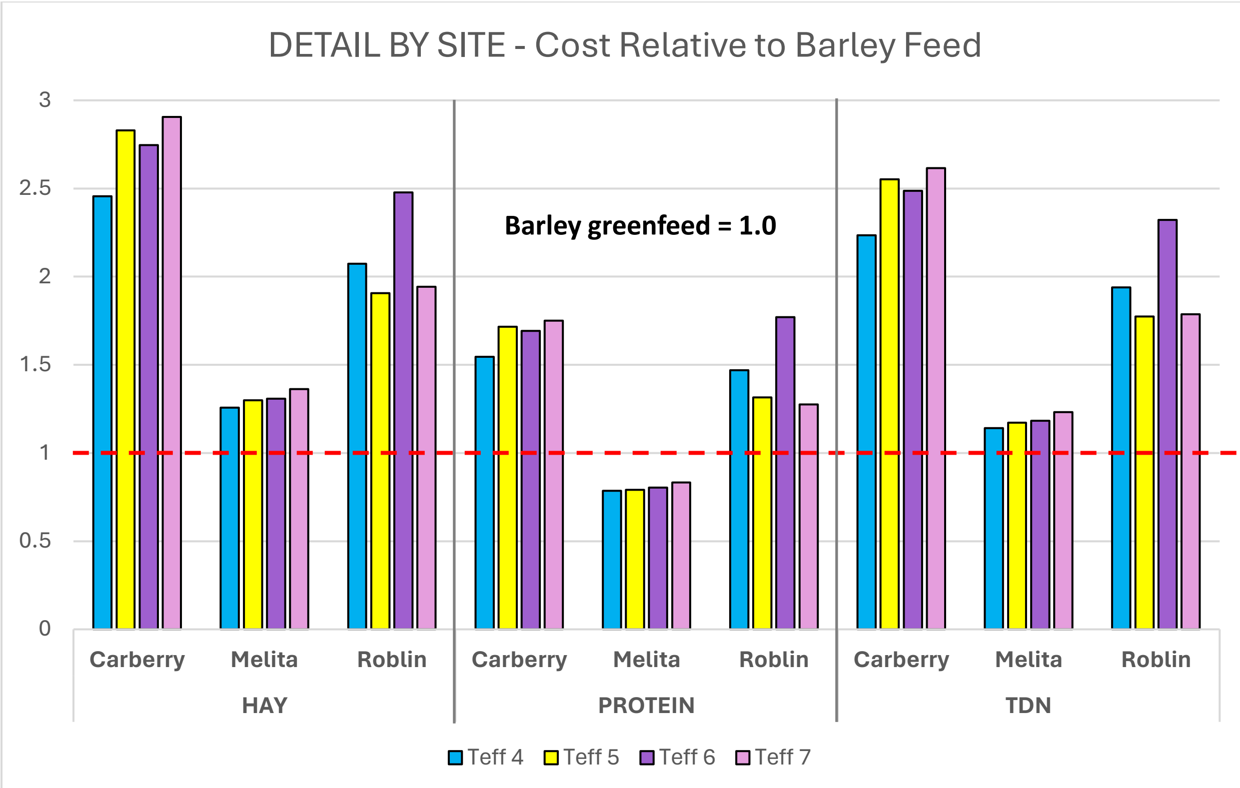

Figure 21b: Detailed cost of production by site, relative to barley greenfeed.

The relative cost of production presented here is directly influenced by the yield of barley greenfeed. In 2021, when dry conditions resulted in low barley yields at Roblin, the relative cost of production for teff was favorable (about half the cost of barley greenfeed for all categories). However, under the more favorable conditions for barley at Roblin in 2022, the relative cost for producing teff increased considerably.

In 2023, barley production was high at Carberry and Roblin, with relatively low yields for teff. As a result, the relative cost of production is high for teff at those sites. At Melita, where barley yields were lower and teff yields were higher, the relative cost of production is more favorable. Notably, the cost of protein at Melita was lower for teff than for barley greenfeed. This highlights the strategic role that teff may play for some producers as a source of high-quality forage. Further, although barley greenfeed provided more protein overall than some treatments, because of the lower concentration in the forage, animals would have to consume more forage to obtain the same amount of protein.

Grain production

Teff grain production in Manitoba presents a promising opportunity. As the community of migrants from Northeast Africa grows in North America, so does the demand for teff flour, which is used to produce *injera*, a staple fermented flatbread. Although milling capacity for teff exists in Manitoba, the grain is currently imported from Ethiopia. Producing teff grain in Manitoba may provide a unique opportunity to tap into pre-existing markets and infrastructure.

The screenings from teff provide a promising additional source of animal nutrition. Due to the very small size of the seed, appropriate combine harvester settings may result in the collection of moderate amounts of chaff. This is primarily comprised of material from the seed head, as well as lightweight seed. With more than 18% protein and good energy values (Table 17b), the chaff may be advantageous to feed this material to livestock in bulk or pelletized form. The very high values for mineral content especially zinc, manganese, and iron, likely result from the presence of teff seed, which is higher in minerals than the forage material alone (Table 17c).

The results from this trial and previous trials suggest that a seeding rate of 5 lbs ac^{-1} is ideal. Lower rates tend to produce lower grain yields, and higher rates increase seeding costs without significantly increasing grain yields.

Nevertheless, more work is needed to identify ideal fertility rates for grain production. Excessive nitrogen applications are to be avoided due to the plant's tendency to lodge, which can result harvest difficulties, yield losses, and spoilage. Testing in 2024 will explore grain yield response at fertility rates ranging from 60 to 140 lbs N ac^{-1}, with 100 lbs N ac^{-1} assumed to be optimal target.

Herbicide tolerance is another area for more study. Additional testing for herbicide is slated for 2024 in Roblin.

25.0 Prairie-Wide Corn Intercropping Project

Project Duration: 2021 – 2023

Collaborators: Dr. Yvonne Lawley (Co-Lead) and Dr. Emma McGeough (Co-Lead) (University of Manitoba), Manitoba Diversification Centres, other prairie wide locations.

Objectives

This experiment compliments four other project objectives listed below (bold pertains to project at WADO).

- Objective 1: Identify optimal high-protein forage species and nitrogen application rate for intercropping of corn for potential late fall/early winter grazing of beef cattle.

- **Objective 2: Seeding strategies to optimize corn intercropping with high protein forage for potential late fall/early winter grazing of beef cattle.**

- Objective 3: Large Pasture Grazing Study: Evaluate animal performance, feed intake, rumen microbial efficiency and grazing behavior of backgrounded cattle or replacement heifers grazed on corn-based pastures in late fall/early winter.

- Objective 4: Economic analysis of intercropping corn for beef cattle grazing.

Data from this experiment will be utilized to inform treatments selected for the grazing trial in Objective 3 in 2024 and in the economic analysis for Objective 4.

