WADO

Westman Agricultural Diversification Organization

2022 ANNUAL REPORT

2022 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 Canadian Agriculture Partnership (CAP) programs. Smaller amounts of additional funding come from the MCVET committee and other Industry Partners for the contract work that WADO is able to provide for these organizations.

2022 Industry Partners

Agriculture and Agri-Foods Canada
Avondale Seeds
Barker's Agri-Centre
BASF
Bayer
Canada Malt Barley Technical Centre
Canada Manitoba Diversification Centres
Canadian Agriculture Partnership
Crop Development Center
Ducks Unlimited Canada
Fiasco Farms
General Mills
Kirkup Farms
Manitoba Ag & Resource Development
Manitoba Cooperator
Manitoba Crop Alliance
Manitoba Crop Variety Evaluation Team
Manitoba Forage and Grass Association
Manitoba Pulse and Soybean Growers
Manitoba Pulse Growers Association
Manitoba Sunflower Growers Association
Melita Chamber of Commerce
Mustard 21
Parkland Industrial Hemp Growers
Paterson Grain
Phillex Limited
Prairie Mountain Hops
Pulse Genetics
Roquette Canada Limited
Seed MB
Sollio Agriculture
Swanson Farms
Tilbury Farms
University of Manitoba
University of Saskatchewan
Western Produce

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 2022.

Board member	**Location**
Gary Barker - Chairman	Melita
Brooks White	Pierson
Darren Peters	Boissevain
Kevin Beernaert	Hartney
Kevin Routledge	Hamiota
John Finnie	Kenton
Allan McKenzie	Nesbitt
Patrick Johnson	Killarney
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 2022 Trial Locations

Cooperator - Location	Kirkup - Melita	Fred Greig - Reston	Tilbury/Swanson - Melita	Barker - Melita	Clarke - Melita/Bernice
Legal Land Location	SW22-3-27W1	SE11-7-27W1	SW18-4-26W1	NW 6-4-26W1	NE 19-4-27W1
Soil type	Waskada Loam	Alexander Loam	Waskada Loam	Mentieth Loamy Fine Sand	Chaucer Loamy Fine Sand

WADO Staff

Scott Chalmers (P.Ag.) is the Applied Research Specialist for Manitoba Agriculture. Scott is responsible for project development, staff management, data analysis and extension/communications. Scott has been working with WADO since 2007.

McKenzie Rowe 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 the casual summer students who helped the staff with daily tasks throughout the summer.

WADO staff Top (L-R): Tylan Chalmers, Tom Burnett, Joy Mayes. Bottom (L-R): Scott Chalmers, McKenzie Rowe, Chantal Elliott, Leanne Mayes.

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.

A new annual project intake process was initiated in November of 2022 where future trial collaborators can submit project ideas to be considered and selected in a more formal process. 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

2022 Weather Data – Melita Area

Table 1a. Melita 2022 Seasonal Report by Month (Normal is based on 30-year Average)

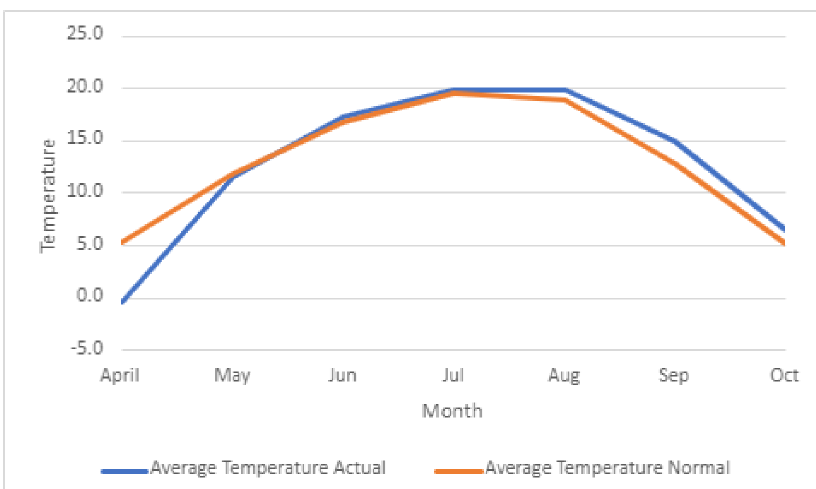
Month	Precipitation (mm)		Ave. Temperature (Celcius)		Corn Heat Units		Growing Degree Days	
	Actual	Normal	Actual	Normal	Actual	Normal	Actual	Normal
April	47	29	-0.4	5.3	19	78	7	24
May	83	53	11.5	11.9	346	365	204	205
June	54	104	17.3	16.8	583	583	364	351
July	49	69	19.9	19.6	737	712	462	453
August	13	78	19.9	18.9	713	659	461	415
September	18	35	15.0	12.9	478	369	299	211
October	20	31	6.5	5.1	177	116	79	40

Source:
Seasonal Report - Manitoba Ag-Weather Program (gov.mb.ca)
Canadian Climate Normals 1981-2010 Station Data - Climate - Environment and Climate Change Canada (weather.gc.ca)

Table 1b: Seasonal Summary (April 15 – October31, 2022)

	Actual	Normal	% of Normal
Number of days	199		
Growing Degree Days	1875	1702	110
Corn Heat Units	3043	2880	106
Total Precipitation (mm)	278	390	71

Source:
Seasonal Report - Manitoba Ag-Weather Program (gov.mb.ca)



Mean Monthly Air Temperature (normal and actual) at Melita (April 15 – October 31, 2022)

Figure 1a. The mean monthly air temperature (°C) recorded at Melita from April 15 to October 31, 2022, compared with the normal mean monthly temperatures at Melita.

In Melita, the average monthly temperature was below normal for April (-0.4°C) and May (11.5°C) then increased through the growing season eventually becoming above average for most of the growing season. The June average temperature was 0.5°C above average, and the average temperature peaked in both July and August (19.9°C). Both the September average (15.0°C) and October average (6.5°C) exceeded normal temperatures for that time of year. 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, 2022)

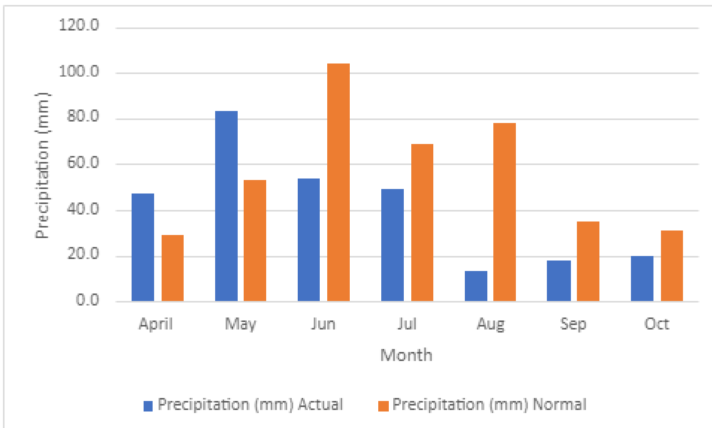


Figure 1b. Monthly precipitation (mm) recorded at Melita from April 15 to October 31, 2022, compared to the normal monthly precipitation for Melita from April to October

Once again, the 2022 growing season was drier than normal, with the total precipitation from April 1 to October 31 being only 71% of the normal precipitation for the area. With 47 mm of precipitation in April and 83 mm in May, the crops did not have to depend on pre-existing soil moisture in order 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, 54mm in June, 49mm in July, and only 13mm in August. The dry trend continued into September (18mm) and October (20mm). With most of the precipitation coming early in the growing season, some yield losses can be attributed to the dry conditions. Deficient fall soil moisture could also have a negative effect on fall seeded crops going into the winter months.

CHU and GDD (normal and actual) accumulated at Melita (April 15 – October 31, 2022)

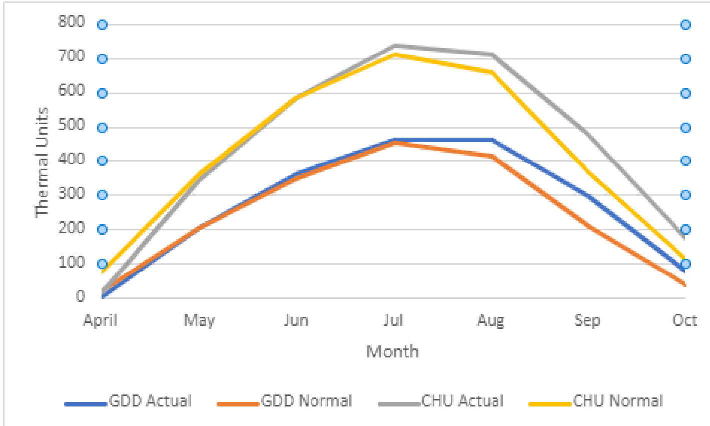


Figure 1c. Growing degree days and corn heat units in 2002 from Melita compared to the 30-year normal growing degree days and corn heat units for the region.

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 2022 Precipitation Map and the 2022 Corn Heat Unit Map. These can be found at http://www.gov.mb.ca/agriculture/weather/manitoba-ag-weather.html.

WADO Tours and Special Events

After being limited by lockdowns, WADO was finally able to get back to normal events in 2022. WADO hosted their annual field day tour on July 21, 2022. There were 66 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, were able to attend Manitoba Ag Days in Brandon for the first time since 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.

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 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) which facilitates variety evaluations of many different crop types in this province. The crops include grain corn, winter wheat, fall rye, sunflower, conventional and roundup ready soybean, peas, barley, spring wheat, oats 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 Resource Development and Ag Industry Offices. The suite of Seed Manitoba products — the Seed Manitoba guide and the websites www.seedinteractive.ca and 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 1 summarizes the WADO grown MCVET trials agronomy for each crop type. The table provides extra insight and 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 2022 are available in supplemental sections 2.0, 3.0, and 4.0 of this report.

Table 1: MCVET Variety Trial Agronomy Practices for 2022. All yield results are published in the 2022 Seed Guide.

Crop	Pre-Emergence Burn-off (rate/ac)	Soil Moisture	Seeding Date	Seeding Depth	Fertilizer Applied (actual lb/ac) N-P-K-S-Zn	Chemistry - Post-Emergence Herbicides (Rate/ac)	Harvest date (2022)
Annual Forages	Roundup Transorb @ 0.33L/ac + Aim @ 20mL/ac	Good	12-May-22	1.0"	95-30-12-1Zn	MCPA Amine 500 @ 0.18L/ac (all except Millets & Sorghum), Achieve @ 0.2L/ac +Turbocharge 0.5% (cereals except oats), Basagran @0.91L/ac on Millets and Sorghum)	22-Jul (Barley, Oats, Intercrops), 05-Aug (Millet, Sorghum, Triticale)
Barley	Roundup Transorb @ 0.33L/ac + Aim @ 20mL/ac	Good	5-May-22	1.0"	80-35-25-15-2Zn + 30lbs/ac N in June	Tundra @ 0.8L/ac, Axial @ 0.5L/ac + Merge @ 284mL/ac	11-Aug
Corn	No burn-off	Ample	18-May-22	2"	150-50-65-23.4-1Zn + 1L/ac of Cu	Roundup Transorb @ 0.67L/ac + Armezon @ 15mL/ac (3-leaf stage)	10-Oct
Fall Rye	Roundup Transorb @ 0.67L/ac + Heat @ 20mL/ac	Good	10-Sep-21	0.75"	61-30-21-13-1.7Zn + 60lbs/ac N in Spring + 30lbs/ac N in June	Achieve @ 0.2L/ac + Turbocharge 0.5% + Mextrol @ 0.5L/ac	16-Aug
Hemp	No burn-off	Ample	24-May-22	0.75"	130-35-25-15-2Zn	Assure II @ 0.2L/ac + Suremix 0.5%, Koril @ 0.4L/ac	06-Sep/12-Sep
NR Dry Beans	Roundup Transorb @ 0.33L/ac + Aim @ 20mL/ac + Rival @ 0.65L/ac	Ample	17-May-22	1.0"	104-30-22-13-1Zn	Viper @ 0.4L/ac + UAN @ 0.8L/ac, Arrow @ 120mL/ac + X act 0.5%, hand weeding for wild buckwheat, Volunteer Canola and lambs quarters	08-Sep/09-Sep
Oats	Roundup Transorb @ 0.33L/ac + Aim @ 20mL/ac	Good	5-May-22	1.0"	100-35-25-15-2Zn	Mextrol @ 0.5L/ac, Stampede @ 0.5Kg/ac + MCPA amine 500 @ 0.23L/ac	16-Aug

Crop	Pre-Emergence Burn-off (rate/ac)	Soil Moisture	Seeding Date	Seeding Depth	Fertilizer Applied	Chemistry - Post-Emergence Herbicides (Rate/ac)	Harvest date (2022)
Peas	No burn-off	Ample	6-May-22	1.0"	15-35-25-15-2Zn	Odyssey @17.3g/ac + Merge 0.5%	10-Aug
Soybeans	Roundup Transorb @ 0.33L/ac + Aim @ 20mL/ac + Rival @ 0.65L/ac	Ample	26-May-22	1.0"	15-35-25-15-2Zn	RR - Roundup Transorb @0.67L/ac, CN - Viper @ 0.4L/ac + UAN @ 0.8L/ac (10gal/ac)	21-Sep
Sunflower	Roundup Transorb @ 0.33L/ac + Aim @ 20mL/ac + Rival @ 0.65L/ac + Authority @ 80mL/ac	Good	18-May-22	1.75"	125-42-30-18-1.2Zn banded at 1.25"	Assure II @ 0.2L/ac + Suremix 0.5% + Muster @ 8g/ac, Assert @ 0.54L/ac + pH adj @ 25 g/2gal	17-May
Wheat	Roundup Transorb @ 0.33L/ac + Aim @ 20mL/ac	Good	5-May-22	0.5"	100-35-25-15-2Zn + 30lbs/ac N in June	Tundra @ 0.8L/ac	22-Aug
Winter Wheat	Roundup Transorb @ 0.67L/ac + Heat @ 20mL/ac	Good	10-Sep-21	0.75"	61-30-21-13-1.7Zn + 60lbs/ac N in Spring + 30lbs/ac N in June	Achieve @ 0.2L/ac + Turbocharge 0.5% + Mextrol @ 0.5L/ac	10-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 2022 including Melita, Carberry, Elm Creek, 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 1 of this report. In 2022, the Melita results were rejected since the coefficients of variation were unacceptable. Results for the 2022 sunflower variety trials from other sites can be found in the 2022 Manitoba Seed Guide or on the MCA website.

3.0 Annual Forage Evaluation

Project duration: Ongoing
Collaborators: MCVET, Manitoba Forage Growers Association

Objectives

- To assess the yield potential and feed quality of various annual forages grown at three sites across Manitoba

Background

The annual forage assessment trials are performed as part of the Manitoba Crop Variety Evaluation Trials (MCVET) and are performed by WADO (Melita), PESAI (Arborg), and PCDF (Roblin). In the annual forage trials, various forage crops are grown in a singular trial and dry matter yields from each crop are collected. Feed quality of each forage crop is assessed based on composite samples from each site. Like with other MCVET trials, yearly data is collected from each site across the province and summarized in the Seed Manitoba Variety Selection & Growers Source Guide.

Materials and Methods

All annual forage crops were established in a single trial with three replicates at each site in 2022. In Melita, forages were established into canola stubble on May 12th at a 1-inch depth. Fertility was banded during seeding at a rate of 95-30-12-1 actual lbs ac-1 (N-P-K-Zn). Burn off was applied as Roundup (0.33 L ac-1) and Aim (20 ml ac-1) on May 11th. Additional herbicide was necessary in many forages, with MCPA 500 Amine (0.18 L ac-1) applied to peas and cereals (not Millet or Sorghum) on June 7th. Achieve (0.2L ac-1) on all cereals except for the oats on June 8th. Basagran (0.91 L ac-1) was applied on Yellow Foxtail Millet, Red Proso Millet, and Sorghum-Sudangrass on June 9th. Crops were harvested on July 22nd at soft dough for cereals and peas and on August 5th at early heading for millet and sorghum.

Results

Dry matter yield results for each forage cut are presented in Table 2 below. Yield data from other sites, as well as feed quality data, can also be found in the Seed Manitoba Variety Selection & Growers Source Guide.

Table 2. Dry Matter Yield results from the 2022 MCVET Annual Forage Trial

Crop	Variety	Dry matter Yield (tonnes/ac)
Barley	AB Advantage	4.963**ab**
Barley	AB Cattlelac	4.53**bcd**
Barley	AB Hague	4.149**bcde**
Barley	AB Tofield	4.667**abc**
Barley	CDC Renegade	4.935**ab**
Oats	CDC Arborg	3.919**cdef**
Oats	CDC Haymaker	4.674**abc**
Oats	CDC Endure	4.291**bcde**
Spring Triticale	Common (Pronghorn)	5.447**a**
Peas/Barley	CDC Lewochko-AB Advantage	4.400**bc**
Peas/Oats	CDC Lewochko-CDC Arborg	4.485**bc**
Millet	Golden German (Foxtail)	3.401**ef**
Millet	Crown Proso	3.438**def**
Sorghum	Forage Sorghum	3.762**cdef**
Sorghum	Sudangrass (delayed maturity)	3.05**f**
Grand Mean		4.274
P-Value		**0.001**
Significant?		**Yes**
MSE		0.3156
CV%		13.1

Values followed by the same letter are not significantly different by Fishers mean separation method at 95% confidence.

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. The Manitoba Corn Committee publishes the annual results with all the yearly data in their brochure, which is available by calling the MCA office. A table of the 2022 Melita results can be found below in Table 4. The brochure is also available on the MCA website: www.mbcropalliance.ca. 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 3. Results of the 2022 Hybrid Corn Trial at Melita, from the Manitoba Crop Alliance.

CHU[1] Rating	Hybrid	Distributor	Technology/Genetic Trait (s)[2]	Melita 2022			
				50% Silk	Yield (bu/ac)	Moisture (%)	Bushel Wgt (lbs/bu)
1925	TH6370 VT2P	Thunder Seed	VT2P	74	128.3	18.4	56.4
1950	P6910AM	Pioneer Brand Seed	YGCB/HX1/LL/RR2	70	112.1	15.2	56.2
2000	P7005AM	Pioneer Brand Seed	YGCB/HX1/LL/RR2	71	129.1	18.1	58.0
2000	MS 6960R	Maizex Seeds	RR2	76	129.0	20.1	55.3
2025	MZ 1200DBR	Maizex Seeds	VT2P	72	125.4	20.8	54.3
2025	TH6072 VT2P	Thunder Seed	VT2P	75	127.7	18.7	54.2
2025	A3979G2 RIB	PRIDE Seeds	VT2P	72	131.3	22.6	54.6
2050	P7211AM	Pioneer Brand Seed	YGCB/HX1/LL/RR2	70	137.4	16.9	54.9
2050	PS 2192VT2P RIB	DLF PICKSEED	GENVT2P	75	77.0	21.9	53.9
2050	DKC20-23RIB	DEKALB	VT2P	74	132.4	17.8	57.3
2050	PV 60172RR	Proven Seed	RR2	75	119.9	24.3	51.4
2050	NS 271	NorthStar Genetics	VT2PRO	71	95.7	19.7	54.7
2075	CX22073A/VT2P	CROPLAN	VT2P/RIB	76	124.1	20.8	54.2
2075	DKC21-36RIB	DEKALB	VT2P	76	141.2	19.0	55.3
2075	PV 60273RIB	Proven Seed	VT2P	74	126.4	21.5	52.5
2100	P7455R	Pioneer Brand Seed	RR2	76	145.5	19.5	55.0
2100	CP1440VT2P/RIB	CROPLAN	VT2P/RIB	77	143.7	20.8	53.2
2100	DKC24-06RIB	DEKALB	VT2P	77	114.9	25.7	51.0
2125	P7417AM	Pioneer Brand Seed	YGCB/HX1/LL/RR2	73	126.7	18.0	53.4
2125	NS EXP75	NorthStar Genetics	VT2PRO	75	132.0	22.5	52.7
2125	EXP75-22	DEKALB	VT2P	78	77.8	26.7	50.8
2150	P7527AM	Pioneer Brand Seed	YGCB/HX1/LL/RR2	78	152.5	19.3	51.6
2150	MZ 1340DBR	Maizex Seeds	VT2P	74	105.3	23.2	53.2
2150	HZ 1265	Horizon Seeds	Agrisure GT	72	126.8	20.4	57.8
2175	TH6977 VT2P	Thunder Seed	VT2P	75	119.8	24.6	52.1
2175	PV 61276RIB	Proven Seed	VT2P	75	140.7	21.5	52.7
2200	PV 61479RIB	Proven Seed	VT2P	75	130.6	20.8	52.3
2200	HZ 1398	Horizon Seeds	Agrisure 3010	75	153.3	19.6	54.3
2200	A4323G2 RIB	PRIDE Seeds	VT2P	74	104.5	20.9	55.6
2225	TH6278 VT2P	Thunder Seed	VT2P	76	141.8	21.6	51.1
2250	MZ 1544DBR	Maizex Seeds	VT2P	77	146.0	20.0	50.9
2250	EXP78-22	DEKALB	VT2P	77	121.0	22.2	50.5
2300	X22080A/VT2P	CROPLAN	VT2P/RIB	77	131.2	26.8	49.7
2300	CP2123VT2P/RIB	CROPLAN	VT2P/RIB	78	130.2	20.7	51.6
			Site Average	75	124.3	21.7	53.5
			CV	1.98	7.90	6.72	1.40
			Sign. Diff.	Yes	Yes	Yes	Yes
			LSD	2	16.1	2.4	1.2
			Planting Date	May 18, 2022			
			Harvest Date	October 10, 2022			

*This is data from one year of trials only. Yield is corrected to 15.5%. The target plant population used was 32,000 plants per acre. This results can also be found by following the link: https://mbcropalliance.ca/assets/uploads/images/MCA_MCC-Table_November-2022_SSZ-Melita-v5.pd

5.0 Barker's Hybrid Corn Demonstration

Project duration: 2022
Collaborators: Canterra Seeds (PRIDE Seeds), Barkers Agri Center

Objectives

- To evaluate the performance of experimental grain corn varieties

Background

Southwest Manitoba is located near the northwestern limits for grain corn production, as corn is a long season crop which requires substantial heat for optimum performance. Manitoba Agricultural Services Corporation insures grain corn production around Melita, which falls into risk zone 1, with risk zones 2 and 3 surrounding the area (Manitoba Agricultural Services Corporation, 2016). Grain corn is insurable in most areas in Manitoba, though the northwestern limit for extended seeding period coverage is located at approximately McAuley, Manitoba. As new grain corn varieties become available, the potential for grain corn acreage to expand northward grows with its improved adaptation modifications through breeding.

In this demonstration, four new hybrid grain corn varieties from Pride Seeds were grown to be evaluated on yield and grain quality.

Materials and Methods

A hybrid grain corn variety demonstration was established near Melita (NW 6-4-26W1) on Mentieth loamy fine sand soil. Four hybrid grain corn varieties were grown: A4514RR, A3979G2RIB, I2402VT2PRO and A3993G2RIB which are varieties by Pride Seeds. This corn was seeded into corn stubble on May 20th at 2-inch depth with 30-inch row spacing using a Wintersteiger Dynamic Disc planter equipped with EasyPlant software. The demonstration was burned off with Prime Xtra II Magnum (0.75L ac^{-1}). Prior to seeding, a total of 150-50-65-23.4-1-4-2 lbs ac^{-1} of actual (N-P-K-S-Zn-Cu-B) was applied to meet the fertilizer needs of the corn. Roundup Transorb (0.67L ac^{-1}) plus Armezon (15mL ac^{-1}) was applied at 3-leaf for additional weed control. Corn was harvested on October 9th by combining the two inner rows of each variety. Yield, test weight, and grain moisture at harvest (from combine) were recorded for each variety.

Table 4a. Spring Soil Test Results for Barker's Hybrid Corn Demonstration at Melita

pH 0-6"	*N 0-6"	*S 0-6"	OM%	Salt 1	P-O (ppm)	Mg (ppm)	Zn (ppm)
8	23	12	1.1	0.14	7	157	0.44
pH 6-24"	***N 6-24"**	***S 6-24"**	**N-(N1+N2)**	**Salt 2**	**K (ppm)**	**Ca (ppm)**	**CEC (meq)**
8	39	60	62	0.16	124	3102	17.19

*lbs/ac

Results

Coming out of a dry 2021 growing season, 138 mm of precipitation was accumulated from September 2021 to April 2022 at the demonstration site. From April 1st, 2022, to the day of seeding (May 22nd) there was 118mm of precipitation accumulated (182% of normal for that time of year) creating good moisture in the soil by the time of seeding. With 83 mm of rain at the site in May, 54 mm in June, 49 mm in July and 13 mm in August, the growing season turned very dry. The site received only 49% of normal rainfall from the day of seeding to the end of August. The 2022 growing season was also warm, with the site receiving 109% of normal corn heat units from planting to harvest. The hot, dry summer explains the early harvest date and dry harvest moisture compared to normal years. The dry conditions could also account for some yield loss in all varieties. Another source of yield loss that this site encountered was wildlife eating.

As shown in Table 4b, the variety that performed the best in terms of yield was I2402VT2PRO at 136bu ac^{-1}. The worst performing variety in this demonstration was A399G2RIB, with a yield of 100bu ac^{-1}.

Table 4b: Hybrid corn demonstration results of test weight, harvest grain moisture, and yield.

	Test Weight	Harvest Moisture	Yield*
Variety	kg/hL	%	bu/ac
A4514RR	64.7	17	114
A3979G2RIB	70.2	18.4	129
I2402VT2PRO	66.1	20.6	136
A3993GRIB	68.7	16.9	100

*Yield is correct for 15% grain moisture
*Grain moisture readings from combine during harvest

6.0 Development of Short Season, Cold Tolerant, Disease Resistant Corn Inbreds

Project duration: 2022
Collaborators: Aida Kebede (AAFC Ottawa)

Objectives

- Development and release of early maturing cold tolerant corn inbred varieties with emphasis on the 1800-2000 CHU market

- Development of corn inbred varieties with improved disease resistance to Goss's wilt

Background

Historically, grain corn was concentrated in areas of the country with the highest available heat units and adequate moisture supply (i.e., southern Ontario); however, many production areas in eastern and western Canada have less than 2800 CHU. Production in these heat-limited environments is expanding rapidly as demand for grain corn increases. There is a lack of suitable early hybrids with acceptable early-season cold tolerance for these expanding regions of corn production. As well, climate change has resulted in a significant increase in common diseases and the arrival of new diseases to Canada. This is an evolving crisis that will affect trade and severely damage growers and their grain customers.

Methods

The objectives will be achieved using conventional corn breeding methodology enhanced by double haploid inbred production and specialized screening techniques for cold tolerance and disease resistance. The trial is being conducted at sites across five Canadian provinces. The anticipated impact of developing earlier maturing, cold tolerant corn will expand the acreage of corn production in Canada. Development of Goss's wilt resistant lines will reduce yield loss due to the disease.

Results

This project is part of a long-term, multi-site study led by Dr. Aida Kebede (AAFC Ottawa). Research findings may be made available by their team upon request.

7.0 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 2022. The yield tests were arranged as randomized complete block design of 30 treatments (varieties) with 3 replicates for both AA barley and AFOO barley. The AA barley was seeded into canola stubble at a 0.5-inch depth on May 5th. Food barley first pass was seeded on May 11th; however, rain prohibited the remainder of the trial being seeded that day. The rest of the Food Barley trial was seeded on May 12. Fertilizer was banded at seeding for AA at a rate of 92-30-17-9-1.7 actual lbs ac^{-1} (N-P-K-S-Zn), and for AFOO barley at a rate of 96-30-22-13-1 actual lbs ac^{-1} (N-P-K-S-Zn) as per soil test results. All plots were top-dressed with urea on June 8th (30lbs ac^{-1} of actual N). Pre-emergent herbicide was applied on May 11th as Roundup Transorb (0.33L ac^{-1}) with Aim (20mL ac^{-1}). Tundra (0.81L ac) was applied on June 6th and Axial (0.5L ac) with Merge surfactant (284mL ac) was applied on June 9th for additional weed control. Plots were not desiccated and were harvested on August 12th and August 16th (food barley).

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.**

8.0 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 2022. Experimental design used was a randomized complete block design with 13 treatments (varieties) replicated 3 times. Before seeding, Roundup Transorb (0.33L ac^{-1}) mixed with Aim (20mL ac^{-1}) was applied as burn-off. Barley was seeded into canola stubble on May 12th. Fertilizer was applied at 90-30-22-13-1Zn (N-P-K-S-Zn) actual lbs ac^{-1}. 30lbs ac^{-1} urea was broadcasted on June 13 due to excessive rainfall. Pesticide applications were identical to that of the Barley advanced yield trials (section 7.0). Plots were harvested on August 11th.

Results

Results from this study may be made available by contacting Agriculture and Agri-Food Canada (Dr. Ana Badea).

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

9.0 Optimizing Nitrogen Fertility in Winter Wheat Varieties

Project Duration: 2022

Collaborators: Ducks Unlimited Canada (Ken Gross, Alex Griffiths, Elmer Kaskiw), Manitoba Agriculture (John Heard)

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 availed to producers to improve economic returns in winter wheat production. Nitrogen is most often the focus of crop fertility in field studies. However, having a balanced approach and considering other essential nutrients, such as phosphorus, potassium, sulfur and micronutrients available in the soil, offers great yield potential when nitrogen needs of the crop are met. Perhaps more efficient return on investment potential can be achieved as fertility management is optimized

Methods and Materials

This study was established at Melita, Roblin and Arborg, Manitoba. In Melita, the trial was established on Waskada Loam soil in canola stubble. The trial design consisted of two variety and 7 fertility treatments, replicated three times, that were laid out in a factorial arranged randomized block design. The plots were seeded on September 10th, 2021, at a rate of 33 plants/ft^2 and a depth of 0.5-inches. The nitrogen treatments were not balanced with the soils test results across site locations. In Melita, a granular blend of fertilizer was applied to achieve 35lbs ac^{-1} of phosphorus, 60lbs ac^{-1} K was sideband on during seeding using MAP and potash, respectively. Specific treatment nitrogen rates were placed at 1.25-inch depth in a separate pass before seeding the wheat. The same day, the plots were burned-off using Roundup (0.67L ac^{-1}) mixed with Heat LQ (46mL ac^{-1}). Achieve (0.2L ac^{-1}) tank mixed with Turbocharge (0.5%) and Mextrol (0.5L ac) was applied on May 27th, 2022, for in-crop weed control. Prosaro (325mL ac^{-1}) was applied on June 23rd, 2022, at early anthesis for Fusarium Head Blight protection. Plots were desiccated on August 8th, 2022, with Roundup Transorb (0.67L ac^{-1}) and Heat LQ (46mL ac^{-1}). All plots were harvested on August 12th, 2022. 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 5a. Fall soil test results by site and fertilizer treatments for winter wheat in the 2021/2022 season

	Fall Soil Test Results (lbs/ac)			Balance Practive Application Recommendations* (50% of N applied in Fall)		
	Melita	Roblin	Arborg	Melita	Roblin	Arborg
N	35	24	36	120	106	110
P	31	48	18	30	15	35
K	132	61	60	0	33	60
S	42	29	20	0	0	0
Zn	0.45	0.64	0.12	0.09	0	0.40

*Balance application practice based on recommendations from the Western Ag Professional Agronomy Laboratory

Treatments

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

Fall nitrogen treatments used a 50/50 blend of ESN and urea while spring treatments were broadcasted urea that was treated with Agrotain. 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. All spring applications were applied on April 4th, 2022. The spring nitrogen application of 120kg ha^{-1} is the currently producer fertility practice when growing winter wheat.