Background

Extending the grazing season by maintaining beef cattle on pasture in late fall/winter has been adopted by many Prairie producers as it significantly reduces labor and feed costs compared to feeding cattle in confinement. As cattle typically graze on grass/legume forages in the summer that sharply decline in quality in fall/winter, a high-quality stockpiled forage for extended grazing is crucial to maintaining animal productivity. Corn provides a windbreak and abundant energy that helps cows through cold winter months, however, its limited crude protein concentration restricts animal rate of liveweight gain and energetic efficiency, therefore limiting the suitability of this winter grazing system for both cows and growing cattle with high nutrient demands. Partnering with the beef and forage industry, and using a range of agronomic, animal, and economic analyses, our multidisciplinary team of scientists will identify the potential feasibility for intercropping corn with high protein forages to increase the nutritive value of these mixed stands for beef cattle grazing in late fall/early winter under western Canadian winter conditions. Investigation of agronomic management practices for intercropping corn will provide flexible options to increase adoption across the Prairies. Due to the growing interest in intercropping, crop-livestock integration, and regenerative agriculture, these new grazing strategies will enhance the long-term resiliency, adaptability, competitiveness, and profitability of Canadian beef production to enhance food security.

This project is in the first stages of research. In 2022 and 2023 at all sites, the plot trials were replicated to obtain adequate data to interpret and use for integrating the following phases of this project. WADO only be participated in the small plot trial phase of this project in Objective 2.

Methods and Materials

Plot trials for this experiment were performed in Melita, Glenlea, and Roblin Manitoba, and other places across Western Canada. The trial design was a randomized complete block design with 5 treatments which were replicated four times. The treatments included four different cover crops (Italian ryegrass, crimson clover, forage radish, and hairy vetch), and one control treatment which had no cover crop. The corn variety used was DKC31-85RIB; corn in the cover crop treatments was planted at 60-inch row spacing, and the control treatment had 30-inch row spacing. The 60-inch spaced corn was planted at a population of 18,000 seeds ac^{-1} (with the wide rows this is equivalent to 36,000 seeds ac^{-1} when planting all rows on 30-inch spacing), while the 30-inch spaced corn was planted at a population of 36,000 seeds ac^{-1}. In Melita, these plots were established near SE34-3-27 W1 in Waskada Loam soil on oat stubble. The corn was planted on May 16th using a Wintersteiger Dynamic Disc planter equipped with EasyPlant software at a depth of 2-inches and seed spacing of 5.8-inches. Granular fertilizer was banded and incorporated into the soil before planting the corn. A total of 100-40-29-17-1 actual lbs ac^{-1} (N-P-K-S-Zn-Cu-B) was applied to meet the fertilizer requirements for the corn. The cover crops were seeded on June 13th. Due to emergence issues, the clover and vetch treatments were reseeded on July 5th. Before the cover crops were planted, the plots were sprayed with

Roundup Transorb (0.67 L ac^{-1}) to kill any unwanted weeds on May 30th, then more Round Up was used for clean up on June 16th. The data collected included plant counts for both corn and intercrops, biomass samples for corn and intercrops (once in September and once in October), corn grain yield, feed test analysis on samples, and weather data from the growing season.

Results

The 2023 season was a challenge with drought, gophers, grasshoppers, and cattle damage. It was difficult to establish covered due to the drought conditions in June as well as gophers despite applying poison. Additionally, grasshoppers moved into finish the covers off for good, followed by a browsing of cattle over a single event, despite spraying for grasshoppers and electric fencing for cattle. Final report will be made available by Dr. Emma McGeough and Dr. Yvonne Lawley at the University of Manitoba in 2024/25, the final reporting year.

Figure 22a & 22b. Left: the WADO staff seeding the cover crops with garden seeders after the area was rototilled. Below: the difference in radish growth with and without severe grasshopper pressure.

Year 2022: Without Grasshoppers Pressure in Radish   *Year 2023:* Impact of Grasshoppers Pressure in Radish

26.0 Winter Intercrops

Project Duration: 2023
Collaborators: Western Ag & Professional Agronomy, Ken Greer

Objectives:

- To determine the adaptability of these fall seeded winter crops in southwest Manitoba growing conditions in terms of winter survivability, agronomic potential.
- To assess intercrop compatibility of fall seeded winter pea or lentil for agronomic potential
- To compare fall seeded winter crops to dormant (ultra early spring) seeded winter crops

Background

Farmers have utilized fall-seeded crops such as winter wheat or fall rye on their operations for many years and reasons. Some of those reasons could be adding diversity to their crop rotation, improving weed control, or spreading out their harvest timing between different fields. While winter wheat and fall rye are the most common fall-seeded crops grown, this project tries to determine if other types of fall-seeded crops would be suitable for farmers to implement into their operation. This project is evaluating the performance of winter peas, lentils, oats, barley, and camelina as fall seeded crops in Southwest Manitoba's agroclimate.

Methods and Materials

This winter crop trial was established at a location near Melita, Manitoba in 2023 (NW10-4-26 W1) in Stanton Loamy Sand. The plots were seeded using a 6-row dual knife Seedhawk air seeder into canola stubble at a depth of 0.5-inches. Plots were seeded on September 22nd into excellent moisture. The site was burned off chemically beforehand using Round Up Transorb (0.67 L ac^{-1}) and Koril (0.2 L ac^{-1}) on September 16th; the day after seeding, September 23rd, the plot area was burned off again, this time using Round Up Transorb (0.67 L ac^{-1}) and Liberty (0.5 L ac^{-1}) for extra control of volunteer canola. Target seeding rate was 225 plants per meter squared (ppms) for the cereals and peas, 500 ppms for camelina and lentils. The seeding rates for all crops involved were calculated using the seed germination rates, test weights, and accounted for 20% mortality. Varieties of crops included 'Emerson' winter wheat, 'Endeavor' winter barley, 'R30(21) line A x 302 030C001' winter oat, 'Goldenwood' winter pea, and 'Super

Cool' winter lentil obtained from Ken Greer at Western Ag & Professional Agronomy and a camelina variety 'Y10-22-W001' from Yield10 Biosciences. At the time of seeding, the peas and lentils were inoculated (Nodulator, BASF), and granular fertilizer was side-banded at 16-30-21-13-1 (N-P-K-S-Zn actual lbs ac^{-1}) to all plots. Agrotain treated urea was applied to the plots on May 11th as per crop type and requirements. Hand weeding of the plots was required; due to limited herbicide options for some of these crop types.

All plots that made it to maturity were harvested on August 18th. The only plots that survived through winter months included the winter wheat and camelina plots. Data collected throughout the season includes the following: emergence dates and counts (spring and fall), head dates (cereals), flower date (peas and lentils), maturity date, weed severity percentage, harvest yield and moisture, and grain quality indicators including thousand kernel weight and protein content.

Results

Unfortunately, most of the plots were overtaken by weeds and had to be destroyed. The heavy weed pressure was exacerbated by poor spring emergence of some crops, making the plots virtually impossible to save. The plots that were able to be harvested included the camelina and winter wheat plots. The camelina yield ranged from 720 to 969Kg ha^{-1} over the three replicates in the trial, which is about half of the average yield for normal camelina grown in the prairies.

Pictures

Figure 24: shows an overview of the winter camelina site. It is easy to spot the heavy weed pressure that was present.

27.0 Corn Soybean Companion Trial

Duration: 2023 – On-going
Collaborators: Covers & Co. (Joe Gardiner)

Background

Grazing or feeding silage corn can offer exceptional feed quantity and quality in an annual cropping situation which can provide high energy feed to pregnant cows late into fall and winter. Soybean interseeded into corn could offer improved forage quality to corn silage systems and also offer beneficial grazing days post grain harvest. Once corn has been harvested for grain the remaining stover doesn't provide much for nutritional quality as a forage. Including a legume or alternative cover crop can provide livestock with improved forage quality with higher protein contributions per acre compared to stand alone corn stover. Including a cover such as fall rye, Italian rye grass, clovers, hairy vetch or perhaps a soybean could offer better grazing potential. Several farmers in the region have tried glyphosate tolerant soybeans as a companion crop with grazing corn and have had neutral to beneficial results. In addition, the glyphosate tolerant crop can offer additional weed control benefits in parallel with glyphosate tolerant corn. Soybean as a companion in corn could also alter the grain and forage production quantity in corn though direct competition with corn for resources like fertilizer, water and even light. Adding a companion crop like soybean could reduce or improve the potential for overall yield over the entire field but this is not well understood locally. In addition, late maturing soybean could lead to problems with nitrate poisoning in the livestock if not properly managed in corn companion systems. These concepts must be investigated since farms are starting to use this as an alternative production system in corn.

A late maturing (from South Carolina) glyphosate tolerant soybean variety has been a popular choice by farmers (retail sold by Joe Gardiner from Covers and Co.) .The late maturing nature of the variety could potentially extend the number of days of active growth in the field of corn beyond the full maturity of corn, whereas an early variety would have matured similar to corn resulting in no further growing days beyond the maturity of corn. The idea is to have something green and growing later than the corn itself to increase grazing quality and palatability. Joe Gardiner at Covers and Co. recommends seeding soybean at a rate of 15-20 lbs ac^{-1}. Soybean also fixes nitrogen so there could be an increase in nitrogen economy within the field of the intercrop compared to corn monocrop fields.

Farmers would prefer to do an “all-in-one" pass with corn and soybeans, or potentially two passes at one time, however we do not know what timing or row orientation is most suitable. A trial has been designed to investigate feed/grain quality/quantity and timing of soy and row orientation of corn. Wide row corn planted on 60-inch rows may offer better conditions for soybean as a companion crop to flourish compared to 30-inch rows. This concept will be compared in addition to the practice of planting soybean at the same time or later as a second factor.

Results and Discussion

In 2023 at the Melita site, the project was hit severely with grasshoppers and gophers. Despite efforts to reseed the forage soybeans, spray and bait the grasshoppers, and bait and shoot the gophers at the site, ultimately the trial was not harvestable. Unfortunately, 2023 was the last year for field trials of this project in Melita.

Pictures

Figure 25a, 25b, & 25c: Left: seeding soybeans between the 30-inch corn rows. Top right: corn in 30-inch rows with soybeans growing between the rows. Bottom right: corn growing in 60-inch rows with two rows of soybeans growing in between.

28.0 Evaluation of Mustard Meal as a Biofumigant

Duration: 2023-Ongoing
Collaborators: WADO, McKenzie Friesen

Objectives

- To determine how mustard meal affects root rot and damping off incidence in field peas
- To evaluate other effects mustard meal has on peas growing in a field where Aphanomyces Root Rot has been confirmed
- To determine if the effects of biofumigation by mustard meal could provide an alternative to chemical fungicide seed treatments in field peas

Background

Aphanomyces root rot is a soil-borne disease that causes infection in field peas. The symptoms of this disease in peas include yellowing and stunted plants, poor root growth, little to no nodulation, and browning or caramelization of the roots (Alberta Seed Guide, 2021). Aphanomyces is becoming more of an issue in Manitoba. In 2017, only 47% of surveyed fields were infected with Aphanomyces root rot; now in 2023, 98% of the surveyed fields were found to be infected (Manitoba Pulse, 2023). What's alarming is that once Aphanomyces is in your soil, it is virtually impossible to get rid of. Currently, the best management practices (BMPs) for growing peas in a confirmed Aphanomyces root rot field include a 8-year rotation between susceptible crops (i.e., field peas, lentils), diversifying the crop rotation, and implementing biosecurity measures when moving between fields to reduce the spread of the disease to uninfected fields. Right now, there are no pea varieties available that have any resistance to Aphanomyces.. Additionally, there are no available foliar fungicides that can be used to control or prevent the disease from progressing once symptoms are noticed in a field.

There is research into more cultural ways of dealing with Aphanomyces root rot, one being biofumigation with the use of mustard plants. Biofumigation is a method of fumigation for pest control, where the fumigant is made from decomposing plant material (FAO, 2023). The plants, usually from the Brassica family (i.e., mustard, broccoli), are grown in place of a marketable crop, then are cut down and cultivated into the soil where the plant tissues break down into compounds that can kill the Aphanomyces pathogen. Mustard and other plants of the Brassica family produce compounds called glucosinolates; when these compounds come in contact with water and an enzyme that is found in plant cells, isothiocyanates are produced (Growing Mustard for Biofumigation, 2015). The isothiocyanate is the compound responsible for controlling the pathogen; it is also responsible for the bitter, hot, or spicy taste of the plants in the Brassica family (Growing Mustard for Biofumigation, 2015). For mustard, the isothiocyanate create is called Allyl isothiocyanate, or AITC (Growing Mustard for Biofumigation, 2015).

This project uses the seed of the mustard plant instead of the entire plant being incorporated into the soil. This way, the producer does not need to take their land out of production for a year, and the fumigation product can be applied using their normal seeding equipment. The use of mustard seed as a biofumigant may also offer the benefit of using less synthetic nitrogen fertilizer that is needed for starter nitrogen for the peas, therefore, decreasing the cost of production (COP), this because it comes with some nutrient value.

The logistics of this trial will be further explained in the following section.

Methods and Materials

Evidently, this trial needed to take place in a field where the Aphanomyces root rot pathogen is present. The trial was established in a field near SE11-7-27 W1, which is known to have the Aphanomyces pathogen in the soil. Before seeding, the biofumigant, or mustard seed had to be prepared in the following way:

Two versions of the biofumigant were made, an active type and a non-active type. The non-active biofumigant was needed in case the amount of seed meal used was going to cause a nutrient response in the pea plants. Therefore, the same amount of seed meal is applied to each plot as a mixture of active and non-active biofumigant to ensure the nutrient levels were not favorable to one treatment over another. The inactive version of mustard meal was baked to an internal temperature of 200°C to ensure the seeds were dead, therefore, inactivating the volatile glucosinolates. The seeds were baked at 400°F for 30 minutes to achieve this. Next, the seeds were run through a hammer mill twice to increase the surface area of the seed pieces and decrease the chances of any seeds germinating when placed in the soil. This will help ensure maximum release of glucosinolates when the seed meal comes in contact with the soil moisture. This milling process was performed on both the active and inactive versions of the seed meal.

The trial was laid out in a RCBD with three replicates. There were 5 treatments (3 rates, 2 checks) that included:

1. 50 lbs ac^{-1} active meal : 100 lbs ac^{-1} non-active meal
2. 100 lbs ac^{-1} active meal : 50 lbs ac^{-1} non-active meal
3. 150 lbs ac^{-1} active meal : 0 lbs ac^{-1} non-active meal
4. 0 lbs ac^{-1} active meal : 150 lbs ac^{-1} non-active meal (Check 1)
5. 0 lbs ac^{-1} meal (Check 2)

All treatments, except Treatment 5, will include the same amount of mustard meal with different ratios of active and inactive meal to eliminate nutrient differences and responses between the plots. Within 150 lbs ac^{-1} of mustard meal could have up to 5 lbs ac^{-1} nitrogen-use to the peas – why this practice could reduce COP, as mentioned above. Treatment 5 is included to determine if there is a significant nutrient value of the mustard meal to the growing pea crop.