Each site where this trial was grown used slightly different agronomic practices and had different growing conditions which are outlined in the following Table 5b.

Table 5b. Agronomic practices and Description of Sites in the 2022 Ducks Unlimited Winter Wheat Fertility Trial in Melita, Roblin, and Arborg.

Location	Melita	Roblin	Arborg
Cooperator	WADO	PCDF	PESAI
Legal	SW22-3-27W1	NE20-25-28W1	River Lot-37-22-02E
Rotation (2 yr.)	2020: S. Wheat 2021: Liberty Link Canola	2020: Oat Silage 2021: Round Up Ready Canola	2021: Liberty Link Canola
Soil Series	Waskada Loam	Erickson Clay Loam	Heavy Clay
Soil Test Done? (Y/N)	Yes	Yes	Yes
Field Prep	None	None	None
Stubble	Yes. LL Canola	Yes. RR Canola	Yes. LL Canola
Burn off	Yes	Yes	None
(Date/Rate per acre/Products)	Sep. 10 - Round Up (0.67L/ac) + Heat LQ (20mL/ac)	Sep. 16 - Round Up (0.67L/ac) + Heat LQ (37mL/ac) + Merge (0.4gal/ac)	
Soil Moisture at Seeding	Good	Dry	Good
Seed Date	10-Sep	16-Sep	14-Sep
Seed depth (Inches)	0.5	0.5	0.5
Seeder (drill/planter?)	Air Drill	Disc Drill	Disc Drill
Errors at seeding	None	None	None
Topdressing Date	04-Apr	End of May	06-Apr
Herbicides: (Date, Rate/ ac, Name)	May. 27 - Achieve (0.2L/ac) + Turbocharge (0.5%) + Mextrol (0.5L/ac)	July 15 - Bentazon (0.105gal/ac)	Sep. 22 - Pardner (480mL/ac)
Fungicides	Jun. 3 - Prosaro (325mL/ac)	None	Jun. 30 - Prosaro (325mL/ac)
Insecticides	None	None	Matador (34mL/ac)
Harvest Date	12-Aug	25-Aug	17-Aug
Total Precipitation (Seeding to Harvest)	369mm	437mm	617mm

Results and Discussion

Variety use was found to have a significant ($P < 0.001$) effect on wheat yield at the Roblin trial site in 2022 (Table 5c). Wildfire winter wheat produced the highest yield at that site and was significantly different than the yield of Vortex at Roblin. Across the two site years (Roblin & Arborg combined), Wildfire winter wheat produced the greatest average yield, and this yield was significantly ($P < 0.001$) different from that of Vortex. Winter wheat variety significantly influenced grain protein content at the Roblin and Arborg sites in the 2021/2022 growing season. At the Roblin site, protein content of Vortex (12.3%) was significantly ($P < 0.001$) greater than that of Wildfire (11.4%). At the Arborg site, protein content of Vortex (13.4%), again, was significantly ($P < 0.001$) greater than the protein of Wildfire (12.8%). Wildfire resulted in the lowest average grain protein content at the Roblin and Arborg sites, as well as the Melita site, though protein was not found to be significant at that site. This indicates a potential protein content disadvantage of this variety in Manitoba compared to the other variety used in this trial. The data for grain protein content was not able to be combined and analyzed for the Roblin and Arborg sites as the yield was due to variation between sites. Test weight significantly varied across the two varieties at the Melita and Arborg sites. At these sites, the greatest average test weight was observed from Vortex winter wheat.

Fertilizer management practice had a significant influence on grain yield at the Melita and Roblin sites. In Melita, winter wheat grown with the current producer fertility practice (100% N in spring) had a significantly ($P < 0.001$) greater average yield than winter wheat grown with a balanced fertility practice (50% N in fall). Also, in Roblin, winter wheat grown with the current producer fertility practice (100% N in spring) had a significantly ($P < 0.001$) greater average yield than winter wheat grown with a balanced fertility practice (50% N in fall). It is assumed at these two sites that signficant winter and spring moisture events may have leached away fall applied nitrogen causing these treatments to be less effective than spring applied applications. At Roblin, the spring fertility yield (6515 kg ha^{-1}) was the greatest yield at that site, though was not significant from the that of balanced (50% N in fall) applications of 90, 120, and 150 kg ha^{-1} of N. There was no significant effect of fertility on yield found at the Arborg site, but when that data is combined with Roblin's site data, there is a significant ($P < 0.001$) effect seen on yield. When Roblin and Arborg site years are combined, the balanced (50% N in fall) fertility practice of 150 kg ha^{-1} had the greatest yield (7351kg ha^{-1}), though it was not significantly different that the yield of the balanced fertility practices of 120 and 180 kg ha^{-1}, or the current producer fertility practice of 120 kg ha^{-1} applied in the spring. Significant effects of fertility practice on winter wheat grain protein content were observed at the Melita and Roblin sites, but not on the winter wheat grown in Arborg. Winter wheat grown at the Roblin and Melita sites, were found to have significantly ($P < 0.001$) higher grain protein contents (12.3% and 12.7%) using the current producer fertility practice (120lbs ac of N in the spring) than using balanced fertility practices. Fertility management practice had a significant influence on grain test weight at the Roblin site and the Arborg site. In Roblin, the test weight of grain grown under the check rate of fertilizer (no added N) was significantly ($P = 0.005$) higher (70.5kg hL^{-1}) that the other fertility practices but was not significantly different from the balanced fertility practices of 60 and 90kg ha^{-1}. In Arborg, the test weight of grain grown under the balanced fertilizer practice of 60lb ac^{-1} was significantly ($P < 0.001$) higher (73.1kg hL^{-1}) that the other fertility practices but was not significantly different from the balanced fertility practice of 90 kg ha^{-1}. However, when data from Roblin and Arborg sites was combined and analyzed, no significant influence of fertility management practice on winter wheat grain test weight or protein content was observed.

No significant variety and fertility practice interactions (variety x fertility) were observed at the Melita site, but there were significant interactions seen individually in Roblin and in Arborg. No significant yield differences were observed between fertility practices for Wildfire and Vortex winter wheat varieties over three site years. When Roblin and Arborg site data was combined and analyzed, Wildfire grown with the current producer fertility practice (100% N in spring) was found to have a significantly ($P = 0.037$) higher yield (7476kg ha) than other fertility practices, but it was only significantly different than the yield of four other treatments in the trial. In Arborg, the protein content of Vortex grown under the check rate of fertilizer (no added N) was significantly ($P = 0.022$) higher (13.8kg hL^{-1}) that the other fertility practices interactions but was not significantly different from Vortex grown with a balanced fertility practice of 180 kg ha^{-1}. At the Roblin site, Vortex winter wheat grown under balanced fertility practice (150 kg ha^{-1}) resulted in the greatest average test weight (70.9 kg hL^{-1}), though this test weight was only significantly different from that of four other treatments. Finally, at the Arborg site, Vortex winter wheat grown under balanced fertility practice (90 kg ha^{-1}) resulted in the greatest average test weight (73.6 kg hL^{-1}), though this test weight was not significantly different from that Vortex grown with the balances fertility practices of 120 and 150 kg ha^{-1}, or Wildfire grown with 60 kg ha^{-1} balanced fertility practice.

Overall, results from the 2021/2022 growing season indicate that yields of two winter wheat varieties grown in Manitoba respond better to the current producer fertility practice (100% N applied in spring) in Roblin and Melita. Arborg site was unresponsive in terms of yield and protein but did show some differences in terms of test weight to nitrogen application. Arborg also received an excessive moisture event during the growing season compared to the other two sites did potentially voiding all potential for responses. Winter wheat protein content was not demonstrated to be more or less influenced by variety or fertility program in the 2021/2022 growing season. This could be explained by the drought conditions faced this year, that could have resulted in protein content results not fitting a particular trend. It was also difficult to find a pattern when looking at test weight; at some sites test weight was higher in balanced fertility programs, then at a different site it was higher under the current producer practice. Environmental conditions seemed to influence the characteristics of the two varieties of winter wheat under the different fertility practices. Also, grain protein content and test weight across the sites were not able to be combined then analyzed because the values were too variable. This implies that the geographical area could also be a factor affecting the performance of the winter wheat. Continued field study is necessary to further evaluate the performance of new winter wheat varieties under fertility management strategies, and to effectively develop fertilizer management recommendations that winter wheat producers in different areas of the province can implement in their production systems. The table of results discussed can be found in the table below.

Figure 2. The winter wheat nitrogen optimization trial located at Melita in 2022. Differences in treatments are easily seen.

Table 5c. Results including yield, protein, and test weight from the 2022 Ducks Unlimited Winter Wheat Fertility Trial in Melita, Roblin, and Arborg.

Treatment			Location									Arborg & Roblin Combined*
			Melita			Roblin			Arborg			
			Yield (kg ha^{-1})	Protein (%)	Test Wt. (kg hL^{-1})	Yield (kg ha^{-1})	Protein (%)	Test Wt. (kg hL^{-1})	Yield (kg ha^{-1})	Protein (%)	Test Wt. (kg hL^{-1})	Yield* (kg ha^{-1})
Variety	Wildfire	1	5266	10.7	77.5b	6232a	11.4b	68.40	8185	12.8b	71.2b	7195a
	Vortex	2	5053	10.8	78.5a	5731b	12.3a	69.50	7803	13.4a	73.0a	6767b
Fertility	check	1	3031f	10.2c	77.5	5034c	11.0c	70.5a	7646	13.1	72.2c	6340c
	60	2	4366e	10.1c	78.0	5706b	11.0c	69.9a	8030	12.9	73.1a	6868b
	90	3	4844d	10.4bc	77.5	6005b	11.8b	70.1a	7808	13.0	73.0ab	6906b
	120	4	5312c	10.5bc	77.9	6042b	12.0b	68.4abc	8180	12.9	72.3bc	7111ab
	150	5	5799b	10.5bc	78.5	6507a	11.9b	69.6ab	8195	13.2	71.6cd	7351a
	180	6	5955b	10.9b	78.3	6065ab	12.3ab	67.8bc	8056	13.5	70.8d	7060ab
	Spring120	7	6810a	12.3a	78.1	6515a	12.7a	66.5c	7948	13.2	71.7c	7232ab
Variety x Fertility		1,1	3230	10.1	77.0	5386	10.6	70.4ab	8386	12.4f	71.7cd	6886bcd
		1,2	4532	10.1	77.6	5800	10.5	70.1ab	8109	12.6ef	72.9ab	6955abcd
		1,3	5192	10.4	76.6	6578	11.0	69.9ab	8155	12.7def	72.4bc	7367ab
		1,4	5525	10.5	77.3	6028	11.6	66.3cd	8505	12.6ef	71.3de	7266abc
		1,5	5740	10.5	78.4	6648	11.4	68.3abc	8295	13.0cde	69.9f	7472a
		1,6	6095	10.8	78.0	6188	12.1	66.1cd	7700	13.3bc	69.8f	6944abcd
		1,7	6545	12.3	77.3	6999	12.2	67.9bcd	7953	13.2bcd	70.4ef	7476a
		2,1	2831	10.3	77.9	4683	11.4	70.5ab	6906	13.8a	72.7abc	5795e
		2,2	4199	10.2	78.4	5612	11.4	69.6ab	7950	13.3bc	73.3ab	6781cd
		2,3	4495	10.5	78.5	5431	12.6	70.3ab	7460	13.3bc	73.6a	6446d
		2,4	5099	10.5	78.4	6056	12.3	70.5ab	7856	13.2bc	73.3ab	6956abcd
		2,5	5857	10.5	78.6	6365	12.5	70.9a	8095	13.4abc	73.3ab	7230abc
		2,6	5815	11.1	78.6	5942	12.5	69.4ab	8412	13.6ab	71.8cd	7177abc
		2,7	7076	12.3	78.9	6030	13.1	65.1d	7943	13.2bc	73.0ab	6987abcd
P-Values	Variety		0.074	0.465	<0.001	<0.001	<0.001	0.064	0.065	<0.001	<0.001	<0.001
	Fertility		<0.001	<0.001	0.251	<0.001	<0.001	0.005	0.676	0.060	<0.001	<0.001
	V x F		0.132	1.000	0.599	0.110	0.384	0.025	0.108	0.022	0.011	0.037
	CV%		7.2	4.7	1.01	6.5	3.8	2.6	7.46	2.34	0.91	7.19

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

*Does not include Melita site

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10.0 General Mills Oat Variety Evaluation

Project duration: 2020 - ongoing
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

A variety trial was conducted in Melita, Manitoba on Waskada Loam soil in 2022. Entries were replicated 3 times. Varieties used for the advanced variety yield trial were Ore3541m, 2018Y0255, 2018Y0147, 2018Y1315, 2018Y0435, 2018Y1334, 2018Y0689, OT3112, WARRIER, HAYDEN, CS CANDEM, AAC WESLEY, AAC DOUGLAS, CDC KYE, CDC ARBORG, and CDC ENDURE. Plots were established on canola stubble under a no-till system on May 5th. Plots were seeded at 1-inch depth using a dual knife Seedhawk air seeder. Fertilizer was banded at seeding at a rate of 90-35-25-15-2 actual lbs ac^{-1} (N-P-K-S-Zn). Fertility application was based on soil test results and crop requirement estimates. Roundup Transorb (0.33L ac^{-1}) and Aim (20mL ac^{-1}) were applied as pre-emergence weed control on May 11th. Mextrol 450 (0.5 L ac^{-1}) was applied on June 6th and Stampede (0.5kg ac^{-1}) plus MCPA Amine 500 (0.23L ac^{-1}) were applied on June 9th for additional weed control. Plots were harvested on August 16th; the first three plots were subsampled on September 7th due to herbicide damage. Data collected included heading date, lodging assessment, maturity date, moisture content, test weight and grain yield. Additionally, green stems were scored at maturity.

Results

Results are proprietary and more information can be made available by request to General Mills Inc. (Brookings, South Dakota). Samples were taken for quality and milling analysis.

References

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11.0 Sollio Oat Variety Evaluation

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

Objectives

- To evaluate potential of 30 oat varieties interest for varioua 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 30 treatments (varieties) and three replicates. Plots were seeded into canola stubble on May 5th at a 0.5-inch depth using a Seedhawk dual knife opener air seeder. Fertility was banded during seeding at a rate of 100-35-25-15-2 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 (0.33L ac^{-1}) and Aim (20mL ac^{-1}) were applied as pre-emergence weed control on May 11th. Mextrol 450 (0.5 L ac^{-1}) was applied on June 6th and Stampede (0.5kg ac^{-1}) plus MCPA Amine 500 (0.23L ac^{-1}) were applied on June 9th for additional weed control. Plots were harvested on August 12th. 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

Yield data and samples were sent to the collaborators for analysis. This study is aimed at variety development and results may be made available from the collaborator upon request.

References

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12.0 Linseed Coop Variety Evaluation

Project duration: 2022

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. Sixteen varieties were arranged in a 4 x 4 alpha lattice design and replicated three times. The Melita trial was seeded at one-inch depth on May 16th into harvested hailed oat stubble. Roundup Tran (0.33L ac^{-1}), Aim (20mL ac^{-1}), Rival (0.65L ac^{-1}) and Authority (80mL ac^{-1}) were applied as burn-off at the time of seeding. Fertilizer was banded during seeding at a rate of 104-30-22-13-1 (N-P-K-S-Zn) actual lbs ac^{-1} following recommendations based on soil test results from AgVise Laboratories Inc. Assure II (0.2L ac^{-1}) plus Suremix surfactant (0.5%) on June 8th and Basagran (0.91L ac^{-1} at 20gal H_2O ac^{-1}) on June 10th were applied as extra weed control. Plots were desiccated September 1st by application of 0.5 L ac^{-1} Reglone and LI-700 surfactant at 0.1%. Plots were harvested on September 13th. 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, top yield was the variety CDC Rowland, though the best performing variety over Zone 3 what the experimental line FP2608 (Table 6). Maturity for FP2608 is several days later than CDC Bethune or other check varieties. Varieties CDC Kernen, CDC Glas, and the experimental line FP2609 were also notably high yielding in Melita was well as the rest of Zone 3. The lowest yield for newly released varieties was 2540 kg ha^{-1} for FP2610 (Table 6). 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 6. Predicted means for flax variety yield trial at Melita versus overall in Zone 3 in 2022.

	Yield ('00 kg/ha)			Prairie Wide	
	Melita	Zone 3 Avg	Zone 3 Rank	Days to Maturity	Height (cm)
Checks					
CDC Bethune	27.3	27.0	11	105	58.6
AAC Bright	28.2	28.1	9	106	59.6
CDC Glas	28.5	28.5	8	105	61.1
SVPT Entries					
CDC Rowland	29.4	28.9	4	108	59.7
AAC Prairie Sunshine	27.1	27.2	10	107	60.1
CDC Dorado	24.5	24.2	16	104	55.0
CDC Kernen	29.3	29.5	2	106	62.7
FP2591	27.9	28.6	6	108	59.4
3rd Year Entries					
FP2600	27.5	27.0	12	110	62.9
FP2602	26.1	25.7	14	109	64.3
FP2604	26.0	25.5	15	107	59.9
2nd Year Entry					
FP2606	27.0	28.5	7	106	59.9
1st Year Entries					
FP2607	28.1	29.0	3	108	61.1
FP2608	29.2	29.6	1	107	61.3
FP2609	28.5	28.8	5	106	60.2
FP2610	25.4	26.3	13	106	60.6

13.0 Development of improved varieties of Camelina for the Canadian Prairies 2022

Project duration: 2018-2023
Collaborators: Christina Eynck (AAFC), Smart Earth Camelina Corporation

Objectives

- To develop adapted early maturing camelina lines with superior seed yield, high seed oil, high meal protein content, and resistance/tolerance to biotic stresses such as disease and insect pests

- To develop camelina lines with greater seed size

Background

The oilseed camelina (*Camelina sativa*) is being developed as a lower-input crop which can be grown profitably on land where other oilseeds perform poorly, providing much needed rotation options, a new source of revenue, and a reduction of risk for producers. Camelina seed is rich in oil (30–46%), with unique properties that make it suitable for a wide range of uses. The high omega-3 fatty acid content and stability of the oil makes it well-suited both for food and feed applications and for oleochemical and fuel uses. Camelina seed meal has high nutritional value and is already approved for use in livestock feed.

The major breeding objectives for camelina include—but are not limited to—developing adapted early-maturing lines with superior seed yield, high seed oil and meal protein contents as well as resistance/tolerance to biotic stresses such as disease and insect pests. Another breeding objective that deserves attention is the improvement of seed size. Most camelina varieties are relatively small seeded when compared to other oilseeds such as canola or flax. The replicated camelina performance evaluation conducted in Melita, MB is part of a Diverse Field Crops Cluster project which started in 2018 and will continue until 2023. The project is working to continue spring camelina breeding activities to combine favourable agronomic traits, such as high seed yield potential, disease resistance, and large seed size with quality traits such as high seed oil content, improved fatty acid profile, and herbicide resistance. There were nine accessions tested. Both Smart Earth Camelina Corporation and AAFC, as the current champions for this new crop, are working together on this activity. More information on the project can be found at: https://www.dfcc.ca/camelina or by contacting Dr. Christine Eynck directly at AAFC in Saskatoon, SK.

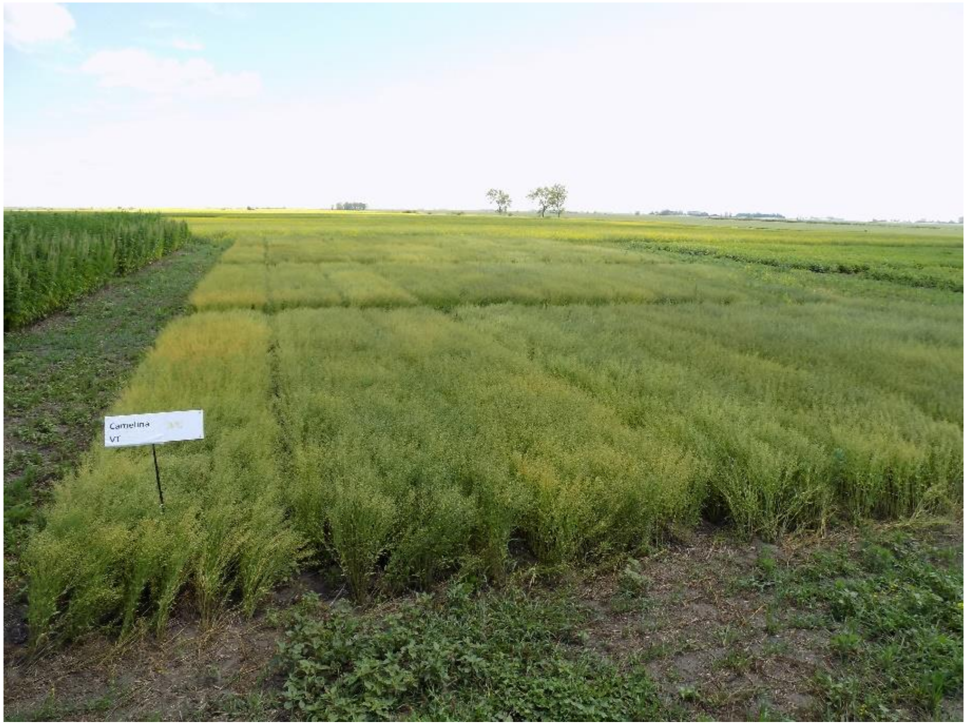

Figure 3. Camelina trial grown at Melita in 2022.

14.0 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 performance and help producers select varieties which prevail in their areas of production.

Methods and Materials

Pre-registration coop variety trials were conducted at Melita and Reston in 2022 and laid out in randomized complete block design with 14 treatments replicated 4 times at each site. The Melita site (Waskada Loam) trials were established on hailed oat stubble and the Reston site (Alexander Loam) trials were established on soybean stubble. Seeding was done on May 16th at the Melita site and on May 27th 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 104-30-22-13-1 and at the Reston site at 104-35-25-15-2 actual lbs ac^{-1} (N-P-K-S-Zn).

In-crop weed and insect control at both sites are displayed in the table below:

Table 7a and 7b. In-crop weed and insect control in Yellow Mustard at the Melita and Reston sites.

Melita Site		
Date of application	Products and Rates	Reason
01-Jun	Pounce @ 70mL/ac	Flea Beetles
06-Jun	Pounce @ 70mL/ac	Flea Beetles
07-Jun	Matador @ 34mL/ac	Flea Beetles
08-Jun	Assure II @ 0.2L/ac + Suremix @ 0.5% + Muster @ 8g/ac	In-crop Weed Control

Reston Site		
Date of application	Products and Rates	Reason
03-Jun	Pounce @ 70mL/ac	Flea Beetles
08-Jun	Matador @ 34mL/ac	Flea Beetles
13-Jun	Suremix @ 0.5% + Muster @ 8g/ac - tank mixed with Matador @ 34mL/ac	In-crop Weed Control + Flea Beetles
22-Jun	Arrow @ 120mL/ac + X act @ 0.5% - tank mixed with Matador @ 34mL/ac	In-crop Weed Control + Flea Beetles

Prior to harvesting both sites were desiccated with Reglone (0.69L ac^{-1}) and LI700; Melita on August 8th and Reston on August 19th. Melita plots were harvested on August 15th, and Reston plots were harvested on August 30th. 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

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15.0 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 2022. 14 varieties of Oriental Mustard and 16 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 14.0). 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 30th. 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

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16.0 Dry Bean Cooperative Registration Trial

Project duration: 2019 - 2022
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 for potential registration.

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

The trial was established near Melita, on Waskada Loam soil SW18-4-26. The treatments were seeding into harvests hailed oat stubble at a depth of 1 inch on the 16th of May. Granular fertilizer was banded at seeding at a rate of 97-30-22-13-1 (N-P-K-S-Zn) actual lbs ac^{-1}. Chemical weed control included a burn-off application of Roundup Transorb (0.33L ac^{-1}), Aim (120mL ac^{-1}) and Rival (0.65 L ac^{-1}) on the day of seeding. Viper (0.4L ac^{-1}) plus UAN (0.8L ac^{-1}) was applied on June 20th and Arrow (120mL ac^{-1}) plus X act (0.5%) was applied on June 29th for addition in-crop weed control. On June 13th, Matador (15mL ac^{-1}) was applied targeting corn seed maggots, cutworms, and grasshoppers. On July 5th, hand weeding was done for additional control of buckwheat, volunteer canola, and lamb's quarters. The beans were desiccated on September 1st with Reglone (0.69L ac) with LI700. The plots were harvested on September 8th. 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

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17.0 Roquette Canada Variety Adaptation Trial for Higher Protein Pea Lines

Project Duration: 2022
Collaborators: Roquette Canada Ltd.

Objectives

- To identify new pea variety genetics with competitive yields, higher protein as well as reduced lodging and seed coat breakage.

Background

New pea genetics are being evaluated to find if there are varieties that will be competitive with, or better than, the pea varieties that are most commonly grown currently. These varieties were also evaluated for protein content and seed quality, both of which are important traits for the protein processing industry. With the results from this variety trial, producers in Manitoba can make decisions about variety selection that can assist them in growing better quality peas more efficiently and profitably, while also sustaining the acreage available in Manitoba for pea protein processing.

Methods and Materials

A conventional field pea variety trial was established near Melita, Manitoba in 2022. These plots were established on Waskada Loam soil near SW18-4-26 into oat stubble. The trial was arranged in a randomized complete block design with eight treatments (varieties). The varieties grown were AAC Carver, CDC Spectrum, and AAC Beyond as checks, and Eq301S22, Eq2311B1, DL1813, DL1814, and DL15203 as experimental lines. The plots were seeded with a Seedhawk dual knife air seeder on May 6th at a depth of 1-inch. The plots were seeded into ample moisture with 15-35-25-15-2 (N-P-K-S-Zn) actual lbs ac^{-1} side-banded. One application of in-crop weed control was applied on June 3rd as Odyssey (17.3g ac^{-1}) with Merge at 0.5%. Cygon (120mL ac^{-1}) was applied on July 12th for control of aphids. The plots were desiccated on August 4th with Reglone (0.69L ac^{-1}) with LI-700 at 29gal ac^{-1} water volume. All the pea plots were harvested on August 10th.

Results and Discussion

Table 8. Results from the 2022 Roquette Conventional Pea Variety Trial in Melita.

Variety	Plant Stand 4-5 WAP (ppms)	Lodging 14-16 WAP	Ascochyta (Y/N)	Days to Maturity	Pod shatter yes/no	Plot Yield kg/ha	Yield bu/ac
DL 1813	78	1.3	Y	84	Y	4949**ab**	74
Eq 301S22	98	1.3	Y	86	Y	3899**c**	58
Eq 2311B1	65	2.0	Y	85	Y	4340**bc**	64
AAC Beyond	85	1.7	Y	85	Y	4830**ab**	72
CDC Spectrum	95	2.0	Y	86	Y	5106**ab**	76
DL 1814	83	2.7	Y	86	Y	5339**a**	79
AAC Carver	70	2.0	Y	84	Y	4909**ab**	73
DL 15203	99	2.0	Y	85	Y	5265**a**	78
P value	0.210	0.688	-	**0.001**	-	**0.001**	**0.001**
Grand Mean	84	1.9	-	85	-	4830	71.750
MSE	300	0.833	-	0.2971	-	107916	-
CV%	21	49	-	1	-	7	7
Yield is corrected to 14% moisture Values followed by the same letter are not significantly different by Fishers mean separation method at 95% confidence.							

In this trial, plant counts were not found to be significant (P = 0.210) between the 8 different treatments (Table 8). The variety DL 15203 had the highest plant count (99 ppms), and the variety Eq2311B1 had the lowest count (65 ppms). The lodging rating was also not found to be significant (P = 0.688) between the 8 varieties. The variety DL 1814 had the highest lodging score (2.7) and the varieties DL 1813 and Eq301S22 both had the best lodging score (1.3). All the treatments had Ascochyta presence during the growing season, as well as some degree of pod shatter at the time of harvest. Days to maturity was found to be significant (P = 0.001) between the different varieties. The varieties AAC Carver and DL1813 both had the least number of days to maturity (84). Three varieties, Eq 301S22, CDC Spectrum and DL 1814 had the highest days to maturity (86). Lastly, the yield of the 8 treatments were statistically significant (P = 0.001). The variety DL 15203 had the highest overall yield (5265kg ha^{-1}). Eq 301S22 was the variety with the lowest yield (3899kg ha^{-1}), which was not significant from the yield of Eq 2311B1 (4340 kg ha^{-1}).

Grain samples were delivered to Roquette for further protein testing.

18.0 Phillex: Quinoa Variety Performance Trial

Project duration: 2022
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.

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

A quinoa variety trial was established near Melita, Manitoba in 2022. Melita's plots were established on Waskada Loam soil near SW18-4-26 into oat stubble. The trial was arranged in a randomized complete block design with seven treatments (varieties) and three replicates over four site years. Varieties seeded were PHX22-01, PHX22-02, PHX22-03, PHX22-04, PHX22-05, PHX22-06 and PHX22-07. In Melita, plots were seeded with a Seedhawk dual knife air seeder on May 16th, 2022, into ample soil moisture at 0.5-inch depth and at a seed rate of 10 lbs ac^{-1}. Fertility was side banded during seeding at 104-30-22-13-1 (N-P-K-S-Zn) actual lbs ac^{-1} based on the soil tests taken in the spring. No pre-emergence weed control was needed; 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 June 10th. On June 5th, Matador was applied at a low rate for control of unidentified moths, stem flies, and grasshoppers. The WADO crew scouted and sampled for the mystery moths and eggs in hopes to get an identification. Cygon (120mL ac^{-1}) was applied to get some control over bertha armyworms and stem borer fly larvae (*Amauromyza karli* [Hendel]). Plots were swathed on September 21st and were harvested on September 28th. 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 Fishers LSD method at 95% confidence.

Results and Discussion

Table 9. Means and analysis of variance for plant height, plant lodging (1-5, 5=flat), days to maturity (DTM), vigor rating (1-9, 9= most), and yield of seven quinoa varieties grown in Melita, Manitoba in 2022.

Variety	Height	Lodging	Vigor	Days to Maturity	Yield Kg/ha
PHX22-01	118**c**	1.25**b**	7**c**	107	1323.8**b**
PHX22-02	135.5**a**	2**a**	5**e**	107	883.1**d**
PHX22-03	96**d**	1.25**b**	7**c**	106	1700.2**a**
PHX22-04	125**c**	1.25**b**	6.5**d**	107	1217.3**bc**
PHX22-05	134.8**ab**	1**b**	8**a**	107	757.6**d**
PHX22-06	125.3**c**	2.25**a**	7.5**b**	107	1019.3**cd**
PHX22-07	126.3**bc**	1**b**	8**a**	107	975.5**cd**
Grand Mean	123.0	1.43	7.0	106.9	1125.3
P-Value	**<0.001**	**0.011**	**<0.001**	*	**<0.001**
Significant?	**Yes**	**Yes**	**Yes**	No	**Yes**
MSE	39.59	0.25	0.095	*	36385
CV%					

Values followed by the same letter are not significantly different by Fishers mean separation method at 95% confidence.