The trial was seeded on May 25th into wheat stubble with good moisture. The peas, inoculant, and mustard meal were placed at a depth of 1.25 inches in the same seed furrow. To avoid making two passes over the soil with the seeder, it was decided to place the mustard meal down the same run as the peas. Fertility was side-banded at 10-35-25-15-1 actual lbs ac^{-1} of N-P-K-S-Zn. Chemical burn off was applied as Round Up Transorb (0.67 L ac^{-1}) before seeding and Authority (85 mL ac^{-1}) and Rival (0.67 L ac^{-1}) after seeding on the same day. In-crop herbicide was applied as Arrow (120 mL ac^{-1}) with X-Act (0.5% v./v.) tanked mixed with Pounce insecticide. All plots were desiccated with Reglone (0.65 L ac^{-1}) with LI700 (0.25% v./v.), but the trial was not harvested. The following data was to be collected throughout the growing season: soil temperature, plant counts, nodule counts, plant heights, pod counts, lodging ratings, root rot presence, leaf disease presence, flowering and maturity dates, seed quality data, and plot yield. The failure of the trial will be explained in more detail in the following section.

Results and Discussion

There are a few circumstances that may have led to the failure of this experiment. The most obvious condition for the failure was the seed burn of the peas caused by the mustard seed meal. The peas subjected to the lower rates of mustard meal emerged, even though they were slow and thin. The peas that were in treatments with higher rates barely emerged at all. The rates that were chosen were too high for the peas to grow though. The study that was used as the base for this research project had applied the mustard meal throughout the soil instead of in a seed furrow (Sarhan, et al. 2020). The increase in concentration of the volatile AITC compounds caused the seed burn of the peas without question. A less severe issue that also became apparent was the volunteer mustard plants growing through the trial. While they did not cause significant problems and can be treated with in-crop herbicides if needed, it is an advantage for future trials to see that they were present. The meal was not milled small enough and/or the inactive version of the meal was not deactivated properly. One last hurdle the trial threw was how tedious seeding became because of the volume of material that was moving through the seed run at one time. Seeding was slow with some problems with the seeder plugging with peas and mustard meal packed together in the seed runs.

While unfortunate that there were no results this year, the advantage is knowing what improvements to make going forward into the next growing season. The goal is to find out whether this practice would be something sustainable, achievable, and affordable for producers dealing with Aphanomyces root rot.

Pictures

Figures 26a & 26b: Left: high rate of mustard meal with the peas as it comes out of the seeder. Right: the poor emergence of the peas is easily observed.

References

Yaremko, S. (2021) *How to prevent, detect and manage Aphanomyces - Grainews*. Available at: https://www.grainews.ca/columns/wheat-chaff/how-to-prevent-detect-and-manage-aphanomyces/

Schmidt, L. (2023) *Aphanomyces: We're not a fan - manitoba pulse & soybean growers*. Available at: https://www.manitobapulse.ca/wp-content/uploads/2023/05/Aphanomyces-Were-Not-a-Fan-article-Spring-2023.pdf

Rudolph, R. (2023) *What is biofumigation and does it have potential to be used in Pacific Northwest Red Raspberry Production Systems?: Whatcom Ag Monthly: Washington State University*, *Whatcom Ag Monthly*. Available at: https://extension.wsu.edu/wam/what-is-biofumigation-and-does-it-have-potential-to-be-used-in-pacific-northwest-red-raspberry-production-systems/

FAO (2023) *Biofumigation*, *Plant Production and Protection Division: Biofumigation*. Available at: https://www.fao.org/agriculture/crops/thematic-sitemap/theme/climatechange0/methyl-bromide/alt/biofum/en/

Agriculture, Aquaculture, and Fisheries. "Growing Mustard for Biofumigation." *Government of New Brunswick*, 2015, https://www2.gnb.ca/content/dam/gnb/Departments/10/pdf/Agriculture/GrowingMustardBiofumigation.pdf.

Fatima, Samiya. "Aphanomyces Is an Emerging Threat to Peas and Lentils." *Alberta Seed Guide*, 19 Jan. 2021, www.seed.ab.ca/aphanomyces-is-an-emerging-threat-to-peas-and-lentils/.

Sarhan, Et al. "Influence of Biofumigation with Mustard or Canola Seed Meal in Controlling Soil Borne Pathogenic Fungi of Chickpea." *Egyptian Journal of Agricultural Research*, 2020, https://ejar.journals.ekb.eg/article_101417_942a2da510f67c7fa5d7bbd156d35068.pdf.

29.0 Pea-Canola Intercrop Project

Project Duration: 2023
Collaborators: WADO (Westman Agricultural Diversification Organization), SERF (South East Research Farm), University of Alberta (Linda Gorim), CNH Industrial (David Larsen)

Objectives

- Compare seeding rates of forage peas in a peaola system and its effect on crop performance
- To assess peaola in the presence of different pea types (maple, field, and forage)
- Address the performance of a custom-built double shoot plot drill made by CNH Industrial as a test for future trials.

Background

Pea-canola (peaola) is the most common intercrop combination, but the seed size of these two crops are very different, making the determination of seeding depth difficult, resulting in non-uniform germination, consequently affecting yield.

When intercropping peas with canola, the producer is able to use less fertilizer but get a higher return due to the price of both the canola and the peas when marketing their grain. Intercropping canola with pea also gives advantages such as reduced disease incidence and severity, increased standability (reduced lodging), greater competition against weeds and insects, added diversity to the field environment, and increased grain yields compared to the monocrops of both crops. Reducing lodging of peas is a significant advantage to producers as a lodged crop can be very difficult to harvest whether combining for grain or cutting for silage or green feed. In this project, different seeding rates are evaluated between all types of peas and the canola to determine which rate delivers the optimum plant competition and yield, and reduced lodging for ease of harvesting.

The three types of peas evaluated in this project include field peas, maple peas, and forage peas. All types of peas are nitrogen-fixing legumes and therefore, will come with all the related benefits. They also have the same agronomic characteristics when grown in a field situation. While being similar, they all have their own place in agriculture. Field peas are probably what most producers are most familiar with. There are yellow and green varieties of field peas, both usually harvested as a dry seed which is then used in different food products for human consumption, as well as for livestock feed. Sometimes field peas are also used to produce silage for livestock feed, but they are generally grown for grain yield.