*Yield adjusted to 13% moisture

^Assessed on a scale of 1-9 (1 = least vigour, 9 = most vigour)

There were significant (P<0.001) height differences among quinoa varieties grown in Melita in 2022, with PHX22-02 resulting in the greatest average plant height (135.5cm). Average height of PHX22-01, PHX22-04, PHX22-06 and PHX22-07 plots was not significantly different from that of PHX22-02 and PHX22-05 (Table 8). All varieties had average quinoa height significantly greater than PHX22-03, which resulted in the lowest average plant height (96 cm). Despite significant height differences observed among quinoa varieties, only two varieties, PHX22-02 and PHX22-06, had significant lodging (P = 0.011). The lack of observed lodging in the rest of the plots was likely due to very dry conditions in Melita in 2022 resulting in relatively low plant height. A significant (P<0.001) vigor rating difference was observed among quinoa varieties in 2022. The lowest vigor was observed in PHX22-02 quinoa plots (5.0); the highest vigor rating was observed in PHX22-07 and PHX22-05 (8.0). Days to maturity of quinoa varieties grown at the Melita site in 2022 had no significant differences. PHX22-03 matured in 106 days, and the rest of the varieties matured in 107 days. Very large yield differences were observed among quinoa varieties in 2022, with the greatest yield being observed from PHX22-03 (1700.2 kg ha^{-1}). Yield from that variety was more than double of the lowest yielding varieties, PHX22-02 (883 kg ha^{-1}) and PHX22-05 (758 kg ha^{-1}).

Quinoa grain yield in 2022 was much higher than yields observed in 2021, likely due to not as extremely dry conditions and high temperatures at the trial site in the early growing season past flowering of quinoa. However, grain yields were still below average and may have been reduced due to high insect pressure at the trial site. While insecticide was used for the control of stem borer fly larvae in late June, another application of insecticide was necessary in early July as well. Moderate diamondback moth and lygus bug populations were also a concern in late September. Late emerging lamb's quarters had to be hand weeded out of plots and could have also contributed to reduced quinoa yields. Quinoa yields could potentially be increased in the Prairies if varieties are continually improved and if more insect and disease control options are made available. Currently, there are few chemical pest control options which are registered for use in quinoa, making it difficult to address pest concerns during the growing season and maximize quinoa yields. Quinoa variety trials will continue to be conducted in Southwest Manitoba and other suitable areas to identify varieties which are well adapted to the Canadian Prairies.

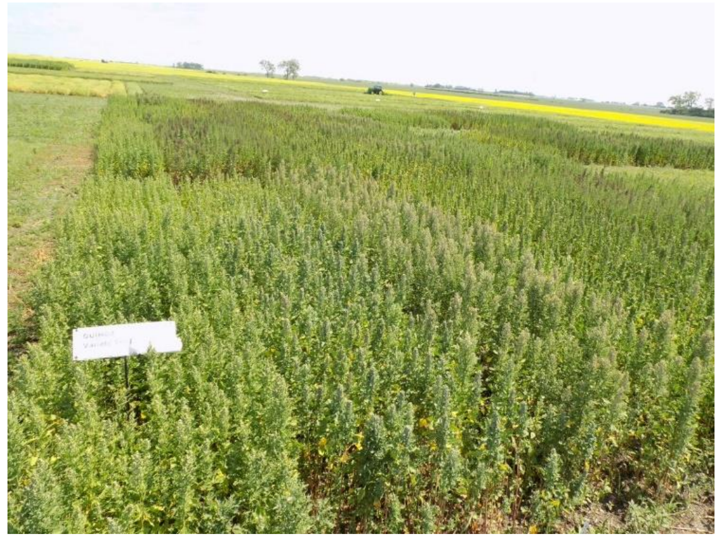

Figure 4. A picture of the quinoa variety trial that was grown at Melita in 2022.

19.0 Phillex: Evaluation of Quinoa Seeding Date

Project duration: 2022

Collaborators: Phillex Ltd. - Percy Phillips, WADO

Objectives

- Evaluate the effect of seeding date on quinoa grown in Manitoba

Background

Now that quinoa variety trials have been established for several years in Manitoba, there are more characteristics that researchers want to observe in different quinoa varieties. This trial is focused at observing the agronomic effects of seeding date on a number of quinoa varieties.

Materials and Methods

A quinoa seeding date trial was established near Melita, Manitoba in 2022. Melita's plots were established on Waskada Loam soil near SW18-4-26 into oat stubble. The trial was arranged in a randomized complete block design with four treatments (varieties) and replicated three times. All the seeding practices, apart from the seeding dates, for this trial were the same as the quinoa variety trial. The seeding date #1 was May 6th, #2 was May 17th, and #3 was June 3rd. There was no pre-emergence weed control used on the seed date #1 or #2 plots; Roundup Transorb (0.5L ac) tanked mixed with Aim (20mL ac) was applied as burn-off for seed date #3 plots. Fertility was side banded during seeding at 101-30-22-13-1 (N-P-K-S-Zn) actual lbs ac^{-1} based on the soil tests taken in the spring. In-crop weed control applications were the same as the variety trial, seed date #1 and #2 being applied on June 10th, and seed date #3 applied on June 22nd. On June 5th and 12th, the same insecticide treatments of Matador and Cygon that were applied to the variety trial were also applied to this trial for protection against bertha army worms, stem borer larvae, and grasshoppers. Plots for seed date #3 also got treated with Matador (34mL ac) for grasshoppers on June 22nd. All plots were swathed on September 21st and harvested on September 29th.

Results and Discussion

Table 10a. Means and analysis of variance for emergence date, plant height, lodging (1-5, 5=flat), vigor (1-9, 9=most), days to maturity and yield based on variety alone in the 2022 Quinoa Seeding Date Trial planted at Melita.

Variety	Emergence (ppms)	Height (cm)	Lodging	Vigor	Days to Maturity	Yield (kg/ha)
PHX22-02	150**a**	132**a**	1.9	5**c**	113**b**	1396**b**
PHX22-03	148**b**	99**b**	1.3	7**b**	109**c**	1781**a**
PHX22-05	149**b**	131**a**	1.3	8.**a**	116**a**	1189**b**
PHX22-07	150**a**	138**a**	2.2	6b	114**b**	1723**a**
Grand Mean	149.375	124.78	1.7	6.500	113	1522
P Value	**<0.001**	**<0.001**	0.058	**<0.001**	**<0.001**	**0.003**
Significant?	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**
C.V.%	0.1	9.2	45.6	13.3	2.0	21.8

There were significant (P = 0.000) differences in emergence between the four varieties of quinoa grown in the seeding date trial in 2022 (Table 10a). PHX22-03 and PHX22-05 had earlier emergence (approximately the 148th day of the year) while PHX22-02 and PHX22-07 had later emergence (approximately the 150th day of the year). The differences in height between the varieties where also significant (P = 0.000). PHX22-07 was the tallest (137.67cm), and its height was not significantly different from varieties PHX22-02 and PHX22-05. PHX22-03 was the shortest (98.56cm) variety of the trial. There were no significant lodging differences (P = 0.058) found between the varieties. The quinoa varieties did show significant (P = 0.000) differences in vigor in the seeding date trial. PHX22-05 had the highest vigor (8.111 out of a possible 9) while PHX22-02 had the lowest vigor rating (5.111 out of 9). PHX22-03 and PHX22-07 where in between on the vigor rating scale and not significantly different than each other. Without considering the date of seeding as a factor, there were still significant (P = 0.000) differences in days to maturity between the four varieties seeded. PHX22-05 took the longest to mature (116.1 days) and PHX22-03 took the shortest time to mature (109.1 days). PHX22-02 and PHX22-07 matured in the middle (113.7 and 112.8 days) and were not significantly different from each other. Yield, arguably the most interesting characteristic evaluated in this project, was found to be significant (P = 0.003) when comparing the four varieties. PHX22-03 had the highest yield (1781 kg ha^{-1}) but was not significant from PHX22-07 (1723 kg ha^{-1}). PHX22-05 had the lowest yield (1189 kg ha^{-1}) and it was also not significant from PHX22-02 (1396 kg ha^{-1}). In this trial, when only considering variety characteristics, the varieties could be categorized as short season or long season. For a variety with a shorter maturity, PHX22-03 performed the best, while PHX22-07 performed the best for a longer season variety.

Table 10b. Means and analysis of variance for emergence date, plant height, lodging, vigor, days to maturity, and yield based on seeding date alone for the 2022 Quinoa Seeding Date Trial planted at Melita.

Date	Emergence (ppms)	Height (cm)	Lodging	Vigor	Days to Maturity	Yield (kg/ha)
Seed Date 1	139**c**	131	1.4	6.8	122**a**	1323**b**
Seed Date 2	147**b**	123	1.8	6.2	115**b**	1486**ab**
Seed Date 3	163**a**	121	1.8	6.5	101**c**	1786**a**
Grand Mean	149.4	125	1.7	6.5	113	1532
P Value	**<0.001**	0.109	0.330	0.192	**<0.001**	**0.014**
Significant?	**Yes**	No	No	No	**Yes**	**Yes**
C.V.%	0.1	9.2	45.6	13.3	2.0	21.7

As expected, there are significant (P = 0.000) differences in emergence date when comparing the three different seeding dates that were used in this trial in 2022 (Table 10b). Seeding Date 1 (May 6th) had the earliest emergence, Seeding Date 2 (May 17th) emergence was next, and Seeding Date 3 (June 3rd) had the latest emergence. With each seeding date, the days that it took the crop to emerge decreased; this implicates that quinoa emergence is better when seeded into warmer soils. Again, as expected, there were significant (P < 0.001) differences in days to maturity when compared the different seeding dates used in the trial. Seeding Date 1 had the most days to maturity (122.1 days), Seeding Date 3 had the least days to maturity (101.3 days), and Seeding Date 2 was in between. In the 2022 seeding date trial, the later the plots were seeded, the faster the quinoa matured. That is a great trend to see in an area like Southwest Manitoba that has a relatively short growing season. Lastly, significant (P = 0.014) differences were found when comparing the yield of the quinoa seeded on different dates. Seeding Date 3 plots had the highest yield (1785.8 kg ha), Seeding Date 1 had the lowest yield (1323.3 kg ha) and once again, Seeding Date 2 was in the middle, and was not significant from the other two dates. Just as the trend seen in emergence date, the yield increased as the plots were seeded at later dates. This is an interesting trend to see and is also a positive for the region with the short growing season. Height, lodging, and vigor were not found to be significant between the three seeding dates.

Table 10c. Means and analysis of variance for emergence, plant height, lodging, vigor, days to maturity, and yield based on both variety and the seeding date for the 2022 Quinoa Seeding Date Trail planted at Melita.

Variety	Emergence (ppms)	Height (cm)	Lodging	Vigor	Days to Maturity	Yield (kg/ha)
Seed Date 1						
PHX22-02	139**f**	139	1.7	5.0	123**b**	1040
PHX22-03	139**f**	106	1.0	6.7	117**cd**	1810
PHX22-05	139**f**	134	1.3	8.3	127**a**	844
PHX22-07	139**e**	144	1.7	7.3	121**bc**	1899
Average	139	131	1.1	6.8	122	1398
Seed Date 2						
PHX22-02	147**c**	137	1.7	5.0	114**d**	1377
PHX22-03	146**d**	91	1.3	7.3	110**e**	1669
PHX22-05	146**d**	128	1.7	7.7	119**bc**	1132
PHX22-07	147**c**	138	2.7	4.7	118**c**	1764
Average	147.0	123	1.8	6.2	115	1486
Seed Date 3						
PHX22-02	164**a**	121	2.3	5.3	101**f**	1772
PHX22-03	161**b**	99	1.7	6.7	100**f**	1864
PHX22-05	161**b**	130	1.0	8.3	102**f**	1592
PHX22-07	164**a**	132	2.3	5.7	101**f**	1807
Average	163	121	1.8	6.5	101	1759
Grand Mean	149.4	124.78	1.7	6.5	113.00	1547.5
P Value	**<0.001**	0.645	0.676	0.074	**0.029**	0.482
Significant?	**Yes**	No	No	No	**Yes**	No
C.V.%	0.1	9.2	45.7	13.3	2.0	21.5

Values followed by the same letter are not significantly different by Fishers mean separation method at 95% confidence.

*Yield adjusted to 13% moisture

^Assessed on a scale of 1-9 (1 = least vigour, 9 = most vigour)

The purpose of this project was to find any effects that different seeding dates have on different varieties of quinoa. When seeding date and variety are evaluated together instead of separately, only emergence date, and days to maturity have significance when the statistical data is compared (Table 10c). In 2022, the earlier that the plots (all varieties) were seeded, the earlier they emerged. Varieties PHX22-02, PHX22-03, and PHX22-05 seeded on Seeding Date 1 (May 6th) emerged the earliest (May 19th) overall. Varieties PHX22-02 and PHX22-07 seeded on Seeding Date 3 (June 3rd) emerged the latest (June 13th) overall. In 2022, over all sets of seeding dates, the variety PHX22-07 consistently emerged later, while PHX22-03 and PHX22-05 consistently emerged earlier than other varieties. When evaluating days to maturity, the earlier seeded plots needed more days to maturity than the later seeded plots. This trend can probably be attributed to warmer soil temperature at the time at seeding increasing early season vigor of the quinoa, and the plants emerging into higher levels of Growing Degree Days (GDD) than earlier seeded plots. The variety PHX22-05 have the most days to maturity of the whole trial (127 days) when it was seeded on Seeding Date 1. The variety PHX22-03 had the least number of days to maturity of the whole trial (100 days) when it was seeded on Seeding Date 3, and it was not significant from the other varieties seeded on that date. In each of the three seeding dates, PHX22-05 was consistently the latest maturing variety, while PHX22-03 was consistently the early maturing variety. Varieties PHX22-02 and PHX22-07 fell in the middle for number of days to maturity over all three seeding date treatments. It is interesting that yield is not a significant factor when evaluating it by variety and the seeding date.

Looking at the results of this trial, it appears that seeding date had a definite effect on the performance of different quinoa varieties. There is not enough confidence to confirm one variety is better suited for long or short growing seasons by one year of data alone. The data does look promising; hopefully in the future, tables of characteristics used by producers similar to those in the MB Seed Guide can be made for quinoa varieties.

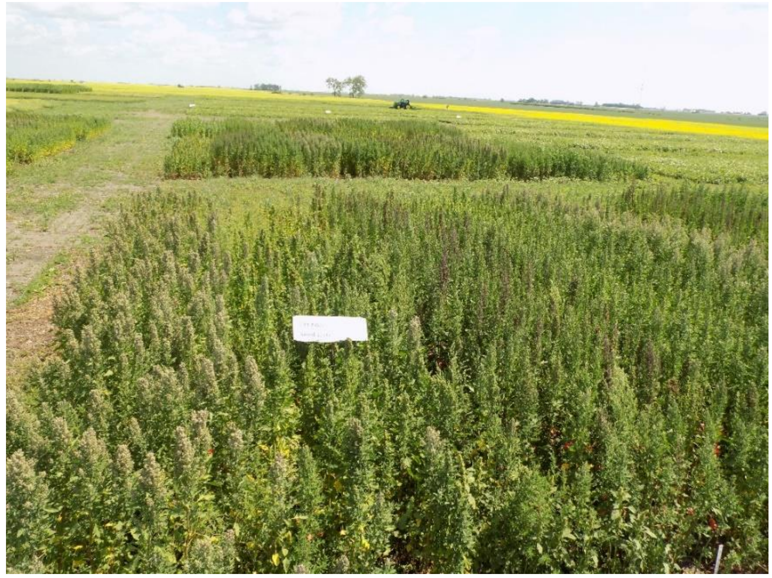

Figure 5. A view of the Quinoa Seeding Date Trial that took place by Melita in 2022.

20.0 Assessment of Dormant Spring Seeded Winter Wheat Spring Wheat, Winter Peas, Winter Oats, and Winter Barley for Adaptability in Manitoba's Agro-climate

Project Duration: 2022
Collaborators: Ducks Unlimited, Western Ag & Professional Agronomy, MB Diversification Centres

Objectives:

- To assess ultra-early seeded winter wheat (vs. spring wheat), winter peas, winter oats, and winter barley for adaptability in Manitoba's agro-climate.

Background

Seeding time can be busy and in years where the conditions allow it, dormant seeding would help spread out the seeding and harvest timeframe for farmers. In this case, dormant seeding is when the first two inches of the soil has thawed to 0.0-1.0°C. If it is going to be a dry spring and there is bare ground, some fields could get in the ground 'ultra-early' to utilize the moisture that is there and prevent soil erosion. Winter wheat and fall rye are the most common winter crops grown in Manitoba, but there are many other winter crops that could be utilized on farms to increase diversification and lengthen rotations. This trial looked at different winter crops (barley, oats, and peas) to see if they would be suited for earlier-than-normal spring seeding instead of fall seeding in this region's agro-climate. These crops if seeded in the fall may be too soft for the harsh winters in Manitoba, thus dormant spring seedings may prove successful. The crops were evaluated in terms of flowering and head date, days to maturity, yield, and grain quality to see if this could be a suitable practice for Southwest Manitoba. Beyond their ability to tolerate frost in Manitoba springs is likely the larger concern of getting the seeds to reach the required vernalization time like fall seeded winter wheat or fall rye. Vernalization is the process where plants need to sense exposure to cool temperatures to reach flowering (NDSU). We know that winter wheat will not be able to go through its reproductive stages (flowering) and develop seeds if it has not vernalized. When we move from fall seeding to spring dormant seeding, the length of time that the seeds are exposed to the cold soil temperature is of concern because vernalization only happens when the soil temperature is 0 to 7-10°C (Weir et al. 1984). In the spring there may not be enough time before the soil warms for vernalization to finish. What we don't know in this case, is what length of time of vernalization is required for reproduction. If the correct time of vernalization is not reached, the seeds may still germinate, but will not be able to produce seed.

Methods and Materials

This trial was established at locations near Melita, Roblin, Carberry and, Manitoba in 2022. Melita's plots were established on Waskada Loam soil on SW22-3-27W1. The plots were seeded using a 6-row dual knife Seedhawk air seeder into canola stubble at a depth of 1-inch. Plots were seeded on April 8th into excellent moisture, and no pre-emergence herbicide was required. Target seeding rate was 225 plants m^{-1} for cereals, 90 plants m^{-1} for peas and 130 plants m^{-1} for lentil; all plots assumed 20% mortality, germination and seed weights. Varieties of crops included 'Goldrush' and 'Wildfire' winter wheat, 'Brandon' sping wheat, 'Endeavor' winter barley, 'R30(21) line A x 302 030C001' winter oat, 'Blaze' winter pea, and 'Super Cool' winter lentil. The later 5 crop seed was sourced from Western Ag & Professional Agronomy. Soil temperature at seeding was 0°C. A soil temperature station was already placed at the site and recordings were taken every hour at a 2" depth from November 1st, 2021, to May 10, 2022. At the time of seeding, the peas were inoculated with pea granular inoculant (Nodulator, BASF), and fertilizer was side-banded at 13-30-21-13-2 (N-P-K-S-Zn actual lbs ac^{-1}) to all plots. Agrotain treated urea was applied to the plots on April 11th; rates can be found below in Table 11a. In Melita, three plots of winter lentils were added onto the trial to see what would result. In-crop weed control for peas was applied as Sencor (120g ac^{-1}) at 20gal water volume ac^{-1}, and for cereals as Mextrol (0.5L ac^{-1}) at 10gal water volume ac^{-1} on May 27th. All the in-crop herbicides were applied using a CO_2 pressurized hand sprayer. Some hand weeding was required. All plots except the winter wheat plots were harvested on August 16th. The winter wheat plots were harvested on September 1st. Data collected throughout the season includes the following: emergence dates and counts, soil temperature, stand percent, head dates (cereals), flower date (peas and lentils), maturity date, and harvest yield and moisture

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Table 11a. Rates of Urea (46-0-0) applied to winter crop plots.

Crop	Urea (Actual N) Rate*
Winter Wheat	120lbs/ac
Spring Wheat	120lbs/ac
Winter Barley	100lbs/ac
Winter Oats	80llbs/ac
Winter Peas	0lbs/ac
Applied on April 11th, 2022 *Treated with Agrotain	

Results and Discussion

Soil temperatures were recorded after seeding (Figure 6a) each hour until soil temperatures remained consistently over 10°C. Soil temperature time between 0°C and 8° C required for vernalization were tracked and accumulated by the hour. Approximately 340 hours or 14 days accumulated between these temperatures after seeding. During this time two blizzards occurred April 12th and 23rd which likely enhanced the accumulation of time within these temperatures until the snow was melted once again April 27th allowing for warmer fluctuations.

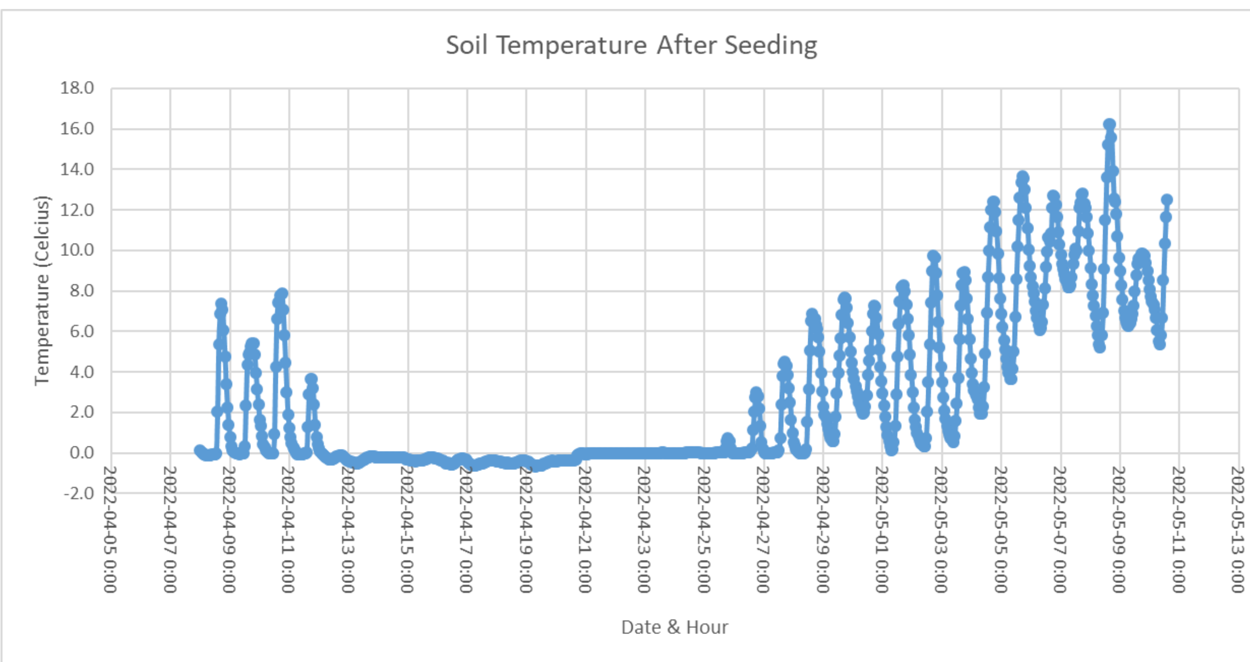

Figure 6a. Soil temperature values at 2” depth each hour from April 8th to May 10, 2022 when station removed from site.

Table 11b. The means, variances, and standard deviations of plant counts in the winter crops grown at Melita in 2022.

		Plant Counts (1 Meter Squared)					
Crop	**Variety**	**2WAE (Mean)**	**Variance**	***S.D.**	**6WAE (Mean)**	**Variance**	***S.D.**
Winter Wheat	**Wildfire**	120	149.0	12.2	108	420.0	20.5
	Goldrush	196	169.5	13.0	148	363.7	19.1
Spring Wheat	**Brandon**	146	340.7	18.5	112	159.9	12.6
Winter Peas	**Blaze**	40	15.4	3.9	44	39.8	6.3
Winter Barley	**Endeavor**	116	211.5	14.5	100	140.7	11.9
Winter Oats	**R30 (21)**	166	349.9	18.7	142	406.2	20.2
Winter Lentils	**Super Cool**	64	243.3	15.6	66	334.8	18.3
*Standard Deviation (from the mean)							

Some crop counts were higher, and some lower in the 6-week after emergence (WAE) plant counts compared to the 2-week counts (Table 11b). Having a lower number of plants in the second count may indicate seedling mortality, while a higher number of plants in the second count may indicate delayed emergence. To compare to the target plant counts recommended by Manitoba Agriculture, all the cereal crops should fall into the range of 20-28 plants per square foot, or 215-300ppms (plants per meter squared). In this trial, not one of the cereal crops planted met the desired rates. Although no cereals reached the target stands, there are some that did better under these conditions than others. Since all the cereals were seeded at the same seeding rate, it is easy to see which crops handled the ultra-early seeding better. For the winter wheat varieties grown, Goldrush had substantially higher plant counts than Wildfire. Just evaluating counts overall, the best to worst cereal crops are as follows: Goldrush winter wheat, winter oats, spring wheat, Wildfire winter wheat, then winter Barley. Barley is interestingly in last place; usually barley is more competitive than the other cereal crops. Looking at the variances instead of numbers, the 2WAE counts had less spread across the collected data than the 6WAE counts; this again can be contributed to seeding mortality and/or delayed emergence in the plots. Across the cereals, both winter wheat varieties had lower variances for the 2WAE counts, and for the 6WAE counts, the winter barley had the lowest variance and therefore lowest spread in data points.

Manitoba Agriculture recommends a stand of 7-8 plants per foot squares, or 70-80ppms for peas. The pea plots in this trial had stands that were roughly half of that target. For lentils, it is recommended to have a stand of 10-14 plants per foot squared or 108-150ppms; the lentils only reached half the target as well. The lentil plots also had severe weed pressure throughout the season which required hand-weeding multiple times; perhaps some plants were lost to this competition. Looking at the variances instead of numbers, the winter peas had the lowest variances in both the 2WAE and 6WAE counts across the whole trial. This implies the peas had the most consistent plant stands across all the crops even though the total counts were below the targeted stand. The winter lentils had variances that were more similar to the cereals, having more variation in count numbers compared to the peas.

Table 11c. The means, variances and standard deviations of yield, and crop development information in the winter crops grown at Melita in 2022.

		Crop Development		Yield		
Crop	Variety	Date of Flower/Head	Days to Maturity	Kg/ha	Variance	*S.D.
Winter Wheat	Wildfire	18-Jul	138	1319	263786	514
	Goldrush	15-Jul	126	2972	46547	216
Spring Wheat	Brandon	29-Jun	120	3353	15518	125
Winter Peas	Blaze	29-Jun	119	2198	198109	445
Winter Barley	Endeavor	11-Jul	120	5139	52881	230
Winter Oats	R30 (21)	04-Jul	112	4142	126557	356
Winter Lentils	Super Cool	29-Jun	129	360^	-	-

Days to Maturity = days from seeding to maturity
*Standard Deviation (from the mean)
^the material of all three lentil plots were combined due to poor yield then divided by 3 plots

Days to maturity is the measurement of how long the crop takes to mature from the day of seeding. Maturity is an important characteristic to evaluate since Manitoba has a relatively short growing season, and the crop may not be harvestable if it has not matured by a certain time. In this trial, these dates were noted for all the winter crops to be compared to the maturity timing that is desired for these same crops at normal seeding times. The purpose of this evaluation is to see if the practice of seeding ultra-early may cause issues at harvest time. The rate of crop development can also give indications of shifts in fungicide timing. For days to maturity (DTM), the winter crops will be compared to the average DTM of the same crop from the 2022 Manitoba Seed Guide. For the spring wheat, AAC Brandon was the variety used; according to the Seed Guide, it's normal days to maturity is 101 days, while in this trial it matured in 120 days (Table 11c). The Seed Guide outlines 88 days for barley and 96 days for oats; in the trial they matured in 120 and 112 days, respectively. Since the Seed Guide does not have any focus on days to maturity for winter wheat, and the seeding dates being extremely different compared to regular-seeded winter wheat, it is hard to make a comparison. The MCVET winter wheat trial grown at the same site was harvested on August 10th which is a normal harvest time for winter wheat. Harvest of the winter wheat grown in this trial was delayed because of how green the crop was; the plots were harvested on September 1st. With roughly 3 weeks difference in harvest time, it can be assumed that the ultra-early seeded winter wheat had delayed maturity compared to winter wheat seeded in the fall. Normally, peas mature in roughly 91 days; in this trial they matured in 119 days. According to Sask Pulse, early-season lentils mature in 100 days, and late-season in 110 days. In this trial, they matured in 129 days. Every crop grown in this trial had delayed maturity which could be a result of reduced early-season seedling vigor and weed competition due to the stressful environment that the seeds were growing in. This could also explain why the plots had such low emergence counts and therefore yield. Reduced Growing Degree Days early in the growing season likely contributed to the slow maturity of the plants.

In terms of yield, all crops had significantly lower than normal yields when compared to other trials of the same fall or spring crops which were seeded at the regular time at the same site (Table 11d) under similar agronomy. All yields were compared in kg ha^{-1} and corrected to 14% moisture to make the comparison more accurate. When compared to the average yield of the other trials at the same site, the winter barley had the closest yield to the average yield of the corresponding barley trial. The winter wheat variety Wildfire had the lowest yield of the cereals in the winter crops and was also the lowest when compared to the average yield of the corresponding winter wheat trial. It is hard to compare yield in this situation since the crops were seeded at the correct target rates, but the counts were extremely reduced.

It would be positive to have extended seeding and harvest periods to reduce the stress and rushing. This trial has only one year of data, but initial findings indicate that while early spring dormant seeding does delay maturity and consequently harvest, yield reductions are significant enough to disqualify this as an economical option for farmers. Possible advancements of genetics of winter crop varieties could improve the emergence and vigor of the seedlings early on, enabling more plants are able to be harvested. Further site years and data would be needed to make definite conclusions on if this could be beneficial to producers.

Table 11d. Seeding dates, days to maturity, harvest dates, and yields of other MCVET cereal trials at the same site to use as a comparison to the winter crops grown in this trial.

	Results from Other Trials on Site for Comparison			
Crop	**Seeding Date**	**Days to Maturity**	**Harvest Date**	**Kg/ha @ 14%**
Winter Wheat	2021-09-10	-	2022-08-12	6770.6
Spring Wheat	2022-05-05	-	2022-08-22	4690.8
Barley	2022-05-05	89	2022-08-12	5892.9
Oats	2022-05-05	90	2022-08-16	6414.9
All values are averages taken from all varieties and reps in the trial. These values were collected to compare to the winter crops that were grown at the same site.				

Pictures

Figure 6b. From left to right: Wildfire winter wheat, Goldrush winter wheat, Brandon spring wheat, winter barley (Endeavor).


Figure 6c. From left to right: winter oats, winter peas, very weedy winter lentils.

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21.0 Fusarium Head Blight

Project Duration: 2022
Collaborators: Dr. Mkhabela (University of Manitoba)

Background and Protocol

This year, WADO teamed up with the University of Manitoba to assist in improving the current Fusarium Head Blight Model by collecting head samples from the MCVET winter wheat, spring wheat, and barley trials. The seeding, harvest, and agronomic information about these trials can be found in Table 2 (MCVET table). The varieties used for the collection can be found in Table 11, below. In Melita, the winter wheat heads were collected on July 11th, spring wheat heads on July 25th, and the barley heads on July 27th when the plots were approximately 18-21 days past anthesis. For each plot (three plots for each variety) there were 50 heads collected for a sample.

In previous years, spikelet ratings had been done to evaluate the presence of FHB, but this year the heads were frozen to preserve any spores present and sent away for testing along with the weather data from the growing season. 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 4 years (including 2022), 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. Hopefully this project can continue in 2023 and be able to link to the MCVET trials for a long-term Fusarium Head Blight study.

Table 12. Varieties used for Fusarium Head Blight Analysis from Melita in 2022.