Maple peas are referred to as “high tannin” peas and they are easily distinguished from field and forage peas because of their purple flower color and their brown, dimpled seed. The original niche end-use of maple peas was feed for racing pigeons in Europe (farming for Tomorrow, 2021). Now, China is a large customer interested in maple peas for the use in a sprouted food product for human consumption (Farming for Tomorrow, 2021). In addition to bird and human food, maples peas are also used in the livestock industry, being made into processed feeds, or being cut for green feed or silage. In a study performed in northern Saskatchewan, maples peas were shown to have great yields (both grain and biomass) and a good LER (Land Equivalency Ratio) when intercropped with canola; though this report did not include forage peas in the analysis (AgriARM, 2019). In the same article, the peas that were grown in an intercrop had reduced lodging than when grown in a monocrop, no matter the type of pea (AgriARM, 2019). You can see more details of this report at the link below. Though there are not many varieties of maple pea to pick from in comparison to field peas, the market price of these niche peas can be very appealing to producers (Farming for Tomorrow, 2021).

https://conservationlearningcentre.com/wp-content/uploads/2020/11/Peola_Factsheet.pdf

Lastly, the forage pea or ‘silage pea’ is the most desirable type for producing silage and green feed for livestock because of their smaller seed size and greater biomass yield (Saskatchewan

Pulse Growers, 2023). While forage peas have many similar agronomic characteristics to field peas, the plant breeding preferences are different. Small seed size, increased plant biomass, and higher lodging resistance are more sought-after characteristics for forage peas rather than high grain yield (Saskatchewan Pulse Growers, 2023). Forage peas are grown mostly in the beef and dairy industries because of their high digestibility, high biomass, protein, and relative feed value. Resistance to lodging is important for forage peas since they produce so much biomass; when growing in an intercrop, they can bring the other crop down with them, increasing the difficulty of harvest. Though there are still questions to answer about the correct mixtures, seeding rates, seeding depths, and harvest timing, adding forage peas to an intercrop can improve the quality of the forage produced and increase protein in greed feed and silage crops (Saskatchewan Pulse Growers, 2023).

Training

Before the 2023 seeding season begun, WADO and SERF met in Storthoaks, Saskatchewan at Chicoine Farm & Equipment where David Larsen (CNH) came to deliver a training demonstration on a custom plot seeding implement. The seeding implement was a P2082 Double Shoot Disc Drill with a P-series air cart that was specifically designed for seeding small plots (Figure 27a). CNH was interested in feedback on the drill's performance in a small research plot situation as this opener is a new design to facilitate banding of fertilizer and seed placement in the same pass.

Methods and Materials

The experimental design of this project was a randomized complete block design (RCBD) with eight treatments what were replicated four times, resulting in 32 plots per site. The treatments included:

1. Canola monocrop
2. Field pea monocrop
3. Maple pea monocrop
4. Forage pea monocrop
5. Field pea-canola (pea – 100% seed rate, canola – 50% seed rate)
6. Maple pea-canola intercrop (pea – 100% seed rate, canola – 50% seed rate)
7. Forage pea (pea – 100% seed rate, canola – 50% seed rate)
8. Forage pea (pea – 50% seed rate, canola – 50% seed rate)

85 ppms (plants per meter squared) was used as the target rate for all the peas in the trial except in Treatment 8, where the forage peas were seeded at 50% of the normal rate.

The Melita trial was established near NW15-3-17 W1 on Waskada Loam soil into wheat stubble with good moisture. The plots were seeded on June 6th; the peas were seeded at a 0.75-inch depth and the canola at a 0.5-inch depth. Peas were treated with liquid Rhizobium inoculant (Nodulator, BASF). Fertility was applied the day before seeding based on a soil test at 50-35-25-15-1 actual lbs ac^{-1} N-P-K-S-Zn with a Seedhawk Dual Knife Drill. The CNH drill was not capable of applying the two different types of seed and the fertilizer at the same time, but it was capable of seeding both types of seed at the same time at different depths. A Clearfield canola variety was used in this project to make in-crop herbicide application easier. The canola seed was side-banded close to the peas, and rolling was performed after seeding to minimize soil disturbance and loss of soil moisture. Chemical burn off was applied on June 7th as Round Up Transorb (0.67 L ac^{-1}) and Aim (20 mL ac^{-1}) before crop emergence. In-crop herbicide was applied as Odyssey (17.3 g ac^{-1}) with Merge (0.5% v./v.) on June 23rd when the canola had reached the 3-leaf stage, and the peas were 3 inches tall. An insecticide application has needed for the control of high grasshopper populations on August 9th; Matador (34 mL ac^{-1}) was used. All plots were desiccated on September 5th with Reglone (0.65 L ac^{-1}) with LI-700 (0.25% v./v.) and harvested on September 13th. Data for this trial included emergence counts, plant heights, days to flower, aphid counts, days to maturity, thousand kernel weights, pea split percentage, seed protein content, yield for crops combined and separated, and land equivalency ratios (LER) for each crop and combination of crops.

Results and Discussion

The forage peas were taller in all treatments compared to the field peas, which was expected. The forage peas had lodged completely flat when they were grown as a monocrop; planting them with canola as an intercrop helped hold them off the ground, decreasing the lodging incidence. The field peas experienced very little lodging when grown with or without canola. The forage peas did not produce as much yield as the field peas in any of the growing combinations, which is as expected since forage peas are designed to have more biomass than grain yield for feed purposes. The field peas, while yielding higher, also had a greater thousand kernel weight and a greater amount of split peas in the final sample. The forage peas, while yielding lower, had greater protein content than the field peas.

When the peas were seeded at the same rate with or without canola, the peas yielded lower when in an intercrop. This is easily explained by the competition between the two crop types being planted so close to each other. The thousand kernel weights of both the forage pea and the field peas were increased when planted in an intercrop. The number of split pea seeds was increased when the forage peas were planted with canola and were decreased when the field peas were planted with canola. The forage peas had higher protein than field peas overall, but the protein was lower when the Ige peas were planted with canola than when planted without canola; the same trend was seen for the field peas. The thousand kernel weight of the canola was slightly decreased when it was planted with forage peas for both 100 and 50 percent of the recommended seeding rate of forage peas. The protein content of the canola was greater when grown in an intercrop compared to the monocrop. Within the intercrop systems, the canola yielded the highest when the forage pea seeding rate was reduced by half; less competition by the peas allowed the canola to yield higher.

Of the intercrop combinations, field peas at the recommended seeding rate with canola at half the recommended seeded rate produced the highest yield (1931 Kg ha^{-1}). Forage peas with canola grown at those same seeding rates produced the lowest yield of the intercrops in the trial (1510 Kg ha^{-1}). A Land Equivalency Ratio (LER) shows how much more area is needed by the intercrop to produce the same yields as the monocrops; an LER over 1.0 indicates that efficiency to produce equivalent yield is greater in the intercrop system compared to the monocrop system. In this case, all three intercrop combinations and a total LER (TLER) over 1.0. The forage pea and canola both seeded at half of their recommended rates produced the highest TLER (1.95) meaning, it was the most efficient combination at producing the same yield on the same area of land as it would take the monocrops to produce the same yield on their own. While this combination did not produce the highest overall yield, in a field situation it would most likely be the most profitable since more canola seed yield is produced.

Many issues were encountered during seeding using the implement designed by CNH industries. The maple peas were excluded from the data analysis as a result of these errors. Calibration errors and row plugging during the seeding of the maple peas resulted in some plots having a shortage of seed; after the plots were harvested, the data was not able to be used in the analysis. All the technology that is needed is available, but the implement needs some adjusting in regard to being used for small plot research projects.

Moving forward there are more objectives being added to this project that will look at intercropping canola with different types of peas under a more in-depth lens.

Table 19. Table of fitted means of the data collected for the pea-canola intercrop project established at Melita in 2023.