Winter Wheat	Emmerson
	Network
	AAC Vortex
Spring Wheat	AAC Brandon
	CDC Silas
	AAC Rimbey
Barley	AAC Synergy
	AAC Connect
	CDC Bow

22.0 Evaluation of Dry Bean Inoculants in Manitoba

Project duration: 2020-2022
Collaborators: University of Manitoba, MPGA, Kristen MacMillan

Objectives

- To determine if recent commercially available inoculants improve nodulation and yield in pinto, navy and black beans compared to non-inoculated checks and if the response varies by bean type.

Background

Dry bean is an important legume crop in most parts of the world. Nitrogen is one of the most yield-limiting factors in all dry bean producing regions globally. Maximum yields are usually achieved through supply of adequate nitrogen, which can be sourced from synthetic fertilizers, biological nitrogen fixation or both (Fageria et al. 2013). In most dry bean production systems, it is recommended to inoculate seed before planting in order to improve nodulation, as dry bean tends to be a poor N-fixing crop, and thereby improving yield potential of the crop through biological nitrogen fixation (Manitoba Pulse and Soybean Growers, 2022). Inoculation of dry bean (*Phaseola vulgaris* L.) can increase symbiotic nitrogen fixation and yield and reduce dependence on synthetic fertilizers (Sanyal et al., 2020). Various forms of dry bean inoculants are available, including granular, peat or liquid forms. The choice of an inoculant can depend on its impact on nodule formation or its compatibility with seeding equipment. Dry bean inoculants have been in use for a while in Manitoba, but there is need to assess recently available inoculants for improved dry bean nodulation and yield as historical success of bean inoculant products in Manitoba has been limited.

Materials and Methods

The trial was established on Waskada Loam soil in Melita, Manitoba in 2022. Twenty treatments were factorially arranged in randomized complete block design with four bean types (market classes) and five inoculation strategies replicated four times. The four dry bean market classes were Navy bean (T9905), Pinto bean (Vibrant), Black bean (Eclipse), and Kidney bean (Pink Panther). The five inoculation strategies included non-inoculated/non-fertilized (control), BOS (self-adhering peat), N-Charge (self-adhering peat), N-Charge + Accolade (liquid growth stimulant), and new for 2022, Rhizoliq Top Bean (liquid inoculant) treatments. The burn-off for the trial consisted of Roundup Transorb (0.5L ac^{-1}) before seeding, and Rival (0.65L ac^{-1}) after rolling the plots.

Seeding was done on June 6th at a depth of 1.25" using a 6-row dual knife Seedhawk air seeder at 100 000 seeds ac^{-1} for Pinto and Kidney beans and 130 000 seeds ac^{-1} for Navy and Black beans. Target plant stand was 70 000 plants ac^{-1} for Pinto and Kidney beans and 90 000 plants ac^{-1} for Navy and Black beans. Basal granular fertilizer blend was side banded during seeding at 16.5-30-22-13-1 (N-P-K-S-Zn) actual lb ac^{-1} consisting of monoammonium phosphate, potash, ammonium sulfate and zinc sulfate. It was necessary to sterilize seeding parts and seed boxes between inoculant treatments using 20% household bleach solution followed by compressed air to reduce cross-contamination between inoculation strategies. In-crop weed control was done in two different applications: Viper (0.4 L ac^{-1}) plus 28% UAN (0.81 L ac^{-1}), and Arrow (120mL ac^{-1}) plus X act (0.5%) both applied with a water volume of 10gal ac^{-1} using TeeJet® low drift spray nozzles. Plots were desiccated using Reglone on September 6th. Kidney bean plots were harvested on September 13th to avoid more shatter damage, while the remaining plots were harvested the next day, September 14th. Data collection included soil sampling, weekly staging from emergence until maturity, plant stand assessment (3-meter counts in two middle rows of plot – four weeks after seeding), nodulation ratings between R2 and R3 development stages, days to maturity, grain yield, grain moisture at harvest, and grain protein content.

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)

Acknowledgements

Manitoba Pulse and Soybean Growers Association, University of Manitoba.

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23.0 Optimizing Nitrogen and Phosphorous Management for Dry Beans in Southwest Manitoba

Project Duration: 2020-2022

Collaborators: Ramona Mohr (AAFC Brandon), Daryl Domitruk (Manitoba Pulse and Soybean Growers), Tom Henderson (AAFC Brandon), Mohammad Khakbazan (AAFC Brandon), Haider Abbas (CMCDC)

Objectives

- Determine the effect of nitrogen fertilizer rate, applied with and without inoculant, on the growth, yield, and quality of solid-seeded dry bean in southwestern Manitoba

- Determine the effect of phosphorus fertilizer rate and placement on dry bean performance

Background

Dry bean acreage in Manitoba has been steadily increasing, with 125,000 acres grown in 2015 and 185,000 acres grown in 2020 (Manitoba Pulse and Soybean Growers, 2020). As dry bean acreage in Manitoba increases, so does the need for dry bean management practices which are optimal for the region. Specifically, there is need for the development of nitrogen and phosphorus fertilizer management practices suitable for dry beans grown in Manitoba, as relatively little research has been done on dry bean production in the region. Though dry beans are a pulse crop, they are considered poor nitrogen fixing crops compared to peas and soybeans, and generally fix less than 50% of their required nitrogen (Manitoba Pulse and Soybean Growers, 2022). Though commercial inoculants are available, dry bean nitrogen application is typically managed like a non-legume crop. Adequate phosphorus application is also important to dry bean production, though little field research has been done in Manitoba to optimize phosphorus management strategies in dry bean crops. Two dry bean trials were developed to investigate the response of dry beans to various nitrogen or phosphorous management strategies in Manitoba. The nitrogen trial investigated the response of pinto and black beans to various nitrogen rates banded during seeding with or without commercial inoculant. The phosphorus trial investigated the response of black and pinto beans to various phosphorus rates side banded or placed with seed during seeding.

Materials and Methods

Nitrogen Trial

A dry bean nitrogen rate trial was established near Melita (SW 18-4-26) in 2022 on Waskada Loam soil. Black bean (Eclipse) and pinto bean (Windbreaker) trials were separately arranged in randomized complete block design with twelve treatments replicated four times (Table 12a). Beans were seeded using a Seedhawk dual knife opener air seeder at 1-inch depth on May 25th. All trials were seeded at a rate of

105, 000 plants/ac (26 live plants per m^2). Nitrogen was side banded at varied rates as urea (or SuperU for treatments 11 and 12), and BOS self-adhering peat inoculant (BOS Inoculants – Nutriag) was used for inoculated treatments. Monoammonium phosphate (MAP) was side-banded at 25 kg ha^{-1} actual phosphorus. To avoid contamination of non-inoculated treatments via seeding machinery, inoculated treatments were seeded after all non-inoculated treatments. Plots were burned off after seeding using Roundup Transorb (0.33L ac^{-1}), Aim (120mL ac^{-1}), and Rival (0.65L ac^{-1}) at 10 gallons of water ac^{-1}. In-crop weed control was delivered using Viper (0.4 L ac^{-1}) mixed with 28% UAN (0.8 L ac^{-1}) on June 20th, and Arrow (120mL ac^{-1}) with X act (0.5%) on June 29th. Plots were desiccated using Reglone (0.65 L ac^{-1}), Roundup (0.5 L ac^{-1}), and LI700 surfactant (0.25%). Pinto beans were harvested on September 7th and Black beans on September 12th. Data collection included: Spring soil sampling, soil temperature and moisture at seeding, emergence date, days to flowering, days to end of flowering, days to maturity, plant stand determination, vigor rating, greenness score, chlorophyll meter and NDVI readings, nodulation score, lodging ratings, plant height, grain yield, and grain moisture at harvest.

Phosphorous Trial

A dry bean phosphorus rate trial was established adjacent to the nitrogen dry bean trials near Melita (SW 18-4-26W1). Black bean (Eclipse) and pinto bean (Windbreaker) trials were separately arranged in randomized complete block design with eight treatments replicated four times (Table 13b). Phosphorus was either placed with seed while seeding or side banded as monoammonium phosphate (11-52-0) at rates of 0, 20, 40 or 60 actual kg ha^{-1} phosphorus. A small amount of urea was applied to balance nitrogen values from applied MAP treatments. Weed control and desiccation protocol was similar to that of the nitrogen trials. Pinto beans were harvested on September 7th and black beans on September 13th. Data collection included: Spring soil sampling, soil temperature and moisture at seeding, emergence date, days to flowering, days to end of flowering, days to maturity, plant stand determination, biomass (five weeks after emergence), vigor ratings, lodging ratings, plant height, grain yield, and grain moisture at harvest.

Table 13a and 13b. Treatments used in dry bean nitrogen and phosphorus trials established near Melita in 2022.

Nitrogen Trials		
Treatment	Nitrogen applied (actual kg ha^{-1})	+/- inoculant
1	0	+ inoculant
2	0	- inoculant
3	35	+ inoculant
4	35	- inoculant

Phosphorus Trials		
Treatment	P_2O_5 applied (actual kg ha^{-1})	Phosphorus Placement
1	0	Seed placed
2	0	Sideband
3	20	Seed placed
4	20	Sideband

5	70	+ inoculant
6	70	- inoculant
7	105	+ inoculant
8	105	- inoculant
9	140	+ inoculant
10	140	- inoculant
11	35 (as SuperU)	+ inoculant
12	105 (as SuperU)	+ inoculant

5	40	Seed placed
6	40	Sideband
7	60	Seed placed
8	60	Sideband

Results

Trial data and samples were sent to AAFC Brandon for analysis. This is ongoing research and preliminary results from all sites will be presented by Dr. Ramona Mohr.

In Melita, the nitrogen trials produced visual differences among beans which received different amounts of nitrogen fertilizer. Dry beans which received more nitrogen were generally greener and exhibited greater vigor.

Figure 7a and 7b. Left: Black bean phosphorous trial. Right: Pinto bean nitrogen trial. Both grown at Melita in 2022.

References

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25.0 The Effects of Pre-emergent and In-Crop Herbicides on Hairy Vetch

Project Duration: 2022
Collaborators: WADO

Objectives

- To demonstrate how hairy vetch responds to applications of pre-emergent and in-crop herbicides that are commonly used in agriculture, either for control of hairy vetch or for tolerance within hairy vetch

Background

Hairy Vetch (*Vicia villosa*) is a viny legume that thrives in cool conditions. It can be planted in either spring or fall and is considered to be a high nitrogen fixer. Hairy vetch is a very competitive, prolific, and sizeable plant, giving it great grazing potential, and it is also a good natural tool to use against weeds and soil erosion (Cover Crops Canada, 2022). Hairy vetch is commonly used by organic producers as a plough-down cover crop that creates nutrient reserves for the following year's crop (VanRaes S., 2013). Most conventional farmers are concerned about using vetch because management can be difficult. Recently, there has been more use of hairy vetch as an intercrop; specifically intercropping with glyphosate tolerant corn. This intercrop is designed for later-season grazing, and since hairy vetch has some tolerance to glyphosate it's a good partner for glyphosate tolerant corn. A big issue that farmers run into when dealing with hairy vetch is that termination of the crop can be difficult, and vetch can turn into a cumbersome volunteer weed. There are no registered herbicides for use in hairy vetch in Canada and few are known for its control. This demonstration was created to gain understanding of the efficacy in terms of tolerance and injury that common agricultural herbicides have on hairy vetch. Adding to this there is building weed resistance to glyphosate in kochia (Bassia scoparia), known to already have issues in corn in western Manitoba. There is a need to better understand options available to hairy vetch for tolerance or control but also with weed resistance in corn production systems. The trial design had 18 treatments that were un-replicated. The treatments include one untreated check that was not weeded, one untreated check that was hand weeded, 6 treatments with herbicide applied pre-emergence, and 10 treatments with herbicide applied in-crop at the 3-4 leaf stage. At the end of the project, all the treatments were evaluated on how they performed in terms of different desired situations (pre-emergence tolerance/safety, pre-emergence control, in-crop tolerance/safety, and in-crop control/termination)

Materials and Methods

The hairy vetch was seeded into oat stubble on June 22nd into ample moisture. All plots were sprayed with 0.5L ac^{-1} Roundup Transorb (glyphosate) tank mixed with 1.0L ac^{-1} Interline (glufosinate) as a pre-seeding burn-off before seeding. A dual knife Seedhawk air seeder was used to seed the hairy vetch at a target rate of 20lbs ac^{-1} at a depth of 0.5-inches. All plots were seeded into Waskada Loam with 16-35-25-15-2 (N-P-K-S-Zn) lbs ac^{-1} of actual fertilizer applied. The vetch was also inoculated with granular pea and lentil inoculant (Nodulator, BASF). Because the amounts of chemical that were used in only 1 liter of water (10gal ac^{-1} water volume), the chemicals were measured using pipettes; a small scale was used to measure the granular products. Between each treatment, the CO_2 sprayer was triple rinsed using ammonia and water to avoid cross-contamination of treatments.

Treatments

There were 18 total treatments that were demonstrated, Table 14a. Further information about the herbicides used for this trial, including trade name, chemical name, group, mode of action, and formulation can be found below.

Table 14a. Overview of treatment specifications.

Trt #	Trade Name	Chemical Name	Chemical Group	Mode of Action	Formulation	Mixer (if applicable)	Field Rate
1	Untreated	-	-	-	-	-	-
2	Heat	Saflufenacil	14	C	342g/L	Glyphosate	59 ml/ac
3	Mextrol 450	Bromoxynil + MCPA	4 & 6	C & S	225g/L	-	0.5 L/ac
4	Valtera	Fluioxazin	14	C	51% WDG	Glyphosate	85 g/ac
5	PrimeXtra II Magnum	Metoclachlor + Atrazine	5 & 15	C & S	400g/L + 320g/L	-	1.4 L/ac
6	Spike	Tribenuron	2	S	75% WDG	Glyphosate	4 g/ac
7	Pyroxasulfone	Pyroxasulfone	15	S	85%WG	Glyphosate	40 g/ac
8	Armezon	Topramezone	27	S	336 g/L	Glyphosate	15 ml/ac
9	Interline (Liberty)	Glufosinate	10	C	150g/L	-	1.35 L/ac
10	Muster	Ethametsulfron-methyl	2	S	75% WDG	Prosurf 0.2L/ac	12 g/ac
11	Assert	Imazamethabenz	2	S	300g/L	pH adjuster 25g/2 ga	0.5 L/ac
12	Roundup	Glyphosate	9	S	540 g/L	-	0.67 L/ac
13	MCPA	MCPA Amine 500	4	S	500g/L amine	-	0.45 :/ac
14	Koril	Bromoxynil	6	C	235g/L	-	0.5 L/ac
15	Mextrol 450	Bromoxynil + MCPA	4 & 6	C & S	225 g/L + 225 g/ac	-	0.5 L/ac
16	2,4D	2,4D	4	S	564g/L	-	0.5 L/ac
17	Banvel II	Dicamba	4	S	480g/L	-	0.5 L/ac
18	Hand- Weeded	-	-	-	-	-	-

*C = Contact, S = Systemic

Application

All herbicide treatments were applied using a 4-nozzle CO_2 sprayer. The nozzles were Teejet AI8002 fan nozzles with 50cm spacing. The boom on the sprayer is the correct length to cover the entire plot in one pass. The CO_2 sprayer was pressurized to 40 psi. At the correct pressure, the nozzles of the spray deliver 10 gallons of volume (water plus chemicals) at a speed of 5 mph. The same person applied both sets of treatments (pre-emergence and in-crop) to ensure consistency throughout the trial. Pyroxasulfone was used in a pure form (not available on the market) to keep the methods and results of the demonstration simple. There are multiple products such as Fierce and Focus that contain pyroxasulfone with a partner chemical. The interest in this demonstration was to look at the effects of a single chemical at a time (i.e., pyroxasulfone with no partner chemical), to evaluate where the effects on the vetch stem from. Other chemicals tested were products that would be the most likely chosen by farmers for vetch termination. Some chemicals required a carrier chemical to be tank mixed with for application. Heat, Valtera, Spike, Pyroxasulfone, and Armezon were tank mixed with glyphosate (Roundup Transorb Transorb), Muster was tank mixed with ProSurf adjuvant, and Assert was tank mixed with a pH adjuster. Below, Table 13b demonstrates further information about burn-off, spraying, and the date of assessments.

Table 14b. Spraying Information and Assessments. (WAA = weeks after application)

Spraying and Assessment Information		
Spray Nozzle		Teejet AI8002
Water volume		10gal/ac
Burn off Product		Round Up & Interline
Burn off Rate		0.5L/ac & 1.0L/ac
Pre-emergence application		23-Jun
In-Crop application		13-Jul
Assessments		
Pre-emergence	**3WAA**	14-Jul
	6WAA	03-Aug
In-Crop	**3WAA**	03-Aug
	6WAA	24-Aug

Assessments

There were three different types of assessments that were taken during this demonstration:

1. Injury Assessment
2. Weed Comparison Assessment
3. Biomass (wet weight) Assessment

The injury assessment gave a percentage of crop injury compared to the untreated check (UTC) plots. Percent injury was only evaluated for the hairy vetch, and not the weeds present in the plots. The weed comparison assessment was a visual comparison of the sprayed treatment plots to the UTC plot that had no hand weeding; the value given represented the percentage of achieved weed control. This assessment was used to evaluate the level of weed control that was established in each treatment and was not evaluating the condition of the vetch. Wet weight biomass samples were collected 6 weeks after the application of the herbicide for each plot. These values are important to collect in a herbicide trial since they give insight into how much or how little a herbicide damaged the crop.

Results and Discussion

Table 14c. Assessment results of the vetch herbicide trial at Melita in 2022.

Treatment #	Product	% Injury 3WAA	% Injury 6WAA	6WAA Biomass Kg/m2	Weed Control % of Check
1	Untreated	-	0	-	0
2	Heat	10	5	0.66	0
3	Mextrol 450	<5	<5	0.92	0
4	Valtera	20	25	0.52	50
5	PrimeXtra II Magnum	50	75	0.2	75
6	Spike	<5	<5	0.88	0
7	Pyroxasulfone	10	10	0.88	75
8	Armezon	85	25	1.28	0
9	Interline (Liberty)	95	80	0.2	0
10	Muster	0	0	1.98	0
11	Assert	75	25	1.12	0
12	Roundup	50	20	1.48	50
13	MCPA	90	85	0.66	0
14	Koril	80	75	1.24	25
15	Mextrol 450	95	95	0.76	0
16	2,4D	98	98	0.1	50
17	Banvel II	99	100	N/A	0
18	Hand- Weeded	-	-	03-Aug = 0.9 24-Aug = 2.3	100

*WAA = weeks after application

Plot Evaluation

Treatment 1: Untreated Check

% Injury: N/A	Biomass: N/A	Weed Control: 0%

This plot was not sprayed with any herbicides other than the burn-off that was used before seeding, which was applied to all plots. This UTC was also not used for biomass samples, its purpose was for weed control comparisons.

Treatment 2: Heat Pre-emergence

3WAA injury: 10%	6WAA injury: 5%	Biomass: 0.66kg	Weed Control: 0%

This treatment stunted the vetch crop slightly at the beginning of the growing season, but the vetch still grew through the herbicide. Although the crop recovered, it was not able to recover to full capacity. At the time of evaluation, the plot was mostly weed-free except some grassy weeds and volunteer canola. Since Heat is a broadleaf herbicide, this result would be expected and at the rate used, it only provides suppression of volunteer canola.

Treatment 3: Mextrol 450 Pre-emergence

3WAA injury: <5%	6WAA injury: <5%	Biomass: 0.92kg	Weed Control: 0%

This treatment had very little residual effect on the hairy vetch. The biomass sample of the vetch in this sample weighed slightly more than the biomass sample from the weeded UTC (0.9kg). There was also very little weed control over post emergent red root pigweed, wild oats, and volunteer canola. Mextrol 450 is a broadleaf-only herbicide and red root pigweed is listed as a controlled weed (up to 4-leaf stage). Possibly, the redroot pigweed was also not emerged yet, and was able to grow through the pre-emergence application unaffected.

Treatment 4: Valtera Pre-emergence

3WAA injury: 20%	6WAA injury: 25%	Biomass: 0.52kg	Weed Control: 50%

The vetch was stunted from this pre-emergent application. Valtera is a broadleaf-only herbicide and at the rate used, it only provides suppression of volunteer canola and wild buckwheat. Interestingly, there were no grassy weeds present in the plot at the time of evaluation, but there were some red root pigweed and wild buckwheat present.

Treatment 5: Prime Xtra II Magnum Pre-emergence

3WAA Injury: 50%	6WAA Injury: 75%	Biomass: 0.20kg	Weed Control: 75%

The vetch was more affected in this treatment than the previous ones, and it was not able to recover during the growing season, the effects only worsened. At the time of evaluation, it seemed that some parts of the plot were able to recover somewhat from the herbicide injury compared to other areas. There was volunteer canola present, but considering the stage, it was likely from a second wave of seeds that germinated after the treatment effects had worn-off. Prime Xtra II Magnum works better when the crop receives rainfall within 10 days of application, perhaps different results would have been observed under those conditions.

Treatment 6: Spike Pre-emergence

3WAA Injury: <5%	6WAA Injury: <5%	Biomass: 0.88kg	Weed Control: 0%

In this treatment, there was very little control of both grassy and broadleaf weeds, as well as hairy vetch. Tribenuron is usually used as a pre-seeding burn off for crops such as clover, therefore it is understandable that it does not affect vetch. The lack of weed control could be the result of multiple environmental factors.

Treatment 7: Pyroxasulfone Pre-emergence

3WAA Injury: 10%	6WAA Injury: 10%	Biomass: 0.88kg	Weed Control: 75%

There was very little effect to the hairy vetch in this treatment, similar to Spike. Pyroxasulfone is a broadleaf and grassy weed herbicide, and only provides suppression of wild oats. The plot was relatively clean in this demonstration other than some volunteer canola.

Treatment 8: Armezon In-crop

3WAA Injury: 85%	6WAA Injury: 25%	Biomass: 1.28Kg	Weed Control: 0%

There was significant damage to the vetch after this in-crop application. By 6 weeks after application the crop had recovered well and had an impressive biomass wet weight for the severity of the damage early in the demonstration. Armezon is a grass and broadleaf weed herbicide that is registered to control red root pigweed. In the plot at the time of evaluation, there was a significant patch of red root pigweed which could have been newly growing plants after the effects of the treatment had worn off.

Treatment 9: Interline In-crop

3WAA Injury: 95%	6WAA Injury: 80%	Biomass: 0.20kg	Weed Control: 0%

This treatment almost terminated the vetch in the plot, but some plants were able to regrow slightly by the time the plot was evaluated. This plot was also full of weeds; since the vetch was not a competitive crop anymore, weeds were able to take over the area. The weeds that were present mostly consisted of volunteer canola, red root pigweed, and wild oats. The volunteer canola was from Liberty Link Canola planted the previous year; Interline would have no control over these volunteers. The Glufosinate activity may have also been reduced because of the drought conditions.

Treatment 10: Muster In-crop

3WAA Injury: 0%	6WAA Injury: 0%	Biomass: 1.98kg	Weed Control: 0%

Muster seemed to have virtually no detrimental effect on the vetch crop. If the crop was stunted, it had recovered well enough to be the closest in weight of biomass to the weeded UTC. The only weeds present in the plot were volunteer canola plants; expectedly since Muster is registered for use on Canola.

Treatment 11: Assert In-crop

3WAA Injury: 75%	6WAA Injury: 25%	Biomass: 1.12kg	Weed Control: 0%

In this treatment, the vetch was hit hard and by 6 weeks after application, it had recovered to only 25% damage. Cheat grass, red root pigweed, and prostrate pigweed were abundant in the plot; Assert is not registered for control of these weeds.

Treatment 12: Roundup Transorb In-crop

3WAA Injury: 50%	6WAA Injury: 20%	Biomass: 1.48kg	Weed Control: 50%

The vetch was stunted after this treatment, but not as hard as in the Assert treatment. The vetch was able to recover well, but still had a reduced biomass from the weeded UTC. The plot was mostly clean with some volunteer canola and wild oat plants making up the weed population.

Treatment 13: MCPA In-crop

3WAA Injury: 90%	6WAA Injury: 85%	Biomass: 0.66kg	Weed Control: 0%

MCPA nearly eliminated all the vetch plants in the plot; slowly the vetch grew back and still had a respectable biomass weight. In this case, the vetch would not have reached flowering or seed before freeze up in the fall which would kill the remaining plants, or they would have grown back in the spring like winter annuals. MCPA is a broadleaf only herbicide which does not control volunteer canola and has little control over red root pigweed. The plot was very weedy with both grass and broadleaf weeds.

Treatment 14: Koril In-crop

3WAA Injury: 80%	6WAA Injury: 75%	Biomass: 1.24kg	Weed Control: 25%

Koril was observed to have a slightly less effect on vetch, and the plot was less weedy than the MCPA treatment. The weeds mostly consisted of wild oats and red root pigweed. Koril only controls red root pigweed at higher rates and since it is a broadleaf herbicide, there is no control of wild oats.

Treatment 15: Mextrol 450 In-crop

3WAA Injury: 95%	6WAA Injury: 95%	Biomass: 0.76kg	Weed Control: 0%

Mextrol was used again for an in-crop treatment to complement the separate effects of Bromoxynil (Koril) and MCPA. This treatment terminated the crop, then later some plants were able to regrow. Again, in this treatment, the weeds present were wild oats and red root pigweed.

Treatment 16: 2,4-D In-crop

3WAA Injury: 98%	6WAA Injury: 98%	Biomass: 0.1kg	Weed Control: 50%

This treatment completely eliminated the vetch in the plot and only a couple plants were in a square meter to take a biomass sample. The plants that were able to survive the treatment were very stunted.

At time of evaluation, there were some wild oats present as well as a new set of red root pigweed plants. This treatment had the lowest applicable biomass sample in the demonstration.

Treatment 17: Banvel II In-crop

3WAA Injury: 99%	6WAA Injury: 100%	Biomass: N/A or 0.0kg	Weed Control: 0%

Banvel II completely terminated the plot, and no vetch plants were able to recover from the treatment. Since there was no viable vetch present, a biomass sample was not able to be collected. At the time of evaluation, the plot had weeds present that could have emerged after the application and were able to thrive in this no-competition situation.

Treatment 18: Hand-weeded Untreated Check

Injury: 0%	Biomass 03-Aug: 0.9kg	Biomass 24-Aug: 2.3kg	Weed Control: 100%

This untreated check was hand-weeded all season long to mimic perfect growing conditions to achieve the greatest biomass possible. For comparison to the pre-emergence treatments, a biomass sample was collected on August 3rd (0.9kg), and for the in-crop treatments, a sample was taken on August 24th (2.3kg). This was the only plot that was able to reach 50% flowering across the plot in the entire demonstration.

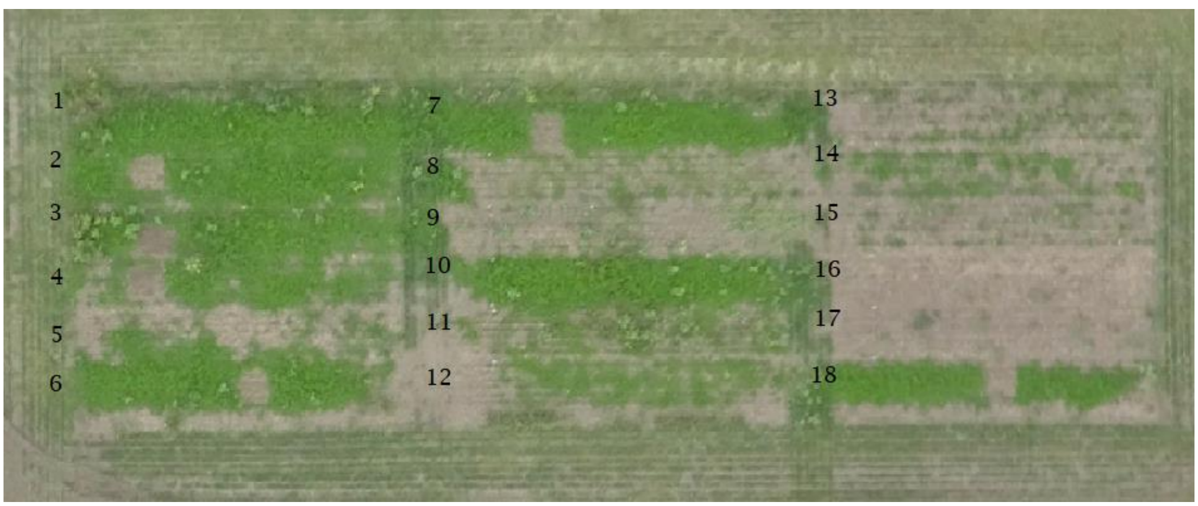

Figure 8a. An aerial look at the herbicide-vetch demonstration at Melita in 2022.

*The large empty squares that can be seen in some plots are where biomass samples were taken.

This aerial photo was taken on August 17th, 2022, which was two weeks after the last assessment done on the herbicide injury of the pre-emergence treatments, and one week before the last assessment of herbicide injury of the in-crop treatments. The numbers represent the treatment number.

Figure 8b. Key to the Aerial photo showing which products were demonstrated.

1 - Untreated Check	7 - Pyroxasulfone	13 - MCPA
2 - Heat	8 - Armezon	14 - Koril
3 - Mextrol 450	9 - Interline (Liberty)	15 - Mextrol 450
4 - Valtera	10 - Muster	16 - 2, 4D
5 - PrimeXtra LL Magnum	11 - Assert	17 - Banvel II
6 - Spike	12 - Roundup	18 - Hand Weed Check
Pre-emergence application	Post-emergence application	Checks

Weather

Table 14d. Shows the seasonal weather report from seeding to August 24th

At Melita	Actual	Normal	% of Normal
GDDs	939	900	104%
Precipitation	67	162	42%

From the day of seeding (June 22nd) to the last day of any evaluations (August 24th) there was only 42% of the normal rainfall that is normally received during this period, and there were also more growing degree days (GDDs) than normal. These conditions may have affected the growing of the vetch. If the vetch was stressed because of the drought conditions, it may not have had the best uptake of the herbicides, lessening their effects. If there had been more rainfall through this growing season higher biomass weights may have been seen, as well as better post-application vetch recovery. During this window of time, there were four significant rain events on June 24th, July 4th, 16th, and 19th. The rain on July 19th was the last rainfall event before the 6WAA evaluations were made. Both the pre-emergence treatments and in-crop treatments had small rainfall events in the following days after application. This could have improved or worsened the effects of some products depending on the active ingredients and formulations.

Discussion of Results

The results of the demonstration will be discussed in terms of which treatment performed the best in each of these 4 different categories:

1. Pre-emergence: Prevent hairy vetch (pre-emerge burn-off application)
2. Pre-emergence: promote vetch & terminate weeds (burn-off application that does not affect hairy vetch)
3. In-Crop: termination of hairy vetch
4. In-Crop: promote vetch & terminate weeds

Pre-emerge: Prevent hairy vetch (pre-emerge burn-off application)

- Prime Xtra Magnum II (Treatment 5) caused the most damage to the vetch in the pre-emergence applications. The vetch was not able to recover from this treatment; the condition of the vetch got worse as time went on. Perhaps a higher rate would achieve complete burn off but following the product label and being careful of residues is important.

Pre-emerge: Promote vetch & kill weeds (pre-emerge burn-off application that does not affect hairy vetch)

- Prime Xtra Magnum II (Treatment 5) and Pyroxasulfone (Treatment 7) had the same percentage of weed control, 75%, which was the highest out of the pre-emergence applications. The Pyroxasulfone caused the least damage to the vetch (10% injury) compared to Prime Xtra Magnum II (75% injury). Spike (Treatment 6) had virtually no effect on the vetch, except there was also no weed control in that plot. Pyroxasulfone would be the most desirable option, having the combination of less vetch damage and more weed control. Further research into pre-emergence products to use when planting vetch could be done to find a better option.