		Monocrop: Canola	Moncrop: Field Pea	Monocrop: Forage Pea	Field Pea 100% + Canola 50%	Forage pea 100% +canola 50%	Forage pea 50% + canola 50%	P-Value
		Table of Fitted Means						
Pea	Emergence Counts (ppms)	–	102	96	91	97	58	0.167
Pea	Height (cm)	–	82.8**B**	112.1**A**	79.8**B**	114.1**A**	118.1**A**	**<0.001**
Pea	Days to Flower	–	48	59	56	56	53	0.430
Pea	Days to Maturity	–	81**AB**	84**A**	79**B**	85**A**	85**A**	**0.036**
Pea	Grams per 1000 seeds	–	198.7**A**	129.4**C**	206.4**A**	169.7**B**	176.2**B**	**<0.001**
Pea	Splits (g/500 seeds)	–	4.2**A**	0.4**B**	3.9**A**	0.7**B**	0.9**B**	**<0.001**
Pea	Yield (Kg/ha)	–	2115**B**	907**B**	1474**AB**	1239**B**	1020**B**	**0.024**
Pea	Protein (%)	–	24.2**CD**	27.9**A**	23.8**D**	26.2**B**	25**C**	**<0.001**
Pea	PLER	–	1.00	1.00	0.85	1.58	1.63	0.228
Canola	Emergence Counts (ppms)	92**A**	–	–	47**B**	52**B**	66**B**	**0.006**
Canola	Height (cm)	127.5	–	–	115.3	121.3	123.6	0.353
Canola	Days to Maturity	84**AB**	–	–	80**B**	85**A**	86**A**	**0.029**
Canola	Grams per 1000 seeds	3.29**AB**	–	–	3.51**A**	2.92**C**	3.05**BC**	**0.005**
Canola	Yield (Kg/ha)	1711**A**	–	–	457**C**	271**C**	953**B**	**<0.001**
Canola	Protein (%)	18.2**C**	–	–	20.6**BC**	24.1**A**	22.2**AB**	**0.009**
Canola	CLER	1.0**A**	–	–	0.26**B**	0.16**B**	0.3**B**	**<0.001**
Pea + Canola	Lodging (1-5 rating)	1.0**C**	1.5**BC**	5.0**A**	1.0**C**	4.5**A**	2.3**B**	**<0.001**
Pea + Canola	Total Yield (Kg/ha)	1711**A**	2115**A**	907**B**	1931**A**	1510**AB**	1597**A**	**0.018**
Pea + Canola	TLER	1.00	1.00	1.00	1.13	1.73	1.95	0.051

*Values with the same letters are not significantly different by Fisher's mean comparison at 95% confidence

Pictures


Figures 27a, 27b, & 27c. Top left: training day at Storthoaks; checking out the new machine. Right: overview of the pea-canola combinations seeded at Melita. Bottom left: severe lodging that was observed in the forage peas in the pea-only plots. High incidence of white mould can also be seen.

References

Alberta Pulse Growers. "Peas." *Alberta Pulse Growers*, albertapulse.com/marketing-pulses/peas/.

Fleury, D. (2023) *Understanding forage pea varieties*, *Saskatchewan Pulse Growers*. Available at: https://saskpulse.com/resources/understanding-forage-pea-varieties/

Do Pea types differ in suitability for intercropping with canola? (2020) *AgriARM Applied Research Management*. Available at: https://conservationlearningcentre.com/wp-content/uploads/2020/11/Peola_Factsheet.pdf

Hursh, K. (2021) *The good and bad of niche crops*, *Farming For Tomorrow*. Available at: https://farmingfortomorrow.ca/a-farmers-viewpoint/the-good-and-bad-of-niche-crops/

30.0 Preliminary Results: Establishing an Annual Crop-Living Mulch System at Four Manitoba Locations

Project Duration: May 2023 – September 2024
Collaborators: Jessica Frey (PCDF), Joanne Thiessen Martens (Department of Soil Science, U of M), MCA, PESAI, MCDC, WADO

Objectives:

- To examine the performance of living mulches planted with a spring wheat crop, as well as the impact on wheat grain yield, at four Manitoba locations.

Background

The use of perennial cover crops outside of the normal growing season provides well-documented benefits to the soil. In Manitoba, where the growing season typically consists of 90-110 frost-free days, establishing a cover crop that persists into the next growing season is a niche form of cover cropping that is termed "living mulch". Perennial legumes are of particular interest in this system for their ability to take up atmospheric nitrogen into their root tissues. When a legume living mulch is planted with an annual field crop, the latter can benefit from the transfer of nitrogen though direct contact with the roots of the legume crop (Xiao et al., 2004). After harvest, the legume remains in the soil, providing similar benefits to the following crop.

Growing multiple crops in the same system results in three possible outcomes: complementarity, facilitation, or competition.

- Complementary systems are typically observed in nature, where plants of different species make use of the same soil space and other resources at different times, varying depths, and even different chemical forms, creating a diverse, resilient, and multipurpose system (Martens et al., 2015). The potential for species to complement each other comes about because of differences in root structure, and timing and balance of nutrient demand (Dowling et al., 2021a).
- Facilitative systems are interplant relationships that take time to develop, such as the decomposition of roots and organic matter from one plant that then contributes to the

plant and soil health of the other. In the case of legumes, this leads to an increase in soil N (Wivstad, 1999).

- A competitive system is described by (Dowling et al., 2021a) as one in which "two individuals in a stand interact in such a way that at least one exerts a negative effect on the other", such as through competition for water, soil nutrients and light. In an agricultural setting, this interaction will typically result in decreased yields and financial loss.

The goal of a living mulch system is to take advantage of the complementary and facilitative features of the interacting crop species, while minimizing competition. To achieve this, the living mulch can be seeded in Year 1 at the same time and the same depth as the annual field crop, which allows the more vigorous annual field crop to establish ahead of the slower growing living mulch crop. After harvesting the annual field crop, the living mulch grows without competition.

In Year 2, the living mulch is strategically set back through mowing or a non-lethal application of herbicide. This is done to decrease the competitiveness of the living mulch before seeding of annual field crop. Importantly, research indicates that damage caused to the top growth of a legume can result in a release of nitrogen in a stable, plant-available form from the legume's roots (Bergkvist, 2003). This release could provide a timely boost of nutrients to the annual field crop.

Materials and Methods

This report presents preliminary results for a spring wheat-living mulch system established in May 2023 at four Manitoba sites (Arborg, Carberry, Melita, and Roblin). Four legume species and one grass species were seeded in the same row and at the same depth as wheat.

Table 20a: Treatments in the Annual Crop – Living Mulch trial in 2023.

Wheat- only Control 1	Wheat-only Control 3	Wheat – Alfalfa	Wheat – White Clover
Wheat-only Control 2	Wheat – Sweet Clover	Wheat – Red Clover	Wheat – Perennial Ryegrass

Wheat-only control plots will be assigned differing fertility targets in Year 2

Table 20b: Profiles for the four sites that established the Annual Crop – Living Mulch trial in 2023.

	Arborg	Carberry	Melita	Roblin
Soil Sample Date	08-May	28-Apr	28-Apr	27-Apr
Stubble	Canola	Canola	Canola	Millet
Soil Preparation	Direct seed	Direct seed	Direct seed	Direct seed
Seeding Date	23-May	12-May	10-May	12-May
Moisture at Seeding	dry	good	Very good	poor
Added N	All sites background N topped up to 140 lbs/ac			
Added P	All sites applied P to match 70 bu/ac target yield			
Pre-emergence spray	May 31 Pardner @ 0.4 L	May 8 Glyphosate @ 0.8L + Heat @ 60ml	May 10 Roundup @ 0.67L + Aim @ 20ml	Glyphosate @ 0.64 L
Mid-season spray	Jul 14 Pardner @ 0.4L	Jun 19 Basagran Forte @ 0.8 L + UAN @ 1.6L	Jun 1 Koril @ 0.5L (3 leaf)	Jun 21 Axial @ 0.5L + Basagran Forte @ 0.7L
Anthesis	12-Jul	06-Jul	27-Jun (heading)	28-Jun
Soft Dough	first week August	20-Jul	17-Jul	03-Aug
Reseed	NA	30-Aug	05-Sep	NA

Table 20c: Seasonal Weather Data January 1 to December 21, 2023, at all four sites included in the Annual Crop – Living Mulch trial.