In-Crop: termination of hairy vetch

- Banvel II (Treatment 17) completely terminated the vetch, and 2,4-D (Treatment 16) almost did the same. Because dicamba is usually not a farmer's first choice, and 2,4-D does not control grassy weeds if needed, the next best option for vetch termination from this demonstration would be Mextrol 450 (Treatment 15). Mextrol 450 also has less risk of herbicide residues affecting subsequent crops.

In-Crop: Promote Vetch &terminate weeds

- Muster (Treatment 10) did not damage the vetch, and even though the weed control rating given was 0%, the only weed in the plot was volunteer canola (which Muster does not control). Muster would be a great option to use in a field that had not been seeded to canola the previous year.

Roundup Transorb (Treatment 12) had the next best weed control rating out of the in-crop applications (50%), but the vetch was affected enough to substantially decrease the yield.

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26.0 Intercropping Corn and Hairy Vetch

Project duration: 2021-2022
Collaborators: WADO

Objectives

- To determine the effect of hairy vetch on corn grain yield and corn biomass in an intercropping system
- To determine the effect of corn seeding rate on corn yield, corn biomass, and vetch biomass in an intercropping system
- To determine an optimal corn-hairy vetch intercropping system for grain production, cattle production, and field nitrogen economy

Background

Corn production on the Canadian prairies for both grain and forage has been increasing in recent years. As fertilizer prices increase, the reduction of reliance on synthetic fertilizer inputs is of interest to producers. Additionally, the focus of many producers is shifting to sustainability as they look for ways to protect their crops and soils. Intercropping is becoming a popular option for producers who wish to integrate sustainable systems into their operation, as intercropping has been shown to benefit soil health, reduce pest pressure, and increase residual soil nitrogen content if a legume is included in the intercropping system. Intercropping corn with hairy vetch (*Vicia villosa*) has been shown to provide many benefits to a field, including protection against soil erosion and improved weed control due to hairy vetch's creeping growth habit (Brainard et al., 2012). In addition, nitrogen fixation by hairy vetch may result in reduced expenses on fertilizer, improved potassium availability for subsequent crops, and improved soil biodiversity (Cook et al., 2010; OMAFRA, 2012). Intercropping corn with hairy vetch may provide producers with the opportunity to use the intercrop as cattle feed by either grazing the whole system or removing the corn grain and grazing the corn stubble and vetch. This trial examined the effects of intercropping corn with hairy vetch at various corn seeding rates on corn grain yield, corn biomass, vetch biomass, total field nitrogen derived from biomass, fixation and residual soil nitrogen, and feed quantity and quality for cattle grazing.

Methods and Materials

An intercrop trial with corn and hairy vetch was established near Melita, Manitoba (NW 6-4-26 W1) in 2022 on Mentieth loamy fine sand soil on corn stubble. Treatments consisted of corn seeded at 20000, 26000, or 32000 plants ac^{-1} (49421, 64247, 79073 plants ha^{-1}) with or without hairy vetch. Treatments were arranged in randomized complete block design with four replicates. Plot size was approximately 13.72 m^2. Corn variety used was Dekalb 26-28RR, and hairy vetch was a winter hearty long season variety sourced from the University of Manitoba and originally distributed by Walter Seeds & Honey Co. (Iowa). Corn was seeded with a Wintersteiger Dynamic Disc planter at 2-inch depth with 30-inch row spacing using EasyPlant software, and vetch was seeded into corn at 20 lbs ac^{-1} along with BASF inoculant at 3.6 lbs ac^{-1} using a Seedhawk dual knife opener air-seeder at 0.5-inch depth and 9.5-inch row spacing. Fertility was applied according to soil test results (Agvise, North Dakota) and fertilizer was banded at 150-50-65-23-1Zn-4Cu-2B actual lbs ac^{-1} (N-P-K-S-Zn-Cu-B) prior to seeding (Table 14a). Both the boron and copper chelates were applied following seeding.

Weeds were controlled at the 3-leaf stage of corn using glyphosate (540 g L^{-1} a.i) applied at 0.5 L ac^{-1} in a water application volume of 10 imperial gallons $acre^{-1}$. Some kochia was hand-weeded on July 5th. The plots were harvested on October 9th.

Table 15a. Spring soil test results for the trial site in 2022.

Depth (cm)	pH	OM (%)	N (ppm)	P-Olsen (ppm)	K (ppm)	Zn (ppm)	Ca (ppm)	Mg (ppm)	Na (ppm)	S (ppm)
0-15	8.0	1.1	23	7	124	0.44	3102	157	13	12
0-61	-	-	39	-	-	-	-	-	-	60

Data collected included emergence counts, vetch nodulation date, weed biomass (at corn silking), corn and vetch biomass (corn sampled in two one-meter rows, vetch sampled in two one-meter^2 areas of plot), corn grain yield, and soil test for post grain harvest residual N and organic matter. Feed tests (2FF, Central Testing Labs, Winnipeg) were done based on different senarios of grazing methods (corn biomass with grain, corn biomass without grain, corn biomass with grain + vetch, corn biomass without grain + vetch, vetch only) using biomass samples based on seeding rate effect. Data were analyzed by Minitab 18.1 software using a general linear model. Data was tested for normality and outliers, and a two-factor analysis of variance was performed. Mean separation was done on variables with P-values less than 0.05 by Tukey's test at 95% confidence.

Results

The presence of vetch in corn plots significantly ($P < 0.001$) reduced corn biomass, as corn with no vetch had an average biomass of 16492 kg ha^{-1}, while corn intercropped with vetch had an average biomass of 14326 kg ha^{-1} (Table 15b). Corn grain yield followed the same trend, with the sole corn crops resulting in an average yield of 5622 kg ha^{-1} and the corn-vetch intercrops resulting in a significantly ($P < 0.001$) lower average yield of 4833 kg ha^{-1}. These results were expected, as including hairy vetch in the corn system increases competition for water, nutrients, and space. When grain yield was subtracted from the biomass of each system, the corn-vetch intercrop treatments resulted in a greater average biomass than the corn only treatments, indicating that vetch compensates for corn biomass lost due to competition. Intercropping corn with hairy vetch was demonstrated to effectively reduce weed biomass, as the average weed biomass of treatments without vetch was two times greater than that of treatments with vetch.

Table 15b. Means and analysis of variance for data collected on corn-vetch intercrops and corn monocrops grown near Melita, Manitoba in 2022.

		Corn Plants per ha	Vetch (ppm2)	Weeds Wet kg/ha	Corn Biomass kg/ha dry	Vetch Biomass kg/ha dry	Total Biomass Corn + Vetch kg/ha	TW kg/hL	Grain Yield kg/ha corrected at 15% moisture	Biomass Less Grain Yield kg/ha
System	(1) No Vetch	57415	-	2942**a**	16492**a**	-	16492	69	5622**a**	10870
	(2) Vetch	61789	39	1158**b**	14326**b**	1740	16066	69	4833**b**	11233
Rate	(1) 20000	47572**c**	40	2388	14583	1825	15496	69	4664**c**	10832
	(2) 26000	58235**b**	33	2313	15650	1855	16577	69	5301**b**	11276
	(3) 32000	72999**a**	43	1450	15994	1540	16764	69	5718**a**	11046
System x Rate	1x1	45932	-	3375	15518	-	15518	69	5056	10463
	1x2	57415	-	3450	16404	-	16404	69	5713	10692
	1x3	68897	-	2000	17553	-	17553	69	6098	11455
	2x1	49213	40	1400	13648	1825	15473	69	4273	11201
	2x2	59055	33	1175	14895	1855	16750	69	4889	11861
	2x3	77100	43	900	14436	1540	15976	69	5338	10638
P value System		0.157		**<0.001**	**0.002**		0.461	0.740	**<0.001**	0.538
P value Rate		**<0.001**	0.416	0.069	0.158	0.102	0.172	0.689	**<0.001**	0.822
P Value S x R		0.645		0.356	0.518		0.361	0.601	0.979	0.360
	C.V.%	12	26	40	9	11	8	1	6	13
	R-square (%)	78.5	50	72.8	83.7	70	83.2	56.3	89.6	75.7

*Means with the same letter are not significantly different by Tukey's mean separation method at 95% confidence

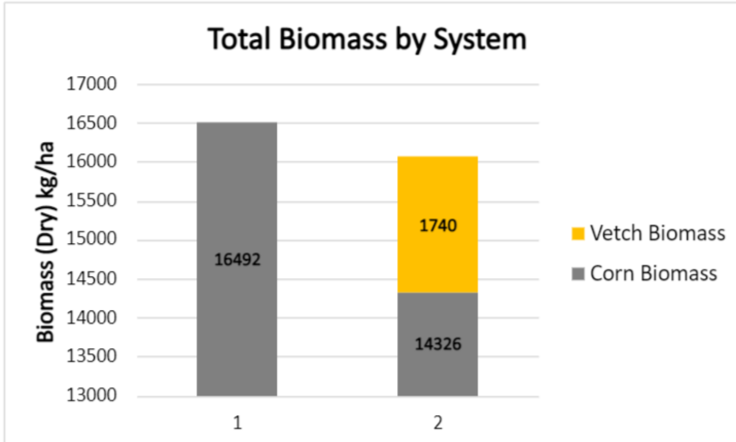

Figure 9a. Total corn and vetch biomass in corn monocrops (1) or corn-vetch intercrops (2) grown near Melita, Manitoba in 2022. Values followed by the same letter are not significantly different by Tukey's mean separation method at 95% confidence.

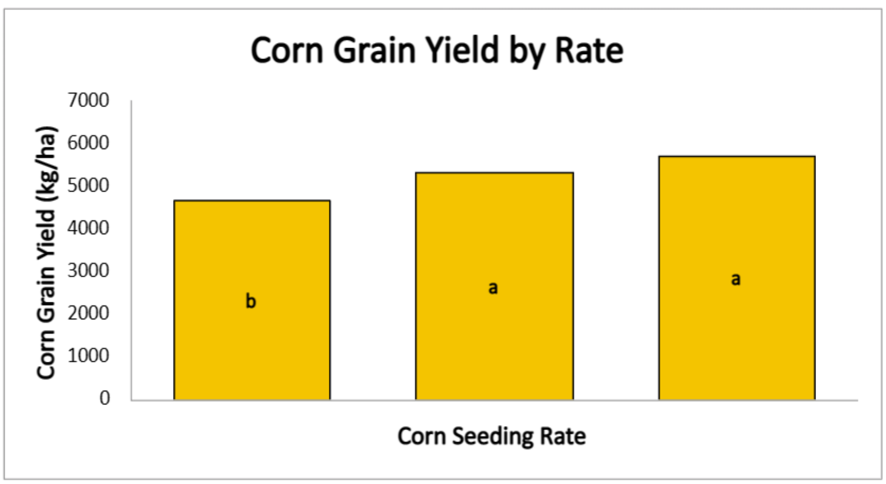

Figure 9b. Average grain yield of corn seeded at 49400, 64220, or 79040 plants ha^{-1} grown near Melita, Manitoba in 2022, respectively. Bars marked with the same letter are not significantly different by Tukey's mean separation method at 95% confidence

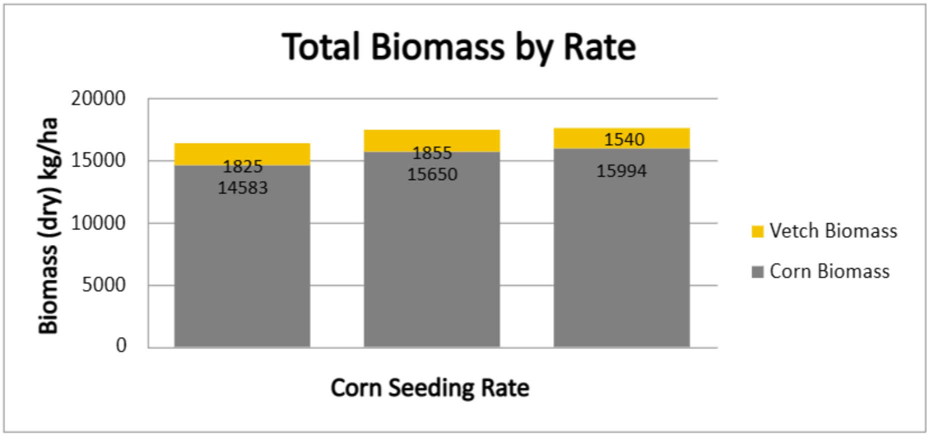

Figure 9c. Total corn and vetch biomass of corn-vetch intercrops with corn seeded at 49400, 64220, or 79040 plants ha^{-1}. Bars marked with the same letter are not significantly different by Tukey's mean separation method at 95% confidence.

Grain yield of corn was significantly influenced by seeding rate, as yield from corn seeded at 64 220 and 79 040 plants ha^{-1} was significantly ($P < 0.001$) greater than that of corn seeded at 49 400 plants ha^{-1} (Figure 9b). Unexpectedly, corn seeding rate did not significantly influence corn biomass, or total system biomass (Figure 9c). However, seeding rate did significantly ($P < 0.001$) influence the corn plant population (Table 15b). An increase in corn seeding rate also did not significantly reduce vetch biomass, as would be expected due to increased competition as corn seeding rate increases. It was also expected that weed biomass would decrease as corn rate increased due to increased competition, but this was not observed. Weed biomass mass was only decreased by the presence of vetch compared to no vetch. In 2022, the corn populations were found to be significantly different from one another however, there was still no influence on corn biomass, vetch biomass, or weed biomass. Environmental conditions in Melita in 2022 were also extremely hot and dry, with the area receiving 112% of normal growing degree days, and 109% of the normal corn heat units, while only receiving 47% of the normal rainfall during the time of planting to corn grain harvest (Manitoba Agriculture – Growing season summary for Melita). Though the corn seeding rates were significant, the hot and dry weather experienced may have reduced the overall biomass potential of the plots.

Feed tests were conducted on biomass material from each treatment based on different grazing practices, which may be employed by cattle producers incorporating a corn-vetch intercrop into their production system. A producer may choose to harvest the corn grain and let cattle graze on the vetch and remaining corn biomass, or they may choose to let cattle graze the whole intercrop system. Feed tests for vetch and monocrop corn treatments (with or without grain included) are also presented for comparison to intercrop feed tests (Figure 9d). It was expected that relative feed value (RFV) and total digestible nutrients (TDN) would be the greatest when the whole intercrop system is grazed. Though in 2022, RFV and TDN are highest when the whole system, not including vetch (only corn plus grain) is grazed. The inclusion of vetch in the feed slightly increased crude protein (CP). RFV is highest in the corn plus grain grazing system and is higher in the vetch monocrop than in the corn monocrop, which is expected. The corn without grain system had the lowest overall RFV and TDN, indicating that vetch is adding value to the grazing system and enhances grazing systems when grain corn is harvested, though more research would be required to conclude which system is the best.

Corn Rate (plants ha-1)	ADF	Ca	CP	DE	Mg	Met E	NDF	Phos	Pot	RFV	TDN
Corn Only without Grain											
49400	53.45	0.47	4.69	1.83	0.26	1.52	81.12	0.11	0.85	54	41.53
64220	56.23	0.50	5.10	1.70	0.32	1.41	81.62	0.13	0.69	51	38.56
79040	53.92	0.60	4.91	1.81	0.29	1.50	79.94	0.11	0.93	55	41.03
Corn only Plus Grain											
49400	17.92	0.18	8.72	3.41	0.16	2.83	34.43	0.31	0.63	198	77.44
64220	18.23	0.10	8.35	3.38	0.14	2.81	33.40	0.28	0.53	203	76.76
79040	29.72	0.23	6.50	2.80	0.18	2.32	53.84	0.23	0.60	109	63.45
Corn Plus Grain + Vetch											
49400	30.82	0.39	8.27	2.74	0.19	2.27	52.30	0.23	0.83	111	62.10
64220	33.88	0.43	8.70	2.58	0.21	2.14	55.60	0.22	0.87	100	58.47
79040	29.50	0.37	8.23	2.81	0.19	2.33	47.90	0.24	0.80	123	63.80
Corn without Grain plus Vetch											
49400	48.57	0.68	7.67	1.83	0.30	1.52	74.30	0.19	0.99	59	41.62
64220	49.80	0.73	7.09	1.77	0.31	1.47	74.89	0.15	1.03	57	40.17
79040	47.22	0.77	7.83	1.90	0.30	1.58	72.76	0.16	1.01	62	43.15
Vetch only (Inside Plot)											
49400	42.76	1.41	19.22	2.33	0.29	1.94	55.91	0.36	2.09	92	52.95
64220	45.35	1.58	18.38	2.21	0.33	1.84	54.83	0.34	2.06	91	50.22
79040	42.70	1.51	19.42	2.34	0.33	1.94	56.77	0.35	1.93	91	53.02
Vetch Only (Outside Plot)											
	41.73	1.14	18.33	2.38	0.26	1.98	51.65	0.29	1.93	102	54.05

Figure 9d. Feed test results for various grazing options in a corn-vetch intercrop or corn monocrop system. Acid Detergent Fiber (ADF), Calcium (Ca), Crude Protein (CP), Digestible Energy (DE), Magnesium (Mg), Metabolizable Energy (Met E), Neutral Detergent Fiber (NDF), Phosphorous (Phos), Potassium (Pot), Relative Feed Value (RFV) and Total Digestible Nutrients (TDN) values for each treatment and grazing method are presented.

The nitrogen dynamics of a field also change with the inclusion of vetch due to the fixation of nitrogen and the low carbon to nitrogen ratio in the vetch biomass. Soil was tested by treatment for residual nitrogen and organic matter content following the trial, but results were inconclusive as there was high spatial nutrient variability (Table 15c). Crude protein in feed contains 6.25% nitrogen by weight (Methods of Food Analysis, 2020). In 2022, when vetch was included in the system, the crude protein nearly doubles compared to without vetch in the without grain system, however, does not change much in the grain system. Thus, our calculations suggest vetch adds an additional 1-16 kg ha^{-1} of nitrogen to the field when crude protein values feed tests are applied to total biomass yield in those systems with and without vetch in addition to post harvest soil test values, in 2022. In 2021 this credit was 15.8-30.3 kg ha^{-1}. The difference between years is likley due to less rainfall in 2022 than in 2021, reducing biomass potential.

Table 15c. Soil nitrogen, phosphorus and organic matter content by treatment following a corn and hairy vetch intercrop trial established at Melita in 2021.

		N ppm 0-6	N ppm 6-24	N ppm 0-24	Soil Organic Matter
System	(1) No Vetch	6.7	15.2	15.2	1.1
	(2) Vetch	7.8	13.8	13.8	1.2
Rate	(1) 20000	8.8	16.3	16.3**a**	1.1
	(2) 26000	7.9	17.3	17.3**a**	1.2
	(3) 32000	5.1	10.0	10**a**	1.2
System x Rate	1x1	7.0	16.0	16.0	1.1
	1x2	7.8	18.3	18.3	1.2
	1x3	5.3	11.3	11.3	1.2
	2x1	10.5	16.5	16.5	1.2
	2x2	8.0	16.3	16.3	1.2
	2x3	5.0	8.8	8.8	1.1
P value System		0.344	0.580	0.580	0.635
P value Rate		0.063	0.049	**0.049**	0.238
P Value S x R		0.402	0.858	0.858	0.114
	C.V.%	40	40	40	7
	R-square (%)	43.3	45.1	45.1	83.8

*Means with the same letter are not significantly different by Tukey's mean separation method at 95% condifence

Conclusions

Intercropping corn with hairy vetch was demonstrated to be a successful intercrop combination at Melita in 2022 despite drought conditions. While the presence of vetch in corn plots resulted in lower corn yield and biomass than the corn monocrops, the vetch compensated for the loss of corn biomass by increasing the total biomass (less grain weight) of the system above that of the corn monocrop. Vetch was also demonstrated to effectively reduce weed population, as average weed biomass in corn-vetch intercrops was two times less than in corn monocrops. Increasing seeding rate of corn was demonstrated to increase grain yield, but did not significantly affect corn biomass, weed biomass, or total system biomass. The hot, dry conditions experienced in Melita in 2022 likely reduced the observable effects of varying corn seeding rate, and additional trial years where growing season conditions are closer to normal may allow the optimal corn seeding rate for corn-vetch intercrops to be identified. The inclusion of hairy vetch into a corn crop was also demonstrated to increase feed value and crude protein content compared to a corn-only feed, indicating the potential for a corn-vetch intercrop to be implemented into a grazing system. Vetch can also alter the nitrogen economy of a field and contribute additional nitrogen to the system whether corn grain is removed for harvest or not.

Though hairy vetch's thick growth habit allows for effective weed suppression, challenges during corn harvest may arise if vetch wraps around the corn header or silage reapers. Additionally, few herbicides effectively kill vetch which has over-wintered, and any volunteer vetch may cause weed control issues during subsequent growing seasons. Producers should be aware of their crop and herbicide rotations to ensure that volunteer vetch control is possible in years following vetch seeding.

Figures 10a and 10b. Corn and Vetch intercrop plots (at VT stage of corn). It is seen how prolific the hairy vetch can be.

References

Brainard, D., Henshaw, B. and Snapp, S. 2012. Hairy Vetch Varieties and Bi-Cultures Influence Cover Crop Services in Strip-Tilled Sweet Corn. *Agronomy Journal* **104 (3): 629-638.** doi:10.2134/agronj2011.0360

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27.0 Intercropping Corn and Hairy Vetch – 2-Year Summary

Project duration: 2021-2022
Collaborators: WADO

Objectives

- To determine the effect of hairy vetch on corn grain yield and corn biomass in an intercropping system

- To determine the effect of corn seeding rate on corn yield, corn biomass, and vetch biomass in an intercropping system

- To determine an optimal corn-hairy vetch intercropping system for grain production, cattle production, and field nitrogen economy

Materials and Methods

An intercrop trial with corn and hairy vetch was established near Melita, Manitoba (NW 6-4-26 W1) in 2021 and again in 2022, on Mentieth loamy fine sand soil (Table 16a). Treatments consisted of corn seeded at 49400, 64220, or 79040 plants ha^{-1} with or without hairy vetch. Treatments were arranged in randomized complete block design with four replicates. Plot size was approximately 13.72 m^2. Corn variety used was Dekalb 26-28RR, and hairy vetch was a winter hearty long season variety sourced from the University of Manitoba and originally distributed by Walter Seeds & Honey Co. (Iowa). Corn was seeded with a Wintersteiger Dynamic Disc planter at 2-inch depth with 30-inch row spacing using EasyPlant software, and vetch was seeded into corn at 20 lbs ac^{-1} along with BASF inoculant at 3.6 lbs ac^{-1} using a Seedhawk dual knife opener air-seeder at 0.5” or 0.75” depth and 9.5-inch row spacing. Fertility was applied according to soil test results (Agvise, North Dakota) (Table 16b).

Table 16a. Agronomic information for the corn vetch intercrop trials in 2021 and 2022 grown at Melita.

Corn Vetch Intercrops 2021-2022		
Location	Melita	
Legal	NW6-4-26W1	
Soil Series	Mentieth Loamy Fine Sand	
Burn-off (Date/Product)	None	
Corn Vetch Intercrops	**2021**	**2022**
Rotation	2019: Canola 2020: Wheat	2020: Wheat 2021: Corn
Stubble	Wheat	Corn
Seed Date	07-May	23-May
Seeding Depth	Corn: 2" Vetch: 0.75"	Corn: 2" Vetch: 0.5"
Seeding Method	Corn: Planter - Vetch: Air Seeder	
Fertility Applied (actual lbs/ac)	Fall: 50 lbs/ac K Spring: 100-30-0-0-5 lbs/ac (NPKSZn) and 2L/ac Bo + 2L/ac Cu post-seeding	Spring: 150-50-65-23.4-1 (NPKSZn) in two separate app. 2L/ac Bo + 2L/ac Cu post-seeding
Topdressing Rates (actual lbs/ac)	18-10-60-25 lbs/ac (NPKS)	None
Herbicide Applications (Date/Product)	08-June - Glyphosate	20-June - Glyphosate
Harvest Date	06-Oct	09-Oct
Weather	**2021**	**2022**
GDD Actual (SD to HD) Base 5*C	1930	1722
GDD Normal (SD to HD)	1636	1544
CHU Actual (SD to HD)	2969	2754
CHU Normal (SD to HD)	2686	2527
Precipitation Actual (SD to HD)	286	149
Precipitation Normal (SD to HD)	337	317

Table 16b. Spring soil test results at the site of the corn vetch trials in both 2021 and 2022.

Year	Depth (cm)	pH	OM%	N (ppm)	P-Olsen (ppm)	K (ppm)	Zn (ppm)	Ca (ppm)	Mg (ppm)	Na (ppm)	S (ppm)
2021	**0-15**	8.1	1.6	14.5	8	88	0.49	3252	395	27	12
	15-61	8.5	-	3	-	-	-	-	-	-	32
2022	**0-15**	8.0	1.1	23	7	124	0.44	3102	157	13	12
	15-61	-	-	39	-	-	-	-	-	-	60

Data collected included emergence counts, vetch nodulation date, weed biomass (at corn silking), corn and vetch biomass (corn sampled in two one-meter rows, vetch sampled in two one-meter^2 areas of plot), corn grain yield, and soil test for post grain harvest residual N and organic matter. Feed tests (Central Testing Labs, Winnipeg) were done based on different grazing methods (corn biomass with grain, corn biomass without grain, corn biomass with grain + vetch, corn biomass without grain + vetch, vetch only) using biomass samples bulked based on seeding rate. Data were analyzed by Minitab 18.1 software using a general linear model. Data was tested for normality and outliers, and a two-factor analysis of variance was performed. Mean separation was done on variables with P-values less than 0.05 by Tukey's test at 95% confidence.

Results

Over both years, the presence of vetch in corn plots significantly ($P < 0.001$) reduced corn biomass, as corn with no vetch had an average biomass of 16877 kg ha^{-1}, while corn intercropped with vetch had an average biomass of 14288 kg ha^{-1} (Figure 11a). Average corn grain yield from both years followed the same trend, with the sole corn crops resulting in an average yield of 6237 kg ha^{-1} and the corn-vetch intercrops resulting in a significantly ($P < 0.001$) lower average yield of 5250 kg ha^{-1} (Table 16c). These results were expected, as including hairy vetch in the corn system increases competition for water, nutrients, and space. When grain yield was subtracted from the biomass of each system, the corn-vetch intercrop treatments resulted in a greater average biomass than the corn only treatments, indicating that vetch compensates for corn biomass lost due to competition. Intercropping corn with hairy vetch was demonstrated to effectively reduce weed biomass, as the average weed biomass of treatments without vetch was four times greater than that of treatments with vetch.

Table 16c. Means and analysis of variance for data collected on corn-vetch intercrops and corn monocrops grown near Melita, Manitoba in 2021 and 2022 combined.

		Corn Plants per ha	Vetch (ppm2)	Weeds Wet kg/ha	Corn Biomass kg/ha dry	Vetch Biomass kg/ha dry	Total Biomass Corn + Vetch kg/ha	TW kg/hL	Grain Yield kg/ha corrected at 15% moisture	Biomass Less Grain Yield kg/ha
System	(1) No Vetch	54407	-	1713**a**	16877**a**	-	16877	72	6237**a**	10641
	(2) Vetch	53860	33	627**b**	14288**b**	2110	16398	72	5250**b**	11148
Rate	(1) 20000	41011**b**	35	1426	14887**b**	2288	16031	72	5044**b**	10987
	(2) 26000	57825**a**	30	1261	15699**ab**	2017	16734	72	5914**a**	10821
	(3) 32000	63566**a**	34	827	16162**a**	1970	17147	72	6272**a**	10875
System x Rate	1x1	41011	-	2094	15904	-	15904	72	5484	10420
	1x2	56594	-	1876	17151	-	17151	72	6477	10674
	1x3	65617	-	1168	17577	-	17577	72	6750	10828
	2x1	41011	35	751	13870	2288	16157	72	4604	11554
	2x2	59055	30	646	14247	2071	16318	72	5351	10968
	2x3	61516	34	485	14747	1970	16717	72	5795	10923
P Value System		0.898	-	**<0.001**	**<0.001**	-	0.229	0.881	**<0.001**	0.208
P Value Rate		**<0.001**	0.505	0.079	**0.044**	0.118	0.076	0.721	**<0.001**	0.941
P Value S x R		0.817	-	0.418	0.624	-	0.425	0.307	0.742	0.530
P Value Year		**0.011**	**0.031**	**<0.001**	0.807	**0.001**	0.624	**<0.001**	**0.022**	0.798
	C.V.%	27	29	64	9	14	8	1	8	13
	R-square (%)	46.5	54.2	74.8	77.2	78.1	71.5	92.9	86.1	61.8

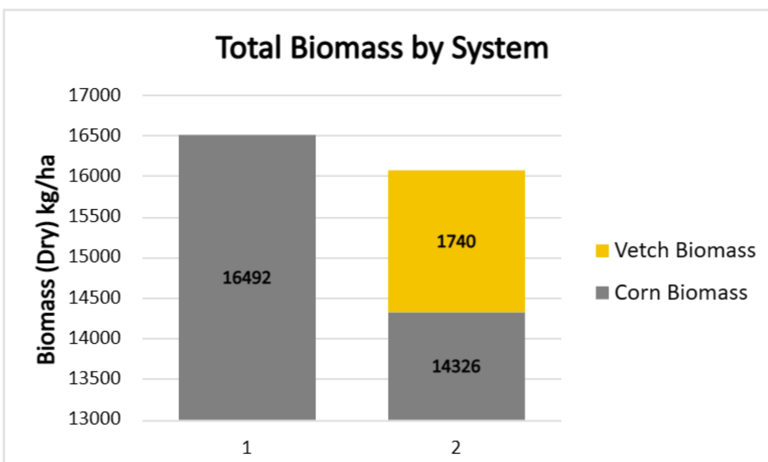

Figure 11a. Total corn and vetch biomass in corn monocrops (1) or corn-vetch intercrops (2) grown near Melita, Manitoba in 2021 & 2022 combined. Values followed by the same letter are not significantly different by Tukey's mean separation method at 95% confidence.

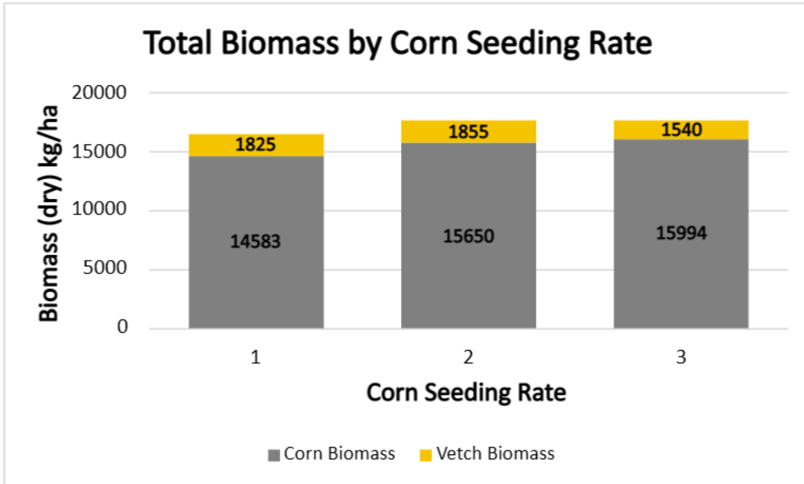

Figure 11b. Average grain yield of corn seeded at 49400 (1), 6220 (2), or 79 040 (3) plants ha^{-1} grown near Melita, Manitoba in 2022. Bars marked with the same letter are not significantly different by Tukey's mean separation method at 95% confidence

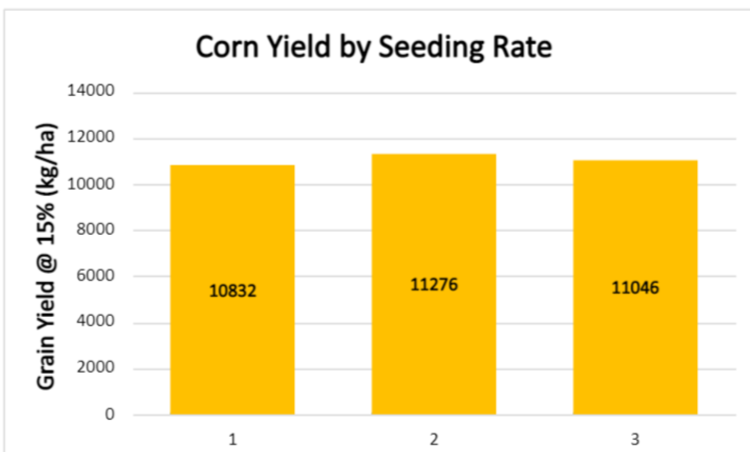

Figure 11c. Total corn and vetch biomass of corn-vetch intercrops with corn seeded at 49400 (1), 64220 (2), or 79040 (3) plants ha^{-1}. Bars marked with the same letter are not significantly different by Tukey's mean separation method at 95% confidence.

Grain yield of corn was significantly influenced by seeding rate, as yield from corn seeded at 64220 and 79040 plants ha^{-1} was significantly ($P < 0.001$) greater than that of corn seeded at 49400 plants ha^{-1} (Figure 11b). When the two sets of data were combined, it was found that corn seeding rate did significantly ($P = 0.044$) influence the corn biomass (Figure 11c). This trend was not seen when the data sets were analyzed separately. Though unexpectedly, corn seeding rate did not significantly influence total system biomass.

However, seeding rate did significantly ($P < 0.001$) influence the corn plant population (Table 16c) to be expected.

An increase in corn seeding rate also did not significantly reduce vetch biomass, as would be expected due to increased competition as corn seeding rate increases. Though not seen in 2021 or 2022 data, when combined it was found that weed biomass would decrease as corn rate increased due to increased competition, as would be expected. In 2022, the corn populations were found to be significantly different from one another however, there was still no influence on corn biomass, vetch biomass, or weed biomass. Environmental conditions in Melita in both growing seasons were extremely hot and dry, with the area receiving above-normal growing degree days and corn heat units, while only receiving a fraction of the normal rainfall during the time between planting and corn grain harvest (Table 16a). Though the corn seeding rates were significant, the hot and dry weather experienced may have reduced the overall biomass potential of the plots. It would be helpful to analyze this project in a year that receives adequate to above normal rainfall and temperature conditions.

Feed tests were conducted on biomass material from each treatment from each trial year based on different grazing practices, which may be employed by cattle producers incorporating a corn-vetch intercrop into their production system. A producer may choose to harvest the corn grain and let cattle graze on the vetch and remaining corn biomass, or they may choose to let cattle graze the whole intercrop system. Feed tests for vetch and monocrop corn treatments (with or without grain included) are also presented for comparison to intercrop feed tests (Figure 11d). It is expected that relative feed value (RFV) and total digestible nutrients (TDN) are greatest when the whole intercrop system is grazed. When using the combined data, RFV was seen to be the highest in the whole system sample; this was not seen in the individual growing seasons. Unexpectedly, TDN was again found to be highest when the whole system (corn plus grain) with no vetch included is grazed, instead of the whole system (corn plus grain) that includes vetch. The inclusion of vetch in the feed increased crude protein (CP). RFV is higher in the vetch monocrop than in the corn monocrop, which is expected. The corn without grain systems had the lowest overall TDN, indicating that vetch is adding value to and enhances grazing systems when grain corn is harvested, though more research would be required to conclude which system is the best.

	Corn Rate (plants ha-1)	ADF	Ca	CP	DE	Mg	Met E	NDF	Phos	Pot	RFV	TDN
Corn Only without Grain												
	49400	49.75	0.46	4.92	2.01	0.30	1.67	79.16	0.08	1.06	59	45.49
	64220	51.56	0.47	4.71	1.92	0.35	1.60	78.62	0.09	0.81	58	43.55
	79040	51.64	0.54	4.90	1.92	0.37	1.59	78.46	0.08	0.98	58	43.47
Corn only Plus Grain												
	49400	23.97	0.23	7.85	3.17	0.20	2.64	44.45	0.24	0.79	155	72.01
	64220	23.22	0.17	7.72	3.20	0.19	2.66	40.92	0.24	0.59	166	72.64
	79040	28.10	0.24	6.83	2.95	0.22	2.45	49.06	0.21	0.66	126	66.91
Corn Plus Grain + Vetch												
	49400	26.29	0.33	8.66	3.03	0.21	2.52	44.39	0.23	0.86	147	68.75
	64220	25.48	0.30	8.56	3.06	1.17	2.54	42.45	0.22	0.74	170	69.43
	79040	26.94	0.32	8.58	3.01	0.22	2.50	43.90	0.22	0.85	143	68.20
Corn without Grain plus Vetch												
	49400	46.67	0.64	8.54	2.04	0.35	1.69	71.67	0.16	1.32	66	46.22
	64220	47.95	0.66	8.31	1.98	0.36	1.64	71.68	0.13	1.22	65	44.78
	79040	47.02	0.64	7.78	2.02	0.36	1.68	72.21	0.13	1.20	65	45.88
Vetch only (Inside Plot)												
	49400	41.72	1.19	20.35	2.38	0.30	1.98	53.31	0.34	2.55	99	54.07
	64220	43.57	1.29	18.91	2.30	0.33	1.91	52.81	0.31	2.32	97	52.11
	79040	42.61	1.22	19.67	2.35	0.32	1.95	54.21	0.32	2.60	96	53.12
Vetch Only (Outside Plot)												
		42.22	1.04	18.32	2.36	0.26	1.96	25.98	0.28	2.01	101	53.54

Figure 11d. Average of feed test results in 2021 and 2022 for various grazing options in a corn-vetch intercrop or corn monocrop system. Acid Detergent Fiber (ADF), Calcium (Ca), Crude Protein (CP), Digestible Energy (DE), Magnesium (Mg), Metabolizable Energy (Met E), Neutral Detergent Fiber (NDF), Phosphorous (Phos), Potassium (Pot), Relative Feed Value (RFV) and Total Digestible Nutrients (TDN) values for each treatment and grazing method are presented.

The nitrogen dynamics of a field also change with the inclusion of vetch due to nitrogen fixation of vetch. Soil nitrogen and organic matter was tested by treatment following the trial, but results were inconclusive as there was high spatial nutrient variability (Table 16c). Crude protein contains 6.25% nitrogen by weight (Methods of Food Analysis, 2020). When vetch was included in the system, the crude protein of the grazing system was significantly increased. Thus, whether corn is removed from harvest or not, our calculations suggest vetch adds an additional two-year average of 12-24 kg ha^{-1} of nitrogen to the field when crude protein values feed tests are applied to total biomass yield in those systems with and without vetch in addition to post harvest soil test values.

Table 16d. Soil nitrogen, phosphorus and organic matter content in 0-6" and 6-24" depths by treatment following a corn and hairy vetch intercrop trial established at Melita in 2021 and 2022.

		N ppm 0-6	N ppm 6-12	N ppm 0-24	Soil Organic Matter
System	(1) No Vetch	3.4	8.1	9.8	1.3
	(2) Vetch	4.1	6.3	8.5	1.3
Rate	(1) 20000	4.6**a**	7.4	9.8	1.3**b**
	(2) 26000	3.5**ab**	7.4	8.9	1.4**a**
	(3) 32000	3.1**b**	6.8	8.7	1.3**b**
System x Rate	1x1	3.8	8.1	10.1	1.3
	1x2	3.3	7.9	9.3	1.4
	1x3	3.1	8.3	10.0	1.3
	2x1	5.4	6.8	9.6	1.3
	2x2	3.7	6.9	8.6	1.4
	2x3	3.2	5.4	7.3	1.3
P Value System		0.075	0.062	0.163	0.631
P Value Rate		**0.013**	0.823	0.561	**0.006**
P Value S x R		0.240	0.694	0.595	0.372
P Value Year		0.647	0.965	0.069	**0.011**
	C.V.%	37	44	35	7
	R-square (%)	41.8	34.0	53.8	88.2

Summary

Intercropping corn with hairy vetch was demonstrated to be a successful intercrop combination at Melita from 2021 to 2022 despite drought conditions. While the presence of vetch in corn plots generally resulted in lower corn yield and biomass than the corn monocrops, the vetch compensated for the loss of corn biomass by increasing the total biomass (less grain weight) of the system above that of the corn monocrop. Vetch was also demonstrated to effectively reduce weed population, as average weed biomass in corn-vetch intercrops was almost three times less than in corn monocrops. Increasing seeding rate of corn was demonstrated to increase grain yield and corn biomass, but did not significantly affect weed biomass, or total system biomass. The hot, dry conditions experienced in Melita over these two growing seasons likely reduced the observable effects of varying corn seeding rate, and additional trial years where growing season conditions are closer to normal may allow the optimal corn seeding rate for corn-vetch intercrops to be identified. The inclusion of hairy vetch into a corn crop was also demonstrated to increase feed value and crude protein content compared to a corn-only feed, indicating the potential for a corn-vetch intercrop to be implemented into a grazing system. Vetch can also alter the nitrogen economy of a field and contribute additional nitrogen to the system whether corn grain is removed for harvest or not.

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Brainard, D., Henshaw, B. and Snapp, S. 2012. Hairy Vetch Varieties and Bi-Cultures Influence Cover Crop Services in Strip-Tilled Sweet Corn. *Agronomy Journal* **104 (3): 629-638.** doi:10.2134/agronj2011.0360

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28.0 Prairie-Wide Corn Intercropping Project

Project Duration: 2022 – On-going
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 2023 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 will be repeated to obtain adequate data to interpret and use for integrating the following phases of this project. WADO will only be participating 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 (with the wide rows this is equivalent to 36,000 seeds/ac when planting all rows on 30-in spacing), while the 30-inch spaced corn was planted at a population of 36,000 seeds/ac. In Melita, these plots were established near NW6-4-26 in Mentieth loamy fine sand on corn stubble. The corn was planted on May 20th using a Wintersteiger Dynamic Disc planter equipped with EasyPlant software at a depth of 2-inches and seed spacing of 5.8-inches. Fertilizer was banded and incorporated into the soil before planting the corn. A total of 150-50-65-23.4-4-2 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 broadcasted on June 21st then were incorporated into the soil with a 40-inch rototiller at a depth of 0.5-inches. After being incorporated, the cover crops were rolled with a pea roller to ensure good seed-soil contact. Before the cover crops were planted, the plots were sprayed with Roundup Transorb (0.67L ac^{-1}) to kill any unwanted weeds on June 20th. When weeds became a problem, the plots were hand weeded because of the lack of products registered for use on the cover crops used in the treatments. 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 – Not available

This is an on-going project; results are not being released at this time.

29.0 Pea (Oat-Barley-Canola) Intercrop Evaluation

Project duration: 2020-2022 (reporting 2022 year)
Collaborators: Roquette, WADO

Objectives

- Intercrop various below-normal seeding rates of barley, oats or canola with normal seed rates of yellow field peas to determine effects on grain yield and seed quality parameters of both crops
- Understand agronomic changes such as disease, insect pressure, crop behavior, and economical shifts while intercropping compared to monocrops
- Establish potential extension recommendations for pea intercrops as a focus crop for production

Background

Intercropping is fast becoming an alternative sustainable cropping system in Canada and around the world. Success of intercropping may be influenced by both plant density and relative frequency of the intercrop components (Hauggaard-Nielsen et al., 2005). Compatibility and objectives of intercrop components is of paramount importance when selecting crops for a particular system. Many intercropping systems involve a legume component to take advantage of biological nitrogen fixation, which saves on applied fertilizer costs for both the current and succeeding crops in rotation. Other factors to consider when selecting intercrop combinations and densities include; the competitive ability of the component crops against weeds, suppression of disease and insect pests, capability of improving soil conditions by aeration or moisture conservation, overall cost of production, and revenue obtained from the selected option. Protein yield improvement is also a major factor when selecting intercrop combinations to use. Many studies have shown that pea-cereal intercrops have an advantage over cereal monocrops in relation to protein yield per unit area due in part to the contribution by the pea component (Lauk and Lauk, 2008). Various intercrop options involving pea that farmers can use include pea-oat, pea-canola, pea-wheat, and pea-mustard. This study seeks to determine the influence of seeding rate in pea-oat, pea-barley and pea-canola intercrops on yield, quality, disease and pests pressure on component crops and understand the shift in behavior of the crops involved.

Materials and Methods

Three intercrop trials were arranged as randomized complete block design with five treatments each for pea-oat and pea-barley, and six treatments for pea-canola. Final plot size at harvest was approximately 12.96 m^2. Treatments were replicated four times. Soil sampling and testing was done in spring prior to seeding and fertilizer application was based on soil analysis results to meet crop requirements (Table 17a). The trials were conducted near Melita, Manitoba with detailed legal land description and agronomy of the site described in Table 17b. Seeding rate treatments for the pea-oat trial included 100% pea (control), 100% pea: 15% oats, 100% pea: 25% oats, 100% pea: 50% oats, and 100% oats (control). Pea-barley trial included 100% pea (control), 100% pea: 15% barley, 100% pea: 25% barley, 100% pea: 50% barley, and 100% barley (control). Pea-canola trial included 100% pea (control), 100% pea: 25% canola, 100% pea: 50% canola, 75% pea: 25% canola, 75% canola: 25% canola, and 100% canola (control). The target plant stand for 100% crop density was 75 plants per m^2 for peas (Amarillo), 225 plants per m^2 for oats (CS Camden) and barley (CDC Austenson), and 65 plants per m^2 for canola (5545CL). Data collected included crop emergence counts (plants per meter) in row 2 and 5, weed counts (plants per meter squared), aphid counts per 10 random plants, foliar diseases, root rot, lodging and grain yield. Additional data included crude protein content analysis, percent split peas by weight, grain yield, partial and total land equivalence ratio (LER) calculation for each crop and thousand kernel weights. Data were analyzed with Minitab (ver. 18.1) by running a GLM two-way ANOVA. A Tukey Least Significant Difference (LSD) test was used to compare means at 5% level of significance. P-values were derived from raw means, or data transformed using the Johnson method to better fit a linear model. Economic analysis was done based on operating cost, fixed cost, and labor cost assumptions established in 2021 (see appendix). These assumptions were applied to determine the cost of production of each treatment and used to calculate net revenues. Gross revenue was calculated based on average yield from each treatment and market prices established in 2021.

Table 17a. 2022 Spring Soil Test Results for the Melita Site.

pH 0-6"	*N 0-6"	*S 0-6"	OM%	Salt 1	P-O (ppm)	Mg (ppm)	Zn (ppm)
7.4	11	20	3	0.28	7	568	66
pH 6-24"	***N 6-24"**	***S 6-24"**	**N-(N1+N2)**	**Salt 2**	**K (ppm)**	**Ca (ppm)**	**CEC (meq)**
7.4	27	66	38	0.37	230	2828	19.57

*lbs/ac

Table 17b. Field History and Agronomic Practices used for Pea Intercropping in 2022.

Location	Melita	
Legal	SW18-4-26W1	
Rotation (2 yr.)	2020: LL Canola 2021: Oats	
Soil Series	Waskada Loam	
Field Prep	None	
Stubble	Harvested Hailed out oats	
Burn-off (Date/Rate-ac/Products)	Roundup Transorb (0.33L/ac) + Aim (120mL/ac) + Rival (0.65L/ac) @ 10 gal/ water/ac	
Soil Moisture at Seeding	Good	
	Pea-Barley and Pea-Oat	**Pea-Canola**
Seed Date	16-May	16-May
Seed depth	0.75"	0.75"
Seeder (drill/planter?)	Seed hawk dual knife air seeder	
Fertility Applied (N-P-K-S-Zn-lb/ac Actual)	16-30-22-13-1, Granular Pea Nodulator (BASF)	
Topdressing (Date/Rate)	None	
Herbicides (Date, Name, Rate/ac)	07-Jun: MCPA Amine 500 (0.18L/ac) @ 10gal water/ac	
Fungicides	None	
Insecticides	13-Jun: Cygon (120mL/ac) for aphids	01-Jun/06-Jun: Pounce (70mL/ac) for flea beetles. 13-Jun: Matador (34mL/ac) for flea beetles. 05-Jul: Matador (34mL/ac) for blister beetles
Desiccation Date, Product, Rate	16-Aug Reglone (0.69L/ac) + LI700 @ 20gal water/ac	16-Aug Reglone (0.69L/ac) + LI700 @ 20gal water/ac
Harvest Date	26-Aug	26-Aug
GGDs actual (Seed Date>Harvest) Base 5*C	1334	1334
GGDs Normal (Seed Date>Harvest)	1299	1299
Precipitation (Actual) SD>HD	143	143
Precipitation (Normal) SD>HD	267	267

Combine settings	Concave clearance: 8 mm Cylinder: 890 rpm Fan speed: 940 rpm	Concave clearance: 12 mm Cylinder: 600 rpm Fan Speed: 820 rpm
Cleaning	Spiral Separator then table cleaner Barley and pea splits were hard to separate	Table cleaner

Results and Discussion

In 2022, the drought conditions that had been experienced in 2021 were slightly alleviated early in the spring in the Melita area. After July, there was essentially no rainfall in the area which may have impacted the yields and therefore, revenues of the treatments in this trial. Precipitation accumulated throughout the growing season was well below the 30-year normal precipitation for Melita.

When peas were intercropped with oats, days to maturity (DTM) for all pea crops was not significantly different (Table 18a). All intercrop oat treatments DTM was significantly ($P < 0.001$) longer than the sole oat crop. The reduced density of oats in these intercrop treatments, compared to the monocrop, may have resulted in better access to resources and led to longer maturity times. Longer maturity time may also be a result of nitrogen transfer from pea to oat, increasing the amount of nitrogen available to oats when intercropped with pea. Leaf disease prevalence was low in pea-oat intercrops, with no significant difference in leaf disease ratings among treatments. Seed weight of pea was not significantly different across treatments. Seed weight of oats was significantly ($P < 0.001$) greater in the oat monocrop (21.3g/500 seeds) than all the other oat treatments. Protein content of peas was not significantly different across treatments, though protein content of oats in all intercrop treatments was significantly greater ($P = 0.001$) than the oat sole crop, with 100Pea:15Oat and 100Pea:25Oat treatments having the greatest protein content (12.0% and 12.1%, respectively). This implies that intercropping oats with peas may have protein content benefits for oat crops. Seed disease, root rot, and aphid prevalence in pea crops were not significantly impacted by intercropping with oat, though percentage of split peas was significantly ($P < 0.001$) reduced when pea was intercropped with oat (0.9-1.1%), compared to the sole pea crop (13.7%) (Table 18b). This implies that intercropping pea with oat could increase pea grain quality compared to a sole pea crop, perhaps because oats offer some protection to peas during crop harvest. Lodging ratings and weed pressure were not significantly different across treatments.

Table 18a. Means and analysis of variance for Pea-Oat emergence, leaf diseases, days to maturity, seed weight, and protein content at Melita in 2022.

Treatment	Description	Emergence (ppms)		Leaf Disease		DTM (days)		TKWT (g/500)		Protein (%)	
		Pea	Oat	Pea	Oat	Pea	Oat	pea	Oat	Pea	Oat
1	100% Peas (check)	74	-	4.25	-	88	-	114.8	-	21.6	-
2	100% Peas, 15% Oats	68	34**c**	4.58	2.48	86	92**a**	109.2	17.3**c**	21.2	12.0**a**
3	100% Peas, 25% Oats	75	45**c**	4.15	3.00	86	91**a**	110.4	18.0**bc**	21.5	12.1**a**
4	100% Peas, 50% Oats	66	82**b**	4.40	2.55	84	90**a**	114.9	18.9**b**	22.2	11.8**a**
5	100% Oat	-	178**a**	-	2.88	-	86**b**	-	21.3**a**	-	10.5**b**
	P value	0.493	**<0.001**	0.472	0.899	0.28	**<0.001**	0.083	**<0.001**	0.532	**0.001**
	CV%	12	16	9	77	3	1	3	4	3	4
	Grand Mean:	71	84	4.3	1.5	85	89	112.5	19	21.6	11.6

Table 18b. Means and analysis of variance for Pea-Oat lodging score, weed population, pea splits, seed diseases, root rot and aphid count at Melita in 2022.

Treatment	Description	Lodging 1 to 5	Weeds ppms	Peas			
				Pea Splits (%)	Seed Disease (%)	Root Rot (1-7)	Aphids (per plant)
1	100% Peas (check)	2.5	11	13.7	8.3	1.6	2.3
2	100% Peas, 15% Oats	1.0	7	0.9	9.3	1.6	2.4
3	100% Peas, 25% Oats	1.5	5	1.1	12.0	1.5	2.4
4	100% Peas, 50% Oats	1.3	7	1.1	7.0	1.4	2.6
5	100% Oat	1.3	11	-	-	-	-
	P value	0.109	0.514	**<0.001**	0.195	0.817	0.988
	CV%	51	11	18	34	20	49
	Grand Mean:	1.5	8.2	4.2	9.1	1.5	2.4

As expected, there were significant (P<0.001) yield differences between pea sole crop, oat sole crop, and pea-oat intercrops (Table 18c). Pea yield in 100Pea:15Oat (37.0 bu ac^{-1}) and 100Pea:25Oat (34.5 bu ac^{-1}) was significantly lower than the sole pea crop (69.4 bu ac^{-1}), but greater than the 100Pea:50Oat treatment (29.3 bu ac^{-1}). As expected, all oat intercrop treatments had a significantly (P<0.001) lower oat yield than the sole oat crop, with oat yield decreasing with oat density. However, oat yield from the 100Pea:25Oat treatment was not significantly different from either the 100Pea:15Oat or 100Pea:50Oat treatments. Oat yield generally increased with an increase in oat density while pea yield decreased, likely as a result of interspecific competition for nutrients and growing space between the two crops. Partial land equivalent ratios for pea and oats followed the same pattern as yield, with significantly higher LER (P<0.001) in the sole crops compared to the pea-oat intercrop treatments. Pea LER decreased with an increase in oat density, though no significant LER differences were observed between 100Pea:15Oat and 100Pea:25Oat treatments. Oat LER generally increased with an increase in oat density, however LER of the 100Pea:25Oat treatment was not significantly different than that observed in the 100Pea:15Oat treatment. Though differences in partial LER were observed in each crop, there was no statistically significant difference in TLER for sole and intercrop treatments by Tukey's means comparison despite the ANOVA being significant. Table 18c gives insight into what a producer can expect in terms of operating costs, gross revenue and net revenue from different pea-oat intercrop options. For 2022, all of the pea-oat combinations were profitable, the sole pea crop being the most profitable.

Table 18c. Mean Pea-Oat yield, land equivalence ratio and economic analysis at Melita in 2022.

Treatment	Description	Yield (bu/ac)		Land Equivalent Ratio			Economic Analysis		
							COP	Gross Rev	Net Rev
		Pea	Oat	Pea	Oats	TLER	$/ac	$/ac	$/ac
1	100% Peas (check)	69.4**a**	-	1.00**a**	-	1.00**a**	$ 336	$ 566	$ 231
2	100% Peas, 15% Oats	37.0**b**	63.9**b**	0.60**b**	0.54**c**	1.07**a**	$ 348	$ 543	$ 196
3	100% Peas, 25% Oats	34.5**bc**	72.5**b**	0.51**bc**	0.61**c**	1.11**a**	$ 363	$ 556	$ 192
4	100% Peas, 50% Oats	29.3**c**	86.8**b**	0.42**c**	0.73**b**	1.15**a**	$ 354	$ 567	$ 213
5	100% Oat	-	122.0**a**	-	1.00**a**	1.00**a**	$ 305	$ 461	$ 156
	P value	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.027			
	CV%	7.6	12.1	6.8	6.6	6.0			
	Grand Mean:	2873.1	3095.8	0.615	0.717	1.109			

When pea was intercropped with barley at various densities, no significant differences were observed in leaf disease ratings in either crop, and emergence and DTM in peas (Table 19a). Though not significantly affected, the grain weight of peas decreased as the density of barley in the intercrops increased. Grain weight of barley increased as the density of barley in the intercrops decreased, indicating that intercropping with pea may have grain quality benefits at these barley densities. Protein content of both pea and barley were significantly ($P < 0.001$) affected by intercropping; protein content of peas increased as barley density increased, and protein content of barley decreased as barley density increased. Further demonstrating a possible grain quality benefit when barley is intercropped with pea at certain concentrations. No significant differences were observed in lodging and weed pressure across treatments (Table 19b). In peas, no significant difference in root rot, seed disease, or aphid pressure was observed across treatments. Percentage of pea splits were significantly ($P < 0.001$) affected by intercropping with barley. The number of splits in the sole pea crop was significantly lower than in the intercrop treatments. In order to thresh the barley and not throw it out of the back of the combine, the concaves of combine caused mechanical damage to the peas.

Table 19a. Means and analysis of variance for Pea-Barley emergence, leaf diseases, days to maturity, seed weight and protein content at Melita in 2022.

Treatment	Description	Emergence (ppms)		Leaf Disease		DTM (days)		TKWT (g/500)		Protein (%)	
		Pea	Barley	Pea	Barley	Pea	Barley	Pea	Barley	Pea	Barley
1	100% Peas (check)	70	-	4.4	-	81	-	111.8	-	16.8**c**	-
2	100% Peas, 15% Barley	76	29**c**	5.3	2.4	78	85**a**	109.1	24.4	17.9**b**	12.1**a**
3	100% Peas, 25% Barley	68	36**c**	5.0	3.0	78	85**ab**	106.3	24.1	17.9**b**	11.8**b**
4	100% Peas, 50% Barley	69	108**b**	4.9	3.3	78	84**bc**	106.1	23.6	18.9**a**	11.0**c**
5	100% Barley (check)	-	191**a**	-	3.2	-	84**c**	-	23.8	-	10.3**d**
	P value	0.765	**<0.001**	0.143	0.538	0.13	**0.008**	0.087	0.322	**<0.001**	**<0.001**
	CV%	16	16	10	29	2	0	3	3	2	1
	Grand Mean:	71	91	4.9	3	79	85	108.3	24	17.9	11.3

Table 19b. Means and analysis of variance for Pea-barley lodging, weed population, split peas, seed diseases, root rot and aphid count at Melita in 2022.

Treatment	Description	Lodging 1 to 5	Weeds (ppms)	Peas			
				Pea Splits (%)	Seed Disease (%)	Root Rot (1-7)	Aphids (per plant)
1	100% Peas (check)	0	5	13.2**c**	6.8	1.3	3.3
2	100% Peas, 15% Barley	0	7	70.9**a**	5.0	1.5	2.9
3	100% Peas, 25% Barley	0	5	59.3**ab**	9.0	1.1	1.2
4	100% Peas, 50% Barley	0	7	54.6**b**	7.3	1.3	1.9
5	100% Barley (check)	0	8	-	-	-	-
	P value	-	0.335	**<0.001**	0.162	0.479	0.316
	CV%	-	43	14	32	23	72
	Grand Mean:	0	6.25	47	7	1.3	2.3

Pea yield of the pea monocrop was greater than that of the intercropped peas, with pea yield decreasing as barley density increased (Table 19c). Barley yield followed a similar trend, as yield was greatest in the barley sole crop and declined with barley density. Pea yield in 100Pea:25Barley and 100Pea:50Barley treatments were not significantly different. Barley yield in 100Pea:15Barley and 100Pea:25Barley treatments were not significantly different. Partial LER of both the pea and barley crops followed the same trend as yield, with intercrop treatments having lower partial LERs than sole pea and barley crops. The TLER of each intercrop combination was greater than that of the sole pea and barley crops, this is significantly different (P = 0.032), but the differences were small. While this result does not point to a clear LER benefit from intercropping pea with barley, it does demonstrate that land equivalence ratios were not reduced by intercropping. For 2022, all of the pea-barley treatments were profitable, the 100Pea:50Barley combination being the most profitable. Across the three crop combinations, the pea-barley combination was the least profitable overall.

Table 19c. Mean Pea-barley yield, Land Equivalence Ratio and economic analysis at Melita in 2022.

Treatment	Description	Yield (bu/ac)		Land Equivalent Ratio			Economica Analysis		
		Pea	Barley	Pea	Barley	TLER	COP $/ac	Gross Rev $/ac	Net Rev $/ac
1	100% Peas (check)	42.9**a**	0.0	1.00**a**	-	1.00**b**	$ 336	$ 350	$ 14
2	100% Peas, 15% Barley	30.1**b**	31.9**c**	0.62**b**	0.45**d**	1.06**ab**	$ 344	$ 389	$ 46
3	100% Peas, 25% Barley	24.2**bc**	42.0**c**	0.50**c**	0.59**c**	1.09**ab**	$ 345	$ 386	$ 41
4	100% Peas, 50% Barley	19.2**c**	55.8**b**	0.39**c**	0.78**b**	1.17**a**	$ 349	$ 408	$ 59
5	100% Barley (check)	0.0	72.2**a**	-	1.00**a**	1.00**b**	$ 301	$ 325	$ 24
	P value	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.032**			
	CV%	10.6	10.9	8.4	7.6	6.6			
	Grand Mean:	2062.3	2715.5	0.626	0.564	1.108			

When pea was intercropped with canola, there was no significant difference in leaf disease incidence among treatments (Table 20a). Pea grain weights were not significantly different across treatments. For canola, there were significant (P = 0.001) differences in grain weight in the intercrop treatments and the sole canola crop. Though the grain weights were higher than the sole canola crop, there were no significant differences found in the grain weight of canola between the different densities. The protein content was significant (P < 0.001) between the sole canola crop and the canola intercrops, but there were no differences found between the intercrops. No significant lodging or weed pressure differences were observed between treatments (Table 20b). In pea crops, no significant differences were observed in percentage of split peas, seed disease or aphid pressure, but the incidence of root rot was significant (P = 0.009) in all combinations, including the sole pea crop, but only varied by a small amount. These results demonstrate little influence of Pea:Canola density ratios on grain quality and pest suppression, as varying the density of each crop in the intercrop did not produce a consistent trend.

Table 20a. Means and analysis of variance for pea-canola emergence, leaf diseases, days to maturity, seed weight and protein content at Melita in 2022.

Treatment	Description	Emergence (ppms)		Leaf Disease		DTM (days)		TKWT (g/500)		Protein (%)	
		Pea	Canola	Pea	Canola	Pea	Canola	Pea	Canola	Pea	Canola
1	100% Peas (check)	84**a**	-	3.63	-	82	-	120.9	-	21.2	-
2	100% Peas, 25% Canola	79**ab**	5**b**	4.35	0.00	81	92**b**	120.8	2.1**a**	21.3	23.4**a**
3	100% Peas, 50% Canola	63**bc**	17**b**	4.30	0.00	80	92**b**	120.4	2.2**a**	20.5	22.4**a**
4	75% Peas, 25% Canola	59**c**	7**b**	4.03	0.00	82	92**b**	120.5	2.2**a**	20.9	23.3**a**
5	75% Peas, 50% Canola	47**c**	13**b**	4.00	0.00	81	92**b**	118.6	2.1**a**	20.6	22.3**a**
6	100% Canola (check)	-	41**a**	-	0.00	-	93**a**	-	1.8**b**	-	18.2**b**
	P value	**<0.001**	**0.002**	0.392	-	0.422	**0.017**	0.897	**0.001**	0.52	**<0.001**
	CV%	13	59	14	-	2	1	3	4	4	5
	Grand Mean:	66	17	4	0	81	92	120.2	2.1	20.9	21.9

Table 20b. Means and analysis of variance for pea-canola lodging, weed population, split peas, seed disease, root rot and aphid count at Melita in 2022.