	Arborg		Carberry		Melita		Roblin	
	Actual	**% Normal**	**Actual**	**% Normal**	**Actual**	**% Normal**	**Actual**	**% Normal**
Precipitation	296	67	255	59	438	89	248	58
Crop Heat Units	3116	115	3097	115	3155	109	2888	118
Growing Degree Days	1898	119	1922	123	1970	116	1757	124

The seeding rate for all the mulch crops targeted the high end of recommendations. The wheat seeding rate targeted the low end of recommendations and was uniform across all treatments. The seeding rates are provided in Table 20d.

Table 20d: Seeding rates for each crop type used in the 2023 Annual Crop – Living Mulch trial.

Crop Type (Variety)	Seeding Rate
Wheat (Landmark)	250 plants/m2
Alfalfa (Stellar II)	12 lbs/ac
Red Clover (Single Cut)	10 lbs/ac
Sweet Clover (Yellow Blossom)	10 lbs/ac
White clover (Bombus)	6 lbs/ac
Perennial Ryegrass (Soraya)	12 lbs/ac

Results and Discussion

Establishment

Wheat establishment at three out of the four sites was found to be unaffected by the presence of the living mulch as compared to the wheat-only control plots, even though precipitation received between May 1 and June 15 was well below the 30-year average at all four locations (Arborg 21%, Carberry 41%, Melita 63%, Roblin 67%). In only one case (Roblin) was the emergence of wheat seeded with alfalfa found to be significantly lower. However, subsequent measurements throughout the summer did not show those wheat plots to be disadvantaged. Establishment for wheat is shown in Table 20e.

Table 20e: Wheat Establishment in pl/m^2 (target plant stand 250 pl/m^2) at each site for the 2023 Annual Crop – Living Mulch trial.

Treatment	Arborg	Carberry	Melita	Roblin
Seeding Date	May 23	May 12	May 10	May 12
Date of plant count	May 30	May 30	May 23	May 29
Wheat-only Control	351	255	234	122
Sweet Clover	368	225	224	80
Alfalfa	401	276	248	56
Red Clover	374	266	254	81
White Clover	410	264	251	76
Perennial Ryegrass	377	280	253	72
SEM	27	2	21	12
P-Value	0.7	0.4	0.9	**0.03**

Mulches in Melita established equally well, with no significant outliers performing better or worse. Alfalfa established significantly better at both Arborg and Carberry with sweet clover not far behind alfalfa in Carberry. Alfalfa also established very well in Roblin, although it was initially surpassed by white clover. Establishment for mulches is shown in Table 20f.

Table 20f: Mulch Establishment (pl/m^2) at each site for the 2023 Annual Crop – Living Mulch trial.

Treatment	Arborg		Carberry		Melita	Roblin	
	Jun 8		Jun 7		May 31	Jun 9	
Sweet Clover	18	b	110	a	148	89	c
Alfalfa	90	a	148	a	158	193	ab
Red Clover	12	b	49	bc	101	128	bc
White Clover	25	b	22	c	145	206	a
Perennial Ryegrass	37	b	97	ab	130	167	ab
SEM	11		13		20	15	
P-Value	**0.02**		**<0.001**		0.3	**<0.001**	

Summer Wheat Biomass

No significant differences were noted between treatments at any of the sites for biomass produced by the wheat plants at soft dough stage when compared to the wheat-only control. The ability of wheat to produce enough biomass to subsequently harness and store the sun's energy through photosynthesis was unaffected by the competitive presence of the mulch.

Table 20g: Wheat Biomass at Soft Dough (Kg ha^{-1}) at each site for the 2023 Annual Crop – Living Mulch trial.

Treatment	Arborg	Carberry	Melita	Roblin
Date	Aug 9	Jul 24	Jul 24	Aug 3
Wheat-only Control	9786	6733	7213	7774
Sweet Clover	8682	7713	6412	7128
Alfalfa	9006	7120	7281	6715
Red Clover	8358	6733	7728	7291
White Clover	10,155	7532	7296	7357
Perennial Ryegrass	8543	6990	7059	6981
SEM	695	571	588	409
P-Value	0.4	0.8	0.7	0.9

Mulches did not perform equally well for production of biomass. By late July, biomass samples of the mulch crops began to show some clear advantages or disadvantages for the individual mulches by site. The mulches with superior establishment at Arborg and Carberry continued to perform the best with perennial ryegrass coming forward as a late contender in Arborg. In Roblin, good early establishment did not guarantee the most biomass production. Red clover and alfalfa produced the most biomass, but a sharp decline was seen between the emergence of white clover and its subsequent biomass production, while sweet clover (which did not establish well) demonstrated a marked increase of growth by late July.

Table 20h: Summer Mulch Biomass (Kg ha^{-1}) at each site for the 2023 Annual Crop – Living Mulch trial.

Treatment	Arborg	Carberry	Melita	Roblin	
Date	Aug 9	Jul 24		Aug 3	
Sweet Clover	14	820	-	94	a
Alfalfa	121	895	-	153	a
Red Clover	-	-	-	125	a
White Clover	-	-	-	10	b
Perennial Ryegrass	159	-	-	11	b
SEM	34	337	-	18	
P-Value	0.08	0.9	-	**<0.001**	

<u>Anomalies</u>

The following anomalies occurred at the participating sites:

- At Melita, an application of Bromoxynil, per the protocol, resulted in the termination of most of the mulch crops. This incident was communicated to the other sites to prevent the mistake from happening again, and the protocol was updated for the future. These plots were reseeded after the wheat harvest, with the aim of continuing the trial in Year 2.
- At Carberry, red clover, white clover, and perennial ryegrass were reseeded at the end of summer, due to negligible emergence for those crops.
- At Arborg, red clover and white clover produced very low amounts of biomass, but based on the plant counts, the crops were not reseeded. The plants are expected to produce sufficient biomass in Year 2.

It is interesting to note that, with the exception of perennial ryegrass in Arborg, the mulches with the lowest biomass production were the ones that have fibrous root systems. It is possible that these mulches were less able to compete with wheat for the limited moisture, as they were exploring the same rooting zone.

Wheat Yield and Protein

Whereas yields and protein content differed between sites, no significant difference was observed between treatments on each site when compared to the wheat-only control. Although higher yields and protein content were observed at Arborg as compared to the other sites, the results remain comparable with the wheat-only control, with no significant difference between treatments. Wheat-only treatments are likewise comparable to the other wheat-mulch treatments at Roblin and Carberry (Table 20i).

Table 20i: Wheat Yield (bu ac^{-1}) and Protein content (%) for each site for the 2023 Annual Crop – Living Mulch trial.