Treatment	Description	Lodging 1 to 5	Weeds (ppms)	Peas: Pea Splits (%)	Peas: Seed Disease (%)	Peas: Root Rot (1-7)	Peas: Aphids (per plant)
1	100% Peas (check)	1.5	1.5	4.5	6.5	1.3**a**	0.7**ab**
2	100% Peas, 25% Canola	1.5	0.5	4.5	4.3	1.2**ab**	1.1**ab**
3	100% Peas, 50% Canola	2.5	1.8	4.4	3.0	1.1**b**	0.6**b**
4	75% Peas, 25% Canola	2.4	1.5	3.6	4.5	1.2**ab**	1.6**a**
5	75% Peas, 50% Canola	2.3	3.8	3.9	4.3	1.1**b**	1.3**ab**
6	100% Canola (check)	0.0	4.0	-	-	-	-
	P value	0.053	0.57	0.795	0.21	**0.009**	0.057
	CV%	39	142	34	43	7	46
	Grand Mean:	1.9	2.2	4	4.5	1.17	1.02

Pea yield was greatest in the pea sole crop and canola yield was greatest in the canola sole crop (Table 20c). There were no significant pea yield differences among sole pea crop, 100Pea:25Canola, and 75Pea:25Canola treatments. Among intercrop treatments, the 100Pea:50Canola intercrop resulted in the greatest canola yield, while the lowest canola yields were produced by 100Pea:25Canola and 75Pea:25Canola treatments. Partial land equivalence ratios followed the same trend as yield. All pea-canola intercrop combinations had a greater TLER than the sole crops, though this difference was not statistically significant. While the results presented here do not clearly demonstrate optimal ratios for pea-canola intercrops, they do demonstrate that TLER was not reduced by intercropping peas with canola. For 2022, all of the pea-canola treatments were profitable, the sole pea crop and 100Pea:25Canola treatments being the most profitable. The sole canola crop turned out to be the least profitable treatment, indicating there is an economic benefit to intercropping canola with peas.

Table 20c. Mean Pea-canola yield, Land Equivalent Ratio, and economic analysis at Melita in 2022.

Treatment	Description	Yield (bu/ac): Pea	Yield (bu/ac): Canola	Land Equivalent Ratio: Pea	Land Equivalent Ratio: Canola	Land Equivalent Ratio: TLER	Economic Analysis: COP $/ac	Economic Analysis: Gross Rev $/ac	Economic Analysis: Net Rev $/ac
1	100% Peas (check)	66.5**a**	0	1.00**a**	-	1.00	$ 336	$ 543	$ 207
2	100% Peas, 25% Canola	61.9**ab**	5.7**c**	0.93**ab**	0.14**c**	1.07	$ 368	$ 575	$ 208
3	100% Peas, 50% Canola	47.7**c**	12.6**b**	0.72**c**	0.31**b**	1.03	$ 383	$ 545	$ 162
4	75% Peas, 25% Canola	56.5**abc**	7.6**bc**	0.85**abc**	0.19**bc**	1.04	$ 359	$ 555	$ 196
5	75% Peas, 50% Canola	50.3**bc**	10.4**bc**	0.76**bc**	0.27**bc**	1.02	$ 375	$ 539	$ 164
6	100% Canola (check)	0	39.6**a**	-	1.00**a**	1.00	$ 354	$ 489	$ 135
	P value	**0.002**	**<0.001**	**0.001**	**<0.001**	0.126			
	CV%	9	20	9	20	4			
	Grand Mean:	3804.6	850.7	0.852	0.318	1.041			

In 2022, every treatment across all three intercrop combinations were profitable. Compared to the 2021 growing season, the trial had a better chance at revealing financial and non-financial benefits to intercropping. Non-financial benefits of intercrops must be considered, as producers would also benefit from pest and disease suppression effects of intercropping demonstrated in previous studies. Here, pea-oat, pea-barley, and pea-canola intercrops all demonstrated an increase in cereal and oilseed crop protein content compared to sole crops. Pea-canola and pea-oat intercropping was also demonstrated to reduce the incidence of pea splits in pea crops, suggesting the potential of companion crops to protect the pea crop during harvest. It would also be worthwhile to consider fall soil sampling in order to determine if soil nutrient dynamics are affected by various pea intercrop combinations and densities. In 2022, drought conditions were only experienced later in the growing season, not throughout the entire growing season like in 2021. The dry conditions in the fall likely led to reduced synergistic effects of intercropping compared to wetter years, and it is likely that more over-yielding would have been observed if crops were under less drought stress.

Pictures

Figures 12a, 12b, and 12c. Top Left: Pea- Canola Intercrop trial. Top Right: Pea-Barley intercrop trial. Bottom: Pea-Oat intercrop trial. All grown at Melita in 2022.

Appendix

	Pea	Oat	Canola	Barley	PeaCan	PeaCan	PeaCan	PeaCan	PeaOat	PeaOat	PeaOat	PeaBar	PeaBar	PeaBar
Crop System	1	5	6	5	2	3	4	5	2	3	4	2	3	4
Operating Cost														
Seed and Treament	$ 35.06	$ 18.13	$ 62.50	$ 15.00	$ 50.69	$ 66.31	$ 41.92	$ 57.55	$ 37.78	$ 53.19	$ 44.13	$ 37.31	$ 38.81	$ 42.56
Fertilizer	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26
Herbicide*	$ 34.00	$ 24.00	$ 34.00	$ 21.00	$ 34.00	$ 34.00	$ 34.00	$ 34.00	$ 24.00	$ 24.00	$ 24.00	$ 21.00	$ 21.00	$ 21.00
Fuel	$ 20.39	$ 20.39	$ 21.09	$ 24.21	$ 24.21	$ 24.21	$ 24.21	$ 24.21	$ 24.21	$ 24.21	$ 24.21	$ 24.21	$ 24.21	$ 24.21
Machinery Operating	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00
Crop Insurance	$ 8.90	$ 9.31	$ 7.89	$ 9.75	$ 8.40	$ 8.40	$ 8.40	$ 8.40	$ 9.11	$ 9.11	$ 9.11	$ 9.33	$ 9.33	$ 9.33
Other**					$ 12.00	$ 12.00	$ 12.00	$ 12.00	$ 12.00	$ 12.00	$ 12.00	$ 12.00	$ 12.00	$ 12.00
Land Taxes	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00
inoculant cost	$ 11.00				$ 11.00	$ 11.00	$ 11.00	$ 11.00	$ 11.00	$ 11.00	$ 11.00	$ 11.00	$ 11.00	$ 11.00
Interest (5% for 6 months)	$ 4.35	$ 4.43	$ 6.77	$ 5.09	$ 5.56	$ 5.56	$ 5.56	$ 5.56	$ 4.39	$ 4.39	$ 4.39	$ 4.72	$ 4.72	$ 4.72
Total Operating	**$ 169.96**	**$ 132.52**	**$ 188.51**	**$ 131.31**	**$ 202.11**	**$ 217.74**	**$ 193.35**	**$ 208.97**	**$ 178.74**	**$ 194.16**	**$ 185.09**	**$ 175.83**	**$ 177.33**	**$ 181.08**
Fixed Cost														
Land Investment	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06
Machinery Cost	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31
Storage Cost***	$ 4.88	$ 11.93	$ 4.77	$ 9.09	$ 4.83	$ 4.83	$ 4.83	$ 4.83	$ 8.41	$ 8.41	$ 8.41	$ 6.99	$ 6.99	$ 6.99
Total Fixed	**$ 139.25**	**$ 146.30**	**$ 139.14**	**$ 143.46**	**$ 139.20**	**$ 139.20**	**$ 139.20**	**$ 139.20**	**$ 142.78**	**$ 142.78**	**$ 142.78**	**$ 141.36**	**$ 141.36**	**$ 141.36**
Labour Cost^	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40
TOTAL COST	**$ 335.61**	**$ 305.22**	**$ 354.05**	**$ 301.17**	**$ 367.71**	**$ 383.33**	**$ 358.94**	**$ 374.57**	**$ 347.92**	**$ 363.33**	**$ 354.27**	**$ 343.58**	**$ 345.08**	**$ 348.83**

* based one burnoff application of Roundup Transorb

**based on an extra cost of $1/ac to use a rotary seed cleaner, $1/ac for an extra auger, $10/ac cleaning cost: (20 yr depreciation cost), 350 bu/hr, $20/hr labour

***based on needing double the storage for two separate crops

^Labour cost inflated for intercropping due to the extra labour needed to ship, clean and harvest intercrops

Market Prices	$/bu
peas	$ 8.16
Oat	$ 3.78
canola	$ 12.35
Barley (malt)	$ 4.50

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30.0 Pea (Oat-Barley-Canola) Intercrop Evaluation – Three-Year Final Report

Project Duration: 2020-2022
Collaborators: Roquette Canada Ltd.

Objectives

- Intercrop various below-normal seeding rates of barley, oats or canola with normal seed rates of yellow field peas to determine effects on grain yield and seed quality parameters of both crops
- Understand agronomic changes such as disease, insect pressure, crop behavior, and economical shifts while intercropping compared to monocrops
- Establish potential extension recommendations for pea intercrops as a focus crop for production

Abstract
Intercropping systems can benefit both producers and the environment by exhibiting biological control mechanisms which reduce weed, disease, and insect pressure, and in turn reduce the need for synthetic chemical crop inputs.

This study evaluated the agronomic and economic success of oat, barley, and canola intercropped with peas near Melita, Manitoba from 2020 to 2022. Crop emergence, weed counts, disease incidence data, grain yield and grain quality including percent pea seed splits and pea crude protein content was collected over three growing seasons at each trial location and data was combined prior to analysis for each trial. Three-year average total land equivalence ratio (TLER) of all intercrop combinations were above 1, indicating consistent over-yielding from each of these intercrop combinations at all sites. TLER of pea-oat, pea-barley, and pea-canola intercrops were all significantly greater than that of the sole pea crop in all

three years. While no significant net revenue difference was observed among intercrops for all three intercrop combinations, the sole pea treatment was the most profitable. Over all three years of the intercropping trial, the sites only received roughly 75% of the normal rainfall; perhaps if adequate moisture was received, more over-yielding of the intercrops would have been seen, increasing the revenue of the systems. There was a significant difference observed in split pea incidence between intercrops and pea sole crop in the pea-barley trial, and no significant differences in pea grain protein content was seen in any combination. The only differences in protein content were observed in the intercropping partner to the peas. Disease pressure was low at all sites in all trial years therefore, no disease incidence trends could be identified. Overall, while no weed, disease, or insect suppression effects was observed from intercropping, pea-oat, pea-canola, and pea-mustard intercrops generally performed well in terms of yield, TLER, and net revenue at each site. The results presented here expand on existing intercrop research and contribute to providing pea producers insight on the yield and revenue potential of various pea intercrop systems in Manitoba.

Materials and Methods

Trials were established in 2020, 2021, and 2022 near Melita (Tables 22a, 22b, and 22c). For three years, three intercrop trials were arranged as randomized complete block designs with five treatments for pea-oat and pea-barley intercrops, and six treatments for pea-canola intercrops under no-till conditions. Plots were seeded with a Seedhawk dual knife opener in 6 rows with 24 cm row spacing. Treatments were replicated four times, and the final plot size at harvest was approximately 12.96 m^2. Seeding Rate treatments in the pea-oat trial included 100% pea (control), 100% pea: 15% oats, 100% pea: 25% oats, 100% pea: 50% oats, and 100% oats (control). Pea-barley trial included 100% pea (control), 100% pea: 15% barley, 100% pea: 25% barley, 100% pea: 50% barley, and 100% barley (control). Pea-canola trial included 100% pea (control), 100% pea: 25% canola, 100% pea: 50% canola, 75% pea: 25% canola, 75% canola: 25% canola, and 100% canola (control). The target plant stand for 100% crop density was 75 plants per m^2 for peas (Amarillo), 225 plants per m^2 for oats (CS Camden) and barley (CDC Austenson), and 65 plants per m^2 for canola (5545CL). Soil tests were conducted to determine nutrient status before seeding at all sites, and fertilizer was applied during seeding as a sideband. Granular pea inoculant (SCG Nodulator, BASF) was also applied during seeding at recommended rates with the pea seed. The use of in-crop herbicides, insecticides, and desiccants can be seen in the tables below. Data collected included crop emergence counts in row 2 and 5, weed counts, aphid counts per 10 random plants, foliar diseases, root rot, lodging and grain yield. Additional data included crude protein content analysis, percent split peas by weight, grain yield, partial and total land equivalence ratio (LER) calculation for each crop and thousand kernel weights. All three years of data was combined and analyzed with Minitab (ver. 18.1) by running a REML mixed model ANOVA where treatment was a fixed factor and year was nested within the replication as random factors. A Fisher's Least Significant Difference (LSD) test was used to compare means at 5% level of significance.

Economic analysis was calculated per treatment based on operating cost, fixed cost, and labor cost assumptions that were fixed over the three years (Appendix). These assumptions determined the cost of production of each treatment and were used to calculate net revenues. Gross revenue was calculated based on average yield from each treatment and market prices established in 2020. The cost of production amounts were also adjusted for the extra cost of cleaning, storage, labor and shipping costs that are involved with intercropping.

Table 21. General field and seasonal information for the pea intercrop trials in 2020, 2021, and 2022 at Melita.

Roquette Pea Intercrops 2020-2022			
Year	**2020**	**2021**	**2022**
Legal Location	SE26-3-27W1	NW27-3-27W1	SW18-4-26W1
Rotation (2 yr.) at site	2018: RR Soybean 2019: Wheat	2019: RR Canola 2020: Wheat	2020: LL Canola 2021: Oats
Herbicide rotation (2yr.) at site	2018: Viper, Roundup 2019: Puma, Traxos 2	2019: Roundup 2020: Puma, Traxos 2	2020: Liberty, 2021: Stellar
Soil Series	Newstead Loam	Alexander Loam	Alexander Loam
Growing Degree Days	**Seeding Date to Harvest Date**		
Actual	1303	1305	1334
Normal	1249	1172	1299
Precipitation (mm)	**Seeding Date to Harvest Date**		
Actual	166	175	143
Normal	262	254	267

Table 22a. Agronomic information for pea-oat intercrops in 2020, 2021, and 2022 at Melita.

Roquette Pea-Oat Intercrops			
Year	**2020**	**2021**	**2022**
Burn-off Date	08-May, 11-May	None	None
Seeding Date	08-May	04-May	16-May
Seeding Depth	0.75"	1.00"	0.75"
In-crop herbicide application dates	05-Jun, 09-Jun	08-Jun	07-Jun
Insecticide Application Dates	None	None	13-Jun
Desiccation Date	None	03-Aug	16-Aug
Harvest Date	19-Aug	12-Aug	26-Aug

Table 22b. Agronomic information for pea-barley intercrops in 2020, 2021, and 2022 at Melita.

Roquette Pea-Barley Intercrops			
Year	**2020**	**2021**	**2022**
Burn-off Date	08-May, 11-May	None	None
Seeding Date	08-May	04-May	16-May
Seeding Depth	0.75"	1.00"	0.75"
In-crop Herbicide Application Dates	05-Jun, 09-Jun	08-Jun	07-Jun
Insecticide Application Dates	None	None	13-Jun
Desiccation Date	11-Aug	03-Aug	16-Aug
Harvest Date	12-Aug	12-Aug	26-Aug

Table 22c. Agronomic information for pea-canola intercrops in 2020, 2021, and 2022 at Melita.

Roquette Pea-Canola Intercrops			
Year	**2020**	**2021**	**2022**
Burn-off Date	08-May, 11-May	None	16-May
Seeding Date	08-May	07-May	16-May
Seeding Depth	0.75"	0.75"	0.75"
In-Crop Herbicide Application Dates	04-Jun	08-Jun	None
Insecticide Application Dates	26-May, 28-May	10-Jun	01-Jun, 06-Jun, 13-Jun, 05-Jul
Desiccation Dates	11-Aug	10-Aug	16-Aug
Harvest Dates	19-Aug	16-Aug	26-Aug

Table 23. Combine settings used over all three years in all three intercrop trials that were performed at Melita.

Setting	Pea-Oat and Barley	Pea-Canola
Concave	8mm	12mm
Cylinder	890 rpm	600 rpm
Fan Speed	940 rpm	820 rpm

The combine settings were kept constant throughout the duration of the trial to conserve consistency. The pea-oat and pea-barley plots were combined at the same settings, which worked well. These settings were fine-tuned by trial and error over time before this project had begun. In the pea-barley plots, more peas were found to be split than in the other crop combinations; this was impossible to avoid since the barley would not have been threshed properly otherwise.

Results and Discussion

Accumulated precipitation at the Melita site was lower than the 30-year normal precipitation in 2020, 2021, and 2022 (Table 21). Low accumulated precipitation in all three years contributed to lower-than-expected yields across the intercropping combinations. In 2021, the low yields led to negative net revenue calculations for all intercrop combinations, but in the combined results over the three years, only one combination resulted in a negative net revenue. Having at least one year with adequate rainfall may have given better insight into the benefits of intercropping. Adequate rainfall may also have given more data relating to weed, disease, and insect pressure incidence differences between the treatments in each trial.

Samples harvested from the plots were cleaned with the intention of separating the two crop types, which producers would need to do before selling the grain. For the pea-canola samples, the peas and canola were easily separated by using a table cleaner with little-to-no issues. For the pea-oat and pea-barley samples, the separation was only established by running the samples through a spiral cleaner. When the barley samples were examined after cleaning, it was observed that the pea splits were virtually impossible to remove from the barley seeds since they are both similar in size, shape, and weight.

When oats were intercropped with peas, emergence corresponded with seeding rate significantly (P<0.001) and days to maturity was significantly affected (P = 0.006) (Table 24a). The days to maturity of the oats increased when the density of the oats in the intercrop system decreased; this could be attributed to the oats have more nutrients available in intercrops due to reduced plant densities compared to sole crop oats, and therefore staying green longer when paired with peas. The grain protein content of both oats and barley increased when the density of the cereal crop decreased in the intercrop, indicating a grain quality benefit of intercropping with pea, though the percentages were not found to be significantly different (Table 24b). Canola protein content was significantly (P < 0.001) increased when intercropped with pea compared to the sole canola crop; protein being highest in the 100%Pea:25%Canola treatment (21.8%) (Table 24c).

Table 24a. Three-year means of emergence, days to maturity, grain protein content, and seed weight of pea-oat intercrops at Melita in 2020-2022.

Treatment	Description	Emergence (ppms)		DTM		Protein (%)		TKWT (g/500)	
		Pea	Oat	Pea	Oat	Pea	Oat	Pea	Oat
1	100% Peas (Check)	60	-	86	-	23.2	-	114.7	-
2	100% Peas, 15% Oats	58	28**c**	85	89**a**	23.1	12.8**a**	110.4	19.0
3	100% Peas, 25% Oats	65	35**c**	85	87**ab**	23.1	12.7**a**	111.3	19.1
4	100% Peas, 50% Oats	60	64**b**	84	86**b**	23.4	11.9**a**	111.2	19.8
5	100% Oats (Check)	-	149**a**	-	84**c**	-	10.6**b**	-	20.5
	P-Value:	0.589	**<0.001**	0.143	**0.006**	0.840	**0.005**	0.166	0.529

Table 24b. Three-year means of emergence, days to maturity, grain protein content, and seed weight of pea-barley intercrops at Melita in 2020-2022.

Treatment	Description	Emergence (ppms)		DTM		Protein (%)		TKWT (g/500)	
		Pea	Barley	Pea	Barley	Pea	Barley	Pea	Barley
1	100% Peas (Check)	55	-	83	-	21.6	-	112.6	-
2	100% Peas, 15% Barley	63	24**c**	82	83	22	13.3**a**	110.9	21.3
3	100% Peas, 25% Barley	62	33**c**	81	83	22.1	12.8**a**	110.7	21
4	100% Peas, 50% Barley	61	79**b**	81	82	22.4	12.4**a**	108.7	20.5
5	100% Barley (Check)	-	153**a**	-	81	-	10.9**b**	-	20.8
	P-Value:	0.225	**<0.001**	0.057	0.192	0.333	**0.005**	0.085	0.686

Table 24c. Three-year means on emergence, days to maturity, grain protein content, and seed weight of pea-canola intercrops at Melita in 2020-2022.

Treatment	Description	Emergence (ppms)		DTM		Protein (%)		TKWT (g/500)	
		Pea	Canola	Pea	Canola	Pea	Canola	Pea	Canola
1	100% Peas (Check)	67**a**	-	85	-	23.2	-	117	-
2	100% Peas, 25% Canola	65**a**	12**b**	85	92	23.3	21.8**a**	118	1.9
3	100% Peas, 50% Canola	58**a**	19**b**	84	91	23.1	21.0**a**	119.3	1.9
4	75% Peas, 25% Canola	48**b**	17**b**	85	92	23	21.4**a**	117.4	1.9
5	75% Peas, 50% Canola	42**b**	18**b**	85	92	23	20.7**a**	118.2	1.9
6	100% Canola (Check)	-	44**a**	-	92	-	17.9**b**	-	1.8
	P-Value:	**0.001**	**0.001**	0.447	0.126	0.495	**<0.001**	0.709	0.630

Regarding lodging, weed counts, disease and insect pressure, and percentage of split peas, no data was found to be significant in the three years combines for pea-oat and pea-canola intercrops (Table 25a, and 25c). In the pea-barley intercrops, the foliar disease incidence slightly decreased when the pea population in the combination increased (P = 0.047) (Table 25b). The conditions over the three years were not conducive to for disease pressure, therefore disease incidence benefits of intercropping were not seen.

Table 25a. Three-year means for agronomic characteristics and seed quality of pea-oat intercrops at Melita in 2020-2022.

Treatment	Description	Lodging (1-5)	Weeds (ppms)	Aphids #/plant	Folar Disease		Pea Root Rot (1-7)	Pea Splits %	Pea Seed Disease %
					Pea	Oat			
1	100% Peas (Check)	1.67	7	1.4	2.4	-	1.1	7.4	5.3
2	100% Peas, 15% Oats	1.08	7	1.6	2.7	2.1	1.2	1.6	5.8
3	100% Peas, 25% Oats	1.25	5	1.4	2.6	2.6	1.3	1.8	7.7
4	100% Peas, 50% Oats	1.42	8	1.4	2.4	2.3	1.3	2.1	5.4
5	100% Oats (Check)	1.67	10	-	-	2.9	-	-	-
	P-Value:	0.546	0.180	0.957	0.400	0.154	0.766	0.108	0.243

Table 25b. Three-year means for agronomic characteristics and seed quality of pea-barley intercrops at Melita in 2020-2022.

Treatment	Description	Lodging (1-5)	Weeds (ppms)	Aphids #/plant	Folar Disease Pea	Folar Disease Barley	Pea Root Rot (1-7)	Pea Splits %	Pea Seed Disease %
1	100% Peas (Check)	0.67	9	1.6	2.5	-	1	7.4	6.3
2	100% Peas, 15% Barley	0.67	10	1.5	2.9	2.2**b**	1.2	26.8	5.3
3	100% Peas, 25% Barley	0.67	11	0.9	2.6	2.7**ab**	1.4	23.1	6.2
4	100% Peas, 50% Barley	0.92	11	1	2.6	2.7**ab**	1.3	23.3	4.5
5	100% Barley (Check)	0.67	12	-	-	2.9**a**	-	-	-
	P-Value:	0.461	0.860	0.341	0.142	**0.047**	0.361	0.147	0.517

Table 25c. Three-year means for agronomic characteristics and seed quality of pea-canola intercrops at Melita in 2020-2022.

Treatment	Description	Lodging (1-5)	Weeds (ppms)	Aphids #/plant	Folar Disease Pea	Folar Disease Canola	Pea Root Rot (1-7)	Pea Splits %	Pea Seed Disease %
1	100% Peas (Check)	1.17	4	0.6	2.3	-	1.3	2.9	4.3
2	100% Peas, 25% Canola	1.25	6	0.9	2.5	0.1	1.3	2.9	4.1
3	100% Peas, 50% Canola	1.58	5	1.1	2.4	0	1.3	2.7	2.1
4	75% Peas, 25% Canola	1.58	6	1.4	2.4	0	1.3	2.4	3.7
5	75% Peas, 50% Canola	1.50	3	1	2.4	0	1.1	2.6	3.1
6	100% Canola (Check)	1.00	9	-	-	0	-	-	-
	P-Value:	0.262	0.169	0.605	0.806	0.504	0.614	0.538	0.105

In the pea-oat intercrops, the greatest pea grain yield was established in the sole pea crop (4112 kg ha^{-1}) and was significantly different (P = 0.001) from the pea grain yield when intercropped with oat (Table 26a). The highest oat grain yield was also seen in the sole oat crop (3536 kg ha^{-1}) which was significantly different (P < 0.001) from the oat yield when intercropped with pea. The LER for both pea and oats were significantly different (P < 0.001); as the density of each crop decreased, the corresponding LER decreased. Though LER and yields decreased with decreasing crop density, the TLER was higher in intercrops than the sole crops in all intercrop combinations. Though the intercrops TLER values were not significantly different, TLER was not reduced by intercropping oat with pea. The highest TLER in the pea-oat trial was established in the 100%Pea:50%Oat treatment.

In the pea-barley intercrops, the greatest pea yield was seen in the sole pea crop (3627 kg ha^{-1}), and was significant (P < 0.001) from the pea grain yield when intercropped with barley (Table 26b). The highest barley grain yield was seen in the barley sole crop (2986 kg ha^{-1}) and was significantly different (P < 0.001) from the barley yield when intercropped with pea. The LER for both pea and barley were significantly different (P = 0.002, and P < 0.001, respectively); as the crop density of each pea and barley decreased, the corresponding LER decreased. Though the LER and yields both decreased as crop density decreased, the TLER was higher in the intercrops than the sole crops of both pea and barley. The TLER of the crops combined were significantly (P = 0.017) higher than the TLER of the sole crops. The highest TLER in the pea-barley trial was established in the 100%Pea:50%Barley treatment.

In the pea-canola intercrops, the greatest pea grain yield was seen in the sole pea crop (4295 kg ha^{-1}), and that was not significantly different (P = 0.006) than the pea grain yield of the 100%Pea:25%Canola intercrop treatment (3821 kg ha^{-1}) (Table 26c).The highest canola grain yield was seen in the canola sole crop (1806 kg ha^{-1}) and was significantly higher (P < 0.001) than the canola yield in any other treatment. The LER values were significant (P < 0.001) for both the canola and pea crops. The TLER values of the sole pea and canola crops were significantly lower (P < 0.001) than the TLER of the intercrops, except for the 75%Pea:25%Canola treatment. Though the yields of the canola in any of the intercrop treatments was lower than expected, the TLER was still higher in the intercrop than in the sole crop. The highest TLER in the pea-canola trial was established in the 100%Pea:50%Canola treatment.

Table 26a. Three-year mean of Yield and Land Equivalency Ratio of oat grown in monocrop or with pea at Melita in 2020-2022.

Treatment	Description	Yield (kg/ha)		Yield (bu/ac)		LER		
		Pea	Oat	Pea	Oat	Pea	Oat	TLER
1	100% Peas (Check)	4112**a**	-	61.1	-	1.000**a**	-	1.000**b**
2	100% Peas, 15% Oats	2645**b**	1676**c**	39.3	46.7	0.639**b**	0.473**d**	1.112**a**
3	100% Peas, 25% Oats	2359**bc**	2002**c**	35.1	55.8	0.576**b**	0.565**c**	1.141**a**
4	100% Peas, 50% Oats	1877**c**	2518**b**	17.7	70.2	0.435**c**	0.715**b**	1.150**a**
5	100% Oats (Check)	-	3536**a**	-	98.6	-	1.000**a**	1.000**b**
	P-Value:	**0.001**	**<0.001**	-	-	**<0.001**	**<0.001**	**0.021**

Table 26b. Three-year mean of Yield and Land Equivalency Ratio of barley grown in monocrop or with pea at Melita in 2020-2022.

Treatment	Description	Yield (kg/ha)		Yield (bu/ac)		LER		
		Pea	Barley	Pea	Barley	Pea	Barley	TLER
1	100% Peas (Check)	3627**a**	-	53.9	-	1.000**a**	-	1.000**b**
2	100% Peas, 15% Barley	2610**b**	1209**c**	38.8	22.5	0.710**b**	0.400**c**	1.110**a**
3	100% Peas, 25% Barley	2341**b**	1562**c**	34.8	29.0	0.614**bc**	0.518**c**	1.131**a**
4	100% Peas, 50% Barley	1929**c**	2061**b**	28.7	38.3	0.482**c**	0.678**b**	1.160**a**
5	100% Barley (Check)	-	2986**a**	-	55.5	-	1.000**a**	1.000**b**
	P-Value:	**<0.001**	**<0.001**	-	-	**0.002**	**<0.001**	**0.017**

Table 26c. Three-year mean of yield and Land Equivalency Ratio of canola grown in monocrop or with pea at Melita in 2020-2022.

Treatment	Description	Yield (kg/ha)		Yield (bu/ac)		LER		
		Pea	Canola	Pea	Canola	Pea	Canola	TLER
1	100% Peas (Check)	4295**a**	-	63.9	-	1.00**a**	-	1.000**b**
2	100% Peas, 25% Canola	3821**ab**	348**b**	56.8	6.2	0.886**b**	0.196**c**	1.082**a**
3	100% Peas, 50% Canola	3442**bc**	589**b**	51.2	10.5	0.791**c**	0.324**b**	1.115**a**
4	75% Peas, 25% Canola	3454**bc**	434**b**	51.4	7.7	0.800**c**	0.246**c**	1.045**ab**
5	75% Peas, 50% Canola	3206**c**	645**b**	47.7	11.5	0.739**c**	0.370**b**	1.109**a**
6	100% Canola (Check)	-	1806**a**	-	32.2	-	1.000**a**	1.000**b**
	P-Value:	**0.006**	**<0.001**	-	-	**<0.001**	**<0.001**	**<0.001**

When the three years of data was combined it was found that across the combinations of intercrops, the sole pea crop generated the greatest net revenue each time (Tables 27a, 27b, and 27c). Across the trials, the sole pea crop treatment in the pea-canola trial had the highest net return ($185.81 ac^{-1}) of all the treatments. In the pea-oat intercrop, the 100%Pea:50%Oat treatment generated the least net revenue ($55.52 ac^{-1}); in the pea-canola trials, the sole canola crop produced the least net revenue ($43.62 ac^{-1}). The least profitable treatment overall was the sole barley crop (-$51.42 ac^{-1}), and it was also the only treatment that generated a negative net revenue when all three years of data was combined.

Table 27a. Cost of Production, Gross Revenue, and Net Revenue of pea-oat intercrops, based off the three-year means of yield at Melita in 2020-2022.

Treatment	Description	Cost of Production $/ac	Gross Revenue $/ac	Net Revenue $/ac
1	100% Peas (Check)	335.61	**498.58**	**162.97**
2	100% Peas, 15% Oats	347.92	497.22	149.3
3	100% Peas, 25% Oats	**363.33**	497.35	134.02
4	100% Peas, 50% Oats	354.27	409.79	55.52
5	100% Oats (Check)	305.22	372.71	67.49

*The cost of production and crop prices are based off of 2022 numbers. The cost and prices are also adjusted to reflect the extra storage, labour, and cleaning required for intercrops.