Treatment	Arborg		Carberry		Melita		Roblin	
Harvest Date	Sep 13		Aug 29		Aug 17		Aug 30	
	Yield	Protein	Yield	Protein	Yield	Protein	Yield	Protein
Wheat-only Control	92	15	37	12	60	12.4	60	12.9
Sweet Clover	91	15	38	12	53	12.0	61	13.2
Alfalfa	88	14.2	39	12	59	12.8	53	13.6
Red Clover	91	15.1	33	13	66	11.8	57	12.9
White Clover	94	15.1	40	12	53	13.4	58	13.0
Perennial Ryegrass	83	14.9	40	12	60	12.0	60	13.3
SEM	6	0.3	2	1	5	0.7	2	0.3
P-Value	0.8	0.4	0.2	0.6	0.5	0.6	0.4	0.5

Post-harvest Mulch Performance

After the annual field crop is harvested, the mulch has unrestricted access to sunlight and soil moisture. Biomass samples taken in the late fall indicate the mulch's ability to grow before a killing frost, fixing nitrogen in the case of the legumes, and enhancing features such as soil structure and aeration, water penetration, and mycorrhizal activity. Table 20j shows the post-harvest performance of the mulch crops.

Table 20j: Post-harvest mulch performance (kg ha^{-1})* at each site for the 2023 Annual Crop – Living Mulch trial.

Treatment	Arborg		Carberry	Melita	Roblin	
Date	Oct 18		Oct 20	Oct 20	Oct 17	
Sweet Clover	84	b	R	R	290	bc
Alfalfa	452	ab	273	R	557	a
Red Clover	-		301	R	339	b
White Clover	-		R	R	118	c
Perennial Ryegrass	1365	a	R	R	297	b
SEM	203		83	-	40	
P-Value	**0.03**		0.8	-	**<0.001**	

** R = Reseeded after wheat harvest*

Trends already observed at earlier points in the season continued with the fall biomass cut. Alfalfa was the only mulch crop with a significantly higher level of biomass production at Roblin. Alfalfa also performed well (though not “best”) at Carberry and Arborg. Perennial ryegrass produced the most biomass at Arborg and red clover produced slightly more biomass than alfalfa at Carberry. For the mulches that were reseeded at Carberry and Melita, perennial ryegrass re-established significantly better than the other reseeded mulches.

Discussion

The dry field conditions in early 2023 made challenges to the establishment of the treatments more readily observable than if soil moisture had been abundant. Each of the mulch crops has a different type of rooting system: whereas wheat has a fibrous system of roots, alfalfa and sweet clover are best described as having deep tap roots. It is hypothesized that these differences are a determining factor in whether the interaction that develops between the two crops is complementary (i.e., one that drives both crops to greater exploration of their soil resources), or competitive (i.e., where one crop overpowers the other for water and nutrients). When moisture is scarce, wheat roots will tend to explore more laterally for soil moisture, while alfalfa and sweet clover will tend to explore deeper into the soil. Dowling et al. (2021) refer to this more complementary interaction as “sparing” relationship, in which each crop “spares” soil moisture for the other. Conversely, when moisture is scarce, the more fibrous root systems of red clover, white clover, and perennial ryegrass can result in direct competition with the root systems of wheat plants, as each plant will search for moisture.

Biomass production at mid-season is an important measurement for both crops that have been seeded together. For wheat, this measurement, taken at soft dough stage, represents how much resources the plants have been able to allocate to vegetative growth throughout the season. The measurement corresponds with the photosynthetic capacity to harness and store energy for the next generation of seeds (yield) and protein storage (as a measure of seed quality). A significant decrease in biomass production for wheat seeded with a mulch crop, as compared to a wheat-only crop, would indicate that the mulch had outcompeted the wheat for water and nutrients.

For the mulch crop, biomass production signifies the plant's ability to perform its beneficial functions. Although not measured directly in this project, it is well understood that below-ground biomass (roots) increases in tandem with above-ground biomass. More root growth translates to increased soil aeration, water penetration and soil structure, the ability to form beneficial fungal hyphae networks, and increased surface area for nitrogen fixing soil bacteria to nodulate (Blackshaw et al., 2010). In the complementary relationship between legumes and nitrogen fixing bacteria, greater photosynthetic capacity for legume mulches also enhances the bacteria's nitrogen fixing potential. In an intercrop scenario, excess nitrogen can be shared with the non-leguminous annual field crop.

The measurement of greatest interest in Year 1 is wheat yield and protein content. The comparable wheat yields for intercropped and wheat-only treatments is an indicator that, at the very least, the competition from the mulch has not detracted from the quantity (yield) and quality (protein content) of wheat that was produced.

Summary

Ultimately, it is desirable for both plants in this system to do well. Whereas no decline in wheat performance is an encouraging result, there was also no increase in wheat grain yield. This indicates that, in the year of establishment, the mulch crops did not provide observable advantages to the wheat crop (such as nitrogen resulting in increased yield or protein content). Based on the relatively dry growing conditions and the overall low levels of biomass production that were observed, these results are not surprising.

Year 2 will provide another layer for understanding the interactions between the annual field crop (canola) and the living mulch. As a tap-rooted crop, it is anticipated that the interactions between canola and the mulch crops will be effectively reversed: the deep-rooted alfalfa and sweet clover crops may develop a more competitive relationship with canola, whereas the more fibrous-rooted crops may develop more complementary relationships. Nevertheless, the release of nitrogen caused by disturbing the top growth of the mulches is expected to benefit the canola crop during critical phases of its development.

References

1. Bergkvist, G. (2003). Effect of White Clover and Nitrogen Availability on the Grain Yield of Winter Wheat in a Three-Season Intercropping System. *Acta Agriculturae Scandinavica, Section B - Soil & Plant Science*, *53*(3), 97–109. https://doi.org/10.1080/09064710310011953
2. Blackshaw, R. E., Molnar, L. J., & Moyer, J. R. (2010). Suitability of legume cover crop-winter wheat intercrops on the semi-arid Canadian Prairies. *Canadian Journal of Plant Science*, *90*(4), 479–488. https://doi.org/10.4141/CJPS10006
3. Dowling, A., O Sadras, V., Roberts, P., Doolette, A., Zhou, Y., & Denton, M. D. (2021a). Legume-oilseed intercropping in mechanised broadacre agriculture – a review. *Field Crops Research*, *260*, 107980. https://doi.org/10.1016/j.fcr.2020.107980
4. Dowling, A., O Sadras, V., Roberts, P., Doolette, A., Zhou, Y., & Denton, M. D. (2021b). Legume-oilseed intercropping in mechanised broadacre agriculture – a review. *Field Crops Research*, *260*, 107980. https://doi.org/10.1016/j.fcr.2020.107980
5. Martens, J. R. T., Entz, M. H., & Wonneck, M. D. (2015). Review: Redesigning Canadian prairie cropping systems for profitability, sustainability, and resilience. *Canadian Journal of Plant Science*, *95*(6), 1049–1072. https://doi.org/10.4141/cjps-2014-173
6. Wivstad, M. (1999). [No title found]. *Plant and Soil*, *208*(1), 21–31. https://doi.org/10.1023/A:1004407119638
7. Xiao, Y., Li, L., & Zhang, F. (2004). Effect of root contact on interspecific competition and N transfer between wheat and fababean using direct and indirect ^{15}N techniques. *Plant and Soil*, *262*(1/2), 45–54. https://doi.org/10.1023/B:PLSO.0000037019.34719.0d

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