Table 27b. Cost of Production, Gross Revenue, and Net Revenue of pea-barley intercrops, based off the three-year means of yield at Melita in 2020-2022

Treatment	Description	Cost of Production $/ac	Gross Revenue $/ac	Net Revenue $/ac
1	100% Peas (Check)	335.61	**439.82**	**104.21**
2	100% Peas, 15% Barley	343.58	417.86	74.28
3	100% Peas, 25% Barley	345.08	414.47	69.39
4	100% Peas, 50% Barley	**348.83**	406.54	57.71
5	100% Barley (Check)	301.17	249.75	-51.42

*The cost of production and crop prices are based off of 2022 numbers. The cost and prices are also adjusted to reflect the extra storage, labour, and cleaning required for intercrops.

Table 27c. Cost of Production, Gross Revenue, and Net Revenue of pea-canola intercrops, based off the three-year means of yield at Melita in 2020-2022.

Treatment	Description	Cost of Production $/ac	Gross Revenue $/ac	Net Revenue $/ac
1	100% Peas (Check)	335.61	521.42	**185.81**
2	100% Peas, 25% Canola	367.71	540.06	172.35
3	100% Peas, 50% Canola	**383.33**	**550.74**	167.41
4	75% Peas, 25% Canola	358.94	514.52	155.58
5	75% Peas, 50% Canola	374.57	531.26	156.69
6	100% Canola (Check)	354.05	397.67	43.62

*The cost of production and crop prices are based off of 2022 numbers. The cost and prices are also adjusted to reflect the extra storage, labour, and cleaning required for intercrops.

Conclusion

Economics of intercropping are variable at any given time or situation. Input prices of seed, fertilizer and chemicals change from year to year as do commodity prices. Therefore, the economics briefed in this report may not be representative of other years or situations.

The pea-canola intercrops were the most profitable combination. Drought conditions in the three years likely led to reduced synergistic effects of intercropping compared to as seen in wetter years in other research findings at WADO. Non-financial benefits need to be considered; pea-oat and pea-barley intercrops were demonstrated to increase cereal crop protein content compared to sole cereal crops. Pea-canola and pea-oat intercropping was also demonstrated to reduce the incidence of pea splits in pea crops, suggesting the potential of companion crops to protect the pea crop during harvest. Perhaps if adequate rainfall was received in at least one year of data collection, beneficial effects of intercropping could have been more clearly seen in terms of weed, disease, and pest incidence.

Appendix

	Pea	Oat	Canola	Barley	PeaCan	PeaCan	PeaCan	PeaCan	PeaOat	PeaOat	PeaOat	PeaBar	PeaBar	PeaBar
Crop System	1	5	6	5	2	3	4	5	2	3	4	2	3	4
Operating Cost														
Seed and Treament	$ 35.06	$ 18.13	$ 62.50	$ 15.00	$ 50.69	$ 66.31	$ 41.92	$ 57.55	$ 37.78	$ 53.19	$ 44.13	$ 37.31	$ 38.81	$ 42.56
Fertilizer	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26	$ 31.26
Herbicide*	$ 34.00	$ 24.00	$ 34.00	$ 21.00	$ 34.00	$ 34.00	$ 34.00	$ 34.00	$ 24.00	$ 24.00	$ 24.00	$ 21.00	$ 21.00	$ 21.00
Fuel	$ 20.39	$ 20.39	$ 21.09	$ 24.21	$ 24.21	$ 24.21	$ 24.21	$ 24.21	$ 24.21	$ 24.21	$ 24.21	$ 24.21	$ 24.21	$ 24.21
Machinery Operating	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00
Crop Insurance	$ 8.90	$ 9.31	$ 7.89	$ 9.75	$ 8.40	$ 8.40	$ 8.40	$ 8.40	$ 9.11	$ 9.11	$ 9.11	$ 9.33	$ 9.33	$ 9.33
Other**					$ 12.00	$ 12.00	$ 12.00	$ 12.00	$ 12.00	$ 12.00	$ 12.00	$ 12.00	$ 12.00	$ 12.00
Land Taxes	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00	$ 15.00
inoculant cost	$ 11.00				$ 11.00	$ 11.00	$ 11.00	$ 11.00	$ 11.00	$ 11.00	$ 11.00	$ 11.00	$ 11.00	$ 11.00
Interest (5% for 6 months)	$ 4.35	$ 4.43	$ 6.77	$ 5.09	$ 5.56	$ 5.56	$ 5.56	$ 5.56	$ 4.39	$ 4.39	$ 4.39	$ 4.72	$ 4.72	$ 4.72
Total Operating	**$ 169.96**	**$ 132.52**	**$ 188.51**	**$ 131.31**	**$ 202.11**	**$ 217.74**	**$ 193.35**	**$ 208.97**	**$ 178.74**	**$ 194.16**	**$ 185.09**	**$ 175.83**	**$ 177.33**	**$ 181.08**
Fixed Cost														
Land Investment	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06	$ 67.06
Machinery Cost	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31	$ 67.31
Storage Cost***	$ 4.88	$ 11.93	$ 4.77	$ 9.09	$ 4.83	$ 4.83	$ 4.83	$ 4.83	$ 8.41	$ 8.41	$ 8.41	$ 6.99	$ 6.99	$ 6.99
Total Fixed	**$ 139.25**	**$ 146.30**	**$ 139.14**	**$ 143.46**	**$ 139.20**	**$ 139.20**	**$ 139.20**	**$ 139.20**	**$ 142.78**	**$ 142.78**	**$ 142.78**	**$ 141.36**	**$ 141.36**	**$ 141.36**
Labour Cost^	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40	$ 26.40
TOTAL COST	**$ 335.61**	**$ 305.22**	**$ 354.05**	**$ 301.17**	**$ 367.71**	**$ 383.33**	**$ 358.94**	**$ 374.57**	**$ 347.92**	**$ 363.33**	**$ 354.27**	**$ 343.58**	**$ 345.08**	**$ 348.83**

* based one burnoff application of Roundup Transorb

**based on an extra cost of $1/ac to use a rotary seed cleaner, $1/ac for an extra auger, $10/ac cleaning cost: (20 yr depreciation cost), 350 bu/hr, $20/hr labour

***based on needing double the storage for two separate crops

^Labour cost inflated for intercropping due to the extra labour needed to ship, clean and harvest intercrops

Market Prices	$/bu
peas	$ 8.16
Oat	$ 3.78
canola	$ 12.35
Barley (malt)	$ 4.50

References
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31.0 Roquette Canada Phosphorous Trial for Pea Maturity and Standability
Project duration: 2022
Collaborators: Roquette Canada Ltd.

Objectives
- To explore if precise and targeted phosphorous application can result in more consistent field pea crop dry-down, increase yield, and seed quality

Background
Peas have a relatively high requirement for phosphorous; if the soil is very deficient in phosphorous, the current producer recommendations (Manitoba Agriculture) say that up to 55 lbs ac^{-1} of P_2O_5 can be applied. This study is evaluating the different responses from field peas under different rates of applied phosphorous. Crop maturity and dry down, as well as yield and seed quality are the traits of main interest in this project. There have been other sources report significant field pea responses to phosphorous rates, especially in yield and seed protein content. One study also proposed the idea that proper phosphorous management in peas can help regarding plant vigor, root health and therefore nodulation and the efficiency of nitrogen fixation (Fleury, D. 2021). Peas are not the most profitable crop to grow; the point of this trial and the other pea trials that WADO took a part in for Roquette Canada Ltd., is trying to find ways to grow peas that can be more profitable and efficient for producers in Manitoba.

Methods and Materials
A pea and phosphorous rate trial was established near Melita, Manitoba in 2022. The plots were established on Waskada Loam soil on SW18-4-26 into oat stubble. Prior to seeding a soil test was conducted (Agvise Labratories) indicating in the combined 0-24" depth values to be 30 lbs/ac N, 9 ppm P, 307 ppm K, 182 lbs/ac S. The trial was arranged in a randomized complete block design with four fertilizer treatments with three replicates. The four treatments consisted of four different rates of phosphorous

applied as monoammonium phosphate (MAP). The rates were 25, 50, 75, and 100 lbs actual ac^{-1}. In the first seeder pass of the plots, the nitrogen fertility was side banded at a depth of 1.25-inches, and MAP fertilizer was applied at variable rates in the corresponding plots. The peas were seeded with inoculant (Nodulator, BASF) on May 17th with a Seedhawk dual knife air seeder at ¾-inch depth into oat stubble. In-crop weed control was applied as Odyssey (17.3 g ac^{-1}) with Merge adjuvant at 0.5% on June 3rd. On July 12th Cygon (120mL ac^{-1}) was applied for control of aphids. The plots were desiccated on August 4th with Reglone (0.69L ac^{-1}) and LI-700 with a water volume of 20 gal ac^{-1}. All the plots were harvested on August 18th.

Results and Discussion

Table 28. The results from the 2022 Pea-Phosphorous Trial in Melita

Treatment	Plant stand ppms 4-5 WAP	Lodging 14-16 WAP	Ascochyta (Y/N) R1-R2	Maturity Days to brown pod R6-R7	Acochyta (Y/N) R6-R7	Yield Kg/ha
25 lb/ac P	59	1	Y	81	Y	3637
75 lb/ac P	72	1	Y	81	Y	3888
50 lb/ac P	64	1	Y	81	Y	3865
100 lb/ac P	68	1	Y	81	Y	3745
P value	0.349	-	-	-	-	0.503
Grand Mean	65.92	1	-	81	-	3784
MSE	65.53	-	-	-	-	46214
CV%	12	-	-	-	-	6
Fisher Comparison only found a significant difference between Rep (p<0.006) and Yield, Rep 1 was higher yield than Rep 2 and Rep 3						
Lodging Scale (1-5, 1 being erect, 5 being flat)						

Plant stand was not significant (P = 0.349) between the four treatments in this trial. The 75lbs ac^{-1} treatment had the highest plant count (72 ppms) and the 25lbs ac^{-1} treatment had the lowest (59 ppms) (Table 28). Lodging was not significant, and since there was no variation between the treatments, there is no P-value. Perhaps phosphorous does influence plant standability since no treatments had any lodging (rate of 1). All the plots in this trial had Ascochyta presence at the R1-R2 stage (flowering) then of course again at stage R6-R7 (brown pod). Days to maturity in this trial was also not significant, and since there was no variation between the treatments, there is no P-value. Lastly, yield was also not significant (P = 0.503) between the treatments. The 75lbs ac^{-1} treatment had the highest yield (3888kg ha^{-1}) and the 25lbs ac^{-1} treatment had the lowest yield (3637kg ha^{-1}). As noted at the bottom of Table 28, there was a significant different found between the yields in Rep 1 compared to those is both Rep 2 and Rep 3. This increase in yield could possibly be attributed to spatial differences across the trial. For example, the soil in which the first rep was planted may have had slightly different nutrient or moisture levels throughout the season that increased the yield potential of those four plots. Its is unlikely a phosphorus yield response would have been detected since soil test P values were found to be relatively sufficient for crop needs.

Pictures

Figure 13. The Roquette pea-phosphorous trial located at Melita in 2022.

References

Government of Saskatchewan. 2022. Inoculation of Pulse Crops. https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/crops-and-irrigation/soils-fertility-and-nutrients/inoculation-of-pulse-crops

Manitoba Agriculture and Resource Development. 2022. Field Pea – Production and Management. Fertilizer Recommendations for Pea. https://www.gov.mb.ca/agriculture/crops/crop-management/field-peas.html#fertilizer

32.0 Roquette Canada Nitrogen Trial for Nodulation Success/Failure and Resulting Yield

Project duration: 2022
Collaborators: Roquette Canada Ltd.

Objectives

- To explore if high nitrogen levels in the soil effect nodulation in peas and impact yield potential

Background

Traditionally farmers have followed the rule that the more nitrogen you apply to peas, the less nodules they will form and use to create their own nitrogen. Right now, Manitoba Agriculture does not recommend applying nitrogen when growing peas unless the field is severely deficient. This specific trial is looking to see if this recommendation remains true. Peas usually allow farmers a nitrogen credit during the year of seeding because they are a pulse crop that can fix their own nitrogen. In terms of economics, over-application of nitrogen is not desirable, especially if it has no effect on the crop, not creating more return for the producer. Peas are not the most profitable crop to grow. The point of this trial and the other pea trials that WADO took a part in for Roquette Canada Ltd., is trying to find ways to grow peas that can be more profitable and efficient for producers in Manitoba.

Methods and Materials

A pea-nitrogen trial was established near Melita, Manitoba on Waskada Loam soil by SW18-4-26 into oat stubble in 2022. Prior to seeding a soil test was conducted (Agvise Labratories) indicating in the combined 0-24" depth values to be 30 lbs/ac N, 9 ppm P, 307 ppm K, 182 lbs/ac S. The trial was arranged in a randomized complete block design with three treatments and had three replicates. The three nitrogen treatments were 50, 80, and 120 actual lbs ac^{-1}. The plots near Melita were seeded on May 16th at 1-inch depth into ample moisture with a Seedhawk dual knife air seeder. The seeder also applied pea inoculant (Nodulator, BASF) with the seed, and 16-30-22-13-1 (N-P-K-S-Zn) actual lbs ac^{-1} fertility, along with the variable rates of nitrogen as UAN (46-0-0) based on the residual levels in the soil. In-crop weed control was needed and applied as Odyssey (17.3 g ac^{-1}) with Merge adjuvant(0.5% v/v) on June 3rd. On July 12th the insecticide Cygon (120 mL ac^{-1}) was applied for control of aphids. The plots were desiccated on August 8th with Reglone (0.69L ac^{-1}) and LI700 with a water volume of 20 gal ac^{-1}. All the pea plots were harvested on August 18th.

Results and Discussion

In this trial, plant counts across the three treatments were not significant (Table 29). Though the 50lbs ac^{-1} treatment had higher plant counts, the counts were still not significant from the other treatments. Different levels of nitrogen in the soil did not seem to influence plant emergence and survivability. Lodging was not significant (P = 0.444) between the treatments; nitrogen rate did not seem to have an influence on plant standability.

Table 29. Results from the 2022 Roquette Pea-Nitrogen Trial in Melita

Treatment	Plant Stand ppms	Lodging 1 to 5 (5-flat)	Plant Nodulated % of plants	Nodulate Score 0 to 4	Days to Maturity	Yield Kg/ha
50 lb/ac Nitrogen	80	1.0	74	1.3	83	4608
80 lb/ac Nitrogen	64	1.3	66	1.0	83	4517
120 lb/ac Nitrogen	64	1.0	76	1.3	83	4328
P value	0.164	0.444	0.785	0.775	-	0.400
Grand Mean	69	1	72	1.2	83	4484
MSE	87.333	0.1111	324.06	0.29211	-	52830
CV%	13	30	25	45		5

Values followed by the same letter are not significantly different by Fishers mean separation method at 95% confidence.
Yield is corrected to 14%
ppms = plants per meter square

The number of plants in each plot that had nodules was not found to be significantly different (P = 0.785) between plots. This denotes that nitrogen rate did not influence whether the plants created nodules or not. Complementary to if plants have nodules, the number of nodules that the plants created and used were also not found to be significant (P = 0.775) between the different application rates of nitrogen. Lastly, the yield between the treatments was also not significant (P = 0.400). The 50lbs ac^{-1} treatment had the highest yield (4608kg ha^{-1}), while the 120lbs ac^{-1} treatment had the lowest (4328kg ha^{-1}). Although the statistical analysis does not see the yield results as significant, there is a trend seen that when nitrogen rate increases, yield decreases. In retrospect of trial design, an additional zero applied nitrogen check treatment would have possibly added better resolution to the spectrum of effects from applied nitrogen.

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33.0 Roquette Canada Variety x Seeding Rate trial under pesticide free production practices

Project Duration: 2022
Collaborators: Roquette Canada Ltd.

Objectives

- To identify pea varieties that perform superior under pesticide-free management (to mimic organic production) for yield, protein, standability, and seed quality. These traits will help organic farmers with variety selection

- To observe the effect of seeding rate effects on weed control and crop performance traits across varieties

Background

This variety adaptation trial is specifically evaluating field peas grown under organic producer practices. It is comparing different varieties and seeding rates to determine which combinations perform best under organic practices. Each variety grown was seeded at a low seeding rate and a high seeding rate. Higher seeding rates are a common practice in organic cropping systems to combat weed competition during the growing season. Other traits were evaluated that are relevant to organic producers in Manitoba. Peas are not a very profitable crop to for producers; Roquette Canada Ltd. Is interested in finding ways to grow and manage field peas that produce more income for the farmer.

Methods and Materials

This organic adaptation trial was established at Melita, Manitoba in 2022. The trial was conducted on Waskada Loam soil on SW18-4-26 into oat stubble with ample moisture. The trial was randomized in a factorial fashion with 8 varieties at two different seeding rates (Low – 10 plants per ft^2 and High – 12 plants per ft^2), and treatments were replicated three times. The varieties used in the trial included AAC Carver, AAC Chrome, CDC Meadow, AAC Amarillo, AAC Profit, CDC Inca, CDC Lewochko, and CDC Spectrum. The Melita plots were seeded on May 6th at 1-inch depth with a Seedhawk dual knife air seeder. There was no fertility or pesticides applied to mimic organic production. The plots were harrowed on June 2nd for weed control when the plants were approximately 4-inches tall and had 3 nodes. All the plots were harvested on August 18th when the majority of the plots reached 16% moisture content. Data collected included the following:

1. Early season vigor – emergence counts in set area at 14 days after seeding
2. Plant stand counts and staging assessed 4-5 weeks after planting (WAP) and 14-16 WAP (pre-harvest)
3. Weed count – taken as 1 quarter-meter square counts in each plot, identifying weed count and general species composition,
4. Height Assessment: at lodging timing (R5 to R6)
5. Canopy closure – use Licore equipment and analysis for light infiltration at R1.
6. Lodging tolerance - assessed at pre-harvest, (stage R5 to R6)
7. Disease assessment at flowering and at pre-harvest (presence/absence Ascochyta)
8. Approximate maturity
9. Date of Maturity
10. Net Yield (dockage removed), pod shatter, % moisture at harvest.
11. Quality - seed size (TKW), pea seed disease, seed coat breakage (protocol provided), % splits, protein, % dockage.
12. Cracked seed coats – measured out 50 g clean pea sample. Of the 50 grams, pick out the pea seed that have cracked seed coats from whole peas (not splits), weigh the seed with cracked seed coats and x 2 for cracked seed coat %
13. Splits – measured out 100 gram composite, uncleaned sample. Separate the sample through 11 slotted screen over a 12 round screen to separate out the whole peas from the split peas. Weighed the amount of splits remaining on top of the 12 round screen as the % splits.
14. Dockage – record unclean and cleaned weights to determine % dockage
15. Photos at key timing: early season, mid- season, at maturity (pick representative rep and do per plot.)

Table 30. Results from the 2022 Roquette Organic Adaptation Trial in Melita.

			Emergence Counts ppms	Weed Count ppms	Height cm	Lodging	Ascochyta (Y/N) R1-R2	Canopy Closure Licore % interception R1	Days to Maturity R6-R7	Ascochyta (Y/N) R6-R7	Pod shatter %	Net Yield (no dockage) KG/HA @14%	Seed Size TKWT grams	Pea seed yes/no	Seedcoat Breakage	% Splits	% Protein DM basis	% Dockage
Variety	1	AAC Carver	96abcd	19	68bc	1.3	Y	22bc	84bc	Y	3.8	3317cd	247abc	Y	1.7b	1.0d	19.6d	4.9bcd
	2	AAC Chrome	89bcd	31	53d	1.3	Y	29ab	84bc	Y	3.0	3648ab	252a	Y	0.5b	2.0c	19.0d	6.2ab
	3	CDC Meadow	97abc	18	63c	1.3	Y	27ab	82d	Y	2.8	3063d	210d	Y	2.5b	0.9d	20.4c	6.1ab
	4	AAC Amarillo	81cd	26	73ab	1.0	Y	29ab	85b	Y	3.2	3094cd	249ab	Y	18a	1.5cd	20.4c	6.5ab
	5	AAC Profit	78d	19	70bc	1.5	Y	29ab	86a	Y	2.0	3197cd	250ab	Y	0.7b	2.8b	21.0b	6.6a
	6	CDC Inca	104ab	20	72bc	1.2	Y	17c	86a	Y	3.0	3813a	239c	Y	0.6b	1.5cd	21.9a	3.9cd
	7	CDC Lewochko	109a	20	79a	1.2	Y	15c	86a	Y	2.8	3771a	242bc	Y	1.3b	1.9c	21.6ab	3.2d
	8	CDC Spectrum	88abcd	23	63c	1.2	Y	32a	85b	Y	3.3	3388bc	248ab	Y	1.1b	3.5a	21.7a	5.5abc
Rate	1	Low	86b	22	68	1.3	Y	26	85	Y	3.2	3457	242	Y	3.4	1.8	20.8	5.3
	2	High	99a	22	68	1.3	Y	24	84	Y	2.8	3366	242	Y	3.3	2.0	20.6	5.4
Variety x Rate																		
1 AAC Carver	1	Low	86	9	64	1.7ab	Y	22	84	Y	4.0	3463bcdef	248	Y	2.0	0.7	19.8	4.5
1 AAC Carver	2	High	107	28	71	1.0b	Y	21	83	Y	3.7	3172efgh	246	Y	1.5	1.3	19.4	5.3
2 AAC Chrome	1	Low	88	38	55	1.0b	Y	29	84	Y	2.3	3665bcd	252	Y	0.3	1.7	19.2	6.7
2 AAC Chrome	2	High	90	24	52	1.7ab	Y	30	84	Y	3.7	3631bcd	252	Y	0.7	2.3	18.8	5.7
3 CDC Meadow	1	Low	92	21	66	1.7ab	Y	26	83	Y	2.3	3189efgh	207	Y	1.6	0.7	20.0	5.2
3 CDC Meadow	2	High	104	14	60	1.0b	Y	29	81	Y	3.3	2937h	213	Y	3.5	1.1	20.9	7.0
4 AAC Amarillo	1	Low	78	20	74	1.0b	Y	27	85	Y	3.7	3035gh	249	Y	19.2	1.5	20.7	7.1
4 AAC Amarillo	2	High	84	32	72	1.0b	Y	31	85	Y	2.7	3154efgh	249	Y	16.8	1.5	20.1	5.9
5 AAC Profit	1	Low	75	20	67	1.0b	Y	27	85	Y	1.7	3046fgh	251	Y	0.9	2.9	21.3	7.2
5 AAC Profit	2	High	81	19	72	2.0a	Y	31	86	Y	2.3	3347cdefgh	248	Y	0.5	2.7	20.8	6.1
6 CDC Inca	1	Low	96	19	71	1.0b	Y	22	86	Y	4.0	3871ab	239	Y	0.5	1.7	21.6	2.6
6 CDC Inca	2	High	113	21	74	1.3ab	Y	11	86	Y	2.0	3754abc	238	Y	0.7	1.4	22.1	5.2
7 CDC Lewochko	1	Low	102	17	81	1.3ab	Y	16	86	Y	4.3	4116a	240	Y	1.3	1.7	21.6	2.9
7 CDC Lewochko	2	High	117	24	77	1.0b	Y	13	85	Y	1.3	3426cdefg	245	Y	1.3	2.1	21.5	3.5
8 CDC Spectrum	1	Low	78	29	64	1.3ab	Y	35	84	Y	3.0	3272defgh	249	Y	0.9	3.5	21.9	6.5
8 CDC Spectrum	2	High	99	16	62	1.0b	Y	28	85	Y	3.7	3505bcde	248	Y	1.3	3.5	21.5	4.4
P-values		Variety	**0.025**	0.738	**<0.001**	0.750	-	**0.001**	**<0.001**	-	0.677	**<0.001**	**<0.001**	-	**<0.001**	**<0.001**	**<0.001**	**0.001**
		Rate	**0.012**	0.896	0.934	1.000	-	0.501	0.092	-	0.456	0.221	0.777	-	0.932	0.231	0.357	0.908
		V x R	0.947	0.445	0.279	**0.044**	-	0.530	0.055	-	0.189	**0.041**	0.954	-	0.951	0.742	0.150	0.104
		CV%	17		8	39	-	28	1	-	51	7	3	-	82	27	2	27
		MSE	261.61	201.99	27.161	0.2375	-	0.00482	0.4389	-	2.333	63834	53.34	-	7.306	0.27	0.2434	2.0871
		Grand Mean	93.167	21.938	67.646	1.25	-	0.25	84.542	-	3	3411.4	242.1	-	3.3	1.9	20.6958	5.4

Values followed by the same letter are not significantly different by Fishers mean separation method at 95% confidence.
Lodging Scale = 1-5, 1 being erect, 5 being flat
ppms = plants per meter square
WAP = weeks afer planting

Results

All the characteristics that were recorded and analyzed where found to be significant when examining the effects of variety except for weed counts, lodging, and percentage of pod shatter (Table 30). Emergence counts were significant ($P = 0.025$) affected by variety; CDC Lewochko had the highest plant count (109 plants per meter squared). This was not significantly different from four other varieties: CDC Inca, CDC Meadow, AAC Carver, and CDC Spectrum. AAC Profit had the lower plant counts of all the varieties (78ppms). Plant height was significant ($P < 0.001$) between varieties; CDC Lewochko was the tallest variety (79cm) and was not significantly different from the height of CDC Amarillo. AAC Chrome was the shortest variety in the trial (53cm). Canopy closure, measured by a Li-core reading at the R1 stage (flowering), was found to be significant ($P = 0.001$) between varieties. CDC Spectrum had the highest percentage of interception (32%), which was not significantly different from four other varieties: AAC Chrome, AAC Amarillo, and AAC Profit (29%), and CDC Meadow (27%). CDC Lewochko had the lowest percentage of interception (15%). Days to maturity was found to be significantly ($P < 0.001$) affected by variety in the statistical analysis. CDC Meadow matured in the shortest amount of time (82 days), and three varieties AAC Profit, CDC Inca, and CDC Lewochko all matured in the longest amount of time (86 days). The remaining varieties matured between 82 and 86 days. As expected, net yield was found to be significantly ($P < 0.001$) different between the varieties. CDC Inca had the highest overall net yield (3813 kg ha^{-1}) which was not significant from the yields of two other varieties: CDC Lewochko and AAC Chrome. CDC Meadow had the lowest overall net yield (3036 kg ha^{-1}) which was not significantly different from the net yields of AAC Amarillo, AAC Profit, and AAC Carver. Seed size (TKWT) was significant ($P < 0.001$) between varieties; AAC Carver had the highest TKWT (252g) and that was not significant from four other varieties: AAC Profit, AAC Amarillo, CDC Spectrum, and AAC Carver. CDC Meadow was the variety with the lowest TKWT (210g). The percentage of seed coat breakage was significant ($P < 0.001$) between varieties; AAC Amarillo had the highest level of seed coat breakage (18%). The remaining varieties had remarkably lower seed coat breakage, the lowest being AAC Chrome (0.5%). The percentage of split seeds was found to be significant ($P < 0.001$) between the varieties. CDC Meadow had the lowest number of splits (0.9%) and was not significant from three other varieties: AAC Carver, AAC Amarillo and CDC Inca. CDC Spectrum was the variety with the highest number of splits (3.5%). As expected, seed protein content was significantly ($P < 0.001$) affected by variety. CDC Inca had the highest protein content (21.9%), and that was not significant from two other varieties, CDC Spectrum and CDC Lewochko. AAC Chrome had the lowest protein content overall (19.0%) which was not significantly different from the protein content of AAC Carver. Lastly, the percentage of dockage in the sample was also significantly ($P = 0.001$) affected by pea variety. CDC

Lewochko was the variety that had the least dockage (3.2%) and that was not significantly different from the dockage of varieties CDC Inca and AAC Carver. AAC Profit had the highest amount of dockage (6.6%) which was not significantly different from the dockage of four other varieties: AAC Amarillo, AAC Chrome, CDC Meadow, and CDC Spectrum.

The only characteristic that was found to be significantly (P = 0.012) affected by seeding rate was emergence counts (Table 30). As you would expect, the higher seeding rate plots had higher counts (99ppms), and the lower seeding rate plots had lower counts (86ppms).

There are 16 separate treatments when the effects of seeding rate on specific varieties of peas is examined simultaneously (Table 30). Interestingly, the statistical analysis only found two characteristics important. Lodging was significantly (P = 0.044) influenced by the effects of seeding rate on variety. Nine out of 16 treatments had the lowest lodging score of possible (1.0) (1 being standing and 5 being flat). AAC Profit at the high seeding rate had the higher lodging score (2.0), which was not significantly different from six other treatments in the trial. Overall, the plots did not experience a lot of lodging. The effects of seeding rate on variety had significantly (P = 0.041) affected yield as well. CDC Lewochko at the low seed rate yielded the highest (4116 kg ha^{-1}). Though the highest, CDC Lewochko's yield was not significantly different from that of the yields of CDC Inca at both the low and high seed rate. CDC Meadow at the lower seeding rate had the lowest net yield (2937 kg ha^{-1}). The lowest yield was found to not be significantly different from seven other treatments that can be found in the table.

Discussion

The data that was collected in this trial all relate to what you would look for in a variety to grow under organic conditions. Two different seedings rates were also included in the factors since it is a commonly used organic cultural control for weeds. The low seeding rate target stand was 10 plants ft^{-2} and the high seeding rate target stand was 12 plants ft^{-2}. The means that were calculated for emergence counts had the high and low seeding rate plots combined for each variety. If the average emergence for a variety is on the low side, it could indicate that the variety is not as suitable to grow at high seeding rates. This could be due to the need for more space and access to resources compared to other varieties. All the varieties grown in this trial landed in the target zone except for AAC Profit and AAC Amarillo. Weed counts were also taken throughout the season, and they were not found to be important in any part of the trial. Therefore, we can not make any conclusions on how the weed population and control was affected by the variety or seeding rates. It is possible the choice of seeding rates were too close in nature to achieve discernible differences, perhaps the low treatment should have been 8 plants per square foot for example.

Height of the plants was also recorded during the growing season. In peas, taller plants are usually more competitive against weeds, but they are also more prone to lodging. There were no significant effects on weeds from the height of the variety, and the plants suffered little to no lodging. Perhaps in a year were normal or significant amounts of rainfall were to occur, we would see more lodging in the pea crops. In organic farming systems, the rate of canopy closure is an important factor to considered. The more the canopy closes early in the growing season, the harder it will be for weeds to compete for resources such as sunlight. Days to maturity were found to be significant in the trial, but the differences were not large. Days to maturity are increased when the crop stays green for longer; this is usually seen in higher seeding rates. The entire trial had relatively low amounts of pod shatter. Pod shatter can be affected by lodging, and maturity and it can cause substantial yield losses. In organic systems, desiccation is not allowed, so when maturity is not uniform, dry parts of the field can start to shatter before other parts are ready to harvest.

Yield is always an important factor to consider in any trial. When considering variety only, yield of the crop can vary, but it also depends on many other factors. Seeding rate is usually directly related to yield, but interestingly in this trial, the yield was not significantly affected by seeding rate. Though, yield is significant when considering *both* seeding rate and variety; the results also have low variance. Thousand kernel weight (TKWT) was found to only be significantly affected by the variety which is expected. Seed coat breakage was also only affected by variety. It is important to consider seed coat breakage when choosing a variety since processing facilities need to sort out broken seeds before they can be processed; some facilities will also charge a cleaning fee or dockage fee. There was not a lot of dockage found in this trial; dockage can be caused by lodging, harvest conditions, and also by harvesting and handling equipment.

Overall, the trends seen in the trial were interesting but further years of data collection would be needed to confirm trends and use this information as a guide.

Figure 15. A view of the organic adaptation pea variety trial that was located at Melita in 2022.